Analysing Urban Solid Waste in Developing Countries: a Perspective on Bangalore, India

Pieter van Beukering, Madhushree Sehker, Reyer Gerlagh and Vijay Kumar.

Working Paper No 24

March 1999

Authors details

Drs Reyer Gerlagh and Pieter van Beukering are researchers with the Institute for Environmental Studies (IVM), Amsterdam. They may be contacted at:

IVM
De Boelelaan 1115
1081 HV Amsterdam
THE NETHERLANDS

	R. Gerlagh	P. van Beukering
tel	(31) 20 444 9502	(31) 20 444 9524
fax:	(31) 20 444 9553	(31) 20 444 9553
email:	reyer.gerlagh@ivm.vu.nl	pieter.van.beukering@ivm.vu.nl

Dr Madhushree Sekher is Assistant Professor, and Vijay Kumar areat the Institute for Social Economic Change, Bangalore. They may be contacted at:

Institute for Social and Economic Change (ISEC)
Nagarbhavi
P O Bangalore 560 072
INDIA

tel: (91) 80 321 5468
fax: (91) 80 321 7008
email: dgp@isec.kar.nic.in/ssisec@ren.nic.in

The programme of Collaborative Research in the Economics of Environment and Development (CREED) was established in 1993 as a joint initiative of the International Institute for Environment and Development (IIED), London, and the Institute for Environmental Studies (IVM), Amsterdam. The Secretariat for CREED is based at IIED in London. A Steering Committee is responsible for overall management and coordination of the CREED Programme.

Environmental Economics Programme, IIED

IIED is an independent, non-profit organisation which seeks to promote sustainable patterns of world development through research, training, policy studies, consensus building and public information. The Environmental Economics Programme is one of seven major programmes of IIED; it conducts economic research and policy analysis for improved management of natural resources and sustainable economic growth in the developing world.

Environmental Economics Programme
IIED, 3 Endsleigh Street
London WC1H 0DD, UK
Tel +44 (0)171 388 2117; Fax +44 (0)171 388 2826
e-mail: Jacqueline.Saunders@iied.org

Institute for Environmental Studies, (IVM)

IVM is a non-profit research institute, based at Vrije Universiteit, Amsterdam. The Institute's primary objective is to carry out multi- and interdisciplinary research on environmental issues, based on cross-fertilisation of monodisciplinary sciences. Environment and the Third World is one of eight major IVM research programmes.

IVM, Vrije Universiteit
De Boelelaan 1115
1081 HV Amsterdam
The Netherlands
Tel: +31 20 444 9555; Fax: +31 20 444 9553
e-mail:secr@ivm.vu.nl

CREED Steering Committee members include:

Abstracts of CREED publications and details of all CREED projects are now available on the Internet. Visit the CREED Web site at:

http://www.iied.org/creed

Acknowledgements

This study, which examines the process of urban waste management in Bangalore, was commissioned by the programme for Collaborative Research in the Economics of Environment and Development (CREED) and the Urban Waste Expertise Programme (UWEP), both sponsored by the Dutch Ministry of Foreign Affairs. We are grateful to CREED, UWEP and the Ministry for the financial support. Dr. M. Verma, Dr. P.P. Yadav and Mrs. P. Pandey of the Indian Institute of Forest Management provided many inputs and advice during the course of the study, and assisted with the review of this paper. We are deeply grateful to Prof. Abdul Aziz, Project Director, Decentralised Governance and Planning, ISEC, under whose able guidance, supervision and encouragement this study was carried out. We are also grateful for the collaboration with colleagues from the Advisers on Urban Environment and Development (WASTE, Gouda), Dr L. Hemelaar and Dr A. van de Klundert.

The onerous task of collecting data from the field, and processing and tabulating was undertaken by Messrs. M. S. Patil, M.R. Shivalingaiah and K. Narasimha Phani. We sincerely appreciate the work put in by all of them. We would like to express a special word of thanks to Mr. M. S. Patil who took great pains in computerising and tabulating the field data, and whose valuable insights were important for us for understanding the problem in the field. Our thanks are also due to Ms. Manjula and Ms. Lakshmi for their patience and efficiency in word processing this paper.

We are grateful to ISEC Director, Dr. P. V. Shenoi, for his constant support during the study. We also appreciate the help and assistance given by our former Registrar, Dr. S. N. Sangita, present Registrar, Dr. M. Venkata Reddy and ISEC administrative staff in facilitating the study.

We shall be failing in our duty if we do not adequately thank all the experts who spared their valuable time in providing us with useful information about the waste management process in Bangalore. A special word of thanks goes to the officials of Bangalore City Corporation, staff of M.S. Ramaiah Medical College, TERI and Mr. Anselm Rosario, Waste Wise, Bangalore. We also wish to gratefully acknowledge the co-operation shown by our numerous respondents whose contributions form the basis of this study. Thanks are also due to all our colleagues in the Decentralised Governance and Planning Project.

Finally, we want to acknowledge the helpful comments of Robert Smith and Jane C. Powell, who extensively reviewed the paper.

Abstract

Increasing amounts of waste, both solid and liquid, are being generated as a result of the rapid rate of urbanisation. This in turn presents greater difficulties for disposal. The problem is more acute in developing countries, such as India, where the pace of economic growth as well as urbanisation is faster.

Various concepts have been developed over theyears to provide the basis for improving the solid waste conditions in developing cities. Among them, integrated Solid Waste Management (SWM) provides a framework which has been very successful in various industrialised countries. However, urban governments in developing countries are constrained by limited finances and inadequate services which prevent them from tackling the problem effectively. In addition, their SWM planning is hampered by a lack of data while information at all levels, if available, is generally unreliable, scattered and unorganised. As a result, planning of SWM is a difficult task.

This paper attempts to understand the SWM process on the basis of an evaluation of the waste flow in the study area of Bangalore. The objective here is to review the available literature in order to derive lessons and apply the insights to an analysis of the situation in the field. In addition to the literature data are collected from the field. Despite several analytical shortcomings of this study, the flow evaluation highlights various priority issues that need to be addressed in future SWM planning in Bangalore as well as other Indian cities. These include:

- inadequate municipal services due to limited resources;

- an absence of hygienic and scientific disposal systems;

- a lack of public awareness for waste management resulting in high levels of unsegregated waste generation and littering;

- the existence of an extensive informal network which is mainly driven by market forces and functions partly on subsistence levels;

- the absence of sufficient capacity for waste processing, in particular for organic waste which is in most abundance;

- the existence of a relatively small market for recycled waste products.

Although SWM includes a range of stakeholders, the contribution of government is imperative. This does not necessarily have to be financial. For example, the government should make a formal commitment to an integrated SWM approach, and recognise the contribution of existing informal recycling networks. Moreover, waste recycling can be promoted through consumer campaigns encouraging citizens to co-operate in waste separation. A more realistic fee for waste services could be extracted in return for a guarantee that these services will be provided. Finally, to be effective. SWM requires regular and proper monitoring of disposal activities.

Un análisis de desechos sólidos en zonas urbanas de países en desarrollo

La rápida tasa de crecimiento urbano ha generado un aumento en el volumen de desechos sólidos y líquidos. Esto produce a su vez dificultades para su disposición. En países en desarrollo, como la India, el problema es más grave debido a la tasa acelerada en el desarrollo económico y al rápido proceso de urbanización.

Con el tiempo se han llegado a proponer varios conceptos que establecen las bases para mejorar las condiciones de desechos sólidos en ciudades en desarrollo. La Gestión de Desechos Sólidos (GDS) entre otros ofrece un esquema que ha sido muy exitoso en varios países industrializados. Sin embargo, las limitaciones financieras y los servicios inadecuados impiden a los gobiernos urbanos en los países en desarrollo enfrentar con efectividad el problema de los desechos. Además, la falta de datos y la información inexacta, dispersa y desorganizada a todo nivel hace que la planificación de su GDS sea una tarea difícil.

La presente monografía aspira a entender el proceso de GDS basándose en una evaluación del flujo de desechos en el área de estudio de Bangalore, India. El objetivo de este documento es hacer una revisión de la literatura disponible para aprender lecciones y aplicar las reflexiones a un análisis de esta situación específica. También se recogen datos empíricos además de revisar la literatura. A pesar de algunas deficiencias en el análisis, la evaluación del flujo pone de relieve varios asuntos prioritarios que deben tenerse en cuenta en la planificación futura de GDS en Bangalore y en otras ciudades de la India. Estos incluyen los siguientes puntos:

- los servicios municipales son inadecuados debido a recursos limitados;

- existe una ausencia de sistemas de recolección higiénicos y científicos;

- no hay consciencia por parte del público acerca de la gestión de desechos lo cual conlleva a niveles altos de generación de desechos desagregados y de basuras dispersas fuera de los botaderos;

- existe una extensa red informal que responde principalmente a las fuerzas del mercado que opera parcialmente a niveles de subsistencia;

- no hay capacidad suficiente para el procesamiento de desechos, en particular desechos orgánicos los cuales son los más abundantes;

- existe un mercado muy pequeño para productos de desechos reciclados.

Aunque la GDS responde a varios intereses, la contribución del gobierno es muy importante. Dicha contribución no es necesariamente financiera. El gobierno debe, por ejemplo, comprometerse formalmente a participar en un enfoque integrado de la GDS reconociendo la contribución de las redes informales existentes. El reciclaje de desechos se puede además promover mediante campañas dirigidas a los consumidores en las cuales se fomente la cooperación en la separación de desechos. Mediante la garantía de que se ofrecen servicios de gestión de desechos es más factible cobrar una tarifa por dichos servicios. Finalmente, para ser efectiva, la GDS requiere un control frecuente y adecuado de las actividades de recolección.

Abrégé

L'analyse des déchets solides urbains dans les pays en développement.

L'urbanisation se déroule à un tel rythme que l'on produit des quantités croissantes de déchets, tant solides que liquides, ce qui présente à son tour des difficultés accrues pour s'en débarrasser. C'est un problème encore plus aigue dans les pays en développemeent, comme en Inde, où le rythme de la croissance économique, comme celui de l'urbanisation, est plus rapide.

Au fil des ans, divers concepts ont été élaborés pour servir de base à une amélioration de la situation des déchets solides dans les cités en développement. L'un d'entre eux, le concept de Gestion intégrée des déchets solides (GID) [*integrated Solid Waste Management - SWM*] propose un cadre d'analyse qui a donné de très bons résultats en divers pays industrialisés. Mais sur les collectivités locales urbaines pèsent des contraintes: finances limitées et services inadéquats les empêchent de s'attaquer efficacement au problème. Par ailleurs, leur planification de GID souffre d'un manque de données alors que si l'information est disponible à tous niveaux, elle s'avère généralement peu fiable, dispersée et désorganisée. En conséquence, planifier une GID est une tâche bien difficile.

Ce texte cherche à comprendre le processus de GID en partant d'une évaluation des flux de déchets dans la zone étudiée, celle de Bangalore. L'objectif est ici de passer en revue la documentation disponible afin d'en tirer des leçons et de les appliquer à une analyse de la situation sur le terrain. Outre la documentation existante, des données ont été recueillies sur le terrain. Malgré plusieurs déficiences analytiques de l'étude, l'évaluation des flux fait apparaître diverses questions qu'il faudra traiter prioritairement dans la planification future de la GID de Bangalore ainsi que d'autres villes indiennes. Il s'agit:

- de l'inadaptation des services municipaux, due au caractère limité des ressources;

- de l'absence de systèmes de rebut hygiéniques et scientifiques;

- du manque de conscience du public en matière de gestion des ordures, ce qui aboutit à des degrés élevés de production de déchets indifférenciés et de jonchée;

- de l'existence d'un réseau de récupération informel et extensif, animé surtout par les forces du marché et fonctionnant en partie à des niveaux de subsistance;

- de l'absence d'une capacité suffisante de traitement des déchets, en particulier des déchets organiques, qui sont les plus abondants;

- du fait que n'existe, pour les produits issus du recyclage des déchets, qu'un marché relativement restreint.

Bien que la GID englobe déjà toute une gamme de parties prenantes, la contribution de l'État est un impératif. Elle ne doit pas nécessairement prendre une forme financière: il faut, par exemple, que le gouvernement s'engage formellement en faveur d'une approche de GID et reconnaisse la contribution, en matière de recyclage, des réseaux informels existants. Qui plus est, la promotion du recyclage peut passer par des campagnes auprès des consommateurs, encourageant les citoyens à coopérer à la séparation des déchets. On pourrait obtenir un paiement plus réaliste pour les services de collecte et de traitement des déchets, en échange de la garantie qu'ils soient effectivement fournis. Enfin, la GID exige un suivi régulier et correct des activités de mise au rebut

Contents

Introduction

Increasing amounts of waste, both solid and liquid, are being generated as a result of the rapid rate of urbanisation. This in turn presents greater difficulties for disposal. The problem is more acute in developing countries, such as India, where economic growth as well as urbanisation is more rapid. Effective management of urban waste is required, but urban governments in many countries in the south are constrained by limited finances and inadequate services.

In this context, a research study was carried out in an urban metropolis in India to develop an integrated Solid Waste Management (integrated SWM)[1] model. This model aims to evaluate alternatives for the efficient management of urban solid waste by including all stakeholders. This paper, which forms part of the study, attempts to understand the SWM process on the basis of an evaluation waste flows in the study area and to identify key areas where an integrated SWM may be implemented. The objective here is to review the available literature with a view to deriving lessons and applying the insights gained to an analysis of the field situation. In addition to the literature data are collected from the field.

The paper comprises five sections. The second section discusses some major concepts that are used in the analysis of solid waste management, and outlines a global perspective differentiating between high income and low income countries. The third section briefly reviews the present status of SWM in India, while the fourth section discusses the situation in Bangalore city where the field study was conducted. Finally, in section five, using Bangalore city an illustration of urban SWM in Indian cities, we derive some main observations and make suggestions for future action.

[1] ISWM provides an inter-disciplinary, comprehensive framework for addressing the problems of managing urban solid waste, particularly in the resource constrained developing countries where SWM service quality is poor, costs are high and often with no effective means of recovering costs. This approach takes into account economic, social, institutional and environmental aspects involved in the process. For details see Lardinois, 1996.

Concepts in Solid Waste Management

Broadly, the material flow stream of waste from generation to ultimate disposal, comprises the following:

- generation
- collection / transportation
- processing
- disposal.

Accordingly, SWM encompasses the full range of activities for these streams, from the generation of used materials to their disposal (Beede and Bloom, 1995; Lardinois, 1996).

Resource recovery includes all activities of waste segregation, collection and processing which are carried out taking into consideration the economic viability of the material (Cointreau, *et. al.*,1984; Baud and Schenk, 1994; Beede and Bloom, 1995). Re-use and recycling provide an opportunity to capture some of the values from the waste (Cointreau, *et. al.*, 1984; Beede and Bloom, 1995). Of these two techniques, reuse is a simpler process involving reutilisation of material in its end -use form without the necessity of reprocessing (Beukering, 1994). Recycling, on the other hand, involves processing waste through remanufacture and conversion of parts in order to recover an original raw matter (Cointreau, *et. al.*, 1984; Beukering, 1994).

A review of existing literature reveals that a great number of studies on SWM have been undertaken, even prior to 1970. Earlier studies show that refuse management was assumed to be the main responsibility of the public officials whose prime consideration was the quick removal of waste and its destruction (Melosi, 1980). During the 1970s the debate shifted to issues of waste utilisation. Studies during this time focused on the technical and economic issues surrounding the allocation and utilisation of available resources, and examined existing state-of-the-art of resource recovery for managing urban grime (Bever, 1976; Heidenstem, 1977). The early studies reveal that recycling in the past was mostly industrial and based on financial considerations to reduce production cost, unlike the current emphasis on recycling as a way of reducing waste in the environment and preserve dwindling resources (Cointreau, *et. al.*, 1984).

The collection of waste and its recovery from different waste generating points is carried out by many agents, formal and informal, which represent a variety of organisational structures and relationships (Cointreau, 1987). In most developing countries, including India, urban SWM comes under the auspices of the local municipal bodies who are the main formal stakeholders responsible for the collection, removal and disposal of garbage from public places and for the maintenance of dumping grounds (Hadker, 1995). Sometimes the private formal sector, such as private contractors and small and large reprocessing enterprises, as well as the non-government and community based organisations (NGOs & CBOs), assist the municipal authorities in collecting, treating and disposing waste (Gidman, *et. al.*, 1995).

Alongside the formal sector, in developing countries resource recovery and recycling activities are also marked by the involvement of the informal sector. This comprises waste pickers, itinerant waste buyers (IWBs) and middlemen such as junk dealers and wholesalers (Aziz, 1984; Hardoy *et. al.,* 1992; Huysman, 1994; Furedy, 1989). This informal sector mostly refers to those employers which are classified as "own account" workers, eg unpaid family workers and those who collect and treat mostly unregistered waste material (World Bank, 1995).

Integrated solid waste management

Looking at historical citations one can assume that the concept of integrated solid waste management (integrated SWM) developed gradually over time. For example, in many European countries in the 1660s, burial in cotton or linen shrouds was banned to allow more cloth for paper making (World Resource Foundation, 1997). In 1896, the first combined waste incineration and electricity scheme began operation in East London. Until the early 1890s, New York's garbage was mainly dumped in the Atlantic Ocean, polluting the beaches, resulting in protests by the resorts on the shores of New Jersey and New York. Then in 1894, a "program of source separation was implemented on the premise that mixed refuse limited the options for disposal, whereas the separation of wastes at the source allowed the city to recover some of the collection costs through the resale and reprocessing of materials" (Gandhy 1994). In the early part of this century, an ethnic minority in Egypt, the Zabbaleen, was one of the world's first communities to integrate recovery and recycling of municipal waste (Baaijens, 1994).

Yet, it was the environmental movement in the late 1960s which formally presented integrated SWM as a guiding principle for managing societies' refuse. Since this was also a period of economic prosperity in most industrialised countries, waste managers were not constrained by narrow budgets. Thus, until the economic recessions of the early-1980s the new paradigm of integrated SWM was widely implemented in industrialised countries (Schall, 1995).

Integrated SWM is a very broad concept. Figure 1 shows the overall framework, although it is not intended to be an exhaustive list of categories. Essentially integrated SWM implies that decisions on waste handling should take into account economic, environmental, social and institutional dimensions. Economic aspects may include the costs and benefits of implementation, the available municipal budgets for waste management, and the spin-off effects for other sectors in the economy in terms of investments. The environmental dimension may consist of local problems (ie, increased risk of epidemics and groundwater pollution), regional problems (ie, resource depletion and acid rain), and global problems (ie, global warming and ozone depletion). Social aspects include employment effects for both the formal and the informal sector, impact on human health and ethical issues such as the use child labour. Finally, the institutional dimension of integrated SWM aims to develop a system which effectively involves the main stakeholders.

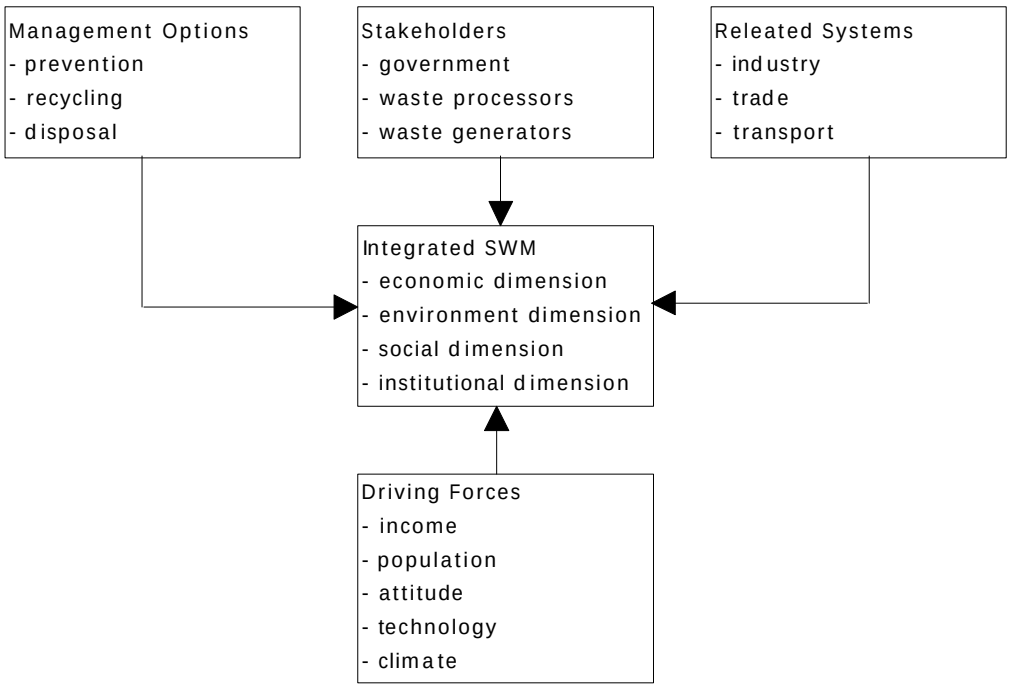
The integrative aspect lies in the trade-off between these four dimensions. For example, in certain situations, although recycling may be preferred from an environmental perspective, the economic costs involved or the presence of institutional complications may prevent waste recycling from being promoted and implemented in integrated SWM. This is the case, for example, with recycling polyethylene bags in industrialised countries, where the environmental benefits are limited when weighed against the high labour costs and the absence of sufficient infrastructure. Obviously, trading-off between these four dimensions is a rather complex exercise. The actual integration can take place at various levels (Lardinios and Klundert 1997):

1. The use of a range of different collection and treatment options. These include prevention, recycling, energy recovery and sound landfilling of solid waste. A discussion on these options is presented in below in the section on the waste hierarchy.

2. The involvement and participation of all the stakeholders. These may include waste processors such as formal and informal recyclers, waste generators such as households, industry and agriculture, and government institutions such as waste managers and urban planners.

3. The interactions between the waste system and other relevant systems such as industry. For example, product design at the industry level can have a significant impact on the 'recyclability' of the product after consumption. Since few examples from developing countries are reported in the literature, this category will not be considered in this paper. However, it may be very important in the concept of integrated SWM and should therefore be considered for future research.

Figure 1. Framework for analysing the concept of Integrated SWM



It is difficult to include all these aspects at the same time, since the factors affecting solid waste management are constantly changing For example, income and population growth contribute significantly to the amount of waste which has to be managed. Similarly, differences in educational background and environmental awareness results in varying attitudes of waste generators. Finally, technological progress in the field of waste management is rapid, so certain technologies may outdate more rapidly.

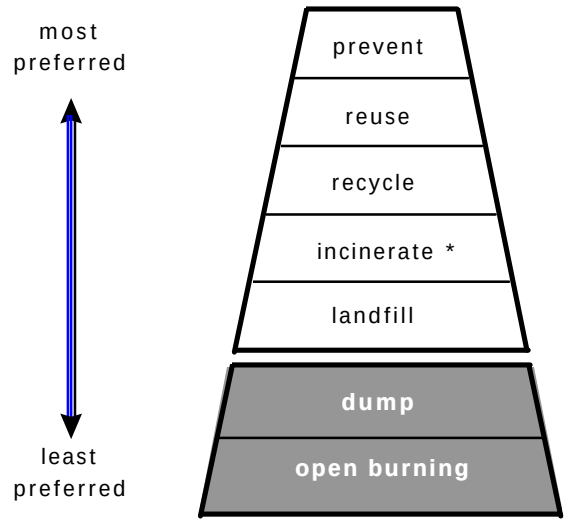
These problems are more severe in developing countries where limited municipal budgets for waste management exacerbate the difficulties of integration. As a result, policies tend to focus mainly on the waste hierarchy. This paper will argue that since the social, economic and institutional factors in developing countries are quite different from those in the industrialised countries, for a waste management policy to be successful it needs to adapt concepts developed in the North to suit the circumstances in the South. In some cases, it is even doubtful if the concepts may be applied at all. For example, the prospects for curbside recycling programmes, which are very popular in Europe and the US, are questionable given both the expense and the potential impact on the existing informal recovery sector operating in most Southern cities (Beukering *et al*. 1996).

The waste hierarchy

The waste hierarchy is accepted as a key element in integrated SWM, particularly in the North where it is widely applied. The hierarchy is based on environmental principles which propose that waste should be handled by different methods according to its characteristics, ie a certain amount should be prevented either by reducing the content of waste or by reusing the waste; another share of the waste stream should be converted into secondary raw materials; some parts can be composted or used as source of energy, and the remainder may be landfilled (see Figure 2). Reality does not adhere to this environmentally based sequence. Indeed, in developing countries, a large quantity of waste is dumped in an uncontrolled manner, or worse, burned in the open air. Obviously, these options do not belong to the waste hierarchy because of their unacceptable high levels of environmental damage. These latter two options are therefore added in the shaded area.

Although this ranking of waste management options provides policy makers with an effective base, integrated SWM goes beyond the waste hierarchy. It is generally known that the hierarchy has to be applied in a flexible way and it is only intended as a general guideline to achieve the best environmental solution in the long term. Still, the hierarchy has always been subject to fierce criticism for various reasons. First, although the ranking may indeed be correct in terms of environmental pressure for certain materials, this is not the case for all materials or products. For instance, it may be better to recycle an old refrigerator rather than reuse it because its inefficient energy consumption creates more environmental damage than the recycling related burdens. Second, the hierarchy only refers to environmental effects and not to economic or social criteria. Obviously, these aspects can not be ignored.

Figure 2. The waste hierarchy



* with energy recovery

Therefore, many believe that the options should not be ranked in a particular order but should be considered as a "menu" of alternatives. "It is not a question of good and bad waste management options or technologies. Rather, each option was equally appropriate under the right set of conditions addressing the right set of waste stream components" (Schall, 1995). In an effort to determine whether the hierarchy is applicable in developing countries, the following section evaluates the essential differences between the North and the South.

Differences between SWM in high and low-income countries

Experiences and lessons which can be drawn from the literature, both from the north and south, vary for often obvious reasons. In this section these differences are addressed from three perspectives: waste generation, collection and disposal, and recovery and recycling.

Waste generation

On a global level, it is estimated that in 1990, approximately 1.3 billion metric tonnes of municipal solid waste was generated, averaging about two-thirds of a kilo per person per day (Beede and Bloom, 1995). Yet, the difference between high and low income countries is considerable, especially in terms of composition. As economic prosperity increases, the amount of solid waste produced consists mostly of luxury waste such as paper, cardboard, plastic and heavier organic materials. In cities in the south, on the other hand, waste densities and moisture contents are much higher (Cointreau, *et al.*, 1984). In addition, the hazardous content is quite high since the regulatory and enforcement system to control such waste disposal are usually non-existent or not operating (Cointreau - Levine, 1997)[2]. This is a

[2] This does not imply that hazardous waste is not a problem in industrialised countries. Especially with regard to household waste, mixing toxic materials with harmless residues is still a common practise, although an opposite trend is emerging in many European countries.

particular problem with waste from hospitals located within the city area, which is often found mixed with municipal waste in open dumps and landfills (Indapurkar, 1996).
These differences mean that waste management systems each require distinct approaches. For example, as the waste content in developing countries is highly organic and susceptible to rapid decay, the emphasis of the SWM process in these countries should be on the collection process. Studies have shown that expensive collection trucks and compactors developed and used in industrialised countries are difficult to operate and maintain, and are unsuitable for narrow lanes, the high traffic density and the nature of waste in developing countries (Cointreau and de Kadt, 1991).

Waste collection and disposal

The level of service for waste collection also varies markedly. In most industrialised countries services have expanded to the extent that over 90 per cent of the population (and 100 per cent of the urban population) have access to waste collection. This is not the case in developing countries (UNEP, 1991). The failure to provide adequate collection services poses a serious threat to human health in many developing countries (WHO, 1992). Yet, it should be noted that municipal services in developing countries are handicapped by limited finances and an ever-increasing demand on urban services.

Studies show that in many developed countries, burial in controlled landfills continues to be the most prevalent means of disposing of solid waste including hazardous waste- about 70 per cent of urban solid waste is disposed off in this way in the United States and most European countries. Incineration and recycling also play a key role in the management of urban and industrial waste (UNEP, 1994). It is worth noting that these options are particularly popular in highly densely populated countries such as Japan and the Netherlands. In contrast, in developing countries the prevalent methods of solid waste disposal is through uncontrolled dumping or burning on open ground or city streets (UNEP, 1994; Cointreau-Levin, 1997). This often results in more pollution and loss of salvageable economic value (Bartone, *et. al.*, 1990; UNEP, 1994; Beede and Bloom, 1995).

Waste recovery and recycling

In recent years there has been a surge of interest in waste recovery and recycling in both the developing and developed world. Among the industrialised countries recycling activities are on the increase, primarily due to the political pressure of public opposition to disposal sites, and the economic pressure of the high cost of waste disposal attributable to land shortage, increasing costs of sanitary landfills, the unwillingness on the public's part to have landfills located in "their backyards",[3] and stringent regulatory standards of waste disposal (Cointreau and de Kadt, 1991; Hooper and Neilson, 1991; UNEP, 1994). In developing countries, on the other hand, which are still grappling with the basic task of collecting garbage, recycling of waste is carried out in direct response to industrial demand for materials to use as raw materials; ie, what is being recycled has some commercial sale value (Cointreau and de Kadt, 1991).

[3] This so-called NIMBY (not-in-my-back-yard) syndrome drives up the costs of locating new landfill sites as large compensation sums have to be paid to neighbouring households who for instance see their house prices decline.

An important feature of waste recovery and recycling in low income, developing countries is the involvement of the informal sector. Studies reveal that this sector is mainly engaged in the recovery and re-sale of most of the recyclables and is highly labour intensive (Bromley, 1978; Aziz, 1984; Cointreau, 1987; Furedy, 1989, 1990 and 1994; Cointreau and de Kadt, 1991; Huysman and Baud, 1994). But notwithstanding their significant contribution to waste recovery and recycling process, their role in urban waste management is not recognised and their earnings continue to be meagre (Cointreau and de Kadt, 1991; Furedy, 1990 and 1992; van Eerd, 1995).

The studies, thus, indicate that waste recovery and recycling processes in poorer developing countries are based on market considerations, in the sense that it helps to create economic value out of waste. In the resource poor developing countries, this has a positive impact on the economy. There is also the added benefit of providing a source of livelihood to many economically deprived persons who would otherwise be unemployed.

SWM in India

With an urban population of about 27 per cent of the country's total population, urban[4] SWM in India today represents a formidable challenge. While the country's overall annual population growth rate is about 2 per cent, the estimated urban population growth rate is much higher - around 3.5 per cent per annum (World Bank, 1998). In addition the per capita income of the urban population has increased resulting in a rise of approximately 1.3 per cent of urban waste generation per head in the last five years (TERI, 1998). These two factors have led to a yearly increase of the overall burden of solid waste in Indian cities of almost 5 per cent. But it was the outbreak of plague due to waste in Surat in September 1994 which drew attention to seriousness of the problem. To obtain a better understanding of the context of Bangalore as a case study, the main features of SWM in India are described in the following sections.

Solid Waste Streams

Nature and quantum

Although there is a dearth of precise and reliable data on waste generated in India, it is roughly estimated that the country produces about 30 million tonnes of urban solid waste annually (GOI, 1998). Per capita waste varies between 0.1 kilograms and 0.6 kilograms per day, with an average of 0.33 kilograms (Bhide, 1990). It is also estimated that the per capita waste generated in a typical Indian metropolitan city increases by 1.3 per cent per year (TERI, 1998). Studies show that there is a large difference between urban and rural levels of waste generation, which reflect the economic extremes existing within Indian society. The larger cities are centres of major economic activity which is manifested in the prosperity and the culture of consumerism among the residents, together with increased waste.

Solid waste may be categorised according to its source (a) domestic solid waste (b) commercial and industrial solid waste which is bulky but not hazardous; and (c) hazardous waste from industries and hospitals that require special handling (Appasamy, 1994). The waste composition varies significantly across different areas within urban centres, such as between residential, commercial/market and industrial areas. As in most low-income developing countries, urban solid waste in India is comprised mainly of organic matter which amounts to anywhere between 30 and 75 per cent of total generation (Venkateswaran, 1994a). The percentage of luxury waste-material such as paper, plastic, metals and glass is comparatively low (Bhide and Sundaresan, 1984). Although economic prosperity is one reason for the generation of more luxury waste materials, as observed in developed countries, the low content in India may also be explained by the fact that traditionally such waste materials are segregated at source for reuse.

[4] The official definition of 'urban' in India is any place with: (i) a minimum population of 5000; (ii) at least 75 per cent of the male working population involved in non-agricultural activities; and (iii) a population density of at least 400 per square kilometre. However, typical for India is that it suffers from "under-urbanisation" because the estimations exclude numerous large urbanised villages with populations up to 20,000 inhabitants which are urban in every sense except in name. One explanation for the phenomenon is that staying "rural" has many financial benefits for the community: electricity and water are subsidised, land and property are taxed less and these areas qualify for various rural development funds and development programmes initiated by the central and state governments.

Waste disposal and processing

Waste disposal and processing are also important in waste management practices in India. Given its high organic content and moisture, and correspondingly small amounts of combustible matter like paper and plastic, it is argued that the best method for disposing of garbage is by composting or in sanitary landfills (Appaswamy, 1994). The most common practice in the country is dumping at landfill sites located around the city which are generally uncontrolled dumps. Dumping is also carried out illegally on private farmlands located in the city vicinity. One reason for this is the lack of landfill space in the cities. Often, siting plans for potential landfills are strongly opposed by surrounding residents which causes complications; the case of Bangalore is a good example of this.

Various forms of resource recovery activities are practised in India, such as composting and recycling. According to a recent estimate, urban solid waste in India generally contains up to 20 per cent of recyclable matter, whereas the compostable material may constitute around 40 - 50 per cent, the rest being stones, dust etc, (GOI, 1998). Existing studies on resource recovery examine the following issues: the recovery process for a particular waste material like plastics and paper recycling or composting of biodegradable wastes and the economics involved (Beukering *et. al.*, 1996; Shah and Rajaram, 1997); the actors involved in this process (formal and informal) and the linkages between them (Huysman and Baud, 1994; Baud and Schenk, 1994; Hadker, 1995); and the specific socio-economic issues, such as gender and health, together with a cost benefit analysis of different activities involved (Beukering, 1994; van Eerd, 1995 and 1997; Rao, 1995; Mehta and Satyanarayana, 1996; Pathak, 1996)

.

Agents

Formal (municipal) sector

The municipal body[5] is the main group involved in most urban SWM systems in India. Although other sub-systems, such as private organisations engaged in waste processing and informal recycling system, are actively involved in the waste management process in India, their activity is dependent on the operation of the municipal body (Sudhir, *et.al.*, 1996). It is broadly estimated that between 10 to 40 per cent of the municipal budget is utilised for SWM (Bhide, 1990). Yet, it is generally argued that the Indian waste management system is starved of resources when the demands of increasing urbanisation are taken into account (Shekdar, *et. al.*, 1992). Hence the services provided by the municipal authority are, for the most part, inefficient (Furedy, 1994). On average, as much as 30 per cent of disposed solid waste are left uncollected (NIUA, 1989; India today, 1994).

[5] The 74th Constitutional Amendment Act (1993) provides for three types of urban local bodies (municipal bodies). They are - (i) Nagar Panchayats for transitional areas, (ii) Municipal Councils for smaller urban areas and (iii) City Municipal Corporations for larger urban areas.

Studies show that in most urban areas it is the slums and areas where the poorer communities reside which are most badly served (Fritz, 1990; NIUA, 1993; Furedy, 1994). One possible reason could be that municipal authorities give priority to localities where the elite and the better-off populations reside because of their influence and political weight. Meanwhile, the areas which are not serviced are faced with clogged sewers and littered waste, creating serious health problems for the resident population (NIUA, 1993; India today, 1994).

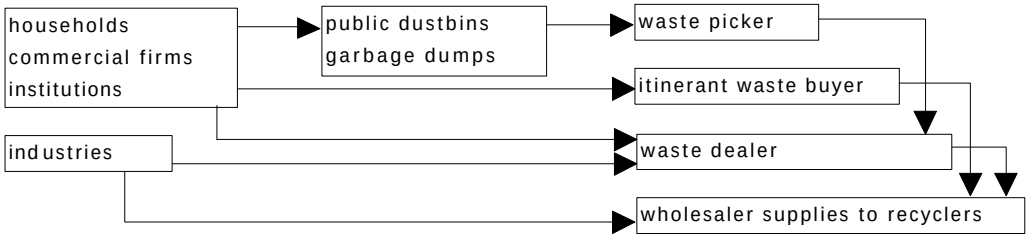
The economics of SWM services are gaining importance in India. Because of the widening gap resulting from increased municipal costs of provision and limited finance, the emphasis is on improving efficiency. (Vidya and Ramachand, 1993; NIUA, 1996; Mathur, 1996; Mehta and Satyanarayana, 1996; Pathak, 1996). However, the municipal authorities are constrained by the fact that historically service prices in India have been extremely low and do not adequately reflect the costs incurred in providing them. Hence any change in this scenario should take into account public opposition.

In India, the predominant instruments for cost recovery for all types of urban infrastructure include development charges, betterment levy and sale of land. In the case of some services, such as water supply and electricity the emphasis is on cost recovery, while for road maintenance and garbage removal the norm is to cover only the operating cost. This is achieved through taxes for individual services linked to the property tax and consolidated service charge/tax. Direct user charges in the form of a levy by weight of disposed waste - an instrument which is gaining popularity in industrialised countries such as the Netherlands - would most probably not be very effective in India. The costs of the enforcement and the risk of illegal dumping would be too high.

Informal Sector

As in most developing countries, there is an active informal network in the SWM process in Indian cities (Aziz, 1984; Furedy, 1990; Venkateswaran, 1994b). It exists as a parallel system to the formal waste management process and is highly labour intensive. Figure 3 illustrates the channels for informal sector involvement in the SWM process in Indian cities.

Figure 3. Informal waste management recovery process in India



The informal sector is mainly guided by market forces which affect the waste trading and recycling enterprises (Beukering, 1994). There are varying estimates of the quantity of waste recovery taking place within the informal sector. Bhide (1990) estimates that waste pickers recover between 6 to 7 per cent of waste generated, while Souza (1991) puts the figure at around 15 per cent. Whichever estimate is correct, there is little doubt that this sector makes a significant contribution to the overall waste management process in Indian cities. Moreover, it provides employment opportunities to numerous people.

In terms of interventions for improving urban SWM in the country, three issues need to be addressed: first, plans for revamping the formal system should not ignore the social and economic dimensions of the informal sector in the waste management process (Baud and Schenk, 1994). Second, it is necessary to supplement the predominantly technological nature of the SWM system which views waste management as a responsibility of the municipal body and treats waste picking as an illegal activity (Venkateswaran, 1994a and 1994b). Third, excessive "municipalisation" of SWM does not necessarily lead to significant economies of scale. Therefore, it is worth considering the integration of the informal practices with the existing formal system (Bose and Blore, 1993).

Innovative Practices

In addition to traditional practices, innovative urban waste management experiments are being initiated in India both by governmental (municipality) and non-governmental institutions (Baud *et.al.,* 1994; Adarsh Kumar, 1996; Shah, G, 1997a and 1997b). They are location-specific viable options in response to analyses of the local problem areas. They complement and supplement the efforts of the municipal authority. These innovative practices have been primarily concerned with[6]:

- Ensuring *people's participation* in the collection, segregation and disposal of garbage by forming eco-clubs or community based organisations.

- Encouraging the *involvement of NGOs* in working on various environmental programmes and areas related to urban SWM, including educating the public about the importance of better waste management. A typical example, often referred to, is the case of Exnora International operating in many Indian cities, and particularly active in Madras. Exnora aims to improve cleanliness through a loose membership of local community based groups and organise civic amenities and sanitary facilities on a voluntary self-help basis. Although it is difficult to classify the numerous NGOs active in urban waste management, they may be grouped broadly, as those dealing with social issues in the SWM process; those focusing on participatory principles in SWM; and those emphasising awareness building activities.

[6] The order of the innovative practises does not indicate the order of importance.

- Developing public-private partnerships leading to the *privatisation* of some aspects of garbage collection, recovery and disposal. Studies make reference to companies such as Terra-Firma and Sunrise Industries in Bangalore, and EXCEL Industries in Mumbai, which are collaborating with city municipalities in garbage treatment and conversion into useful manure. In some cities (ie, Bangalore) garbage collection on a contract basis to private contractors is also being explored by the municipality.

- Applying *technological innovations* for effecting improved recovery and disposal of waste. Some of the known technologies observed in Indian cities are incineration, conversion to bio-gas, refuse derived fuel, fuel palletisation and composting.[7]

- Initiating provisions aimed at *administrative restructuring* of the urban local bodies (municipalities) to enable them to discharge their specific responsibilities more efficiently. From a national perspective, the constitutional 74th Amendment Act has initiated institutional changes to decentralise urban local governance. Changes are also being introduced in some cities by municipal authorities themselves for better management of urban waste. Surat offers a typical example where the municipality succeeded in modernising SWM practices in the post-plague period. Three types of administrative changes can be identified

    - motivating the municipal staff and improving their capacity by training and by improving methods

    - ensuring close monitoring and supervision of waste management practices by the officers

    - introducing structural changes within the administration aimed at decentralising authority and responsibilities, ie,. more frequent meetings among the staff and between the executive and elected wing of the Corporation.

[7] The efforts of the municipal corporation of Shimla can be cited as an example which has embarked upon four projects for scientific management of the city's solid waste - bio-conversion of waste into organic fertiliser, energy from waste through methanogenation, incineration of hospital waste and hazardous material, and recycling of paper, plastics and other useful waste.

SWM in Bangalore City

Drawing lessons from the national scenario, a case study analysis based on field investigations in one Indian city was undertaken to obtain specific insights into SWM issues which need to be considered when developing an integrated waste management model.

Methodology

Keeping in mind the framework of analysis mentioned earlier, a qualitative and quantitative analysis of the waste issue in Bangalore is attempted. Bangalore, capital of the southern Indian state of Karnataka, is among the largest metropolises in the country, and provides a useful example of similar growth driven urban centres in the country faced with increasing urban waste, inadequate municipal services and scarce resources. Bangalore city was chosen for several reasons:

- various institutional dynamics can be found in the city's waste management process.
- the SWM process in Bangalore is characterised by the involvement of the private formal sector, including CBOs, NGOs, small and large recycling units located within the city.
- there is a large active informal sector comprising waste pickers, IWBs and middlemen (small enterprises) such as junk dealers and wholesalers.
- the city municipal corporation is now taking steps to integrate the activities of the community and the private formal sector (including privatising collection services to contractors) in the city's waste management process.

Data Collection

In this study the various stakeholders in the SWM process in Bangalore are grouped broadly as waste processors (all agents directly active in waste processing) and waste generators (all agents generating waste and consuming services provided by the waste processors). A comprehensive explanation of the field survey and the questionnaires is provided in project report.

- The waste processors consist of waste pickers, itinerant waste buyers (IWB), middlemen, city municipal corporation and various recycling units, both private and government. While the first three agents listed as producers constitute the informal network, the city corporation and the recycling units are formal agents[8].

- The waste generating category comprises of four types of agents, namely households, commercial establishments (markets and hotels), institutions (offices, educational institutions and hospitals) and industries (large, medium & small).

[8] This division is arbitrary. Informal stakeholders are generally characterised as those who are not registered with municipality and who do not pay tax. For a number of recycling plants, this characteristic also holds. Moreover, they often employ informal workers. However, since the majority of recycling plants are registered we chose to consider them part of the formal sector. As mentioned, the opposite could also be claimed.

For the purpose of data collection, a limited sample survey was undertaken for some stakeholders and, wherever possible, existing data were used. The primary survey was limited to the waste generating category. This involved weighing and categorising the actual waste generated over a certain period. For the waste processors available secondary data were used to minimise time and budget costs. It needs to be emphasised here that this exercise was more in the nature of a benchmark survey. After identifying and characterising all the stakeholders involved in the city's waste management process individually, their profiles were linearly extrapolated to provide a rough picture of the whole city. This was the first time in Bangalore city that such an approach (ie collecting data on all agents) was attempted.

The sample survey was carried out for households, hotels, markets, institutions and industries. The survey aimed to ensure that spatially, the households were representative of the entire city, although this was not a consideration in the choice of the other agents (see the enclosed city map). A short description of the approach and results is given in the following overview. A more comprehensive description is provided in the appendix.

1. In consultation with municipal officials, Bangalore city was divided into five zones reflecting particular economic classes. A total of 200 households were randomly surveyed, using 40 from each zone. Waste generation data was collected by giving the selected households garbage bags and requesting them to save all waste generated. The waste collected was then weighed in an aggregated manner.

2. No direct waste information was available for restaurants and hotels. As an alternative, a figure about the number of various categories of hotels and restaurants was located in the Administration Report of 1992 of the city corporation which formed the basis for extrapolation. A sample from each of these categorised establishments was identified and structured questionnaires were administered to the relevant hotel management (6 hotels/restaurants were sampled). The data thus collected was then extrapolated for Bangalore - data on waste generation, recovery and disposal for each identified category was multiplied with the number of total hotels under that category to obtain a figure for the entire city.

3. According to information provided by Bangalore municipal corporation, there are five major markets in the city as well as numerous small ones. These are under the jurisdiction of Bangalore City Corporation (BCC). Data about the total number of stalls was collected from the relevant. In addition, waste data were collected by administering structured questionnaires to randomly selected stalls (numbering 25), taking a sample from each type of stall located in the complexes. Data about the total waste generation in the selected complexes were collected by going with the trucks transporting the waste to the disposal points and weighing them on the weighing bridge.

4. Data were also collected from the three types of institutions, including educational institutions, offices and hospitals. Estimations about the number of hospitals and their bed capacity was collected from different sources such as the Directorate of Public Health, the Association of Private Nursing Homes in Bangalore and M.S. Ramaiah Medical College. A primary survey was carried out for educational institutions and offices, taking one sample from each category (school, college, technical institution, university and a government office), using a structured questionnaire. For hospitals, data generated by a research study that was carried

out by M.S. Ramaiah Medical College was used. For each of the three types of the institutions waste generation information was collected on a per capita basis (for hospitals it was calculated on per bed basis) and then extrapolated.

5. It is a statutory requirement that industries manage their waste and not depend on BCC for its disposal. With this in mind, a sample survey of industries was carried out among industries representing four major product groups: electrical and electronic, fibre based, wood/rubber/leather based and chemical: a large scale public sector electronic industry, a medium scale textile industry, and four small scale industries (rubber, metal, garments and chemical).

At this point it should be noted that in this study, data about waste generation was collected only from the organised sectors. However, informal activities and certain categories of waste such as debris, burnt waste, street wastes, marriage halls etc., have not been taken into account, mainly due to lack of data. Thus the estimates can be considered lower bounds of the real situation in Bangalore. However, to ensure the reliability of the data as far as possible, key informants were consulted and data were cross-checked with existing information (see Appendix I for basic statistics on the different SWM stakeholders in Bangalore).

Difficulties and limitations

As mentioned earlier, time and financial constraints precluded the possibility of a more rigorous approach for data collection in Bangalore. Therefore, the sample survey carried out for this study is limited in both size and coverage (the agents listed as producers were not covered by the primary survey). In this sense, the data generated for the study should basically be regarded as 'educated guesstimates', and should be used with care.

Furthermore, obtaining reliable information about numbers and waste recovered from producers was difficult, particularly wastepickers, IWBs, middlemen and recycling units. First, there is no 'single window' data source about them. Second, there are varying estimates on their number and waste recovered, so that averages were worked out and taken into consideration. Third, as most of the producers belong to the informal sector where there is a lot of day to day variations, attempts to make representative estimates was very difficult.

Waste flows and factor use

With a population presently (1998) estimated at 5 million, Bangalore is among the fastest growing cities in India. With a population density of about 2,203 inhabitants per km^2 (1991 census) compared to the national figure of 267 km^2 for the same period, it is also one of the most crowded. The city also has a large migrant worker population which has been increasing at the rate of 30 to 40 per cent per annum (source: BCC office).

These figures indicate that waste generation is likely to be significant in Bangalore and that its management needs urgent attention. Only a few studies have been carried out on waste recovery and management in Bangalore. Some have adopted either a case study approach or focused mainly on the contributions made by NGOs (Rosario, 1987 and 1988; Rosario and Mani, 1992; Huysman, *et. al.*, 1994; CEE, 1995). Studies have also investigated the waste management process, focusing on the recovery and recycling sector in Bangalore (Baud and Schenk, 1994; Beukering, 1994; Shah, E and Bhubaneshwari, 1997; Shah, E and Sambaraju, 1997; Shah, E and Rajaram, 1997). Literature is also available on the socio-economic aspects of solid waste recovery in the city such as the position of the informal sector, health and environmental impacts and gender related issues (Aziz, 1984; Furedy, 1989a and 1994; Huysman, 1994; van Eerd, 1995; Shah, E, 1996). These works have drawn on a wide range of empirical data on different aspects of SWM process in the city (See the main report of the CREED project)

Waste generation

According to earlier estimates, during the mid 90s Bangalore generated approximately 2,000 tonnes of solid waste per day, which was in the later years estimated to be around 2,500 tonnes per day. In the present study, it is estimated that Bangalore generates about 3,613 tonnes of solid waste per day (Table 1). The difference is mainly due to the fact that in this study, industrial waste (approximately 1,400 tonnes per day) is also considered as a component of the total urban solid waste generated in Bangalore.

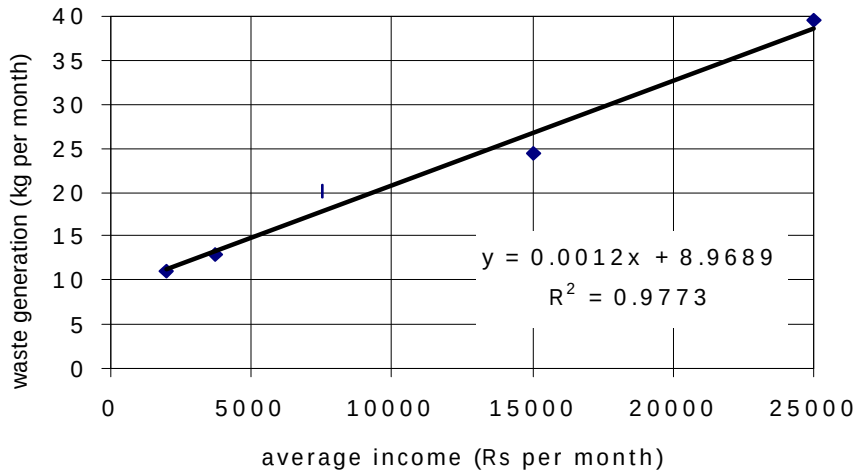
Table 1. Source-wise Generation of Solid Waste in Bangalore (tonnes per day)

Stakeholders	**Volume**	**%**
Households	650	18
Commercial Establishments	1436	39
- *markets*	*369*	
- *hotels*	*1066*	
Institutes	128	4
- *hospitals*	*20*	
- *offices*	*15*	
- *educational institutions*	*92*	
Industries	1399	39
Total	3613	100

As observed in Table 1, commercial establishments are the major contributors of solid waste in Bangalore, accounting for about 39 per cent of the total, while households contribute about 18 per cent. The waste generated by various institutions located in the city accounts for only about 4 per cent. Although industries[9] also generate a significant amount of solid waste, from the analysis it was evident that most of this is recovered for recycling and reuse, and only a small per cent finds its way into the city waste stream.

Although households are not yet the main contributors to waste generation, it may well be useful to know how this may change with economic development. Figure 4 clearly shows the positive relationship between income levels and waste generation at the household level. The survey revealed that roughly the level of waste generated increased by 1 kilogram for each increase in income of 1000 Rs per month.

Figure 4. Correlation between per capita income and waste generation



Waste Composition

As shown in Table 2, the city's solid waste consists to a large extent of organic and other biodegradable matter (43 per cent of the total city waste). Comparatively, the percentage of recyclables like paper, glass, plastics, metals, cardboard/packaging material and rubber is lower. (36 per cent).

[9] In this study we have not taken into consideration other types of industrial waste like sludge, effluents, etc., which are major pollutants. Only the solid waste generated has been considered. It mostly comprises of high quality recyclables.

Table 2. Physical composition of the Total Waste in Bangalore (tonnes per day)

Composition	quantity	percentage
glass	103.8	2.9
plastic	220.8	6.7
paper / cardboard	594.2	16.5
metal	54.7	1.5
rubber	357.9	9.9
organic waste	1206.1	33.4
other biodegradable	332.2	9.2
hazardous hospital	97.5	2.0
miscellaneous #	645.9	17.9
Total	**3613.1**	**100.0**

This includes old clothes, gunny bags, coconut shells, dust etc.,

The total waste collected in the public dustbins (PDBs)[10], reflects a similar trend. As shown in Table 3, the main sources of PDB waste are the commercial establishments, accounting for 73 per cent of the waste in the dustbins. The other important sources of PDB waste are households (24 per cent) and institutions (3 per cent). The PDB waste has a high content of organic and other biodegradable matter (approximately 57 per cent). The analysis shows that the amount of environmentally unfriendly wastes like polythene carrier bags in PDBs is rather low (1.3 per cent of the total). Despite this low volume, its impact may still be serious given its potential harmful characteristics which affect drainage and sewage systems.

Table 3. Physical composition of Public Dustbin Waste in Bangalore (tonnes per day)

	Sources			Total	
Composition	**household**	**comm.**	**institutes**	**quantity**	**share**
glass	2.77	0.63	0.00	3.41	0.24
plastic	3.12	3.80	0.00	6.92	0.48
paper / cardboard	3.12	3.17	38.89	45.18	3.12
metal	0.69	0.00	0.00	0.69	0.05
organic waste	322.78	474.94	0.00	797.72	55.12
other biodegradable	2.77	25.02	0.00	27.80	1.92
hazardous hospital	11.79	0.00	3.58	15.36	1.06
miscellaneous #	0.00	548.33	2.24	550.56	38.04
Total	**346.70**	**1055.90**	**44.70**	**1447.30**	**100**

This includes old clothes, gunny bags, coconut shells, dust etc.**,**

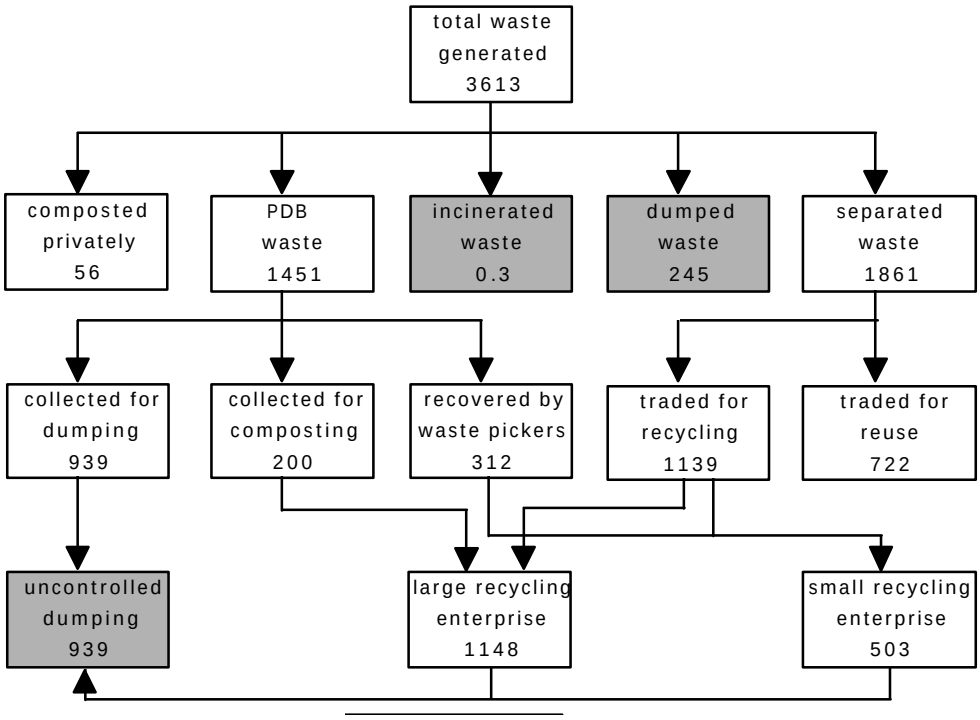
[10] Approximately, there are about 14,000 PDBs in Bangalore (Source: BCC office).

Waste collection and disposal

As seen in Figure 5, the municipality collects about 1,139 tonnes of waste per day from the PDBs. Of this, about 200 tonnes are directly sent from the major markets to large composting units such as Karnataka Composting Development Corporation (a government concern) and several private composting units located in the city (Sunrise and Terra-firma). The remaining waste collected by the municipality is dumped in open spaces and on road sides outside the city.

In addition, the analysis shows that about 245 tonnes of waste per day is dumped or burned by the generators themselves. This may include debris, burnt waste etc., (unorganised waste) which remain uncollected in the city.

Figure 5. Collection agents and processes involved (tonnes per day).



Although there are nine landfill sites[11] leased by the BCC from the Government, these sites are currently not used for landfilling due to local opposition and concern about the potential health risks. Landfill operations have been halted while the issue is going through the court system. However in the meantime, there are no effective alternative solutions for the management of the collected solid waste and dumping at the road side is often the only option available. One possible solution is to compensate the neighbouring and exposed households for the inconvenience. The compensation could, for example, be based on the possible reduction in real-estate value in the surrounding area. This is not an uncommon practice in most industrialised countries. Certainly, the absence of a proper landfill site can be considered as the most important short term issue in solid waste management in Bangalore.

The sweeping, collection and transportation of garbage through BCC is done by *Poura Karmikas* (municipal sweepers). The BCC has 6671 sanctioned posts of *Poura Karmikas,* a number of which are vacant for numerous reasons. Recently, a contract cleaning system has been introduced by BCC. On average 90 BCC trucks and 160 contract lorries are moving daily to transport waste (BCC, 1994).

Table 4. Disposal by Stakeholder (tonnes per day)

Stakeholders	Waste generated	Waste Disposed			
		PDB waste	composted privately	incinerated waste	dumped/gone waste
Households	650.5	346.7	56.0	0.0	27.4
Com.Est.	1435.9	1055.9	0.0	0.0	4.9
- *markets*	369.5	246.1	0.0	0.0	1.9
- *hotels*	1066.4	809.7	0.0	0.0	3.2
Institutes	127.5	44.7	0.0	0.3	21.2
- *hospitals*	20.4	16.0	0.0	0.3	4.1
- *offices*	14.8	14.8	0.0	0.0	0.0
- *ed. Inst.*	92.4	13.9	0.0	0.0	17.2
Industries	1399.2	3.8	0.0	0.0	191.6
Total	**3613.0**	**1451.0**	**56.0**	**0.3**	**245.4**

Incineration has not taken off in a substantial way. As can be seen in Table 4, only 0.3 tonnes per day, consisting mainly of hazardous hospital waste, is incinerated. Although most of the bigger hospitals claim that they have incinerators to dispose of infectious waste material, many of them are not functioning. Studies carried out by groups such as Tata Energy Research Institute (TERI) and M.S. Ramaiah Medical college show that most medical institutions in Bangalore city tend to dump their biomedical waste with the rest of the garbage. Given the extent of scavenging at the dumpsites, this is a very dangerous practice.

[11] According to a Government Order No RD 126 LGB 94, dated: 11.11.94, nine sites have been leased at the rate of Rs.500/acre/annum for 50 years to the BCC for sanitary land-filling, The nine sites, totalling about 53.5 acres, are located in *B. Narayanpura (K.R. Puram), Vibhuthipura (K.R. Puram), Devara Chicknahalli (Beguru), Hangasandra (Beguru), Sarraki (Utharahalli), Laksandra (Beguru), Audugodi (Beguru), Koddihalli (Varthuru) and Hennuru (Kasaba) areas of Bangalore city.*

Waste Recovery

As shown in Figure 5, 66 per cent of the total waste generated in the city is collected for recovery (about 2,373 tonnes per day). While 722 tonnes per day is reused, the remaining (1,450.2 tonnes per day) goes for recycling. Agents involved in the collection and recovery process are waste pickers, IWB, middlemen, the municipality, and recycling units (both small and large). While the three agents in the informal sector and the municipality are directly involved in waste collection activities, the waste is processed by the recycling units which receive recyclable waste both from middlemen and municipality.

The high level of 66 per cent is rather deceiving. Part of the fraction of compostable materials is collected by the municipality and delivered to farmers near Bangalore city who use it to enrich their soil. Although this may be considered a form of composting, as we do in this analysis, it could be considered a form of landfilling. In that case it should be subtracted from the recycled portion. The true form of composting by the municipality accounts for approximately 200 tonnes of waste per day. In addition, 56 tonnes of waste are collected directly from households by CBOs (small recycling units) for composting. In this sense, about 17 per cent of the total organic and biodegradable waste generated in the city goes for composting.

Table 5. Waste recovery and collection by stakeholder (tonnes per day)

		for recycling		
Stakeholders	**for reused**	**waste pickers**	**IWB**	**middle men**
households	101.7	74.5	60.4	57.7
comm. est.	350.8	227	0.0	24.3
- markets	112.7	200	0.0	8.8
- hotels	238.1	27	0.0	15.4
institutes	0.0	9.6	0.0	61.3
- hospitals	0.0	1.0	0.0	0.0
- offices	0.0	8.4	0.0	0.0
- ed. inst.	0.0	0.2	0.0	61.3
industries	269.3	0.8	0.0	934.5
Total	**721.8**	**312**	**60.4**	**1077.8**

The remaining quantity of waste for recycling is recovered through middlemen (about 1,139 tonnes per day) and waste pickers (312 tonnes per day). This amounts to about 40 per cent of the total waste generated. The middlemen accumulate recyclables directly from the consumers, as well as from IWBs and waste pickers. Our analysis shows that middlemen receive about 77 per cent waste from consumers themselves of which a major contribution is from the industries.

On a more micro level, it is also useful to look at household behaviour with regard to waste generation. To evaluate recovery behaviour among households, the survey distinguished three types of separation. From Table 6 it can it can be seen that recovering high quality recyclables is a very common practice in India. The households which were involved in separating both high and low quality waste were mainly recorded in areas where waste NGOs were operating. There was a small group which did not separate at all. These were the poorest households (slum households in the sample) who do not find it profitable to separate recyclables as high quality waste is practically nil in their case.

Table 6. Waste separation in sample households

	No. of HHs	Percentage
Only high quality recyclables (Newspaper, Bottles etc.)	159	80
Both high quality and low quality (wet and dry) recyclables*	21	10
No separation attempted (Mixed waste)**	20	10

note: the percentage inaccuracy are the result of rounding of practices

The contribution of the waste pickers in the informal waste recovery process in Bangalore needs special reference. Although, exact figures are not available, in this study, it was estimated (on the basis of the earlier studies) that there are roughly 25,000 waste pickers in the city whose average per capita collection is about 15 kilograms per day. Collecting about 312 tonnes of waste per day, the waste pickers recover about 21 per cent of the 1,451 tonnes of waste that goes to the PDBs.

The waste collected by the middlemen goes to various small and large recycling units located in the city. It was estimated that about 503 tonnes of waste per day goes to the small recycling enterprises and about 1,148 tonnes of waste per day to large ones. Based on discussions, it was roughly estimated that 90 per cent of waste going for recycling is eventually recycled.

Stakeholders in Bangalore

Clearly there are a several inter-sectoral partnerships and inter-related activities within the SWM system in Bangalore. An analysis of these inter-dependencies reveals a complex situation involving a number of actors and institutions engaged in processing and disposing of the city waste. These have been summarised in Table 7.

Table 7. Existing partnerships in Bangalore for managing solid wastes

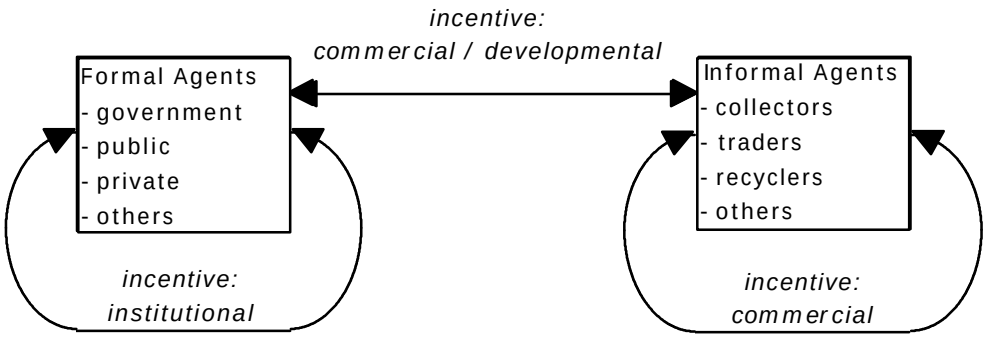
Partnerships	Agents Involved	Activities	Relationship	Incentives
Government - Government	Municipality - Government recycling unit	Collection & supply of Biodegradable waste for composting	Formalised	Government policy
Government - Public	Municipality - NGOs/CBOs	Supporting micro composting activities undertaken by NGOs/CBOs by providing institutional backing Creating an interface between government & non-government efforts through SWABIMAN[12] platform	Networking	Government policy & NGO initiatives
Government - Private	Municipality - Private Contractors & recycling units	Privatising waste collection & disposal Privatising waste processing (recycling & composting)	Contractual Supportive	Government policy & economic compulsions
Public - Public	NGOs/CBOs - Citizens	Increasing civic awareness among the public. Promoting people co-operation at neighbourhood level in keeping their environs clean	Cooperative	Voluntarism & service motivation
Informal - Informal	Scavengers/ IWBs - Junk Dealers & Wholesalers	Conduit for waste recovery from source - first step in the recovery process	Commercial	Subsistence & Profit
Informal - Formal	Junk Dealers & Wholesalers - Small & large recycling units	Conduit for waste processing from middlemen to the recyclers - second step in the recovery process	Commercial	Other Profit
Informal - Government	Scavengers/IWBs/Junk Dealers & Wholesalers - Municipality	Externalised involvement of the informal network in waste recovery - complimenting the activities of the municipality	Weak relationship (Parallel existence)	--
Informal - Public	Scavengers/IWBs/Junk Dealers & Wholesalers - NGOs/CBOs	Recognising waste pickers' contributions & developing their capacities	Develop-mental	Service Motivation
Consumers - Informal	Households/ Institutions/Commercial firms/Industries - IWBs/Junk Dealers & Wholesalers	Collection of recyclables	Commercial	Profit

The relationships in the system are illustrated in Figure 6. These exist between (i) two or more agents in the formal sector, (ii) formal and informal agents, and (iii) among the informal agents. The nature of the relationships varies. Among the formal actors, collaboration is driven by incentives for 'institution' building. The relationship ranges from formalised patterns where the linkages are quite strong to more voluntaristic networking and co-operation. The partnerships between formal and informal actors are either 'commercial' and guided by profit,

[12] SWABIMAN is a program for peoples participation to solve the civic problems at local level. It has a core membership down from environment friendly NGOs operating in Bangalore. It works with the BCC on various issues pertaining to provision of civic amenities.

or 'developmental' where the objectives are to provide service. Among the informal actors the relationships are primarily commercial and are driven on the one hand, by subsistence and income earning factors and on the other by profit considerations.

Figure 6. Relationships in the SWM sector of Bangalore



The nature of relationships existing among the various agents in the overall SWM process in Bangalore can be broadly grouped as follows:

- regulatory (formalised and contractual relationship guided by government interventions)
- conditional (commercial relationship based on principle of reciprocity - supply of recyclables for a price)
- voluntary (co-operative and developmental relationships due to people's or own perception of a certain situation)

This situation can be explained in terms of the specific nature of the services required within the SWM process. As laid down in the Karnataka Municipal Corporation Act, 1976, keeping the city clean is a responsibility of the civic administration (BCC), but this activity cannot be performed by the BCC alone. The SWM process has various dimensions which require the involvement of the private, the non-government and the informal sector. This necessitates co-operation and co-ordination among the various sectors, rather than an insular approach, for better management of urban waste. Table 7 structures these interdependencies.

As mentioned in the analytical framework, in addition to institutional intervention, one variable influencing urban SWM is the source of waste and its composition. It is typical that a large resource pool of organic waste is left unused. Although composting as a method of waste recovery does exist in the city, the percentage of waste composted is low when compared to the total compostable waste generated. The main reason for this is the fact that a large percentage of the organic and biodegradable waste is unsegregated and hence unsuitable for composting. Another reason is that while recyclables have an extensive trading network, the market for organic waste is limited. Similarly, while there is a market for recycled products, the market for compost as a fertiliser is still relatively undeveloped.

Discussion

Analyses of solid waste management is severely hampered by a lack of data. Information at all levels, if present at all, is generally unreliable, scattered and unorganised. Levels of waste generation, waste composition and waste disposal are generally unknown to government officials. As a result, planning of solid waste management is a difficult task. These problems are even more acute in developing countries.

Earlier in this paper we discussed the concept of integrated SWM as a possible solution to waste management problems in Indian cities. Although in theory there is sufficient reason to assume that the concept can be effective in developing countries, in practise it is not always the case. Adapting the concept to a specific situation requires proper information about waste flows and the stakeholders.

Through an investigation of SWM in Bangalore, we attempted to provide a rough picture of the waste situation there. In addition to a literature review, field surveys were conducted to help fill the gaps. We focused on aspects of integrated SWM: (1) the range of management options, and (2) the stakeholders involved in the waste management process.

In investigating the range of management options, we conclude that this analysis should only be considered as a first attempt to determine the structure of the waste sector in Bangalore. The uncertainties arise for two reasons. First, the sector is rather volatile. In the short term, seasonal fluctuations may have a major impact on waste flows. In this paper we used annual averages, not specifying for this distortion. In the long term, waste levels and composition are very sensitive to income levels. Although the Asian crisis may also have had its impact on the Indian economy, economic growth is significant. Therefore, this overview should only be considered a snapshot.

In studying the stakeholders involved, we concluded that an integrated SWM perspective on waste implies that it is not only the responsibility of the civic administration (BCC) to keep Bangalore clean. Collaboration with other stakeholders is crucial, implying an integration between the formal and informal recycling agents. To some extent this process is already taking place, driven by economic incentives. Also the involvement of the waste generating agents is important. For example, the segregation of household waste at the source would reduce the burden of solid waste significantly while at the same time improve the supply of compost, serving the nutrient poor farmers near Bangalore.

The third dimension of integrated SWM – the link with related systems such as industry and transport – was not included for practical reasons. As mentioned earlier, we feel that this is an area for future research.

Despite the shortcomings of the current study, the overview has highlighted various issues which may receive priority in future planning of SWM in Bangalore and possibly also other Indian cities. These bottlenecks and priority areas include:

- inadequate municipal services arising out of limited resources;
- the absence of hygienic and scientific disposal systems;
- lack of public awareness for waste management leading to high levels of un-segregated waste generation and littering;
- the existence of an extensive informal network which is mainly driven by market forces and partly functions on subsistence levels;
- the absence of sufficient capacity for waste processing, in particular for organic waste which is the most abundant waste disposed;
- the existence of a relatively small market for recycled waste products.

To date, no concerted efforts have been made to consider these issues. . Considering that a number of marginal and poor segments are present in the waste management, any strategy aimed at strengthening SWM process needs to be cost-effective and beneficial to society, as well as allow for income generating opportunities to the poor along its route.

Regardless of the type of waste management selected for developing cities, no amount of urban planning nor SWM strategies will translate into reality unless the government takes the required initiatives and makes the necessary inputs available. These inputs do not necessarily have to be financial. For example, the government can make a formal commitment for an integrated SWM approach, fully recognising the advantages of the existing informal recycling network. Moreover, waste recycling can be promoted through consumer campaigns encouraging citizens to co-operate in waste separation and promoting to them the purchase of recycled products. Also, citizens should be requested to pay a more realistic fee for waste services in return for the guarantee that indeed these services will be provided. Finally, no SWM can effective without proper monitoring of its disposal activities. Therefore, its effectiveness should be tested on a regularly basis.

References

Adarsh, Kumar. 1996. *Urban Waste Management: Innovative Practices in Shimla*. Paper presented in South Asian Conference of Mayors and Local Authorities (Habitat II Conference Sub regional Consultations), 8-10. October, Katmandu.
.

Appaswamy, P. 1994. *Institutional Options in the Provision of Urban Services: The Case of Solid Waste Management in Indian Cities*. Paper presented at the Workshop on Linkages in Urban Solid Waste Management, 18-20 April, Indian Institute of Science, Bangalore. (unpublished).

Aziz, A. 1984. *Urban Poor and Urban Informal Sector*. Ashish Publishing House, New Delhi.

Baaijens, A. 1994. "In Cario kom je als vuilnisman ter wereld." *Internationale Samenwerking*.11: 10-11.

Bartone, Carl R., Bernstein, J.D. and Wright, F. 1990. *Investments in Solid Waste Management: Opportunities for Environmental Improvement*. Policy Research and External Affairs Working Paper No. 405. The World Bank, Washington DC.

Baud, Isa and Schenk, Hans (eds.) 1994 . *Solid Waste Management: Modes, Assessments, Appraisals and Linkages in Bangalore*. Manohar Publishers, New Delhi.

Baud, Isa, Huysmann, Marijk and Schenk , Hans. 1994. "Urban Solid Waste Management: Raising the Issues" (Chapter I). In: *New Approaches to Urban Solid Waste Management: Linkages between Formal and Informal Systems of Source Separation, Collection and Recycling in Indian Cities*. University of Amsterdam, Amsterdam. (mimeo).

Baumol, William, J. and Oates, Wallace, E. 1988. *The Theory of Environmental Protection*. Cambridge University Press, Cambridge, UK.

Beede, David N. and Bloom, David E. 1995. "The Economics of Municipal Solid Waste". *The World Bank Research Observer* 10(2) August: 113-50.

Beukering, Pieter van. 1994. "An Economic Analysis of Different Types of Formal and Informal Entrepreneurs Recovering Urban Solid Waste in Bangalore (India)". *Resource, Conservation and Recycling* 12: 229 - 252.

Beukering, Pieter van, Schoon, Edwin and Mani, Ajit. 1996. *The Informal Sector and Waste Paper Recovery in Bombay*. CREED Working Paper Series No. 5. IIED, London and Institute for Environmental Studies, Amsterdam.

Bever, M.B. 1976. "The Recycling of Metals: Ferous Metals and Non-Ferous Metals". *Conservation and Recycling* 1(1): 55- 69.

Bhide, A.D. and Sundaresan, B.B. 1984. *Solid Waste Management in Developing Countries*. Indian National Scientific Documentation Centre, New Delhi.

Bhide, A.D. 1990. *Regional Overview on Solid Waste Management in South East Asia Region*. World Health Organisation, New Delhi.

Bose, A. and Blore, I. 1993. "The Economics of Solid Waste Management in Calcutta". *Nagarlok* 25(2): 32-47.
Bromley, R. (ed) 1978. "The Urban Informal Sector: Critical Perspectives". *World Development*. 6
CEE. 1995. *Study on City-wide Best Practices in Solid Waste Management (Collection, Transportation and Disposal): Bangalore Study*. Report submitted to Human Settlements Management Institute, New Delhi. Centre for Environment Education, South, Bangalore.

Cointreau-Levine, Sandra. 1997. "Occupational and Environmental Health Issues of Solid Waste Management". In S. Cointreau-Levine (ed): *International Occupational and Environmental Medicine.* Mes by, St. Louis (USA).

Cointreau, Sandra J. 1987. *Solid Waste Recycling: Case Studies in Developing Countries*. The World Bank, Washington DC.

Cointreau, Sandra J., Gunnerson, Charles G., Huls, John M and Seldman, Neil, N. 1984. *Recycling from Municipal Refuse: A State of the Art Review and Annotated Bibliography.* World Bank Technical Paper No. 30. The World Bank, Washington DC.

Cointreau, Sandra, J. and de Kadt, Maorten. 1991. "Living With Garbage: Cities Learn to Recycle". Development Forum, January-February: 12-13.

Eerd, Maartje van. 1995. *Gender Related Labour Market Fragmentation in the Informal Recycling Sector: A Study in Bangalore (India*). University of Amsterdam, the Netherlands.

Eerd, Maartje van. (1997. *The Occupational Health Aspects of Waste Collection and Recycling: An inventory study in India*. UMEP Working Documents (UWEP working document 4 - part II). WASTE, Gouda, the Netherlands.

Fritz, Jack. 1990. *Comparatives Issues in Solid Waste Management in India and China*. Paper presented at the "International Workshop on Waste Management and Resource Recovery", October 27 - November 4, Kathmandu.

Furedy, Christine. 1989. "Social Considerations in Solid Waste Management in Asian Cities". *Regional Development Dialogue*. 10(3) August : 13-38.

Furedy, Christine. 1990. *Social Aspects of Solid Waste Recovery in Asian Cities*. Environment Sanitation Review, No. 30. Environment Sanitation Information Centre, Bangkok.

Furedy, Christine, (1992). "Garbage: Exploring Non-conventional Options in Asian Cities". Environment and Urbanisation, Vol. 4, No. 2, October: 42-61.

Furedy, Christine. 1994. "One World of Waste: Should Countries Like India Deal With Solid Waste Problems Through Source Separation ?". In: Elliot Tepper and Johan Wood (eds*). Enriched by South Asia: Celebrating 25 years of South Asian Studies in Canada, (Volume Two).* 89-106. Canadian Asian Studies Association, Montreal:

Gandhy, M. 1994. *Recycling and the Politics of Urban Waste*. Earthscan Publications Ltd., London.

Gidman, P.C. et. al. 1995. *Public - Private Partnerships in Urban Infrastructure Services*. Habitat Working Paper No. 4. Urban Management Program, UNDP/UNCHS. The World Bank, Washington DC.

GOI- Government of India. 1998. "Launching a Clean City Campaign in the States in the 50th Year of Independence." Brochure published by the Ministry of Urban Affairs and Employment (Department of Urban Development) in *Quarterly Journal of the All India Institute of Local Self-Governance*, Vol. LXIX, No. 2, April - June: 96 - 105.

Hadker, Nandini. 1995. *Accounting for Informal Sectors: A Case Study of Solid Waste Management Systems in Bombay*. Prepared for the ESCAP project on Environmental Accounting for India. Indira Gandhi Institute of Development Research, Bombay (mimeo).

Hardoy, J.E., Mitlin, D. and Satterthwaite, D. 1992. *Environmental Problems in Third World Cities*. Earthscan, London.

Heidenstam, O. von. 1977. *Swedish Experience in Separation at Source Solid Wastes*. Institute of Solid Waste Management, London.

Hooper, J. R., and Neilsen, J.N. 1991. "Recycling as altruistic behaviour: normative and behavioral strategies to expand participation in a community recycling program". *Environment and Behaviour* 23 (2) March: 195 - 210.

Huysman, Marijk and Baud, Isa. 1994. "Solid waste recovery, reuse and recycling: formal and informal aspects of production and employment in indian cities". In Isa Baud and Hans Huysman (eds) *Solid Waste Management: Modes, Assessments, Appraisals and Linkages in Bangalore*, Manohar Publishers, New Delhi

Huysman, Marijk. 1994. "The position of waste pickers in solid waste management in bangalore". In Isa Baud and Hans Huysman (eds) *Solid Waste Management: Modes, Assessments, Appraisals and Linkages in Bangalore*, Manohar Publishers, New Delhi

Huysman, Marijk, Velu, J.S., Ganesh, K.N. and Bhuvaneswari, R. 1994. *Approaches to Urban Solid Waste Management: Linkages between Formal and Informal System of Source Separation, and Recycling (Profile of Bangalore).* Paper presented in the workshop on: 'Linkages in Urban Solid Waste Management', Bangalore, 18th - 20th April, 1994.

Indapurkar, Shrinivas. 1996. "Hospital waste management: a burning issue". *FRCH Newsletter* X (5) September - October : 6 - 7.

India Today. 1994. "Our Filthy Cities: Can We Clean Up the Mess?". 31st October : 62-79.

Lardinois, Inge. 1996.. *Integrated Sustainable Waste Management: Concept and Examples from Latin America.* Lecture at the seminar on Sustainable Urban Development in Developing Countries, organised by WASTE, IIUE and NUHG, 12 September 1996. Published in*: Capability Statement: Capabilities for the Support of Projects in the South on Urban Environment and Development.* WASTE, Gouda (Netherlands).

Lardinios, I. and Klundert, van de, A. 1997 *Integrated Sustainable Waste Management*. Paper for the Programme Policy Meeting Urban Waste Expertise Programme. April 1997. p.1-6

Mathur, O.P. 1996. *Charging for Municipal Services: International Experiences*. Paper presented in the Seminar on 'Pricing and Cost Recovery of Urban Infrastructure and Services', National Institute of Urban Affairs, Institute of Public Finance and Policy and Community Consulting International, held at New Delhi (November).

Mehta, Meera and Satyanarayana, V. 1996. *Pricing and Cost Recovery For Urban Services: A City Perspective - Case of Pune Municipal Corporation.* Paper presented at the Seminar on 'Pricing and Cost Recovery of Urban Infrastructure and Services' organised by National Institute of Urban Affairs, National Institute of Public Finance and Policy, and Community Consulting International in November at New Delhi.

Melosi, M.V. 1980. *Garbage in the Cities: Refuse, Reform and the Environment, 1880-1980.* Texas A & M Press, College Station, Texas.

NIUA. 1989. *Upgrading Municipal Services: Norms and Financial Implications (Vol. 1).* National Institute of Urban Affairs, New Delhi.

NIUA. 1993. *Handbook of Urban Statistics*. National Institute of Urban Affairs, New Delhi.

NIUA. 1996. *Urban Infrastructure in India: A Financing Inventory*. Report prepared for the Urban Sector Profile Project of the Asian Development Bank, August, New Delhi.

Pathak, Pushpa. 1996. *Pricing and Cost Recovery of Urban Services: A Case Study of Four Indian Cities*. FIRE(D) Working Paper Series No.3. National Institute of Urban Affairs, New Delhi.

Rao, M. Nageswara. 1995. *Financial and Institutional Management of Urban Services (water supply, sewerage, solid waste and drainage): A study on Bangalore city.* IDPAD Commissioned Paper. Institute for Social and Economic Change, Bangalore (mimeo).

Rosario, A. 1987. *Waste Disposal to Resource Utilisation: A Innovative Scheme in Bottom-Up Approach* (unpublished).

Rosario, A. 1988. *A Document on the Action Among the Waste-workers of Bangalore City*. (unpublished).

Rosario, A. and Mani, A. 1992. *A Funding Proposal: Waste Wise Garbage Project, Bangalore*. Sistas Pty Ltd., Bangalore (unpublished).

Schall, J. 1995. *Does the Solid Waste Hierarchy Make Sense? A technical, economic and environmental justification for the priority of source reduction and recycling*. Yale University. New Haven.

Shah, Esha 1996. *Capacity Building at Local Level: Health and Environmental Impact of Solid Waste Management in Bangalore*. Wastewise, Bangalore (mimeo).

Shah, Esha and Sambaraju, K. 1997. *Financial Marketing Analysis of Composting Enterprises in Bangalore.* Draft report prepared for WASTE, Gouda, the Netherlands (mimeo).

Shah, Esha and Bhubaneswari, R. 1997. *Approach, Method and Economics of Separation of Waste at Source in Bangalore*. Draft report prepared for WASTE, Gouda, the Netherlands (mimeo).

Shah, Esha and Rajaram. 1997. *Plastic Recycling in Bangalore*. Report prepared for WASTE, Gouda, the Netherlands (mimeo)

.

Shah, Ghanshayam. 1997a. "Bureaucracy and urban improvement: can it be made to last? post plague scenario in surat". *Economic and Political Weekly*, Vol. XXXII (12) March 22: 607 - 613.

Shah, Ghanshyam. 1997b. *Public Health and Urban Development: The Plague in Surat*. Sage Publication, New Delhi.

Shekdar, A. V., Krishnaswamy, K.N., Tikadar, V.G. and Bhide, A.D. 1991. "Long term Planning for Solid Waste Management in India". *Waste Management Research*, 9: 511-523.

Shekdar, A. V., Krishnaswamy, K.N., Tikadar, V.G. and Bhide, A.D. 1992. "Indian Solid Waste Management Systems: Jaded Systems in Need of Resource Augmentation". *Waste Management Research*, 12: 379 - 387.

Sudhir, V., Muraleedharan, V.R. and Srinivasan, G. 1996. "Integrated Solid Waste Management in Urban India: A Critical Operational Research Framework" *Socio-economic Planning Science* 30(3): 163-181.

Souza, A. de. 1991. *The Waste that People Want: An Intermediate Report on Solid Waste Collection and Disposal in Bangalore* (unpublished).

UNEP. 1991. *Environmental Data Report 1991/92*. United Nations Environment Program. Basil Blackwell, Oxford, UK.

UNEP. 1994. Environmental Data Report 1993/94. A Report for the Global Environment Monitoring System. United Nations Environment Programme. Basil Blackwell, Oxford, UK.

Venkateswaran, Sandhya . 1994a. "Managing Waste: Ecological, Economic and Social Dimensions". *Economic and Political Weekly*, Vol. XX, No. 19, November 5 - 12: 2907 - 2911.

Venkateswaran, Sandhya. 1994b. *The Wealth of Waste: Waste Pickers, Solid Wastes and Urban Development*. Friedrich - Ebert - Stigtung, New Delhi.

Vidya, C., and Ramchand, K. 1993. "Cost Recovery in Urban Services" *All India Housing Development Association Journal*, Volume 1993/2: 62-80.

WHO. 1991. *Regional Overview of Solid Waste Management in South East Asian Region*. World Health Organisation, New Delhi.

WHO. 1992. *Our Planet, Our Health:* Report of the WHO Commission on Heath and the Environment. World Heath Organisation, Geneva.

World Bank. 1995. *Workers in an Integrated World: World Development Report,1995*. Oxford University Press, New York.

World Bank. 1998. *World Development Indicators, 1998*. The World Bank, Washington, DC.

World Resource Foundation. 1997. . Information sheet: paper making and recycling. *Warmer Bulletin* No.55.

Appendix I. Profile of SWM stakeholders in Bangalore

CONSUMERS	
HOUSEHOLDS	
Bangalore city Population	5000000
Area, sq.kms.	226.15
No. of Households	1011123
COMMERCIAL ESTABLISHMENTS	
markets - No. of Stalls	
BCC Complexes	
1. Sri K R Market	1924
2. Yashavantapur Market	161
3. Malleshwaram Market	267
4. SJR Wholesale Market	452
5. Russel Market	482
6. Others	3082
Agri. Producers Marketing Cooperative Yard	900
General Stall in Bangalore	25000
(Roughly about 250 Stalls per Ward)	
Total	32268
hotels	
No. of Hotels	4099
No. of Bakeries	1529
No. of Tea Stalls	322
No. of Star Hotels	11
INSTITUTIONS	
Educational Institutions	
No. of Schools	3225
No. of Colleges	329
No. of Technical Institutes	90
Universities	3
Total	3647
Offices	
No of Employees	263497
Hospitals	
No. of Major/Corporate Hospitals	15(6053 beds)
No. of Govt. Hospitals	14(10500 beds)
No. of Private Nursing Homes	350(8750 beds)
No. of General Practitioners	5000
No. of Diagnostic Laboratories	50

No. of Blood Banks	50
PRODUCERS	
WASTE PICKERS	
Estimated Total Number	25000
ITINERANT WASTE BUYERS	
Estimated Total Number	600
MIDDLEMEN	
No. of Paper Wholesalers	25
No. of Glass Wholesalers (Cullets)	5
No. of Glass Wholesalers (Liquor)	15
No. of Glass Wholesalers (Medicine)	3
No. of Plastic Wholesalers	55
Middlemen Total	103
GOVERNMENT - BCC	
Area Covered (Sq. Kms.)	226.15
No. of Ranges	17
No. of Wards	100
RECYCLING UNITS	
Small Enterprises	
No. of Small Composting units (CBOs)	32
No. of Small Plastic recycling units	300
No. of small Paper Recycling units	17
Large Enterprises	
No. of Large Composting units	3
No. of Large Glass recycling units	3
No. of Large Paper Recycling units	5
INDUSTRIES	
No. of Large & Medium Industries	396
No. of Small Industries	13086

Appendix II. The data survey

Various survey techniques have been used in generating the data on waste flows in Bangalore:

1. For the household survey Bangalore city was divided into five zones in consultation with the officials of the city municipal corporation. Although each zone comprised a mixture of all classes of people, for the purpose of this study it was decided to broadly categorise them as representative of a particular economic class taking into consideration the types of localities. Accordingly, the north zone was identified as representative of upper class households; the central zone, which is mainly a commercial area, was taken as representative of lower middle and business class houses; the west zone was considered a salaried and lower middle class house area; the south was taken as representative of middle and upper middle class houses; and the east was considered as representative of slums and households characterised by rural & urban features (households having cow sheds etc). A total of 200 households were randomly surveyed, taking 40 households from each zone. It was decided to consider the building size (structure of the house) as roughly indicative of the economic class of the households selected for the study. Structured questionnaires were administered to the households. Data about waste generation was collected by giving the selected households garbage bags and asking them to put all waste generated in one day into the bags. The waste collected in the bags were then weighted to obtain household waste generation data. This exercise was repeated twice for each household for an an average.

2. Regarding hotels, no single source of information was available about the total number of hotels/restaurants in Bangalore city. A consolidated figure was traced in the Administration Report of 1992 of the city corporation, where it was recorded that the number of hotels (including boarding and lodgings) in Bangalore was 4,099, Bakeries and Confectioneries amount to 1,529 and Tea stalls (snack joints) numbered 322. In addition, it was estimated that there are 11 corporate hotels (star hotels) in the city. It is accepted that there are a good number of small tea stalls and pull-carts where a variety of consumables are prepared and sold. These also generate some quantity of bio-degradable waste which are disposed in public dustbins, but as the number is not recorded anywhere they have not been taken into consideration while during the sample survey for hotels as it would not be possible to extrapolate the information gathered about them for Bangalore. Accordingly, the hotels were broadly categorised as - star hotel, major vegetarian restaurant with lodging facilities, a big non-vegetarian popular joint, the small non-vegetarian hotel, medium-scale fast food joint (*Dharshinis)*, small vegetarian restaurant, and bakeries. One sample from each of the above listed categories was identified and structured questionnaires were administered to the hotel management. The data thus collected was then extrapolated for the Bangalore situation -data on waste generation, recovery and disposal for each identified category was multiplied with the total number of total hotels under that category to get a picture for the whole city.

3. According to information provided by Bangalore municipal corporation, there are five major markets in the city - namely *Sri. K.R. Market, Yeshwanthapura Market, Malleshwaram Market, SJR Wholesale Market and Russel Market.* These constitute the major market complexes under the jurisdiction of Bangalore City Corporation (BCC). The BCC also maintains a number of other small market complexes and shops spread throughout the city. Data regarding the total number of stalls in these complexes wer collected from the BCC office. In addition, there is one wholesale agricultural products market in Bangalore - the Agricultural Producers Marketing Co-operative Society (APMC). Data about the total number of stalls at APMC were also collected. Further, after discussions with BCC officials, it was roughly estimated that in addition there are about 250 stalls in each of the 100 wards constituting Bangalore city. Primary data were collected from two major market complexes (Sri. K.R. Market and APMC) - both, data from selected stalls and the total waste generated. The former was collected by structured questionnaires to randomly selected stalls (numbering 25), taking a sample from each type of stall located in the complexes. Data about the total waste generation in the selected complexes were collected by accompanying the trucks transporting the waste to the disposal points and weighing them on the weighing bridge. The data about total market waste generation for that specific market was then divided by the number of stalls to validate information collected. The information thus collected was extrapolated for all the stalls in the city.

4. Data regarding three types of institutions were collected - educational institutions, offices and hospitals. Information about the total number of educational institutions in Bangalore city and the number of students enrolled in them was obtained from 'Karnataka At a Glance, 1997' published by the Directorate of Economics and Statistics, Government of Karnatak which classifies educational institutions into schools, colleges, technical institutions and universities. The total number of such institutions in Bangalore city are 3,647 with 1,212,905 student strength. Regarding offices, due to the lack of reliable information about the number of private/business establishments and the persons working in them, in this study only government offices were covered. Information about the total number of personnel in these offices was collected from the Department of Personnel and Administrative Reforms, Government of Karnataka which indicates that there are about 2,63,497 government employees in Bangalore city. Estimations about the number of hospitals and bed strength was collected from a range of sources, including the Directorate of Public Health, Association of Private Nursing Homes in Bangalore and M.S. Ramaiah Medical College. A consensus figure about the hospitals and their bed strength was finally determined in consultation with doctors from M.S. Ramaiah Medical College (Community Health Department). A primary survey was carried out for educational institutions and offices, taking one sample from each category (school, college, technical institution, university and a government office), using a structured questionnaire to the management to obtain information about various aspects of waste management in their institutions, including the total waste generated. For hospitals, data generated by a research study carried out by M.S. Ramaiah Medical College was used. For each of the three types of the institutions waste generation information was collected on a per capita basis (for hospitals it was calculated on per bed basis) and then extrapolated.

5. It is a statutory requirement that industries manage their waste and do not depend on BCC for its disposal. With this in mind, a sample survey of industries was carried out, taking into consideration the three broad types of industries listed under Bangalore Urban District Industrial Directory published by District Industries Centre, Bangalore, Government of Karnataka. According to this, there are 396 large and medium industries, and 13,086 small scale industries in Bangalore. A sample selection for primary data collection was made after categorising the industries into four major groups based on the major industrial products, namely electrical and electronic, fiber based, wood/rubber/leather based and chemical. Accordingly, the following industries were surveyed - a large scale public sector electronic industry, a medium scale textile industry, and four small scale industries (a rubber, metal, garments and chemical industry).