# INTEGRATED SOLID WASTE MANAGEMENT
## CITIZEN PERCEPTIONS

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Hamburg - Germany Mumbai - India

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This report Integrated Solid Waste Management Programme - Citizen Perceptions by Priya Salvi is the outcome of the collaboration between Save Bombay Committee and Hamburger Umwelt Institut of Hamburg Germany for the study of various programmes and practices at the disposal of the community for handling solid waste generated by the members of the community in search of developing a holistic and integrated solid waste management programme for an urban centre and for showing the viability of such a programme.

This required an indepth study of the existing solid waste disposal practice followed in Bombay renamed as Mumbai by the Municipal Corporation of Greater Bombay (MCGB) and also a look at various programmes taken up in Mumbai and other centres of Maharashtra by committed young enthusiasts and the citizens on their own without any outside help and sometimes in the face of the opposition of the administrators. Mumbai daily generates about 5000 plus tons of solid waste comprising of biodegradable organic waste originating mainly in kitchens and markets, recyclable waste like plastic, paper, glass, leather etc. from day to day activities and inert debri material generated from construction and repairs work. The present practice is to lift this heterogeneous material from the MCGB's waste bins kept at specified locations or from heaps of garbage lying strewn on roads and common properties and dump it at the dumping sites in the mixed up condition. The citizens spend Rs 2200 million annually and employ around 27000 workers in the solid waste management department yet there is no respite for the people. In fact, solid waste has become a major source of pollution and illhealth in Mumbai. The pilot project could not be set up because of apathy from the municipal officers. Fortunately for Priya, so many programmes incorporating citizen initiative were available which point out to the possibility of tackling the problem with citizen initiative, involvement and participation.

Solid waste programme of any human centre has to be viable economically, socially acceptable in addition to be environment friendly. Health of living beings has to have high priority in any programme for solid waste disposal. This would call for an integrated solid waste management programme worked out on holistic considerations. Priya has attempted to evolve one for Mumbai based on her perceptions of citizen preferences. As the habits for generating waste are common to all the human beings, so can also be the programme they develop for satisfactory management of the waste. Her prescription can be replicable to other centres of human habitation, small or big. Our burgeoning towns and cities are all facing the mounting problem of waste disposal. It is hoped that authorities in both Mumbai and other cities would try out her recommendations so as to create better conditions in their cities.

Having been close to Priya during the course of study, I have seen the trials and tribulations as well as moments of relief and happiness that she passed through. It was her perseverance and forbearance that has helped her to evolve this admirable study. We recommend the citizen perceptions to the citizens without any reservation.

Mumbai 22nd March 1996 ***Kisan Mehta***

## FORWARD TO THE SECOND EDITION

The first edition published in March 1996 was widely distributed. Copies have become unavailable for sometime now. Reactions received from the senior municipal officers indicated their preference for programmes that are economically viable. The chapter Integrated Solid Waste Management Programme is rewritten to point out the economic viability of the ISWMP. The object is to reduce the use of finite resources as well. We hope that this would provide an additional ground to the municipal authorities to implement the programme as proposed herein.

Mumbai 21st January 1997 ***Kisan Mehta***

## ACKNOWLEDGEMENTS

This project for the study of solid waste disposal and management is the outcome of a discussion of Mr Kisan Mehta of Save Bombay Committee and Prakruti with Dr. Michael Braungart of the Hamburger Umwelt Institut (HUI) hence I should first of all thank Kisanbhai for discussing this study with the HUI and Dr. Michael Braungart for accepting Kisanbhai's proposal for a study of solid waste management with particular reference to the relevance of vermiculture in developing an integrated solid waste management programme. I am grateful to Ms Anke Bujanowski, a colleague of Dr Braungart in the HUI, for suggesting initial guidelines for the project.

Having studied horticulture with research in tissue culture for my Master's Degree, this subject was comparatively new for me however Kisanbhai gave me all the support that I needed so badly in the beginning. He put me in touch with individuals and organisations working in vermiculture and related fields. He also guided me in delineating the scope of the study and offering useful suggestions on the first draft. But for Kisanbhai's continuous support, it would have been difficult for me to complete the study.

During the course of this study, I met a large number of individuals who have done pioneering work in the areas of biodegradation of organic matter in general and of vermiculture in particular. It is difficult to recount the names of all of them at this juncture. Special thanks are due to Dr H.S.Shankar, Mrs Vidula and Mr Uday Bhawalkar, Dr Mrs Hemangi Jambhekar, Mr Jayant Barve, Mr P A Deshpande, Mr M S Deshpande, Dr S V Mapuskar, Mrs Lata Shrikhande, Mr Shantu Shenai, Mrs Neena Sawhney as well as the officers of the Excel Industries in charge of the composting plant, Mr A D Patel, Mr Mohan Kadam and Mr Vidyut Arunkumar. Mr J V Mali Chief Engineer Solid Waste Management of the Municipal Corporation of Greater Bombay, Mr Pushparajan, Deputy Chief Engineer and other officers in the department extended help and gave information on the municipal practice solid waste disposal.

I should not forget my colleagues in the Prakruti office, Mr Jagdish Redij and Mrs Nancy Menezes who helped me in many ways. Their everready support lightened my task throughout the period of study. Though so many individuals have contributed in this effort, the responsibility for any likely shortcomings in the presentation is solely mine.

***Priya Salvi***

## FORWARD TO THE THIRD EDITION

The second edition published in January 1997 is fast getting exhausted hence the need for publishing the third edition. Basically this study was undertaken with the dual purpose of informing the citizens on the conditions prevailing in Mumbai and to provide a working guide to the Brihan Mumbai Mahanagar Palika for implementing the Integrated Solid Waste Management Programme. While the first object is being widely realised, it is disappointing to observe that the municipal authorities have refused to take notice of the ISWMP. We are venturing to republish the study in the hope that a better understanding will prevail amongst the municipal officers.

Mumbai November 14, 1997 **Kisan Mehta**

## INTRODUCTION

Amongst many environmental crises tormenting the communities of the world today, garbage or solid waste disposal is perhaps the most tormenting. It is the unplanned disposal of solid waste that causes pollution while its proper management ensures healthy conditions. Countries all over the world face the problem of waste disposal and it is aggravating day by day. In fact every community that generates waste has to face the problem of its disposal. Quantities of waste go on increasing with the progress in civilisation so much so that the progress of a country is evaluated on the basis of the quantity of waste generated. On the other hand, avenues for their proper disposal are being reduced..

In the developed countries quantity of solid waste generated per capita is comparatively larger as against the ones in the developing countries. An average American generates 1.8 kg of waste a day while the daily generation of waste by an average Indian is 0.40 kg.

The composition of waste also varies significantly between the developed and the developing countries. In the developing countries organic matter forms a major component in the waste generated while in the developed countries the proportion of organic matter is lower with recyclables forming a major component. Again in the household waste, organic matter predominates in the developing countries as against recyclables resulting from massive consumption of processed foods in the developed countries.

Solid waste generated in the urban areas is normally carried to low lying areas, swamps, creeks etc. and dumped in the mixed condition as collected and without any corrective treatment. As the dumped waste is a mix of organic and inorganic material, improper decomposition of the waste results in the creation of insanitary conditions at dumping sites. The anaerobic decomposition generates obnoxious gases like methane, carbon dioxide and hydrogen sulphide creating pollution and quite often cause fire. Once accidentally ignited, fires can never be extinguished because inflammable gases continuously being generated feed to the ignited fires at all the time. Heavy clouds of black soot and suffocating smoke are a constant feature in the dumping sites. Conditions prevailing at the dumping sites are extremely unhygienic, affecting adversely the health of people not only in the vicinity but also in distant areas where the suffocating smoke moves and settles dictated by the wind direction. Direct sufferers of these unhealthy conditions are the rag pickers who swarm the dumping sites to retrieve otherwise insignificant quantity of recyclable substances from the waste dumped at the sites. Continuous leaching from wet waste at dumping sites affect ground water sources and aquifers.

Presently solid waste from the time and place it is generated till the time and place it is disposed off has assumed gigantic proportions and has become a matter of concern for the citizens, community and authorities. An estimated 100 000 tons of solid waste is generated in the burgeoning Indian urban centres daily which spread illhealth and cause pollution to the environment. No effective panacea that can straightaway be applied has been developed. Solid waste disposal is a matter of everyday discussion at local and global levels yet the problem evades solution.

Though acknowledged universally as a hazardous practice, dumping of waste as landfill is followed in practically all communities and countries, irrespective of their resources. Generation and disposal of solid waste affects the poor countries and congested urban centres more than the developed countries who have or can raise adequate financial resources to offset the adverse effects on environment and health. It is the developing countries huddled with many more pressing priorities and their people who suffer from mounting heaps of waste on public areas and indiscriminate dumping in low lying areas. Between 10 to 15% of the resources of urban centres are expended on solid waste collection and disposal and equal amount on sewage disposal yet clean cities are hard to find in the developing countries.

Continuing ill-effects of improper collection and disposal of solid waste in Mumbai attracted the attention of Save Bombay Committee (SBC) in the late seventies. The SBC represented to the authorities that indiscriminate dumping in low lying areas was polluting the environment and affecting the health of the living beings and pointed out to the need for developing a pragmatic programme that would provide a holistic management of solid waste giving the environmental and health aspects the topmost priority. Smouldering dumping yards emitting poisonous gases into the atmosphere created suffocating conditions in the neighbourhood. Existing dumping sites were fast getting filled up which would require hunting for new dumping sites within congested boundaries of Mumbai or acquire large plots of land outside their boundaries. The second option would mean that people who were not responsible for the generation of waste would be subjected to unhealthy conditions. Continuing adverse impact on environment and health of living beings has become a regular predicament nevertheless.

Emergence of Prakruti as a non-government organisation in the eighties promoting sustainable farming for an environmentally viable society lent another angle for looking to city waste. While organic solid waste continued to create environmental and health problems in towns and cities, agricultural lands were simultaneously witnessing fast depletion of biomass so essential for cultivation of good quality food and fibre. Organic solid waste could, on proper biodegradation, become compost or soil conditioner and could, on application, enable the soil to grow healthy food in optimum quantity. Prakruti could visualise a possibility of linking city's highly maligned solid waste as a source of biomass to meet the need of agriculture and as a natural corollary started experimenting in expediting the conversion of city waste into compost, better understood as soil conditioner. Active members started programmes and found vermiculture to be cost effective and highly efficient process for turning organic biodegradable waste into soil conditioner. Kisanbhai as the President of both the SBC and Prakruti could visualise a link to connect two apparently divergent areas- urban and rural - in a way that would meet the needs of both.

The experience has shown that the three "Rs" that is Reduce, Reuse and Recycle have a great relevance to satisfactory handling of solid waste. Reduction of waste at source ensures reduction in the quantity to be handled, transported and finally disposed off. Elimination of organic waste from the heaps of municipal solid waste within the urban centres and from the dumping sites could raise the levels of public health. Vermiculture comes to the rescue in reducing the organic biodegradable waste. It can be pursued at individual home as well as at community levels with ease. It ensures that the organic matter reenters the natural cycle in an appropriate form like soil conditioner that improves the soil. It is only when the organic

matter returns to the soil as nutrient biomass that we can expect the soil to grow good quality food free of hazardous chemical pesticides and fertilisers.

Segregating of the recyclables itself at the generating point, during the process and at dumping sites as well as putting them back to use through recycling signifies the desire and commitment of the citizens to conservation of finite natural resources of the earth while reducing the quantity of waste to be dumped at dumping sites.

One discussion between Mr. Kisan Mehta of Prakruti and Dr Michael Braungart of the Hamburg Umwelt Institut (HUI) gave the shape to the present project of Solid Waste Management. The object behind taking up this project is to show to the community that an environmentally friendly, economically viable and socially acceptable programme for satisfactory disposal of organic component of the solid waste is easy to implement at every level and once the biodegradable component is properly treated, the waste ceases to be serious threat to the environment. The main stress is on converting the organic biodegradable waste into soil conditioner so that it could return in an environmentally acceptable form back to the soil reducing the quantity to be handled, transported and deposited at the dumping sites. Formulating ecofriendly management of solid waste was an unavoidable and natural need that calls for immediate attention and action.

The views of Dr Braungart on the need for the efficient use and reuse of the finite resources are well documented. His efforts are directed to linking industrial production processes so that a substance becoming superfluous or unwanted, normally condemned as waste, in one process becomes the raw material for another leaving nothing behind as waste in the community. What the SBC and Prakruti are endeavouring is to link substances becoming superfluous following the reductionist approach in the urbanised communities to the soil in agrarian communities to enrich the soil which has the obligation of producing food and fibre required by living beings inhabiting in both urban centres and village communities. Vermiculture thus re-establishes the link between urban areas and rural communities fast being forgotten forever in human societies operating on market forces.

The study provided to me a highly enlightening and satisfying, but least expected, insight into the working of the minds of people articulating in the field. All of them invariably, including those working even in urban areas and context, exhibited a deep and affectionate attachment to the soil and environment even though many of them were pursuing the activities for their sustenance. They manifested a deep love, almost filial, for the earth, the survival of which critically depends on the extent to which its inhabitants protect the environment. This study gave to me an opportunity to feel the inner working of the minds of these devoted individuals whom I would term as the committed volunteers for protecting the earth.

I could also notice high degree of commonality between Dr Braungart's approach in the field of industrial processes and manufactured products on one side and the urban-rural symbiosis provided by vermiculture in turning urban waste into valuable input for the soil on the other.

The study has reaffirmed our conviction that evolution of an appropriate solid waste management programme is not as difficult as is made out by the public officials having the duty of handling solid waste. Solid waste disposal is messed up due to sheer neglect creating

severe problems for the community. It is increasingly being accepted worldwide that the only environmentally acceptable solution for proper management of solid waste lies in applying the appropriate treatment separately to various components that make up the waste instead of taking the mixture of various components as one substance to be collected, transported and dumped at far off locations. Biodegradable organic component needs special treatment. We came across many individuals who treat the biodegradable component of waste with the natural process of biodegradation for converting into a product beneficial to the soil. The simple process of vermiculture is capable of being carried out successfully because it is the same process the nature applies for converting organic waste.

This report is built around a case study of the present practice of the Municipal Corporation of Greater Bombay (MCGB) in handling solid waste generated in Bombay together with data on the administrative structure created for the same. Many initiatives developed in vermiculture by individuals and voluntary organisations in and around Mumbai are studied simultaneously with an object of checking their relevance and applicability to tackle municipal solid waste as well as of developing an eco-friendly economically viable alternative to the vexing problem of disposing of municipal solid waste. There is a specific reason for not including in the present study the issue of hazardous waste coming out of manufacturing processes or specific human activities because such waste needs specific treatment depending on the nature and composition of the hazardous waste. Municipal solid waste generally is not hazardous requiring specific treatment in areas away from the dumping yards. The study however of medical waste and abattoir waste is covered because these waste are generated along with other city waste and are more often than not dumped along with municipal solid waste.

An attempt is made to develop an integrated Solid Waste Management (SWM) programme which is environmentally acceptable, financially affordable and people participatory. The programme for any SWM to be successful and satisfying has to be low cost because the end products resulting from biodegradation of organic waste as well as from the reuse of recyclables go back to the community for reuse. The cost of such biodegraded and recycled products have to be kept low for ready reuse in the areas of consumption. Involvement and participation of people at every stage from planning to conversion is a prerequisite to ensure the optimum reuse of the products coming out of the waste. As the people are associated with the waste as the generators of waste, they are equally interested in the proper handling and utilisation of the waste as consumers. As improper handling or neglect of waste affects the environment and health of living beings, its appropriate management ensures conversion of environment and better health. The stakes of the community in the handling of solid waste are indeed very high and hence consistent involvement of the people is the assurance for the success of appropriate programme evolved with the active participation of the people.

Out of the estimated 100,000 tons of waste generated daily in the Indian cities and towns, about 35,000 tons of soil conditioners can be harvested every day whose application to the soil can reduce the use of capital and energy intensive chemical fertilisers. Adoption of organic farming practices can as well cut down drastically the use of chemical pesticides as positive farming practices can ensure integrated pest management reducing the dependence on chemical pesticides ii farming operations. Elimination of chemical inputs like synthetic fertilisers and hazardous pesticides can, in turn, guarantee improved environment and assured health to living beings. The realisation that the abominable waste resulting from anthropogenic activities every minute can also be a boon for conserving environment and health of living beings gives one a hope that everything is not lost for the survival of the earth.

## THE PRESENT SCENARIO

Solid waste disposal as seen in the present context presents a dreadful scenario the world over. Every urban centre whether it is in the developed or in the developing countries faces the problem of waste management. Use of new technologies particularly one based on incineration adopted in and applied in the developed countries since the sixties have not only not abated the magnitude of the problem but has severely affected the environment while creating difficult to handle after-effects. The situation in Bombay, renamed as Mumbai, is not different from other urban centres. Though meetings, high level discussions, campaigns, demonstrations have been held ad infinitum to grasp the seriousness of waste disposal and to develop remedies to correct the existing inadequacy, no effective action programme has emerged with the result that the problem continues to aggravate.

The National Environmental Engineering Research Institute, Nagpur (NEERI) conducted in April 1994 a study of the practices of the Municipal Corporation of Greater Bombay(MCGB) now known as Brihan Mumbai Mahanagar Palika (BMMP) for handling solid waste generated in Mumbai as a part of the Metropolitan Environmental Improvement Programme organised by the Government of Maharashtra under the aegis of the World Bank. The study pointed out to the inadequacies in MCGB's existing practices and recommended alternatives aimed at improving the situation. The Additional Municipal Commissioner stated during the discussion that the MCGB was anxious to implement an integrated programme for recycling of the recyclable component and of biodegrading of the organic component through vermiculture and added that the 400 tons per day capacity vermiculture facility set up in 1994 would be progressively expanded to cover the biodegradation of the entire quantity of organic waste generated in Mumbai. With the organic component being properly taken care of, other components would fit naturally into their proper place resulting in a comprehensive solution ensuring satisfactory disposal of solid waste. However the Municipal Commissioner Mr Sharad Kale and Additional Municipal Commissioner Mrs Sudha Bhave who were committed to eco-friendly alternative were soon transferred and the new set of executives succeeding them discarded emerging waste management pattern resulting in utter chaos.

The municipal vermiculture facility has since been closed down on the direction of Mr J.D. Jadhav, the new Municipal Commissioner. Daily increasing quantum of waste has become a major threat to the environment and the community. The municipal authorities have hardly shown any interest in developing eco-friendly innovations that can improve the present waste disposal practice. There is increasing nonaccountability and insensitivity at higher levels. An ecofriendly and economically viable alternative exists for treating municipal solid waste however the new set of municipal officials is in no mood to try it out for the common good.

Mumbai generates 5000 tons of solid waste daily of which 3000 tons is biodegradable organic while the remaining consists of 200 tons of recyclable and 1800 tons of debri material. Observation shows that the entire quantity of waste generated is not cleared by and considerable quantity is left out in the public areas. A study carried out in 1989 on delivery and financing of urban services by Operations Research Group, Baroda revealed that the collection efficiency

in Mumbai is 76.9% while that in Madras is 90%, Bangalore is 68.1% and Pune is 70%. These statistics do not reveal the actual conditions prevailing in our cities. Mounting piles of waste and overflowing bins are a regular spectacle at many locations in the city. Municipal authorities however claim that they are performing their duty of keeping their cities clean by lifting the waste in time and disposing the same away from the sight of the majority of citizens.

The question arises as to what happens ultimately to the waste lifted. The collected waste is dumped at preselected dumping sites and it is fairly well accepted that the dumping sites have a limit on the quantity of waste they can handle. This requires the municipal authorities to remain on constant look out for low lying areas and sea shores where they could dump the waste. Mumbai has limited space for accommodating its ever increasing population but with the sea on three sides, the municipal authorities seem to feel that space for dumping of waste is no constraint. Like the release of untreated sewage and liquid waste into the sea, the MCGB has all along selected creeks and low lying areas for dumping of the solid waste. Because the sea and water bodies cannot formally object to dumping, the MCGB has continued to dump these areas filling up low lying areas till they become habitable. Water bodies between Sion and Mahim on the south and Kurla and Bandra on the north have disappeared in the living memory while Hornby Vellard and Backbay and Cuffe Parade Areas became land following dumping of the waste between the thirties and seventies of the present century. Even after such seemingly unlimited possibilities, dumping areas are in short supply. Deonar dumping yard has gifted over 200 hectares of land by pushing off the sea further yet the MCGB has to be on look out for new dumping areas because of dumping of fast increasing quantities of solid waste.

Just carrying the waste and dumping it at a site is not the end of the problem. It is essential that different components of waste are treated appropriately to avoid subsequent pollution. What is waste? It is just a mixture of substances that we used at one time and threw them away when we could not find for us any utility in them anymore. We know by now that the manmade substances like paper, plastic, glass etc. have resale value because they can be reused while organic biodegradables can go back into the natural cycle. It is therefore necessary to understand and apply biological processes for putting back everything in the proper order.

Biodegradables which are mainly food and vegetable remnants need to go back to the soil in an appropriate form that enriches the soil. Existing practice of throwing the biodegradables away at dumping sites as the final act only adds to the environmental and health problems while occupying precious lands for ever. Throwing recyclables in dumping sites aggravates problems at the dumping sites because they are not only incapable of being biodegraded but also inhibit considerably the natural biodegradation of the biodegradables.

Out of the 3000 tons of biodegradable waste presently 200 tons are being converted by the Excel Industries into compost. The rest is being dumped at dumping sites. Mr. Shantu Shenai of the Green Cross Society applies vermiculture biotechnology developed by Mr. Uday Bhawalkar in many locations in Mumbai at community and individual levels. Ordinary citizens have shown keen interest in the initiative taken by Mr Shenai.

Operations of the SWM Department are found to be inefficient and inadequate in tackling properly the waste generated in Mumbai. They are not able to overcome their inadequacy as brought out in the NEERI report. Bulk of the sanctioned budgeted amount is spent in the salaries of the staff and transportation of the waste . The SWM department has only a limited number of vehicles hence it has to hire heavy duty vehicles belonging to private contractors.

Private vehicles are open trucks creating unhygienic conditions and emitting foul odour while they transport waste to the dumping sites. The waste needs to be transported to long distances in smaller vehicles as two existing transfer stations cannot cope up with the transfer of bulk of the material to larger vehicles. Transport costs increase significantly.

As regards the working conditions, workers employed in the SWM Department are not provided with appropriate facilities and have to work under filthy conditions. This ultimately affects the health of the workers. Such conditions affect the efficiency of the SWM Department and also the cleanliness in the city.

Different practices are adopted in the city for collecting the waste. However the effective ones out of them - the House to House collection and Bell Ringing system - serve very small fraction of the society. If these practices are adopted to the city's other areas then there would be no need for placing bins with garbage spilling everywhere and the city can be maintained clean.

The solid waste as we know consists of different components like biodegradable organics, recyclable inorganics and inert debri material. Amongst various processes presently adopted for tackling the organic waste the vermiculture biotechnology is found to be the most efficient one as it converts the organic waste into a form appropriate for taking back to the soil thus completing the nature's cycle. The processes like composting aerobically as well as anaerobically are also applied however vermiculture is observed to possess a much higher efficiency. Vermiculture is practice that can be set up at an individual level and also on a large scale. No conscious efforts are made for utilising vermiculture on an extensive scale as yet. Composting and vermiculture and the likes can efficiently work only if the organics are separated from the other recyclable items. This will result not only in giving a good value added product back to the soil but will also put other recyclable items into a proper channel for further reuse.

It is observed that even the sophisticated technologies have failed to solve the problem of waste disposal. The practice of burning organic waste and recyclables on massive scale became attractive as the incinerators emerged on the scene. The feeling was among the human communities and civic authorities during the sixties and seventies that the natural resources existed in great abundance and one could as well ignore natural resource conservation and environment protection. Incinerators provided a seemingly easy solution because they could turn stinking waste into vanishing smoke and insignificant ash. Such practices promoted wasteful and consumerist approach as the waste was removed from the sight of the citizens without trace. It was only in the late eighties that the deleterious effects of incinerators on environment and health came to light when the people started feeling concerned about dwindling natural resources. The experience the world over has exhibited that incineration is not only the the most inefficient process for treating the waste but the most hazardous mechanism for damaging the environment and public health irreparably. Other practices for converting the waste, like generation of gas by anaerobic process and burning the gas for producing electricity are harmful as they generate dangerous gases and leave harmful residues. They are energy and capital intensive technologies resulting in underutilisation of the organic component of waste.

It is thus clear that the simplest and the most efficient way of handling the solid waste lies in putting different components of waste back into proper place. Therefore it is necessary that the organic waste goes back into the soil whereas the recyclables like plastic, rubber etc. are recycled and reused. It is however important that the use of recyclable items like plastics and paper is reduced since even after conversion/reuse the hazards of petroleum based substances cannot be totally eliminated in addition to the depletion of natural resources. The change in life

styles has resulted in increased dependence and higher use of manmade synthetic items. In Mumbai alone five million polythene bags are circulated daily while the large departmental stores give out about eight hundred thousand bags daily. This increased use of plastics is aggravating the problems of solid waste disposal. It is wellknown that the plastics do not degrade and hence remain harmful all along. This requires the community to control the use of manmade items and to reduce their use in the long run.

The solid waste management to function properly needs the involvement of people at every stage. People are not informed on what this solid waste is , where it is taken and what happens to it afterwards. The predicament of the urbanites is more pitiable as they are cut-off from nature and are not aware about the link between the organic matter and the soil that produces food and fibre for the living beings. Not only this but they are equally ignorant about how harmful is the presence of the recyclable items in the waste. It is therefore essential first of all to inform the people on the illeffects of the use of plastic material.. Once this is done on a priority basis then other measures like the conversion of waste can be carried out. It is equally important to compel the industries producing materials like plastics etc. to recycle and reuse them thus minimising their wastage. All this can only work when every individual accepts that it is obligatory for him to reduce the use of substances that deplete the natural resources.

The ragpickers play a very important role in managing the solid waste. They retrieve almost all possible recyclable items from the waste and thus put these materials back to proper reuse which otherwise would have been wasted and aggravated the already existing problems of waste management. Today the community does not recognise the role of ragpickers in conservation of natural resources and in appropriate management of waste hence their services are not put to efficient use. It is therefore necessary that the SWM department should incorporate the ragpickers in the waste management programme and harness their services in a manner that assures them minimum sustenance.

## MUMBAI IN BRIEF

**Location and History**: Bombay, now Mumbai, originally a group of seven islands, but admeasuring 437.68 sq km after joining up and reclamation, has now grown into the most important commercial and financial city of India. The city being surrounded by the Arabian sea on all the sides except the North can extend in the north only. Designated as Greater Bombay since the fifties, it is also the capital of the State of Maharashtra.

**Climate**: Mumbai has a moderate climate with an average maximum and minimum temperatures of 31.5 and 21.8 degree Celsius and average maximum and minimum relative humidity of 87.0% and 48.0% respectively. Average annual rainfall is around 2000 mm occurring during the monsoons that is between June and September.

**Mumbai's set-up**: The history tells us as to how Mambai has, from a very small beginning in the early 18$^{th}$ Century, developed into the most important metropolitan, commercial and industrial centre of India. The original seven islands were joined between the seventeenth and nineteenth centuries through filling up of water bodies and marshy areas separating them to form into a single landaus. This landaus was further connected to the larger Salsette Island on the north which now provides shelter to two-third of its population. Mumbai with a protected harbour facing the east has since become the country's largest port handling about 30% of the import and export trade of the country.

Commercial, industrial and technological activities in Mumbai have attracted people from every region of the country. This incessant influx has made Mumbai the most congested city in the world with an average population density exceeding 21000 persons per sq km (Census 1991). The fast expansion of the city has taken place in an unplanned manner resulting in the severe problems of water supply, waste disposal and many more. Population density in some areas exceeds even 100,000 per sq. km which brings strains on civic services. The population of Mumbai is as varied as the city ranging from billionaires to slum dwellers living side by side. Nearly 60% of the Mumbai's population resides in slums not provided with waste disposal facilities and even basic amenities like water, sanitation, etc. The population of Metropolitan Region of Mumbai which was 14.5 million as per Census 1991 is slated to touch 27.1 million by the year 2015 when it would be the largest urban conglomerate in the world.

## EXISTING PROGRAMME

**Solid Waste Management of Mumbai:** The MCGB provides civic amenities within Mumbai's boundaries. Greater Mumbai is divided into 23 different operating areas known as wards in order to facilitate smooth functioning. The MCGB has the obligation to provide basic civic amenities to the citizens under Section 61 of the BMC Act of 1881 and handling of solid waste generated within Mumbai is one of them. A special Solid Waste Management (SWM) Department is in charge of solid waste disposal.

**Organisational Set-up of the SWM Department :** The Chief Engineer, Solid Waste Management is in charge of the disposal of soild waste within municipal limits. He is assisted by a set of Deputy Chief Engineers in his work.

The Municipal Commissioner is the MCGB's Chief Executive who has a number of Additional Municipal Commissioners and Deputy Municipal Commissioners under him to assist him in discharging his duties as the chief executive. The Municipal Commissioner delegates the MCGB's various responsibilities amongst these officers. The Chief Engineer SWM operates under one of the Deputy Municipal Commissioner.

The SWM department with a staff of around 27000 is divided into two operational wings, namely the Conservancy Wing and the Transport Wing . The Head Supervisor(HS), assisted by three Deputy Head Supervisors (Dy HS) and their staff manages street sweeping and primary collection work. Twenty-three wards of Greater Mumbai are administratively grouped under three zones, the City Zone covering A, B, C, D, E, F South and F North and G South and G North wards, the Eastern Suburban Zone covering L, M East and M West, N, S and T wards and the Western Suburban Zone covering H East and H West, K East and K West, P South and P North, R South and R North Wards. The work at the zonal level is managed by a Dy HS while an Assistant Head Supervisor (AHS) handles the work at the ward level. The AHS is responsible for the sweeping of the streets as well as collection of the waste from buildings and putting it on to the transport vehicles in the ward area. He takes instructions from the Dy HS for technical matters and from the Ward Officer for collection and administrative matters.

Transfer and transportation of waste involving the deployment of transport vehicles, provision of garages and workshop facilities are looked after by two Executive Engineers (Transport). Research and Development as well as planning activities are the responsibility of the third Executive Engineer who also looks after the repairs, maintenance and civil construction of the SWM Department.

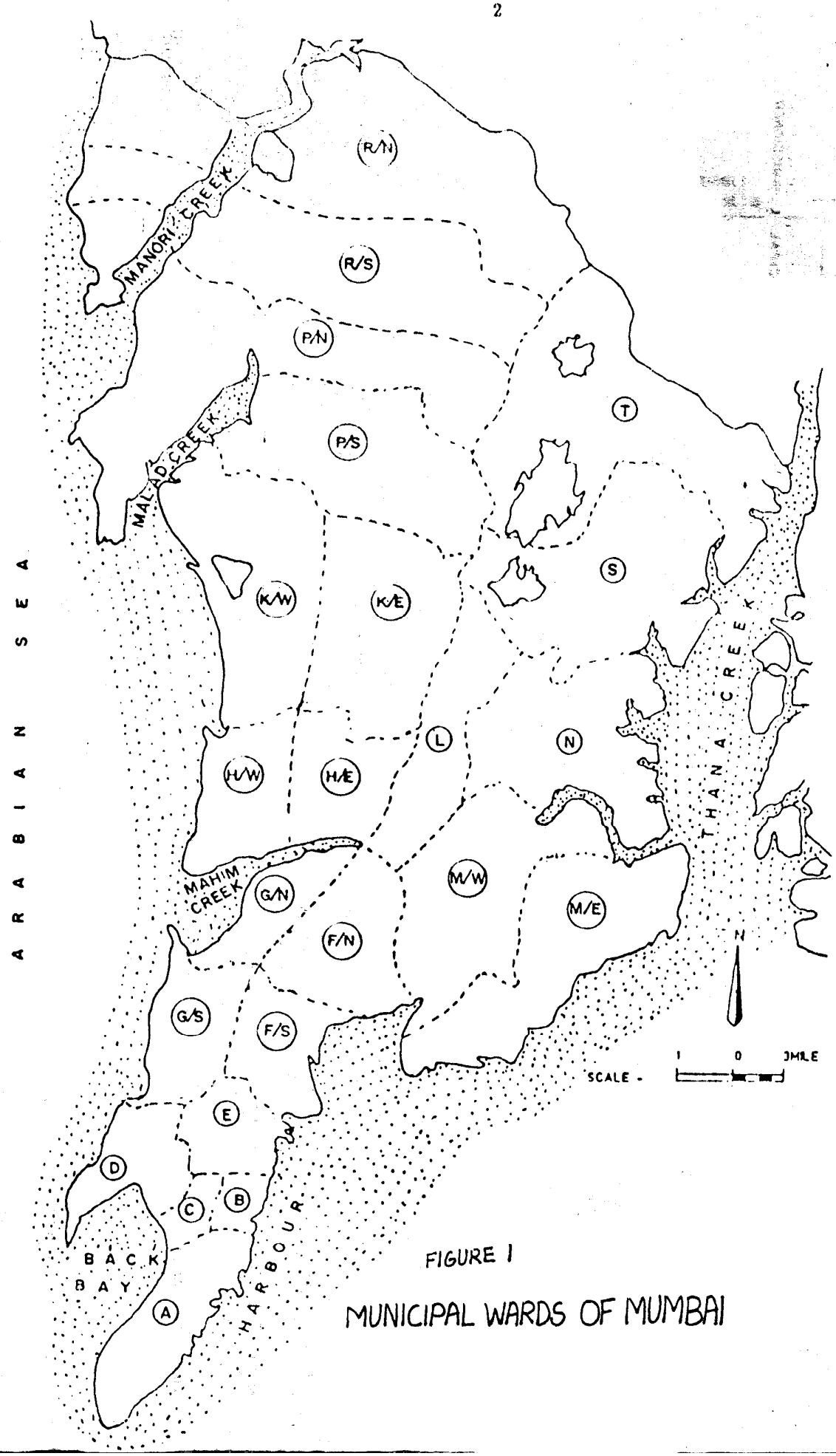



FIGURE 1

MUNICIPAL WARDS OF MUMBAI

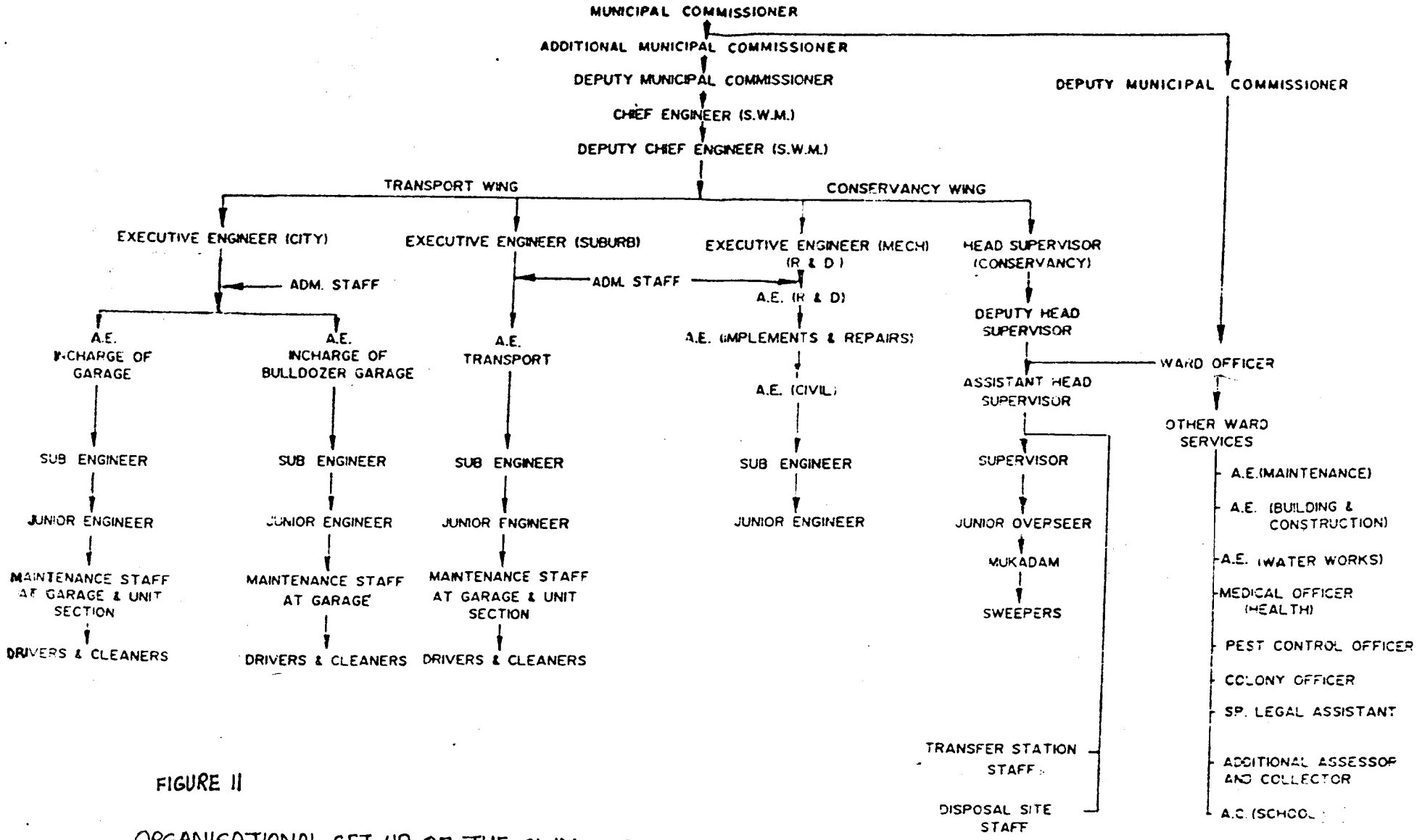



FIGURE II

ORGANISATIONAL SET-UP OF THE SWM DEPARTMENT

**Budget Allocation for the SWM Department:**

Nearly 7 to 8 % of the entire municipal budget is allocated to the SWM Department to meet its annual liability. The following is the budget provision to the SWM Department for the past 3 years :

| Year | Budget Provision |
|---|---|
| 1993-94 | Rs 1,337,817,400 |
| 1994-95 | Rs 1,496,634,000 |
| 1995-96 | Rs 1,785,181,000 |

The Municipal Commissioner has proposed an amount of Rs 2202 millions in the budget for the year 1996-97 now pending ratification by the MCGB. About 75% of the budget allocation is spent in payment of salaries to the staff. Substantial amount is spent on collection of waste from the source of generation and its transportation to dumping sites. Practically nothing is provided in the budget for proper management of waste at the dumping sites that could reduce or control the environmental pollution.

The MCGB does not levy any charge to the citizens for the services rendered and the total expenditure of the SWM Department is debited to the MCGB's general revenue account.

## COMPOSITION OF SOLID WASTE

Solid waste consists of a variety of substances such as biodegradable organic material, non-biodegradable inorganic inert material, recyclable material etc. depending on the source of generation. All these together constitute the solid waste that the SWM Department has to handle. Following are different sources where different types of waste are generated along with information on the procedure followed for specific waste collection and disposal.

**Medical Waste:** The waste generated in the hospitals, clinics, nursing homes, dispensaries and medical and research institutions, normally known as medical waste, are infectious, hazardous, radio active and normally include glass, plastics, medicine remnants as well as materials like human tissues, blood, soiled bandages etc. A number of the municipal and government hospitals as well as some private hospitals have incineration plants for incinerating tissues, blood etc. however many of the plants do not function. Official monitoring on the incinerators is non-existent. It would be safe to assume that resorting to incineration of medical waste is not extensively practised. The SWM Department collects medical waste from public hospitals whenever incineration plants are non-functional while medical waste from private hospitals and hundreds of private nursing homes as well as private and public dispensaries find their way to the nearby municipal general purpose waste bins or to the heaps located on public areas to be lifted by municipal vehicles for dumping in the dumping site along with other components of waste. Collection of medical waste by the SWM Department comes to 37.7 tons a day while data on waste generated in private hospitals and dispensaries and thrown away in the nearby community bins or on the streets is not available. On the whole whatever is not incinerated goes to the dumping sites and lie mixed up with other components of waste dumped at the site.

None of the health care centres of Mumbai uses autoclaving of the medical waste prior to final disposal to our knowledge. At present no norms or guide lines exist for monitoring or controlling the disposal of medical waste exist hence one of the most serious source for the spread of ill health and diseases is allowed free hand by the government and municipal health care administration in Mumbai.

**Household**: More than 50% of the municipal solid waste originates from households in which biodegradable organic waste generated in the kitchen forms a major component. Municipal authorities claim that community bins cover more than 90% of the population by which the authorities would like the citizens to believe that the municipal services cover the bulk of Mumbai's households.

The MCGB provides different types of bins in Mumbai. The bins which serve as intermediate storage facility are located at designated spots where the collected waste is deposited by the municipal road sweeping staff for onward transportation to transfer stations or dumping sites in the municipal refuse vehicles. Citizens in the neighbourhood are required to empty their own waste in such bins however this rarely happens. Waste is thrown away in the nearest public premises or in the compound which needs to be collected by the municipal sweepers.

Solid waste storage facilities are provided in the form of following types of refuse bins:

Square bins
Rectangular bins
Masonry bins
Cylindrical reinforced concrete bins
Container bins of 4.5, 1 and 0.2 cum capacity

In the City Zone, intermediate storage facility is in the form of movable storage containers and large enclosures with roof known as 'sheds'. In the suburbs, cylindrical concrete bins and masonry bins are usually provided as waste storage facility. Movable containers are occasionally used. Major proportion of the waste is collected through intermediate storage facility which requires the residents to deposit their waste in the bins placed at designated locations.

House to house collection system is applied in certain areas where the residents deposit their waste in the masonry containers located within their properties. Municipal workers lift the waste from the other side of masonry containers and deposit them in the trucks. Such facility serves only 8.61% of the population.

Certain residential areas have "Bell Ringing System" wherein the refuse vehicle arrives at specific locations and on ringing of the bell, residents bring the waste from their homes to empty into the refuse vehicle. In the area covered by Bell Ringing System, community bins or containers are not provided as the house holders are required to deposit the waste directly in the trucks. Such areas by contrast present a cleaner look compared to areas where house to house collection service and community bins are provided at specified locations. In the old parts of the city and in the slum areas householders are accustomed to throwing their waste at public places and the same remain unattended for days.

Collection of debri material thrown by the property owners and residents on the streets is lifted and transported to dumping sites by a separate set of heavy duty vehicles. Waste from all sources is collected, transported and emptied at the dumping sites without segregation, resulting in the mix up of all components of waste.

**Hotels and Eating Houses:** The waste usually consists of biodegradable organic kitchen waste and food remnants as well as small proportion of recyclables like plastic and paper. Eating houses deposit their waste in the nearest community bins or empty in convenient public places. The MCGB collects the waste from hotels and eating houses in the two municipal wards- A and H -for which a special vehicle is allocated for the purpose. It is observed that small and large hotels and eating houses, roadside juice extractors, snack vendors leave their day's waste at the place it is generated or throw at the nearest corner. As the municipal collecting practice is restricted to two wards only, one can surmise that majority of hotels and eating houses of Mumbai are left to disposing off their waste in a manner most convenient to them.

**Markets:** There are in all 86 markets in Mumbai of which 7 are wholesale and the remaining are retail markets. The waste collected from markets is transported directly to the dumping sites. The 73.14 tons of waste generated daily in wholesale markets is handled independent of the SWM Department by the Ward Officer (Markets) who arranges for collection and

transportation to an assigned dumping site. With the implementation of the public policy of decongesting south Mumbai and consequently shifting wholesale trading in vegetable activities from Jyotiba Phule Mandai and Byculla markets on Lokmanya Tilak and Dr Ambedkar Roads respectively, the quantity of waste generated in the wholesale markets is on decline and would be reduced drastically in near future. The waste from the retail markets and by pavement vendors is handled by the SWM Department like any other waste.

**Beach waste:** All the seven beaches of Mumbai are provided with municipal service for waste collection. Special community bins are provided on these beaches from where the waste is transferred into small sized containers to be drawn by tractors. The tractors bring the waste at a central location from where it is transferred to municipal vehicles for transporting to the dumping site. Quantum of waste collected from beaches is 11.4 tons per day. A private organisation run by Mr George Gopali has taken up the responsibility of collecting the waste generated on the Juhu beach and maintaining it clean. The MCGB has allotted him three ho. rdings in the area, the income from which pays for the salaries of the staff employed by him to clean the beach. The waste hand picked by the staff from the Juhu sands is lifted by the municipal trucks. Such innovative activity involving citizen participation has resulted in the quantum improvement in the cleanliness at the Juhu beach.

**Animal Waste:** A number of cattle stables exist in the Eastern and Western Suburbs of Mumbai which create serious waste and dung disposal problem. Stable owners deliver a portion of the dung in raw condition to enthusiastic gardeners. Many of the stables are located in out of way places where normal sized heavy duty vehicles cannot reach hence dung remain unattended for months together. In the monsoons, heaps of dung flow on to the roads choking the rain water drains. Out of the 11.5 tons of dung generated every day, only a negligible portion is turned into and used as compost. Use of raw dung in gardening and heaps of unlifted dung create serious environmental and health problems.

**Dead Animals:** Existence of a large number of animals in Mumbai accounts for death of many animals as well. Animal owners discard dead animals in public areas creating serious environmental and health problems. Khadi and Village Industries Commission, a Government of India undertaking for revival of khadi and village industries, promotes the recycling of animal skin and fat. 'Kora Kendra', a department of the KVIC, is licensed to lift dead animals and to put the parts of dead animals to economic use. Footwears and safety equipment are some uses to which the animal skin is put to while gelatine is used in the industry. Though this recycling is fairly well accepted, one can see dead animals lying unattended on the roadside off and on.

**Street Sweepings:** City streets need to be cleaned regularly. In some areas street sweeping is done daily on a regular basis while many streets are never swept or cleaned. Sweeping is carried out by pairs of workers each pair comprising of a male and a female sweeper. The female sweeper sweeps the street, using long handled broom and forms heaps of the swept material at specific spots. The male sweeper then collects the heaps of material in a handcart having 2 cane baskets of 0.05 cum. capacity each and carries to the community waste containers lying at designated spots. Area allotted to the pair for sweeping varies between 3000-5000 sq. metres in the city area and 5000-8000 sq. metres in the suburb area. Sweepers normally sweep the hedge between the carriageway and the pavement assuming that

the dust and waste on the carriageways would fly off with the moving vehicles. The work of 10 to 12 workers is supervised by a Mukadam and that of 4 to 5 Mukadams is supervised by a Junior Overseer. The Assistant Head Supervisor, operating under the administrative control of the Ward Officer, is in charge of the staff attached to his ward for carrying out the solid waste disposal work.

The sweeping staff works for seven hours from 6.30 am onwards with half an hour break at 10.30 am. Their duties are suitably staggered to make the sweeping service available on all the days of the week. The sweeping staff report for duty at reporting chowkies in the respective Ward where brooms, baskets, handcarts and other implements are also stored.

**Debri:** Debri or inert construction material is generated in locations where repairs and reconstruction work are carried out. Property owners or the residents carrying out repairs in their property or premises are responsible for the disposal of the debri at the designated dumping sites. However they hardly take that care. Debri is invariably deposited on the streets and especially on pavements creating movement problems for the citizens. The MCGB is left to carry out the removal operations. Quite often heaps of debri remain on public streets for indefinite period. Silt removed from underground drains kept on the streets to dry out gets mixed up with debri and other daily refuse. Thus the debri almost invariably gets mucked up with the other waste aggravating the problem in public areas. Though the SWM Department maintains a separate service for lifting of debri independent of other waste, the debri and waste end up in dumping at the same dumping sites. Classic observation is that two types of segregated waste transported independently of eachother are mixed up at the dumping sites. The SWM officers use the debri for spreading over freshly dumped organic waste thus compounding the problem. In fact the sweet soil is required to be spread over the emptied fresh organic waste for removing stench. Debri material brought to the dumping site comes handy to the SWM officials to spread instead of the sweet soil. The object of covering up the waste to avoid unhealthy conditions is defeated in the process while uncontrolled decomposition results in generation of gases that fuel the fire at the dumping sites.

**Abattoir Waste:** Waste from the municipal abattoir is transported directly to the dumping site for indiscriminate dumping after skin, bones, tissues etc. are retrieved for converting into marketable products. A very small quantity of waste is turned into manure. Illegal butchering of animals carried out on an extensive scale in public areas results in dumping of remnants in public places and such remnants remain unattended creating unhealthy conditions and environmental pollution. Illegal butchering and remnants of the butchered animals lying on public premises is a common sight in the sprawling slum areas.

**Quantity of Solid Waste:** The total quantity of waste generated in Mumbai daily comes to around 5000 tons, which includes household waste and debri. Of this, organic waste accounts for 3000 tons while 1800 tons is debri and the remaining 200 tons is recyclables. The per day per capita waste generation comes to about 400 grams after the waste generated by industries is properly accounted for. Details on constituents of solid waste follow:

**Components of Solid Waste: Quantity and Source**

| Constituent | Quantity | Composition and Source |
|---|---|---|
| Biodegradable organic waste | 3000 tons | households, hotels, eating houses, vegetable markets, abattoirs, roadside slaughter |
| Recyclables | 200 tons | paper, plastic material, rubber, glass, metal |
| Debri | 1800 tons | building and construction material |

**Zonewise Physical Composition of Solid Waste**

| Constituent | City | Eastern Suburbs | Western Suburbs |
|---|---|---|---|
| Biodegradable | 42.29 | 35.72 | 39.52 |
| Paper | 6.16 | 10.93 | 6.61 |
| Plastic | 4.23 | 4.87 | 5.47 |
| Metal | 0.85 | 0.65 | 1.42 |
| Glass and Crockery | 1.28 | 0.87 | 3.48 |
| Bioresistant* | 4.15 | 11.81 | 11.07 |
| Inert and others | 41.09 | 35.20 | 32.43 |
| Total | 100 | 100 | 100 |

*includes leather, rubber, bones and synthetic material

## TRANSPORTATION OF SOLID WASTE

Solid waste is transported by conventional trucks or dumpers (5 cum), compactor vehicles (1 cum), dumper placers (4.5 cum) and tipping type vehicles (5 cum). As the MCGB does not have adequate number of transport vehicles for transporting the entire quantity of waste generated, the SWM Department hires vehicles from private contractors.

The average expenditure per trip for a municipal vehicle comes to Rs. 502 while private contractors are paid Rs. 560 for every trip. The average total cost per trip including the salaries of municipal staff is around Rs.1385 and Rs.1165 for municipal and private vehicles respectively.

Vehicles used by the SWM Department.
Hand cart - 1 cum. container and 4.5 cum. container for collection
Compactor vehicle, Dumper placer, Bulk refuse carrier for transport
Dumper, Tractor trailer, Bull dozer, Landfill compactor, Fire fighting tanker at dumping sites.

The waste is transported to dumping sites by vehicles which normally operate in two shifts, the morning shift between 6.00 am and 2.00 pm and the evening shift between 2.00 pm and 10.00 pm. Occasionally a third shift operates between 10.00 pm to 6.00 am.

Municipal vehicles and drivers are under the control of the Transport Wing while the loading staff is provided by the Conservancy Wing. Every vehicle initially reports at the check post in the ward where it is assigned the area to be served. After collecting the waste from the assigned route the vehicle reports back at the check post, where the extent to which the vehicle has been loaded is recorded. The vehicle then proceeds to the assigned dumping site or to a transfer station, where again the quantum of filling is recorded. The number of municipal vehicles is 261. Hired private vehicles make on an average 542 trips for transport of debri and 398 trips for transport of refuse. A filling of 11.32 cu m of waste in a truck is treated as a full load and accordingly the payment is made for the trip. The contractor provides the vehicle along with the driver and fuel, while the MCGB provides six labourers and a mukadam on every vehicle.

Tipping and non-tipping type general purpose trucks are provided by the contractors on a two year contract basis. A multiplicity of municipal vehicles, comprising of general purpose tipping as well as non-tipping type trucks, dumper placers and compactor vehicles with following loading capacity are used for transporting the waste.

| | |
|---|---|
| Municipal trucks | 5 tons |
| Contractor vehicles | 2.5-5 tons |
| TDP( Tata Dumper Placer) | 1 ton |
| Compactors | 5- 6 tons |

Some vehicles carry the waste directly to the dumping site while others carry to one of the two transfer stations where the waste is transferred to other types of vehicles for onward carriage to

the dumping site. Large trailers of different capacities are used to transport the waste from transfer stations to respective dumping sites. Front end loaders are used for loading of the refuse vehicles.

**Transfer stations:** There are two transfer stations, one located at Mahalaxmi and the other at Kurla where waste transported from collecting points is transferred to other vehicles for onward transportation to the dumping sites. Municipal vehicles transporting waste from south Mumbai arrive at the Mahalaxmi transfer station and discharge their contents directly into the bulk refuse carriers. The latter then transport the waste to the dumping site. Normally dumper placers are received here during all the three shifts. A few truck trips of sewage silt and offal waste are also received at this site. Occasionally dumpers bring the waste to this transfer station.

The Kurla transfer station is a single level site where incoming waste brought by municipal vehicles is unloaded on the ground and thereafter loaded into contractors vehicles for transport to the disposal site. The transfer is carried out by using front end loaders. The transfer station is unfenced and surrounded by slums. Everyday 120 and 35 vehicles visit Mahalaxmi and Kurla transfer station respectively.

**DUMPING SITES**

In order to dump the waste, the MCGB has at present 4 landfill sites namely Deonar and Mulund in the eastern suburbs and Malad and Gorai in the western suburbs. These sites were originally creeks and swampy areas which are getting reclaimed and filled up through continuous dumping. Slums have come up on the areas thus reclaimed with slum dwellers engaged in the ragpicking at the dumping sites. With this, have come the traders who provide to the slum communities with their basic necessities and who buy the retrieved recyclables from the dumped waste. In fact, slum sprawl is widespread such that slum households are practically touching the existing municipal check points meant for entry of the vehicles into the dumping sites. A check post is provided at the entrance of each dumping site, where the details of the arriving vehicles are recorded. The site staff is supposed to direct and monitor the emptying operations of the incoming vehicles however it can hardly cope up with the large number of vehicles laden with waste arriving at the site.

No specific supervision is provided to the actual waste dumping operations. The waste unloaded from trucks is supposed to be levelled by bulldozer provided at each of the site. Quite often bulldozers allocated to the dumping sites are out of order hence the emptied waste remains in the condition it was emptied. There is no provision for occasional spreading of sweet soil over the dumped waste. In fact sweet soil is non-existent at the dumping sites. Debri brought to the dumping site normally lies in heaps far away from the area of actual dumping. Debri consisting of large sized building materials can hardly provide the protective cover to the waste emptied earlier. Dumping sites are not securely fenced. In fact, they are totally open providing free access to rag pickers who are found on the dumping grounds in large numbers retrieving the recyclable substances. Cows and buffaloes also found roaming in large numbers at the sites feed on the food remnants and cellulose provided by crumpled and soiled newsprint and cardboard boxes. It is to be wondered as to where milk drawn from these milch animals is consumed.

**Deonar site:** The Deonar site is the largest having an area of 800 ha initially out of which 111 ha are now left for dumping. This site receives waste round the clock during all the three shifts. Located to the north of Chembur and Deonar it is approachable from the road connecting the Eastern Express Highway and Mumbai Pune Road.

After checking at the entrance check post the vehicles are directed for unloading to one of the 4 loops. Two of these are used during the monsoons while the other two during the remaining period of the year. While the waste is unloaded in three shifts, bulldozers operate during the first and second shifts and that too inadequately. The Deonar dumping site receives waste brought by municipal and private trucks from the eastern suburbs as well as from the Mumbai Port Trust, Navy Installations and non-toxic industrial waste possessing the necessary permit. As no system for controlling or checking the composition of the waste unloaded exists, there is no way to know as to what is being dumped. In case any excavation is involved, it is carried out with the help of dumper cum excavator provided at the site.

A part of the site known as Shivaji Nagar receives the waste brought in by compactors. It has a separate approach as well as an independent check post. Broken down asphalt roads with innumerable potholes connect both the Deonar and Shivaji Nagar entrance check posts to the crowded thoroughfare passing through slum communities. Drainage channels provided on either side of the internal roads within the dumping areas drain out to the creeklet near the entrance side of the site. Near the entrance check post on the outer periphery of the site is a pond whose overflow crosses the road through a pipe line emptying into the creek. The site is surrounded by a creek on two sides and the depth of filling is upto 9 metres.

The site has a staff of 82 persons supervised by an AHS working under the overall control of the Dy.HS Eastern Suburbs. As the site is open and surrounded by slum dwellers a large number of ragpickers retrieve recyclables from the dumped waste.

**Mulund site:** Abutting the boundary of Greater Mumbai on the North East and adjacent to the Eastern Express Highway and spread over an area of 25.2 ha is the Mulund dumping site receiving waste from the Eastern Suburbs. Loaded vehicles reporting at the entrance checkpost are directed to deposit waste at specific locations. Nine persons work at this site under the control of AHS, Deonar. The municipal as well as private vehicles from the S and T wards deposit the refuse and debris here. The site is operated in two shifts. The deposited waste is levelled by a bulldozer. Rag pickers retrieve recyclables from the unfenced site. Animals roam about unhindered searching for stale food bits and news paper to be eaten to fill up the belly. No control on the entry of the site is exercised. A rivulet passes through the dumping site with a number of deep ponds formed in between. These ponds holding leachates from the waste come handy for the rag pickers to be used as swimming pools with high jumping facility.

**Gorai site:** Located on the extreme north-west side of Mumbai about 4.5 kms away from the Western Express Highway is the Gorai dumping site having an area of 14.50 ha. A staff of 9 persons provided at the site work under the AHS working under the overall control of Dy. HS Western Suburbs. It is a marshy land receiving waste from the R/N and R/S wards. The bulldozer provided for levelling the emptied waste gives service whenever it is in operational condition.

**Malad site:** Located on the western side of Mumbai is the Malad dumping site stretching 19.22 ha. A staff of 16 persons works under the AHS (dumping) P/N ward who in turn works under the Dy.HS (western suburbs). The refuse and debri from western suburbs H/W, H/E, K/W, K/E, P/S and P/N wards are deposited by the municipal as well as private vehicles. A bulldozer is provided to level the waste. The site is operated in two shifts. Loaded vehicles report at the check post.

## ROLE OF RAG PICKERS IN SOLID WASTE MANAGEMENT

The waste pickers, or rag pickers as they are often called, play an intrinsic role in the handling of solid waste. They help in segregation of waste in the sense that they can and do pick up the recyclable components from the waste at different stages during the journey of waste from the source of generation to the dumping sites. This intervention helps in reducing the quantity of waste to be transported to and/or handled at the dumping sites in addition to enabling the recyclables to be reused by the community thus avoiding overexploitation of the natural resources. Their positive contribution in the management of solid waste is not recognised by the community and the authorities alike and they are consequently blamed for the unhealthy conditions prevailing in the city. Having not been integrated in the municipal solid waste disposal programme, they are maligned and blamed for the pollution prevailing in the city and in the dumping sites. They have become the target of the MCGB programme of punishing the erring citizens since the launching of the Cleanliness and Zero Garbage Programmes by the MCGB in January 1997. The MCGB has claimed in an affidavit in a court case before the Supreme Court that constant fining of rag pickers in the Dumping Sites has been very effective in controlling the activities of the rag pickers in the Dumping Sites. For rag pickers, picking the rags from the stinking waste is so critical for their survival that they cannot refrain from rag picking even after being fined and harassed frequently. Neither the authorities nor the citizens have realised as to how worse would have been the conditions in Mumbai if picking of rags was not carried out from the waste bins in the city and at the dumping sites. Dumping of recyclables together with biodegradables causes irreparable damage to the environment and public health.

The rag pickers retrieve substances that interest them from the heaps of waste. They are therefore selective in their approach and pick up only one type of recyclable from the waste. There are different categories of rag pickers like plastic retrievers, paper retrievers, glass retrievers and so on. Rag pickers are to be found everywhere. They are seen collecting items of interest from the bins, from the streets, public places, private properties and all imaginable locations in addition to the dumping sites.

No count of citizens engaged in rag picking in Mumbai appears to have been taken. One estimate indicated that rag pickers number about 40,000 with women constituting about 52% of the lot and the balance equally divided amongst children and men. In a recent workshop, Dr Sneha Palnitkar, Director, All India Institute of Local Self Government disclosed that during the course of the working of a project that her Institute is carrying out in cooperation with Stree Mukti Sanghatana they observed a figure of 125,000 to 150,000 to be nearer to the reality. Taking a family unit of five, the number of citizens depending on rag picking would come to 625,000 to 750,000 forming 5 to 6 % of Mumbai's estimated population of 12 million. Obviously rag picking attracts all types of people those totally or partially unemployed, school drop outs and what not. A child of the poor becomes a rag picker as soon as his family pushes him onto this activity for augmenting the family income.

Rag pickers retrieve paper, plastics, rags, metals and everything that possesses intrinsic value and sell the retrieved material to the primary rag dealers. The material is cleaned and assorted and is put to use either straightaway or after conversion. Child ragpickers usually collect paper and plastic while the men concentrate more on getting metal, glass etc. which fetches higher returns. Women usually collect plastic, paper and also glass and metal sometimes. Women earn about Rs.500 per month, while men earn a little higher about Rs.725 per month. Between 10 to 15 kg material is collected on an average daily by a rag picker. Rag pickers are condemned to working and living under very harsh and filthy conditions even though they render an invaluable service to the community in the form of conservation of natural resources and reduction in the quantity of waste to be transported and/or dealt with at the dumping sites.

## MCGB'S EXISTING PROCESSING OF ORGANIC SOLID WASTE

A number of processes have been applied for treating solid waste generated in Greater Mumbai in addition to the usual dumping at the four dumping sites.

**Composting:** In 1979 a mechanised composting plant of 300 tons per day input capacity was set up on a 4 ha. land adjacent to the Deonar dumping site as a joint venture of the MCGB, Maharashtra Agro Industries Corporation and Fertiplant Limited. However, the plant was closed down due to the absence of buyers of compost resulting from unrealistic marketing policy. The process involved aerobic composting in windrows after separating inorganics with the help of magnetic separators, followed by mixing in a homogeniser after size reduction in a rasper. The windrows were turned by an auger mechanism for aeration and additional diffused aeration was also provided. The capital cost for the plant was Rs.14.5 million and the operating cost Rs.300 per ton. The main reasons for its failure were over mechanisation, use of redundant units, unrealistic market policy and absence of demand for the product at the unrealistic sale price fixed by the enterprise.

**Composting plant of Excel Industries Limited:** Excel Industries Limited started working in the processing of organic solid waste for which a semimechanised pilot plant was developed. The plant processed 20 tons of market waste per day. The process involves stacking of the waste in different layers in windrows to which a microbial slurry is added. Turning of the windrow for aeration is carried out after three weeks by using front end loaders. After six weeks the stabilised material is passed over a vibratory screen and air separation unit to separate the inorganics and light materials. The process provided about 25-33% of the input as compost which is found to be beneficial in agricultural operations.

Finding the Excel process of converting the biodegradable component of solid waste into compost as satisfactory, the MCGB has allotted to Excel Industries 6 hectare of land in the Malad dumping site for processing upto 500 tons per day of solid organic waste to produce 160 tons of compost a day. The capital investment is expected to be Rs. 38 million while operating cost is estimated to be Rs.1000 per ton. The compost is expected to be sold at Rs.1300 per ton. Though the plant has been commissioned since November 1993, it presently handles only about 200 tons of waste per day because of shortage in supply.

**Refuse Derived Fuel Pelletisation Plant:** The Department of Science and Technology, Government of India has set up in 1991 a plant to process 200 tons of solid waste into 80 tons per day of fuel pellets at a capital cost of Rs 20 million on a municipal land admeasuring 0.4 ha given free of charge for the purpose. The plant has a connected load of 500 kW. The process involves the reduction of moisture through sun drying, removal of sand, silt and soil by screening, air separation of combustibles, followed by drying using hot gases, removal of metals, addition of binders and its conversion to pellets for use as fuel. The plant was supposed to employ 95 workers. The cost of production and sale price of the pellets were expected to be Rs.1000 and Rs.1200 per ton respectively. Fuel pellets need to have a minimum calorific value to ignite and to be used as fuel. A calorific value of 3500-4000 kcal/kg would be considered as minimum for burning. Though commissioned in 1991, the plant operates at a reduced capacity processing 50-80 tons of waste per day. It is understood that

studies on the burning of organic waste as fuel and on the impact on the environment and public health of burning large quantity of pellets made out of organic waste are not carried out by the promoters. They now realise that the plant is not economically viable and feel that considerable subsidy may have to be extended for a long time for marketing the product as fuel.

**MCGB'S Vermiculture Plant:** After being convinced on the viability of the vermiculture biotechnology the MCGB has set up on 20 hectare of land in the Deonar dumping site a project to convert biodegradable waste by using the vermiculture process developed by Dr H S Shankar at the Indian Institute of Technology (IIT), Mumbai. The plant has the capacity of turning 400 tons per day of organic waste into 140 tons of soil conditioner. The project involves a capital investment of Rs. 5.15 million on land development, civil works and for the first supply of earthworm culture while the running costs are estimated to be Rs.11 million in the first year rising progressively to Rs.15.9 million in the third year. Labour requirements are worked out at 50 in the beginning going upto 100 when full capacity is achieved. The cost of production is estimated to be Rs.800 per ton, when organic waste is offloaded directly at the site. The soil conditioner could be sold at a wholesale price of Rs.2000 per ton against a prevailing market price of Rs.4000 per ton. The payback period is anticipated at 4 years. The production started in 1994 and it is expected to reach the full capacity of 50,000 tons of soil conditioner in the third year.

While top municipal officers are satisfied with the highly viable environment friendly project and have declared their desire to extend the capacity to cover the entire quantity of biodegradable organic waste generated in Mumbai, enquiries show that only a fraction of the capital amount sanctioned for the programme is invested uptill now and even the basic facilities are not provided. Other difficulties like non-supply of adequate labour, labour unrest, non-supply of biodegradable waste and non-availability of water have now resulted in the closing down of the facility with the killing of the micro-organisms and culture. A study of the working at the site convinces the visitor that the vermiculture technology could become most appropriate for satisfactory treatment of biodegradable waste and in that way avoiding the dumping of such waste which can create environmental problems. Vermicompost coming out of the process has for the first time created greenery in the dumping site itself. Initial quantity of vermiculture harvested before the closure of the facility was delivered to the Superintendent of Gardens of the MCGB for use as soil conditioner in Mumbai's public gardens. However on enquiry, it is understood that the MCGB has not cared to apply the culture to the soil and is packed in jute bags and stacked. The culture has been lost for ever in the process.

**Mining of stabilised material:** Stabilised organic matter is screened at the Deonar dumping site out of which one truck load daily is lifted daily by an agency on the payment of Rs 100 per truck to the MCGB. The material is composted after adding cowdung to the extent of 8-10% of the gross waste. Certain additives are added to the composted material and then the product is marketed for use in the farming operations. The end product -compost- containing 8-10% moisture content is sold at the rate of Rs.115 per bag of 40 kg or Rs 2875 a ton. The recommended rate of application is one ton per ha for cultivation of sugar cane and sapota.

## SOLID WASTE PROCESSING PROJECTS

Many organic waste processing programmes are functioning in different centres. A Mumbai based business house named Excel Industries Limited has set up a plant for treating daily 500 tons of organic waste received from the MCGB into organic manure. Conversion is accomplished through aerobic process using microbial culture.

Similarly a number of projects operate in Pune, an urban centre having a population of 1.8 million located about 180 km from Mumbai. A project initiated by Dr. S.V.Mapuskar is set up for conversion of market waste generated in Pune's Gultekdi vegetable market. The vegetable waste is treated anaerobically liberating in the process gas directly to be used as fuel. The residue that is left is used as an organic manure.

Mr. Uday Bhawalkar has developed in Pune vermiculture biotechnology which utilises deep burrowing species for the conversion of solid and liquid organic waste. Dr Mrs Hemangi Jambhekar also of Pune converts organic waste with the help of imported species of earthworms which are essentially surface dwellers. These programmes utilise earthworms and micro-organisms to convert the organic biodegradable waste into vermicompost or popularly known as soil conditioner. The end products are extensively used in diverse farming operations for different types of crops. Producers extend comprehensive advice to farmers on the use of vermicompost in cultivation of crops, vegetables and fruits as well as help in setting up vermiculture facility on the farms.

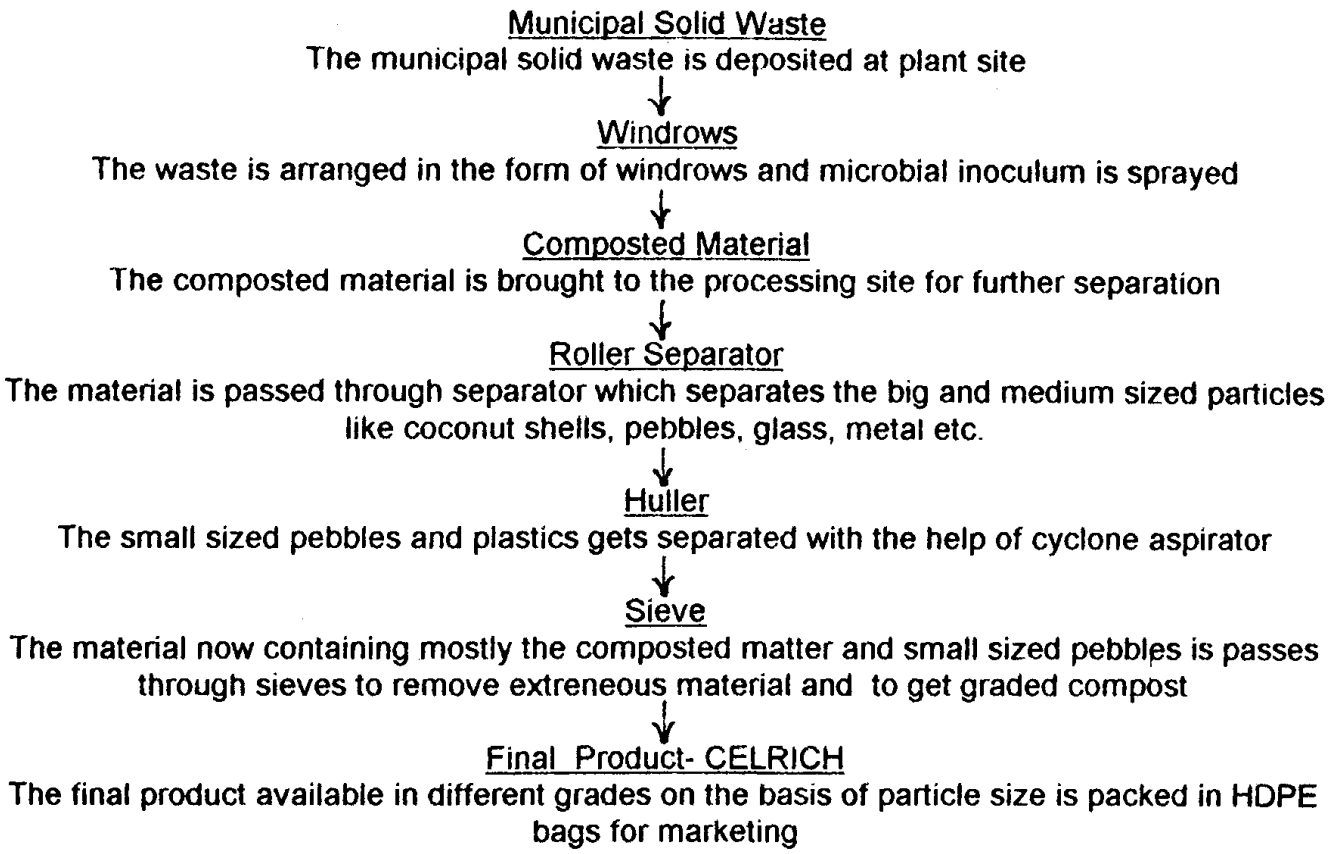
These programmes are known to be operating successfully and acceptance of their efficacy is growing in the community. They are effective only on biodegradable organic waste hence it is essential that inorganic substances like plastics, rubber, leather etc. are not subjected to these processes. In fact, their presence affects and delays the process of decomposition of biodegradable waste. Solid waste kept in the mixed condition as at present, be it in a city or a village, creates problems just because there is nothing that one can do to put back such hotch-potch of divergent substances into environmental cycle. A number of processes have shown as to how organic waste if properly handled can deliver an environmentally safe and valuable product that can help the soil to grow high quality food and fibre in optimum quantity. Other synthetic materials if properly segregated and recycled can further ensure appropriate disposal of waste while ensuring conservation of scarce natural resources.

## SOLID WASTE PROCESSING PLANT OF EXCEL INDUSTRIES

Excel Industries Limited has established at Chincholi within the Malad dumping site a plant for processing municipal organic waste generated in the western suburbs from Andheri to Borivali of Mumbai and normally brought to the Malad dumping site. The project has been set up in 1993 to process 500 tons of organic waste daily using microbial process which turns the organic waste into humus rich compost compound within 45 days. .

Though the installed capacity is for handling 500 tons of waste per day, the plant has been converting about 200 tons only since the inception. Organic waste comprising mainly of market and kitchen waste generated in households, hotels, restaurants and eating houses is

FIGURE III




FLOW CHART SHOWING EXCEL INDUSTRIES AEROBIC COMPOSTING PROCESS FOR CONVERTING ORGANIC SOLID WASTE

being processed. The waste delivered is not sorted and contains other recyclable materials like plastics, metal, glass etc. After the waste is unloaded, rag pickers retrieve recyclable items on a selective basis leaving behind a number of other recyclables which are not taken out before processing. Tender coconut shells received in large numbers do not decompose quickly hence though organic they are removed from the mixed material having moisture content of 50-60 % initially.

Waste delivered through compactors is emptied on the ground and is then formed into windrows with the help of mechanised handling equipment. About 2 ha is required for processing 100 tons of material which comes to about 200 cu. m in volume. Windrow dimensions are not pre-determined except that the height is maintained at 2.5 m. The length and width depends on the space available. The size of the windrows in no way affects the process.

Formed windrows are inoculated with a microbial culture known as innoculum at the rate of one kg per ton of organic waste. Animal dung is added to the innoculum to form into a slurry which is sprayed on the heaps as well as injected inside. Beneficial micro-organisms in the innoculum generate exothermic heat which kills or repels insects, pathogens, parasites etc. The direct effect of the spray is the removal of obnoxious odour within a couple of hours of spray. Microbes start their activity resulting in raising of the temperature to 60-70 degree Celsius in 3 to 4 days. The temperature remains at that level for 10 to 15 days and then starts declining to the ambient level. Being an aerobic process, occasional turning of the waste is needed for ensuring proper aeration.. To achieve this objective, large chunks from the formed heaps are transferred to a new site, resulting in upturning of the entire volume. Shifting of the waste is organised twice or thrice at an interval of 10-15 days.

At the end of 45 days samples from the heap are sent for analysis to check whether the waste is properly converted into compost. If the conversion is adequately accomplished, the processed material is transported to another site for separating of recyclables and coconut shells with the help of a fully mechanised process.

Processed material is transferred with the help of excavator cum loader for emptying into the tray feeder to reach the rotary separator. The volume of the material reduces to half the original with moisture reducing to 20-30 %. Two separators, one with a screen having a mesh size of 25 mm and another with 12 mm are used. When passed through the first separator, items having size larger than 25 mm like coconut shells are left behind while the second separator allows material having size smaller than 12mm to pass through it. The sieved material is then carried by bucket elevator into hoppers and then into huller where the lighter material like plastic, fibre etc. and heavy particles like stones, metal, glass etc. get separated. The composted material still containing small stones and recyclables like glass, plastics, metal etc. is then transferred to the main unit for sieving through electrically operated sieves resulting in the removal of small sized stones and recyclables. Small stones are used for landfilling, landscaping etc. while recyclables go for conversion. The final product is then packed in 50, 25, and 1 kg polybags and sold as compost under the brand name of CELRICH.

**Analysis of Celrich**

A. Physical

Appearance - dark brown rich humus like coarse material free of foul smell, live weed seeds etc.
Direct manurial value about 4 to 6 times higher than normal farm yard manure.
High contribution to crop by free living nitrogen fixing organisms and phosphorous solubilisers.

B. Chemical

| | |
|---|---|
| pH | 7.0 - 8.2 |
| Organic carbon % | 16.0 |
| Nitrogen % | 1.50-2.00 |
| Phosphorus % | 1.25 |
| Potassium % | 1.05 |
| Calcium % | 2.00 |
| Magnesium % | 0.70 |
| Sulphates % | 0.50 |
| Iron % | 1.00 |
| Zinc ppm | 250-700 |
| Manganese ppm | 200-700 |
| Copper ppm | 100-300 |
| Cobalt, Boron and Molybdenum | all present |

C.Biological

| | |
|---|---|
| Nitrobactor/gm | $10^{2}$ |
| Actinomycetes/gm | $10^{4}$ |
| Root nodule bacteria/gm | $10^{4}$ |
| Fungi/gm | $10^{6}$ |
| Azatobactor/gm | $10^{6}$ |
| Phosphate solubilisers/g | $10^{6}$ |
| Total Bactor count /g | $10^{10}$ |

The MCGB has provided land and other services like electricity, water and other minor supplies required for the process and agreed to deliver the mixed waste at the site. Royalty to municipality is fixed at 15 % on the sale price in the form of the processed material for their

gardens. Manual labour requirements are comparatively low for the production programme however technicians are required to monitor the process and to operate the plant.

**Comparison of Celrich with farm yard manure(FYM)**

( values based on the dosage of 2.5 tons per ha)

| Contents | Celrich kgs/ha | FYM kgs/ha |
|---|---|---|
| Direct Nitrogen | 35 | 12.5 |
| Indirect Nitrogen | 45 | quantity unknown |
| Phosphorous | 30 | 10 |
| Potassium | 25 | 12.5 |
| Trace elements | present | present |

**Cost estimate for 1000, 500 and 50 tons per day capacity**

| Plant size Tons per day (TPD) | 1000 TPD | 500 TPD | 50 TPD |
|---|---|---|---|
| Project Feasibility Survey etc. | 3.5 | 2 | 0.5 |
| Site development and infrastructure | 24 | 12 | 1.5 |
| Plant machinery | | | |
| i. Defouling and waste treatment facilities | 10 | 5 | 1.0 |
| ii.Fermentation,aeration, material preparation | 12 | 6 | 1.5 |
| iii. Separation, grading | 16 | 8 | 1.5 |
| iv. Sieving, finishing | 6 | 3 | 1.0 |
| v. Blending, packing | 6 | 3 | 0.5 |
| Electrical and Operating expenses | 7 | 4 | 0.8 |
| Grand Total Rs. | 84.5 | 43 | 8.3 |

( in million rupees )

**VERMICULTURE ECOTECHNOLOGY by Mr Uday Bhawalkar**

The Bhawalkar Earthworm Research Institute (BERI) has done pioneering work in the harnessing of earthworms for conversion of organic solid waste and also of liquid waste. The vermiculture biotechnology, termed by the BERI as Vermiculture Ecotechnology, utilises the activity of earthworms and beneficial bacteria to convert organic waste into good quality biofertiliser. The species used is *Pheretima elongata,* a deep burrowing species. Earthworms 'cull' out pathogens and inefficient bacteria .by consuming them and promote the growth of selected effective strains of aerobic bacteria thus maintaining appropriate bacterial population. The process involves the conversion of organic waste into biofertiliser with the help of beneficial bacteria which act on organic waste. Earthworms produce balanced plant nutrients, vitamins, plant growth hormones and antibiotics from the organic waste.

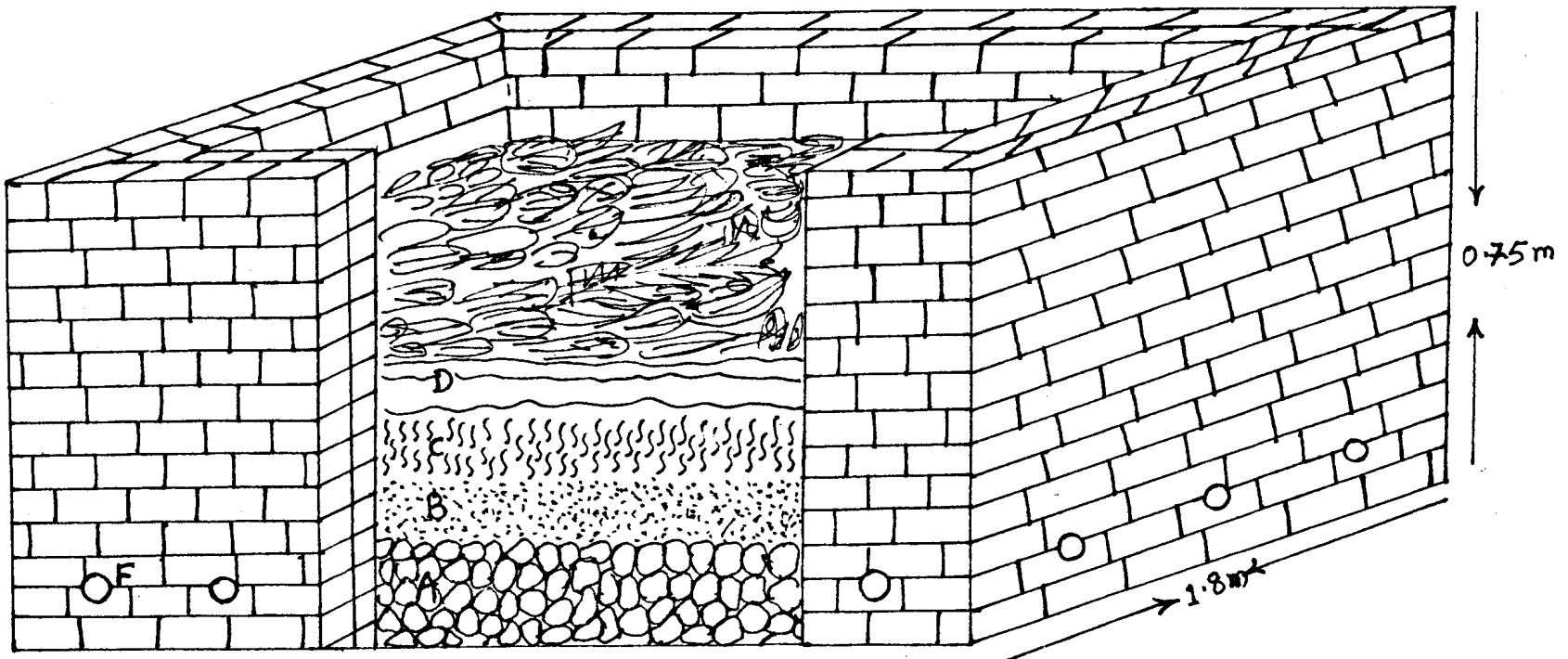
Converting organic waste by using vermiculture is comparatively a simple home-grown practice. Organic waste is fed into special brick masonry bins constructed at ground level with drainage holes for draining out excess water. In areas prone to waterlogging, bins need to be constructed on a raised base. Width of the bins is between 3 to 5 m to enable easy spreading of the waste. Length of the bins is decided to suit specific site conditions. The height of the bins is 0.75 m. Soil is invariably required to spread as bedding for the earthworms. Where the ground is hard rock, a bedding of soil is required. The construction of bins is carried out on normal foundations.

Vermiculture can be developed at an individual level and can also be adopted to process large quantities of waste. Processing of waste with the help of vermiculture can be achieved when an optimum quantity of waste is spread on a specified area. Establishing and maintaining vermiculture facility is comparatively easy, once the optimum requirements of temperature and moisture are ensured. Construction of bins is not a prerequisite however bins become necessary where confining the waste to a limited area is essential as well as to protect earthworms against rodents and animals. Construction of bins should take the site conditions into consideration.

To convert the waste generated in a family of five, a bin of 1 sq m base is adequate. A brick masonry structure is constructed at ground level having a height of about 0.75 m provided with drainage holes at the bottom. The base of the bin is filled with small sized stones for about 5 cm depth to be covered with a 3 cm thick layer of finely sieved soil. Vermiculture is spread at the rate of 5 kg per sq m on the base over which a 3 cm layer of fresh cowdung and a layer of green leaves about 7cm thick are spread. The bin is regularly watered to maintain moisture of about 50-60%.

Vermicasting is applied in the bins as seed stock. This is covered with cowdung to hasten the growth of earthworms and micro-organisms and to acclimatise the seed stock. Mulch material like farm residues or raw vegetable waste are initially used to cover the seed stock. Feeding of raw material like fruit and food remnants is started in small quantities after about 15 days and is slowly increased to attain full scale loading in about 3 to 4 months. The feed spread in thin layer gets converted to vermicasting within a period of 8 days in the form of thin layer not exceeding 1 to 2 millimetres. Mineral grit is spread on the waste material at the rate of 10-15%. The bin is regularly watered to maintain optimum moisture. Once the process is well established, the bins are regularly fed with organic waste and care is taken to see that the moisture is properly maintained. Overloading the bins with organic material affects the biodegradation process adversely. Bad odour is generated and flies proliferate in such a situation. To mitigate this condition feeding should be immediately stopped till the process is normalised. Stench and flies are indicators that the process is not going on well.

Earthworms farm the beneficial soil bacteria that produce the plant growth factors including diverse plant nutrients, vitamins, hormones etc. They farm bacteria because bacteria are their food. They consume the inferior strains of bacteria thus maintaining improved culture of beneficial soil bacteria. Earthworms weed out pathogens, nematodes and other undesirable microbes. They do not allow conditions that may permit proliferation of termites, white grubs and other insects. They function as biomanagers of the soil and ensure conversion of waste into a resource. They also achieve need based nitrogen production with the help of nitrogen fixing bacteria. Organics have about 50% biocarbon and act as fuel for these processes. The nutrient content of the organics which initially is very low improves significantly following the earthworm and micro-organism activity.




A Small stones 5cm thick layer
B Fine sieved soil 3cm " "
C Vermicasting 5kg/1sqm
D Fresh cowdung 3 cm thick layer
E Garden leaves 8 cm " "
F Drain holes

FIGURE IV

VERMICULTURE BIN DEVELOPED BY THE BHAWALKAR EARTHWORM RESEARCH INSTITUTE (BERI)

Earthworms grind rock particles to neutralise acids invariably produced during the decomposition process. Decomposition is faster at neutral pH. Faster weathering of rock particles takes place because of the acidity caused by organic decay. Otherwise, natural weathering due to rainwater (which has a low acidity) is quite a slow process. Earthworms can speed up the rate of soil formation 20 times faster than the natural process in the field. With the availability of waste organics in appropriate quantity, soil formation may go up by a factor of 7000. The grinding of rock particles releases diverse plant nutrients locked in them in the form easily assimilable by plants. Conventional composting, in contrast, is the burning of organics with compost becoming a sort of biological ash providing no food for earthworms and bacteria.

Vermiculture for the first time is harvested from the bins at the end of an year after commissioning. Subsequent harvestings can be obtained every 40 to 50 days thereafter. A part of the converted material is retained as bed material and the balance is harvested. The harvested material is sieved to separate out the undigested material which is returned to the bin and the vermicasting is packed for sale.

**Project cost estimate of a 5 ton/day capacity plant**

| Item | Quantity required | Rate | Amount Rs. |
|---|---|---|---|
| Fixed Capital | | | |
| Cost of land | 5000sq m area | Free/bought | -- |
| Construction of bins | 2500sq m area | @ Rs.250/sq.m | 6,25,000 |
| Construction of buildings, storagesheds | 50 sq m area | @ Rs. 2000/sq m | 1,00,000 |
| Site development (fence, roads etc) | | | 4,00,000 |
| Pump installation for supplying water | | | 33,000 |
| Bioseedstock, commissioning and training | for six months | | 8,25,000 |
| Recurring Cost | on 300 working | days a year basis | |
| Organic waste | 5 t/day | Free or at nominal rate | |
| Mineral grits | 1 t/day | @ Rs.100/t | 30,000 |
| Water | 25cum/day | @ Rs.7/cum | 52,500 |
| Electricity to run 5HPpump | | | 27,000 |
| Labour | 10 unskilled and | @ Rs.1500/m | 1,80,000 |
| | 1 supervisor | @ Rs.2500/m | 30,000 |
| Harvesting cost | | | 2,87,280 |
| Total Cost recurring+ fixed | | | 25,89,780 |
| Returns | | | |
| Vermicasting | 2.28 t/day | @ Rs.5000/t | 34,20,000 |

According to Mr Bhawalkar, conventional composting involves the activities of assorted bacteria and fungi on organic residues whereas in vermiculture, beneficial soil bacteria along with earthworms are involved as the prime workforce to process the organics. These are about ten times faster in their work when compared to the bacteria and fungi associated with the conventional composting practice. Moreover, beneficial micro-organisms are precisely selected by earthworms to produce the exact nutrient formula required by individual crops. Vermiculture, when practised in the vicinity of the growing plants, promotes synergistic activity between earthworms, plants and bacteria. This cannot be realised in conventional composting techniques.

If 100 kg of waste organics are processed through earthworms, about 300 kg of fresh living soil with 6 kg of NPK and several trace elements is produced. Nutrient magnification takes place because of earthworms producing extra nutrients from grinding rock particles and enhancing atmospheric nitrogen fixation. If on the other hand, 100 kg of the same organics is composted conventionally, about 30 kg of compost is achieved with about one kg of 3% NPK. Another 1 kg may be lost due to leaching or volatalizing during the process. Compost or biogas slurry is not the ideal food for the earthworms. External composting without earthworms is a wasteful and slow process. In absence of the earthworms, organic waste may feed the pathogens and several microbes which cause environmental pollution by producing obnoxious odour and proliferation of flies, mosquitoes, cockroaches, rats etc. while developing undesirable acidity in the medium.

**GULTEKDI MARKET YARD PROJECT by Dr S. V. Mapuskar**

The Gultekdi Market Yard is a major wholesale vegetable market located in Pune generating about 20 tons of vegetable waste daily. To achieve reduction of waste at source, a proposal for converting vegetable waste into biogas and manure using anaerobic digestion within the Market Yard itself was mooted. Reduction of waste at the source by turning the waste into biogas and manure at the the Market Yard where it is generated would not only treat the vegetable waste in the most hygienic way but would save the cost of transporting it to the dumping site. It was observed that the recovery and utilisation of biogas and manure would make the set-up economically viable.

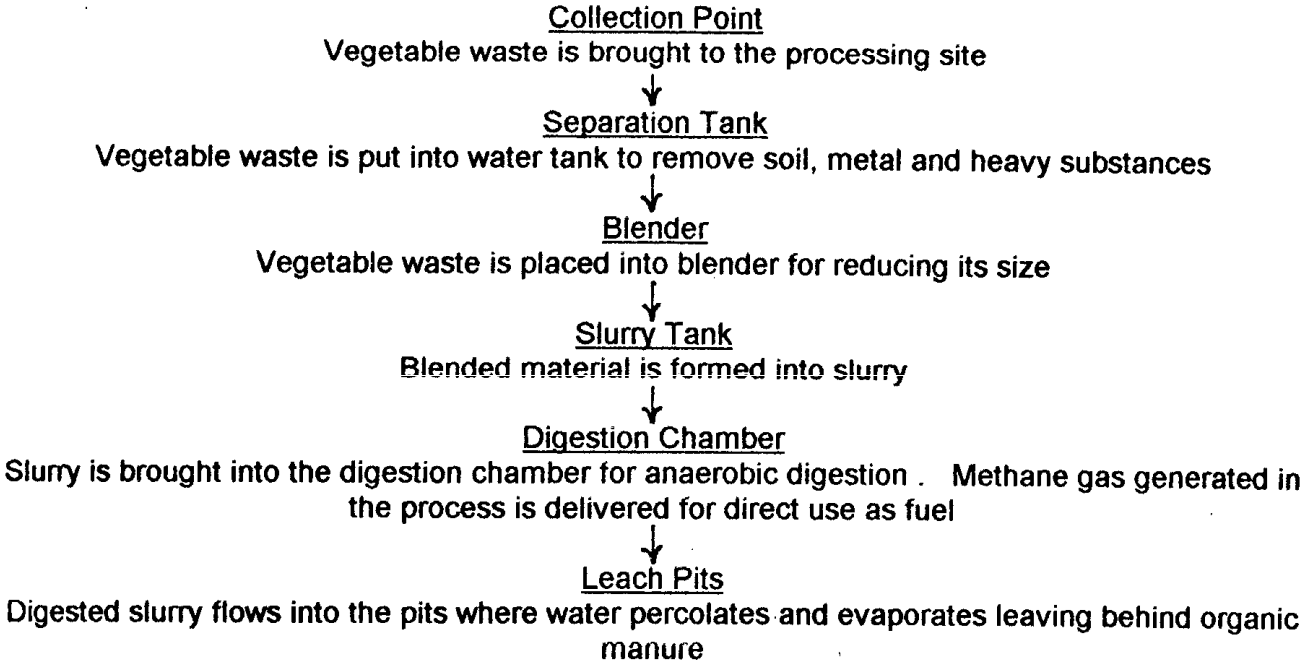
A pilot project for conversion of market waste by anaerobic process was undertaken at Krishi Utpanna Bazar Samiti, Gultekdi Market Yard, Pune. The project was executed by Maharashtra Gandhi Smarak Nidhi, Pune and Appa Patwardhan Safai and Paryavaran Tantraniketan, Dehu-Pune.

The project was commissioned in November 1992 with the funding provided partly by the Ministry of Non-conventional Energy and partly by the Market Yard Committee. The plant located on a plot of 1000 sq m plot within the Market Yard Complex has a capacity to convert 1 ton of vegetable waste daily.

Project process

Anaerobic digestion converts the waste into manure and biogas through biomethanation. The waste having a Carbon/Nitrogen(C/N) ratio of 25-30:1 undergoes anaerobic digestion for a period of 30 days passing through various stages of hydrolysis, acid formation, and

FIGURE V




FLOW CHART FOR CONVERTING ORGANIC SOLID WASTE BY ANAEROBIC DIGESTION EMPLOYED AT GULTEKDI MARKET YARD

methanogenesis in a continuous process. Methane gas generated is supplied as a fuel replacing the L. P. G. to the restaurants in the market yard area. The slurry after drying is sold to farmers as manure.

The biogas plant is a floating dome daily fed type with hydraulic retention time of 30 days. Two 4.5 m diameter biogas plants having a 500 kg capacity each are installed to make up the one ton capacity.

The waste material constituting vegetable matter is brought to the plant site with the help of 1.5 ton capacity trailer. The material has a C/N ratio of 25-30:1 which is most appropriate for the process, however the presence of lignins requires some more time to degrade. The material is initially emptied into a 4000 litre capacity tank containing water where heavy materials like metals, soil etc. settle down while the floating vegetable matter is manually collected with a rake for feeding to the shredder. The 2 kW electrically operated shredder shreds the material to 3mm size particles. The shredded material is transferred in a tank where it is mixed with water in the proportion of 1:2 to form into a slurry. The slurry then passes by gravitation through pipes attached to the tank into the digestion chamber of the biogas plant.

The process of methane formation starts within 4 to 5 days and is fully accomplished within 8 to 10 days after loading. Generated methane gas accumulates in a gasholder for onward distribution and use. It is directly utilised by the market yard restaurants as fuel supplied through pipeline. The digested slurry flowing out of the digestion chamber is led to circular leach pits for drying. Three leach pits having 3 m diameter and 0.60 m depth simultaneously receive the slurry. Water from the slurry gets leached into the soil and is also evaporated whereas the solid content dries up to be used as manure.

The plant produces 80 cu m of biogas and 50 kg of manure per day out of 1 ton of the market waste fed to the plant daily. One cum. of biogas is equivalent to 0.43 kg of LPG or 0.62 litres of kerosene or 4.7 kW of electricity. Considering the cost-benefit ratio it is an economically viable programme. Income generated from the sale of biogas and manure pays for the wages of the staff, covers the depreciation and maintenance costs of the plant as well as the interest charges on the capital invested. Connected load is 3 kW covering the 2 kW shredder running continuously and the 1 kW slurry pump operated occasionally to pump back water from the digested residue to be used in case of water shortage. Electricity, water and labour costs total up to about Rs 8000 to 9000 a month.

The project was installed at a cost of Rs 0.6 million excluding the cost of land. The project started giving returns within a month of its installation in the form of biogas and manure, however the total pay back period is estimated at maximum 10 years. The gas is presently sold at Rs.7 per cu m while the residue marketed as manure fetches Rs.2000 per ton.

Taking into consideration the running cost and the revenue earned, the project can be considered as favourable economically with an acceptable pay-back period. Energy consumption is very low. Not involving complicated technology and equipment, the plant does not require highly qualified personnel but can be operated and maintained by workers who have received basic training and instructions. Of late, the project managers have started inoculating the manure with earthworm culture of *Eisenia foetida* which turns it into vermicompost.

**VERMICULTURE by Dr Mrs Hemangi Jambhekar**

Located on the outskirts of Pune is the vermicomposting project of Dr Mrs Hemangi Jambhekar having a capacity to convert 10 tons of organic matter a day. The process utilises surface feeding earthworms, *Eisenia foetida* and *Eudrilus euginae* species to process organic waste consisting of 20% vegetable matter, 20% agricultural residues and 60% animal dung. These worms are fast breeders and convert the partially digested organic matter into vermicompost within 45 days.

The organic waste is formed into heaps having width of 1.2 m and height not exceeding 0.7 m. The length varies and can be extended according to one's choice and space availability. Heaps of the raw material consisting of vegetable matter, agricultural residues and dung are formed on the ground and are left as such for 8 to 10 days which is a pre-treatment period during which the temperature rises and partial decomposition of the material is achieved. The earthworm culture usually adult worms are inoculated only after the temperature comes down to normal after about 10 to 12 days. Vegetable matter and agricultural residues are comparatively dry while the dung initially contains 40 to 45% moisture. It is essential to maintain a moisture of 45 to 50% and a temperature of 28 to 30 degree Celsius for normal worm activity.

The heaps are formed within 1.30 m high sheds having thatched roof. They provide shade and ventilation to the heaps. To maintain the moisture of about 45% the heaps are kept covered with gunny bags and watered once a day. Cost of construction varies depending on the material used. The operations require about 10 labourers for a 10 tons/day plant. The period required for the conversion of organic waste is around 40 days. The compost can be harvested after 21 days from the time of inoculation of culture. The ratio of output to input is 1:0.5 which means that about 4.5 to 5 tons of vermicompost are realised everyday from the daily input of 10 tons of waste, farmyard manure and dung. The process is simple, however the critical aspect is the proper maintenance of moisture throughout.

Once the process is complete, watering is stopped. With the vermicastings getting drier, worms move towards the base of the heap in search of moisture. The material at the top is manually removed and is made into conical heaps for further drying. When the moisture content gets reduced to 20-30%, the vermicompost is packed in 1, 2, 5,10 and 50 kg polythene bags for marketing. The worms that settle at the base of the heap are further used for inoculating new material.

Major cost is the transport of raw materials to the processing site from different sources. This ultimately decides the cost price of the processed material. Vermicompost containing 1.5-2% of N, 0.5-0.75% of P and 0.5-0.75% of K and possessing a neutral pH is sold at the rate of Rs.1500 to 1600 per ton however a number of other products formed by blending the vermicompost with different organic residues like neem cake, castor cake, groundnut cake etc. for enhancing their nutrient content are sold at prices ranging from 3000 to 6000 per ton.

## SOLID WASTE MANAGEMENT - PEOPLE'S CAMPAIGNS

As already observed, unplanned disposal of solid waste poses serious environmental and health problems the world over. No municipal body has arrived at an appropriate solution to overcome this vexing problem and though a number of sophisticated technologies have been applied, none of them has succeeded in managing solid waste in an environmentally acceptable manner. The failure to tackle solid waste satisfactorily is the basic reason for illhealth prevailing in the community.

In India the approach towards waste is markedly different from the one in the developed countries. The rich countries have developed a throwaway culture. The per capita waste generated in the USA is 1.8 kg and in Germany 1.4 kg while in Mumbai it is 0.4 kg. Urban centres of India have much lower per capita generation of waste than Mumbai.

Entire quantity of waste is not treated as disposable garbage. The people were and still are accustomed to reusing almost everything that is usable. But today with burgeoning urbanisation and fast changing life styles, the approach towards waste has undergone drastic changes. Although there is a vast difference in the composition of waste, people have adopted the western throwaway approach during last few years. While biodegradable organics still continue to constitute the bulk of the waste, the quantum of recyclables like paper, plastic and hazardous waste from the industry and hospitals as well as metals like packaging materials is increasing significantly. It is these recyclables and other material that are difficult to biodegrade which continue to damage the environment in addition to depleting the natural resources of the earth. Mixing of these recyclables with organics hinders the biodegradation of the organics while affecting the ground water resources and the soil adversely.

Segregation is the first and foremost step for the proper management of waste. Unless this is primarily accepted and put into practice one cannot talk of solving this problem. People in the developed countries have now realised this and have started separating the different components of the waste and accordingly different containers are provided to keep the waste separate. This separated waste can now easily flow into the recycling process. Some manufacturers are now offering to buy back the packing material and containers used for packaging their products with a view to reuse them for subsequent deliveries. Citizens have started understanding the deleterious effects on environment of using petroleum based products like plastic and are now trying to shift towards using eco-friendly material.

The organic biodegradable waste dumped along with other components of waste decomposes and causes peculiar obnoxious stink which can be eliminated only if the waste heaps are properly aerated. There have been sporadic attempts for solving this vexing problem but the concerned authorities have failed to do so. Stinking waste being a major pollutant of atmosphere, its appropriate disposal has become a critical issue.

Prakruti, committed to developing environmentally viable society, observed in the biodegradable component of waste a potential for creating for the soil, biomass essential for sustainable agriculture. Prakruti and other non government organisations campaigned for conversion of biodegradable city waste into soil conditioner through the adoption of vermiculture. It is observed that micro-organisms and earthworms in the soil can enhance the fertility by converting organic components. Committed citizens started thinking about the problem and came up with encouraging solutions. One of the major breakthrough in this has been the adoption of vermiculture for treating the waste which could be successfully taken up at any level from individual to community. The process involved being very simple, people have started to work on it and could find a solution most suitable and perfect to treat the biodegradable solid waste.

A number of founder members of Prakruti started working in this direction. Mr Vijay Bhat, Agriculture Officer in a bank used his position to experiment with different types of earthworms simultaneously while communicating to farmers on the role of earthworms and micro-organisms in accelerating the biodegradation of city waste. Dr H. S. Shankar, Professor of Chemical Engineering in the Indian Institute of Technology, Mumbai initiated the study in the academic circles. Mr Uday Bhawalkar, a student under Dr Shankar was drawn to the silent invisible working of these organisms and made this a subject for his PhD. Mr Ravindra Bhole, a scientist, studied the possibility of accelerating the biodegradation of organic matter and has been promoting vermiculture for well over ten years.

Farmers were not to be left behind. Following their adverse experience with chemical farming, Mr Punamchand Baphna of Dahanu in Maharashtra and Mr Bhaskar Save of Kalpavriksha, Deheri in Gujarat both stopped using fertilisers and pesticides since the early eighties. They noticed that the fertility of the soil improved on discontinuing the input of chemical substances and promoting the natural processes to operate. Their efforts are directed towards creating appropriate conditions for the proliferation of beneficial organisms. They are acclaimed as enlightened farmers who place the protection of the environment as the most crucial consideration in farming.

Mr Mohan Shanker Deshpande, an enlightened farmer of Ajra in Maharashtra also observed the beneficial effects of micro-organisms and earthworms in the early eighties and stopped using chemical substances in his farming operations. He has now become an indefatigable crusader in Maharashtra promoting the concept of natural farming which enables micro-organisms and earthworms to play a pivotal role.

In last ten years great strides have taken place in sustainable agriculture in which vermiculture plays an important role. Not only the number of farmers following different forms of ecofriendly practices has gone to thousands, but vermiculture is being applied for tackling a wide range of organic wastes.

Mr. Bhawalkar has since established the Bhawalkar Earthworm Research Institute (BERI) in Pune to undertake research in the field of satisfactory management of waste. The BERI observed that earthworms have the capacity to accelerate the biodegradation of organic biodegradable waste and could succeed in converting organic waste into a value added product which could be put back into the soil to enhance its fertility. He found that the deep burrowing

species of earthworm *Pheretima elongata* to be most suitable for converting the waste. The BERI could also treat sewage and waste from food processing units. A vermiculture facility set up by the BERI in the Salisbury Park, Pune converts organic waste from 3000 households.

Another challenge soon came up when Mr Bhawalkar was called upon by Venkateshwara Hatcheries to treat waste generated in their enterprise. The hatchery generates around 4 tons of waste from the 10,000 birds processed daily. Mr Bhawalkar applied vermiculture biotechnology involving extremely low capital investment. The entire waste is converted into soil conditioner which the entreprise markets under the brand name of BioGold. The project is being carried out successfully. Many individuals who took up treating the biodegradable waste using vermiculture technology got encouraging results.

Mrs. Lata Shrikhande and her neighbours residing in Kanchan Gully in Pune were exasperated with the municipal waste collecting system and mounting garbage heaps. Twohundred families came together with an object of keeping their neighbourhood clean hence developed collection of waste through their own agency. The practice they follow is first sorting the waste after it is lifted from respective homes. Recyclable component is picked up by so called rag pickers while organic matter is turned into soil conditioner using vermiculture. Kanchan Gully now gives a cleaner look.

Many a farmers witnessed quantum improvement in their yields and reduction in cost on applying vermiculture obtained from Mr Bhawalkar. They started culturing earthworms themselves on their farms. One such farmer Mr Jayant Barve from Vita in Sangli District, Maharashtra used vermiculture in his grape orchard. Cultivation of grapes is perennially associated with intensive use of chemical substances. Mr Barve substituted chemical input by vermiculture. The results were profoundly impressive. He started producing vermiculture on his own. He entered into an understanding with the Vita town municipality for delivering the market waste on his farm which he can convert into vermicompost. Mr Barve has also started processing agricultural residues, dung from his farm and dead poultry birds from an adjoining poultry firm. A part of the produce is used on his own farm and the remaining is sold to other farmers. Vermiculture is a single application product unlike compost or manure which needs to be applied periodically. Vermiculture producers extend after sale service involving training to farmers and technical advice on the proper use of vermiculture and vermicast.

Dr Mrs Hemangi Jambhekar of Pune cultivates *Eisenia foetida* and *Eudrilus euginae* species of earthworms for converting the organic waste into vermicompost. She prefers these surface dwelling worms because of their capacity of prolific breeding and ability to convert partially digested organic matter at a faster pace.

Many individuals have adopted Mrs Jambhekar's technology for processing organic waste. Mr P A Deshpande residing in Pune is one such individual. He initiated a programme covering 500 families in a housing society known as Happy Colony to treat the entire quantity of kitchen and domestic waste generated in the colony. This programme has extended to cover 25000 families in due course of time. A truck acquired for the programme goes around the colony to collect the waste between 7 and 10 hours in the morning. The driver rings a bell in front of every building. On hearing the bell, residents bring the waste and empty it directly in the truck. Residents, who find it inconvenient to empty the waste in the truck at the stipulated time, can leave it in a common bin inside their compound from where the driver empties into

his vehicle. Two rag pickers moving along with the vehicle retrieve recyclables from the waste which they can sell off in the market. Remaining waste which is primarily organic is carried to a depot where it is converted into soil conditioner by using vermiculture. Land for the depot has been allotted by the Pune Municipality to the Happy Colony residents in return to which it will have no responsibility for handling the waste generated in the colony.

The wet organic waste is formed into a heap and is kept covered with black polythene film for 8 to 10 days. This increases microbial activity with temperature rising to 50 to 60 degrees centigrade which in turn accelerates the digestion process. When the temperature comes down to normal atmospheric temperature, earthworms are inoculated for turning the material into vermicompost in another 20 to 25 days. The Happy Colony residents have purchased agricultural land about 15 km away where this vermicompost is used for growing chemically free vegetables and fruits. The produce is brought to the colony for the residents to purchase for their consumption. Vermicompost is supplied to other farmers for growing produce organically. Their produce is also brought to the colony for sale to the residents. In the process both the farmers and residents are benefitted. The scheme operates to the satisfaction of the residents who contribute Rs. 10 per month per family for running the scheme.

In Mumbai Mr Shantu Shenai promotes the vermiculture technology developed by Mr. Bhawalkar and gets a very good response. An Electronics Engineer by profession, he is totally devoted to promoting the concept of vermiculture as a way to ensure cleanliness in neighbourhoods.

Amongst various programmes involving householders in keeping their neighbourhoods clean, his novel programme for turning the waste generated on the St. Louis School Road is worth special mention as the most innovative programme for involving the people as generators of waste as well as protectors of cleanliness in their neighbourhood. This road connecting to the J. P Road in Versova a suburb in western Mumbai remained perennially overcrowded with hawkers and peddlers creating serious impediments in the movement of people and vehicles. After he was assured space for setting up vermiculture facility in the nearby municipal Versova Pumping Station, Shantu approached the hawkers with a proposal that his men would keep the area clean provided the vendors co-operated by depositing all the waste generated by them only into baskets provided to them and then deposit it into the specially designed tricycle loader. The hawkers co-operated and reorganised themselves into a single row on the pavements and agreed to place all the waste only into baskets provided by Shantu. The tricycles move periodically and the vendors empty their waste into the loader. The scheme has transformed the entire neighbourhood into a pleasant promenade for the shoppers buying their daily needs and for the vehicles to move without hindrance. About one ton of vegetable and fruit waste collected everyday is segregated on arrival at the Pumping Station. All recyclables and other material that cannot biodegrade are taken out. Special masonry bins of 3 m by 7m and about 0.9 m high are constructed to receive the separated biodegraded waste to be processed by using vermiculture. This programme of nature's way of biodegradation deserving considerable understanding and human ingenuity provides to the community and authorities an encouraging example for attending to the waste in a socially satisfactory manner. Vermiculture has pointed out to a prospect for participatory collaboration between different components of the community such as the authorities, citizens, waste generators and consumers to evolve and develop clean atmosphere.

More and more people are realising the relevance of the vermiculture and are intent on utilsing this technology to process the waste. Vermiculture programmes have been started in housing colonies where the residents have come together to set up vermiculture for improving vegetation in their compounds.

Mrs Neena Sawhney a resident from Mahalakshmi in South Mumbai got other housewives staying in the apartment to come together to set up a vermiculture facility for converting organic waste generated in her co-operative housing society. Majority of the 54 society members have joined the programme. They separate out the waste in their homes and hand over only the organic component to the vermiculture programme. The vermicast when ready is used as soil conditioner in the common garden and delivered to householders having their individual garden. Mrs Sawhney is so much attached to the programme which turns waste into a valuable product for enriching the soil that she has taken upon herself to promote vermiculture everywhere. She visits schools and explains to the children the magic of turning the waste generated by them into valuable product which can grow healthy plants even in this congested and polluted city. Children go back to their homes to persuade their parents and neighbourhood to set up the facility to convert their waste into valuable product. Word about Mrs Sawhney's initiative has gone round and housewives in other housing colonies and multi-storeyed buildings have started setting up similar vermiculture facilities in their premises with the advice of Mrs Sawhney. She has at the same time received offers from citizens to assist in promoting this activity. These volunteers extend guidance to householders wanting to change their way of life. Such a movement brings about a change in one's behaviour towards the nature.

Mrs Kunti Oza, a long time volunteer for clean neighbourhood, as well as Mrs Shanta Chatterjee, resourceful communicator for environment conservation, move amongst the people asking them to adopt vermiculture for getting rid of their organic kitchen waste and for improving local conditions. An increasing number of people have understood the need for handling the organic waste generated by them and are adopting vermicultrure.

Dr Ramesh Doshi, having acquired a doctorate in agricultural economics a couple of decades back got interested in organic farming and in biodegradation processes after retiring from active business. He looked at his pots of plants located in his 110 sq metre terrace and came upon an idea of applying the kitchen waste generated in his home into his terrace garden instead of throwing away as a garbage. He improvises used high density polyethylene bags with both ends open as pots for his plants. The lower half of the improvised container is filled up with biomass. He has found sugar cane trash as an ideal biomass for his purpose. A layer of soil is spread over this for quarter of height above which kitchen waste is spread. He introduced in his garden micro-organism and earthworm culture once in the beginning. These organisms accelerate the biodegradation of the newly dropped stock of organic waste. To his surprise and certainly to his satisfaction he has found mangoes, sugar cane, pomegranates, bananas, guava growing along with vegetables of his choice. Fruit trees start fruiting within one to two years of planting instead of the normal fruiting period of five to seven years. One can see mango, pomegranate, guava, sapota, aonla, fig fruits in his garden. Dr Doshi's experiment which he terms as City Farming has been received well. Not only have many residents taken up this programme in Mumbai under Dr Doshi's guidance but centres for the propagation of City Farming have come up in other urban centres. Dr Doshi's City Farming is a unique way for reducing the organic waste at source.

There is a growing awareness amongst people on the efficacy of vermiculture however one has to concede that as yet it is not spread widely to cover the entire quantity of organic waste generated in an urban centre or even the major portion thereof. People are anxious that there should not be any waste around them but it is the uncontrolled and unplanned development which results in uncontrolled waste generation and deposition. It is time that the municipal authorities responsible for waste management to launch programmes for supporting people's initiative in vermiculture with an objective of reducing the waste at source.

However in order to arrive at a satisfactory solution it is most important to adopt the three R approach that is Reduce, Recycle and Reuse to whatever is presently treated and thrown away as waste. Reduction of waste at the source and also at the dumping sites is the first measure for minimising the handling and transport of waste from the point of generation to the point of disposal and to cut down space needs at the dumping sites. The second step is of recycling items like paper, plastics, metal so often found in the waste heaps. Items that can be used directly or after conversion should not be discarded as waste. Paper and plastic material should be recycled and brought back to use to ensure conservation of natural resources . Converting organic waste into soil conditioner and using it back in the fields reduces the quantity of waste to be dumped at the dumping site. It is on the basis of this three R approach that a lasting and satisfactory solution can be carved out for managing the solid waste generated in urban centres.

The people are equally responsible for the prevalent filthy conditions because they dispose off jumbled up waste in which different categories of waste are mixed up together. This possibly results from the ignorance on the part of the citizens on the hazards of unsorted mixed up waste and that different components of waste need to be given different treatment for their proper disposal or reuse. The civic authorities can bring about an awareness among people on the proper way of waste management which will reduce their work load and ensure efficiency.

## INTEGRATED SOLID WASTE MANAGEMENT PROGRAMME FOR MUMBAI

Note 1: This chapter has been rewritten to respond to the feedback we received since the publication of the first edition in March 1996. The earlier edition was widely circulated amongst municipal and government officers, citizens and press. It drew special attention from all circles. Reactions from the municipal officers stemmed however from their unwillingness to give a fair trial to recommendations for bringing about a permanent solution to the problem facing Mumbai. This is an effort to explain the issues that came up in discussions with municipal officers.

Note 2: Since Bombay has officially become MUMBAI, we are using the new name Brihan Mumbai Mahanagar Palika instead of Municipal Corporation of Greater Bombay in this chapter.

It has become clear from the study undertaken that solid waste disposal is being improperly handled by the Solid Waste Management (SWM) department of the Brihan Mumbai Mahanagar Palika (BMMP). The study at the same time shows as to how numerous citizen initiatives for handling biodegradable organic waste have been successful in handling and recycling of the 'so called' waste and yet the BMMP has not come forward to support such citizen initiatives or to adopt them itself. Despite the glaring apathy of civic officers to citizen efforts to improve conditions in the city, there is a possibility of collaboration between the citizens and the municipal authorities. Citizens feel increasingly concerned about civic services deteriorating mainly due to non-accountability of senior civic officers and casual working of the lower staff. Citizens realise that appropriate solid waste management requires their close and continued association for evolving an environment friendly programme. They further realise that the democratic set up requires the public servants to consult and involve citizens at every stage from planning to implementation of public programmes. An attempt is made hereunder to develop a closely knit efficient, comprehensive and integrated waste management programme that ensures cleanliness and healthy conditions in the city.

**Need For Developing An Integrated Approach**: As already observed, the existing BMMP practice for solid waste disposal is insufficient and wasteful at every point from collection to disposal because the BMMP treats every stage as unrelated to other stages. Waste is thrown by waste generators at any place convenient to them. Lifting and collection are sporadic hence heaps of waste are seen lying everywhere. Substantial resources are expended in lifting and transporting to dumping sites components of waste that need not at all go to those sites. Their transport to dumping sites causes severe environmental problems en route. Waste carried to dumping sites is not treated resulting in avoidable environmental pollution and wasteful filling up of limited space at dumping sites. It therefore becomes essential to develop an integrated approach that can treat the waste appropriately from generation to final disposal that is from 'cradle to grave'. The plan has to be comprehensive linking every stage in a synergic cycle. It has to be a composite one requiring it to be implemented totally and simultaneously as all steps are interlinked. There can be no room for applying a 'pick and choose' approach. In fact, any effort to implement in parts is bound to defeat the very objective of keeping Mumbai clean and healthy.

**Objectives For An Integrated Solid Waste Management Programme:** An Integrated Solid Waste Management Programme (ISWMP) ensures a total work programme for not only collecting the waste but also incorporates processes for treating every component of waste in an environment friendly manner. The ISWMP is formulated to realise the following objects:

* Establishing and maintaining cleanliness and health in the city
* Securing support of citizens and rag pickers in ensuring proper recycling and reuse
* Improving the health of dumping sites by avoiding dumping of unwanted substances
* Treating different components of waste in the manner appropriate for each of them
* Streamlining waste collection system for saving handling and transport costs
* Promoting return of recyclables for reuse thereby reducing quantity of waste at source
* Converting total biodegradable organic waste into soil conditioner by adopting environment friendly processes thus putting them back into soil
* Rationalising the use of space at dumping sites.

**Generation Of Waste:** Solid waste comprises of components that can broadly be divided into recyclable waste, biodegradable organic waste and inert debri waste. Waste generated in homes, markets and industrial processes are recyclable waste and biodegradable waste. Inert debri waste is generated at demolition, repair and construction sites. According to the data provided by the SWM Dept, Mumbai generates daily approximately 6,000 tons of waste comprising of the following components :

| Component | | Quantity generated daily (in tons) | Quantity generated annually (in tons) |
|---|---|---|---|
| Recyclable Waste | | | |
| Paper & cardboards | 600 | | |
| Plastics | 30 | | |
| Metals | 34 | | |
| Glass | 16 | | |
| Sub-total | | 680 | 248,200 |
| Biodegradable and Reusable Waste | | | |
| Organic | 1,920 | | |
| Sand & fine earth | 1,400 | | |
| Sub-total | | 3,320 | 1, 211,800 |
| Building Material Debri Waste | | 2,000 | 730,000 |
| Grand total | | 6,000 | 2,190,000 |

**Lifting And Collection Of Waste**: At present 680 tons of recyclable and 3320 tons of biodegradable components totalling 4,000 tons are collected in mixed condition and transported to dumping sites by one group of municipal staff while 2,000 tons of inert debri material are lifted and transported separately to the very same dumping sites by another group. On arrival at the dumping sites, all the three components are dumped together. Such dumping creates anaerobic biodigestion of the biodegradables causing generation of toxic gases, fires and smoke affecting the health of living beings staying in the vicinity. Fires once ignited can never be extinguished

because the continuous generation of highly inflammable methane gas keeps the fire alive for all the time.

**Segregation Of Different Components Of Waste:** The first requirement is of maintaining different components as separate items as they need different treatment. No one single broad spectrum treatment exists that can make all the three components harmless to the community. In fact, mixing up of all these three components raises severe pollution problems. That is the reason why they should be maintained separate of each other. If they get mixed up at any stage including the point of generation, they should be segregated and maintained in separate lots. Three components need to be treated in the specific manner appropriate to each of them.

The extent of success of any waste management programme depends on the degree to which segregation of different components of waste is achieved. It is essential to realise 100% segregation to avoid damage to health and environment resulting from erratic mixing of solid waste. As the inert waste is not generated on a regular basis and as it is lifted by the BMMP separately, everybody generating biodegradable and recyclable waste should be required to maintain them separately all throughout. The integrated approach thus will first of all require the creation of an awareness and understanding amongst citizens and municipal staff that different components should be kept separate because they need different treatment.

**Role Of Rag Pickers In Conserving Natural Resources:** Involvement of rag pickers is crucial as they are the ones to pick up recyclable components and put them back to reuse. Rag pickers can lift recyclables at the point of generation. Their services can be utilised profitably at municipal collection centres as well. What they are doing presently at the sufferance of the authorities and waste generators should be permitted to pursue under the aegis of and in cooperation with the authorities and citizens. The BMMP and citizens can evolve mechanisms for organised retrieval of recyclables and for obtaining economic price for the recyclable waste retrieved by rag pickers. The BMMP should not lift recyclables for transporting to the dumping sites and discourage waste generators from handing over recyclables to the BMMP. They should instead return the recyclables to the market for reuse directly or with the help of rag pickers. The BMMP should extend support to the NGOs to take up campaigns for advising the citizens to refrain from handing over recyclables to the BMMP and instead dispose them off directly. Rag pickers in fact render a unique service to the community and to the earth by conserving natural resources. The ISWMP accepts rag pickers as an important link in ensuring better conditions in the community. We visualise the emergence of complimentary relations between waste generators, municipal authority and rag pickers for achieving thorough segregation of solid waste into recyclables and biodegradables as well as for direct return of recyclables to the community for reuse.

**Treatment And Management Of Recyclable Waste:** Paper, plastics, glass, leather, metals, linens, texile rags and everything that can be recycled should be brought back in the community for reuse. In fact, the country depends on recyclable waste so much that large quantities of waste paper, plastics, metals etc are imported for reclycling. Reuse of recyclables ensure conservation of natural resources and rationalisation of product costs. Yet it is painful to observe that there is no conscious effort on the part of citizens and administrators to stop throwing away of recyclables in the dumping sites. In any case, recyclables need not go to dumping sites for dumping as they are too valuable for discarding and a better alternative is their reuse directly or after conversion. The first prerequisite for maintaining healthy environment at the dumping sites is that recyclables are not brought to the dumping sites at all.

With the BMMP stopping dumping of recyclables at dumping sites, many of the problems faced by the community would automatically disappear. Anaerobic biodigestion of biodegradables resulting in the generation of methane, carbon dioxide and hydrogen sulphide will stop. Fires will not break out or continue in the dumping sites. Burning of plastic and paper in the dumping sites will be eliminated and so also the generation of furan, dioxins and other gases highly hazardous to living beings. Conditions at the dumping sites would improve as gases, fire and smoke will stop for all the time. Quantity of waste to be handled by the BMMP would drastically be reduced. Considerable saving in handling and transport costs would result following the non-lifting of that quantity of recyclables. Rational use of limited space of dumping sites would emerge. The role of rag pickers as savers of natural resources would be recognised.

**Treatment And Management Of Biodegradable Waste:** Micro-organisms and earthworms accelerate the process of biodigestion of the biodegradables and turn them into soil conditioner. The process is exceedingly simple suitable for waste generated by one family as well as by one lakh families. Decentralisation of operations is the forte of the process. Requiring no large capital, any body keen on environment conservation can set up vermiculture facility without difficulty. Waste generators should be encouraged to set up vermiculture facility in their homes, work areas as well as in the vicinity. Under the policy decision taken by the BMMP to set up minimum five Neighbourhood Vermiculture Centres (NVC) in each ward, a minimum of 115 NVCs of capacities varying from 10 to 30 tons can come up for biodegrading organic waste within the manageable distance of their generation. Active association and support of citizens and NGOs can ensure successful and effective operations of the municipal NVCs. Vermicastings generated in the homes, community and NVCs can be used for bringing greenery in respective wards. As the object is of linking biodegradables into an ecological cycle, vermiculture facilities should be set up in all the four dumping sites for treating biodegradables arriving at dumping sites. A policy decision shall have to be taken that biodegradables and recyclables shall not be dumped in the dumping sites.

Campaigns to promote citizens to set up vermiculture facilities on individual and community basis should be conducted regularly. Housing colonies, eating houses, markets can be persuaded to set up their own biodegradation programmes. Only that quantum of biodegradable waste that cannot be processed at or near the source should be transported to the nearest NVC or to the respective dumping site vermiculture facility. The BMMP should encourage householders, housing societies and large generators of waste to set up facilities for direct disposal of recyclables and conversion of organic waste through vermiculture. If required financial and infrastructure support should be extended for promoting such measures that reduce the waste to be handled by the BMMP subsequently. Housing colonies and work centres under development should be persuaded to create waste management facilities within their premises so that their waste does not require to be handled by the BMMP.

**Collection Of Waste:** The BMMP has provided waste bins and receptacles of varying capacities throughout the city to enable the citizens to throw their waste. Citizens are, in addition, accustomed to throwing waste at any site they like making Mumbai a filthy city. All types of waste are thrown in the same bins resulting in the unhealthy mixing of various components of waste. Locations where waste bins are kept have notoriously become the dirtiest spots in the city because they are strewn with every unwanted items that the citizens have discarded for good. Rag pickers while lifting recyclables from the waste bins spread the unwanted biodegradables around. <u>The practice of providing waste bins in public places has to discontinue.</u> The citizens should hold their biodegradable waste with them and deposit in the municipal waste transport trucks directly. A few areas of Mumbai at present served by what is known as "bell ringing system" present a cleaner look comparatively as no waste bins are

provided in the public areas. The residents are required to hold their waste with them till the visiting waste collection truck rings the bell to announce its arrival. This practice should be progressively extended in all parts of the city as that ensures cleaner conditions in public areas and transferring the waste to the official waste handling agency.

Where "house to house collection system" is followed, residents should be required to deposit the biodegradables only in the receptacle constructed in the premises from where municipal staff will lift that component only. They may develop a separate receptacle for recyclables to be handled by them. The municipal staff shall not lift the recyclables.

What remains to be ultimately transported through refuse vehicles is biodegradables and inert debri material. Biodegradables should necessarily be converted into soil conditioner and used properly to avoid wasteful filling up of space. Once it is realised that the BMMP has to spend more than Rs 1.10 for every kilogram of waste handled, it would be beneficial to support the retrieval of recyclables and the turning of biodegradables into soil conditioner near the source thus reducing the collection and transport costs. Reduction at the point of generation being our first priority, efforts should be made to make people aware about reusing items wherever possible and especially on cutting down the use of environmentally unfriendly materials like plastics, chemicals etc. This approach can ensure considerable reduction in the quantity of waste to be transported to dumping sites. It will guarantee not only total retrieval of recyclables at source but will generate amongst rag pickers a sense of confidence that their job is suitably valued by their fellow citizens.

**Handling Of Inert Debri Waste:** Inert debri waste should be transferred to dumping sites for vertical deposition in a planned manner. Dumping sites can be developed into a hillock beautifully landscaped and covered with trees for use as public recreation areas. Vertical land filling is the proper alternative to ensure optimum use of the space designated for dumping. Erratic landfilling now pursued creates environmental problems in addition to consuming unlimited area of space. Soil conditioners produced at dumping sites can be used for greening of newly created hillocks of inert waste.

**Large Generators Of Waste:** Eating houses, hotels and large generators of waste should be required to treat waste generated in their premises. They should dispose off the recyclable component directly and set up vermiculture facilities for handling biodegradable waste within their premises as the first choice. If they cannot set up such facility for any pressing reason, the BMMP can take up the work charging them the full cost of collection, transportation and biodegradation in addition to deterrent levy for not executing the responsibility that they should have carried out themselves.

**Handling Medical Waste:** Medical waste should necessarily be autoclaved before putting into the waste stream. All health care centres should be required to autoclave their hazardous medical waste. The BMMP should monitor the operations of incinerators closely and should maintain register of incinerators in possession of the health care centres and other activity centres. It should chalk out a programme for their easing out in the ultimate interests of the community.

**Transportation Of Waste:** It would be interesting to observe as to how the ISWMP helps in reducing the quantity of waste at the source. With the handling of recyclables eliminated, the BMMP will have only to lift a considerably smaller quantity of that biodegradable waste which cannot be converted at source of generation and transport to the NVC and the Dumping

Site Vermiculture Centres. Not only the quantum of waste to be lifted and transported will be reduced but also the movement orientation will change drastically. Distances to be transported will be reduced following the transfer to the NVC ensuring higher utilisation of the transport facilities. In fact transfer of biodegradables to the NVCs can be done by non-motorised transport thus reducing dependence on petroleum based fuels. Debri waste will however continue to be transported to dumping sites. As quantitities to be transported are considerably reduced, transport requirements will be reduced. The BMMP can dispense with or drastically reduce the use of private contractor transport for transporting the waste.

We are confident that elimination of the transport of recyclables and drastic reduction in the quantity of biodegradables along with shorter haulage would ease the traffic jams and snarls on public roads as well as reduce the environmental pollution considerably. Movement of municipal refuse trucks increase the congestion on road while tattered private contractors' trucks moving in narrow streets add to air and noise pollution.

**Expenditure On Waste Management:** The present practice employs a large number of people to carry out the operations of the SWM Department. The BMMP considers the ratio of labour to the quantity of waste and to population to be low, though the major portion of the sanctioned budget is taken away by the salaries to top officers and payments to the lower staff. Transport after salaries ranks as the second largest outgoings. It is essential to bring efficiency in the working staff by allotting them appropriate duties. Further improvement in the type of vehicles is equally important so that the number of vehicles can be reduced without affecting the operations adversely.

The ISWMP should bring about substantial reduction in the total expenditure now incurred by the SWM Department. Because waste to be handled is voluminous, a truck can carry only half the quantity of waste by weight. A 10 ton capacity truck carries maximum 4 to 5 tons of recyclable and biodegradable waste. Under the present practice, six labourers and a Mukadam are provided on each truck and trucks, on an average, make a single trip per shift. Split up information on lifting and hauling cost is not available from municipal sources hence the cost has been assumed for arriving at outgoings and savings in implementing the ISWMP.

The ISWMP can bring about quantum change in the BMMP revenue and expenditure for the SWM Department:

**Revenue:** The BMMP does not charge the citizens and waste generators for the waste generated by them. Because the service is free and not related to the quantity of waste generated, there is a tendency amongst the waste generators to not to worry about reducing the waste. Thus charging a tax or levy on the waste handed over by them to the BMMP would work as a deterrent on the waste generators. One way of charging could be levying a percentage on the rateable value of properties. Large generators could be charged on the basis of quantity of waste handed over by them to the BMMP. A rate of Rs.600 to Rs 1000 a cum would appear to be adequate to cover the cost of the conservancy services.

**Savings in Expenditure:** The implementation of the ISWMP can bring about considerable savings. The BMMP spends well over Rs.1100 per ton of waste at present, in which labour charges and transport expenses form the major components. Separate figures are not available however it would be safe to assume the per ton cost of handling and transporting the waste to be Rs.800 for the following computation:

A. Quantity of waste not required to be lifted and transported on yearly basis

A.1. Recyclable waste total quantity 248,200

A.2. Biodegradable waste not required to be transported
60% of total quantity of 1,211,800 tons 727,080
Adjust 10% of total quantity
to cover the cost of short haul to NVC 121,180
Net quantity of biodegradable 605,900
Total quantity of waste not required to be lifted 854,100 tons

Saving at Rs.800 per ton on 854,100 tons Rs 68,32,80,000 that is Rs 68.32 crores

B. Capital cost for setting up

B.1. 115 NVCs @ Rs.10 lakhs per unit Rs. 11.5 crores

B.2. 4 Vermiculture centres at 4
dumping sites @ Rs.50 lakhs per unit Rs. 2.0 crores
Total capital cost - one time investment Rs.13.5 crores

C. Recurring cost for operating

C.1 115 NVCs @ Rs.20 lakhs per unit Rs. 23 crores

C.2 4 Vermiculture Centres @ Rs.
100 lakhs per unit Rs. 4 crores
Total recurring cost per year Rs. 27 crores

D. Production

D.1 Vermicastings at 115 NVCs
60% of total of 1211800 tons - 727080 tons
Vermicasting realised at 30% 218124 Tons per year

The Gardens Dept should lift 68124 tons of
NVC produced vermicastings for use in its
gardens and save Rs.1.3 crores of public
money annually spent on inferior quality compost
Quantity to be handed over to the Gdns Dept 68214 tons

Vermicastings to be sold 150000 tons
at Rs 2000 per ton (Excel product price
Rs 3000 per ton) Realisation Rs 30,00,00,000

D.2 Quantity of biodegradables taken for vermiculture
at dumping sites- 40% of 1211800 tons of waste
484720 tons. This quantity turned into 145416 tons
of vermicastings to be disposed off at Rs 2000 per ton Rs 29,08,32,000
Rs 59,08,32,000

(Vermicastings sold at Rs.5000 a ton ex Pune factory site)

E. Implementation of the ISWMP requires better understanding amongst the civic officers and citizens. The BMMP shall have to maintain live public relations with the citizens and develop awareness campaigns. A minimum of 5 regional Information Centres for the city, suburbs and extended suburbs to develop awareness. They will be run by designated voluntary organisations the cost of which will be borne fully by the BMMP Estimated annual expenditure Rs 30 lakhs per centre Total expenditure Rs 1.5 crores
(One lakh= 100,000 One crore= 10 million or 100 lakhs or 1,00,00,000)

The BMMP has for the first time raised the question of economic viability while looking to the ISWMP. This approach shows that the BMMP is not concerned about protection of environment and health. It is an admitted situation that the BMMP is not a business house operating for maximising its profits. In fact, the annual expenditure of Rs 220 crores on the SWM Dept can never be justified on economic grounds. The BMMP officers raising the issue of economic viability have not taken into consideration the benefits of the ISWMP on environment and health. The above study would prove that the ISWMP can bring about considerable saving in addition to improving the environment and health of the city. Immense benefit flowing from the ISWMP can never be quantified in money terms.

**Overall Benefits:** The objects enumerated above can be realised by adopting the ISWMP. Recycling and reuse of waste ensures better environment and health. Total quantity of waste is drastically reduced by directing its reuse. Space at the dumping sites is optimally utilised. Immense advantages in the form of better overall conditions, improved public health, raising of general efficiency of citizens cannot be evaluated in money terms. Immeasurable benefits follow to the community.

**Conclusion:** As observed earlier, efficient management of gigantic quantity of solid waste ensures the physical health and well-being as well as in creating and maintaining condusive environment in the community. It is well nigh impossible to develop and sustain any effective programme without the active association and participation of individuals within the community. As generators of solid waste the citizens have a responsibility to handle the waste generated by them appropriately. As consumers, they have a stake in ensuring healthy living conditions in the community. The authorities have an obligation to avoid nuisance and create healthy conditions for the citizens in the areas falling within their purview. They have an opportunity for providing efficient and effective services with the active involvement of people they are serving. The Integrated Solid Waste Management Programme operating with the sensitive support of the citizens and with the efficient administrative machinery at the disposal of the senior municipal officers who are committed and want to dedicate themselves for improving the conditions can be the only hope for better Mumbai.

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