Solid Waste Management in Dehradun City

(A Dissertation report)

Submitted By

Prem Dayal Saini
&
Hitesh Khatkar

College of Engineering
University of Petroleum and Energy Studies
Dehradun

Under the guidance of
Dr. Nihal Anwar Siddiqui
Senior Lecturer
College of Engineering
University of Petroleum and Energy Studies
Dehradun

Solid Waste Management in Dehradun City

(A Dissertation report)

Submitted By

Prem Dayal Saini
&
Hitesh Khatkar

College of Engineering
University of Petroleum and Energy Studies
Dehradun

Under the guidance of
Dr. Nihal Anwar Siddiqui
Senior Lecturer
College of Engineering
University of Petroleum and Energy Studies
Dehradun

UNIVERSITY OF PETROLEUM & ENERGY STUDIES

CERTIFICATE

This is to certify that the major project report on "Solid Waste Management In Dehradun City" completed and submitted to University of Petroleum and Energy Studies, Dehradun by Prem Dayal Saini and Hitesh Khatkar in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology in Applied Petroleum Engineering, is bonafide work carried out by them under my supervision and guidance.

To the best of my knowledge and belief the work has been based on investigations made ,data collected and analyzed by them. Their work has not been submitted anywhere else for the award of others degree or diploma.

Dr. Nihal Anwar Siddiqui
Senior Lecturer
College of Engineering
University of Petroleum and Energy Studies, Dehradun

Acknowledgement

This major project on "Solid Waste Management in Dehradun city" allowed us to gain comprehensive knowledge of various nuances associated with health, safety and environment.

We sincerely thank to Dr. C K Jain, course coordinator, who has been torch bearer and driving force in completing this task by giving his invaluable inputs and sharing his experiences. The learning we have got from him will prove to be useful throughout our professional and personal lives.

We express our indebtness to Dr. Nihal Anwar Siddiqui for his tremendous patience in answering our queries. He helped and guided us at every step along the way, and without his help, support and coordination this project would not be completed.

We are grateful to Dr. B.P Pandey for giving us this opportunity to work on this project.

We also acknowledge the support of Dr.R.P Badoni and Prof. Kamal Bansal and other staff, whether teaching or non teaching who directly or indirectly helped us in the completion of this project.

Prem Dayal Saini
(R010103029)
B-Tech (Applied Petroleum Engineering)
University of Petroleum and Energy Studies
Dehradun

Hitesh Khatkar
(R010103016)
B-Tech (Applied Petroleum Engineering)
University of Petroleum and Energy Studies
Dehradun

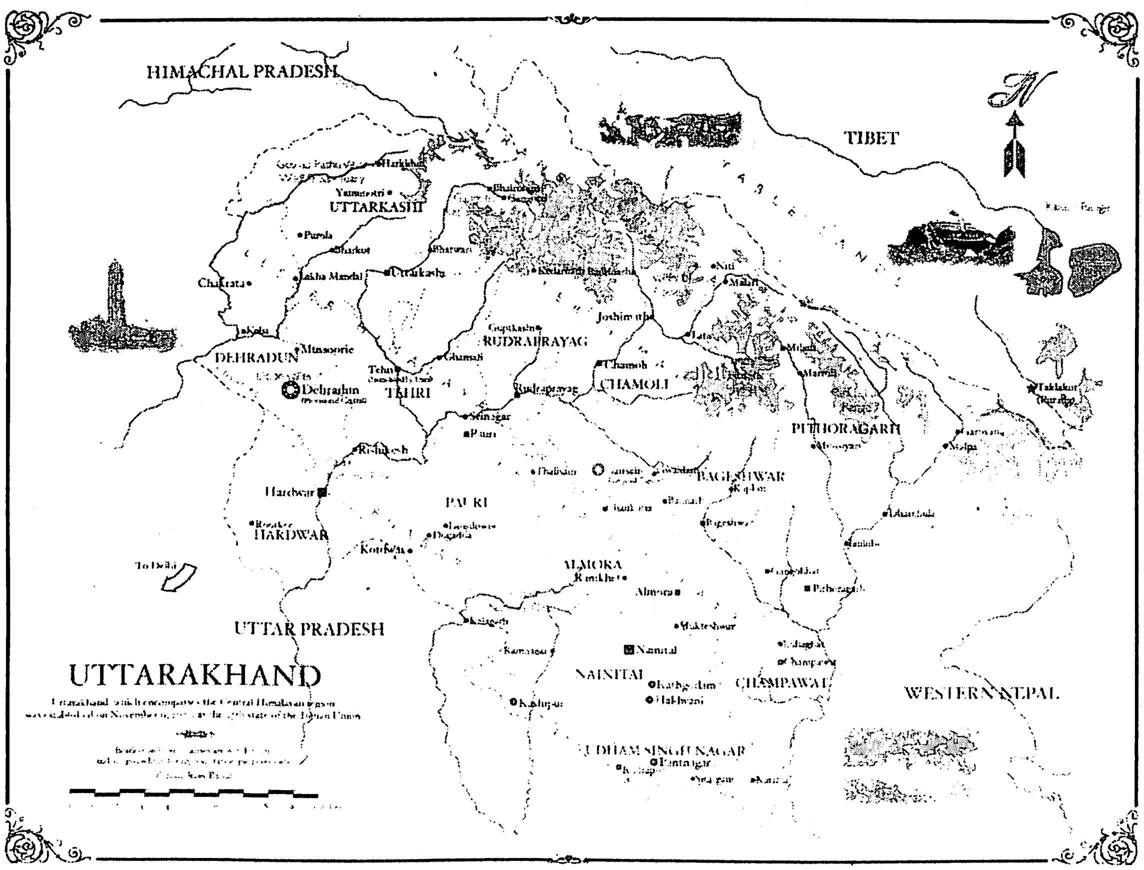
Table of Contents

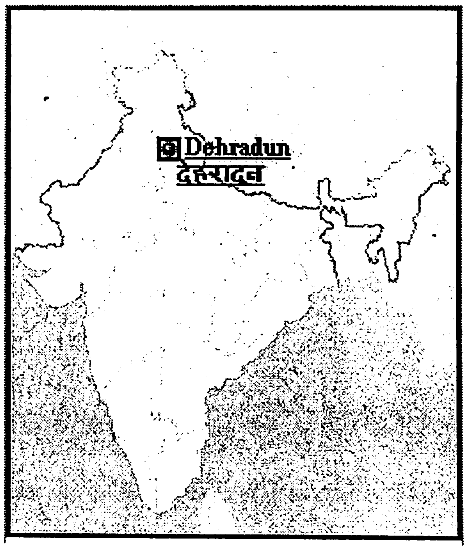
Introduction

There are various core areas where the municipal bodies are involved for providing their services for the betterment of the city. These services are often described as the obligatory and the mandatory functions. It is with these functions only where the municipal bodies have to perform in a way that they could maximize their revenue generation and perform and deliver the services in a better way. One of the important things which are missing in the system is that data is not managed properly. Because of the improper management of the data and records, it often becomes difficult to know about the functioning of the system in an efficient way. The core solution to maximize the profit generation and efficient delivery of the urban services lies in the overall management of the data system of the organization. The data's are always linked to each other and often lies in an isolated form. It is very important to manage the data in an integrated way so that complexity of the various systems could be reduced to solve various issues related to the functions of the municipal bodies.

Dehradun

Nestled in the mountain ranges of the Himalaya, Dehradun is one of the oldest cities of India and is recently declared as the Provisional Capital of newly created Uttaranchal (Now Uttarakhand) State in the month of Nov'2000. Also known as the 'Adobe of Drona', Dehradun has always been an important center for Garhwal rulers which was captured by the British. The headquarters of many National Institutes and Organizations like ONGC, Survey Of India, Forest Research Institute, Indian Institute of Petroleum etc are located in the city. Some of the premier educational and Training Institutes like Indian Miltary Academy, RIMC(Rashtriya Indian Military College), Indira Gandhi National Forest Academy(IGNFA), Lal Bahadur Shahstri National Academy of Administration(LBSNAA)etc are also there in Dehradun. It is a favoured tourist destination as it attracts tourists, pilgrims and enthusiasts from various walks of life to its serene environs. Add to this the abundance of special Basmati rice, tea and leechi gardens which contribute in turning the city into a paradise.





The district is named after its chief city Dehra Dun. Dehra appears to be a corruption of dera signifying a temporary abode or camp. During the reign of Aurangzeb, Ram Rai, Guru of the Udasi Sikhs on being ordered by the Mughal king to retire to the wilderness of the Dun, had pitched his tents here in what is now the Khurbura locality of the town and has also built a temple near Dhanawala. Around these two sites, grew up the town popularly known as Dehra. The term dun or doon means the low lands at the foot of a mountain range, and as the bulk of the district lies in such a terrain, it justified the dun part of the name.

Another derivation of the term dun is stated to be from Dronashram, hermitage of Guru Dronacharya of Mahabharata fame, who sojourned for a season in the village of Devara, situated near to Dehra to perform his devotions at a lonely spot.

District Boundaries and other Details

The district is situated in the north-west corner of the state.
It is bounded on the north and to some distance in the north-west by the district of Uttarkashi,
In the east by the district Tehri Garhwal and Pauri-Garhwal
In the south by the district of Saharanpur(Uttar Pradesh) ,
At its southern tip touching the boundary of district Haridwar.
Its western boundary adjoins the Sirmur(Nahan) district of Himachal Pradesh with the rivers Tons and Yamuna separating the two.
Lies between 29 degrees 58' and 31 degrees 2' 30" north latitudes and 77 degrees 34' 45" and 78 degrees 18' 30" east longitudes.
Total area of the district is 3088 sq kms.
Altitude is 640 mts.(2100 ft) above sea level

Climate & Rainfall in Dehradun District

The Climate of the district is generally temperate. It varies greatly from tropical to severe cold depending upon the altitude of the area. The district being hilly, temperature variations due to difference in elevation are considerable. In the hilly regions, the summer is pleasant, but in the Doon, the heat is often intense, although not to such degree as in the plains of the adjoining district. The temperature drops below freezing point not only at high altitude but even at places like Dehradun during the winters, when the higher peaks are also under snow. The area receives an average annual rainfall of 2073.3 mm. Most of the annual rainfall in the district is received during the months from June to September, July and August being rainiest. Climate Data of Doon Valley for all the months is as under on the basis of mean of last 25 years.

Month	Rainfall	Relative Humidity	Temperature		
	(mm)	(%)	Max	Min	Ave.
January	46.9	91	19.3	3.6	10.9
February	54.9	83	22.4	5.6	13.3
March	52.4	69	26.2	9.1	17.5
April	21.2	53	32	13.3	22.7
May	54.2	49	35.3	16.8	25.4
June	230.2	65	34.4	29.4	27.1
July	630.7	86	30.5	22.6	25.1
August	627.4	89	29.7	22.3	25.3
September	261.4	83	29.8	19.7	24.2
October	32.0	74	28.5	13.3	20.5
November	10.9	82	24.8	7.6	15.7
December	2.8	89	21.9	4.0	12.0
Average Annual	2051.4	76	27.8	13.3	20.0

Historical Background & Topography

HISTORY

According to Skanda Purana, Dun formed part of the region called Kedar Khand.
It was included in the kingdom of Ashoka by the end of the 3rd century B.C.
It is revealed by history that for centuries the region formed part of the Garhwal kingdom with some interruption from Rohillas. For about two decades till 1815 it was under the occupation of the Gorkhas. In April 1815 Gorkhas were ousted from Garhwal region and Garhwal was annexed by the British. In that year the area now comprising tehsil Dehra Dun was added to district Saharanpur. In 1825, however, it was transferred to the Kumaon Division. In 1828, Dehra Dun and Jaunsar Bhabar were placed under the charge of a separate Deputy Commissioner and in 1829, the Dehra Dun district was transferred from the Kumaon Division to the Meerut Division. In 1842, Dun was attached to Saharanpur district and placed under an officer subordinate to the Collector of the district but since 1871 it is being administered as separate district. In 1968 the district was taken out from Meerut division and included in the Garhwal Division.

LANGUAGES AND RELIGION

Main languages spoken in the district are Hindu, Sindhi, Punjabi, Garhwali and Urdu.
Religion-wise breakup of population is indicated below as per 1991 census:

- Hindus : 8,74,760
- Muslims : 98,748
- Christians : 8,949
- Sikhs : 30,417
- Buddhists : 8,345
- Jains : 4,159
- Others : 301

GEOGRAPHY

Dehra Dun can be divided into two distinct tracts i.e. the montane tract and the sub-montane tract. The montane tract covers whole Chakrata tehsil of the district and consists entirely of a succession of mountains and gorges and comprises Jaunsar Bhabar. The mountains are very rough with steep slopes. The most important features of the tract is the ridge which separates the drainage are of Tons on the west from that of Yamuna on the east.
Below the montane tract follows the sub-montane tract, which is the famous Dun valley bounded by Shivalik hills in the south and outer scarp of the Himalayas in the north.

FORESTS

Dehra Dun is distinguished from most other districts in the state by the existence of very large forests chiefly stocked with sal. Forest products play an important role in the economy of the district. Besides, supplying fuel, fodder, bamboos and medicinal herbs, they also yield a variety of products like honey, lac, gum, resin, catechu, wax, horns and hides. The forests account for 1477 sq.kms of area, giving a percentage of 43.70 of the total area of the district. Owing to the variation in altitudes and other aspects, the flora of the district vary from tropical to alpine species. Different types of forests and varying species of shrubs, climbing plants and grasses, depending upon the aspect, altitude and soil condition are found in the district. Sal forest and coniferous forests are predominant in the western part of tehsil Dehra Dun. Chir is the only coniferous species in the old reserved forests of Dehra Dun. Besides other associates of chir, a few deodar trees are also seen in the district. Wide ranges of sal forest occur in this part of the tehsil. Sal is the main timber species and is generally pure towards the Siwalik ridges. A mixture of miscellaneous species are found in the lower parts.
In the eastern part of tehsil Dehra Dun, the flora may be divided into a number of Botanical divisions mentioned below :

Moist Siwalik Sal Forests :

These forests are found in the Motichur and Thano forest ranges. Low quality of sal is found in these forests. The main associates of sal are bakli and sain.

Moist Bhabar Doon Sal Forests :

These forests are found in a large areas in Thano and Barkot forest ranges. Sal is pure in the overwood and its typical associates are sain and dhauri. the underwood growth includes karaunda and chameli.

West gangetic Moist Deciduous Forests :

These are found in the Kansro, Barkot, Motichur and Thano forest ranges. These are closed forests from medium to good height. The main associates of sal are safed siris, jhingan, bohera and dhauri.

Dry Siwalik Sal Forests :

These forests are found on the higher slopes of Siwaliks. In Chakrata tehsil they occur near the junction of the Tons and the Yamuna rivers in the neighborhood of Kalsi. Sal is the predominant species mixed with other associates viz. bakli, sain, haldu, jhingan etc.
Besides the above many other types of forests occur in small belts in the plain of the district.

RIVERS, CANALS AND WATERWAYS

The Siwalik (outer and lower ranges of Himalayas) lies at its feet, the outer- scrap of the Himalayas bound it on the north and the scared Ganga and the Yamuna skirt in on the east and the west respectively. The Ganga enters the district in the eastern Dun at Tapoban and meandering south-west goes to Hardwar via Raiwala near Rishikesh. The Yamuna enters the district in Jaunsar and flows southwards for about 32 kms on the south-east border of the district. Besides Ganga and yamuna, the other rivers that flow in the district are Asan, Suswa, Tons, Rispana, Bindal and Amalava.

INSTITUTIONS

Some important institutions are located in Dehradun that provide research facilities and elaborate libraries with some of the best museums. A list of such institutions is given below :

- Forest Research Institute
- Indian Miltary Academy
- Wadia Institute of Himalayan Geology
- Zoological Survey Of India
- Anthropological Survey of India
- Archeological Survey of India
- Botanical Survey Of India
- Central Soil and Water Conservation Research & Training Institute
- Defence Electronics Applications Laboratory (DEAL)
- Indian Institute of Petroleum
- Instrument Research and Development Establishment (IRDE)
- National Institute of Visually Handicapped (NIVH)
- Oil & Natural Gas Corporation Ltd.
- Keshava Deva Malviya Institute of Petroleum Exploration
- Rastriya Indian Military College
- Survey Of India

- Wildlife Institute of India
- Indian Institute of Remote Sensing
- Lal Bahadur Shastri National Academy of Administration
- Indira Gandhi National Forest Academy (IGNFA)
- Indian Council of Forestry Research and Education (ICFRE)

Census-1991

Dehradun District (Total)			
Details	Total	Males	Females
Area in Sq.Kms	3088		
No. of occupied residential houses	1,89,302		
No. of households	1,91,089		
Total Population	10,25,679	5,56;432	4,69,247
SC Population	1,37,464	74,251	63,213
ST Population	84,076	44,510	39,566
Population below 7 years of age	1,66,172	85,489	80,683
Literates	5,97,388	3,67,114	2,30,274
Total Workers	3,32,552	2,81,867	50,685
Cultivators	74,593	49,268	25,325
Agricultural Labourers	31,582	26,136	5,446
WorkersLivestock,Forestry etc	11,192	10,091	1,101
Workers:Mining Quarrying	732	723	9
Workers:Maf.Pro.In H.H.Industry	2,857	2,276	581
Workers:Maf.Pro.other that H.H.I.	37,719	35,248	2,471
Construction Workers	15,886	15,407	479
Trade & Commerce Workers	38,956	37,330	1,626
Transport,Storage & Commu.workers	14,769	14,518	251
Workers in other services	1,04,266	90,870	13,396
Marginal Workers	21,743	3,205	18,538
Non-Workers	6,71,384	2,71,360	4,00,024

Dehradun District (Urban)			
Details	Total	Males	Females
Area in Sq.Kms	2940		
No. of occupied residential houses	1,00,970		
No. of households	1,02,024		
Total Population	5,15,480	2,82,320	2,33,160
SC Population	60,177	32,390	27,787
ST Population	3,071	1,824	1,247
Population below 7 years of age	74,446	38,350	36,096
Literates	3,57,420	2,12,157	1,45,263
Total Workers	1,54,452	1,40,188	14,264
Cultivators	1,989	1,717	272
Agricultural Labourers	2,818	2,511	307
Workers:Livestock,Forestry etc	4,926	4,650	276
Workers:Mining & Quarrying	308	301	7
Workers:Maf.& Pro. In H.H.Industry	979	701	287
Workers:Maf.& Pro.other that H.H.I.	24,543	23,184	1,359
Construction Workers	8,944	8,676	268
Trade & Commerce Workers	30,311	29,140	1,171
Transport,Storage & Commu.workers	9,813	9,709	174
Workers in other services	69,751	59,599	10,152
Marginal Workers	1,209	395	814
Non-Workers	3,59,819	1,41,737	2,18,082

Dehradun District (Rural)			
Details	Total	Males	Females
Area in Sq.Kms	148		
No. of occupied residential houses	88,332		
No. of households	89,065		
Total Population	5,10,199	2,74,112	2,36,087
SC Population	77,287	41,861	35,426
ST Population	81,005	42,686	38,319

Population below 7 years of age	91,726	47,139	44,587
Literates	2,39,968	1,54,957	85,611
Total Workers	1,78,100	1,41,679	36,421
Cultivators	72,604	47,551	25,053
Agricultural Labourers	28,764	43,625	5,139
Workers:Livestock,Forestry etc	6,266	5,441	825
Workers:Mining & Quarrying	424	422	2
Workers:Maf.& Pro. In H.H.Industry	1,878	1,575	303
Workers:Maf.& Pro.other that H.H.I.	13,176	12,064	1,112
Construction Workers	6,942	6,731	211
Trade & Commerce Workers	8,645	8,190	455
Transport,Storage & Commu.workers	4,886	4,809	77
Workers in other services	34,515	31,271	3,244
Marginal Workers	20,534	2,810	17,724
Non-Workers	3,11,565	1,29,623	1,81,942

Dehradun District (Chakrata Blk)			
Details	Total	Males	Females
Area in Sq.Kms	144.33		
No. of occupied residential houses	6,364		
No. of households	6,445		
Total Population	49,097	26,341	22,756
SC Population	13,644	7,291	6,353
ST Population	31,929	16,705	15,224
Population below 7 years of age	10,309	5,151	5,158
Literates	10,621	8,446	2,175
Total Workers	23,333	15,618	7,715
Cultivators	18,129	11,221	6,908
Agricultural Labourers	2,168	1,556	612
Workers:Livestock,Forestry etc	450	415	35
Workers:Mining & Quarrying	6	6	0

Workers:Maf.& Pro. In H.H.Industry	106	94	12
Workers:Maf.& Pro.other that H.H.I.	133	128	5
Construction Workers	472	470	2
Trade & Commerce Workers	347	331	16
Transport,Storage & Commu.workers	147	144	3
Workers in other services	1,375	1,253	122
Marginal Workers	3,708	307	3,401
Non-Workers	22,056	10,416	11,640

Dehradun District (Vikasnagar Blk)			
Details	Total	Males	Females
Area in Sq.Kms	225.52		
No. of occupied residential houses	18,179		
No. of households	18,288		
Total Population	97,771	52,796	44,975
SC Population	12,404	6,706	5,698
ST Population	12,425	6,867	5,558
Population below 7 years of age	18,326	9,529	8,797
Literates	40,057	26,606	13,451
Total Workers	33,188	27,760	5,428
Cultivators	11,118	8,089	3,029
Agricultural Labourers	9,254	7,641	1,613
Workers:Livestock,Forestry etc	2,463	2,358	105
Workers:Mining & Quarrying	88	88	0
Workers:Maf.& Pro. In H.H.Industry	401	314	87
Workers:Maf.& Pro.other that H.H.I.	954	897	57
Construction Workers	1,448	1,430	18
Trade & Commerce Workers	1,556	1,489	67
Transport,Storage & Commu.workers	761	758	3
Workers in other services	5145	4,696	449
Marginal Workers	4,672	665	4,007
Non-Workers	59,911	24,371	35,540

Dehradun District (Sahaspur Blk)

Details	Total	Males	Females
Area in Sq.Kms	354.54		
No. of occupied residential houses	19,001		
No. of households	19,043		
Total Population	1,02,315	54,242	48,073
SC Population	13,444	7,281	6,163
ST Population	1,273	680	593
Population below 7 years of age	17,865	9,083	8,782
Literates	52,681	32,429	20,252
Total Workers	30,389	26,066	4,323
Cultivators	7,903	5,609	2,294
Agricultural Labourers	6,783	6,006	777
Workers:Livestock,Forestry etc	1,167	1,040	127
Workers:Mining & Quarrying	130	129	1
Workers:Maf.& Pro. In H.H.Industry	410	357	53
Workers:Maf.& Pro.other that H.H.I.	2,745	2,493	252
Construction Workers	1,310	1,277	33
Trade & Commerce Workers	1,698	1,655	43
Transport,Storage & Commu.workers	949	926	23
Workers in other services	7,294	6,574	720
Marginal Workers	3,097	549	2,548
Non-Workers	68,829	27,627	41,202

Dehradun District (Raipur Blk)

Details	Total	Males	Females
Area in Sq.Kms	295.32		
No. of occupied residential houses	27,624		
No. of households	27,990		
Total Population	1,44,714	77,966	66,748
SC Population	19,002	10,384	8,618

ST. Population	425	257	168
Population below 7 years of age	23,526	12,126	11,400
Literates	89,515	54,211	35,304
Total Workers	43,365	37,713	5,652
Cultivators	5,854	4,115	1,739
Agricultural Labourers	3,219	2,727	492
Workers:Livestock,Forestry etc	927	798	129
Workers:Mining & Quarrying	187	184	3
Workers:Maf.& Pro. In H.H.Industry	613	544	69
Workers:Maf.& Pro.other that H.H.I.	8,564	7,690	874
Construction Workers	2,735	2,627	108
Trade & Commerce Workers	3,986	3,720	266
Transport,Storage & Commu.workers	2,070	2,036	34
Workers in other services	15,210	13,272	1,938
Marginal Workers	1,784	305	1,479
Non-Workers	99,565	39,948	59,617

Dehradun District (Doiwala Blk)

Details	Total	Males	Females
Area in Sq.Kms	188.01		
No. of occupied residential houses	18,129		
No. of households	18,287		
Total Population	1,02,749	55,656	47,093
SC Population	12,073	6,664	5,409
ST Population	2,338	1,261	1,077
Population below 7 years of age	16,393	8,455	7,938
Literates	60,844	38,472	22,372
Total Workers	34,766	28,465	6,301
Cultivators	12,101	7,918	4,183
Agricultural Labourers	6,101	4,729	1,372
Workers:Livestock,Forestry etc	565	541	24
Workers:Mining & Quarrying	12	12	0
Workers:Maf.& Pro. In H.H.Industry	230	195	35
Workers:Maf.& Pro.other that H.H.I.	4,107	3,986	121
Construction Workers	664	656	8

Trade & Commerce Workers	1,486	1,428	58
Transport,Storage & Commu.workers	1,124	1,105	19
Workers in other services	8,376	7,895	481
Marginal Workers	2,890	435	2,455
Non-Workers	65,093	26,756	38,337

Important District Indicators

GENERAL

Headquarter Dehradun

Total area	3088.00	sq.km.	Relative CMIE Index of Developement	142.00
Forest area	2200.56	sq.km.	Population Growth per annum	2.91
Net sown area	550.57	sq.km.	Population density(persons/sq.km)	332.00
Net Irri. area	217.53	sq.km.	Urbanisation	50.26
Occupied Houses	189.30	thousand	Literacy	69.50
Total Population	1025.68	thousand	Male literacy	77.95
Total Males	556.43	thousand	Female literacy	59.26
Total Females	469.25	thousand	Urban literacy	81.04
Urban Population	515.48	thousand	Rural literacy	57.34
Urban Pop Male	282.32	thousand	Workers as % of total population	34.54
Urban Pop Female	233.16	thousand	Agriculture & allied activ.	35.29
Rural Population	510.20	thousand	Mining & quarrying	0.22
Rural Pop Male	274.11	thousand	Mfg.(non-household) industries	11.34
Rural Pop Female	236.09	thousand	Households industries	0.86
Total Literates	597.39	thousand	Construction workers	4.78
Tot Male Lits	367.11	thousand	Other services	47.51
Tot Fem Lits	230.27	thousand	Forest area as % of reporting area	69.76
Rur Literates	239.97	thousand	Net sown area as % of reporting area	17.45
Rur Male Lits	154.96	thousand	Gross Irri.area as % of reporting area	38.78
Rur Fem Lits	85.01	thousand	Average size of operational holding	0.92
Urban Literates	357.42	thousand	Fertiliser consumption per Hect.	46.00
Urban Male Lits	212.16	thousand	Value of output of major crops/hecta	4282.00
Urban Fem Lits	145.26	thousand	Value of output of major crops/capit	357.00
Rur Male Litcy	68.27	%	Per capita food grains production	93.00
Rur Fem Literacy	44.39	%	Road length per 100 sq.kms	40.12

Urb Male Litcy	86.96	%	Post offices per lakh population	23.40
Urb Fem Literacy	73.71	%	Telegraph offices per lakh population	7.12
Total Workers	354.30	thousand	Bank branches per lakh population	13.36
Main workers	332.55	thousand	Per capita bank deposits	10105.00
Total SC Pop	137.46	thousand	Per capita bank credit	1891.00
SC Pop Rural	77.29	thousand	Per capita bank credit to agricultur	244.00
SC Pop Urban	60.18	thousand	Per hectare bank credit to agricultu	2923.00
Total ST Pop	84.08	thousand	Per capita bank credit to SSI	124.00
ST Pop Rural	81.00	thousand	Per Capita Bank Credit to Industries	901.00
ST Pop Urban	3.07	thousand		

TOWNS, VILLAGES AND AMENITIES

The district, at present comprises of 6 Tehsils, namely Dehradun, Chakrata, Vikasnagar, Kalsi, Tyuni and Rishikesh And 6 Community Development blocks, viz, Chakrata, Kalsi, Vikasnagar, Sahaspur, Raipur and Doiwala. It has 17 towns and 764 villages (746 inhabited villages and 18 uninhabited villages).

The urban population of the district as percentage of total population in the census years 1981 and 1991 is indicated below. It also shows the sex ratio (females per 1000 males) and density (population per sq km) in the urban population of the district.

District	Urban Population % of total population		Sex ratio 1991 (Females per 1000 males)			Density Population per sq.km.
	1981	1991	Total	Rural	Urban	
Dehradun	48.86	50.68	851	878	825	329

Amenities:

Number (with percentage) of villages having one or more amenities in the district as per 1991 census follow:

S.NO.	Amenities	No. inhabited villages	%
1	Education	541	72.52
2	Medical	732	98.12
3	Drinking Water	746	100
4	Post and Telegraph	185	24.8
5	Market/Hat	78	10.46
6	Communications	299	40.08

7	Approach by Pucca Road	305	40.88
8	Power supply	685	91.82

COMMUNICATIONS

The district is served by roads and to some extent by rails. Dehra Dun and Rishikesh are the two railway terminials of the northern railway. The length of railway line in Dehra Dun district is 64.50 kms. The district is served by a total length of 2383 kms of roads. Of the total road length the State Public Works Department manages 1528 kms of which State Highway accounts for 144 kms., main district roads 265 km other district and village roads 1119 kms. Besides 501 kms of roads are managed by the local bodies and about 354kms managed by other state departments.

AGRICULTURE AND IRRIGATION

Agriculture in the Dun Valley is carried on the same way as in the plains, but in the hill areas, it requires hard labour and skill. The facilities for irrigation from canals and rivers are abundant but there is great deficiency of manure. Cultivation in the hill tract of Dehra Dun tehsil and throughout the Jaunsar Bhabar area is ,of two descriptions, regular and intermittent. The hills, however, contain very little level ground and terraced cultivation is therefore, the rule. Intermittent cultivation consists of small patches of hill sides cleared of shrubs and grass usually by fire. These patches are cultivated for a year or so and then left fallow both to recuperate and also to enable the coarse grass to grow. In the district there are two harvests, the kharif sown in June or little earlier in the hills and reaped in September and October and the rabi sown in October-November and reaped in march in the plains and in April and May in the hills. Paddy is one of the most important kharif food crops in the district. Many kinds of rice are sown in the area, both superior and interior. The district is famous for its basmati rice. Other important kharif crops are maize, mandus, jhangora, sonk, urd, kulath, tor (arhar) and sugar cane. Wheat is the principal crop of rabi and is grown in almost all parts of the district. Barley and mustard are other important rabi crops.
The important fruits grown in the district are the mango, guava, peach, grape, strawberry, pear, lemon and litchi. Dehra Dun is famous for its litchi. Among vegetables, potato is the most important crop. Potato cultivation in the Mussoorie hills is an old and established industry. Besides, catering to the needs of the town of the district, a considerable portion of the production of potato is exported to other districts of the state.

ANIMAL HUSBANDRY

Live stock plays an important role in rural areas in raising the income of mall scale farmers. Cows and buffaloes are the main sources of milk, while male cattle are used for ploughing the fields. Sheep and goats are also reared in great number, both for meat and wool. Wool is of immense importance and is used for making home-spun woollen cloth and blankets. The production of milk per milch animal is very low. Action is being taken for the improvement of breed of the cattle. There is ample scope for poultry development in the district.

INDUSTRIES

Tourist Industry possesses tremendous possibilities of development. On the one hand, there are beautiful hill resorts like "Queen of Hills-Mussoorie", Chakrata there are places like Sahasra Dhara, famous for its sulphur springs, religious and ancient places like Rishikesh and Lakhmandal, Dak Pathar-ideal picnic spot and Kalsi - place of historical importance of Ashoka's edic.
Many institutions of national importance like the Forest Research Institute; Oil and Natural Gas Commission; Indain Military Academy; Indian Institute of Petroleum and Survey of India etc. are located in Dehra Dun which makes it a place of national importance attracting tourists in large numbers.
A variety of items are produced in small scale units of industries like dairy, canning and preservation, bakery, chocolate, khandsari, teal, malt, textiles, card board boxes, printing, timber goods, steel furniture, liquor, ayurvedic medicines, resin and turpentine, tubes, leather products, musical instruments, optical lenses, miniature bulbs, medical instruments, agricultural implements, utensils and hospital equipments, sewing machines, metal goods and plaster of paris etc.
In therural areas of the district a number of cottage and village industries like wool industry, handloom cloth, powerloom, durries, tailoring, oil, gur, rice, apiary, baskets, cots and mats, walking sticks, pottery, brick kilns, smithy, leather flourish etc.
Under the sericulture scheme the Government Control Silk Farm was established at Prem nagar in the district. The farm distributes healthy mulberry trees to the silk worm rearers in the district and a good amount is earned from the production of cocoons.

TRADE, COMMERCE AND EXPORT

The table given below shows most important commodity manufactured in imported into and exported from towns of the district.

Name of the towns	Most important commodity		
	Manufactured	Exported	Imported
Chakrata Cantt.	Wollen garments	Potato	Cotton Cloth
Celement town	Soap	Soap	Foodgrains
Dehra Dun	Bulbs	Bulbs	Coal
Dehra dun Cantt.	Carpets	Lime	Rice
Landour Cantt.	Woollen Wear	Wood	Foodgrains
Rishikesh	Plaster of paris	Limestone	Potatoes
Vikasnagar	Gur	Rice	Ginger
Virbhadra	Medicines	Medicines	Sugar

The important commodities manufactured are woollen wears, bulbs, carpets, soap, walking sticks, plaster of paris, gur and medicines. There are also the important commodities which are largely exported. The important items imported are foodgrains, glass, cotton cloth, coal,potato, ginger and sugar.

FAIRS AND FESTIVALS

Important fairs and festivals organised in different ports of the district are mentioned below : Deviji, Bissu, Jagra, Panchon, Gandhi Mela, Chandarbani, Ambika Devi, Jhanda Mela, Bawari, Jyaistha Dusshehra, Mata Bhadraj, Maru Sidh, Shivratri, Tapkeshwar sidh, Laxman Sidh.

EDUCATION

The ratio of 5.11 Primary Schools per 10000 population is obtained in urban areas of the district ranging between the maximum of 15.93 in Mussoorie and the minimum of 0.65 in Clement town Cantt.

The ratio of Middle Schools works out to 2.42 per 10000 if urban population in the district. The maximum ratio of 6.09 Middle Schools is observed in Majra and the minimum of 0.65 in Clement town Cantt.

For every 10000 of urban population there are 1.45 schools of Matriculation Standard. With 5.24 schools of Matriculation Standard, Landour Cantt. presents the highest proportion per 10000 of population.

The ratio of intermediate Colleges works out to 0.94 colleges in urban areas of the district. The maximum ration of 5.24 colleges is observed in Landour Cantt. Thus Landour Cantt. Shows the highest ratio per 10000 of population of schools of Matriculation Standard and Intermediate Colleges.

Solid wastes & Types

Introduction

In the past decades, science fiction (horror) writers used to spawn monsters from putrifying garbage dumps- usually the creature was catalysed by a violent electrical storm acting on the rotting mass of waste. Our times have a way of making science fiction come true- the monster is here! One arm is the sheer volume of Solid Wastes, the other is the environmental contamination resulting from improper interment of wastes in landfills, and the third is the rising cost of disposal. To tackle this 'monster' we need to identify it, its origin, its dynamics, impacts and characteristics. Thus arises the question, what is Solid Waste?

Solid Waste (SW)

Solid Wastes are unwanted materials disposed of by man, which can neither flow into streams nor escape immediately into the atmosphere. These non-gaseous and non-liquid residues result from various human activities. These cause pollution in water, soil and air. Waste is an unavoidable consequence of satisfying man's needs for food, water, air, space, shelter, and mobility. In any material process, by product recovery or recycling can substantially alter waste quantity and quality, but all processes eventually produce some waste. Though generation of SW is not a new phenomenon, it has acquired a danger status of being "third pollution" after air pollution and water pollution with progress in industrialization and population explosion.
Earlier the major constituents of SW were domestic wastes and agricultural residues which are both biodegradable. Since there was much fallow land, SW could be conveniently disposed of on ground or in pits covered with layers of earth. However, since 1960s, not only has the quantity of SW increased but its quality has also changed. Though rural wastes continue to be mainly made of domestic and agricultural wastes, wastes from urban areas and the industrial units contain diverse types of materials which include toxic and hazardous materials. SW is generated because of human activities. Depending upon their origin, the wastes could be grouped under four heads namely agricultural wastes, domestic wastes, municipal waste sand industrial wastes.

QUANTUM AND NATURE OF SOLID WASTE

Per capita waste generation ranges between 0.2 kg and 0.6 kg per day in the Indian cities amounting to about 1.15 lakh MT of waste per day and 42 million MT annually. Also, as the city expands, average per capita waste generation increases (Tables 8.1 and 8.2).

Waste Generation per Capita in Indian cities

Population range (in million)	Average per capita waste generation gms/ capita/ day
0.1 to 0.5	210
0.5 to 1.0	250
1.0 to 2.0	270
2.0 to 5.0	350
5.0 plus	500

Source: NEERI (1995)

Waste Quantities and Waste Generation Rates in
1 million plus Cities and State Capitals

City	Waste quantity generated (MT/d)	Waste generation rate (kg/c/d/)
Vadodara*	157.33	0.12
Kohima	12.48	0.16
Nashik	200	0.19
Lucknow	474.59	0.21
Guwahati	166.25	0.21
Gandhinagar	43.62	0.225
Jabalpur	216.19	0.23
Ranchi	208.27	0.246
Nagpur	503.85	0.25
Dehradun	131	0.29
Raipur	184.27	0.3
Indore	556.51	0.35
Bhubaneshwar	234.46	0.36
Patna	510.94	0.37
Ahmedabad	1302	0.37
Faridabad	448.01	0.38
Dhanbad	77.12	0.387
Bangalore	1669	0.39
Bhopal	574.07	0.4
Agartala	77.36	0.4
Asansol	206.65	0.425
Daman	15.2	0.43
Meerut	490	0.46
Agra	653.57	0.49
Allahabad	509.24	0.51
Ludhiana	734.37	0.53
Jamshedpur	387.98	0.59
Visakhapatanam	600	0.62

Notes: MT/d: metric tonnes per day; kg/c/d: kilograms per capita per day.
*The reporting does not seem to be true. It should be in the range of 0.3 (kg/c/d) kilograms per capita per day looking at the size of the city and commercial activities carried out therein.
Source: Akolkar (2005)

Solid waste can be classified into different types depending on their source:
a) Household waste is generally classified as municipal waste,
b) Industrial waste as hazardous waste, and
c) Biomedical waste or hospital waste as infectious waste.

Municipal solid waste

Municipal solid waste consists of household waste, construction and demolition debris, sanitation residue, and waste from streets. This garbage is generated mainly from residential and commercial complexes. With rising urbanization and change in lifestyle and food habits, the amount of municipal solid waste has been increasing rapidly and its composition changing. In 1947 cities and towns in India generated an estimated 6 million tonnes of solid waste, in 1997 it was about 48 million tonnes. More than 25% of the municipal solid waste is not collected at all; 70% of the Indian cities lack adequate capacity to transport it and there are no sanitary landfills to dispose of the waste. The existing landfills are neither well equipped or well managed and are not lined properly to protect against contamination of soil and groundwater.

Over the last few years, the consumer market has grown rapidly leading to products being packed in cans, aluminium foils, plastics, and other such nonbiodegradable items that cause incalculable harm to the environment. In India, some municipal areas have banned the use of plastics and they seem to have achieved success. For example, today one will not see a single piece of plastic in the entire district of Ladakh where the local authorities imposed a ban on plastics in 1998. Other states should follow the example of this region and ban the use of items that cause harm to the environment. One positive note is that in many large cities, shops have begun packing items in reusable or biodegradable bags. Certain biodegradable items can also be composted and reused. In fact proper handling of the biodegradable waste will considerably lessen the burden of solid waste that each city has to tackle.

Garbage: the four broad categories

Organic waste: kitchen waste, vegetables, flowers, leaves, fruits.

Toxic waste: old medicines, paints, chemicals, bulbs, spray cans, fertilizer and pesticide containers, batteries, shoe polish.

Recyclable: paper, glass, metals, plastics.

Soiled: hospital waste such as cloth soiled with blood and other body fluids.

There are different categories of waste generated, each take their own time to degenerate (as illustrated in the table below).

The type of litter we generate and the approximate time it takes to degenerate

Type of litter	Approximate time it takes to degenerate the litter
Organic waste such as vegetable and fruit peels, leftover foodstuff, etc.	a week or two.

Paper	10–30 days
Cotton cloth	2–5 months
Wood	10–15 years
Woolen items	1 year
Tin, aluminium, and other metal items such as cans	100–500 years
Plastic bags	one million years?
Glass bottles	undetermined

Hazardous waste

Industrial and hospital waste is considered hazardous as they may contain toxic substances. Certain types of household waste are also hazardous. Hazardous wastes could be highly toxic to humans, animals, and plants; are corrosive, highly inflammable, or explosive; and react when exposed to certain things e.g. gases. India generates around 7 million tones of hazardous wastes every year, most of which is concentrated in four states: Andhra Pradesh, Bihar, Uttar Pradesh, and Tamil Nadu.

Household waste that can be categorized as hazardous waste include old batteries, shoe polish, paint tins, old medicines, and medicine bottles.

Hospital waste contaminated by chemicals used in hospitals is considered hazardous. These chemicals include formaldehyde and phenols, which are used as disinfectants, and mercury, which is used in thermometers or equipment that measure blood pressure. Most hospitals in India do not have proper disposal facilities for these hazardous wastes.

In the industrial sector, the major generators of hazardous waste are the metal, chemical, paper, pesticide, dye, refining, and rubber goods industries.

Direct exposure to chemicals in hazardous waste such as mercury and cyanide can be fatal.

Hospital waste

Hospital waste is generated during the diagnosis, treatment, or immunization of human beings or animals or in research activities in these fields or in the production or testing of biological. It may include wastes like sharps, soiled waste, disposables, anatomical waste, cultures, discarded medicines, chemical wastes, etc. These are in the form of disposable syringes, swabs, bandages, body fluids, human excreta, etc. This waste is highly infectious and can be a serious threat to human health if not managed in a scientific and discriminate manner. It has been roughly estimated that of the 4 kg of waste generated in a hospital at least 1 kg would be infected.

Surveys carried out by various agencies show that the health care establishments in India are not giving due attention to their waste management. After the notification of the Bio-medical Waste (Handling and Management) Rules, 1998, these establishments are slowly streamlining the process of waste segregation, collection, treatment, and disposal. Many of the larger hospitals have either installed the treatment facilities or are in the process of doing so.

Agricultural Wastes

In India, the main sources of agricultural wastes are wheat straw, paddy straw, maize straw, sugarcane trash, rice and wheat bran, maize cobs, left over from pulses etc. There has been a great increase in the generation of crop residues and allied wastes. The total production of agro-residues and by products during 1985 was estimated to be 320 million tones.

Industrial Wastes

Huge amount of industrial SW are usually produced by different industries. The estimated SW of industrial origin contribute only 10% of the total wastes generated, the bulk is liquid.

Domestic and Municipal Wastes

There are different sources of the Municipal Solid Wastes (MSW): domestic, market community facilities etc. The amount of MSW generated is dependent on the public- habits which can vary from country to country and even among towns e.g. the per capita production of MSW is much greater in the USA in comparison to other Western countries as well as Asian countries. In India, per capita MSW production in metropolitan cities is significantly high in comparison to the towns and villages. Average MSW production is about 0.33 kg/capita/day in India.

Table: Solid Wastes produced by Human Activities

	Human activities	Example of wastes liberated
1	Agricultural	Plant remains, processing wastes, animal wastes.
2	Domestic	Garbage, rubbish, wastes produced at home from cooking etc.
3	Municipal	Street sweepings, wastes from schools, offices and other institutions.
4	Industrial	Wastes produced by mining operations, manufacturing and construction works.

Waste Characteristics

The waste characteristics in developing nations vary considerably from that in developed countries. The United States, with only 4.6% of the world's population, produces about 33 of the world's SW (Miller, 2004).(Table 1.2). About 1/5th of India's total population lives in urban agglomerations and generates approximately 15 million tones of SW every year
An important and increasing component of domestic refuse has been *plastic* waste. About 100 g per week of waste plastics have been thrown away per dwelling, but the nuisance caused by waste plastics is far greater than suggested by the moderate quantities involved. Plastics do not rot. Although they can be burned, PVC (polyvinyl chloride) is particularly objectionable in that it forms highly corrosive hydrochloric acid when burned. It is even possible for highly poisonous phosgene to be introduced.

Table: Some typical MSW generation rates

Country	Kg/capita/year
Australia	690
France	530
Germany	590
Italy	510
Japan	410
Portugal	440
Spain	650
Sweden	470
Switzerland	660
UK	580
USA	730

The density of SW in India is very high (300- 560 kg/ cubic m.). The metal content is less than 1%. The average calorific value of urban SW is low (1500 kcal/ kg). The per capita generation of SW in Indian cities ranges from 0.15 to 0.25 kg/day.

Classification of Solid Wastes

SW can be classified into various heads as given here under:

a) Garbage: Putrescible (decomposable) wastes from food, slaughter houses, canning, and freezing industries etc.

b) Rubbish: Non-putrescible wastes, either combustible or non-combustible.
Combustible wastes would include paper, wood, cloth, rubber, leather, and garden wastes. Non-combustibles would include metals, glass, ceramics, stones, dirt, masonry and some chemicals.

c)Ashes : Residues (such as cinders and fly ash) of the combustion of solid fuels for heating and cooking or the incineration of SW by municipal, industrial and apartment house incinerators.

d) Large Wastes: Demolition and construction rubble (pipes, plumber, masonry, brick, plastic, roofing and insulating material), automobiles, furniture, refrigerators and other home appliances, trees, tyres etc.

e) Dead animals: Household pets, birds, rodents, zoo animals, etc. there are also anatomical and pathological wastes from hospitals.

f) Sewage Treatment Process Solids: screening, settled solids, sludge.

g) Industrial Solid Wastes: Chemicals, paints, sand, explosives etc.

h) Mining Wastes:' Tailings', slag heaps, culms piles at coal mines etc.

i) Agricultural Wastes: Farm animal manure, crop residues etc.

Table A8.3
Physical Characteristics of Municipal Solid Waste in Indian Cities

Population range (in millions)	No. of cities surveyed	Paper	Rubber, leather and synthetics	Glass	Metal	Total compostable matter	Inert material
0.1 to 0.5	12	2.91	0.78	0.56	0.33	44.57	43.59
0.5 to 1.0	15	2.95	0.73	0.56	0.32	40.04	48.38
1.0 to 2.0	09	4.71	0.71	0.46	0.49	38.95	44.73
2.0 to 5.0	03	3.18	0.48	0.48	0.59	56.67	40.07
5.0 and above	04	6.43	0.28	0.94	0.80	30.84	53.90

Note: All values are in per cent calculated on wet weight basis.
Source: NEERI (1995)

Chemical Characteristics of Municipal Solid Waste in Indian Cities

Population range (in million)	Nitrogen as total Nitrogen	Phosphorous as P_2O_5	Potassium as K_2O	C/N Ratio	Calorific Value kcal/kg.
0.1 to 0.5	0.71	0.63	0.83	30.94	1009.89
0.5 to 1.0	0.66	0.56	0.69	21.13	900.61
1.0 to 2.0	0.64	0.82	0.72	23.68	980.05
2.0 to 5.0	0.56	0.69	0.78	22.45	907.18
5.0 and above	0.56	0.52	0.52	30.11	800.70

Source: NEERI (1995)

Waste Generation in Class 1 Cities with Population above 100,000

Type of cities	Tonnes/day	per cent of total garbage
The 7 mega cities	21,100	18.35
The 28 metro cities	19,643	17.08
The 388 class 1 towns	42,635	37.07
Total	83,378	72.50

Physical Composition of Municipal Solid Waste in 1 million plus Cities and State Capitals in India (average values)

Name of the city	Total compostable	Recyclables				Others including inert						Total
		Paper etc.	Plastic	Glass	Metal	Inert	Rubber and leather	Rags	Wooden matter	Coconut	Bones	
Indore	48.97	6.10	5.77	0.55	0.15	31.02	2.95	2.41	1.17	0.91	0.00	100
Bhopal	52.44	9.01	12.38	0.55	0.39	18.88	0.09	2.65	1.35	2.25	0.01	100
Dhanbad	46.93	7.20	5.56	1.79	1.62	26.93	2.77	4.14	1.56	1.52	0.00	100
Jabalpur	48.07	7.67	8.30	0.35	0.29	26.60	2.15	4.42	1.49	0.66	0.00	100
Jamshedpur	43.36	10.24	5.27	0.06	0.13	30.93	2.51	2.99	4.29	0.22	0.01	100
Patna	51.96	4.78	4.14	2.00	1.66	25.47	1.17	4.17	1.43	2.34	0.89	100
Ranchi	51.49	3.17	3.45	1.79	1.45	25.92	1.45	4.97	2.74	3.19	0.38	100
Bhubaneshwar	49.81	5.74	5.70	0.46	0.79	27.15	2.10	3.21	2.85	2.20	0.00	100
Ahmedabad	40.81	5.28	5.29	0.79	0.30	39.28	0.92	5.00	1.22	1.02	0.10	100
Nashik	39.52	9.69	12.58	1.30	1.54	27.12	1.11	2.53	0.34	4.12	0.15	100
Raipur	51.40	8.31	7.07	0.76	0.16	16.97	1.47	3.90	1.43	6.44	0.08	100
Asansol	50.33	10.66	2.78	0.77	0.00	25.49	0.48	3.05	3.00	2.49	0.95	100
Bangalore	51.84	11.58	9.72	0.78	0.35	17.34	1.14	2.29	2.67	2.28	0.01	100
Agartala	58.57	8.11	4.43	0.98	0.16	20.57	0.76	2.17	0.00	2.56	1.69	100
Agra	46.38	6.12	8.72	0.85	0.11	30.07	1.97	3.92	1.68	0.19	0.00	100
Allahabad	35.49	7.27	10.33	1.23	0.40	31.01	1.83	7.34	2.08	2.74	0.30	100
Daman	29.60	10.54	8.92	2.15	0.410	34.80	2.60	4.90	1.60	4.48	–	100
Faridabad	42.06	8.57	13.73	0.83	0.18	26.52	2.52	4.14	1.26	0.19	–	100
Lucknow	47.41	6.87	7.45	0.92	0.29	18.01	5.38	9.48	2.10	2.09	0.00	100
Meerut	54.54	4.95	54.48	0.30	0.24	27.30	0.49	4.98	0.95	0.66	0.12	100
Nagpur	47.41	6.87	7.45	0.92	0.29	18.01	5.38	9.48	2.10	2.09	–	100
Vadodara	47.43	5.98	7.58	0.47	0.47	27.80	1.28	4.86	1.55	2.58	–	100
Gandhinagar	34.30	5.60	6.40	0.80	0.40	36.50	3.70	5.30	3.70	3.30	–	100
Visakhapatanam	45.96	14.46	9.24	0.35	0.15	20.77	0.47	2.41	0.68	5.51	–	100
Dehradun	51.37	9.56	8.58	1.40	0.03	22.89	0.23	5.60	0.32	–	–	100
Ludhiana	49.80	9.65	8.27	1.03	0.37	17.57	1.01	11.50	0.80	0.00	–	100
Guwahati	53.69	11.63	10.04	1.30	0.31	17.66	0.16	2.18	1.39	1.38	0.26	100
Kohima	57.48	12.28	6.80	2.32	1.26	15.97	0.18	1.86	1.70	0.00	0.35	100

Note: Increasing use of plastics is changing the composition of municipal solid waste and causing harm in the processing of waste. The use of plastics has increased 70 times between 1960 and 1995.
Source: CPCB (2000)

Chemical Characteristics of Municipal Solid Waste plus (Average Values) of 1 million plus Cities and State Capitals.

Name of city	Moisture	ph Range	Volatile matter	C per cent	N per cent	P per cent as P_2O_5	K per cent as K_2O	c/n ratio	hcv Kcal/ kg
Indore	30.87	6.37–9.73	38.02	21.99	0.82	0.61	0.71	29.30	1436.75
Bhopal	42.66	6.99–9.03	35.78	23.53	0.94	0.66	0.51	21.58	1421.32
Dhanbad	50.28	7.11–8.01	16.52	9.08	0.54	0.55	0.44	18.22	590.56
Jabalpur	34.56	5.84–10.94	46.60	25.17	0.96	0.60	1.04	27.28	2051
Jamshedpur	47.61	6.20–8.26	24.43	13.59	0.69	0.54	0.51	19.29	1008.84
Patna	35.95	7.42–8.62	24.72	14.32	0.77	0.77	0.64	18.39	818.82
Ranchi	48.69	6.96–8.02	29.70	17.20	0.85	0.61	0.79	20.37	1059.59
Bhubaneshwar	59.26	6.41–7.62	25.84	15.02	0.73	0.64	0.67	20.66	741.56
Ahmedabad	32	6.2–8.0	63.80	37.02	1.18	0.67	0.42	34.61	1180
Nashik	74.64	5.2–7.0	59	34.22	0.92	0.49	–	38.17	3086.51
Raipur	29.49	6.65–7.99	32.15	18.64	0.82	0.67	0.72	23.50	1273.17
Asansol	54.48	6.44–8.22	17.73	10.07	0.79	0.76	0.54	14.08	1156.07
Bangalore	54.95	6.0–7.7	48.28	27.98	0.80	0.54	1.00	35.12	2385.96
Agartala	60,.06	5.21–7.65	49.52	28.82	9.96	0.53	0.77	30.02	2427
Agra	28.33	6.21–8.1	18.90	10.96	0.52	0.60	0.57	21.56	519.82
Allahabad	18.40	7.13	29.51	17.12	0.88	0.73	0.70	19.00	1180.12
Daman	52.78	5.88–6.61	52.99	30.74	1.38	0.47	0.6	22.34	2588
Faridabad	34.02	6.33–8.25	25.72	14.92	0.80	0.62	0.66	18.58	1319.02
Lucknow	59.87	4.8–9.18	34.04	20.32	0.93	0.65	0.79	21.41	1556.78
Meerut	32.48	6.16–7.95	26.67	15.47	0.79	0.80	1.02	19.24	1088.65
Nagpur	40.55	4.91–7.80	57.10	33.12	1.24	0.71	1.46	26.37	2632.23
Vadodara	24.98	–	34.96	20.28	0.60	0.71	0.38	40.34	1780.51
Gandhinagar	23.69	7.02	44	25.5	0.79	0.62	0.39	36.05	698.02
Visakhapatanam	52.70	7.5–8.7	64.4	37.3	0.97	0.66	1.10	41.70	1602.09
Dehradun	79.36	6.12–7.24	39.81	23.08	1.24	0.91	3.64	25.90	2445.47
Ludhiana	64.59	5.21–7.40	43.66	25.32	0.91	0.56	3.08	52.17	2559.19
Guwahati	70.93	6.41–7.72	34.27	19.88	1.10	0.76	1.06	17.71	1519.49
Kohima	64.93	5.63–7.7	57.20	33.17	1.09	0.73	0.97	30.87	2844

Source: Akolkar (2005)

Physical Characteristics of Municipal Solid Waste in Indian Cities

Population range (in millions)	No. of cities surveyed	Paper	Rubber, leather and synthetics	Glass	Metal	Total compo-stable matter	Inert material
0.1 to 0.5	12	2.91	0.78	0.56	0.33	44.57	43.59
0.5 to 1.0	15	2.95	0.73	0.56	0.32	40.04	48.38
1.0 to 2.0	09	4.71	0.71	0.46	0.49	38.95	44.73
2.0 to 5.0	03	3.18	0.48	0.48	0.59	56.67	40.07
5.0 and above	04	6.43	0.28	0.94	0.80	30.84	53.90

Note: All values are in per cent calculated on wet weight basis.

Source: NEERI (1995)

Physical Composition of Municipal Solid Waste in 1 million plus Cities and State Capitals in India (average values)

Name of the city	Total compostable	Recyclables: Paper, etc.	Plastic	Glass	Metal	Others including inert: Inert	Rubber and leather	Rags	Wooden matter	Coconut	Bones	Total
Indore	48.97	6.10	5.77	0.55	0.15	31.02	2.95	2.41	1.17	0.91	0.00	100
Bhopal	52.44	9.01	12.38	0.55	0.39	18.88	0.09	2.65	1.35	2.25	0.01	100
Dhanbad	46.93	7.20	5.56	1.79	1.62	26.93	2.77	4.14	1.56	1.52	0.00	100
Jabalpur	48.07	7.67	8.30	0.35	0.29	26.60	2.15	4.42	1.49	0.66	0.00	100
Jamshedpur	43.36	10.24	5.27	0.06	0.13	30.93	2.51	2.99	4.29	0.22	0.01	100
Patna	51.96	4.78	4.14	2.00	1.66	25.47	1.17	4.17	1.43	2.34	0.89	100
Ranchi	51.49	3.17	3.45	1.79	1.45	25.92	1.45	4.97	2.74	3.19	0.38	100
Bhubaneshwar	49.81	5.74	5.70	0.46	0.79	27.15	2.10	3.21	2.85	2.20	0.00	100
Ahmedabad	40.81	5.28	5.29	0.79	0.30	39.28	0.92	5.00	1.22	1.02	0.10	100
Nashik	39.52	9.69	12.58	1.30	1.54	27.12	1.11	2.53	0.34	4.12	0.15	100
Raipur	51.40	8.31	7.07	0.76	0.16	16.97	1.47	3.90	1.43	6.44	0.08	100
Asansol	50.33	10.66	2.78	0.77	0.00	25.49	0.48	3.05	3.00	2.49	0.95	100
Bangalore	51.84	11.58	9.72	0.78	0.35	17.34	1.14	2.29	2.67	2.28	0.01	100
Agartala	58.57	8.11	4.43	0.98	0.16	20.57	0.76	2.17	0.00	2.56	1.69	100
Agra	46.38	6.12	8.72	0.85	0.11	30.07	1.97	3.92	1.68	0.19	0.00	100
Allahabad	35.49	7.27	10.33	1.23	0.40	31.01	1.83	7.34	2.08	2.74	0.30	100
Daman	29.60	10.54	8.92	2.15	0.410	34.80	2.60	4.90	1.60	4.48	–	100
Faridabad	42.06	8.57	13.73	0.83	0.18	26.52	2.52	4.14	1.26	0.19	–	100
Lucknow	47.41	6.87	7.45	0.92	0.29	18.01	5.38	9.48	2.10	2.09	0.00	100
Meerut	54.54	4.95	54.48	0.30	0.24	27.30	0.49	4.98	0.95	0.66	0.12	100
Nagpur	47.41	6.87	7.45	0.92	0.29	18 01	5.38	9.48	2.10	2.09	–	100
Vadodara	47.43	5.98	7.58	0.47	0.47	27.80	1.28	4.86	1.55	2.58	–	100
Gandhinagar	34.30	5.60	6.40	0.80	0.40	36.50	3.70	5.30	3.70	3.30	–	100
Visakhapatanam	45.96	14.46	9.24	0.35	0.15	20.77	0.47	2.41	0.68	5.51	–	100
Dehradun	51.37	9.56	8.58	1.40	0.03	22.89	0.23	5.60	0.32	–	–	100
Ludhiana	49.80	9.65	8.27	1.03	0.37	17.57	1.01	11.50	0.80	0.00	–	100
Guwahati	53.69	11.63	10.04	1.30	0.31	17.66	0.16	2.18	1.39	1.38	0.26	100
Kohima	57.48	12.28	6.80	2.32	1.26	15.97	0.18	1.86	1.70	0.00	0.35	100

Note: Increasing use of plastics is changing the composition of municipal solid waste and causing harm in the processing of waste. The use of plastics has increased 70 times between 1960 and 1995.

Source: CPCB (2000)

Chemical Characteristics of Municipal Solid Waste in Indian Cities

Population range (in million)	Nitrogen as total Nitrogen	Phosphorous as P_2O_5	Potassium as K_2O	C/N Ratio	Calorific Value kcal/kg
0.1 to 0.5	0.71	0.63	0.83	30.94	1009.89
0.5 to 1.0	0.66	0.56	0.69	21.13	900.61
1.0 to 2.0	0.64	0.82	0.72	23.68	980.05
2.0 to 5.0	0.56	0.69	0.78	22.45	907.18
5.0 and above	0.56	0.52	0.52	30.11	800.70

Source: NEERI (1995)

Chemical Characteristics of Municipal Solid Waste plus (Average Values) of 1 million plus Cities and State Capitals.

Name of city	Moisture	ph Range	Volatile matter	C per cent	N per cent	P per cent as P_2O_5	K per cent as K_2O	c/n ratio	hcv Kcal/ kg
Indore	30.87	6.37–9.73	38.02	21.99	0.82	0.61	0.71	29.30	1436.75
Bhopal	42.66	6.99–9.03	35.78	23.53	0.94	0.66	0.51	21.58	1421.32
Dhanbad	50.28	7.11–8.01	16.52	9.08	0.54	0.55	0.44	18.22	590.56
Jabalpur	34.56	5.84–10.94	46.60	25.17	0.96	0.60	1.04	27.28	2051
Jamshedpur	47.61	6.20–8.26	24.43	13.59	0.69	0.54	0.51	19.29	1008.84
Patna	35.95	7.42–8.62	24.72	14.32	0.77	0.77	0.64	18.39	818.82
Ranchi	48.69	6.96–8.02	29.70	17.20	0.85	0.61	0.79	20.37	1059.59
Bhubaneshwar	59.26	6.41–7.62	25.84	15.02	0.73	0.64	0.67	20.66	741.56
Ahmedabad	32	6.2–8.0	63.80	37.02	1.18	0.67	0.42	34.61	1180
Nashik	74.64	5.2–7.0	59	34.22	0.92	0.49	–	38.17	3086.51
Raipur	29.49	6.65–7.99	32.15	18.64	0.82	0.67	0.72	23.50	1273.17
Asansol	54.48	6.44–8.22	17.73	10.07	0.79	0.76	0.54	14.08	1156.07
Bangalore	54.95	6.0–7.7	48.28	27.98	0.80	0.54	1.00	35.12	2385.96
Agartala	60,.06	5.21–7.65	49.52	28.82	9.96	0.53	0.77	30.02	2427
Agra	28.33	6.21–8.1	18.90	10.96	0.52	0.60	0.57	21.56	519.82
Allahabad	18.40	7.13	29.51	17.12	0.88	0.73	0.70	19.00	1180.12
Daman	52.78	5.88–6.61	52.99	30.74	1.38	0.47	0.6	22.34	2588
Faridabad	34.02	6.33–8.25	25.72	14.92	0.80	0.62	0.66	18.58	1319.02
Lucknow	59.87	4.8–9.18	34.04	20.32	0.93	0.65	0.79	21.41	1556.78
Meerut	32.48	6.16–7.95	26.67	15.47	0.79	0.80	1.02	19.24	1088.65
Nagpur	40.55	4.91–7.80	57.10	33.12	1.24	0.71	1.46	26.37	2632.23
Vadodara	24.98	–	34.96	20.28	0.60	0.71	0.38	40.34	1780.51
Gandhinagar	23.69	7.02	44	25.5	0.79	0.62	0.39	36.05	698.02
Visakhapatanam	52.70	7.5–8.7	64.4	37.3	0.97	0.66	1.10	41.70	1602.09
Dehradun	79.36	6.12–7.24	39.81	23.08	1.24	0.91	3.64	25.90	2445.47
Ludhiana	64.59	5.21–7.40	43.66	25.32	0.91	0.56	3.08	52.17	2559.19
Guwahati	70.93	6.41–7.72	34.27	19.88	1.10	0.76	1.06	17.71	1519.49
Kohima	64.93	5.63–7.7	57.20	33.17	1.09	0.73	0.97	30.87	2844

Source: Akolkar (2005)

Constraints

REASONS FOR INADEQUACY AND INEFFICIENCY IN SERVICES

Apathy of Municipal Authorities

Though municipal authorities have held the responsibility of managing solid waste from their inception over three centuries ago, the issue seldom got the attention it deserved. Elected representatives as well as the municipal authorities generally relegate the responsibility of managing municipal solid waste (MSW) to junior officials such as sanitary inspectors. Systems and practices continue to be outdated and inefficient. No serious efforts are made to adapt latest methods and technologies of waste management, treatment and disposal. Though a large portion of the municipal budget is allotted for solid waste management, most of it is spent on the wages of sanitation workers whose productivity is very low. There are no clear plans to enhance their efficiency or improve working conditions through the provision of modern equipment and protective gear. Unionization of the workers, politicization of labor unions and the consequent indiscipline among the workforce are all results of bad working conditions and inept handling of labor issues. Almost all the 3955 towns with population below 100,000 run SWM services rather unprofessionally. They depend on sanitary inspectors to manage solid waste with the help of sanitation workers. In many small towns, even qualified sanitary inspectors are not posted and services are left in the hands of unqualified supervisors. The situation of cities with 100,000 plus population is somewhat better, though far from satisfactory. In these cities, generally there are health officers who head the SWM department. In some of the larger cities qualified engineers supervise SWM seeking technical inputs from doctors as well.

Absence of Community Participation

Community participation has a direct bearing on efficient SWM. Yet, the municipal authorities have failed to mobilize the community and educate citizens on the rudiments of handling waste and proper practices of storing it in their own bins at the household-, shop- and establishment-level. In the absence of a basic facility of collection of waste from source, citizens are prone to dumping waste on the streets, open spaces, drains, and water bodies in the vicinity creating unsanitary conditions. Citizens assume that waste thrown on the streets would be picked up by the municipality through street sweeping.

For the general public, which is quite indifferent towards garbage disposal etiquette, the onus of keeping the city clean is entirely on the ULBs. This mind set is primarily responsible for the unscientific systems of waste management in the country.

DRAWBACKS IN PRESENT SWM SERVICES

No Storage of Waste at Source

There is no practice of storing the waste at source in a scientifically segregated way. Citizens have not been educated to keep domestic, trade, and institutional bins for storage of waste at source and stop littering on the streets.

No System of Primary Collection from the Doorstep

There is no public system of primary collection from the source of waste generation. The waste discharged here and there is later collected by municipal sanitation workers through street sweeping, drain cleaning, etc. Street sweeping has, thus become the principal method of primary collection.

Irregular Street Sweeping

Even street sweeping is not carried out on a day-to-day basis in most cities and towns in India. Generally commercial roads and important streets are prioritized and rest of the streets are swept occasionally or not swept at all. Generally, no sweeping is done on Sundays and public holidays and a back log is created on the next working day. The tools used for street sweeping are generally inefficient and out-dated. For instance, the broom with a short handle is still in use forcing sweepers to bend for hours resulting in fatigue and loss of productivity. Traditional handcarts/tricycles are used for collection, which do not synchronize with the secondary storage systems. Waste is deposited on the ground necessitating multiple handling. There are no uniform yardsticks adopted for street sweeping. Though, some states/cities have prescribed work-norms, these are not very scientific. Most of the cities allocate work to sanitation workers on ad hoc basis. The work distribution ranges between 200 meters to 1000 meters of street sweeping each day. Some sanitation workers are found under worked while some over burdened.

Waste Storage Depots

As waste is collected through traditional handcarts/tricycles that can carry only a small quantity of waste at a time, there is a practice to set up depots for temporary storage of waste to facilitate transportation through motorized vehicles. Generally, open sites or round cement concrete bins, masonry bins or concrete structures are used for temporary bulk storage, which necessitates multiple handling of waste. Waste often spills over which are both unsightly as well as unhygienic.

Transportation of Waste

Transportation of waste from the waste storage depots to the disposal site is done through a variety of vehicles such as bullock carts, three-wheelers, tractors, and trucks. A few cities use modern hydraulic vehicles as well. Most of the transport vehicles are old and open. They are usually loaded manually. The fleet is generally inadequate and utilization inoptimal. Inefficient workshop facilities do not do much to support this old and rumbling squad of squalid vehicles. The traditional transportation system does not synchronize with the system of primary collection and secondary waste storage facilities and multiple manual handling of waste results.

Processing of Waste

Generally no processing of municipal solid waste is done in the country. Only a few cities have been practicing decentralized or centralized composting on a limited scale using aerobic or anaerobic systems of composting. In some towns un-segregated waste is put into the pits and allowed to decay for more than six months and the semi-decomposed material is sold out as compost. In some large cities aerobic compost plants of 100 MT to 700 MT capacities are set up but they are functioning much below installed capacity. A few towns are practicing vermi-composting on a limited scale.

Disposal of Waste

Disposal of waste is the most neglected area of SWM services and the current practices are grossly unscientific. Almost all municipal authorities deposit solid waste at a dump-yard situated within or outside the city haphazardly and do not bother to spread and cover the waste with inert material. These sites emanate foul smell and become breeding grounds for flies, rodent, and pests. Liquid seeping through the rotting organic waste called leachate pollutes underground water and poses a serious threat to health and environment. Landfill sites also release landfill gas with 50 to 60 per cent methane by volume. Methane is 21 times more potent than carbon dioxide aggravating problems related to global warming. It is estimated by TERI that in 1997 India released about 7 million tones of methane into the atmosphere. This could increase to 39 million tones by 2047 if no efforts are made to reduce the emission through composting, recycling, etc.

Confronting problems in existing practices

In supporting the existing practices of waste reduction, urban managers and community organizations must not overlook the many problems of traditional waste recovery and recycling systems.

Informal sector entrepreneurs and workers frequently lack the technologies to optimize recycling methods and to deal with new waste materials. They are also usually denied the assistance in financing (e.g., bank loans) that large, established firms can access as a matter of course. The working conditions in recovery and recycling are very bad, especially for the lowest-level workers, such as women sorting or picking materials. Small entrepreneurs and itinerant waste buyers work under others handicaps, such as harassment and extortion from local authorities and larger enterprises. Waste picking is abhorred almost universally, but very little is done to assist waste pickers.

Informal waste trading enterprises must process materials to get the best

Recovery and recycling, although basic principles of sustainable development, impose significant health risks on those involved, especially when carried out informally. This is particularly so in places where sanitary facilities are nonexistent or deficient. Industries using recycled feedstock are in many cases more polluting than those using virgin materials. Such industries tend to be small-scale in developing countries, so they are often not subject to environmental regulation. Environmental improvement must encompass assistance to such small industries.

prices. Simple machines and techniques could improve returns and working conditions. (credit: Ben van Bronckhorst)

Solid waste management

Introduction

Total solid waste generated by 63 urban centers in Uttrakand is about 850tpd for about a population of 16.5 lacs. And estimated capita generation of waste is 500gm/capita per day (state of environment Report for Uttrakand , Uttrakand environment protection and pollution control board, govt. of Uttrakand, Nov. 2004). Thus Dehradun is expected to generate about 224 tons / day. Estimated quantity of municipal solid waste generated in India is 27.4 million tones per year. Thee problem associated with the non bio degradable waste (especially plastic and polythene waste) is also on a rise.

Dehradun is distinguished from most districts in the state by the existence of very large forests chiefly stocked with Sal. Forest products play an important role in the economy of the district. The forest account for 1477 sq. km of area, giving a percentage of 43.70 of the total area of the district.

Problems and justification:

Urbanization in Dehradun:

The current population of Dehradun is around 18 lacks and is growing at a decadal growth rate (1991-2001). According to census 2001, 25.70% of the population lives in the urban areas.

Urbanization is continuously increasing at an alarming rate after it became the capital of Uttrakhand state.

Impact of tourism:

In Uttrakhand, tourism is the most important activity in the non forming sector.

Mussouri is the most prominent hill station of Dehradun.

Sahasradhara is also an important spot.

The inflow of tourists put immense pressure o the existing resources and infrastructure

Municipal solid wastes:

Absence of sewage plant in the city is a big concern.

No specific solid waste management in the city.

Municipal solid wastes have tremendously increased.

The city is facing and array of problem including low and irregular collection services ,crude open dumping and burning without air and water pollution control, the breeding of flies, and the handling and control of informal waste picking or scavenging activities.
These public health, environmental and management problems are caused by various factor which constraint the development of effective solid waste management system. .

They constraints can be characterized as:

1. Tecnical
2. Financial
3. Institutional
4. Economic
5. Social.

Objective

Solid waste generated from domestic, commercial and industrial activities are often indiscriminately disposed off.
Unscientifically disposal in open areas, such wastes leads to environmental problems. This problem is acute in urban areas.
It is quite common to find large heap of garbage in disorganized manner in every corner of the city.
The main goal of this project is to utilize the waste by adopting appropriate waste processing and disposal technologies and to reduce the burden on land fill.

Another aim of the project is to generate electricity out of the organic waste based on the concept of '**Waste to Energy**' and link it with the State Electricity Board stakeholder.

1. The pilot neighborhood is identified as Prem Nagar which is having a population of 15000 and includes a slum area also. Located around 8kms from the main city.

2. Identification and segregation of waste:
   The waste will be identified and segregated according to the organic content of waste.

3. Waste disposal and utilization:
   Once the waste is identified and quantified, it will be disposed off or utilized for electric generation or other uses as applicable.

4. Replica in other part of the city.

Scope of work:

As read under the constitution:

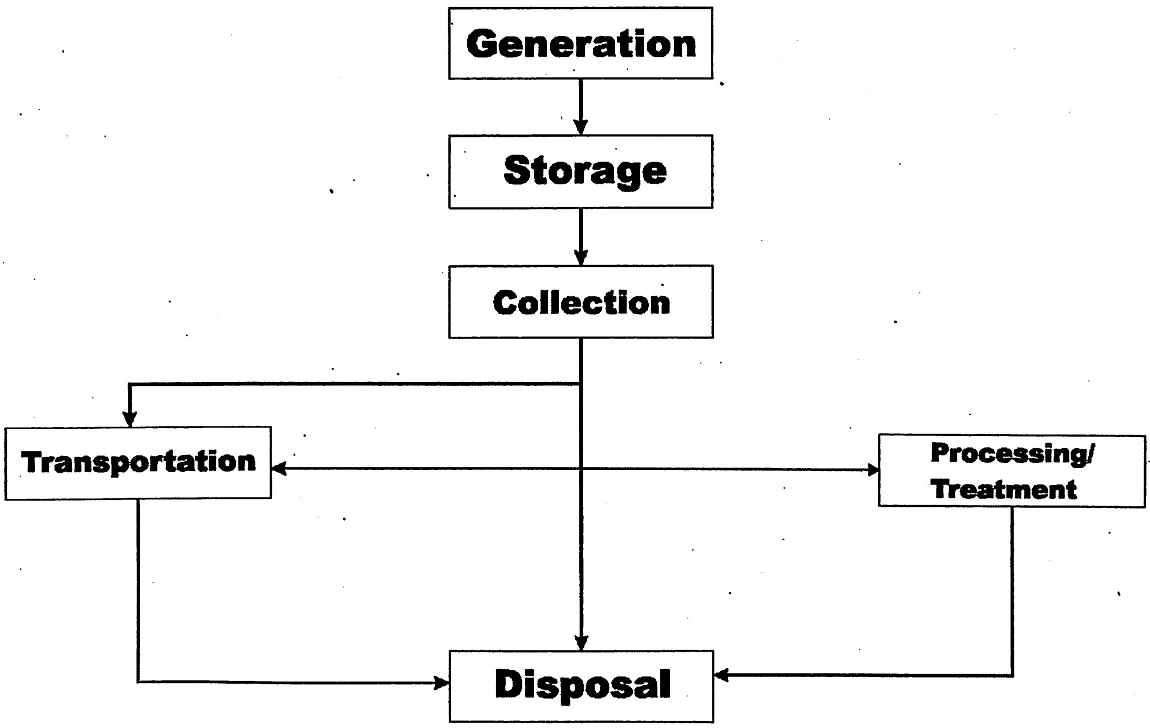
According to the schedule 3 and rule 8 of the municipal waste(management and handling)rules 2000 the special provisions has been given for final disposal of solid waste which states, "**as cities and towns located on hills, shall have location specific methods evolved for final disposal of solid waste. As land filling in hilly areas is not an environmentally safe option the municipalities shall set up processing facility for biodegradable waste. The inert and non biodegradable waste shall be used for construction of buildings roads or filling up of appropriate areas on hills.**"

The scope of our project is:
Proper waste management system which constitutes the following components:

1. Primary and secondary collection of wastes.
2. Onsite/Offsite segregation of waste
3. Transportation of waste
4. Waste processing and its disposal
5. Capacity building and training of local institution and NGOs.

Methodology

Integrated solid waste management plan for Dehradun



COLLECTION OF WASTE:

A. **Primary collection of waste**

Primary collection of the waste is the essential step of the solid waste management at this step it is necessary to ensure that the waste stored at sources is collected regularly & waste is not deposited off on the street & nearby water bodies. There is to provide daily waste collection service to all houses, shops & other establishments for the collection of wastes.The following steps required for the collection.

I. The primary collection of waste from houses shall be arranged on daily basis through hand carts/ tricycle with active community participation. The collection tricycle/ hand carts shall have conventional horn.
II. The operator of tricycle/ hand cart responsible for door to door collection may be given a fix area of 200-300 running m of road length & adjoining houses in congested or thickly populated areas whereas in less congested areas 400-600 running m of road length with adjoining houses may be allotted to each operator.
III. The operator of the primary collection of waste shall ring the or blow whistle announcing his arrival.

IV. Non govt. organizations/ private parties should be encouraged for primary collection of the waste from house to house on their own by making direct contractual arrangement with the residential association or monthly basis charges from individual houses.
V. The concept of mohalla swaeeyatha committee at every 200-250 families shall be encouraged by local bodies.
VI. The hotels and restraunt should be given direction to make their own arrangements for primary collection of waste and segregation its transportation to secondary collection point through their association or contract basis.
VII. A special pick up arrangement shall be made for collection of waste from marriage halls on full recovery basis.The service shall be preferably provided by contractor as local bodies may deem fit.

B. SECONDARY COLLECTION OF WASTE

This is third essential step for an appropriate solid waste manangement system.all the waste collected through primary collection sysytr=ems from the household, shops & establishments has to be taken to the waste processing & disposal sixty- the=ree are variety of container which can be placed at waste storage site. Following are options for considering secondary collection site.

Depending upin the quantity of the waste likely to be deposited at the temporary waste storage site provide one or more large metallic container with the lid.

Secondary collection site should be at distance not exceeding 250m from the area given to person responsible for collection of waste.

II. TRANSPORT OF WASTE:

The transportation of wastes stored at the waste storage depots at regular intervals at regular intervals is essential to ensure that no garbage bins/ containor over flow and wasteis not seen on the streets. Hygienic conditions can be maintained city town only if the clearance of waste storage bins is ensured. The transportation system has to be so designed that it is efficient. Cost effective.

III. WASTE PROCESSING AND ITS DISPOSAL:

The land filled is called sanitary land fill, when a waste is compacted in a layer and covered by soil. At the end of each day's operation in order to minimize the threat to human health and the environment.

I. SITE SELECTION

The land fill site shall be large enough to at least 20-24 years and preferably with in 5kms from present city limits.

- The site shall be at least 0.5 km away from habitation clusters, forest areas, monuments, national parks, wet lands, and some of the important cultural.
- Land fill site shall be at least 20kms away from the airport.

- A 500m wide buffer zone of no development be maintained around landfill site and shall be incorporated in the town planning departments land use plans.

II. FACILITY AT SITE

- Land fill shall be hedged and provided with proper gate to monitor in coming vehicles.
- It should be well protected to prevent the entry of stray animals.
- Approach and other internal road for free flow of vehicles shall exists at the land fill site.
- The land fill site shall have waste inspection facility for record keeping.
- Safety provision including health inspection of workers at land fill site be periodically made.

III. SPECIFICATION FOR LAND FILLING

- Waste subjected to land filling shall be compacted in thin layer using land fill compacater to achive high density of the waste.
- Waste shall be covered imideatelly or at the end of each working day with 7.5 to 10cm of soil.
- Prior to the commencement of the mosoon season, an imideate cover of 40-65cm thichk ness of soil shall be placed on the land fill with proper compaction and grading to prevent in filltrartio during monsoon.
- After compeletion of landfill, a final cover shall be designed to minimize in filtration and erosion shall be adopted.

V. CAPACITY BUILDING AND TRAINING OF LOCAL INSTITUTION AND NGOS

Organized training program for local level NGO'S and officials of state municipal coorparation. A city progaramme implementation committee including members of SMC and local level NGO's will be formulated for project implicational and sustainability.

Solid Waste Management

Solid waste management is one among the basic essential services provided by municipal authorities in the country to keep urban centers clean. However, it is among the most poorly rendered services in the basket—the systems applied are unscientific, outdated and inefficient; population coverage is low; and the poor are marginalized.

Waste is littered all over leading to unsanitary living conditions.

Municipal laws governing the urban local bodies do not have adequate provisions to deal effectively with the overgrowing problem of solid waste management. With rapid urbanization, the situation is becoming critical. The urban population has grown fivefold in the last six decades with 285.35 million people living in urban areas as per the 2001 Census.

The waste generation rates in India are lower than the low-income countries in other parts of the world and much lower compared to developed countries. However, lifestyle changes, especially in the larger cities, are leading to the use of more packaging material and per capita waste generation is increasing by about 1.3 per cent per year. With the urban population growing at 2.7 per cent to 3.5 per cent per annum, the yearly increase in the overall quantity of solid waste in the cities will be more than 5 per cent. The Energy and Resources Institute (TERI) has estimated that waste generation will exceed 260 million tones per year by 2047—more than five times the present level. Cities with 100,000 plus population contribute 72.5 per cent of the waste generated in the country as compared to other 3955 urban centers that produce only 17.5 per cent of the total waste (Table 8.3).

Physical and chemical characteristics of solid waste in Indian cities vary depending on population size and geographical location. Though composition of urban waste is changing with increasing use of packaging material and plastics, yet, as compared to developed countries, Indian solid waste still comprises mostly, of large proportions of organic matter as well as inert material.

Municipal Solid Waste Management (SWM)

Rotting organic refuse is not only aesthetically unpleasant but attracts predators, and carried by these, bacteria thrive in warm, moist, rotting garbage spreading malaria, viral fever (dengue), plague etc. The incident of plague in Oct, 1994 in Surat city pressed everyone to think over SW problem. If this problem is not tackled within preventive time, it may create other dreadful, hazardous and incurable problems.

The proper disposal of SW derived from any source is dependent on management practices.

A management system must be developed and described that incorporates many diverse factors. Those factors considered may include economics, engineering, land use ordinances, environmental regulations, geography and sociology. A Solid Waste Management (SWM) system that could optimize these parameters would be designed based on figure 1 (SWM involves interplay of six functional elements- generation of wastes, storage, collection, transfer and transport, processing, recovery and disposal in a manner that is in accord within the best principles of public health, economics, engineering, conservation, aesthetics and other environment considerations and that also is responsive to public attitude. Over 90% of SW is disposed of in landfill sites. Sanitary landfilling is the main method used in the West but crude dumping is very common in developing countries. Land filling leads to contamination of ground water eventually because of leachates.

Many countries will have to suffer from existing landfillling practice in the near future. By 2010, almost all of England will be suffering from a landfill shortage. Another widely used method of disposal is incineration but it often results in air pollution and thus loses out preference. The commonest method adopted in India is dumping either in ponds or on land. A practice of Collection, Transport and Disposal (CTD) is followed by municipalities. SW is stored till a sizable amount accumulates which may be transported using vehicle of suitable size. When the quantity of SW to be managed is relatively small then collection, handling and short distance transport is done manually.

However, mechanical devices like bulldozers and cranes may be used when quantity is large.

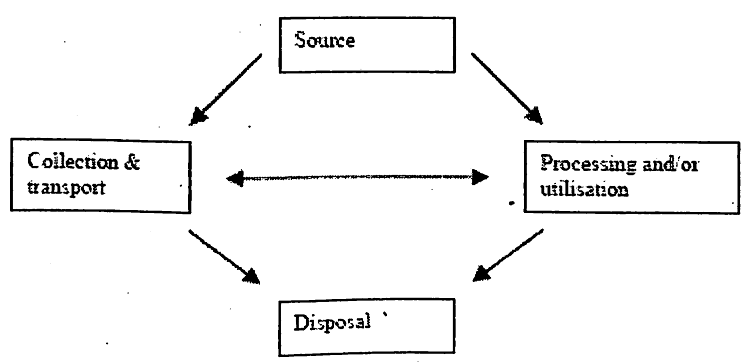
To transport solid Waste over a short distance, wheel barrow may be used. Vehicles commonly employed are open body trucks and flat bed trucks. Nearly 75-80% of all collected residential and commercial SW are sent to open dumps, less than 10% is buried in sanitary landfills, a small amount is dumped into the sea and the remaining is converted to obtain energy and recover metals.

Tourism is one of the fastest growing industries in both developed and developing countries as a tool for economic activity and development. Developing countries see tourism as the opportunity to earn scarce foreign exchange and to generate employment .The Himalayas owing to their majestic snow clad peaks, deep gorges, fertile valleys, bountiful rivers and unique climate have always attracted mediators, philosophers, poets, scientists and trekkers alike. This is also contributing significantly to economy. In the 1960s and 70s, tourism got a nitro-fuel booster from all quarters. Nobody gave any thought to social, cultural, environmental and economic damage resulting from tourism. One of the biggest problems arising out of these activities is the SW problem in sensitive areas of

Recycling of wastes should be given priority in waste management places and land disposal should be avoided as far as possible. It is especially true in hilly topography where due to scarcity of adequate lands, wastes are usually dumped either close to river beds or into the direct flowing river water which remains the source of drinking water in the surrounding settlements.

In a nutshell, the most important aspects of SWM in developing countries are related to the problem of (1) effective shortage in generating premises, (2) collection, (3) efficient transportation of the waste to disposal sites, (4) lack of proper disposal sites except river beds or valleys, (5) lack of co-ordination between related research institutions and administration and (6) inadequate SWM funding

Figure 1 A Solid Waste management System



Need for Innovations

Solid waste management is one of the important areas where the problems arise from time to time.

Municipal bodies are unable to provide a 100% efficient system and even are not able to reach to the efficiency of 60%. Solid waste management frequently suffers more than other municipal service when budget allocations and cuts are made. The provision of collection and disposal services for municipal refuse is not perceived as deserving higher priority. Efforts of people employed to collect, dispose and recycle wastes are rarely appreciated. The existing situation is not satisfactory and often there are complaints by the public which adds anxiety to the concerned officials involved in the management. The real problems are mainly of organization, management and planning , yet the favoured solutions involve more mechanization. One of the simplest way to bring innovations in any system is to document and study the existing system and bring the possible reforms by adopting appropriate measures at various levels through the introduction of innovative and cost effective solutions.

Present Status: Some Observations in Solid Waste Management

Solid Waste management is an obligatory function of the Urban Local Bodies. However if this service is poorly performed it results in problems of health, sanitation and environmental degradation. With over 3.6% annual growth in urban population and the rapid pace of urbanization, the situation is becoming more and more critical with the passage of time. There are various deficiencies related to SWM which are seen in the cities mainly no storage of waste at source, non-segregation at source, no system of primary collection of waste, use of inefficient tools, inefficient system of secondary storage of waste, inadequate transportation of waste, no processing of waste, disposal of waste, lack of institutional and administrative involvement.

The infrastructural development is not in a position to keep pace with population growing owing to the inefficient resources in most of the local bodies.

The following are some of the observations seen in cities:

1. The citizens often complain that solid waste is never lifted from its place; it is observed that the bins are full and the waste is lying for days without being lifted it to the landfill site.
2. The municipal authorities say that citizens often do not throw the garbage in the bins and it usually lies there outside the bins.
3. The other reason for which is claimed by the authorities is that, there is shortage of manpower and equipments and machines which could do the needful.
4. The current lifting capacity is much less as compared to the waste generated per day.
5. The complete inventory of the bins and its locations etc ward wise and sector wise, on major roads is often not available with the authorities.
6. The number of sweepers on a stretch of major and minor roads, in different wards is also missing. They may tell some figure but if some analysis is to be done on map, it is not available with the authorities.
7. The data about the most waste generating areas and along roads is not available to them.

8. Bins of different types are unnecessarily been provided on a stretch of various roads, which basically accounts to additional cost of diesel, manpower, equipment etc.
9. The route planning is never prepared and is currently done as and when need arises.
10. The redressal system is not existing, its just by a system on demand by the community.

How Municipalities can go forward

Create a Phased Action Plan

Based on specific objectives to provide acceptable solid waste management service, and on existing financial constraints, a phased action plan may have two basic elements. Another element of the plan being provisions of planning and management arrangement as well as the improvement of the financial and institutional base upon which the solid waste service relies.
The plan should try to readily incorporate those actions which may realize a major improvement without major capital investment. Therefore, initial emphasis may be placed on actions such as the following:

It is often seen in most of the local bodies that data lies in an isolated form. The availability of SWM data is often not available at one place for arriving at proper decisions regarding the planning and management arrangements. Most solid waste planning efforts emphasize technology with such engineering activities as determining the number of trucks and the siting of landfills. In the existing system there is inadequate supervision of workers, inadequate logistics management, and spatial planning.
Through continuous planning and dynamic management these systems can be designed to have capacity meet demand on a continuous basis.
The following are some of the important points which should be considered as an important exercise to begin with:

1. Identify and prepare the the exact location of the dustbins in the city. This can be done by using GPS or by a survey and marking on the base map of the city.
2. Ward wise inventory of the bins should be made.
3. Current waste generation map showing the waste generated along the main roads, streets and wards of the city.
4. The existing minimum distance between the bins.
5. Identification and inventory of the existing sanitary inspectors, sweepers ward wise. This will help to optimize the ratio of supervisory personnel, inspection personnel, maintenance personnel to direct labor and provide equipment and facilities to facilitate their work.
6. Current lifting cycle pattern identification based on the waste generated along the main roads, streets, and wards.
7. Existing hourly cycle pattern of the vehicles for different wards and main roads.
8. Presence of NGOs, Community Groups, Resident Welfare Associations, Mohalla Sanitation Committees active in SWM issues in various wards of the city.
9. Existing location of the landfill sites.
10. Existing inventory of the tools, equipments, trailers, tippers, dumper placers etc available with the authorities.

11. Identification of the areas where hoardings can be provided for the bins to increase the aesthetic value and maximize the revenue generation of the municipality.

12. Allocation of unique number to each bin based on the area code should be prepared by which bins can be located easily for the complaint redressal system. This will give a complete idea about the wards of the municipal area, by this the authorities will be able to know that how many wards are there which produces more waste daily and haw many produce waste in more than two or more days. With this exercise even the exact position and location of the bins accumulating waste could be know for the planning purpose.

13. Adopt a system of record keeping at main yard and at landfill site to know about the daily collection of waste generated and logistics information about the transportation issues.

14. Clarify responsibilities by such actions as making specific collection crews responsible for specific routes or areas of service, and similarly assigning equipment to individual drivers or operators.

15. Also, clearly designate the chain of communication and coordination for workers to utilize in reporting problems and issues in service provision, and for citizens to utilize in making complaints or commendations

The photographs shown in the paper shows the actual condition of SWM in Dehradun city.

Sustainability in Practice: Exploring Innovations in Domestic Solid Waste Management in India

In recent decades there has been significant growth in urban population, paving enough space for related problems to confront with. One such problem is about improving environmental conditions, particularly through solid waste management. Solid waste is defined as the organic and inorganic waste materials generated by household, commercial and institutional establishments. A solid waste management system is the framework within which all activities regarding solid waste take place. Solid waste management is further defined according to the process administered and/or carried out by the local government, i.e., collection, transport and disposal. The associated activities are generation, storage, collection, transfer and transport, processing and disposal of solid wastes. The prime objective of the project was to gain insights into the 'alternatives' or 'innovations' within the formal and informal solid waste management to reduce waste, in terms of minimising waste, maximising re-use and recycling activities, and to promote ecological sustainability. One of the approaches formulated to examine the project objectives was through a sample study of five cities/ towns in each of the three selected states in India and one city/ town in each state for an in-depth case study.

Key Observations and Findings

1. The impact of macro-level structural reform, economic liberalization and reduction in the role of public sector in infrastructure development has been gradually trickling down to the grass-roots levels.

2. The conventional and traditional approach to 'public service' by the government at the urban local government level is slowly changing, and it is now being realized that community participation and private sector partnership are more appropriate to develop the urban local services.

3. Unfortunately, it is found that the initiatives are coming from the top (higher level government) in the form of policy advice, program guidelines, recommendations and instructions through government orders. In very few instances are attempts being made to improve the standard of urban service management and delivery systems at the local government level.

4. It is observed that in all the case studies on SWM there are two common features:

   i. Partial privatization of garbage collection and transportation; and

   ii. Inviting private sector to install waste recycling plants or produce fertilizers from solid waste.

5. Even though partial private participation (contracting out some components of services) is in vogue in some municipalities, this was treated as a means of convenience rather than reducing the responsibilities of municipality. Hiring of trucks or tractors by the municipality from private parties to transport solid waste is a case in point.

6. Any attempt to 'change' or 'modernise' or introduce advanced techniques is generally viewed as unnecessary and perceived as no better alternative, additional risk and resisted by a large section of elected representatives as well as the municipal staff.

7. It is observed that if the chief executives, administrators and elected chairpersons make a serious attempt to revamp the traditional methods of SWM and decide to introduce new and innovative approaches, there is sufficient scope for success. For example, in Anantapur Municipality, the young, dynamic and forward looking chairperson, with the support and co-operation of the Municipal Commissioner, succeeded in introducing new and innovative approaches in SWM ever since he assumed office.

8. There are also a large number of legislative, legal and administrative hurdles to the introduction of new approaches. Every part of municipal functions is coded in the form of municipal Acts, Laws and bye-laws which remain unchanged over decades.

For example, public health and sanitation rules, regulations and specifications restrict the appointment of the required sanitary staff, purchase of materials, revision of rates and charges.

9. Even though decentralisation in all respects has been preached, in reality there has been no impact on the urban local bodies, as is evident from the fact that they do not administer as per the aspirations and needs of the local people.

10. Although solid waste management is the responsibility of the municipality, as enshrined in the Act, the latter has been seeking the support of non-governmental organisations like EXNORA, CBOs (Community Based Organisations) and workers' societies. This points to the emerging trend of networking between the municipality and other local organisations for managing solid waste.

11. Studies reveal that there are always some operational problems and financial and other constraints, lack of political support and lack of wholehearted support from the citizens, which hinder the promotion of meaningful, effective and responsive waste management endeavours.

12. Discussions with the households indicate that the local organisations are willing to come together to shoulder the responsibility of waste collection and disposal provided the municipality supports their initiatives.

13. The case studies developed on the workers of the informal sector show that their contribution to solid waste management is on an equal footing with the efforts of the formal sector. They, in a

way, are responsible for the re-use and recycling of the waste generated, which is used by different establishments.

14. There is increasing public awareness of the need for collection and proper disposal of garbage. While solid waste management is becoming more and more an important function of the municipalities, the latter are constrained by the lack of funds to perform this function effectively.

15. Owing to financial constraints and ban on recruitment of sanitary workers, the municipalities have been forced to manage the existing personnel more economically but also to evolve innovative methods of collecting and disposing garbage more effectively. As part of this strategy, the municipalities have (a) gone in for methods that effectively use the existing staff, (b) resorted to privatisation of garbage collection and disposal, and (c) encouraged NGOs and CBOs to voluntarily undertake solid waste management in selected areas of the city.

Solid Waste Management (SWM)

Rotting organic refuse is not only aesthetically unpleasant but attracts predators, and carried by these, bacteria thrive in warm, moist, rotting garbage spreading malaria, viral fever (dengue), plague etc.. The incident of plague in Oct, 1994 in Surat city pressed everyone to think over SW problem. If this problem is not tackled within preventive time, it may create other dreadful, hazardous and incurable problems.
The proper disposal of SW derived from any source is dependent on management practices.
A management system must be developed and described that incorporates many diverse factors. Those factors considered may include economics, engineering, land use ordinances, environmental regulations, geography and sociology. A Solid Waste Management (SWM) system that could optimize these parameters would be designed based on figure 1.

SWM involves interplay of six functional elements- generation of wastes, storage, collection, transfer and transport, processing, recovery and disposal in a manner that is in accord with the best principles of public health, economics, engineering, conservation, aesthetics and other environment considerations and that also is responsive to public attitude. Over 90% of SW is disposed of in landfill sites. Sanitary landfilling is the main method used in the West but crude dumping is very common in developing countries .Landfilling leads to contamination of ground water eventually because of Source
Collection & transport Processing and/or utilization Disposal leachates. Many countries will have to suffer from existing landfillling practice in the near future. By 2010, almost all of England will be suffering from a landfill shortage Another widely used method of disposal is incineration but it often results in air pollution and thus loses out preference. The commonest method adopted in India is dumpingeither in ponds or on land. A practice of Collection, Transport and Disposal (CTD) is followed by municipalities. SW are stored till a sizable amount accumulates which may be transported using vehicle of suitable size. When the quantity of SW to be managed is relatively small then collection, handling and short distance transport is done manually.
However, mechanical devices like bulldozers and cranes may be used when quantity is large.
To transport solid Waste over a short distance, wheel barrow may be used. Vehicles commonly employed are open body trucks and flat bed trucks. Nearly 75-80% of all collected residential and commercial SW are sent to open dumps, less than 10% is buried in sanitary landfills, a small amount is dumped into the sea and the remaining is converted to obtain energy and recover

metals. Tourism is one of the fastest growing industries in both developed and developing countries as a tool for economic activity and development. Developing countries see tourism as the opportunity to earn scarce foreign exchange and to generate employment .

Recycling of wastes should be given priority in waste management places and land disposal should be avoided as far as possible . It is specially true in hilly topography where due to scarcity of adequate lands, wastes are usually dumped either close to river beds or into the direct flowing river water which remains the source of drinking water in the surrounding settlements. In the Himalayan region, the SWM problem is considerably aggravated around tourist destinations.
In a nutshell, the most important aspects of SWM in developing countries are related to the problem of (1) effective shortage in generating premises, (2) collection, (3) efficient transportation of the waste to disposal sites, (4) lack of proper disposal sites except river beds or valleys, (5) lack of co-ordination between related research institutions and administration and (6) inadequate SWM funding.

Criteria for evaluating solid waste management

For each technology or policy under consideration, decision makers should ask a number of questions designed to facilitate comparison of the available alternatives. It is not necessarily easy to answer these questions, but attempting to answer them will often shed light on particular points that need to be resolved before a well-informed decision can be made.

- Is the proposed technology likely to accomplish its purpose in the circumstances where it would be used? More specifically, is it technologically feasible and appropriate, given the financial and human resources available?
- Focusing on the financial aspects of the practice, is it the most cost-effective option available?
- What are the environmental benefits and costs of the practice?
- Could the environmental soundness of the proposed practice be significantly enhanced by a small increase in costs? If so, do the environmental benefits justify budgeting for these costs?
  Conversely, would it be possible to significantly reduce the cost of the practice with only a small detriment to environmental soundness? If so, should that cost-reducing option be chosen, perhaps with the aim of more fruitfully investing society's resources in environmental quality improvement or toward other ends?
- Is the practice administratively feasible and sensible?
- Is it practical in the given social and cultural environment?
- How would specific sectors of society be affected by the adoption of this technology or policy? Do these effects promote or conflict with overall social goals of the society?

Background conditions that affect solid waste management

As discussed above, there are many factors that affect what should be considered a sound practice in a particular situation. Decision makers need to assess how the specific, prevailing background conditions constrain the choices available. It is unlikely that all of the following points will be important in any one instance, but the list of conditions that help to determine what sound practice is includes:

Level of development

- Economic development, including relative cost of capital, labor, and other resources
- Technological development; and
- Human resource development, in the MSW field and in the society as a whole.

Natural conditions

- Physical conditions, such as topography, soil characteristics, and type and proximity of bodies of water
- climate temperature, rainfall, propensity for thermal inversions, and winds; and
- Specific environmental sensitivities of a region. Conditions primarily affected by human activities
- Waste characteristics density, moisture content, combustibility, recyclability, and inclusion of hazardous waste in MSW and
- City characteristics size, population density, and infrastructure development.

Social and political considerations

- degree to which decisions are constrained by political considerations, and the nature of those constraints
- degree of importance assigned to community involvement (including that of women and the poor) in carrying out MSWM activities and
- social and cultural practices

The need for planning municipal solid waste management (MSWM)

It should be apparent from the previous discussion that making sound decisions about MSWM issues can be a complex task. There are many questions that need to be asked and, in truth, the answers often lead to more questions. Meanwhile, untreated waste builds up and the problems get worse.

MSWM decisions take place in the context of limited resources. Solid waste problems are not the only environmental problems, and environmental problems are certainly not the only issues competing for attention and funds. In developing countries, where resources are particularly limited, decisions are even more difficult.

Moreover, decisions made now regarding MSWM practices have large effects on the future welfare of people in an area. Spending money on an ineffective technology shifts the burden of cleanup efforts to future generations. On the other hand, the wise choice of a sound technology or practice can sometimes resolve present problems adequately, while preserving funds for expeditiously resolving other environmental, social, or economic problems.

All of these considerations take place on several administrative levels at once: municipal, regional, national, and international agencies all have their own priorities, which often do not fully coincide. Increasingly, major private interests also have a say in the policies that are chosen and how they are carried out.

The complexity of the situation facing MSWM planners can be described in terms of the criteria that must be considered, the background factors that come into play, the limitations on resources, the long-term effects of present-day decisions, and the possibly competing agendas of many public and private interests. It is critical to weigh these considerations in developing an integrated MSWM plan that balances disparate demands and anticipates future requirements. A piecemeal solution may be all that is possible in a particular situation, but the goal should be to develop the administrative, technical, and financial capacity required to implement solutions that can be sustainable in the long term.

Both short-term and long-term plans can be oriented toward achieving results that can work within the given constraints. It is pointless to attempt to design the 'perfect' technical system or set of policies if they cannot be implemented. By explicitly considering resource constraints, planners can avoid the classic error of determining what should be, and instead concentrate on what is possible. 'Resources' usually means money, but can also include expertise, authority, political clout, historic character, civic spirit, and other intangibles. The planning process can serve as a means of determining how to use a limited supply of resources, as well as a useful technique for broadening a community's (or a whole city's) understanding of available resources.

In order to develop a well-integrated and cost-effective MSWM system, planners must evaluate how well each potential piece of the system meshes with other existing or proposed system components. The fit of a particular component can be measured in terms of its purpose, size, location, ownership, operation, system of financing, and relationship to administrative and regulatory agencies. Specifically, individual components of the system should be: (a) chosen so they do not overlap or compete excessively; (b) sized so they can handle the portion of the waste stream they were designed for, without competing with other components; (c) located so that transportation costs between management facilities are minimized and appropriate transportation networks are used; (d) owned, operated, and financed to minimize overall public costs, while ensuring responsible management and cooperation with other system components; and (e) administered by appropriate agencies, with adequate public oversight.

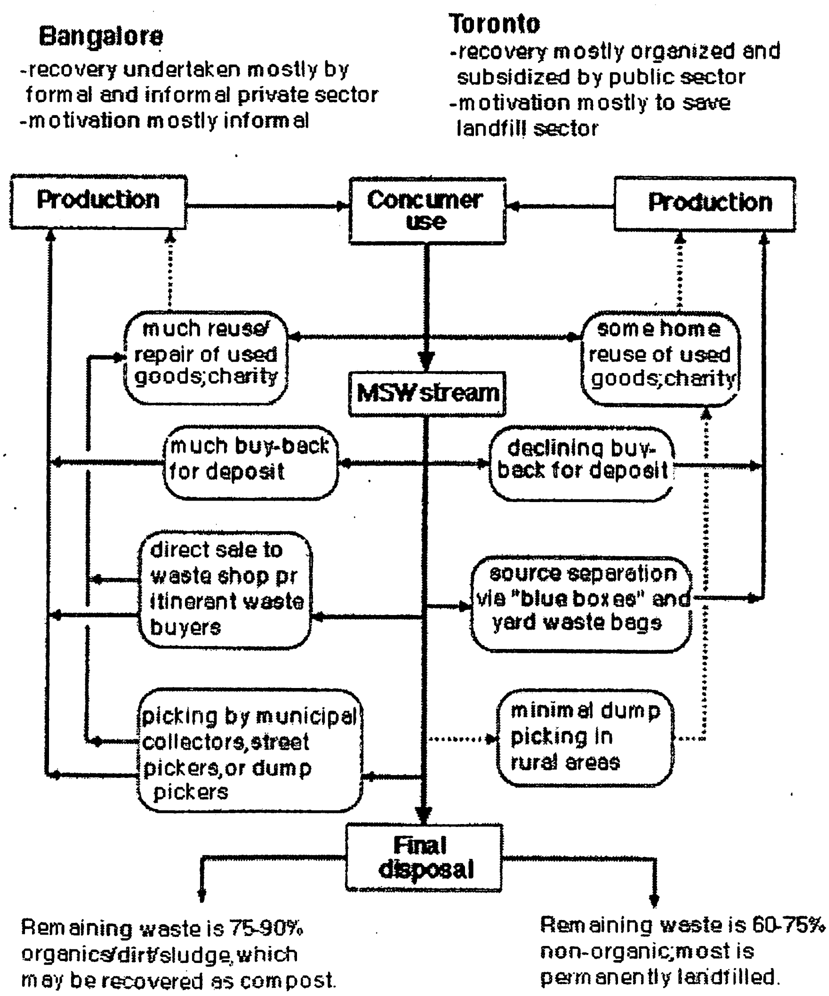
Development of an integrated plan requires coordination of public and private entities with expertise in management, MSWM technical matters, public health, environmental protection, public finance, urban infrastructure, and social issues.

Systems of waste reduction and materials recover

Typical components of municipal systems for source separation and materials recovery in industrialized countries are:

- source separation of different categories of waste from households, offices, shops, and institutions; collection at the curbside or drop-off by generators at bins or centers is subsidized by the government or private industries;
- collection of organics (kitchen and garden wastes) for large-scale composting;
- promotion of backyard composting through education and sometimes the provision of a small compost bin and
- Public subsidization of extensive and varied educational campaigns to sustain participation in all aspects of waste reduction.

Waste reduction and materials recovery: Bangalore compared to Toronto



credit: Chris Furedy and Glen Richardson

Most urban places in the developing world have yet to experience the decline of traditional recovery of recyclables and the corresponding increase in post-consumer wastes, which, together with scarcity of dump space, have led many affluent cities to sponsor materials recovery.

The engines of waste recovery and recycling in the poorer countries include: scarcity or expense of virgin materials, the occurrence of absolute poverty, the availability of workers who will accept minimal wages, the frugal values of even relatively well-to-do households, and the large markets for used goods and products made from recycled plastics and metals. Wastes which would be uneconomical to recycle or of no use in affluent societies have a value (e.g., coconut shells and dung used as fuel). If one takes into account the use of compost from dumps sites as well as materials recovery, in countries like India, Vietnam, and China, the majority of municipal wastes of all kinds are ultimately utilized.

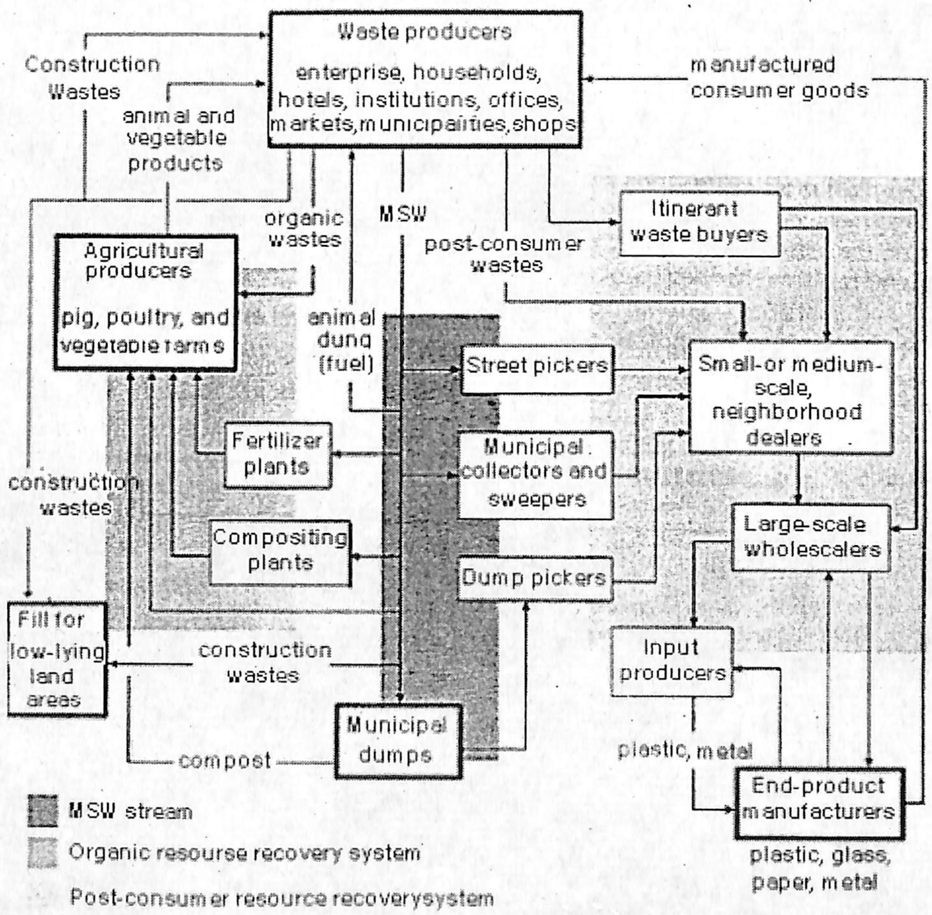
Waste reduction that could be achieved by legislation and protocols (such as agreements to change packaging) is not, at present, a high priority in these countries, although some are now moving in this direction. Because unskilled labor costs are low and there is a high demand for manufacturing materials, manufacturers can readily use leftovers as feedstock or engage in waste exchange. Residuals and old machines are sold to less advanced, smaller, industries. Public health is benefitting from plastic and boxboard packaging that reduces contamination of foods, and much of the superior packaging is recovered and recycled.

This tumbler is used for making pulp from waste paper. This small recycling facility is typical of many others throuthout India.

In offices and institutions, cleaners and caretakers organize the sale of paper, plastics, etc. At the household level, gifts of clothes and goods to relatives, charities, and servants are still significant in waste reduction. All cities and towns have markets for used goods. The greatest amount of materials recovery is achieved through networks of itinerant buyers, small and medium dealers, and wholesaling brokers.The system is adaptive to market fluctuations, as the lowest level workers form a dispensable labor cushion: they must find other work, if they can, when there is reduced demand for the materials they sell.

Because so many people are engaged in the activities of materials recovery, processing, and recycling, and alternative work is scarce, governments and social welfare organizations are often more sensitive to employment needs than to environmental considerations in waste management. Thus, they are prepared to trade off some environmental and public health risks against employment generation.

Overview of post-consumer, organic, and construction wastes in Bangalore, India



credit: Chris Furedy and Glen Richardson

The accompanying box shows the main paths traveled by wastes in Bangalore, due, in large part, to the activities of informal traders and recyclers.

Is municipally sponsored reduction and recovery appropriate?

Municipally sponsored separate collection of recyclables requires research into financing and markets, coordination of the collection with regular garbage pick-up, extensive public education, and often high levels of subsidization.

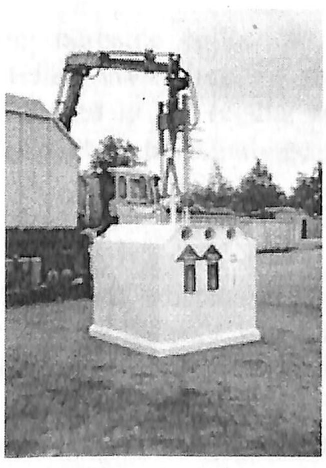
Sound techniques for materials recovery:

- **For glass:** Igloos: closed receptacles of approximately one cubic meter in size with entry ports shaped for the material; i.e., round holes for bottles and cans; long slits for newspaper; etc. Such bins provide continuous collection capacity. Costs for an igloo system are usually moderate.

- **For compostables:** Weekly or bi-weekly collection in 120-liter rolling carts collected by semi-automated compactors.
- **For paper:** For urban or dense village settings, curbside collection in divided bins, with one side used for paper and the other side for other waste. An alternative is collection of paper in bags or boxes. Curbside collection is vulnerable, however, to theft by private operators when paper prices are high. One- or two-cubic-meter containers for residential paper deposit are useful in rural towns.
- **For rigid plastics**: Plastics can be recovered from commingled recyclables, mixed waste, or pre-processed compostables by automated or semi-automated sorting systems (materials recovery facilities).

Materials recovery facilities (MRFs) must be well organized to be safe working places.

This container can be emptied quickly using a specialized collection vehicle.



Guidelines for planning municipally sponsored separate collection

Assessing investments in recycling:

The potential markets for recyclables need to be assessed before investments are made in processing facilities and collection systems. The following factors should be addressed: (a) existing manufacturers and brokers, (b) potential new markets, (c) transportation costs, (d) material specifications, (e) revenues, and (f) the types of contract with subcontractors.

Urban places can increase their market clout by forming cooperatives. A cooperative can negotiate deals with buyers and direct the recyclables to central pick-up points, making transportation more efficient. Communities can also share market risks by contracting with private sector recycling services.

Setting of quality standards:

Buyers have standards for the quality of the recycled materials they use. Standards for quality must be as important as cost considerations, or the recycling program is not likely to succeed. To ensure material quality, residents should be told how to prepare the materials and what materials cannot be recycled.

Controlling collection costs:

One of the keys to controlling curbside collection costs is efficiently integrating collection of recyclables with refuse collection. To minimize collection costs, some communities are collecting recyclables in the regular refuse vehicle by using bags of different colors to differentiate recyclables from garbage.

Maximizing participation:

To maximize participation in a drop-off program, a large number of sites are needed: people are willing to drive their recyclables only a few miles. If the location of drop-off centers is well publicized, residents and businesses will find it easy to participate.

Other motivational techniques include: school education programs, recycling contrainers, and telephone hotlines. Literature on how to source-separate should be kept short and simple and distributed widely and often. Residents need to know exactly what is expected of them when recyclables should be placed at the curb, the location of drop-off centers, and the materials that can be received. If regular garbage vehicles are used to collect recyclables, they should be re-labeled, or residents might think that their carefully separated material is going to the landfill.

Priorities for Dehardun city

The first priority will be how to divert more organics from the MSW stream (for composting or animal feed). The reason is that organics are the largest category of MSW and the greatest reduction in wastes for disposal can be achieved by diverting organics.

The second priority will be, in most cases, supporting maximum reduction/ recovery of synthetic materials, without separate collection by the municipal authority. Solid waste department should encourage waste reduction and materials recovery by the private sector (formal and informal). Municipalities should be cautious about adopting Western-style materials recovery programs and technology, although in some cities these may be appropriate.

This man recycles plastic into sandals.

Arguments against municipally sponsored materials recovery

Solid waste departments should consider carefully their main duties and their managerial capabilities when suggestions are made for adopting municipally managed source separation and materials recovery. Departments which are already overburdened with the duties of public cleansing and waste disposal are not advised to add the responsibility of collecting and selling source-separated recyclables.

Such collection and marketing demands resources, financial and managerial. In many cases, source separation sponsored by the municipal authority will not necessarily significantly reduce the amounts of wastes that must be disposed of by the authority. This is because the most valuable recyclables are already diverted from the municipal waste stream by waste generators, through private and/or informal systems of waste trading and recycling. In such cases, the solid waste department would not be able to recoup the high costs of separate collection by selling the residual materials that are not sold by the generators. Even where local recovery networks have declined, municipalities that collect materials have not been able to recover costs.

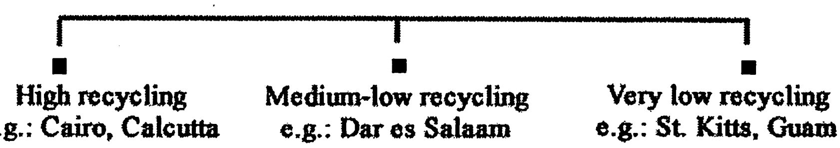
An additional impediment to municipally sponsored materials recovery arises from the fact that there are so many individuals and small enterprises which make a living by recovering and trading recyclables. If source-separated items were set out for collection, it is highly likely that these would be stolen before the municipality could claim them. This has already occurred in pilot schemes in both developing and industrialized countries.

Finally, given the widespread underemployment in most cities, it is often problematic to reduce the jobs provided by private waste recovery and waste trading by transferring these to the public sector. This is especially important where the public sector of waste management is inefficient.

Foundations for MSWM

The great variety among cities and towns in developing countries means that each place must study its waste characteristics and assess local waste reduction potential. Throughout these regions, urban places fall along a continuum from high recycling (e.g., Calcutta, Cairo) to very low recycling potential. (Typically the latter are remote islands or enclosed countries visited by affluent tourists, or having a military base, e.g., Suva, Guam, St. Kitts. Remote islands with low levels of consumption are characterized by high levels of waste reuse, e.g., Commander Islands, Aleutians, where even washed-up drift nets are crocheted into shopping bags).

City types and recycling levels, developing countries



Primary tools for municipalities to use in promoting waste reduction and materials recovery

1. Promote educational campaigns for (a) public support of waste reduction and recycling (especially as individual economic incentives weaken) and (b) reduction of the stigma attached to waste work.
2. Study waste streams (quantity and composition analyses), recovery/recycling systems, markets for recyclables, and problems of existing practices to decide where there may be a facilitative/regulatory role for the municipal authority.
3. Support source separation, recovery, and trading networks with information-sharing (especially of market information) and forums of stakeholders.
4. Facilitate small enterprises and public-private partnerships by new or amended regulations for cooperatives, loans to small-scale businesses, amendment of inhibiting zoning and control regulations, low-rent space for stockpiling depots, etc.
5. Assist waste pickers to move out of manual picking by instituting retraining programs or subsidization of sorting/redemption centers; control harassment of itinerant buyers and waste dealers by police.
6. After consulting the major stakeholders, advocate, where advisable, selective waste reduction legislation on packaging reduction, product redesign, and coding of plastics.
7. Export recyclables if there is high demand in neighboring countries and non-toxicity is assured. Promote innovation to create new uses for goods and materials that would otherwise be discarded after initial use.

Understanding where a city or town is located on this continuum is the starting point for developing tools to promote waste reduction. The main tools available to municipal governments in promoting waste reduction and materials recovery are listed in the accompanying box.

In any of these actions, municipal departments can enter into partnerships with environmental and community organizations, whose members are keen to reduce waste collection and disposal problems. Many examples of such cooperation are being developed. For instance, in Bangalore, the Bangalore City Corporation has provided the land for community-based composting and vermiculture.

All places should undertake some action on points 1 and 2. High and medium recycling cities will additionally explore 3, 4, and 5. Some policies such as waste reduction legislation must be selectively tried according to the local context. Isolated places with very low recycling potential are virtually limited to exploring the opportunity for exporting high-value recyclables and vigorously promoting reuse.

Facilitating small enterprises, cooperatives, and public-private partnerships

Small enterprises and cooperatives need external support to start up and to be successful. It is helpful if this support comes, at least in part, from the local government. Ideally, the local government should provide a location where the recyclable materials can be stored and sorted more thoroughly before being sold to wholesale dealers or factories. Coordination with factories using secondary materials greatly helps the efficient flow of materials. These enterprises also require training and follow-up support. This is best done by a nongovernmental organization (NGO), although in some cases training by recycling industries is also possible. Eventually, an intermediate point between assistance and independence may be found.In summary, assistance to small enterprises and informal workers in waste recovery, trading, and recycling can enhance waste reduction for a whole city. At the same time, working conditions in small undertakings can be improved and adverse environmental impacts reduced. The kind of assistance required is not costly compared to the breaks that are given to big businesses, while the potential benefits for the urban environment are considerable.

Addressing waste picking

The picking out of recyclables from mixed garbage at street bins, transfer stations, and dumps is very common in many cities. This practice is particularly risky where municipal wastes contain human excreta, and biomedical and industrial wastes, and where pickers do not have protective clothing or access to washing facilities. In addition, children and pregnant women are numerous among pickers.

Most municipal authorities do not have the capacity to enforce prohibition of picking, which is a sensitive topic in some cities where many thousands of poor people survive on earnings from this activity. In addition, very poor people obtain some of their basic needs from garbage. City administrations thus face difficult issues with regard to picking. The following actions have been suggested by NGOs and social activists:

- subsidize protective clothing to reduce the health risks of picking (unfortunately, such clothing is usually sold by those to whom it is given);
- provide access to basic health care and inoculations against tetanus ;
- regulate picking, by the provision of designated picking areas at transfer stations and dumps;
- enable pickers to organize cooperatives to improve their earnings and working conditions; and
- Control harassment of street pickers and itinerant buyers (since such harassment tends to increase dump picking).

There are numerous examples of partial attempts to achieve such goals, but no detailed evaluation of the results.

The readiness with which materials taken from mixed garbage can be cleaned and dried can significantly improve the prices that pickers obtain for them, and can reduce the health hazards to which pickers are exposed. NGOs are therefore developing simple cleaning and processing techniques.

Dump picking is more hazardous than street picking. There are no reports of significant reduction in health risks for dump pickers except when there have been substantial improvements in their basic living conditions. The provision of gloves and boots to pickers in Calcutta and other places failed, as they sold the clothes and continued to work as before. On the other hand, NGOs have assisted dumpsite communities more broadly, with housing, sanitary facilities, medical care, and education. It is possible that establishing designated picking areas at dumps, away from the tipping face, would help dump management. In fact, at large dumps, pickers usually cooperate among themselves and with staff to avoid chaos and accidents.

Technology decisions in solid waste management also affect the feasibility of waste picking for poorer families who depend on this source of income. Efficient collection of garbage in closed containers means that more recyclables are deposited in dumps, albeit in a much dirtier and damaged condition. As a result, more people resort to dump picking. Cities with closed MSW collection systems (i.e., collection from lidded containers, in covered vehicles) and substantial numbers of poor people often have dumps controlled by gangs or entrepreneurs, who exploit the pickers. The use of compactor collection trucks and compaction and cover at dump sites damages many materials and renders them useless.

While societies should do everything possible to reduce the attractiveness of picking, it must be recognized that the decline of this activity has occurred in the past only when the general standard of living and employment opportunities for low-skilled people have reduced poverty and unemployment. Help for waste pickers must extend to their living conditions and primary health care; assistance confined to clothing or facilities at dumps may give insignificant returns in terms of health. Sorting sites, access to water, and some simple drying and baling machines are facilities that NGOs or municipal administrations can help picker groups to attain.

In summary, there are four main ways that Dehradun city government can enhance waste reduction:

- **Inform citizens about source separation and recycling, and the needs of waste workers:** extensive public education is needed to develop understanding of the need for further source separation to improve the potential for composting and to remove the stigma of association with waste materials.
- **Promote recycling industries and enterprises.**
- **Divert organics.** The greatest relief for the waste authority will come from reduction of organics, which implies, in the main, successful composting. Keeping organics pure for composting will require more thorough source separation than is done at present.
- **Advocate key areas for waste reduction at the manufacturing level** (e.g., reduction of plastic packaging; coding of plastics to improve recycling).

Waste generation and waste reduction reflect many complex economic and social factors. No city or town can adopt recommendations in a vacuum; each must examine its own wastes, and the potential for extending waste reduction. There are many possible ways to implement the general dictum that waste reduction should be the first principle of solid waste management. Humane concern for waste workers must temper the drive to greater efficiency. During periods of technical change, there are winners and losers, and in the field of materials recovery there should be attention to those who 'loseout' as operations become more efficient. In most cases, the resulting municipal strategy will be a mix of private and public sector activities.

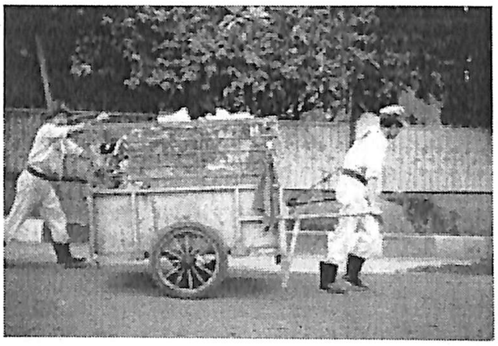
Waste collection

It is fair to say that every MSWM system (except backyard composting or burying the waste in one's own back yard) includes collection in some form or other.

Collection

Many collection activities involve the informal sector: unregistered micro- or small-businesses; poor individuals; squatters or recent arrivals from the country with no papers or who are outside of the social safety net: these people subsist by culling valuable materials from the waste stream and processing them into intermediate or consumer products.

The use of muscle-powered vehicles, including wagons, animal-drawn carts, or rickshaws, is common. Payment either for service (from generator to collector) or for materials (from collector to generator) is often involved. The practical aspects of collection routing, set-out practices, vehicles, collection schedule are highly variable, involve primarily manual labor, often of women and children, and depend on specific circumstances.



Men like these, who belong to the Yellow Brigade, move waste from households to a transfer point in the two-tier collection system of Surabaya, Indonesia.

In most cities, there are many areas that receive no collection at all. For example, collection may miss large areas of poor or squatter settlements; areas that are hilly; neighborhoods with unpaved or impassable streets; or whole areas where houses are too close together for collection vehicles to get through.

In Latin America, women are often involved in small-scale collection enterprises.

The boundary between collection of materials for disposal and recovery in developing countries tends to be blurred, and recoverable materials may be separated during the collection process. The same people waste collection crews, waste pickers, or independent buyers may be involved in both collection of waste and separation and recovery of materials.

A common aspect of collection in cities is chronic and acute lack of adequate service, particularly in poor or marginal areas. This combined with the relatively large volume of human and animal fecal matter means that waste collection has a direct link to public health and sanitation in developing countries: collection failure can lead directly to injury and disease.

Most collection is performed by public employees or firms under contract to the government or to business and industrial waste producers. For efficiency reasons, collection tends to occur early in the morning, using closed compactor trucks. Collection efficiency is important, as is the invisibility of collection and its lack of impact on formal daily life. Recovery systems tend to be separate from waste collection systems, and to involve different sets of actors.

Communal collection points

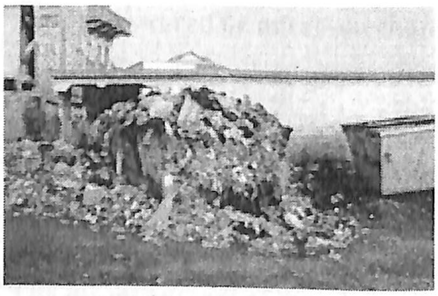
In parts of many cities, residents carry their waste to a container at a "communal collection point." "Collection point" is also used, to mean a point to which recyclable materials can be brought. Communal collection is very common in cities, particularly in areas that are difficult to serve, or in poor areas that municipal authorities are unwilling or unable to serve with door-to-door waste collection.

Payment for collection or materials

Collection may or may not involve payment in either direction. The term "collection fee" describes the situation where the individual disposing of the waste or materials, or an organization representing individuals or a community, must pay the collector to have the materials collected and removed.

Transfer

Transfer refers to the movement of waste or materials from the primary collection vehicle to a secondary, generally larger and more efficient, transport vehicle. While virtually all waste systems have collection, not all include transfer.



This overflowing communal collection container in Accra typifies the lack of attention given to collection in low-income areas throughout the developing world.

The point of transfer is referred to as a "transfer station" or "transfer point".Primary collection vehicles bring their waste to a transfer station and dump it. It is then transferred, with or without compaction, to other vehicles for a longer haul to a disposal site. Transfer, which may include a short storage period, also provides a point of access to the waste or materials stream and an opportunity to remove certain materials or perform processing such as shredding, compacting, screening, wetting, or drying.

Street sweeping and municipal cleansing

Municipal cleansing includes litter control and street sweeping. Street sweeping is a large enterprise, and typically represents as much as 20-30% of municipal public works budgets. Street sweeping may also include washing activities, but this section focuses on the more universal sweeping activity.

Street sweeping is the basic way streets, sidewalks, and public areas are kept clean. It is common for poor or marginal areas to receive reduced or inadequate service, or no service at all, while wealthier or tourist areas receive extensive service.

Collection vehicles

Almost all forms of collection are based on a collector or collection crew which moves through the collection service area with a vehicle for collecting the waste or materials. This vehicle may be small and simple as small as a two-wheeled cart pulled by an individual or large, complex, and energy intensive, such as the rear-loading compactor trucks used in many industrialized cities.

The collection vehicle selected must be appropriate to the terrain, the type and density of generation points, the roads and ways it must travel, the type of waste or the kinds of materials it will be used to collect; the strength, stature, and capability of the crew that will work with it; and the point and manner of discharge of its load. If the vehicle is to be used for multiple purposes, it must be suited to all of these.

Muscle-powered or micro-mechanical vehicles work well:

- in densely populated areas with little street access or unpaved streets;
- in squatter settlements;
- on hilly, wet, or rough terrain; and
- Where there is relatively small volume of waste from a relatively large number of densely settled housing units.

The disadvantages of muscle-powered vehicles include:

- the perception by some that the use of animals or human power is old-fashioned or shameful;
- the fact that the vehicles have limited traveling range and are generally slower than fuel-powered vehicles;
- the fact that animals pulling such vehicles leave waste, which must be cleaned up;

- The fact that weather exposure has a greater effect on humans and animals when they are not in motorized vehicles; and the problems of animal temperament, health, etc.

Small-scale collection and muscle-powered vehicles

Muscle-powered carts or wagons and relatively small rickshaws pulled, pushed, or pedaled by people, bicycles, or animals are an important sound practice for MSW collection in many developing countries, as well as in rural hilly areas of transition countries. Such vehicles are inexpensive and easy to build and maintain, compared with other vehicles. In many cases muscle-powered vehicles represent the soundest mix of capital, labor, and available resources for waste or materials collection.

Small-scale collection can also be accomplished with use of electric or propane-powered vehicles servicing a small or inaccessible area in conjunction with a larger "host" vehicle. Muscle-powered primary collection (or micro-collection) may be coupled with transfer into a larger "host" vehicle at the edge of the neighborhood; this is sometimes done with street sweeping or materials recovery in industrialized countries.

Non – compactor trucks

Non-compactor trucks are more efficient and cost-effective than compactor trucks in small cities and in areas where wastes tend to be very dense and have little potential for compaction. The use of lighter, more energy- efficient box-trucks, vans, and dump trucks can be appropriate for sparsely populated areas, where the main constraint on collection efficiency is distance.

Advantages of non-compactortrucks

Non-compactor trucks are a sound technical practice for solid waste collection under the following conditions:

- the waste is generally very wet or dense;
- labor is relatively inexpensive, compared to capital;
- there is limited access to highly skilled maintenance;
- collection routes are long and relatively sparsely populated;
- controlling capital and operating costs is very important; and
- Downtime for maintenance must be minimized.

Disadvantages of non-compactortrucks

The main problem with the use of non-compactor trucks is not technical, but political:

- government officials tend to see compactors as a means to modernize their waste collection system; they view non-compactor trucks as having low status;

- Equipment salesmen recommend compactor trucks as the only method for proper waste transport.

When non-compactor trucks are used for waste collection they usually need to have a dumping system to easily discharge the wastes. Nevertheless, dump trucks, which have a high loading height, may not represent the best choice for a non-compactor truck. Non-compactor trucks generally need to be covered in order to prevent residues flying off the truck and/or rain soaking the wastes.

"Love Bandung, Love Cleanliness." Public education can be built into collection vehicles. This collection vehicle uses locally made parts.

Compactor trucks

In those cities, the use of compacting vehicles of some type has become the standard of sound practice for waste collection. A compactor truck:

- allows waste containers to be emptied into the vehicle from the rear, the front, or the side;
- compacts the waste to a high density using hydraulic or mechanical pressure;
- removes the waste from view quickly; and
- Inhibits vectors and insects from reaching the waste during collection and transport.

Compactor trucks have the following characteristics:

- high capital cost;
- Sensitive hydraulic mechanisms which must be well maintained in order to function; these can break when an attempt is made to compact waste that is already dense.
- high fuel usage and operating cost;
- moderate skill level to operate;
- At least two persons needed to operate under most conditions.

Compactor trucks work well where:

- there are paved streets wide enough to allow passage and turning;
- the waste is set out in containers or bags, so that crews can pick them up quickly; and
- the density and moisture content of the waste are low.

Compactors work poorly where:

- the waste stream is either very dense or very wet, such as mixed waste in cities

- the materials collected are source separated organics or materials with septic content; compaction tends to squeeze out the moisture and discharge it as leachate;
- collected materials are gritty or abrasive; or
- the roads are very dusty.

The central characteristics of a collection system based on dual collection compactors are:

- the containers are uniform, large, covered, and relatively visually inoffensive;
- health risks to the collectors and odor on the streets are minimized;
- the waste is relatively inaccessible to waste picking; and
- Monitoring compliance with source separation protocols is difficult.

Selection of set-out containers

Most collection systems depend on some kind of set-out container. This is usually a paper or plastic bag, or a metal or plastic garbage can. Scandinavian countries tend to use 120-liter kraft paper bags in a metal or wooden frame.Set-out containers include bags, pots, plastic or paper bags, cane or reed baskets, concrete or brick vats, urns, boxes, clay jars, or any kind of container available.

In some places, waste is stored in a pit in front of houses while awaiting collection. In other places, any container at all can be used to store or organize waste. In many places, storage containers are insufficient and waste is simply piled or heaped on the street or on the ground to await collection.

In places with community transfer, residents use bags or baskets for carrying waste to the containers. Plastic bags, which are increasingly available, are becoming a problem for composting.

Container materials, size, and volume.

The choice of set-out container has an important effect on collection effectiveness. Containers like baskets or paper bags allow wastes to have contact with air, which promotes decomposition while discouraging formation of anaerobic odors.

In cities theft of containers is a major problem. Sometimes even large plastic bags are stolen. This must be factored into all decisions about set-out.

Larger containers encourage generators to keep wastes for longer before setting them out. In locations with cold winters, for example, the use of a larger container allows generators to comfortably accumulate several weeks' waste before setting it out. This efficiently dovetails with less frequent collection.

Container color.

Brightly colored containers that contrast with the surrounding environment increase the speed and ease with which the crew can dump the waste into the vehicle. If collection occurs at dawn or dusk, or in the dark, the visibility of the set-out container is also a factor in determining how quickly collection can proceed, and in preventing missed containers. On the other hand, collection containers should not be too attractive or they may be stolen for other domestic uses.

Container design and materials recovery from waste set-outs.

The waste collection container has a large effect on the feasibility of recovering materials from the waste prior to collection. In systems where the goals are to facilitate waste picking prior to collection (to reduce, among other things, the volume of waste to be collected), the container should be low to the ground, wide mouthed, not too large for an individual to manipulate, and stable. Where the goal is to discourage waste picking, use of a taller container can be beneficial.

Wheeled carts for automated collection.

In places where automated collection systems are in use, the container must be compatible with the lift and dumping system on the collection vehicle, and usually must have wheels.

Route design and operation

Collection service areas and routes

Collection of waste or recyclables tends to be organized into service areas. A service area is the region or area which falls under the responsibility of a government, public authority, or private company. Within the service area, collection is organized into routes. A route is the path followed by a single collection vehicle for waste collection on a single day.

Collection efficiency

Collection efficiency is critical to MSWM as it is the main determinant of collection cost in all types of collection systems. While cost control is increasingly important all over the world, in some cases authorities place a higher priority on employing people or arranging collection at a particular time of day, thus raising collection costs. The savings realized from moving toward efficient collection methods can be used for other social needs.

An efficient collection system aims to collect as much waste as possible with a given amount of labor, capital, and time. If collection takes place at a time when streets are crowded with bicycles or market booths, the ability of the vehicle to travel its appointed route will be diminished. If the vehicle has too small a volume to handle the waste that is generated on the route, and must make several trips to dump the accumulated waste or materials, the amount of time available for collection decreases.

Collection route design

The design of an optimal collection system, therefore, involves far more than the choice of vehicle alone. There is a complex interaction of factors, and ignoring any one of them can result in a collection system which is inefficient or does not successfully meet the policy or technical objectives of the collection program.

Curbside, alley, or backyard collection.

A common point of collection is at the curbside or the alley; the resident places full waste containers at the curb or in the alley behind the residence and retrieves them empty. This represents sound practice in many situations. Backyard collection is much less common, but is used in wealthier areas of some industrialized countries where there is a strong wish to keep waste out of the public eye, backed up by a willingness to pay for the added cost of such service.

Collection frequency.

Sound practice depends on well-chosen collection frequency and timing. In cities, collection occurs as often as once per day, but there is disagreement regarding optimal collection frequency. In most industrialized cities, collection occurs once or twice per week, and even more frequently in urban areas where storage space is limited. Areas with a high density of small retail shops, hotels, and restaurants usually require daily collection.

Sound practice in setting collection frequency should include analysis of the appropriate volume for containers, the needs and desires of the area or neighborhood, the public health risks that would arise from infrequent collection, avoidance of odors from uncollected waste, and the necessity of scheduling collection at times when streets are not crowded.

"Just-in-time" collection.

Some cities use "just-in-time" collection systems, where residents bring out their wastes at the time the collection vehicle reaches a certain spot and signals its presence. This system reduces the health hazards associated with wastes on streets and roadsides, and prevents unauthorized waste picking.

Just-in-time collection only works when households typically have someone at home to carry out the waste at the proper time. To enhance reliability, the collectors can ring a bell or announce their presence from a loudspeaker upon arrival in an area. In squatter settlements in Bombay, an adaptation of the bell system is that the crews have hand carts to fit into narrow lanes and walk along ringing a bell; then they take the carts back to the vehicle on the road.

A Dutch adaptation is to have a truck collecting hazardous wastes move through the neighborhood during the day, and then take up a stationary position at a centrally located point (such as a shopping center) in the neighborhood for several hours at the end of the working day, to allow those who were not at home to deposit their materials.

Special collections.

Special materials, such as bulky items, white and brown goods (old appliances and electronics), furniture, leaves, construction materials and tree stumps, must often be collected separately, due to their size and the fact that they are generated irregularly. Sound practice in this area includes:

- making the rules of collection clear to all residences and businesses;
- collecting with adequate frequency to prevent build-up on the streets; and
- Coordinating collection with the industries and individuals who would like to have these materials for repair, salvage, dismantling, or materials recovery.

Crew size and makeup.

The size, capability, and motivation of the crew is a basic factor in determining efficiency of collection Some variations on sound practice are described below.

Single driver-collector.

All vehicles, whether muscle-driven or mechanical, require a driver, and one crew model is that the driver does the collection as well. Single driver-collector models represent sound practice where:

- the size and volume of the set-outs is small;
- not every stop has set-out materials; and
- The distance to be traveled is relatively long in relation to the quantity of materials to be collected.

Driver separate from collection crew.

A second model of sound practice is that the driver remains in the cab, on the bicycle seat, or at the head of the animal and does no collection. A crew of one or more people walks or rides between set-outs and does all the work of picking up the material. This model represents sound practice:

- in relatively dense areas;
- where the distance from one stop to the next is too short for the driver to get out, load the material, and get back in, but easy for the crew to walk;
- where the volume of waste is high in relation to the distance to be traveled; or
- where the drivers are in a separate union category that does not permit them to handle waste, although it can be useful to renegotiate such rules.

Interchangeable driver and crew.

A third model, the most common and a generally sound practice, involves a revolving crew, where more than one member can drive, and the drivers also assist with the loading.

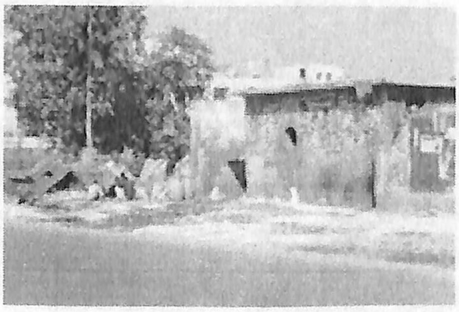
Individual operators who collect fees.

In cases where the collectors pay for material, there is more interaction with the generators during collection, and handling the money is a significant part of the work of collection. These cases frequently involve a single individual with his or her own vehicle or carrying pack, and usually depend on nearby middlemen to buy the collected materials.

Equipment repair and maintenance

Sound practice requires preventive maintenance of equipment, including vehicles, containers, transfer points, and tools. Maintenance includes periodic preventive equipment repair, worn parts replacement, lubrication, and replenishing fluids. For waste-related equipment, daily or periodic cleaning or washing is also highly recommended.

Improvement in maintenance, together with the selection of collection systems that are available locally, is a key element of sound practice in collection systems.



At this communal collection point in

New Delhi, recyclables are usually sorted out and not sent for disposal.

Communal collection

Communal collection, which is very common in developing cities, involves individuals bringing their waste directly to the collection point, usually a container that can be accessed by foot.

Communal collection is a particularly appropriate means of organizing collection where household collection is impossible or marginally feasible, where inadequate resources are devoted to poor areas, or where local customs promote it. The solid waste authority may choose to provide containers on each street corner, at several places on a densely populated street, or at a point on the edge of a neighborhood that is accessible both to generators and collection vehicles.

An advantage of communal collection points for drop-off of household waste is that these facilities provide more or less continuous access to disposal or materials recovery facilities. Disadvantages of communal collection arise from the fact that such facilities may receive little attention from municipal authorities. Additionally, residents may deposit dangerous materials in or near the container.

MSWM in communal collection design requires recognition of the inherent conflict between the physical demands imposed by public convenience in disposal and the strategies required to maintain cleanliness and control waste pickers, odors, vectors, animals, and flies and other insects.

MSWM also involves ensuring that there are an adequate number of containers that are easy to use, even for children. The responsible authority must carry out very frequent collection (often daily) and must be committed to cleaning up overflows.

Ideally, communal containers should be designed to prevent animals from getting access to the contents. While tall containers or those with small openings or heavy lids may accomplish this purpose, they are also difficult to use, especially for children.

Summary of principles for designing collection systems

The principles outlined below represent sound practice, with special reference to the needs of developing countries.

Principles for selection of collection vehicles:

Selection of a collection vehicle as the basis for a collection system involves the following guidelines:

- Select vehicles which use the minimum amount of energy and technical complexity necessary to collect the targeted materials efficiently. High energy prices and vehicles that are difficult to repair both raise the cost of collection. The trade-offs here depend significantly on the relative cost of capital and labor.

- Choose locally made equipment, traditional vehicle design, and local expertise whenever possible, supplemented if necessary by assistance from national or international experts. This is the core of sound practice for developing countries, where there is a long history of internationally provided vehicles that are not appropriate for the waste stream, do not work well in the climate, and break down after only a few months of service.
- Select equipment that can be locally serviced and repaired, and for which parts are available locally.
- Choose muscle- and animal-powered or light mechanical vehicles in crowded or hilly areas or informal settlements in developing countries.
- Choose non-compactor trucks, wagons, dump trucks, or vans where population is dispersed, or waste is already dense. These trucks are lighter, more fuel-efficient, and easier to maintain. In addition, these trucks generally offer lower capital and operating costs in return for higher labor requirements
- Consider the advantages of hybrid systems where appropriate: satellite muscle-, electric-,or propane-powered small vehicles feeding a larger slow-moving or stationary compactor truck or container. Many cities combine an old city center with a modern commercial center, wealthy outskirts, and poor neighborhoods. The appropriate collection vehicles for each of these areas differ greatly.
- Consider compactor trucks in industrialized urban areas where roads are paved, collection routes serve many generators, and waste is not dense or too wet.
- When sidewalks and streets are suitable for containers to be wheeled from the household to the curb or the corner. These allow for the use of the relatively large 120- to 240-liter rolling carts, which in turn make it possible to collect less frequently.
- Select dual collection vehicles in industrialized areas where separate collection of organics or other recyclables is a priority. The use of dual vehicles allows for the efficient collection of two material streams.
- Select specialized recycling collection vehicles for collection of commingled recyclables.The last ten years have seen rapid development of these specialized vehicles, which may provide compaction for plastics, dry storage of paper, and a provision for collection of separate colors or grades of glass, metal, and plastic.

Principles for selection of set-out containers

A similarly conceived set of principles constitutes sound practice when choosing or designing a new system of set-out containers:

- Choose containers made of local, recycled, or readily available materials. Sometimes designing an attractive and uniform container can significantly alter public waste practices and effect a change in behavior..
- Choose containers which are easy to identify, either due to shape, color, or special markings. There is some advantage to specifying a set of uniform containers when introducing a new collection system, as this communicates the official nature of the collection and adds to perception of importance.

- Choose containers which are sturdy and/or easy to repair or replace. This is essential to sustainability of a collection system over the long term.
- Consider identification of containers with generators by address or name or code number. Sometimes having a name or address on a container introduces a greater sense of responsibility and a tendency to keep the container clean and/or retrieve it promptly after emptying from the point of set-out.
- Choose containers that are matched to the collection objectives: easy to open and empty to facilitate waste picking; large enough for storage of materials between collection days; small enough for manual loading if necessary; etc.
- Choose containers that are appropriate to the terrain: on wheels where there are regular paved streets; waterproof where it rains a lot; heavy where there are strong winds, etc.

Transfer stations and transfer points

Transfer stations are centralized facilities where waste is unloaded from smaller collection vehicles and re-loaded into larger vehicles (including in some instances barges or railroads) for transport to a disposal or processing site. This transfer of waste is frequently accompanied by some removal, separation, or handling of waste. In areas where wastes are not already dense, they may be compacted at a transfer station.

Transfer stations represent sound practice when there is a need for vehicles servicing a collection route to travel a shorter distance, unload, and return quickly to their primary task of collecting the waste.

Transfer trailers or compacting vehicles can carry larger volumes of MSW than regular collection trucks, which allows them to travel longer distances carrying more waste. This lowers fuel costs, increases labor productivity, and saves on vehicle wear.

Drawbacks to transfer stations include the additional capital costs of purchasing trailers and building transfer stations, and the extra time, labor, and energy needed for transferring waste from collection trucks to transfer trailers.

Some cities have transfer stations of the type described above, but there are also un mechanized, local transfer points that serve the special needs of particular collection service areas. A micro-collection vehicle designed to service a hilly area or a densely populated area with narrow or congested streets can transfer its load to a larger vehicle or a stationary container at such a transfer point. This can make it possible to service collection areas that a truck could not enter. Such transfer points may also degenerate into unregulated dumps in the absence of institutional commitment and managerial capacity to ensure their efficient operation.

Elements of transfer

Siting

MSWM for the siting of transfer points and transfer stations includes the choice of a site accessible to collection vehicles and positioned for staging of the larger trucks that will haul away the waste. Sound practices for siting transfer points include the following:

- the neighborhood must be willing to accept the transfer point as designed and located;
- agreements made with the surrounding community must be taken seriously and honored by the relevant authorities; and
- Odors, noise, leachate, and increased traffic must be minimized.
- Larger-scale transfer stations should in general be sited

- far enough from residential areas that odors, noise, leachate, and traffic are not acute issues;
- close enough to the collection area that collection vehicles can quickly return to the area;
- at sites that are zoned for commercial or industrial use;
- where there is easy access to major roads;
- on the site of a closed landfill, since the existing land uses and road network around the landfill are already suitable for transfer stations; and
- Where road restrictions (weight, noise, speed, surface, axle weight, truck length) do not conflict with the expected usage related to transfer.

In some large or heavily populated areas, or in regions with dispersed population centers separated by relatively sparsely populated areas, more than one transfer station may be desirable. The appropriate number of transfer stations depends primarily on the number and size of service areas covered by the MSWM system, the distance between the areas, the volume of MSW generated, the distance to disposal, the types of vehicles in use in primary collection, and the size and type of transfer stations selected.

Transfer vehicles

A number of truck types are currently used for transporting wastes from transfer points. At large transfer stations, large transfer trailers are used for bulk transport of compacted waste to more remote disposal facilities. These can be either open-top (usually a cover is required during waste transport) or enclosed.

Large-scale transfer station design

Transfer station design in industrialized countries generally includes a tipping floor serviced by bulldozers for pushing waste into transfer trailers or a compactor blade for packing waste into trailers. Recyclables and special wastes are increasingly being sorted and processed at transfer stations. There are three common types of transfer station that represent sound practice.

Open tipping floor.

In the open tipping floor design, collection trucks unload un compacted waste onto the tipping floor, and bulldozers organize the waste and place it in open-top trailers.

Often the most appropriate choice for cities, this type of facility:

- is more efficient for small volumes of waste than for large;
- can serve to transfer different materials at different times or into different vehicles;
- can easily accommodate recovery of bulky wastes or of materials such as cardboard;
- allows for waste picking at the transfer station; and
- Maximizes the possibility of spreading the waste, ideally on concrete platforms, in order to pre-dry or pre-compost it for a day or two before transfer to a landfill or processing facility.

Open pit design.

An open pit transfer station has the collection trucks dump waste into an open pit, where bulldozers organize the waste and load it into open-top trailers. Alternatively, the waste is compacted and loaded into enclosed trailers. This design:

- allows multiple collection vehicles to unload at the same time that loading and transfer operations are in process;
- can accommodate larger vehicles than an open tipping floor design;
- has higher capital and operating costs than an open tipping floor;
- is not ideal for pre-processing or separation of recoverable materials, although this can be accommodated;
- is vulnerable to breakdown of compaction units, if they are used; and
- Can incorporate waste picking only with difficulty, since the open pit is hazardous.

Direct dumping transfer stations.

In direct dumping, collection trucks unload through hoppers directly into either open-top trailers or compactors. This system:

- has no intermediate handling, which increases efficiency and decreases labor;
- does not permit waste picking or any other type of intermediate handling, and therefore effectively prevents recovery;
- requires an intermediate level of capital investment in the facility, but a significant investment in the transfer trailers themselves;
- can be rapidly constructed and/or moved, since most of the capital investment is in the vehicles, not in the facility itself;

- requires an abundance of extra trailers;
- is vulnerable to a shortage of trailers, since there is no buffer when there are insufficient trailers available to load the waste; and therefore
- Is a poor choice when equipment maintenance,. repair, or replacement represents significant difficulties within the system?

Some of the drawbacks to direct dumping can be solved in hybrid systems, where vehicles discharge onto a tipping apron which allows brief access to the waste before it is pushed by loaders or dozers into the hoppers that feed the transfer trailers.

Distance to processing or final disposal.

Since one of the main reasons for including transfer in a waste system is to increase the efficiency of hauling to disposal or processing, sound practice must include an assessment of the distance from the collection service areas to these facilities in comparison to direct haul to the disposal facility.

Health and environmental considerations of transfer

Environmental benefits of transfer.

From a system-wide perspective, transfer operations have the potential for environmental and health benefit, in the following ways:

- They can reduce air emissions and fuel consumption because of increased collection and transport efficiency and reduced energy use.
- Access to the materials for pre-processing, waste picking, or materials recovery, together with removal of bulky or hazardous items, reduces fuel use and increases recovery.
- Design for safe pre-processing and waste picking can improve the health and working conditions of waste pickers who would otherwise be salvaging materials from the landfill or open dump.
- The availability of transfer in a collection system means that landfill siting becomes less dependent on considerations of accessibility for carts and short-distance vehicles. Landfills can therefore be sited with more consideration for public health and environmental factors such as hydro-geological conditions, the containment of leachate and landfill gases, and physical isolation of the facility to minimize the threat from disease vectors such as rodents.

Environmental problems related to transfer.

Transfer stations and transfer points can also cause problems for human health and the environment.

- Negative neighborhood impacts can include noise, air emissions, and leachate, and oil emissions from the collection and transfer vehicles, and from truck maintenance facilities.
- Like other MSWM facilities, transfer stations and transfer points have potential odor, litter, and disease vector problems. But, since they facilitate greater and more timely collection, they often on balance alleviate such problems.
- A lack of control can result in a neighborhood transfer point serving as a place for uncontrolled dumping.

Summary of selection factors for transfer stations and transfer points

The following design and selection factors for transfer stations and transfer points are associated with sound practice:

- Choose a transfer system that can accommodate the full range of collection vehicles already in use or planned (even when the long-term desire might be to phase out certain types).
- Site transfer stations and transfer points to minimize odor and noise and to allow waste to be accumulated, if necessary, prior to long-haul transport.
- Respect and abide by agreements with the neighborhood in which a transfer point is sited.
- Select and design transfer systems that allow access to the waste for pre-processing and removal of recyclables, compostables, or problem materials, unless there is a compelling reason to do otherwise.
- For large-scale transfer stations, select locally made equipment, local designs, and local expertise whenever possible, supplemented if necessary by assistance from national or international experts

Street sweeping systems

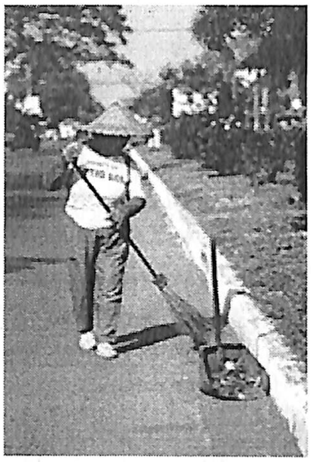
Street sweeping in most cities, is predominantly manual. Street sweeping depends on manual labor.

The use of mechanical sweepers in areas with paved streets is also common in large industrialized cities. Three-wheeled sweepers are mostly used where parked cars are frequently found and maneuverability is desired. Four-wheeled sweepers are used mostly on large thoroughfares or highways where no parked cars are expected.

Litter baskets.

Litter baskets are the primary containers used for collection of waste in public places. The design and placement of litter containers has an important impact on municipal cleansing, as there is a direct relationship between the opportunity to dispose of materials in public places and the amount of litter and garbage that ends up on public streets and requires disposal. Also, the primarily manual street sweepers in developing countries use litter baskets for depositing the sweepings.

Manual systems.



This status of waste workers can be improved with uniforms and good equipment. A workforce that takes pride in cleansing work serves to increase public awareness of the need for a clean city.

Manual systems are the standard in MSWM in cities. MSWM involves designating routes which are feasible to be swept in a work day. A key design feature in a manual system is the approach to collection of the sweepings. MSWM in manual systems includes the following variations:

Sweepers pick up their own sweepings, placing them in a cart. The carts then meet a collection vehicle at a pre-arranged time.

- Sweepers take their carts to small transfer stations located at the intersection of several sweeping routes.
- The wastes are put into plastic or paper bags and lined up at the curb for collection by a special truck.
- The sweepings are lined up in piles at the end of the route and collected by a mechanical sweeper or vacuum truck.

Mechanical systems.

Mechanical systems include four- wheeled and three-wheeled sweepers, and vacuum trucks. Sound practice includes matching the vehicle to the service area; for example, selecting three-wheeled vehicles in areas where there are a lot of parked cars.

Sweeper health and safety.

MSWM includes outfitting sweepers with shoes and other protective clothing and equipment, plus brooms and some type of collector. In areas where there is a high likelihood of human or animal fecal matter in the sweepings, gloves are important. Dust masks may be advisable in dusty areas. The opportunity to wash in hot water at the end of the day is highly desirable.

Routes.

The factors that go into route planning for street sweeping include population and housing or building density, road surface, climate, pedestrian traffic, sand accumulation (if there are nearby beaches), tree density, and topography.

If a heavily used area is swept five times a day, the route will be as little as four to eight blocks. At a frequency of once a week, the route for an individual may be as long as 20 km.

Frequency.

Street sweeping frequency is dependent on type of area and how heavily it is trafficked, and even more heavily on pedestrian education campaigns that address litter- and waste-related behavior. Such campaigns can have an enormous effect when authorities are willing to persist with them. Frequency and reliability of collection service is also an important factor, as better collection can reduce the need for street sweeping. Similarly, covered trucks allow less litter to be spread by the wind.

Sound practice here involves a combination of custom and frequent evaluation of current activities to see if they are meeting the needs and goals of the municipal cleaning program. For example, the introduction into a downtown area of Western-style fast food restaurants that uses disposable plates and packaging may require an increase in sweeping as more packaging is thrown on the street.

Poor, unpaved, marginal, or very hilly areas are seldom swept. MSWM involves regularly scheduled debris and litter collection, even if sweeping is physically impossible. A clean-up once a month represents a bare minimum of service, and sound practice involves a mechanism to respond to neighborhood complaints or notice that a clean-up is overdue.

Sweeping service areas.

Street sweeping is the basic way streets, sidewalks and public areas are kept clean. There are important equity issues in street sweeping, in terms of the amount of municipal resources that go to maintaining cleanliness in various areas. It is common for poor or marginal areas to receive reduced or inadequate service, or no service at all, while wealthier or tourist areas receive extensive service. This disparity occurs in all cities, but is exaggerated in cities. Transition countries formerly had the best distribution of services in this regard, due to ideological considerations about equity; it is not clear at the present time whether equity of distribution has survived the period of economic transition.

Public markets.

A key element in a street sweeping program is the cleansing of public markets, which are a feature of commercial life in most parts of the world.

MSWM in public market sweeping includes not only collection of residues and leftover vegetables and foods, but the removal of food packaging, utensils, bones, peels, etc. Where possible, segregation and separate collection of organic materials for swine feed, composting, or land-spreading is considered a better practice than disposing of these materials. In tropical areas, markets sometimes need to have waste collected twice a day.

MSWM in sweeping of public markets should be built on local custom, in terms of the split of responsibility between the vendors and the municipal or market authorities

Financing

Since street sweeping is a public function, even in residential areas, sound practice will always entail some involvement of the municipal authorities. However, there may be a need for more direct accountability than the municipal government can provide.

Some cities encourage or allow decentralized modes of payment. This occurs particularly in places where residents believe that this is the only way to ensure service.

Street sweeping and economic status

Often a disproportionate amount of funds is spent on meticulous sweeping of prestigious areas and commercial centers, while basic collection and street sweeping is neglected for the poorer ones. MSWM involves an equitable commitment of resources, since the health of the city may depend as much or more on the cleanliness of poor areas as it does on the cleanliness of wealthy ones.

Towns and cities with unpaved or poorly paved streets require a special approach to street sweeping, since they have large amounts of dust and dirt, which both increases the volumes from street sweeping and prevents the use of automated equipment. MSWM here involves, in the first instance, treating the needs of these areas seriously, and then designing appropriate systems to keep them clean and disease-free.

Performance guidelines for municipal workers, both in terms of areas covered and adequacy of sweeping practices is an important element of sound practice.

In summary, sound practice in street sweeping involves not only sound technical choices, with an appropriate mix of manual and mechanical activity, but equity in distribution of services.

Privatization

Privatization

As is the case for waste collection, there is some movement to privatize street sweeping.

Explicit justifications for privatization include the promise of greater efficiency and more direct accountability. Hidden causes include lack of accountability at overstaffed public agencies or the strength of municipal unions to restrict change and increased efficiency.

Technical, regional, and development issues and criteria

In collection, as in any of the other topic areas, it is critical that both the "hard" aspects of the system (set-out containers, vehicles, and transfer points) and the "soft issues" (scheduling, fee systems, and legal framework) be geographically and socio-economically appropriate to the setting. This is perhaps the single most important factor in achieving MSWM in solid waste collection. It is fair to say that no collection system designed without taking these factors into account can be expected to arrive at sound practice, or even to function acceptably. Some examples of points to consider are given below.

Geography, settlement pattern, and cultural preferences

Collection and transfer vehicles must take into account terrain, climate, and settlement pattern. For example, the use of open trucks or carts is often appropriate in dry climates, but there should be both dust control and the option to cover loads in the rainy season or when it is windy. If such vehicles are piled high with waste, the waste will fall off, thus greatly reducing the efficacy of the collection system.

In selecting a vehicle, an important consideration is the density of housing stock and the split between single- and multi-family dwellings, which affect how often the vehicle will have to stop. Street layout, grades, traffic, and road surfaces affect how easy it is to maneuver.

Compactor trucks work poorly in extremely wet climates, where wastes are often wet and dense. Compactor trucks in this situation tend to squeeze out the moisture and discharge leachate onto the street. Also, in coal- burning areas wastes are high in ash, which cannot be compacted much further. The industrialized country models of compactor collection with several crew members may be the appropriate goal in industrialized or rapidly modernizing cities with formal streets that are wide enough for such trucks. In some cases, compactor trucks are feasible when paired with a small satellite collection vehicle, such as a propane- or muscle-driven cart, that collects waste from congested areas and brings it to the truck.

Cultural attitudes towards waste can govern frequency of set-out or choice of set-out container system. Vehicle traditions and the availability of drivers affect the choice of vehicle. Cultural considerations also include whether it is acceptable for people to see the waste in the vehicle or whether it should be immediately hidden from view; whether it is offensive to hear an announcement of the truck's arrival; the issue of who can handle waste and under what circumstances, and what point of set-out is acceptable. It is worth noting that cultural attitudes are sometimes altered through education, to some extent.

Waste composition and characterization

A frequent error in the set-up of collection and transfer systems is to assume that all waste streams are alike. The composition of the waste stream varies not only seasonally, but within ethnic and social divisions in the same country. Between countries, hemispheres, and continents, there is rather large variation.

In low-income countries, waste is usually very high in organics, because other constituents are removed either before set-out or between set-out and collection. High-income countries, by contrast, tend to have a lower proportion of organic waste but more paper, plastic, metal, and glass.

Summary

Where there is variation on many of these points within a single jurisdiction, cities, particularly those in developing countries, may need to have several collection systems, geared to the varying infrastructure and socioeconomic status of the different service areas. Hybrid systems combining muscle and mechanical power are frequently appropriate. Sometimes the best approach is to adapt a system or combination of systems and to tailor them to the needs of the community. Community leaders should be consulted on the design of the systems under their jurisdiction

Economic, institutional, and legislative elements

Accountability

It is often true in developing countries that neither private nor public collectors are held accountable for the extent of waste removal on their route, and their compensation is not tied to their performance. There are typically few, if any, individuals in government who are accountable to their constituents for system performance.

Accountability is crucial to adequate MSWM systems. Government has the ultimate responsibility for public health and welfare, and this makes governments ultimately accountable for the performance and adequacy of the MSWM system. Governments can choose to transfer operations to the private sector, but performance must be monitored and ensured through contractual guarantees. The government retains ultimate accountability.

A secondary level of accountability is that which the collection service organization owes to the generators. The organization and individuals doing the collection are accountable for collecting, transporting, and discharging the waste or materials in a manner consistent with their contract, with ethical practices, and with environmental and public health regulations. They are accountable to their clients, who pay indirectly through taxes or directly through fees, for the removal service.

Optimization of available resources

In general, the best collection practices are context sensitive, eclectic, and make optimal use of a range of local resources, from labor to institutional arrangements. Local resources include the commercial formal and informal sectors operating in the region; the deployment of these resources should be carefully considered as part of the planning process.

Privatization and support of the formal sector

Privatization involving contracting to formal-sector waste management companies often brings significant resources to the solid waste collection arena, and can represent an important element in sound practice. Privatization is sometimes mistakenly seen as a way to solve all of a government's waste management problems.

Privatization of waste collection generally involves the responsible government contracting out collection services to one or more private sector operators. There is competition at the point of securing the contract, but once a contract or a franchise is awarded, the contractor receives a managed monopoly from the government. When these arrangements are well managed and free of corruption, they can deliver a high level of cost-effective service often higher than the government could provide using its own workers.

By contrast, some privatization efforts have entailed the total retreat of the municipal government from the waste management business. In this circumstance, there is no management by government: private collection firms must go directly to generators and contract with individuals. This tends to create redundant systems, where multiple trucks roll down the same streets, with each picking up from only a few of the contiguous residents. The resulting scale effects are very unfavorable, which means that fees tend to be high, and smaller firms are likely to fail or become the target of corporate takeover. This can lead rapidly to an unmanaged monopoly situation, and waste collection costs can become quite startlingly expensive.

Support to the informal sector

Local authorities can make good use of available resources by contracting to small-scale waste collection enterprises, and by providing support and recognition to waste pickers and itinerant collectors, effectively allowing their activities to be included in the overall MSWM system. This is particularly important when new waste services are being introduced, or where existing systems are being upgraded or modernized.

Fiscal commitment

The primary motivation for MSW collection is the need to remove noxious, unpleasant, toxic, or dangerous materials from households and public spaces and thoroughfares. While private sector organizations have a role in the waste management sector, sound practice virtually always requires a fiscal commitment from some level of government to design, finance, create, and maintain the MSWM system. In the case of collection, this means that the collection system must be adequately capitalized, operated, and maintained.

Once the commitment to create the system is made, sound practice calls for the authority to make a set of decisions on how to finance the system and the extent to which costs of the system should be recovered directly from specific beneficiaries.

There is a great deal of interest at the present time in cost recovery systems for waste collection and disposal. In some places this is taking the form of "pay per bag" or volume-based fees, where generators pay for what they throw away. In some cases, such a system has led to increased illegal dumping or burning of waste. In most cities, municipalities are still more likely to levy a flat fee included in a utility bill, or to simply pay for services out of taxes. It is probably true that any sound practice will include these three components:

- a fiscal commitment to capitalize, maintain, and operate the collection system, including public financing of the fixed system capacity;
- a way to recover all or part of the variable costs of collection from its beneficiaries; and
- a monitoring and accounting system that can calculate and deliver such critical pieces of information as cost per stop, cost per ton, and cost per route-day for collection, and cost per ton and cost per year for transfer.

Unambiguous jurisdiction

Many technically adequate waste management systems have failed because of conflicting bureaucratic claims or unclear jurisdictional boundaries. Regardless of the status of the overall system, collection systems must have clear accountability linked to service area. Anyone in the service area must know what body has jurisdiction over their collection, and how to give feedback to that system.

Study of Wing no. 2 in Premnagar area:

On the basis of our survey there were 68 houses present.

The survey included:

Composition of Roof Material

Material used	**No. of houses**
Concrete	58
Concrete and Tin	7
Tin	3
Wood and Plastic	None

Condition	**No. of houses**
Water supply	65
Electric supply	68
sanitation	65
drainage	65

Waste generation:

The amount of waste generated was around 500 gms/capita/day.

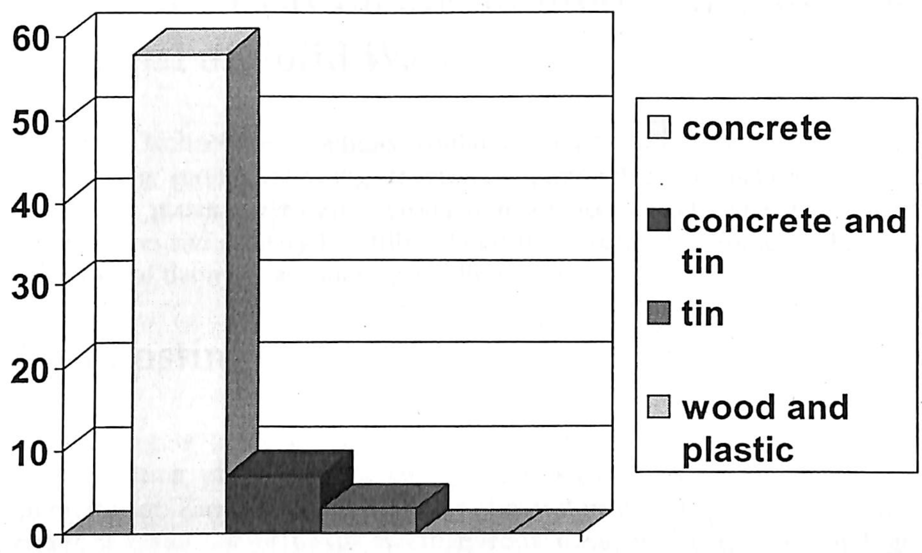
The waste included:

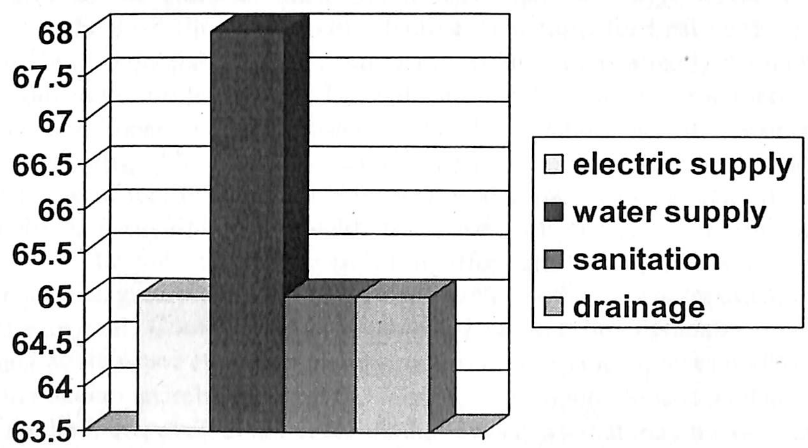
Organic waste: kitchen waste, vegetables, flowers, leaves, fruits

Toxic waste: old medicines, paints, chemicals, bulbs, spray cans, batteries, shoe polish.

Recyclable: paper, glass, metals, plastics

There was no proper Solid Waste Management system. The waste was flooding on the streets and at the corners in the market. Animals roam in the area freely.(cows,dogs etc)


60
50
40
30
20
10
0
concrete
concrete and tin
tin
wood and plastic


68
67.5
67
66.5
66
65.5
65
64.5
64
63.5
electric supply
water supply
sanitation
drainage

Technologies available for processing, Treatment & Disposal of Solid Waste

The main technological options available for processing/ treatment and disposal of MSW are composting, vermicomposting, anaerobic digestion/biomethanation, incineration, gasification and pyrolysis, plasma pyrolysis, production of Refuse Derived Fuel (RDF), also known as pelletization and sanitary landfilling/landfill gas recovery. Not all technologies are equally good. Each one of them has advantages and limitations.

Composting

Composting is a technology known in India since times immemorial. Composting is the decomposition of organic matter by microorganism in warm, moist, aerobic and anaerobic environment. Farmers have been using compost made out of cow dung and other agro-waste. The compost made out of urban heterogeneous waste is found to be of higher nutrient value as compared to the compost made out of cow dung and agro-waste. Composting of MSW is, therefore, the most simple and cost effective technology for treating the organic fraction of MSW. Full-scale commercially viable composting technology is already demonstrated in India and is in use in several cities and towns. Its application to farm land, tea gardens, fruit orchards or its use as soil conditioner in parks, gardens, agricultural lands, etc., is however, limited on account of poor marketing. Main advantages of composting include improvement in soil texture and augmenting of micronutrient deficiencies. It also increases moisture-holding capacity of the soil and helps in maintaining soil health. Moreover, it is an age-old established concept for recycling nutrients to the soil. It is simple and straightforward to adopt, for source separated MSW. It does not require large capital investment, compared to other waste treatment options. The technology is scale neutral. Composting is suitable for organic biodegradable fraction of MSW, yard (or garden) waste/waste containing high proportion of lignocelluloses materials, which do not readily degrade under anaerobic conditions, waste from slaughterhouse and dairy waste.

This method, however, is not very suitable for wastes that may be too wet and during heavy rains open compost plants have to be stopped. Land required for open compost plants is relatively large. Also, issues of methane emission, odour, and flies from badly managed open compost plants remain. At the operational level, if waste segregation at source is not properly carried out there is possibility of toxic material entering the stream of MSW. It is essential that compost produced be safe for application. Standardization of compost quality is, therefore, necessary. The MSW (Management and Handling) Rules 2000 (MSW Rules 2000) have specified certain limits to acceptable percentage of heavy metals in compost produced from MSW and a mechanism is put in place to ensure that the same are strictly implemented.

Marketing of compost is a major concern for private operators. Lack of awareness among the farmers regarding the benefits of using compost is an impediment to its sale. Also, there is a need to market the product near the compost site to minimize transportation cost.

Composting projects in India

There are many small and large composting projects in the country though the exact figure is not known. The treatment capacity designed for these facilities in large cities ranges from 100–700 TPD (Annexe Table A8.9). Many have been closed down or are functioning at a lower capacity. Those functioning are generally being managed by the private sector through a contractual arrangement with municipal authorities. Most of the plants are facing a problem of marketing the compost due to an ineffective marketing mechanism. The capital investment requirement for such projects is typically in the range of Rs 10 to 20 million per 100 MT per day plant depending on sophistication.

Composting Plants in India

No.	State	City	Facility manufacturer	Installed capacity
1.	Andhra Pradesh	Vijayawada	Excel Industries Ltd	125 TPD
2.		Thirumala	NA	NA
3.		Vizianagaram	NA	NA
4.	Assam	Kamarup	NA	NA
5.	Chhatisgarh	Dhamtari	NA	NA
6.		Rajnandgaon	NA	NA
7.		Jagdalpur	NA	NA
8.		Rakpur	NA	NA
9.		Korba	NA	NA
10.		Bhilai	NA	NA
11.		Durg	NA	NA
12.		Raigad	NA	NA
13.	Delhi (UT)	Delhi	Nature And Waste Inc India (BALSWA Plant)	500 TPD
14.		Delhi	Private Organo-PSOS Plant, (Tikri Plant)	150 TPD
15.		Delhi	MCD Plant, Okla	300 TPD
16.		Delhi	NDMC Plant, Okla	300 TPD
17.	Gujarar	Ahmedabad	Excel Industries Ltd, Ahmedabad	500 TPD
18.		Junagadh	NA	NA
19.		Rajkor	NA	NA
20.	Goa	Margao	M/s. Comets International Ltd	40 TPD
21.	Himachal Pradesh	Shimla	L&T	100 TPD
22.		Solan	Janseva Trust	50 TPD
23.		Sirmour	NA	NA
24.		Dharamshala	NA	NA
25.		Bilaspur	NA	NA
26.		Una	NA	NA
27.		Hamirpur	NA	NA
28.		Kangra	NA	NA
29.		Kullu	NA	NA
30.		Mandi	NA	NA
31.	Karnataka	Bangalore	Karnataka Compost Development Corporation	350 TPD
32.		Bangalore	Terra-Fersia Bio-Technologies Ltd	100 TPD
33.		Mysore	Vennar Organic Fertilizer Pvt. Ltd	200 TPD
34.		Mangalore	NA	NA
35.	Kerala	Thiruvananthapuram	POABS Envirotech Pvt. Ltd	300 TPD
36.		Kozhikode	NA	300 TPD
37.		Adoor	NA	NA
38		Atingal	NA	NA
39.		Chalakundy	NA	NA
40.	Madhya Pradesh	Bhopal	M. P. State Agro Industries	100 TPD
41.		Gwalior	NA	120 TPD
42.	Maharashtra	Nasik	M/s. Live Biotech	300 TPD
43		Aurangabad	M/s. Satyam Bio-fertilizer Co. Ltd	300 TPD
44		Thane	M/s. Leaf Biotech Ltd	300 TPD
45	Meghalaya	Shillong	M/s. Anderson Biotech Pvt. Ltd	150 TPD
46.	Orissa	Puri	M/s. Krishi Rashyan, Kolkata	100 TPD
47.	Pondicherry	Pondicherry	Pondicherry Agro Services and Industries	100 TPD
48.	Tamil Nadu	Tiruppur	IVR Enviro Project (P) Ltd	100 TPD
49.		Nagercoil	NA	NA
50.	West Bengal	Kolkata	M/s. Eastern Organic Fertilizer P. Ltd	700 TPD

Vermi Composting

Vermi-compost is the natural organic manure produced from the excreta of earthworms fed on scientifically semi decomposed organic waste. A few vermi composting plants generally of small size have been set up in some cities and towns in India, the largest plant being in Bangalore of about 100 MT/day capacity. Normally, vermi-composting is preferred to microbial composting in small towns as it requires less mechanization and it is easy to operate. It is, however, to be ensured that toxic material does not enter the chain which if present could kill the earthworms.

Waste to Energy

Even though the technology of waste to energy (WTE) projects has been proven worldwide, its viability and sustainability is yet to be to be demonstrated and established in the country.
The main factors that determine the techno-economic viability of WTE projects are quantum of investment, scale of operation, availability of quality waste, statutory requirements and project risks.
WTE projects generally involve higher capital investment and are more complex when compared to other options of waste disposal, but as pointed by Ministry of Non-Conventional Energy Sources (MNES), gains in terms of waste reduction, energy, etc. are also higher. Such plants are financially viable in developed countries mainly because of the tipping fees/gate fees charged by the facility for the service of waste disposal, in addition to its revenue income from power sales. It is thereafter the sole responsibility of the facility operator to treat and dispose of the accepted waste as per statutory requirements.
However, at present in India, revenue from power sales is the only source of revenue for WTE plants.
Most cities generate sufficient waste quantities to enable projects of total power generation capacities ranging from 5–50 MW, which corresponds to MSW generation ranging from 500–5000 TPD. Technologically it is feasible to set up even smaller capacity projects of the 1–5 MW range, corresponding to around 100–500 TPD waste treatment. However, economies of scale generally favour centralized, large-scale projects. Waste from a number of adjoining regions/cities could be treated at a common WTE facility; however, in such cases the costs of waste transportation versus projects benefits must be carefully evaluated.
Enforcement of strict measures for segregation of waste at source in order to avoid mixing of undesirable waste streams will play a major role in making a WTE facility financially viable. The statutory requirements that a WTE facility must comply with, will directly govern the cost of the stringent environmental pollution control measures to be incorporated in the overall facility. The terms for MSW supply, allotment of land and sale/ purchase of power directly affect the net revenue to the facility operator and are factors in determining the financial viability of projects and private sector participation. Since FI lending for such facilities is usually project based, it is critical that all project risks be suitably addressed, with back-to-back agreements. The energy off take agreements must be in place, to ensure marketability.
Some waste to energy technologies are discussed hereunder.

Anaerobic Digestion and Biomethanation

Biomethanation is a comparatively well-established technology for disinfections, deodorization and stabilization of sewage sludge, farmyard manures, animal slurries, and industrial sludge. Its application to the organic fraction of MSW is more recent and less extensive. It leads to biogas/power generation in addition to production of compost (residual sludge). This method provides a value addition to the aerobic (composting) process and also offers certain other clear advantages over composting in terms of energy production/consumption, compost quality and net environmental gains.

This method is suitable for kitchen wastes and, other putrescible wastes, which may be too wet and lacking in structure for aerobic composting. It is a net energy-producing process (100–150 kWh per tonne of waste input). A totally enclosed system enables all the gas produced to be collected for use. A modular construction of plant and closed treatment needs less land area. This plant is free from bad odour, rodent and fly menace, visible pollution, and social resistance. It has potential for co-disposal with other organic waste streams from agro-based industry. The plant can be scaled up depending on the availability of the waste.

However, this method is suitable for only the organic biodegradable fraction of MSW; it does not degrade any complex organics or oils, grease, or ligno-cellulosic materials such as yard waste. Similar to the aerobic composting process input waste needs to be segregated for improving digestion efficiency (biogas yield) and the quality of residual sludge.

While the liquid sludge can be used as rich organic manure, either directly or after drying, its quality needs to be ensured to meet statutory standards. No grinding of waste material should take place. Wastewater generated in the plant requires treatment before disposal to meet statutory standards. Biogas leakage poses a small environmental and fire hazard. This plant is more capital intensive than aerobic composting. The biogas technology developed at BARC in India and commercialized as Nisarguna Biogas Plant is an improvement on this technology

Biomethanation plants in India

Recently a 5 MW power plant based on biomethanation technology was constructed and operationalized at Lucknow but unfortunately it had to be closed down for various reasons, one among them being non-supply of appropriate quality of MSW to the plant. The organic content in the waste supplied to the plant is reported to have been as low as 15 per cent. Biomethanation technology on a small scale is also functioning at Vijayawada and at other places in the country for the treatment of selected organic waste collected from canteens, vegetable markets, etc.

Production of Refuse Derived Fuel (RDF) or Pelletization

It is basically a processing method for mixed MSW, which can be very effective in preparing an enriched fuel feed for thermal processes like incineration or industrial furnaces. The RDF pellets can be conveniently stored and transported long distances and can be used as a coal substitute at a lower price. As pelletization involves significant MSW sorting operations, it provides a greater opportunity to remove environmentally harmful materials from the incoming waste prior to combustion.

The process, however, is energy intensive and not suitable for wet MSW during rainy season. If RDF fluff/pellets are contaminated by toxic/hazardous material, the pellets are not safe for burning in the open or for domestic use.

RDF Plants in India

Such plants are in the initial stage of development in India. The viability and sustainability of the technology process and projects underway, are still being examined. The Department of Science and Technology (DST) of the Technology Information, Forecasting and Assessment Council (TIFAC) New Delhi had initially perfected the technology of processing municipal solid waste to separate the combustible fraction and carry out densification into fuel pellets to a scale of 2 tonnes per hour in a demonstration plant at the Deonar Dump Yard of the Mumbai Municipal Corporation. Fuel pellets produced in the demo plant were found to have a calorific value consistently in excess of 3000 k cal per kg and the fuel was test marketed around Rs 1000 per tonne in and around Mumbai. Thereafter, the DST technology of processing MSW into fuel pellets was transferred to M/s. Selco International Limited, Hyderabad for scaling up and commercial operation.

The Technology Development Board of DST and TIFAC has assisted Selco to set up a 6.6 MW power plant using MSW derived fuel and generate electricity. Selco is using 400 tonnes of MSW to convert into fluff and mix it with 30 per cent rice husk for generation of power. DST has also transferred the technology to M/s Sriram Energy Systems Ltd to set up a similar plant at Vijayawada. Both these plants are operational since November 2003. The proportion of use of agro waste along with municipal solid waste claimed by the operators of these facilities is being challenged by some people and the matter is under judicial scrutiny.

Box 8.1
Nisarguna Biogas Plant

The plant can use vegetable and fruit market waste, fruit and food processing industries waste, domestic and institutional kitchen waste, paper, garden waste, animal and abattoir waste etc. However, the waste that cannot be treated and to be strictly avoided are coconut shells, egg shells, big bones, plastic/polythene, glass, metal, sand, silt, debris and building materials, wood, cloth/clothes, ropes, nylon threads, batteries, tyres/rubber, hazardous and chemical industries waste etc. Municipal authorities, therefore, have to ensure segregated waste before setting up the biogas plant.

Major components of the plants are a mixture/pulper (5 HP motor) for crushing the solid waste, pre-mix tank(s), predigester tank, air compressor, slow water heater, main digestion tank, gas delivery system, manure pits, tank for recycling for water and water pump and gas utilization system. The waste is homogenized in a mixer using water. This slurry enters the predigesting tank where aerobic thermophilic bacteria proliferate and convert part of this waste into organic acids. The slurty then enters the main tank where it undergoes mainly anaerobic degradation by a consortium of archaebacteria belonging to the Methanococcus group. These bacteria are naturally present in the alimentary canal of ruminant animals (cattle). They produce mainly methane from the cellulosic materials in the slurry. The undigested lignocellulosic and hemi-cellulosic materials then are passed on in the settling tank. After about a month, high quality manure can be dug out from the settling tanks. There is no odour to the manure at all. The organic contents are high and this can improve the quality of humus in soil, which in turn is responsible for the fertility.

As the gas is generated in the main tank, the dome is slowly lifted up. This gas is a mixture of methane (70–5 per cent), carbon dioxide (10–15 per cent) and water vapours (5–10 per cent). It is taken through GI pipeline to the lampposts. Drains for condensed water vapour are provided on line. This gas burns with a blue flame and can be used for cooking.

The gas generated in this plant is used for gas lights fitted around the plant. The potential use of this gas would be for cooking purposes. It can also be used to produce electricity in a dual fuel biogas–diesel engine. The manure generated is high quality and can be used for gardening and agricultural purposes. The plant can be installed at hotel premises, army/big establishment canteens (private/government), residential schools/colleges, housing colonies, religious places/temple trusts, hospitals, hotels, sewage treatment plants etc. There are 5 such plants already in operation and about 5 others are proposed mostly in Maharashtra. The plant should be closer to source of waste being produced and the point of utilization of biogas power. The site should be free from underground cables, drainage pipes etc. and water table should be below 3 metres.

It is estimated that the life of the plant could be 20–30 years and payback period is estimated to be 4–5 years (Table B8.1.1).

Table B8.1.1
Cost Details, Savings and Other Requirements in Respect of Various Capacities of Nisarguna Biogas Plant

Treatment capacity (tonnes/day)	Installation cost (Rs in lakhs)	Monthly operation and maintenance charges (Rs)	Methane generation (Cu m)	Manure production (tonnes/day)
1	5–6	8000	100–120	0.1
2	9–10	12,000	200–240	0.2
4	20–22	15,000	400–480	0.3
5	28–30	22,000	500–600	0.5
10	65–70	50,000	1000–1200	2.5

Note: This is an approximate cost for biogas generation plant and may increase by 10–20 per cent depending on location, site specific parameters, cost of materials, labour cost etc. in different states/ cities. Cost of additional infrastructure like office space, toilets, security, compound wall, flood control measures etc. and for power generation will be extra, if required.

Incineration

This method, commonly used in developed countries is most suitable for high calorific value waste with a large component of paper, plastic, packaging material, pathological wastes, etc.
It can reduce waste volumes by over 90 per cent and convert waste to innocuous material, with energy recovery. The method is relatively hygienic, noiseless, and odorless, and land requirements are minimal. The plant can be located within city limits, reducing the cost of waste transportation.
This method, however, is least suitable for disposal of chlorinated waste and aqueous/high moisture content/low calorific value waste as supplementary fuel may be needed to sustain combustion, adversely affecting net energy recovery.
The plant requires large capital and entails substantial operation and maintenance costs. Skilled personnel are required for plant operation and maintenance. Emission of particulates, SOx, NOx, chlorinated compounds in air and toxic metals in particulates concentrated in the ash have raised concerns.

Incinerators in India

An incinerator capable of generating 3.75 MW power from 300 TPD MSW was installed at Timarpur, Delhi in the year 1987. It could not operate successfully due to low net calorific value of MSW. The plant is lying idle and the investment is wasted.

Pyrolysis/Gasification, Plasma Pyrolysis Vitrification

(PPV)/Plasma Arc Process

Pyrolysis gasification processes are established for homogenous organic matter like wood, pulp, etc., while plasma pyrolysis vitrification is a relatively new technology for disposal of particularly hazardous wastes, radioactive wastes, etc. Toxic materials get encapsulated in vitreous mass, which is relatively much safer to handle than incinerator/gasifier ash. These are now being offered as an attractive option for disposal of MSW also. In all these processes, besides net energy recovery, proper destruction of the waste is also ensured. These processes, therefore, have an edge over incineration.
This process produces fuel gas/fuel oil, which replace fossil fuels and compared to incineration, atmospheric pollution can be controlled at the plant level. NO and SO gas emissions do not occur in normal operations due to the lack of oxygen in the system.
It is a capital and energy intensive process and net energy recovery may suffer in case of wastes with excessive moisture and inert content. High viscosity of Pyrolysis oil maybe problematic for its transportation and burning. Concentration of toxic/hazardous matter in gasifier ash needs care in handling and disposal.
No commercial plant has come up in India or else where for the disposal of MSW. It is an emerging technology for MSW, yet to be successfully demonstrated for large-scale application.

Sanitary Landfills and Landfill Gas Recovery

Sanitary landfills are the ultimate means of disposal of all types of residual, residential, commercial and institutional waste as well as unutilized municipal solid waste from waste processing facilities and other types of inorganic waste and inerts that cannot be reused or recycled in the foreseeable future.

Its main advantage is that it is the least cost option for waste disposal and has the potential for the recovery of landfill gas as a source of energy, with net environmental gains if organic wastes are landfilled. The gas after necessary cleaning, can be utilized for power generation or as domestic fuel for direct thermal applications1. Highly skilled personnel are not required to operate a sanitary landfill.

Major limitation of this method is the costly transportation of MSW to far away landfill sites. Down gradient surface water can be polluted by surface run-off in the absence of proper drainage systems and groundwater aquifers may get contaminated by polluted leacheate in the absence of a proper leacheate collection and treatment system. An inefficient gas recovery process emits two major green house gases, carbon dioxide and methane, into the atmosphere. It requires large land area. At times the cost of pre-treatment to upgrade the gas quality and leacheate treatment may be significant.

There is a risk of spontaneous ignition/explosion due to possible build up of methane concentrations in air within the landfill or surrounding enclosures if proper gas ventilation is not constructed.

Urban Local bodies generally find it very difficult to locate a suitable landfill site, which meets the requirements of MSW Rules due to public resistance as invariably, no one wants landfills close to their property. This is popularly known as the Not In My Backyard (NIMBY) Syndrome. The cost of construction and operation and maintenance of an engineered landfill is also high as compared to the minimal expenditure incurred today in the crude dumping of waste. Smaller landfills with overhead costs turn out to be much more expensive as compared to regional landfills run on a cost-sharing basis. The Maharashtra SWM Cell has estimated that a small landfill, may cost over Rs 1000 per MT of waste as compared to Rs 200 per MT of waste disposed at a commonly shared facility.

In India disposal of organic waste at the landfill is prohibited and it is made mandatory to treat the organic matter. India, organic waste is not to be put in landfills, hence there does not exist the potential for this fraction of municipal solid waste before disposal of waste. The scope of landfill gas recovery is, therefore, minimized in the Indian situation.

Sanitary landfill sites in India

Until recently there was not a single sanitary landfill site in India. All cities and towns without exception dispose waste most unscientifically in low lying areas or the lands designated for the purpose within or outside the city. In most of the cities the waste is not even spread or covered to prevent unsightly appearance of foul smell. No pollution prevention measures are taken. Of late four sites have been constructed at Surat (Gujarat), Pune (Maharashtra), Puttur and Karwar (Karnataka). A few more sites are under construction. Under the Municipal Solid (Management and Handling) Rules 2000, it is imperative for all local bodies in the country to have sanitary landfill sites that meet the requirements of law.

As construction of sanitary landfills is quite expensive and needs professional management, siting of regional facilities is, therefore, being actively considered in India in some states of West Bengal, Gujarat, Rajasthan, etc.

Factors Governing Choice of Technology

The decision to implement any particular technology needs to be based on its techno-economic viability, sustainability, as well as environmental implications, keeping in view the local conditions and the available physical and financial resources.
The key factors are:

- The origin and quality of the waste;
- Presence of hazardous or toxic waste;
- Availability of outlets for the energy produced;
- Market for the compost/anaerobic digestion sludge;
- Energy prices/buyback tariff for energy purchase;
- Cost of alternatives, land price and capital and labor cost;
- Capabilities and experience of the technology provider.

It needs to be ensured that any proposed facility fully complies with the environmental regulations as laid down in the Municipal Solid Waste (Management and Handling) Rules 2000 issued by the Ministry of Environment and Forests and as may be amended from time to time.
Moreover, it has been scientifically established that extensive use of chemical fertilizers, has resulted in fertility loss and decrease in carbon content of the soil. Hence, there is an urgent need to provide humus to the soil to enable it to regain its fertility as well as water retaining capacity. Studies by the Indian Council for Agricultural Research have shown that compost used with chemical fertilizers has shown 15 per cent increase in food production creating a strong case for its promotion.
Experience shows that the WTE have been successful in developing countries to handle large quantities of MSW.
Two RDF based waste to energy projects have recently been commissioned in India and few more are under various stages of development. Their results are encouraging; but yet to be confirmed through independent verification as their success is being contested.

Estimated Cost for Vehicle, Tools, Equipments and Composting

City population (in million)	Cost of vehicles, tools and equipment (in Rs lakh)	Cost of composting (Rs lakh)
<0.1	50.97	20
0.1–<0.5	295.00	150
0.5–< 1.0	511.00	500
>2.0	948.00	1000

GOI Subsidy on SWM Plants

Project for power generation from MSW involving refuse derived fuel (RDF)	Rs 1.5 crore per MW
Power project based on high rate bio-methanation technology	Rs 2 crore per MW
Demonstration project for power generation from MSW based on gasification/Pyrolysis and plasma arc technology	Rs 3 crore per MW
Biomethanation technology for power generation from cattle dung, vegetable market and slaughterhouse waste above 250 KW capacity	50 per cent of project cost up to a maximum of Rs 3 crore per MW
Bio-gas generation for thermal application	Up to Rs 1 crore per MW equivalent
Project development assistance	Up to Rs 10 lakh per project
Training course, seminar, workshop, etc.	Rs 3 lakh per event

Note: The financial assistance for any single project will be limited to Rs 8 crore.
Source: Government of India, Ministry of Non-Conventional Energy Source Scheme, 25 July 2005.

Energy production

In waste-to-energy plants, heat from the burning waste is absorbed by water in the wall of the furnace chamber, or in separate boilers. Water is heated to the boiling point and changes to steam. At that point, either the steam is used for heating, or it is used to turn turbines to generate electricity. The amount of energy recovered from waste is a function of the amount of waste combusted, the energy value of the waste stream, and the efficiency of the combustion process.

Most of the MSW incineration currently practiced in industrialized countries incorporates energy recovery in the form of steam, which is used either to drive a turbine to generate electricity or directly for heating or cooling. In past years it was common to simply burn MSW in incinerators to reduce its volume and weight, but energy recovery has become more prevalent since the 1980s.

The three basic types of waste-to-energy incineration involve the generation of electricity, steam, or the 'cogeneration' of both electricity and steam. In North America, communities are generally moving away from developing steam facilities and toward producing electricity; about 90% of operating mass-burn facilities generate electricity. This trend is due partly to a preference for relatively stable electricity markets, such as utilities, as compared to industrial customers of steam, who are perceived as less reliable purchasers. However, deregulation of electricity markets (e.g., in Britain and the US) may change the relative value of steam production vs. electricity production.

In Europe, steam generation for heating and cooling has always been the primary means of waste-to-energy production. In fact, a key factor to consider in evaluating the practicality of MSW incineration is the presence of an existing infrastructure for steam district heating. In Japan, energy produced by incinerators in large cities is widely used for heating community swimming pools or air-conditioning, sometimes as compensation to nearby communities for having the incinerator close to them.

Electricity production and use

Electricity-producing incineration facilities use steam to drive a turbine connected to an electric generator. Of the electricity produced in incineration facilities, about one-fifth is used at the facility for general operations. The remaining electricity is sold to public and private utilities or nearby industries. In many countries utilities provide a stable market for electricity generated from incinerators. The availability of purchasers and rates for electricity sales will, however, vary by region.

Steam production and use

The energy generated by European waste-to-energy plants typically goes to supply steam to district heating loops; the heavy reliance on district heating, and the ready market for steam that it provides, is part of what makes incineration so attractive in European cities. The coupling of incineration with electricity generation, which contributes substantially to the capital costs of incineration, is quite rare in Europe, in part because European countries do not, in general, have utility rate structures that allow non-utility-generated electricity to be sold to the grid.

Steam generated in incineration facilities can also be used directly by a customer for manufacturing operations. Steam generated in an incinerator is supplied to a customer through a steam line, and condensed steam is sometimes returned by a separate line.

Marketing steam to end users requires (a) identifying industries and institutions (e.g., hospitals, colleges, public buildings, and factories) that use steam in the vicinity of the facility or (b) purposely siting the facility near potential steam purchasers. Some cities may also have commercial steam distribution utilities, which may facilitate steam sales.

To ensure a consistent supply of steam to end users, incineration facilities sometimes have a back-up boiler. Likewise, to adjust for variations in demand for steam (including seasonal variation), facilities may also need to be equipped with a by-pass to allow temporary halts in steam generation and/or steam delivery.

Cogeneration

Combined production of steam and electricity is referred to as cogeneration and can occur in two ways. If the energy cus-tomer requires steam conditions (pressure and temperature) that are less than the incineration plantÕs design specifications, a turbine-generator is used to produce electricity and thus reduce steam conditions to appropriate levels for the customer. Or, if the steam purchaser cannot accept all the steam produced by the facility, the excess can be converted to electricity.

Recycling of plastics through environmentally sound manner (Newly Developed Machine):

The main goal for developing green recycling of waste plastic was to design an extruder, which would have "Zero Significant Adverse Environmental Impact". This has been achieved by assigning right motor of minimum capacity, selecting optimum L/D ratio, heat sealing and right temperature for the processes and trapping all the emission in pollution control gadget and treating the pollutants to produce byproducts. The Extrusion & Palletization processes have been redesigned to make the pollution from the process to a minimum level and as a result to enhance the efficiency of the process. The details of process are shown in Flow Chart, which is given below:

Plastic and Waste Management Issues:

It is estimated that approximately 4-5 % post-consumer plastics waste by weight of Municipal Solid Waste (MSW) is generated in India. The plastics waste generation is more i.e. 6-9 % in USA, Europe and other developed countries due their consumption habits. As per data available on MSW, approximately, 4000-5000 tones per day post consumer plastics waste is generated, however, pre-consumer waste or scrap is directly utilised in the industry itself. The plastics waste constitutes tow major category of plastics; (1) Thermoplastics' and (2) Thermoset plastics. Thermoplastics, constitutes 80% and Thermoset, constitutes approximately 20% of total post-consumer plastics waste. The Thermoplastics are recyclable plastics which include; PET, LDPE, PVC, HDPE, PP, PS etc., however, Thermoset plastics contains Alkyd, Epoxy, Ester, Melamine Formaldehyde, Phenolic Formaldehyde, Silicon, Urea Formaldehyde, Polyurethane, Metalised and Multilayer Plastics etc. The major problem in plastics waste management is of collection, segregation and disposal. At present, the plastics waste disposal is done through unorganised sectors i.e. Ragpickers and Kabariwaslas. More importantly, the collection, segregation and to an extent disposal system is carried out through unscientific method which create environmental problem as well as an "Eyesore". Therefore, there is need to reorganise whole recycling process and in this context, CPCB has enlightened this issue to a extent by developing new recycling technique as well as developed innovative technologies for disposal of plastics waste such as "utilisation of plastic waste in road construction" and "re-engineering the recycling process".

Fig. Showing littered plastics waste in an open plot

Plastic manufacturing & recycling units (Statewise)

Status of number of plastics manufacturing/recycling units and registration granted is as under;

Sr. No.	Name of SPCBs/UTs	No of Units	No. of Registration Granted	Comments/Suggestions
1	Andhra Pradesh	150	121	Less than 20 micron carry bags are banned. Littering of plastics carrybag is banned in public places, Levy of penalties against the violators of recycling Norms (vide Notification dated **30.3.2001**). Mass Awareness Programmes are organised.

2	Andmans & Nicobar Islands	Nil	Nil	Recycled Plastics Rule published vide Notification No. 25 **dt. 5.5.2000**
3	Assam	10	Nil	Criteria shall be developed for other plastics products such as ropes, sheets, soap case etc.
4	Arunachal Pradesh	Nil	Nil	
5	Bihar	-	-	Inventory not completed. Rules disseminated through Public Notices
6	Chandigarh	20	-	Notified vide Notification no. **DC/MA/2001/187/dated 14.9.2001**
7	Chhatisgarh	32	11	Inter-state movement of sub-standard carry bags/materials etc.
8	Delhi	147	147	Non-biodegradable Act, 2001 has been brought out to manage plastics waste.
9	Damna &Diu and Dadara & Nagar Haveli	-	-	
10	Gujarat	365	41	
11	Goa	16	-	Notification has been brought out and thickness of plastics carry bagshas been raised to 40 microns regardless of D punch or handle type
12	Haryana			Inventory not completed. Recycled Plastics rule Notified

13	Himachal Pradesh	13	10	Recycled Plastics rule Notified on **26.11.1998**
14	Jharkhand	-	-	Rules disseminated through Public Notices
15	J & K Kashmir	-	-	Recycled Plastics rule Notified
16	Karnataka	302	Nil	Public Notices issued. Fee for registration, involvement of municipality, Reuse of plastics waste in Roads, Inter-state movement of substandard carry bags/ material etc
17	Kerala	193	10	Recycled Plastics rule Notified. Govt. of Kerala has formulated action plan for plastics waste management.
18	Lakshadweep	Nil	Nil	Import of carry bags/plastics material for carrying of foodstuff is prohibited vide **Notification dated 17.7.1998.**
19	Madhya Pradesh	179	83	-
20	Maharashtra	-	-	Recycled Plastics rule Notified
21	Mizoram	Nil	Nil	Mass awareness programmes have been organised stating the ill-effects of polythene bags.
22	Meghalaya	1	Nil	Interstate movement of substandard plastics carries bags, material.

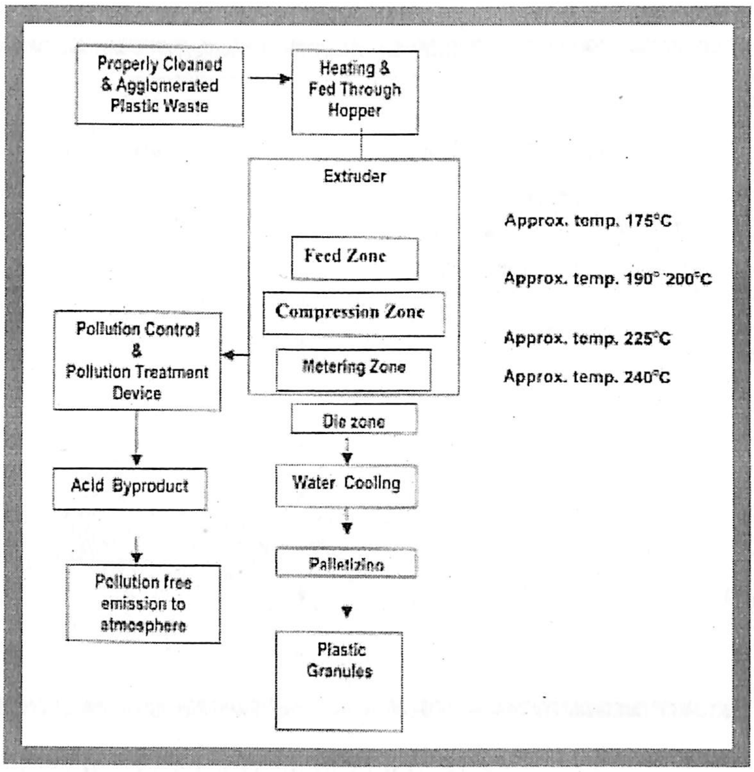
23	Manipur	-	-	-
24	Nagaland	4	4	Less than 20-micron poly carry bags are prohibited vide Notification **12.11.2003.**
25	Orissa	14	2	District Collectors have to be strengthened/pursued for strict vigilance, and provisions of confiscation/seizure, penal action should be in Rule
26	Pondicherry	56	2	Usage of polycarry bags for food stuff banned . Penal provisions should be made, virgin/Recycled plastics carry /containers should not be used for foodstuffs.
27	Punjab	-	-	Vide Order dated 2.11.200. Usage of polycarry bags for food stuff banned
28	Rajasthan	-	-	Vide Circular No. 1.6.2000. Usage of polycarry bags for food stuff banned
29	Sikkim	-	-	Usage of polycarry bags for food stuff banned.
30	Tamil Nadu	588	45	Proposed that Govt. of India to evolve plastics waste processing technologies such as reuse in road construction etc.
31	Tripura	Nil	Nil	The manufacture, sale, distribution and use of virgin and recycled plastic bags and containers are prohibited vide Direction issued by Tripura SPCB dated

				1.9.2003.
32	Uttar Pradesh	-	-	Inventory not yet completed. Usage of polycarry bags for food stuff banned
33	Uttranchal	Nil	Nil	Mass awareness programmes are organised.
34	West bengal	-	-	Draft Plastics Rules Notified.

Recycling of plastics through environmentally sound manner (Newly Developed Machine):

The main goal for developing green recycling of waste plastic was to design an extruder, which would have "Zero Significant Adverse Environmental Impact". This has been achieved by assigning right motor of minimum capacity, selecting optimum L/D ratio, heat sealing and right temperature for the processes and trapping all the emission in pollution control gadget and treating the pollutants to produce byproducts. The Extrusion & Palletization processes have been redesigned to make the pollution from the process to a minimum level and as a result to enhance the efficiency of the process. The details of process are shown in Flow Chart, which is given below:

Flow-Chart of the "Green Recycling Process" – The Pilot Plant



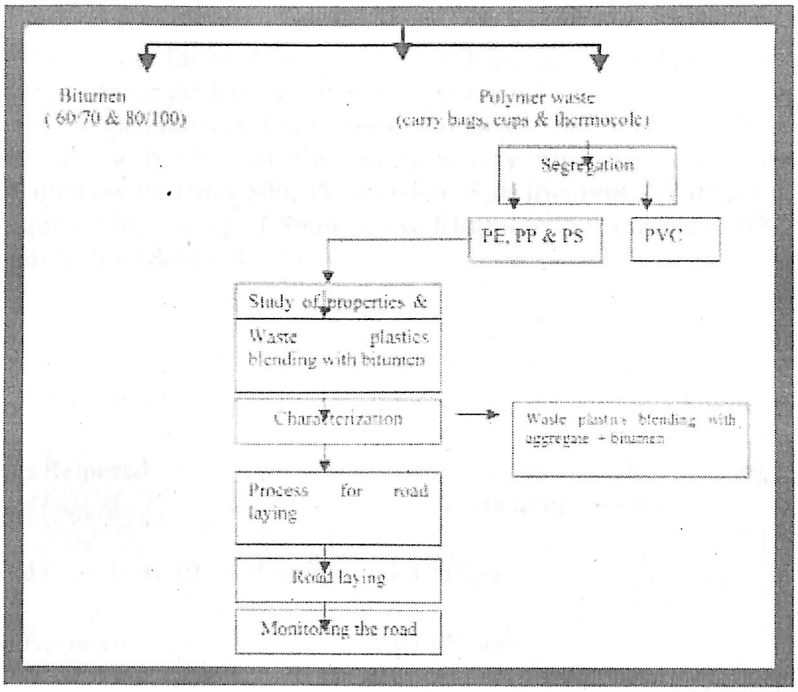
Reuse of plastics waste in Road Construction;

Polymer blended Bitumen shows higher Softening point, lower penetration point, and better ductility. Polymer coated aggregate blended with Bitumen shows higher Marshall value and better stripping value showing that the mix is more suited for road laying.

Process of Road laying using polymer- aggregate – Bitumen mix

The plastic waste (bags, cups, Thermocole) made out of PE, PP, & PS are separated, cleaned if needed and shredded to small pieces (passing through 4.35mm sieve) The aggregate (granite) is heated to 170°C in the Mini hot Mix Plant and the shredded plastic waste is added, it gets softened and coated over the aggregate. Immediately the hot Bitumen (160°C) is added and mixed well. As the polymer and the bitumen are is the molten state (liquid state) they get mixed and the blend is formed at surface of the aggregate. The mixture is transferred to the road and the road is laid. This technique is extended to Central Mixing Plant too.

Flow Chart showing method for construction of Road
Raw material



Salient features of the polymer-waste-bitumen mix Road:

? Road strength is twice stronger than normal roads
? Resistance towards water stagnation i.e. no potholes are formed;
? Less bleeding during summer;
? Burning of plastics waste could be avoided
? It doesn't involve any extra machinery;
? It doesn't increase cost of road construction; and
? It helps to reduce the consumption of bituminous mix vis-à-vis reduce cost

It is observed that addition of plastics waste upto 10-15% by weight of bitumen resulted into higher values of softening point and lower values of penetration, which are appreciable improvements in the properties of the binder. This has resulted and withstood higher traffic load and high temperature variation. Several experimental stretches have been laid in more than 15 locations in Tamilnadu using both Mini hot-mix and Central mixing plants.

Economics of Road Construction:

a. Laying of bitumen road – Indian Roads Congress (IRC) Specifications

There are different types of bitumen roads. They are, Dense Bituminous Macadam, Bituminous Macadam. These roads differ in 3-ways i.e.

1. Composition of the aggregate;
2. Type of bitumen used; and
3. Thickness of layer.

Bitumen is an useful binder for road construction. Different grades of bitumen like 30/40, 60/70, and 80/100 are available on the basis of their penetration values and these grades can be used as IRC Specifications. Waste plastics (10% in place of bitumen) can be used for these different types of bitumen roads. The technology of road laying is very much the same as prescribed by the **Indian Roads Congress (Section 500, IV revision) Specifications. A detailed description of the material required for laying of Semi Dense Bituminous Concrete (SDBC) 25 mm road (on existing road) is described below: -**

a. Materials:

For 1000Mx3.75M (25mm) Road	:11.250 tons (60/70 grade) bitumen needed
Shredded Plastics Required	: 10% by weight (passing 4.74mm sieve & retaining 2.36 mm).
Bitumen replaced (saved) by 10/ % Plastics	: 1.125 tons
Actual Bitumen Required	: 10.125 tons
Aggregate (11.2mm)	:70.875 Cu.M
Aggregate (6.7mm)	: 43.125 Cu.M
Aggregate Dust	: 23.625 Cu.M

b. Cost: The total cost including material as mentioned above, labour charge etc. (At Madurai) is approx. 5.00 lakh, however, the cost may be different from place to place and have to be calculated accordingly. The cost break-up is given below :

(i) Collection of littered plastics	: Rs. 0.50 lakh
(ii) Cost of shredder and other equipment	: Rs. 0.50 lakh
(iii) Laying of road with material, labour etc.	:Rs. 4.00 lakh
Total	**: Rs. 5.00 lakh**

List of roads laid using waste plastics:

	Process	Blend Composition	Area	Date	Nature of Road
TCE	Polymer Blending with Bitumen	5% PE 1% PE	60'x 5'	23rd March -02	Concrete Road
Kovilpatti	Polymer Blending with Metal and the Mixing with Bitumen	10% PE	600'x12'	4th October-02	WBM road
Madurai	Polymer Blending with Metal and the Mixing with Bitumen	15% PE	180'x10'	5th October-02	Concrete Road
Salem	Polymer Blending with Metal and the Mixing with Bitumen	10% PE	1000'x12'	15th October-02	Concrete Road
Komara-palayam	Polymer Blending with Metal and the Mixing with Bitumen	10% Mixture *	300'x12'	15th October-02	Concrete Road
Chennai **	Polymer Blending with Metal and the Mixing with Bitumen	12% Mixture *	600'x18'	22nd November-02	Concrete Road
Trichy	Polymer Blending with Metal and the Mixing with	10% Mixture *	600'x18'	10th January-03	Concrete Road

	Bitumen				
Salem #	Polymer Blending with Metal and the Mixing with Bitumen	10% Mixture *	5000'x 18'	17th April-03	WBM
Erode	Polymer Blending with Metal and the Mixing with Bitumen	10% Mixture *	1500'x 24'	7th May-03	Bitumen road
Theni	Polymer Blending with Metal and the Mixing with Bitumen	10% Mixture *	300'x18'	10th May-03	WBM
Nagercoil	Polymer Blending with Metal and the Mixing with Bitumen	10% Mixture *	1500'x18'	16th May-03	WBM
Madurai-Kombadi	Polymer Blending with Metal and the Mixing with Bitumen	10% Mixture *	1.4 km		WBM

- **Road waste Plastics ** Ten more Roads laid during May 2003**

 # Central Mixing Plant

MSW rules

Municipal Solid Wastes (Management & Handling) Rules, 2000 (MSW Rules) are applicable to every municipal authority responsible for collection, segregation, storage, transportation, processing and disposal of municipal solid

The Rule contains four Schedules namel

*	Schedule-I	:	Relates to implementation Schedule
*	Schedule-II	:	Specifications relating to collection, segregation, storage, transportation, processing and disposal of municipal solid waste (MSW).
*	Schedule-III	:	Specifications for landfilling indicating; site selection, facilities at the site, specifications for landfilling, Pollution prevention, water quality monitoring, ambient air quality monitoring, Plantation at landfill site, closure of landfill site and post care.
*	Schedule-IV	:	Indicate waste processing options including; standards for composting, treated leachates and incinerations.

Local Bodies

POPULATION	CLASS	NO. OF CITIES
>10,00,000 and above (metro only)		35
>1,00,000 and above	Class I	393
50,000 – 99,999	Class II	401
20,000 – 49,999	Class III	1,115
10,000 – 19,999	Class IV	1,344
5,000 – 9,999	Class V	888
>5000	Class VI	191
Unclassified	-	10
		4377

Authorities and Responsibilities.

S.No	Agencies/ Authorities	Responsibility
1.	Municipal Authorities	i. Ensuring that municipal solid wastes to be handled as per rules. ii. Seeking authorization from State Pollution Control Board (SPCB) for setting up waste processing and disposal facility including landfills. iii. Furnishing annual report. iv. Complying with Schedule I, II, III and IV of the rules
2.	**State Government**	
(i)	Secretary In-Charge of	Overall responsibility for the enforcement of the provisions of the rules in the metropolitan cities.
	Department of Urban Development	Overall responsibility for the enforcement of the provisions of the rules within the territorial limits of their jurisdiction.
(ii)	District Magis-trates/ Deputy Commissioner	
3	Central Pollution Control Board (CPCB)	i. Co-ordinate with State Boards and Committees with reference to implementation and review of standards and guidelines and compilation of monitoring data. ii. Prepare consolidated annual review report on management of municipal solid wastes for forwarding it to Central Government along with its recommendations before the 15th of December every year. iii. Laying down standards on waste

		processing/ disposal technologies including approval of technology.
4.	State Pollution Control Board (SPCB)	i. Monitor the compliance of the standards regarding ground water, ambient air leachate quality and the compost quality including incineration standards as specified under Schedule II, III & IV. ii. Issuance of authorization to the municipal authority or an operator of a facility stipulating compliance criteria and standards. iii. Prepare and submit to the CPCB an annual report with regard to the implementation of the rules.

Features of the Rules for plastic waste :»

» Rules are applicable in all the States/Union Territories;

» The prescribed authority for enforcement of these Rules in the States are State Pollution Control Boards and in the Union Territory, the Pollution Control Committees;

» No vendor shall use carry bags/containers made of recycled plastics for storing, carrying, dispensing, or packaging of foodstuffs;

» No person shall manufacture, stock, distribute or sell carry bags made of virgin; or recycled plastics which are <8′ 12 inches in size and <20 micron in thickness;
or recycled plastics which are <8′ 12 inches in size and <20 micron in thickness;
» Carry bags/containers made of virgin plastic shall be in natural shade or white;

» Every Plastics manufacturing and recycling Units shall be registered with concerned State Pollution control Board/Pollution Control Committee fulfilling consent conditions.

Prescribed Authority:

» The prescribed authority for enforcement of the provisions of these rules related to manufacture and recycling is State Pollution control Boards in respect of States and the Pollution control Committees in Union Territories;

» The prescribed authority for enforcement of the provisions of these rules relating to use, collection, segregation, transportation and disposal shall be the District Collector/Deputy Commissioner of the concerned district where no such Authority has been constituted by the State Government/Union Territory Administration under any law regarding non-biodegradable garbage

Conclusion

Though levels of SWM services in the country have started improving on account of active monitoring by the Supreme Court of India, the central and state pollution control boards and finance and technical support from proactive state governments there still is a long way to go. Save the formalization of the MSW Rules 2000, state action in this regard at many levels has been fairly uninspiring thus far. While MSW Rules 2000 is a watershed document in India's history of effective SWM, implementation issues still overwhelm the system. A firm commitment from central and the state governments towards a time bound mission to turn the provisions into action is urgent. Isolated cases of short-term steps to manage solid waste can hardly be cited as instances of governmental awareness and sensitivity to a problem that is only getting more daunting with each passing hour. It is no longer enough to take ad hoc measures to merely postpone the inevitable consequences of decades of neglect and nationwide mismanagement of SWM. A comprehensive nationwide programme needs to be actively implemented keeping in mind possible future scenarios. Key individuals within the governing system and the bureaucracy need to be educated to the magnitude of the crisis and motivated to use their power to influence the system and appropriately channelize resources to actively promote effective and progressive SWM projects and practices.

The results of this study will be used for

- Creating a municipal solid waste management facility as per observed result on the basis of pilot neighborhood area i.e. Premnagar
- Generation of electricity and other alternatives from the organic waste for the main city Dehradun as per the observed results on the basis of the pilot neighborhood area Premnagar.

References

State Of Environment Report For Uttranchal,Uttranchal Evironemnt Protection And Pollution Control Board Nevember 2004
Project IRDC ,UPES Dehradun

http://dehradun.nic.in/

www.gisdevelopement.net

Logistics Management and Spatial Planning for Solid Waste Management System using Geographic Information System
Author:
Aurobindo Ogra
Urban & Regional Planner
B.Tech (Construction) – CEPT, Ahmedabad
M.Plan (Urban & Regional Planning)- CEPT, Ahmedabad
GIS & Remote Sensing – IIRS, Dehradun

www.cpcb.nic.in

www.unep.or.gp

www.en.wikipedia.org

Sustainability in Practice: Exploring Innovations in Domestic Solid Waste Management in India
Abdul Aziz, N Sivanna and M Nageshwara Rao

Overview of Solid Waste Control Laws
,Local Authority & Judicial Forum
March 2006
NJ Department of Environmental Protection
County Environmental and Waste Enforcement
Office of Local Environmental Management

SOLID WASTE MANAGEMENT
P. U. Asnani

An Assessment of Solid Waste Management
through Public Participation in the Valley of Flowers
National Park, Uttaranchal
By
Shiva Garg
GURUKUL KANGRI UNIVERSITY, HARIDWAR

NON-GOVERNMENTAL ORGANIZATION (NGOS) SPEARHEADING PUBLIC PARTICIPATION IN ENVIRONMENTAL ISSUES

Reeni Samuel and Dr. V. Thanikachalam
Technical Teacher's Training Institute, Taramani, Chennai

www.edugreen.tri.rds.in