C. Cash Flow / per Year				
SL No.	Description	Unit / Nos	Revenue / Year in Lakh	Remarks
1	Pyrolysis Plant	1	200	
2	Recyclables and Fines	1	40	
	Sub Total	1	240	

Brief Report of Proposed 10 TPD Live Waste Treatment Plant within Durgapur Municipal Corporation under SWM Project.

The proposed plant is going to be constructed near Correctional Home at ward no.27 and approximately land required to install this plant is ***4800 Sqm (80 m X 60 m)*** .This treatment plant will treat the daily live waste produced at different markets in Durgapur City.The major constitutes of Live Waste are paper , plastics and putrescible organic matter . Metal , glass, ceramics, dirt and wood are also present though in small quantites .Considering this a 10 TPD Plant has been proposed initially.It is proposed that the Bio Gas produced by the treatment plant (Bio-mithenation process) may be used by near by CRPF camp and Crrectional Home. It is worthwhile to mention here that , at present approximately **150-160 TPD** fresh waste is produced at Durgapur City . To combat this fresh waste , larger capacity of treatment plant has to be installed in near future so that complete eradication of pollution from SWM can be possible.

Cost Benefit Analysis *(As per DPR submitted by CSIR CMERI)*

Cost of plant					
A. Capital Cost					
SL No.	Description	Size and Capacity of different Component	Quantity	Cost Amount in Lakh	Remarks
Plant and Equipments.					
1	Mechanical Seggregation Plant	10 TPD fresh Waste	1	500	
2	Installation of Biogas Plant	100 Cum	2	150	
3	Installation of Gas Engine	15 KVA	4	30	
4	Installation of Compost facility	50 Ton	1	40	
5	Installation of Briquette facility	150 Kg/hr	2	30	
6	Installation of Pyrolysis Plant	500 Kg/batch	(included in proposal of iMSWDS of 50 TPD Dead waste)		
7	Procurement Vehicle for Operation in plant	Tractor	(included in proposal of iMSWDS of 50 TPD Dead waste)		
8	Civil Structural and Electrical Works			150	
	Sub Total			900	
	GST @ 18 %			162	
	Total			1062	

B. Recurring Cost per year			
SL No.	Description	Cost Amount in Lakh	Remarks
1	Chemicals and Consumables	8	
2	Other Res. Expenditure	15	
3	Man Power	31	
4	Contingencies	2	
	Sub Total	56	

C. Revenue Generation / per Year			
SL No.	Description	Revenue / Year in Lakh	Remarks
1	Pyrolysis Plant	20	
2	Biogas Plant	25	
3	Recyclables / Compost /Briqutte	12	
	Sub Total	57	

Total Cost For Dead and live Waste Plant : ₹ 3,835.00 Lakh
Sanctioned amount in DPR for treatment Process : ₹ 3,877.00 Lakh

Therefore, total cost of plant is well below sanctioned DPR amount.

CSIR-CMERI has proposed for Design , Development , Installation and Commissioning of integrated Municipal Solid Waste Disposal System (iMSWDS) (Dead and Live Waste) through patented technology vide letter No. NIL dated 17.07.2018.

Asst. Engg/MED
p/s put up a note

Minutes of the 2nd Meeting of State High Powered Committee under Mission Nirmal Bangla (Urban)/Swachh Bharat Mission (Urban)

Date: 28th March 2018	Time: 11.30 AM	Venue: Conference Hall of the Chief Secretary at Nabanna

List of the Members and other Participants Present: Placed at Annexure-I

The Chief Secretary to Government of West Bengal and the Chairman of the State High Powered Committee under Mission Nirmal Bangla (Urban)/Swachh Bharat Mission (Urban) chaired the meeting.

At the outset, the Secretary, Urban Development & Municipal Affairs Department, Government of West Bengal welcomed all the members of the Committee and explained the overall plan and activities under Mission Nirmal Bangla (Urban).

Detailed discussion took place on the progress of the 10 nos. of Solid Waste Management Projects of 14 ULBs under implementation, the proposed 13 nos. of Solid Waste Management Projects of 13 ULBs for approval, Strategy for covering all the ULBs to ensure segregation at source, 100% door to door collection and transportation and action plan of the components for the year 2018-19,

1. **Approval of DPRs of Solid Waste Management:**

   DPRs of following 13 Solid Waste Management Projects of 13 ULBs of West Bengal have been placed before the Committee for consideration. The SWM Projects are technically appraised by Reputed Institutes/Chief Engineers of the Department. Lands for the projects are available with the ULBs in each case. After detailed deliberation, the Committee has approved the DPRs of following SWM Projects:

Sl. No.	ULB	Estimated Cost (Rs. In Lakh)		
		Bulk purchase of Equipments and Vehicles	Construction of SLF, Compost /Bio-gas/Vermi-Compost Plant	TOTAL DPR COST
1	Durgapur MC	2553.47	3877.82	6431.29
2	Bankura	559.63	1088.9	1648.53
3	Purulia	392.72	1066.82	1459.54
4	Coochbehar	266.11	669.16	935.27
5	Burdwan	1683.37	2133.2	3816.57
6	Arambag	298.82	634.86	933.68
7	Raghunathpur	201.61	360.43	562.04
8	Kharagpur	1542.31	1865	3407.31
9	Panihati	1241.04	3281.35	4522.39
10	Kanchrapara	824.37	1879.05	2703.42
11	Baruipur	372.2	892.68	1264.88
12	Garulia	430.4	618.85	1049.25
13	Asansol MC (P-II)	0	2911.69	2911.69
	TOTAL	10366.05	21279.81	31645.86

It was decided that beyond the Government of India share of 35%, the remaining will be borne by the State Government and ULB. This fund sharing pattern between the State Government and ULB will remain same as approved for the earlier Projects i.e. 5% share will be borne by the ULBs having below 10 Lakh Population and 10% share will be borne by the ULBs having above 10 Lakh Population, and the remaining fund will be borne by the State Government as Matching State Share & Additional State Share.

It was decided that for these projects, all the vehicles and equipments will be procured centrally from the end of State Urban Development Agency (SUDA) and construction of Sanitary Landfill & Processing Plants will be done by the ULBs under the supervision of Municipal Engineering Directorate & Kolkata Metropolitan Development Authority.

2. **Procurement of SWM Vehicles and Equipments for 97 ULBs:**

It was decided that to ensure Segregation at source, 100% door to door collection and Transportation in all the ULBs, procurement of all the SWM Vehicles and Equipments of all the ULBs will be done Centrally from SUDA. After that DPR for the ULBs will be prepared for establishment of Processing Plant and Sanitary Landfill site subject to availability of suitable Land.

After detailed deliberation, the Committee has approved the following two DPRs for procurement of SWM Vehicles and Equipments for all the remaining ULBs of West Bengal:

i. A DPR for Improvement of Transportation System of Municipal Solid Waste of the ULBs with total Project Cost of Rs. 64.49 Crore, is prepared by SUDA in consultation with the ULBs and appraised by Municipal Engineering Directorate, Government of West Bengal. Procurement for 23 nos. 8 CuM Movable Compactors, 117 nos. 10 CuM Dumpers, 179 nos. 2.2 CuM Fuel Operated Tippers and 663 nos. Battery Operated Hydraulic Tippers are in progress. In this respect, work order for 23 nos. 8 CuM Movable Compactors has already been issued. Re-tender for the remaining items have been done due to non availability of successful bidders in 1st call.

ii. A DPR for ensuring Segregation at source, 100% door to door collection and Transportation in all the ULBs with total Project Cost of Rs. 258 Crore, have been prepared by SUDA in consultation with the ULBs and appraised by Municipal Engineering Directorate, Government of West Bengal.

Procurement to be made for 10 ltrs Household Bins, 100-120 Ltr. Litter Bin, 240-660 ltrs. Community Bin, Tricycle Van, Battery Operated Cart, Wheel Barrow, Auto Tipper, Compactor (Movable), Dumper, Tractor, TT Container, Jetting cum Suction Machine, Road Sweeping Machine, Cesspool, Loader cum Back Hoe and Safety Measures etc.

3. Annual Action Plan for the Year 2018-19:

The Committee has approved the Annual Action Plan of the Components for the year 2018-19 amounting to total GoI Share of Rs. 237.95 Crore, which will be submitted to Government of India. Details of the Annual Action Plan of all Components for 2018-19 approved by SHPC :

Sl No.	Components	Action Plan	Estimated Project Cost	Total Central Share (Rs in Crore)
1	Community Toilet	Construction of 2000 Seats	Rs. 19.60 Crore (@98000/- per seat)	7.84
2	Public Toilet	Construction of 1000 Toilet Seats	Rs. 9.80 Crore (@98000/- per seat)	3.92
		Construction of 2000 Urinal Seats	Rs. 6.4 Crore (@32000/- per seat)	2.56
3	Solid Waste Management (SWM)	13 Nos of New SWM Projects of 13 ULBs	Rs. 316.46 Crore	110.76
		Procurement of SWM Vehicles for Improvement of Transportation System of Municipal Solid Waste of the ULBs	Rs. 64.49 Crore	22.57
		Procurement of all the SWM Vehicles and Equipments for 97 ULBs to ensure Segregation at Source, 100% Door to Door Collection and Transportation of Grabage	Rs. 258 Crore	90.30
TOTAL				237.95

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4. Claim of Fund from GoI in the Year 2018-19:

The Committee has approved the Claim of Fund amounting to Rs. 332.11 Crore from Government of India in the year 2018-19, which will be submitted to Government of India. Details of Claim of Fund from Government of India in the year 2018-19 approved by SHPC:

Rs. in Crore

Sl No	Financial Year	Installment	SWM Amount	CT Amount	PT Amount	PT -Urinal Amount	Total Amount
1	2017-18	2nd	94.16	0	0	0	94.16
2	2018-19		223.63	7.84	3.92	2.56	237.95
TOTAL			295.22	7.84	3.92	2.56	332.11

5. Miscellaneous:

- As per direction of Hon'ble Chief Minister to Government of West Bengal a Clean & Green City/Ward Competition has been designed to create and maintain a healthy and beautiful environment in the cities and also to develop a competitive environment among the Cities and also among the Wards within the City. In the discussion, it was decided that in the evaluation parameters, cleanliness of Schools should be added.
- The Chef Secretary to Government of West Bengal raised an issue that the market areas & its nearby drains of Darjeeling City remain very much dirty due to accumulation of wastes during ~~piek~~ peak season for the tourists. . In this connection the Secretary, UD & MA Department has explained the activities already taken up through an Integrated Solid Waste Management project under State Plan Fund for Darjeeling City. In the project all kinds of vehicles and equipments are being procured for ensuring segregation at source, 100% door to door and market waste collection and regular Road sweeping. Bio Gas Plant are being constructed for processing of Bio Degradable Wastes and the recyclable items will be sold out. .

Meeting ended with thanks to and from the chair.

(Malay De)
Chief Secretary to Government of West Bengal
& Chairman, SHPC, MNB (U)

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Mail

Annexure-I

List of Members and Other Participants Present

1. Sri Malay De, IAS, Chief Secretary, GoWB
2. Sri Harekrishna Dwivedi, IAS, Additional Chief Secretary, Finance Department
3. Sri Sanjay K Thade, IAS, Principal Secretary, Backward Classes Welfare Department
4. Sri Arnab Roy, IAS, Principal Secretary, Environment Department
5. Sri D. Nariala, IAS, Principal Secretary, School Education Department.
6. Sri Khalil Ahemed, IAS, Municipal Commissioner, Kolkata MC.
7. Sri Onkar Singh Meena, IAS, Secretary, UD & MA Department
8. Sri Arvind Mina, IAS, S.P.D., PBSSM, School Education Department
9. Sri Sutanu Kar, IAS, Director, SUDA
10. Smt. Pragyan Bharati, Wash Specialist, UNICEF

11. Sri J. Chattopadhya, D.L.B., UD & MA Department
12. Sri Amit Das, Chief Engineer, MED, UD & MA Department
13. Sri B. N. Kar, Additional Director, ILGUS, UD & MA Department
14. Sri Subhasish Chattapadhya, Director General (SWM), Kolkata MC
15. Sri K. Ghosh Dastidar, Executive Engineer, Kolkata MC
16. Sri Bijay Krishna Pal, Executive Engineer, SUDA
17. Sri Saumya Bandyopadhyay, Assistant Engineer, M.E.D, UD & MA Department
18. Sri S S S Gous, Programme Coordinator, SUDA
19. Dr. Sujay Mitra, Chief Manager – Planning & Monitoring, SUDA

No. ME/ 519 (22) / 1P-48/2015 Dated: 11.06.18

Copy forwarded for information and necessary action to:-

1. ***The Superintending Engineer**, North / South / East / West / Central Circle, M. E. Dte.*
2. ***The Executive Engineer**, Siliguri/Jalpaiguri/Coochbehar/Malda/Dinajpur/Murshidabad/Burdwan/Birbhum/Asansol /Hooghly/North 24 Pargonas/South 24 Pargonas/ Nadia/ Bankura / Purulia/East Midnapore/ West Midnapore Division, M. E. Dte.*

11.06.18

Chief Engineer, M.E. Dte.

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DURGAPUR MUNICIPAL CORPORATION
CITY CENTRE, DURGAPUR - 713216, DIST. - PASCHIM BARDHAMAN
EPABX ⇨ (0343) 2545842, 2546994, 2546107 ✱ Mayor : 2545828 ✱ Fax No. : 254-6472
Website : durgapurmunicipalcorporation.org ✱ E-mail : durgapurcorporation@gmail.com

O/C

Ref. No. DMC / PW/5429 *Date* 22/03/18

To,
Director ,SUDA and
State Mission Director , MNB (U),
ILGUS BHAVAN, H-C Block, Sector-III,
Bidhannagar, Kolkata-700106.

Sub : *Solid Waste Management of Durgapur Municipal Corporation.*

Ref: i)*Your office letter no. SUDA: 12 /2016 / 1631 dated 06.03.2018.*

ii) This Office letter no. 1496 dated 09/01/18.

iii) This Office letter no. 1498 dated 09/01/18.

Sir,

I have been directed to bring to your kind notice with regard to the subject and reference above, that we have received approval of SWM project submitted as a DPR from our end prepared by Bengal SREI Infrastructure Development Limited.

Meanwhile CSIR-CMERI a central research institute whose main office is at Durgapur town has started a pilot project in their township for disposal of solid waste that contain bio-degradable and non-biodegradable waste through automated mechanized system.

The said project was inaugurated by His Excellency, Governor Of West Bengal on 3rd November, 2017. The institute have informally appealed before Hon'ble Mayor to visit their plant of SWM which is operational. As such a team comprising of Hon'ble Mayor, a group of MMIC, the technical team of MED with SE, EE and AE as well as the engineers of DMC jointly made a visit where apart from the fresh waste that has been generated daily at their township, they have also made demonstration of the treatment process of dumped waste, collecting it from our dumping site at Shankarpur.

It is also to be mentioned here that the technology CMERI has adopted as a pilot project in their township, don't need segregation of disposal item at source. It is preferable but not mandatory. Therefore a considerable cost as per our previous DPR to procure various items for segregation at source will be come down, provided CMERI technology is adopted.

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DURGAPUR MUNICIPAL CORPORATION

CITY CENTRE, DURGAPUR - 713216, DIST. - PASCHIM BARDHAMAN

EPABX ⇨ (0343) 2545842, 2546994, 2546107 ✱ Mayor : 2545828 ✱ Fax No. : 254-6472
Website : durgapurmunicipalcorporation.org ✱ E-mail : durgapurcorporation@gmail.com

Ref. No. DMC / PW/5429 *Date* 22/03/18

The technology they have used is a mechanical one and the main feature is Polymer waste pyrolysis and Anaerobic digestion called bio- methanation which perhaps has a great technical as well as environmental advantages over the conventional SWM process of sanitary landfill which was our earlier proposal as per the DPR.

In the event, it is proposed that CMERI which has submitted a DPR (for which they have not charged anything from DMC), be asked to present a technical demonstration before any other concerned institute like Jadavpur university, IIEST Shibpur or IIT Kharagpur to ascertain technical feasibility on a large scale.

In this regard we are attaching a brief comparison report of techno feasibility as well as financial one between these two processes for your kind perusal please.

Your valuable opinion in this regard *is highly solicited.*

Yours faithfully,

21/3/18
Commissioner
Durgapur Municipal Corporation

Copy: As enclosed above.

Copy To:

1. Hon'ble Mayor, DMC.
2. The Secretary, Urban Development Department and Department of Municipal Affairs, Nagaranayan Bhavan, Block-DF-8, Sector-I, Salt Lake City, Kolkata-700064.
3. District Magistrate, Paschim Burdwan.
4. Chief Engineer, MED, DF Block, Sector-1,Salt Lake City, Kolkata-91.
5. The Superintendent Engineer(West Circle), MED, Patal Bazar,3rd floor, Tinkonia, Purba Bardhaman, Pin-713101.
6. The Executive Engineer, Municipal Engineering Directorate, (Asansol Divn.),Govt. of West Bengal, P.H.E Housing Complex, Ismile Vivekananda Pally, Baraf Kal, Asansol-713302.
7. MMIC(Sewerage & Drainage), DMC.
8. MMIC (Water),DMC.
9. MMIC (Solid Waste).
10. The Secretary, DMC.

21/3/18
Commissioner
Durgapur Municipal Corporation

Enclosure

DURGAPUR MUNICIPAL CORPORATION

REPORT OF SOLID WASTE MANAGEMENT

Techno-feasibility report of Treatment process of Municipal Solid Waste by CSIR CMERI in comparison with DPR prepared by SREI.

CONCLUSION OF DPR SUBMITTED BY SREI :

✓ Processing unit adopted are **A) Treatment-** i) Composting ii) RDF plant

B) **Sanitary Landfill**

- Only manual segregation at collection point, but no segregation process is adopted at treatment plant, which is impractical because segregation of waste at household is not achieved fully till date.
- RDF cannot be burned indiscriminately or openly its need dedicated incineration facilities and well designed combustion system having all necessary pollution control system.
  - **The major disadvantages of Sanitary Landfill are:**
- The site will look ugly while it is being used for landfill;
- Leachate (Toxic liquid) is generated due to decomposition of waste in the landfill which contains acid, heavy metals and other toxic elements which can contaminate ground water resources;
- Dangerous gases are given off from landfill sites.
- Local streams could become polluted with toxic seeping through the ground from the landfill site;
- Methane gas is generated in waste mass which travels underground in cracks of rocks if not pumped out and accumulates in nearby areas (foundation of buildings) which may cause explosion if not taken out;
- Once the site has been filled it might not be able to be used for redevelopment as it might be too polluted.

CONCLUSION OF PROPOSAL SUBMITTED BY CMERI :

✓ Processing unit adopted are **A) Treatment-** i) Pyrolysis for polymer based waste ii) Bio-Methanation Plant for Bio-degradable waste.

- **Mechanical segregation of waste is adopted in the treatment process itself. Therefore, not only segregation of dead waste already dumped at dumping ground is possible, segregation**

- **Advantages of Polymer Waste Pyrolysis Process**

- Stable operation for a broad range of waste quality
- Emissions from the system are well below the limit value.
- Flexibility in design and operation achieved by a modular design.
- Effective recovery of the materials and energy from the process.
- Low operation cost, no supplementary external fuel supply for normal operation, i.e significant reduction of running costs.

- **Advantages of Anaerobic Digestion / Biomethanation**

- It's a renewable energy source
- It's eco-friendly
- Production of biogas happens without oxygen, which technically means there is no form of combustion involved. No combustion means there is zero emission of greenhouse gasses to the atmosphere.
- Reduces the amount of waste going to landfills.
- Sanitary landfill is not required in this process because negligible quantity of residue produce by both the method adopted.

Summary of Total Project Cost by SREI 180 TPD plant (Municipal Daily Waste) :

(A)Processing Plant	Total Cost
Construction of Compost Plant and RDF Plant	234621247
Procurement Of Machines for the plant	55775000
Procurement of vehicles for operations of the plant	11730000
Total	302126247

(B)Sanitary Landfill	Total Cost
Construction of Sanitary Landfill	79540734
Procurement of vehicles for operation of the landfill	29000000
Total	108540734

Total Cost = Rs. 410666981

Summary of Total Project Cost by CSIR-CMERI 175 TPD plant (100TPD Dead, Shankarpur Waste and 75 TPD Live) :

Capital Cost

SI NO	Description	Size/Capacity	INR in Lakh
	Plant and equipments		
1	Installation of mechanized	50 TPD Dead Waste x 2 nos. +	2,000

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	segregation plant	25 TPD Fresh Waste x 1 No. +50 TPD Fresh Waste x 1 No.	
2	Installation of Biogas plant	20TPD Bio-degradable waste x 2 Nos.	700
3	Installation of Pyrolysis plant	10 TPD Polymer Waste x 4 Nos.	1000
4	Procurement of vehicles for operation at site	Tractor-05 Nos., Excavator- 03 Nos., Dozer- 01 No., Loaded cum backhole 02 Nos.	250
5	Civil, Structural & Electrical works	As required	1255
	Total		**5,205**

Project Cost by SREI excluding the cost of procurement of collection vehicles is Rs. 41.06 crore. whereas the cost of the treatment process of CSIR-CMERI is Rs. 52.05 crore including mechanical segregation which is costing about 20 crore .Therefore primary segregation of different type of waste is not essential for the treatment process proposed by CSIR-CMERI which is most essential for the process proposed by SREI ,which is not only cost involved but also impractical during this present day considering non-awareness of general people about segregation of different type waste at the household. Considering the above fact it seems that the mechanical segregation has prime importance to success the entire SWM project of Durgapur Municipal Corporation.

A comparative study of Project Cost proposed by SREI & CSIR-CMERI :

SI NO	Description	Cost of proposed Project By SREI		Cost of proposed Project By CSIR-CMERI	
A	Collection System				
1	Procurement of vehicles for Primary & Secondary Transportation	20,31,61,000 /-	(provided)	Nil	(Non included)
2	Procurement PP Equipments for primary collection	40,18,720/-	(provided)	Nil	
B	Mechanical Segregation Plant				
	At site	Nil	(Non included)	20,00,00,000/-	(provided)
C	Treatment Plant with vehicles for operation of the plant	41,06,66,981/-	(provided)	32,05,00,000/-	(provided)
D	Social Awareness (Per Year)	65,50,000/-	(provided)	Nil	
	Sub Total	62,43,96,701/-		52,05,00,000/-	
E	Contingency-3%	1,87,31901/-		Nil	
F	Administrative Charge-1%	62,43,967/-		Nil	
	Total Rs.	**64,93,72,569/-**		**52,05,00000/- (No collection system or primary and secondary collection is not included in**	

			this DPR. A s Mechanical segregation is included in this process, the costing of segregation at source may be reduced).

Conclusion:

Hence , it is envisaged that the technology developed for treating municipal solid waste by CSIR-CMERI is not only modern, up to date and environmental and eco friendly but also cost effective in respect to the proposed project by SREI. Therefore , it is requested for considering to adopt the better process proposed by CSIR-CMERI for treating solid waste of **Durgapur Municipal Corporation** in lieu of earlier one.

सी एस आई आर - केन्द्रीय यांत्रिक अभियांत्रिकी अनुसंधान संस्थान
CSIR - CENTRAL MECHANICAL ENGINEERING RESEARCH INSTITUTE
(सी०एस०आई०आर० का एक संघटक संस्थापन, भारत सरकार) (A Constitutent Establishment of CSIR, Govt. of India)
महात्मा गाँधी एवेन्यू
दुर्गापुर - 713209, भारत
Mahatma Gandhi Avenue
Durgapur - 713209, India
CSIR-CMERI

से /From

डॉ अंजली चटर्जी, वरिष्ठ प्रधान वैज्ञानिक,
प्रमुख, व्यवसाय विकास समूह
फोन न. : 9434778128 फ़ैक्स न. 0343-2548204 e-mail: bdg@cmeri.res.in

संख्या: बीडीजी/ऐड.जेन/564 & 565
16.07.2018

To/प्रति
The Commissioner
Durgapur Municipal Corporation
City Centre, Durgapur-713216

State Urban Development Agency
Received
5401
25 JUL 2018
Contents not Verified

Debabrata Biswas EE/MED

Sub.: *Design, Development, Installation and Commissioning of integrated Municipal Solid Waste Disposal System (iMSWDS)- 50 TPD(Dead)*

Dear Sir,

We would like to express our sincere gratitude for showing interest with our Organization and glad to inform you that this institute is in a position to undertake the above assignment with enclosed proposal with Terms & Conditions.

The Charges for the above work is 1) **Rs. 23,50,00,00.00 (Rupees Twenty Three corore Fifty Lakh Only)** ***Plus*** Goods & Service Tax as applicable (at present 18% i.e. Rs. 4,23,00,000.00) ***considering procurement, operation and maintenance of vehicles under the scope of DMC*** And 2) **Rs. 24,75,00,000.00 (Rupees Twenty Four Crore Seventy Five Lakh Only)** ***Plus*** Goods & Service Tax as applicable (at present 18% i.e. Rs. 4,46P,00,000.00) ***considering procurement, operation and maintenance of vehicles under the scope of CMERI*** . The amount is payable by Crossed Demand Draft drawn in favor of "**CMERI, Durgapur**" or through online money transfer.

You are requested kindly to communicate your acceptance to our Proposal and remit 100% of project amount along with work order please.

The above mentioned charges are based on man-days as defined by CSIR, New Delhi.

Thanking you and looking forward towards your favorable reply.

Yours faithfully,

(अंजली चटर्जी)

संलग्न । बताए गए

CENTRAL MECHANICAL ENGINEERING RESEARCH INSTITUTE
(COUNCIL OF SCIENTIFIC & INDUSTRIAL RESEARCH)
DURGAPUR – 713209

INSTITUTE ACCOUNT DETAILS FORELECTRONIC CLEARING SERVICE (CREDITCLEARING)/REAL TIMEGROSS SETTLEMENT (RTGS) FACILITY FOR RECEIVING PAYMENTS

* A. DETAILS OF ACCOUNT HOLDER

NAME OF ACCOUNT HOLDER	CENTRAL MECHANICAL ENGINEERING RESEARCH INSTITUTE
COMPLETE CONTACT ADDRESS	M.G. AVENUE, DURGAPUR – 713209
TYPE OF REGISTRATION	A REGISTERED SOCIETY UNDER THE REGISTRATION OF SOCIETIES ACT (ACT XXI OF 1860)
AGENCY NAME	COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH
REGISTRATION No.	X OF 1941-1942
DATE OF REGISTRATION	12.03.1942
REGISTERING AUTHORITY	REGISTRAR OF JOINT STOCK COMPANIES
STATE OF REGISTRATION	DELHI
CONTACT PERSON AND TELEPHONE NUMBER/FAX/EMAIL	Finance & Accounts Officer 0343 6510308 fao@cmeri.res.in
PAN No. (CSIR)	AAATC2716R
TAN No.	CALC04837A
GST REGISTRATION No.	19AAATC2716R2ZB

* B. BANK ACCOUNT DETAILS

BANK NAME	STATE BANK OF INDIA
BRANCH NAME WITH COMPLETE ADDRESS, TELEPHONE NUMBER AND E-MAIL	DURGAPUR BRANCH, DSP MAIN GATE, DURGAPUR-713203 Ph. 0343-2588206 E-MAIL – sbi.00074@sbi.co.in
COMPLETE BANK ACCOUNT NUMBER (NEW)	30280331299
MICR CODE	713002201
IFS CODE OF THE BRANCH	SBIN0000074
TYPE OF BANK ACCOUNT (SB/CURRENT/CASH CREDIT WITH 10/11/13)	SB 10

I hereby declare that the particulars given above are correct and complete.

Date: 03/11/2017

Signature of the Competent Authority of the Institute

अ. अ. (वित्त एवं लेखा)/S.O. (F&A)
सी.एस.आई.आर.–सी.एम.ई.आर.आई
CSIR-CMERI, दुर्गापुर/Durgapur-713209

Certified that the particulars furnished above are correct as per our records.

Date: 03.11.2017

Signature of the Authorized Official of the Bank (with Bank's Stamp)

Detail Project Report

on

Design, Development, Installation and Commissioning of Integrated Municipal Solid Waste Disposal System (iMSWDS)

SUBMITTED TO

Durgapur Municipal Corporation
City Center, Durgapur-713216

BY

Diamond Jubilee

60 Years

1958-2017

CSIR-CMERI

CSIR-CENTRAL MECHANICAL ENGINEERING RESEARCH INSTITUTE

(A Constituent Establishment of CSIR, Govt. of India)

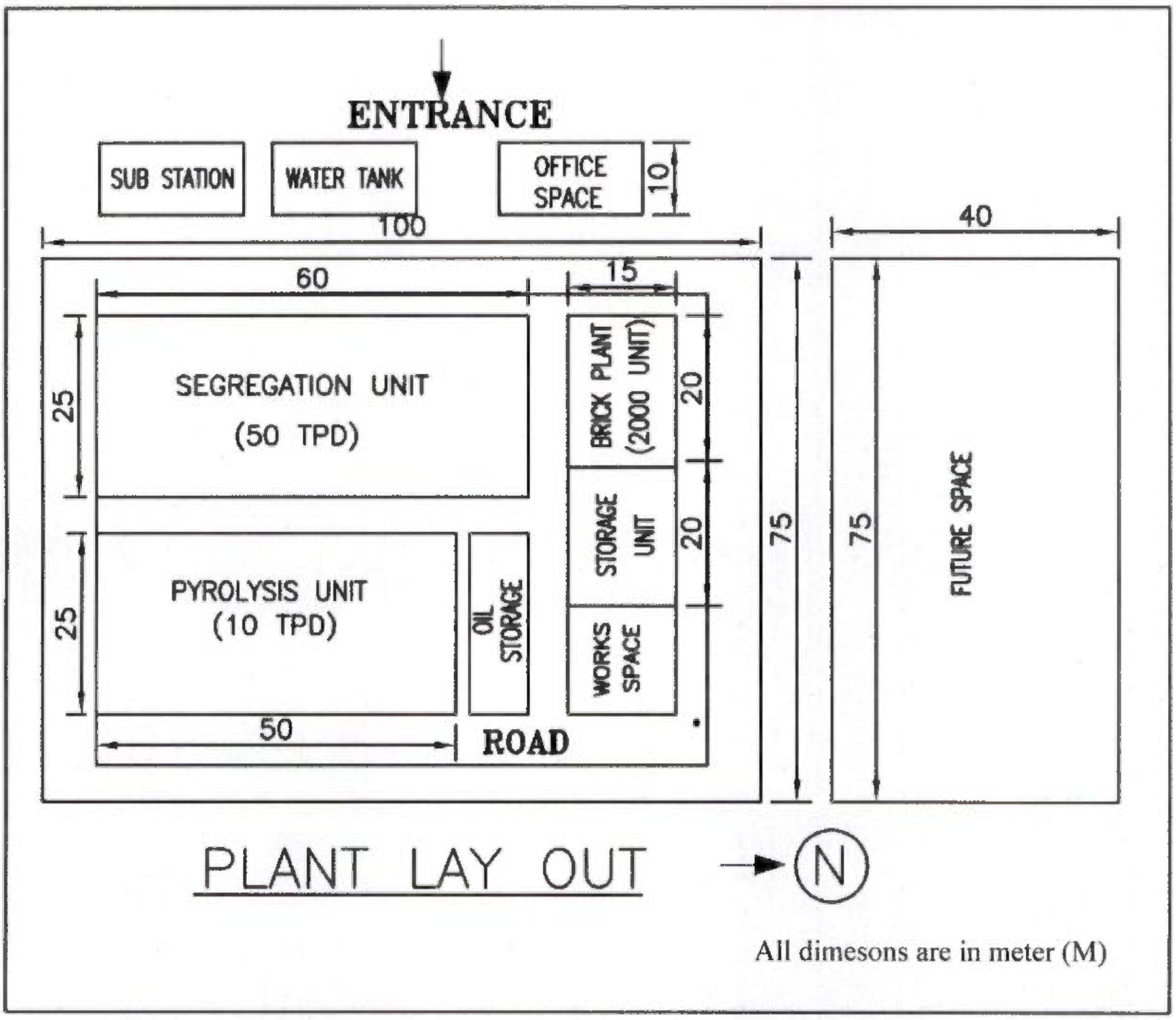
M.G. Avenue, Durgapur-713209, West Bengal

(June, 2018)

CHAPTER 6

PROJECT DETAILS

6.1 Proposed plant layout for disposal of 50 TPD Dead MSW



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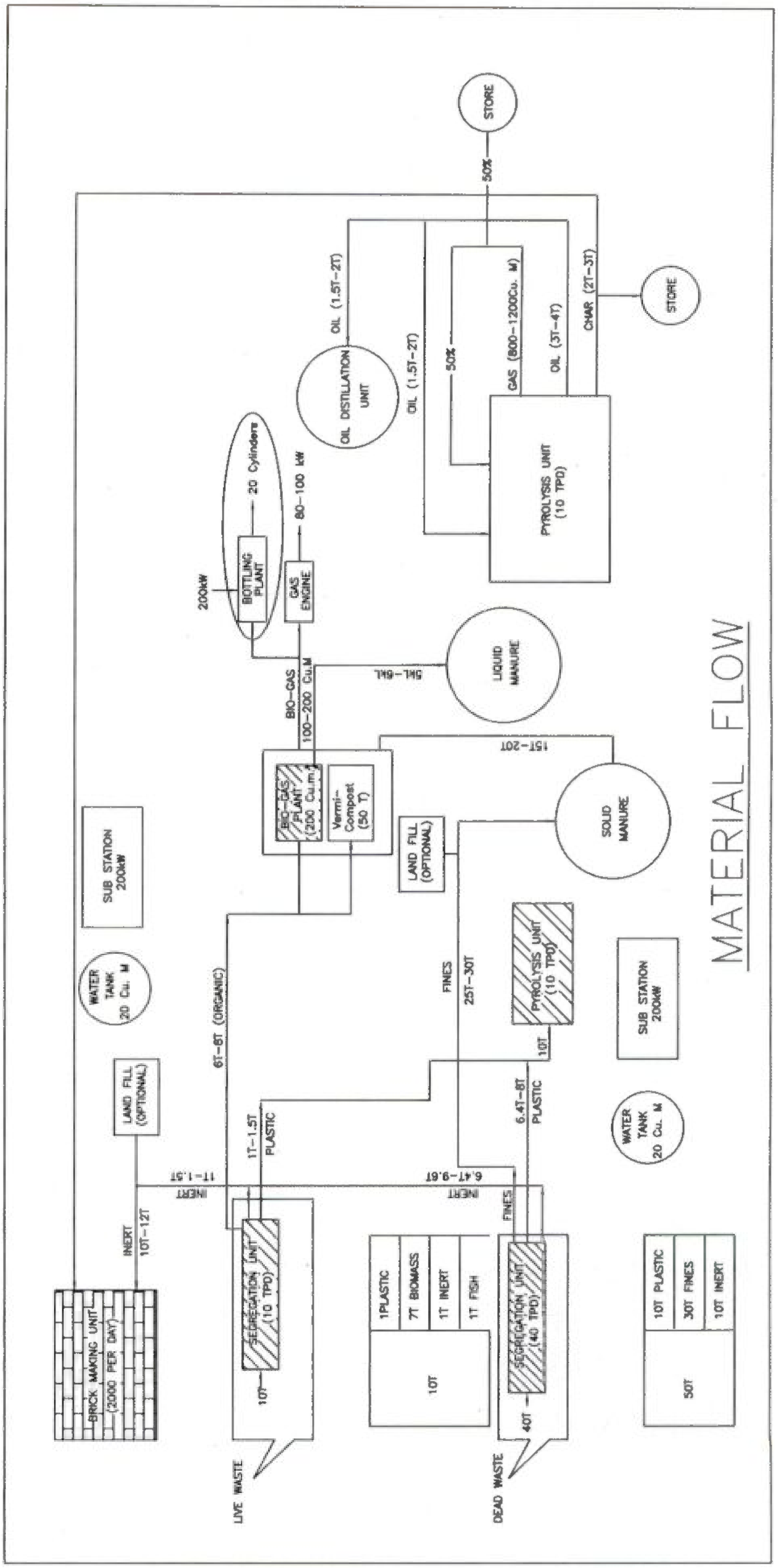
MATERIAL FLOW
BRICK MAKING UNIT (2000 PER DAY)
INERT 10T-12T
LAND FILL (OPTIONAL)
WATER TANK 20 Cu. M
SUB STATION 200kW
INERT 1T-1.5T
LIVE WASTE
10T
SEGREGATION UNIT (10 TPD)
1T-1.5T PLASTIC
6T-8T (ORGANIC)
10T
1PLASTIC
7T BIOMASS
1T INERT
1T FISH
DEAD WASTE
40T
SEGREGATION UNIT (40 TPD)
FINES
INERT 6.4T-9.6T
6.4T-8T PLASTIC
10T
FINES 25T-30T
PYROLYSIS UNIT (10 TPD)
SUB STATION 200kW
WATER TANK 20 Cu. M
50T
10T PLASTIC
30T FINES
10T INERT
LAND FILL (OPTIONAL)
BIO-GAS PLANT (200 Cu.m)
Vermi-Compost (50 T)
SOLID MANURE
15T-20T
BIO-GAS 100-200 Cu.M
LIQUID MANURE
5KL-6KL
200kW
BOTTLING PLANT
20 Cylinders
GAS ENGINE
80-100 kW
OIL DISTILLATION UNIT
OIL (1.5T-2T)
OIL (1.5T-2T)
50%
GAS (800-1200Cu. M)
OIL (3T-4T)
CHAR (2T-3T)
PYROLYSIS UNIT (10 TPD)
STORE
50%
STORE

6.2 Scope of work

6.2.1 Durgapur Municipal Corporation

- Providing land (100 m×75 m) with boundary wall for establishing set-up of Municipal Solid Waste disposal system (Perimeter: 350 m & Height: 2 m);
- Development of space including dismantling of the existing plant, in case the proposed site is not acquired for commencement of the project;
- Approach road for the site;
- Collection of waste from different sites under DMC and providing them at the proposed site;
- Sale of by-products consisting of pyrolysis oil and char from polymer waste pyrolysis plant;
- Sale of recyclables consisting of metals from segregated dead waste;
- Necessary electrical connection up to substation at site for operation of plant;
- Necessary water connection up to tank at site;
- Providing electricity and water for running the plant at no cost;
- Insurance of movable & immovable properties;

6.2.2 CSIR-Central Mechanical Engineering Research Institute

- Necessary civil and electrical works at the proposed site for installation of 50 TPD Integrated Municipal Solid Waste Disposal system for Dead Waste
- Design, development, installation & commissioning of 50 TPD mechanized segregation system to segregate Municipal Solid Waste
- Design, development, installation & commissioning of 10 TPD Polymer waste pyrolysis plant for further processing of polymer waste from segregation plant
- Design, development, installation & commissioning of 2000 brick/day brick plant
- After Commissioning, Operation & Maintenance for subsequent two (2) years, renewed annually.

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6.3 Duration of the Project:

The entire project will be implemented in eighteen months (1.5 year) from the date of handover of site and completion of civil and electrical work.

A. The proposed activities are:

Sl. No.	Item	Type	Capacity	Qty
1	Preparation of site including necessary civil and electrical works	-	-	As per approved drawing
2	Segregation system	Dead Waste	50 TPD	1 No.
3	Pyrolysis plant	Polymer waste	10 TPD	1 No.
4	Brick Plant	Inert/Construction Debris	2000/day	1 No.

6.4 Milestone Activities & Duration:

Sl. No.	Activities Description	0-3 months	3-6 months	6-9 months	9-12 months	12-15 months	15-18 months		18-30 months	30-42 months
1	**Handover of proposed site after Site Clearance (scope of DMC)**									
2	Necessary civil, Structural and electrical works									
3	Desing & Engineering									
4	Purchase & Procurement									
5	Fabrication of Equipment							**Handing Over**	**Operation & Maintenance**	
6	Installation of Segregation Unit (50TPD Dead)									
7	Installation of Pyrolysis Plant (10TPD)									
8	Installation of Brick Plant (2000 nos/day)									
9	Trial Run & Commissioning									

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6.5 Estimated Cost: (INR in Lakh)

Capital Expenditure (A)

➢ **Option-1: Considering procurement of vehicles under the scope of CMERI**

Sl	Description	INR in Lakh	Remarks
1	Works & Services (incl. solar roof)	800	
2	Equipment	1,675	Annexure-A
	GST (@18%)	446	
	Sub-Total (A)	**2,921**	

➢ **Option-2: Considering procurement of vehicles under the scope of DMC**

Sl	Description	INR in Lakh	Remarks
1	Works & Services (incl. solar roof)	800	
2	Equipment	1,550	Annexure-A
	GST (@18%)	423	
	Sub-Total (A)	**2,773**	

Recurring Cost / per year (B)

Sl	Description	INR in Lakh	Remarks
a	Chemicals & Consumables	30	
b	Other Res. Expenditure	75	
c	Manpower	75	
d	Contingencies	10	
	Sub-total	**190**	

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6.6 Cost Benefit Analysis

Total Waste: 50 TPD (Dead waste)

Economic life span of the plant: 15 years

A. Capital Cost

➢ **Option-1: Considering procurement, operation and maintenance of vehicles under the scope of CMERI**

Sl No	Description	Size / Capacity	INR in Lakh	Remarks
a	Land	7,500 sq. m	-	To be provided by DMC at no cost
b	Plant and Equipment			
i	Segregation plant	50 TPD Dead waste	1000	
ii	Pyrolysis Plant	10 TPD	400	
iii	Brick Making Plant	2000 Bricks × 1 Nos.	150	
iv	Vehicles for operation	Tractor – 6 Nos. JCB – 3 Nos. Office Vehicle- 1No.	125	
v	Civil, Structural & Electrical Works	As required	600	
vi	Solar Installation		200	
	Sub-total		**2,475**	

➢ **Option-2: Considering procurement, operation and maintenance of vehicles under the scope of DMC**

Sl No	Description	Size / Capacity	INR in Lakh	Remarks
a	Land	7,500 sq. m	-	To be provided by DMC at no cost
b	Plant and Equipment			
i	Segregation plant	50 TPD Dead waste	1000	
ii	Pyrolysis Plant	10 TPD	400	
iii	Brick Making Plant	2000 Bricks × 1 Nos.	150	
iv	Vehicles for operation	Tractor – 6 Nos. JCB – 3 Nos. Office Vehicle- 1No.	--	To be provided by DMC
v	Civil, Structural & Electrical Works	As required	600	
vi	Solar Installation		200	
	Sub-total		**2,350**	

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A. Recurring Cost / per year

Sl	Description	INR in Lakh	Remarks
a	Chemicals & Consumables	30	Annexure-B
b	Other Res. Expenditure	75	Annexure-C
c	Manpower	75	Annexure-D
d	Contingencies	10	
	Sub-total	**190**	

B. Cash Flow / per year

Sl	Description	Unit/Nos.	Revenue/Yr (INR in Lakh)	Remarks
a	Pyrolysis plant	2	200	Annexure-E
b	Recyclables & Fines	1	40	Annexure-F
	Subtotal		**240**	

Annexure-A

Budget for Permanent Equipment

➢ **Option-1:**

Sl.	Description	Size / Capacity	Amount (₹ in Lakh)
1	Segregation Plant	50 TPD Dead waste	1000
2	Pyrolysis Plant	10 TPD Polymer waste	400
3	Brick Making Plant	2000 Nos/day	150
4	Vehicles for operation at site	Tractor – 06 Nos. JCB – 03 Nos. Office Vehicle- 1No.	125
		Total	**1,675**

➢ **Option-2:**

Sl.	Description	Size / Capacity	Amount (₹ in Lakh)
1	Segregation Plant	50 TPD Dead waste	1000
2	Pyrolysis Plant	10 TPD Polymer waste	400
3	Brick Making Plant	2000 Nos/day	150
4	Vehicles for operation at site	Tractor – 06 Nos. JCB – 03 Nos. Office Vehicle- 1No.	--
		Total	**1,550**

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Annexure-B

Budget for Chemicals & Consumables

Sl.	Component	Amount (₹ in Lakh)
1	Fuel (Diesel)	20
2	Utilities, Consumables & Miscellaneous Supplies	10
	Total	**30**

Annexure-C

Budget for Other Research Expenditure

Sl.	Component	Amount (₹ in Lakh)
1	Repair and Maintenance of plant machinery	35
2	Plant and Office Running Expenses	5
4	Quality check	5
5	Miscellaneous	5
6	TA/DA	25
	Total	**75**

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Annexure-D

Budget for Manpower

Sl.	Position	Nos.	Salary	Amount
1	Supervisor	2	20,000	40,000
2	Operator	8	20,000	1,60,000
3	Mechanic	2	15,000	30,000
4	Helper	4	10,000	40,000
5	Tractor Driver	4	15,000	60,000
6	Security Guard	2	10,000	20,000
7	Unskilled Labour	15	10,000	1,50,000
			Sub Total	5,00,000
			Overhead @ 25%	1,25,000
			Total (per month)	6,25,000
				75,00,000

Annexure-E

Revenue Generation from Pyrolysis Plant (10 Ton/day)

Sl	Description	Quantity/ day (kg)	Annual Quantity (ton)	Price (₹)/kg	Annual (₹)
1	Fuel oil (20% yield)	2,000	600	30	1,80,00,000
2	Carbon (25% yield)	2,500	750	3	22,50,000
3	Gas (30-40%)				
				Total Sale (₹)	**2,02,50,000**

Annexure-F

Revenue Generation from sale of recyclable items

Sl	Parameter	Average %	Quantity in TPD	Unit rate/ ton	Per annum
1	Metals, Glass	1.0%	0.2	20,000	6,00,000

Revenue Generation from fines

Sl	Item	Rate (₹)	Production/day	Amount/day (₹)	Amount/yr (₹)
1	Fines	1/kg	10,000	2,000	30,00,000

Tangible Benefits for DMC:

- Treatment of 50 TPD MSW leading to Clean City
- Recovery of Land: 1.0 acre/year (if no further dumping is ensured)
- Revenue Generation from Treatment of MSW

Sl. No.	Revenue	Unit/Nos	Revenue/Unit (Rs in Cr)	Revenue/ Yr (Rs in Cr)
1	Pyrolysis Plant	1	2.0	2.0
2	Recyclable, Fines		0.4	0.4
			Total	2.4

- Employment Generation

Sl. No.	Item	Nos.
1	Direct Manpower in operation of Plant	40
2	Downstream Employment for selling of By-Product	10
	Total	50

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सी एस आई आर - केन्द्रीय यांत्रिक अभियांत्रिकी अनुसंधान संस्थान
CSIR - CENTRAL MECHANICAL ENGINEERING RESEARCH INSTITUTE
(सी०एस०आई०आर० का एक संघटक संस्थापन, भारत सरकार) (A Constitutent Establishment of CSIR, Govt. of India)
महात्मा गाँधी एवेन्यू
दुर्गापुर - 713209, भारत
Mahatma Gandhi Avenue
Durgapur - 713209, India
CSIR-CMERI

से /From

डॉ अंजली चटर्जी, वरिष्ठ प्रधान वैज्ञानिक,
प्रमुख, व्यवसाय विकास समूह
फोन न. : 9434778128 फ़ैक्स न. 0343-2548204 e-mail: bdg@cmeri.res.in

संख्या: बीडीजी/ऐड.जेन/566 & 567
16.07.2018

State Urban Development Agency
Received 5401
25 JUL 2018
Contents not Verified

Debabrata Biswas, EE/MED

To/प्रति
The Commissioner
Durgapur Municipal Corporation
City Centre, Durgapur-713216

Sub.: ***Design, Development, Installation and Commissioning of integrated Municipal Solid Waste Disposal System (iMSWDS)- 10 TPD(Live)***

Dear Sir,

We would like to express our sincere gratitude for showing interest with our Organization and glad to inform you that this institute is in a position to undertake the above assignment with enclosed proposal with Terms & Conditions.

The Charges for the above work is 1) **Rs. 11,00,00,000.00 (Rupees Eleven Crore Only)** ***Plus*** Goods & Service Tax as applicable (at present 18% i.e. Rs. 1,98,00,000.00) ***considering stand alone project*** And 2) **Rs. 9,00,00,000.00 (Rupees Nine Crore Only)** ***Plus*** Goods & Service Tax as applicable (at present 18% i.e. Rs. 1,62,00,000.00) ***considering additional project along with 50 TPD (Dead waste) iMSWDS project*** . The amount is payable by Crossed Demand Draft drawn in favor of "**CMERI, Durgapur**" or through online money transfer.

You are requested kindly to communicate your acceptance to our Proposal and remit 100% of project amount along with work order please.

The above mentioned charges are based on man-days as defined by CSIR, New Delhi.

Thanking you and looking forward towards your favorable reply.

Yours faithfully,

17/7/2018
(अंजली चटर्जी)

संलग्न । बताए गए

CENTRAL MECHANICAL ENGINEERING RESEARCH INSTITUTE
(COUNCIL OF SCIENTIFIC & INDUSTRIAL RESEARCH)
DURGAPUR – 713209

INSTITUTE ACCOUNT DETAILS FORELECTRONIC CLEARING SERVICE (CREDITCLEARING)/REAL TIMEGROSS SETTLEMENT (RTGS) FACILITY FOR RECEIVING PAYMENTS

* A. DETAILS OF ACCOUNT HOLDER

NAME OF ACCOUNT HOLDER	CENTRAL MECHANICAL ENGINEERING RESEARCH INSTITUTE
COMPLETE CONTACT ADDRESS	M.G. AVENUE, DURGAPUR – 713209
TYPE OF REGISTRATION	A REGISTERED SOCIETY UNDER THE REGISTRATION OF SOCIETIES ACT (ACT XXI OF 1860)
AGENCY NAME	COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH
REGISTRATION No.	X OF 1941-1942
DATE OF REGISTRATION	12.03.1942
REGISTERING AUTHORITY	REGISTRAR OF JOINT STOCK COMPANIES
STATE OF REGISTRATION	DELHI
CONTACT PERSON AND TELEPHONE NUMBER/FAX/EMAIL	Finance & Accounts Officer 0343 6510308 fao@cmeri.res.in
PAN No. (CSIR)	AAATC2716R
TAN No.	CALC04837A
GST REGISTRATION No.	19AAATC2716R2ZB

* B. BANK ACCOUNT DETAILS

BANK NAME	STATE BANK OF INDIA
BRANCH NAME WITH COMPLETE ADDRESS, TELEPHONE NUMBER AND E-MAIL	DURGAPUR BRANCH, DSP MAIN GATE, DURGAPUR-713203 Ph. 0343-2588206 E-MAIL – sbi.00074@sbi.co.in
COMPLETE BANK ACCOUNT NUMBER (NEW)	30280331299
MICR CODE	713002201
IFS CODE OF THE BRANCH	SBIN0000074
TYPE OF BANK ACCOUNT (SB/CURRENT/CASH CREDIT WITH 10/11/13)	SB 10

I hereby declare that the particulars given above are correct and complete.

Date: 03/11/2017

Signature of the Competent Authority of the Institute

अ. अ. (वित्त एवं लेखा)/S.O. (F&A)
सी.एस.आइ.आर.-सी.एम.ई.आर.आइ
CSIR-CMERI, दुर्गापुर/Durgapur-713209

Certified that the particulars furnished above are correct as per our records.

Date: 03.11.2017

Signature of the Authorized Official of the Bank (with Bank's Stamp)

Detail Project Report

on

Design, Development, Installation and Commissioning of Integrated Municipal Solid Waste Disposal System (iMSWDS)

SUBMITTED TO

Durgapur Municipal Corporation
City Center, Durgapur-713216

BY

CSIR-CENTRAL MECHANICAL ENGINEERING RESEARCH INSTITUTE

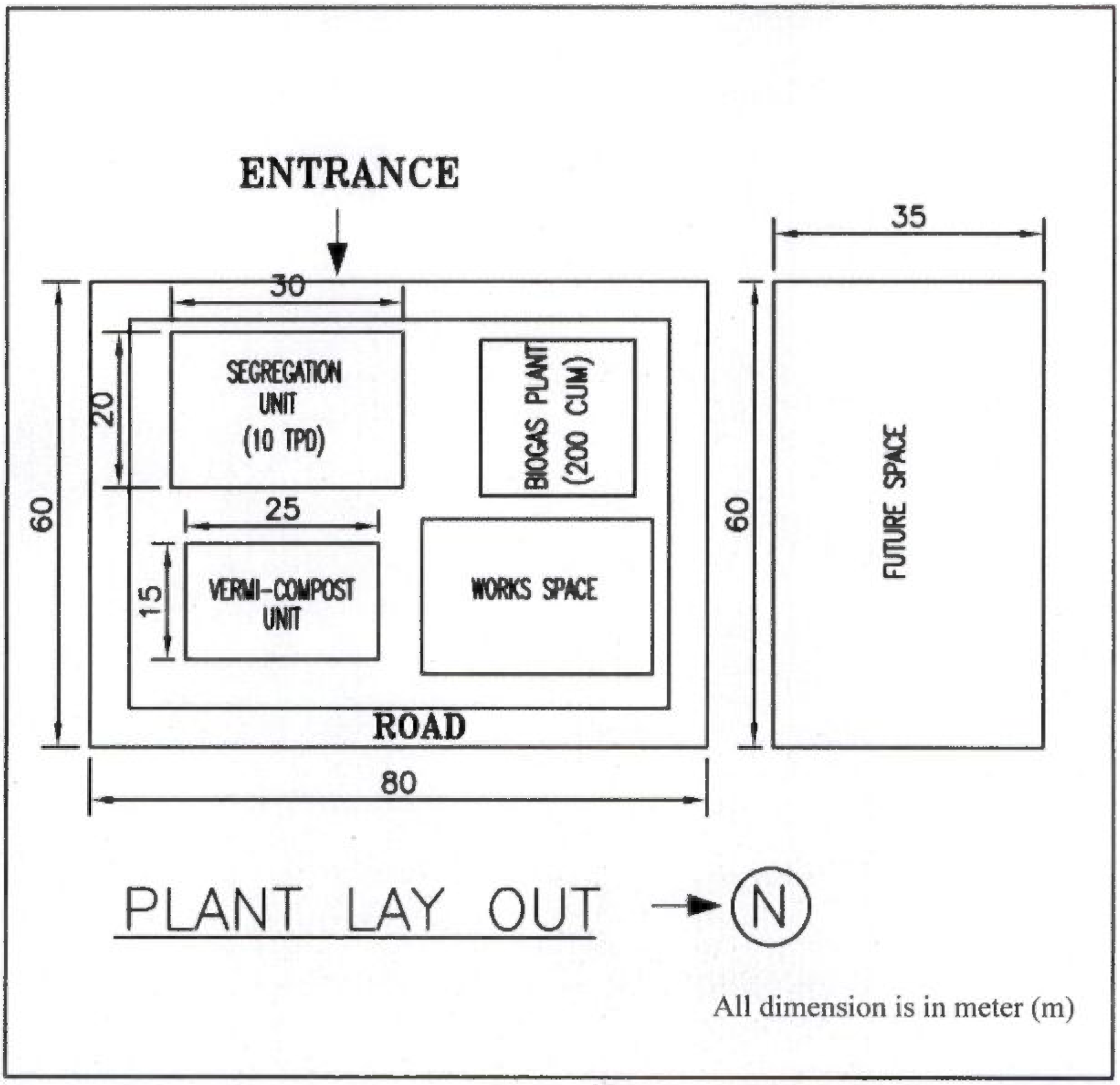
(A Constituent Establishment of CSIR, Govt. of India)

M.G. Avenue, Durgapur-713209, West Bengal

(June, 2018)

CHAPTER 6
PROJECT DETAILS

6.1 Proposed plant layout for disposal of 10TPD MSW



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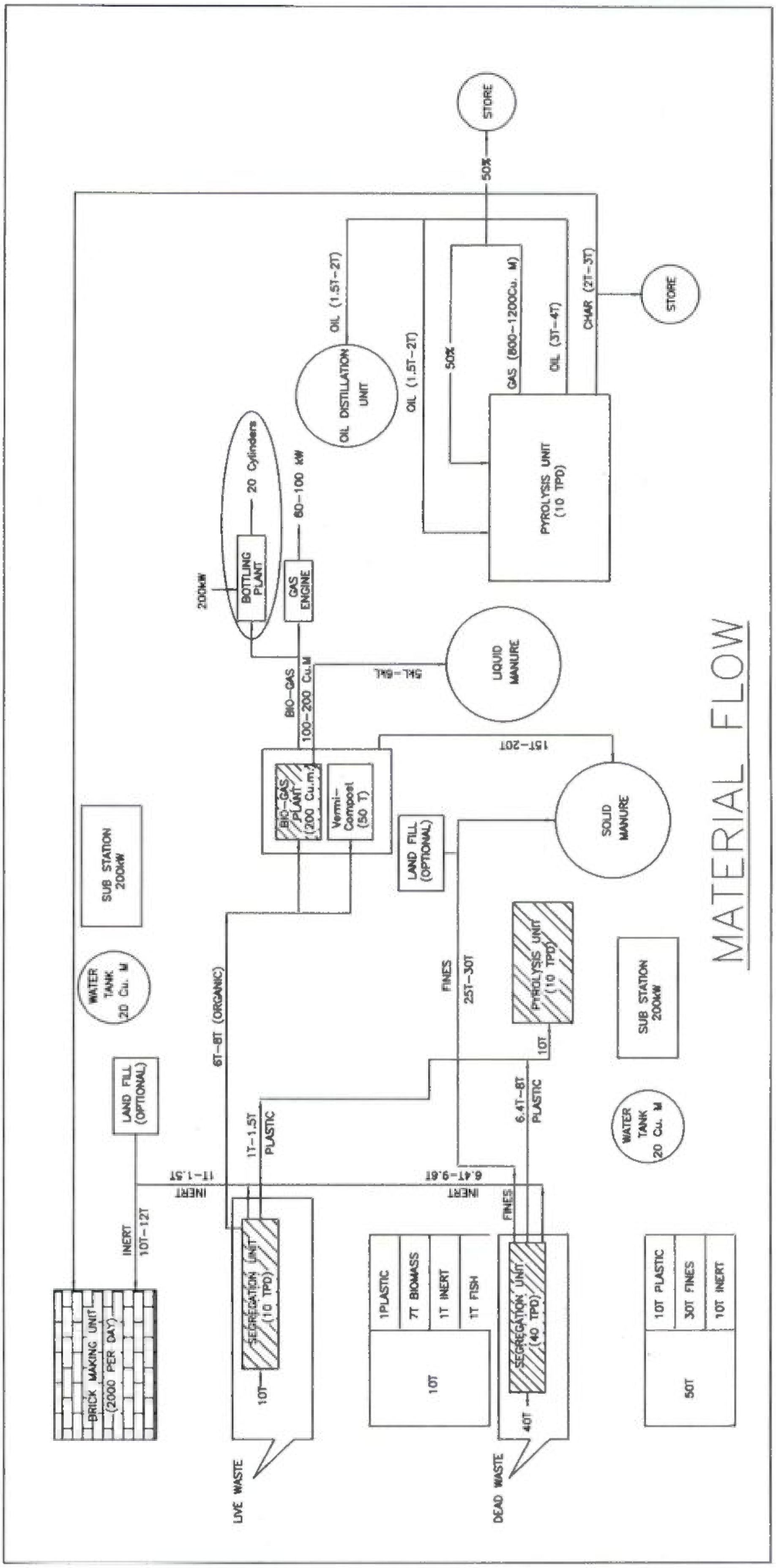
MATERIAL FLOW
LIVE WASTE
DEAD WASTE
SEGREGATION UNIT (10 TPD)
SEGREGATION UNIT (40 TPD)
10T
40T
10T
1PLASTIC
7T BIOMASS
1T INERT
1T FISH
50T
10T PLASTIC
30T FINES
10T INERT
BRICK MAKING UNIT (2000 PER DAY)
INERT 10T-12T
INERT 1T-1.5T
INERT 6.4T-9.6T
LAND FILL (OPTIONAL)
WATER TANK 20 Cu. M
SUB STATION 200kW
1T-1.5T PLASTIC
6T-8T (ORGANIC)
6.4T-8T PLASTIC
FINES
FINES 25T-30T
10T
PYROLYSIS UNIT (10 TPD)
BIO-GAS PLANT (200 Cu.m.)
Vermi-Compost (50 T)
LAND FILL (OPTIONAL)
SOLID MANURE
15T-20T
LIQUID MANURE
5KL-6KL
BIO-GAS 100-200 Cu.M
GAS ENGINE
60-100 kW
BOTTLING PLANT
200kW
20 Cylinders
OIL DISTILLATION UNIT
OIL (1.5T-2T)
OIL (1.5T-2T)
50%
GAS (800-1200Cu. M)
OIL (3T-4T)
CHAR (2T-3T)
PYROLYSIS UNIT (10 TPD)
50%
STORE
STORE

6.2 Scope of work

6.2.1 Durgapur Municipal Corporation

- Providing developed land (80 m×60 m) with boundary wall for establishing set-up of Municipal Solid Waste disposal system (Perimeter: 280 m & Height: 2 m);
- Approach road for the site;
- Necessary electrical connection up to substation at site for operation of plant;
- Necessary water connection up to tank at site;
- Providing insurance, electricity and water for running the plant at no cost;
- Collection of waste from different sites under DMC and providing them at the proposed site;

6.2.2 CSIR-Central Mechanical Engineering Research Institute

- Necessary civil and electrical works at the proposed site for installation of 10 TPD Integrated Municipal Solid Waste Disposal system for Live Waste;
- Design, development, installation & commissioning of 10 TPD live mechanized segregation system to separate Municipal Solid Waste into biodegradable & non-biodegradable components;
- Design, development, installation & commissioning of 1000 kg/day Polymer waste pyrolysis plant for further processing of polymer waste from segregation plant, in an eco-friendly way;
- Design, development, installation & commissioning of 50 ton composting plant;
- Design, development, installation & commissioning of 200 cum biogas plant for processing of biodegradable waste from segregation plant;
- Design, development, installation & commissioning of 300 kg/hr cum briquette plant
- Sale of by-products consisting of pyrolysis oil and char from polymer waste pyrolysis plant;
- Sale of by-products consisting of biogas, solid and liquid manure from biogas plant;
- Sale of recyclables consisting of metals from segregated live waste;
- Sale of by-products consisting of briquette and compost;
- After commissioning, Operation & Maintenance for subsequent two years, renewed annually.

6.3 Duration of the Project:

The total duration of the project is 18 months (1.5 years) after handover of site by DMC.

6.4 Milestone Activities & Duration

Sl. No.	Activities Description	0-3 months	3-6 months	6-9 months	9-12 months	12-15 months	15-18 months		18-30 months	30-42 months
1	**Handover of proposed site after Site Clearance (scope of DMC)**							**Handing Over**	**Operation & Maintenance**	
2	Necessary civil, Structural and electrical works									
3	Desing & Engineering									
4	Purchase & Procurement									
5	Fabrication of Equipment									
6	Installation of Segregation Unit (10TPD Live)									
9	Installation of Biogas Plant (200 cum)									
10	Installation & Commissioning of 300 kg/hr briqutte plant									
11	Installation of compost (50 ton)									
12	Trial Run & Commissioning									

6.5 Estimated Cost: (INR in Lakh)

Capital Expenditure (A):

Option-1: Considering Stand-alone Project

Sl No	Description	INR in Lakh	Remarks
1	Works & Services	180	
2	Equipment	920	
	Sub Total	1100	
	GST (@18%)	198	
	Sub-Total	**1,298**	

Option-2: Considering additional project along with 50 TPD *i*MSWDS

Sl No	Description	INR in Lakh	Remarks
1	Works & Services	150	
2	Equipment	750	
	Sub Total	900	
	GST (@18%)	162	
	Sub-Total	**1062**	

Recurring Cost / per year (B)

Sl. No.	Description	INR in Lakh	Remarks
a	Chemicals & Consumables	8	Annexure-A
b	Other Res. Expenditure	15	Annexure-B
c	Manpower	31	Annexure-C
d	Contingencies	2	
	Sub-Total	**56**	

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6.6 Cost Benefit Analysis

Total Waste: 10 TPD (Live waste)

Economic life span of the plant: 15 years

A. Capital Cost

Option-1: Considering Stand-alone Project

The details of the capital costs are as follows

Sl. No.	Description	Size / Capacity	INR in Lakh	Remarks
a	Land	5,000 sq. m	-	To be provided by DMC at no cost
b	Plant and Equipment			
i	Installation of mechanized segregation plant	10 TPD Fresh waste × 1 Nos.	500	
ii	Installation of Biogas Plant	100 cum × 2 Nos.	150	
iii	Installation of Gas Engine	4 Nos. 15 kVA	30	
iv	Installation of compost facility	50 ton	40	
v	Installation of Briquette facility	150 kg/hr × 2 Nos.	30	
vi	Installation of Pyrolysis Plant	1000 kg/ batch	150	
	Procurement of vehicles for operation at site	Tractor – 2 No.	20	
c	Civil, Structural & Electrical Works	As required	180	
	Sub-total		**1,100**	

Option-2: Considering additional project along with 50 TPD *i*MSWDS

The details of the capital costs are as follows

Sl. No.	Description	Size / Capacity	INR in Lakh	Remarks
a	Land	5,000 sq. m	-	To be provided by DMC at no cost
b	Plant and Equipment			
i	Installation of mechanized segregation plant	10 TPD Fresh waste × 1 Nos.	500	
ii	Installation of Biogas Plant	100 cum × 2 Nos.	150	
	Installation of Gas Engine	4 Nos. 15 kVA	30	
iii	Installation of compost facility	50 ton	40	
iv	Installation of Briquette facility	150kg/hr × 2 Nos.	30	
v	Installation of Pyrolysis Plant	500 kg/ batch	--	(Included in Proposal of *i*MSWDS of 50TPD Dead Waste)
vi	Procurement of vehicles for operation at site	Tractor – 1 No.	--	(Included in Proposal of *i*MSWDS of 50TPD Dead Waste)
c	Civil, Structural & Electrical Works	As required	180	
	Sub-total		**930**	

B. Recurring Cost / per year

Sl. No.	Description	INR in Lakh	Remarks
a	Chemicals & Consumables	8	Annexure-A
b	Other Res. Expenditure	15	Annexure-B
c	Manpower	31	Annexure-C
d	Contingencies	2	
	Sub-total	**56**	

C. Revenue Generation/ per year

Sl. No.	Description	Revenue/Yr (INR in Lakh)	Remarks
a	Pyrolysis plant	20	Annexure-D
b	Biogas plant	25	Annexure-E
c	Recyclables/Compost/Briquette	12	Annexure-F
	Sub-total	**57**	

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Annexure-A

Budget for Chemicals & Consumables

Sl.	Component	Amount (₹ in Lakh)
1	Fuel (Diesel)	5
2	Utilities, Consumables & Miscellaneous Supplies	3
	Total	**8**

Annexure-B

Budget for Other Research Expenditure

Sl.	Component	Amount (₹ in Lakh)
1	Repair and Maintenance of plant machinery	6
3	Plant and Office Running Expenses	1
5	Quality check	2
6	Miscellaneous	1
7	TA/DA	5
	Total	**15**

Annexure-C

Budget for Manpower

Sl.	Position	Nos.	Salary	Amount (Rs)
1	Supervisor	1	20,000	20,000
2	Operator	3	20,000	60,000
4	Unskilled Labour	15	10,000	1,50,000
			Sub Total	2,10,000
			Overhead @ 25%	52,500
			Total (per month)	2,62,500
				31,50,000

Annexure-D

Revenue Generation from Pyrolysis Plant, Capacity: 1000 kg/day

Sl	Description	Quantity/ day (kg)	Annual Quantity (ton)	Price (₹)/kg	Annual (₹)
1	Fuel oil (20% yield)	200	60	30	18,00,000
2	Carbon (25% yield)	250	75	3	2,25,000
3	Gas (30-40%)				
				Total Sale (₹)	**20,25,000**

Annexure-E

Revenue Generation from Biogas Plant, Capacity: 200 cum

Sl	Description	Quantity/day	Unit	Annual Quantity	Unit Rate (₹)	Amount (₹)
1	Biogas	200	cum	60,000	24	14,40,000
2	Sale of Liquid Manure	2,000	INR/L	6,00,000	1	6,00,000
3	Sale of Compost/ Solid Manure	800	INR/Kg	2,00,000	2.5	5,00,000
					Total Sale (₹)	**25,40,000**

Annexure-F

Revenue Generation from sale of recyclable items

Sl	Parameter	Average %	Quantity/day (kg)	Unit rate/ kg	Per annum
1	Metals, Glass	2.0%	100	10	**3,00,000**

Revenue Generation from compost

Sl	Item	Rate (₹)	Production/day	Amount/day (₹)	Amount/yr (₹)
1	Compost	4.25/kg	600	2,550	**7,65,000**

Revenue Generation from Briquette

Sl	Item	Rate (₹)	Production/day	Amount/day (₹)	Amount/yr (₹)
1	Briquette	5/kg	100	500	**1,50,000**

Detail Project Report

on

Design, Development, Installation and Commissioning of Integrated Municipal Solid Waste Disposal System (iMSWDS)

SUBMITTED TO

Durgapur Municipal Corporation
City Center, Durgapur-713216

BY

CSIR-CENTRAL MECHANICAL ENGINEERING RESEARCH INSTITUTE

(A Constituent Establishment of CSIR, Govt. of India)

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Preface

The management of municipal solid waste in India has surfaced or continued to be a severe problem not only because of environmental and aesthetic concerns but also because of the enormous quantities generated every day. Even though only 31% of Indian population resides in urban areas, it generates a gigantic 1,43,449 metric tonnes per day of municipal solid waste, as per the Central Pollution Control Board (CPCB), 2014-15 and these figures increase every day with an increase in population. To further add to the problem, the total number of towns (statutory and census) in the country have also increased from 5,161 in 2001 to 7,936 in 2011, thus increasing the number of municipal waste generation by 2,775 within a decade.

The management of municipal solid waste is one of the main functions of all Urban Local Bodies (ULBs) in the country. All ULBs are required to meticulously plan, implement and monitor all systems of urban service delivery especially that of municipal solid waste. With limited financial resources, technical capacities and land availability, urban local bodies are constantly striving to meet this challenge.

With the launch of the flagship programme by the Government of India, Swachh Bharat Mission in 2014 that aims to provide basic infrastructural and service delivery with respect to sanitation facilities to every family, including toilets and adopting the scientific methods to collect, process and disposal of municipal solid waste. The mission focuses on quality and sustainability of the service provision as well as emphasizing on the commitment on every stakeholder to bring about a visible change in society.

The three most popular options for processing and disposing of MSW are:

- Converting it into compost
- Converting it to energy
- Sanitary landfill

Converting MSW into Compost

In this method, the waste is exposed to anaerobic microbes, like bacteria, which break down the organic matter in the absence of oxygen to form biogas (mixture of methane and carbon dioxide) and compost (solid and liquid residual). Biogas can be used as fuel for cooking or for generator to convert it to electricity. The liquid slurry can be used as organic fertilizer.

Converting Municipal Solid Waste to Energy (WTE)

In this process thermal breakdown of MSW in high temperature environment is done to reduce MSW into a slag and syngas. The syngas can be used in gas engines/ gas turbines to generate electricity, steam or other such forms of energy. Waste to energy generates clean, reliable energy from a renewable fuel source, thus reducing dependence on fossil fuels.

Both these methods (Converting MSW into compost and Converting MSW into energy) have environmental benefits compared to third method disposing of MSW in landfills. Both the methods would reduce the quantity of wastes and generate a substantial quantity of energy which in turn reduce pollution of water and air, thereby offering a number of social and economic benefits. Some of the strategic and financial benefits from implementation of both the methods are:

- **Government Incentives** - The government of India already provides significant incentives for appropriate dispose of MWS, in the form of capital subsidies and feed in tariffs. With concerns on climate change, there are more chances of increased incentives by government.
- **Co-product Opportunities** - Depending on the technology/route used for energy recovery, eco-friendly and "green" co-products such as charcoal, compost, nutrient rich fertilizer or bio-oil can be obtained.
- **Job Opportunities** - With distributed waste management, new opportunities emerge for companies to provide support services. Every machine, required to dispose-off MSW, opportunities of maintaining, servicing, or taking care of it emerge. In other words, the technology will boost job opportunity. To add further this could be significant international expansion possibilities for Indian companies, especially expansion into other Asian countries.

The present project proposal aims to develop novel technologies that are innovative to extract wealth out of waste. The major technological interventions proposed are:

- ➢ Design & development of mechanized segregation system to separate Municipal Solid Waste into biodegradable & non-biodegradable components;
- ➢ Design & development of safe, environment friendly process for disposal of polymer waste utilizing pyrolysis;
- ➢ Design & development of biogas plant for disposal of biodegradable waste.

The major advantages of the proposed technologies include:

- Minimization of Landfill option, which is becoming crucial due to the continuously reducing space for sanitary landfills;
- Lowering environmental footprint through significant reduction in quantities of air pollutants;
- Reducing dependence on imported oil by using pyrolysis oils from waste polymers which are low priced;
- Use of pyrolysis gas generated from polymer waste pyrolysis plant to run gas engines/turbine and produce electricity;
- Environment friendly disposal of biodegradable waste through generation of Biogas which will definitely support the dwindling energy resources. The gas can be used for as fuel in the kitchen or for power generation;
- Generation of high quality, weed free manure from biogas plant which is an excellent soil conditioner. This is very important for replenishing organic carbon in the undernourished soil after years of agriculture;
- Downstream employment generation for the rural/urban poor.

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CONTENT

CHAPTER 1
INTRODUCTION

1.1 PREAMBLE

Over the years, there has been a continuous migration of people from rural and semi-urban areas to towns and cities. The proportion of population residing in urban areas has increased from 10.84% in 1901 to 25.70% in 1991. The number of class I cities has increased from 212 to 300 during 1981 to 1991, while class II cities have increased from 270 to 345 during the same period. The increase in the population in class I cities is very high as compared to that in class II cities. The uncontrolled growth in urban areas has left many Indian cities deficient in infrastructural services such as water supply, sewerage and municipal solid waste management.

Most urban areas in the country are plagued by acute problems related to solid waste and become a tenacious problem. It is not uncommon to find 30-50% of staff and resources being utilized by Urban Local Bodies for these operations. Despite this, there has been a progressive decline in the collection and disposal of municipal solid waste including hospital and industrial wastes, as well as measures for ensuring adequacy of environmental sanitation and public hygiene. In many cities nearly half of solid waste generated remains unattended, giving rise to insanitary conditions especially in densely populated slums which in turn results in an increase in morbidity especially due to microbial and parasitic infections and infestations in all segments of population, with the urban slum dwellers and the waste handlers being the worst affected.

Solid Waste Management is a part of public health and sanitation, and according to the Indian Constitution, falls within the purview of the State list. Since this activity is non-exclusive, non-rivaled and essential, the responsibility for providing the service lies within the public domain. The activity being of a local nature is entrusted to the Urban Local Bodies. The Urban Local Body undertakes the task of solid waste service delivery, with its own staff, equipment and funds. In a few cases, part of the said work is contracted out to private enterprises.

There is lack of community awareness either about the likely perils due to poor waste management or the simple steps that every citizen can take which will help in reducing waste generation and promote effective management of solid waste generated. The degree of community sensitization and public awareness is low. There is no system of segregation of organic, inorganic and recyclable wastes at household level.

It is estimated that the total solid waste generated by 300 million people living in urban India is 38 million tonnes per year. The disposal of municipal solid waste is one of the pressing problems of city life, which has assumed great importance in the recent past. With the growing urbanization as a result of planned economic growth and industrialization, problems are becoming acute and call for immediate and concerted action. The proper disposal of urban waste is not only absolutely necessary for the preservation and improvement of public health but it has an immense potential for resource recovery.

It is estimated that about 1,45,000 MT of Municipal Solid Waste is generated daily in the country. Per capita waste generation in major cities ranges from 0.20 kg to 0.60 kg. Generally, the collection efficiency ranges between 70 to 90% in major metro cities whereas in several smaller cities the collection efficiency is below 50%. It is also estimated that the Urban Local Bodies spend about Rs.500 to Rs.1500 per ton on solid waste for collection, transportation, treatment and disposal. About 60-70% of this amount is spent on street sweeping of waste collection, 20 to 30% on transportation and less than 5% on final disposal of waste, which shows that hardly any attention is given to scientific and safe disposal of waste. Landfill sites have not yet been identified by many municipalities and in several municipalities, the landfill sites have been exhausted and the respective local bodies do not have resources to acquire new land. Due to lack of disposal sites, even the collection efficiency gets affected.

Very few Urban Local Bodies in the country have prepared long term plans for effective Solid Waste Management in their respective cities. For obtaining a long term economic solution, planning of the system on long-term sustainable basis is very essential.

1.2 PROBLEMS BEING FACED BY URBAN LOCAL BODIES

Barring a few progressive municipal corporations in the country, all other local bodies suffer due to non-availability of adequate expertise and experience; thereby the solid waste is not properly handled resulting into creation of environmental pollution and health hazards. As mentioned earlier, these local bodies lack technical, managerial, administrative, financial resources, adequate institutional arrangements. Similarly, Defense, Railways, CPWD and several Government of India Organizations/Undertakings having large establishments in the cities and towns lack the technical knowhow of managing urban solid waste. It is, therefore, very necessary to provide proper guidance in the Urban Local Bodies/Government

Agencies/Establishments referred above, to make them efficient in managing the solid waste generated in their respective areas/cities/towns.

1.3 NEED OF THE PROJECT

Looking to the existing SWM system, the Ministry of Environment & Forest has notified Municipal Solid Waste (Management & Handling) Rules 2016 under the Environment Protection Act 1986. According to these rules, all the municipal authorities were expected to improve solid waste management practices in terms of aforesaid rules by December, 2003. But, the situation did not improve as expected for want of adequate technical know-how and lack of human and financial resources.

It has been estimated that the average daily waste generation from Durgapur is around 250 TPD. With the projected population as 647,361 in the year 2020, it is estimated that 275 tons of MSW would be generated in the year 2020. Currently, the waste is being collected, transported and disposed at Shankarpur a dumping yard without any scientific processing, giving an ugly face to the city. These practices attract a lot of objection in view of open dumping of MSW and obnoxious odour and fly formation in the open dump yard. These practices also pose greater risk of ground water contamination due to percolation. According to World Health Organization (WHO) nearly five million people die due to disease caused by faulty disposal system and poor collection practices of waste over the years. As per the report of WHO, there are twenty two diseases which are directly related to improper management of solid waste. The rodent and vector insects transmit various diseases like dysentery, cholera, plague, typhoid, infective hepatitis and other. haphazard disposal of

In order to protect the public health and environment, it is need of the hour to find a suitable method for MSW disposal. Therefore, the present project has been undertaken to assess the existing SWM system, identify the gaps of the existing system and propose plan for eco-friendly disposal of solid waste. After evaluating various options available for MSW disposal and assessing factors like land availability, calorific value of MSW, paucity of land for Land Fill etc., it is suggested that disposal of MSW through technologies developed by CSIR-CMERI which include mechanized segregation of waste, utilization of the segregated bio-degradable waste and polymer waste are the most ideal ways for eco-friendly disposal of MSW at Durgapur.

CHAPTER 2

PRINCIPLES OF MUNICIPAL SOLID WASTE MANAGEMENT

2.1 INTRODUCTION

Management of municipal solid waste involves (a) development of an insight into the impact of waste generation, collection, transportation and disposal methods adopted by a society on the environment and (b) adoption of new methods to reduce this impact.

2.1.1 Solid Waste Generation

Municipal Solid Waste (MSW) is the trash or garbage that is discarded day to day in a human settlement. According to MSW Rules 2000, MSW includes commercial and residential wastes generated in municipal or notified areas in either solid or semi-solid form excluding industrial hazardous wastes but including treated bio-medical wastes. Waste generation encompasses activities in which materials are identified as no longer being of value (being in the present form) and are either thrown away or gathered together for disposal. Municipal Solid Waste consists of the following kinds of waste.

Fig 2.1: Sources of MSW Generation

The other kinds of waste found in urban settlements are:

1) Industrial or Hazardous Waste,
2) Bio-Medical or Hospital Waste, and
3) E-Waste

The Industrial hazardous waste is managed through Hazardous Waste (Management and Handling) Forth Amendments Rules 2010. Hazardous waste is typically identified with properties of *ignitability, corrosivity, reactivity and toxicity*. Hence urban local bodies must ensure that industrial waste in their command area does not get mixed with the municipal solid waste stream, failing which will result in economic losses (as hazardous waste treatment costs much higher than the municipal solid waste) and health & safety hazards (Contaminants like heavy metals, chromium, mercury, etc. when found in the municipal waste stream will contaminate the compost produced by the city. When farmers buy the compost it will indirectly affect the food chain) while treating such wastes.

According to the Hazardous Waste Management Rules 2010, the onus of managing and treating hazardous waste lie with the waste generator, and the urban local body has to ensure that such waste does not contaminate municipal waste stream in their area of authority.

A society receives energy and raw material as inputs from the environment and gives solid waste as output to the environment. In the long-term perspective, such an input-output imbalance degrades the environment.

2.1.2 Environmental Impact of Solid Waste Disposal on Land

When solid waste is disposed off on land in open dumps or in improperly designed landfills (e.g. in low lying areas), it causes the following impact on the environment:

(a) ground water contamination by the leachate generated by the waste dump
(b) surface water contamination by the run-off from the waste dump
(c) bad odour, pests, rodents and wind-blown litter in and around the waste dump
(d) generation of inflammable gas (e.g. methane) within the waste dump
(e) bird menace above the waste dump which affects flight of aircraft
(f) fires within the waste dump
(g) erosion and stability problems relating to slopes of the waste dump
(h) epidemics through stray animals
(i) acidity to surrounding soil and release of greenhouse gas

2.1.3 Objectives of Solid Waste Management

The objectives for solid waste management are:

- Maximize resource recovery / minimal emissions;
- Minimize impact on environment, human intervention, space requirement, impact on health hazard;
- No waste visibility;
- Elimination of MSW's inherent hazards:
    - Obnoxious odours
    - GHG emissions
    - Disease vectors and transmissions
    - Ground water contamination
    - Attracting stray animals & birds
    - Unhygienic & visually ugly site
- Making a clean & hygienic smart city

2.2 PRINCIPLES OF MUNICIPAL SOLID WASTE MANAGEMENT

Municipal Solid Waste Management involves the application of principle of Integrated Solid Waste Management (ISWM) to municipal waste. ISWM is the application of suitable techniques, technologies and management programs covering all types of solid wastes from all sources to achieve the twin objectives of (a) waste reduction and (b) effective management of waste still produced after waste reduction.

2.2.1 Waste Reduction

It is now well recognized that sustainable development can only be achieved if society in general, and industry in particular, produces 'more with less' i.e. more goods and services with less use of the world's resources (raw materials and energy) and less pollution and waste. The government is committed to reducing the amount of waste.

2.2.2 Effective Management of Solid Waste

Effective solid management systems are needed to ensure better human health and safety. They must be safe for workers and safeguard public health by preventing the spread of disease. In addition to these prerequisites, an effective system of solid waste management must be both environmentally and economically sustainable.

- Environmentally sustainable: It must reduce, as much as possible, the environmental impacts of waste management.
- Economically sustainable: It must operate at a cost acceptable to community.

Clearly it is difficult to minimize the two variables, cost and environmental impact, simultaneously. There will always be a trade off. The balance that needs to be struck is to reduce the overall environmental impacts of the waste management system as far as possible, within an acceptable level of cost.

An economically and environmentally sustainable solid waste management system is effective if it follows an integrated approach i.e. it deals with all types of solid waste materials and all sources of solid waste. A multi-material, multi-source management approach is usually effective in environmental and economic terms than a material specific and source specific approach. Specific wastes should be dealt within such a system but in separate streams. An effective waste management system includes one or more of the following options:

(a) Waste collection and transportation.
(b) Resource recovery through sorting and recycling i.e. recovery of materials (such as paper, glass, metals) etc. through separation.
(c) Resource recovery through waste processing i.e. recovery of materials (such as compost) or recovery of energy through biological, thermal or other processes.
(d) Waste transformation (without recovery of resources) i.e. reduction of volume, toxicity or other physical/chemical properties of waste to make it suitable for final disposal.
(e) Disposal on land i.e. environmentally safe and sustainable disposal in landfills.

2.2.3 Functional Elements of Municipal Solid Waste Management

The activities associated with the management of municipal solid wastes from the point of generation to final disposal can be grouped into the six functional elements: (a) waste generation; (b) waste handling and sorting, storage, and processing at the source; (c) collection; (d) sorting, processing and transformation; (e) transfer and transport; and (f) disposal.

Waste Generation: Waste generation encompasses activities in which materials are identified as no longer being of value (in their present form) and are either thrown away or gathered together for disposal. Waste generation is, at present, an activity that is not very controllable. In the future, however, more control is likely to be exercised over the generation of wastes. Reduction of waste at source, although not controlled by solid waste managers, is now included in system evaluations as a method of limiting the quantity of waste generated.

Waste Handling, Sorting, Storage, and Processing at the Source: The second of the six functional elements in the solid waste management system is waste handling, sorting, storage, and processing at the source. Waste handling and sorting involves the activities associated with management of wastes until they are placed in storage containers for collection. Handling also encompasses the movement of loaded containers to the point of collection. Sorting of waste components is an important step in the handling and storage of solid waste at the source. For example, the best place to separate waste materials for reuse and recycling is at the source of generation. Households are becoming more aware of the importance of separating newspaper and cardboard, bottles/glass, kitchen wastes and ferrous and non-ferrous materials.

On-site storage is of primary importance because of public health concerns and aesthetic consideration. Unsightly makeshift containers and even open ground storage, both of which are undesirable, are often seen at many residential and commercial sites. The cost of providing storage for solid wastes at the source is normally borne by the household in the case of individuals, or by the management of commercial and industrial properties. Processing at the source involves activities such as backyard waste composting.

Collection: The functional element of collection includes not only the gathering of solid wastes and recyclable materials, but also the transport of these materials, after collection, to the location where the collection vehicle is emptied. This location may be a material processing facility, a transfer station, or a landfill disposal site.

Sorting, Processing and Transformation of Solid Waste: The sorting, processing and transformation of solid waste materials is the fourth of the functional elements. The recovery of sorted materials, processing of solid waste and transformation of solid waste that occurs primarily in locations away from the source of waste generation are encompassed by this functional element. Sorting of commingled (mixed) wastes usually occurs at a materials recovery facility, transfer stations, combustion facilities, and disposal sites. Sorting often includes the separation of bulky items, separation of waste components by size using screens, manual separation of waste components, and separation of ferrous and non-ferrous metals.

Waste processing is undertaken to recover conversion products and energy. The organic fraction of Municipal Solid Waste (MSW) can be transformed by a variety of biological and thermal processes. The most commonly used biological transformation process is aerobic composting. The most commonly used thermal transformation process is incineration.

Waste transformation is undertaken to reduce the volume, weight, size or toxicity of waste without resource recovery. Transformation may be done by a variety of mechanical (ex. shredding), thermal (ex. incineration without energy recovery) or chemical (ex. encapsulation) techniques.

Transfer and Transport: The functional element of transfer and transport involves two steps: (i) the transfer of wastes from the smaller collection vehicle to the larger transport equipment and (ii) the subsequent transport of the wastes, usually over long distances, to a processing or disposal site. The transfer usually takes place at a transfer station.

Disposal: The final functional element in the solid waste management system is disposal. Today the disposal of wastes by landfilling or uncontrolled dumping is the ultimate fate of all solid wastes, whether they are residential wastes collected and transported directly to a landfill site, residual materials from Materials Recovery Facilities (MRFs), residue from the combustion of solid waste, rejects of composting, or other substances from various solid waste-processing facilities. A municipal solid waste landfill plant is an engineered facility used for disposing of solid wastes on land or within the earth's mantle without creating nuisance or hazard to public health or safety, such as breeding of rodents and insects and contamination of groundwater.

2.3 HIERARCHY OF WASTE MANAGEMENT OPTIONS

Current thinking on the best methods to deal with waste is centered on a broadly accepted 'hierarchy of waste management' (arrangement in order of rank) which gives a priority listing of the waste management options available. The hierarchy gives important general guidelines on the relative desirability of the different management options. The hierarchy usually adopted is (a) waste minimization/reduction at source, (b) recycling, (c) waste processing (with recovery of resources i.e. materials (products) and energy), (d) waste transformation (without recovery of resources) and (e) disposal on land (landfilling).

The highest rank of the ISWM hierarchy is waste minimization or reduction at source, which involves reducing the amount (and/or toxicity) of the wastes produced. Reduction at source is first in the hierarchy because it is the most effective way to reduce the quantity of waste, the cost associated with its handling, and its environmental impacts.

The second highest rank in the hierarchy is recycling, which involves (a) the separation and sorting of waste materials; (b) the preparation of these materials for reuse or reprocessing; and (c) the reuse and reprocessing of these materials. Recycling is an important factor which helps to reduce the demand on resources and the amount of waste requiring disposal by landfilling.

The third rank in the ISWM hierarchy is waste processing which involves alteration of wastes to recover conversion products (e.g., compost) and energy. The processing of waste materials usually results in the reduced use of landfill capacity.

Transformation of waste, without recovery of products or energy, may have to be undertaken to reduce waste volume (e.g. shredding and baling) or to reduce toxicity. This is usually ranked fourth in the ISWM hierarchy.

Ultimately, something must be done with (a) the solid wastes that cannot be recycled and are of no further use; (b) the residual matter remaining after solid wastes have been pre-sorted at a materials recovery facility; and (c) the residual matter remaining after the recovery of conversion products or energy. Landfilling is the fifth rank of the ISWM hierarchy and involves the controlled disposal of wastes on or in the earth's mantle. It is by far the most common method of ultimate disposal for waste residuals. Landfilling is the lowest rank in the ISWM hierarchy because it represents the least desirable means of dealing with society's wastes.

It is important to note that the hierarchy of waste management is only a guideline.

2.4 WASTE MINIMISATION

Waste minimization or reduction at source is the most desirable activity, because the community does not incur expenditure for waste handling, recycling and disposal of waste that is never created and delivered to the waste management system. However, it is an unfamiliar activity as it has not been included in earlier waste management systems.

To reduce the amount of waste generated at the source, the most practical and promising methods appear to be (i) the adoption of industry standards for product manufacturing and packaging that use less material, (ii) the passing of laws that minimize the use of virgin materials in consumer products, and (iii) the levying (by communities) of cess/fees for waste management services that penalize generators in case of increase in waste quantities.

Modifications in product packaging standards can result in reduction of waste packaging material or use of recyclable materials. Minimization of use of virgin raw materials by the manufacturing industry promotes substitution by recycled materials.

Sorting at source, recycling at source and processing at source (e.g. yard composting) helps in minimizing waste.

One waste management strategy used in some communities in developed countries is to charge a variable rate per can (or ton) of waste, which gives generators a financial incentive to reduce the amount of waste set out for collection. Issues related to the use of variable rates include the ability to generate the revenues required to pay the costs of facilities, the administration of a complex monitoring and reporting network for service, and the extent to which wastes are being put in another place by the generator and not reduced at source.

2.5 RESOURCE RECOVERY THROUGH MATERIAL RECYCLING

Material recycling can occur through sorting of waste into different streams at the source or at a centralized facility. Sorting at source is more economical than sorting at a centralized facility.

2.5.1 Sorting at Source

Sorting at source (home sorting) is driven by the existing markets for recyclable materials and the link between the house holder and the waste collector. The desirable home sorting streams are:

(a) Dry recyclable materials e.g. glass, paper, plastics, cans etc.,

(b) Bio-waste and garden waste,

(c) Bulky waste,

(d) Hazardous material in household waste,

(e) Construction and Demolition waste, and

(f) Commingled MSW (mixed waste).

At present recycling of dry recyclables does take place at the household level in India. However, source separation and collection of waste in streams of (b), (c), (d) and (e) has to be developed in most cities.

2.5.2 Centralized Sorting

Centralized sorting is needed wherever recyclable materials are collected in a commingled (mixed) state.

Hand sorting from a raised picking belt is extensively adopted in several countries.

Mechanized sorting facilities using magnetic and electric field separation, density separation, pneumatic separation, size separation and other techniques are used in some developed countries. Such facilities are usually prohibitively expensive in comparison to hand sorting.

In India, centralized sorting is not adopted. However, some intermediate sorting does occur after household wastes reach kerbside collection bins (dhalaos) through ragpickers. There is a need to formalise this intermediate sorting system or develop a centralized sorting facility to minimize recyclable materials reaching a waste processing facility or a landfill.

2.5.3 Sorting Prior to Waste Processing or Landfilling

Home sorting and centralized sorting processes normally recover most of the recyclable materials for reuse. However, a small fraction of such materials may escape the sorting process. Sorting is also undertaken just prior to waste processing, waste transformation or landfilling to recover recyclable materials. In a landfill, sorting may be carried out by ragpickers immediately after spreading of a layer of waste. In waste processing or transformation centres, manual sorting or size separation is usually undertaken.

Wherever manual sorting is adopted, care must be taken to ensure that sorters are protected from all disease pathways and work in hygienic conditions.

2.6 RESOURCE RECOVERY THROUGH WASTE PROCESSING

Biological or thermal treatment of waste can result in recovery of useful products such as compost or energy.

2.6.1 Biological Processes

Biological treatment involves using micro-organisms to decompose the biodegradable components of waste. Two types of processes are used, namely:

(a) Aerobic processes: Windrow composting, aerated static pile composting and in-vessel composting; vermi-culture etc.

(b) Anaerobic processes: Low-solids anaerobic digestion (wet process), high-solids anaerobic digestion (dry process) and combined processes.

At present recycling of dry recyclables does take place at the household level in India. However, source separation and collection of waste in streams of (b), (c), (d) and (e) has to be developed in most cities.

In the aerobic process the utilizable product is compost. In the anaerobic process the utilizable product is methane gas (for energy recovery). Both processes have been used for waste processing in different countries – a majority of the biological treatment process adopted world-wide are aerobic composting; the use of anaerobic treatment has been more limited.

In India, aerobic composting plants have been used to process up to 500 tons per day of waste.

2.6.2 Thermal Processes

Thermal treatment involves conversion of waste into gaseous, liquid and solid conversion products with concurrent or subsequent release of heat energy. Three types of systems can be adopted, namely:

(a) Combustion systems (Incinerators): Thermal processing with excess amounts of air.

(b) Pyrolysis systems: Thermal processing in complete absence of oxygen (low temperature).

(c) Gasification systems: Thermal processing with less amount of air (high temperature).

Combustion system is the most widely adopted thermal treatment process world-wide for MSW. Though pyrolysis is a widely used industrial process, the pyrolysis of municipal solid waste has not been very successful. Similarly, successful results with mass fired gasifiers have not been achieved. However, both pyrolysis and gasification are emerging as viable alternatives in the present.

To be viable for energy recovery through thermal processing, the municipal solid waste must possess a relatively high calorific value. In the MSW generated in developed countries, presence of significant quantity of paper and plastics yields a high calorific value of the MSW (typically above 2000 kcal/kg) which makes it suitable for thermal processing. In Indian MSW, the presence of high quantities of bio-degradable matter results in a low calorific value of the MSW (typically less than 1000 kcal/kg). In its mixed form, such waste may not be suitable for thermal processing. However, removal of inerts from Indian MSW as well as development of combustion system for low-calorific value wastes can result in a reversal of this position in the future.

2.7 WASTE TRANSFORMATION (WITHOUT RESOURCE RECOVERY) PRIOR TO DISPOSAL

At the end of all sorting processes, biological processes and thermal processes, the non-utilizable waste has to be disposed off on land. Prior to this disposal, waste may need to be subjected to transformation by mechanical treatment, thermal treatment or other methods to make it suitable for landfilling.

2.7.1 Mechanical Transformation

Sorting of waste may be undertaken to remove bulky items from the waste. Shredding of waste may be undertaken for size reduction to enable better compaction of waste.

2.7.2 Thermal Transformation

In regions where land space is very scarce (e.g. islands), waste with low calorific value may be subjected to combustion without heat recovery to reduce the volume of waste requiring disposal on land. Combustion transformation processes are similar to those discussed in Section 2.6.2.

2.8 DISPOSAL ON LAND

Waste is disposed off on land in units called landfills which are designed to minimise the impact of the waste on the environment by containment of the waste. Usually three types of landfills are adopted. Landfills in which municipal waste is placed are designated as "MSW Landfills" or "Sanitary Landfills". Landfills in which hazardous waste is placed are designated as "Hazardous Waste landfills". Landfills in which a single type of waste is placed (e.g. only construction waste) are designated as "Monofills".

2.9 COMPONENTS OF MUNICIPAL SOLID WASTE MANAGEMENT SYSTEM

Currently, in India, source separation and collection of dry recyclables is fairly well developed at the household level, commercial centers and institutional areas. These recyclable are further removed by ragpickers at various intermediate stages. Central sorting, whether manual or mechanized, is not adopted.

Source separation of bio-waste, construction and demolition waste as well as polymer waste is rarely done; consequently, most of the waste collected is a mixture of these components. Such mixed waste is rarely suitable for biological processing or thermal processing as it has high content of inert material, low calorific value and indeterminate mixing of hazardous elements (such as insecticides, paints, batteries etc.) at the micro level.

In some cities, good quality bio-waste is collected from fruit and vegetable markets and subjected to biological processing (aerobic) to produce compost. Such processing plants help reduce the quantity of waste reaching landfills.

Thermal processing of mixed municipal waste has not been successful in India. Biological processing of mixed municipal waste yields low quality compost which may have contaminants in excess of permissible limits.

Biological processing becomes viable once construction and demolition waste and hazardous waste streams are isolated from the bio-waste stream. Thermal processing of waste becomes viable only if sufficient high calorific value components (such as paper, plastic) are present in the waste.

Waste segregation and recovery of energy from segregated waste in an eco-friendly way is usually not a major component in an integrated municipal waste management system at present. However, compaction of raw solid waste before it proceeds the landfill site is the most common route of waste disposal undertaken by local bodies for reduction of landfill area.

CHAPTER 3
COMPOSITION AND QUANTITY OF SOLID WASTE

3.1 INTRODUCTION

The information on the nature of wastes, its composition, physical and chemical characteristics – and the quantities generated are basic needs for the planning of a Solid Waste Management system.

3.1.1 Terminology and Classification

In the literature, it is observed that various authors have used different terminology to describe the nature of wastes. In this text, 'composition' refers to the limited list of components or constituents, such as paper, glass, metal, plastic and garbage, into which an aggregate of municipal waste may conveniently be separated. 'Characteristics' on the other hand, refers to those physical and chemical properties, which are relevant to the storage, collection, treatment and disposal of waste such as density, moisture content, calorific value and chemical composition. In addition to these general terms, there are a number of more specific terms which, for greater clarity, must also be defined. A comprehensive list of definitions is therefore presented later in this chapter. Some terms, like 'domestic waste' and municipal waste refer to the sources of the wastes, while others, such as 'garbage', 'street waste' and 'hazardous waste', indicate the types of wastes.

3.1.2 Variations in Composition and Characteristics

An examination of the composition and characteristics of wastes in different parts of the country underscores the profound influences of national income, socio-economic conditions, social developments and cultural practices, and thereby focuses attention on the importance of obtaining the data locally.

Since different kinds of solid waste management system are designed for the future as well as the present, careful consideration should be given to changes that may occur during the design life of a system. Changes are inevitable, occur at an increasingly rapid rate in response to the increasing pace of social and technological development and the nature and extent of such changes cannot be predicted with accuracy. A built-in flexibility in the waste management system hence becomes essential. Nevertheless, it is possible to identify some of the factors that are likely to cause changes in waste composition and characteristics, which will enable planners to make reasonable judgements about the future.

3.2 DEFINITIONS AND CLASSIFICATION OF SOLID WASTES

In order to plan, design and operate a solid waste management system, a thorough knowledge of the quantities generated, the composition of wastes and its characteristics are essential. As a first step, a proper definition of the terms is necessary to avoid the general confusion that is common in the usage of these terms.

3.2.1 Definitions

There are many terms, which relate to the types and sources of wastes and these too must be defined. Based on the source, origin and type of waste a comprehensive classification is described below:

(i) Domestic/Residential Waste:

This category of waste comprises the solid wastes that originate from single and multi-family household units. These wastes are generated as a consequence of household activities such as cooking, cleaning, repairs, hobbies, redecoration, empty containers, packaging, clothing, old books, writing/new paper, and old furnishings. Households also discard bulky wastes such as furniture and large appliances which cannot be repaired and used.

(ii) Municipal Waste:

Municipal waste includes wastes resulting from municipal activities and services such as street waste, dead animals, market waste and abandoned vehicles. However, the term is commonly applied in a wider sense to incorporate domestic wastes, institutional wastes and commercial wastes.

(iii) Commercial Waste:

Included in this category are solid wastes that originate in offices, wholesale and retail stores, restaurants, hotels, markets, warehouses and other commercial establishments. Some of these wastes are further classified as garbage and others as rubbish.

(iv) Institutional Waste:

Institutional wastes are those arising from institutions such as schools, universities, hospitals and research institutes. It includes wastes which are classified as garbage and rubbish as well as wastes which are considered to be hazardous to public health and to the environment.

(v) Garbage:

Garbage is the term applied to animal and vegetable wastes resulting from the handling, storage, sale, preparation, cooking and serving of food. Such wastes contain putrescible organic matter, which produces strong odours and therefore attracts rats, flies and other vermin. It requires immediate attention in its storage, handling and disposal.

(vi) Rubbish:

Rubbish is a general term applied to solid wastes originating in households, commercial establishments and institutions, excluding garbage and ashes.

(vii) Ashes:

Ashes are the residues from the burning of wood, coal, charcoal, coke and other combustible materials, for cooking and heating in houses, institutions and small industrial establishments. When produced in large quantities at power generating plants and factories these wastes are classified as industrial wastes. Ashes consist of a fine powdery residue, cinders and clinker often mixed with small pieces of metal and glass.

(viii) Bulky Wastes:

In this category are bulky household wastes which cannot be accommodated in the normal storage containers of households. For this reason they require special collection. In developed countries bulky wastes are large household appliances such as cookers, refrigerators and washing machines as well as furniture, crates, vehicle parts, tyres, wood, trees and branches. Metallic bulky wastes are sold as scrap metal but some portion is disposed of at sanitary landfills.

(ix) Street Sweeping:

This term applies to wastes that are collected from streets, walkways, alleys, parks and vacant lots. In the more affluent countries manual street sweeping has virtually disappeared but it still commonly takes place in developing countries, where littering of public places is a far more widespread and acute problem. Mechanized street sweeping is the dominant practice in the developed countries. Street wastes include paper, cardboard, plastic, dirt, dust, leaves and other vegetable matter.

(x) Dead Animals:

This is a term applied to dead animals that die naturally or accidentally killed. This category does not include carcass and animal parts from slaughterhouses which are regarded as industrial wastes. Dead animals are divided into two groups, large and small. Among the large animals are horses, cows, goats, sheep, hogs and the like. Small animals include dogs, cats, rabbits and rats. The reason for this differentiation is that large animals require special equipment for lifting and handling during their removal. If not collected promptly, dead animals are a threat to public health because they attract flies and other vermin as they putrefy. Their presence in public places is particularly offensive and emits foul smell from the aesthetic point of view.

(xi) Construction and Demolition Wastes:

Construction and demolition wastes are the waste materials generated by the construction, refurbishment, repair and demolition of houses, commercial buildings and other structures. It mainly consists of earth, stones, concrete, bricks, lumber, roofing materials, plumbing materials, heating systems and electrical wires and parts of the general municipal waste stream, but when generated in large amounts at building and demolition sites, it is generally removed by contractors for filling low lying areas and by urban local bodies for disposal at landfills.

(xii) Industrial Wastes:

In the category are the discarded solid material of manufacturing processes and industrial operations. They cover a vast range of substances which are unique to each industry. For this reason they are considered separately from municipal wastes. It should be noted, however, that solid wastes from small industrial plants and ash from power plants are frequently disposed of at municipal landfills.

(xiii) Hazardous Wastes:

Hazardous wastes may be defined as wastes of industrial, institutional or consumer origin which, because of their physical, chemical or biological characteristics are potentially dangerous to human and the environment. In some cases although the active agents may be liquid or gaseous, they are classified as solid wastes because they are confined in solid containers. Typical examples are: solvents, paints and pesticides whose spent containers are frequently mixed with municipal wastes and become part of the urban waste stream. Certain hazardous wastes cause explosions in incinerators and fires at landfill sites. Others, such as pathological wastes from hospitals and radioactive wastes, require special handling at all time. Good management practice should ensure that hazardous wastes are stored, collected, transported and disposed off separately, preferably after suitable treatment to render them innocuous.

(xiv) Sewage Wastes:

The solid by-products of sewage treatment are classified as sewage wastes. They are mostly organic and derive from the treatment of organic sludge from both the raw and treated sewage. The inorganic fraction of raw sewage such as grit is separated at the preliminary stage of treatment, but because it entrains putrescible organic matter which may contain pathogens, must be buried / disposed off without delay. The bulk of treated, dewatered sludge is useful as a soil conditioner but invariably its use for this purpose is uneconomical. The solid sludge therefore enters the stream of municipal wastes unless special arrangements are made for its disposal.

3.2.2 Classification

Because of the heterogeneous nature of solid wastes, no single method of classification is entirely satisfactory. In some cases it is more important for the solid waste specialist to know the source of waste, so that classifying wastes as domestic, institutional or commercial, for example, is particularly useful. For other situations, the types of waste, garbage, rubbish, ashes, street waste is of greater significance because it gives a better indication of the physical and chemical characteristics of the waste. The principal classification is given in Table 3.1. The first three types, garbage, rubbish and ashes are those which make up the bulk of municipal wastes, derived principally from households, institutions and commercial areas. These wastes pose the most alarming/serious problems in urban areas.

Table 3.1: Classification of Solid Wastes

TYPES OF SOLID WASTE	DESCRIPTION	SOURCES
Food waste (garbage)	Wastes from the preparation, cooking, and serving of food. Market refuse, waste from the handling, storage, and sale of produce and meats and vegetable	
Rubbish	**Combustible** (primary organic) paper, cardboard, cartons, wood, boxes, plastics, rags, cloth, bedding, leather, rubber, grass, leaves, yard trimmings **Noncombustible** (primary inorganic) metals, tin cans, metal foils, dirt, stones, bricks, ceramics, crockery, glass bottles, other mineral refuse	Households, institutions and commercial such as hotels, stores, restaurants, markets, etc.
Ashes and Residues	Residue from fires used for cooking and for heating buildings, cinders, clinkers, thermal power plants.	
Bulky waste	Large auto parts, tyres, stoves refrigerators, others large appliances, furniture, large crates, trees, branches, palm fronts, stumps, flotage	
Street waste	Street sweepings, Dirt, leaves, catch basin dirt, animal droppings, contents of litter receptacles, dead animals	Streets, sidewalks, alleys, vacant lots, etc.
Dead animals	Small animals: cats, dogs, poultry etc. Large animals: horses, cows etc.	
Construction & demolition waste	Lumber, roofing, and sheathing scraps, crop residues, rubble, broken concrete, plaster, conduit pipe, wire, insulation etc.	Construction and demolition sites, remodeling, repairing sites

Industrial waste & sludges	Solid wastes resulting from industry processes and manufacturing operations, such as food processing wastes, boiler house cinders, wood, plastic and metal scraps and shaving, etc. Effluent treatment plant sludge of industries and sewage treatment plant sludges, coarse screening, grit & septic tank	Factories, power plants, treatment plants, etc.
Hazardous wastes	Hazardous wastes: pathological waste, explosives, radioactive material, toxic waste etc.	Households, hospitals, institution, stores, industry, etc.
Horticulture Wastes	Tree-trimmings, leaves, waste from parks and gardens, etc.	Parks, gardens, roadside trees, etc.

Source: Solid Waste Management in Developing Countries by Bhide & Sunderasan, INSDOC April, 1983

3.3 Composition and Characteristics

The composition and characteristics of municipal solid wastes vary throughout the world. Even in the same country it changes from place to place as it depends on number of factors such as social customs, standard of living, geographical location, climate etc. MSW is heterogeneous in nature and consists of a number of different materials derived from various types of activities. Even then it is worthwhile to make some general observation to obtain some useful conclusions.

- The major constituents are paper and putrescible organic matter;
- Metal, glass, ceramics, plastics, textiles, dirt and wood are generally present although not always so, the relative proportions depending on local factors;
- The average proportion of constituents reaching a disposal site(s) for a particular urban area changes in long term although there may be significant seasonal variations within a year.

For these reasons an analysis of the composition of solid waste, for rich and poor countries alike, is expressed in terms of a limited number of constituents. It is useful in illustrating the variations from one urban center to another and from country to country. Data for different degrees of national wealth (annual per-capita income) are presented in Table 3.2.

Waste composition also varies with socio-economic status within a particular community, since income determines life-style – consumption patterns and cultural behaviour.

Table 3.2: Patterns of Composition, Characteristics and Quantities

	Low Income Countries (1)	Middle Income Countries (2)	High Income Countries (3)
Composition: (% by weight)			
Metal	0.2-2.5	1-5	3-13
Glass, Ceramics	0.5-3.5	1-10	4-10
Food and Garden waste	40-65	20-60	20-50
Paper	1-10	15-40	15-40
Textiles	1-5	2-10	2-10
Plastics/Rubber	1-5	2-6	2-10
Misc. Combustible	1-8	-	-
Misc. Incombustible	-	-	-
Inert	20-50	1-30	1-20
Density (kg/m^3)	250-500	170-330	100-170
Moisture Content (% by wt)	40-80	40-60	20-30
Waste Generation (kg/cap/day)	0.4-0.6	0.5-0.9	0.7-1.8

(1) Countries having a per capita income less than US$360 (1978 prices)
(2) Countries having a per capita income US$360-3500 (1978 prices)
(3) Countries having a per capita income greater than US$3500 (1978 prices)
Source: Holmes, J: Managing Solid Waste in Developing Countries.

Several conclusions may be drawn from this comparative data:

- The proportion of paper waste increases with increasing national income;
- The proportion of putrescible organic matter (food waste) is greater in countries of low income than those of high income;
- Variation in waste composition is more dependent on national income than geographical location, although the latter is also significant;
- Waste density is a function of national income, being two to three times higher in the low-income countries than in countries of high income;
- Moisture content is also higher in low-income countries; and

- The composition of waste in a given urban center varies significantly with socio-economic status (household income).

3.3.1 Characteristics of Municipal Solid Waste in Indian Urban Centres

National Environmental Engineering Research Institute (NEERI) has carried out extensive studies on characterisation of solid waste from 43 cities during 1970-1994. The average characteristics have been presented in Tables 3.4 and 3.5. The paper content generally varies between 2.9 to 6.5% and increases with the increase in population. The plastics, rubber and leather contents are lower than the paper content, and do not exceed 1% except in metropolitan cities. The metal content is also low, viz. less than 1%. The low values are essentially due to the large scale recycling of these constituents. During a study in Bombay (1993-94), samples were collected both at the source as well as disposal sites to ascertain the extent of recycling. The paper is recycled on a priority basis while the plastics and glass are recycled to a lesser extent. The biodegradable fraction is quite high, essentially due to the habit of using fresh vegetables in India. The high biodegradable fraction also warrants frequent collection and removal of solid waste from the collection points. The ash and fine earth content of Indian municipal solid waste is high due to the practice of inclusion of the street sweepings, drain silt, and construction and demolition debris in municipal solid waste. The proportion of ash and fine earth reduces with increase in population due to improvements in the road surfaces. Percentage of inert material increases with the increase in population may be due to fast than construction and demolition waste find its way into the municipal solid waste disposal stream. High ash and earth content increases the density of municipal solid waste which are between 350 and 550 kg/m^3 in Indian cities.

The chemical characteristics indicate that the organic content of the samples on a dry weight basis ranges between 20 to 40%. The nitrogen, phosphorus and potassium content of the municipal solid waste ranges between 0.5 to 0.7%, 0.5 to 0.8% and 0.5 to 0.8% respectively. The calorific value ranges between 800-1000 kcal/kg. Knowledge of the chemical characteristics is essential in selecting and designing the waste processing and disposal facilities.

Ragpickers are observed to be more active in bigger cities. They prefer to remove paper, plastics, rags and packaging and such other material, which is light and also have a high calorific value. The remaining waste hence tends to have a higher inert content and a lower calorific value.

The demolition activity is observed to increase with population leading to increased inert content and reduced organic content in MSW.

Table 3.3: Physical Characteristics of Municipal Solid Wastes in Indian Cities

Population Range (in million)	Number of Cities Surveyed	Paper	Rubber, Leather and Synthetics	Glass	Metals	Total compostable matter	Inert
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	0.35	0.32	40.04	48.38
1.0 to 2.0	9	4.71	0.71	0.46	0.49	38.95	44.73
2.0 to 5.0	3	3.18	0.48	0.48	0.59	56.67	49.07
> 5	4	6.43	0.28	0.94	0.80	30.84	53.90

All values in table 3.3 are in percent, and are calculated on net weight basis
Source: Background material for Manual on SWM, NEERI, 1996.

Table 3.4: Chemical Characteristics of Municipal Solid Wastes in Indian Cities

Population Range (in million)	No. of Cities Surveyed	Moisture %	Organic matter %	Nitrogen as Total Nitrogen %	Phosphorus as P_2O_5 %	Potassium as K_2O %	C/N Ratio	Calorific value* in kcal/kg
0.1-0.5	12	25.81	37.09	0.71	0.63	0.83	30.94	1009.89
0.5-1.0	15	19.52	25.14	0.66	0.56	0.69	21.13	900.61
1.0-2.0	9	26.98	26.89	0.64	0.82	0.72	23.68	980.05
2.0-5.0	3	21.03	25.60	0.56	0.69	0.78	22.45	907.18
> 5	4	38.72	39.07	0.56	0.52	0.52	30.11	800.70

All values, except moisture, are on dry weight basis.
* Calorific value on dry weight basis
Source: Background material for Manual on SWM, NEERI, 1996.

3.4. Quantities

The information regarding waste quantity and density coupled with waste generation rate (by weight), is important while assessing the payload capacity of the collection equipment. It is possible to estimate the number of vehicles required for the collection and transportation of waste each day.

While per capita waste generation is a statistic, which is necessary for indicating trends in consumption and production, the total weight and volume of wastes generated by the community served by the management system are of greater importance in planning and design. As in all other aspects of data collection for the planning and design phases, data on waste generation, weight and volume should be collected by each authority for application in its own area of operation.

3.4.1 Per Capita Quantity of Municipal Solid Waste in Indian Urban Centres

The quantity of waste from various cities was accurately measured by NEERI. On the basis of quantity transported per trip and the number of trips made per day the daily quantity was determined. The quantity of waste produced is lesser than that in developed countries and is normally observed to vary between 0.2-0.6 kg/capita/day. Value upto 0.6 kg/capita/day are observed in metropolitan cities (Table 3.6). The total waste generation in urban areas in the country is estimated to be around 38 million tonnes per annum.

Forecasting waste quantities in the future is as difficult as it is in predicting changes of waste composition. The factors promoting change in waste composition are equally relevant to changes in waste generation. An additional point, worthy of note, is the change of density of the waste as the waste moves through the management system, from the source of generation to the point of ultimate disposal. Storage methods, salvaging activities, exposure to the weather, handling methods and decomposition, all have their effects on changes in waste density. As a general rule, the lower the level of economic development, the greater the change between generation and disposal. Increases in density of 100% are common in developing countries, which mean that the volume of wastes decreases by half.

Table 3.5: Quantity of Municipal Solid Waste in Indian Urban Centres

Population Range (in million)	No. of Urban Centres (sampled)	Total population (in million)	Average per capita value (kg/capita/day)	Quantity (tonnes/day)
< 0.1	328	68.300	0.21	14343.00
0.1-0.5	255	56.914	0.21	11952.00
0.5-1.0	31	21.729	0.25	5432.00
1.0-2.0	14	17.184	0.27	4640.00
2.0-5.0	6	20.597	0.35	7209.00
> 5	3	26.306	0.50*	13153.00

* 0.6 kg/capita/day generation of MSW observed in metro cities
Source: Background material for Manual on SWM, NEERI, 1996.

3.4.2 Estimation of Future per Capita Waste Quantity

For purposes of project identification, where an indication of service level must be estimated and data from the project preparation stage have not yet been developed, the following municipal refuse generation rates are suggested:

Residential refuse	:	0.3 to 0.6 kg/capita/day
Commercial refuse	:	0.1 to 0.2 kg/capita/day
Street sweepings	:	0.05 to 0.2 kg/capita/day
Institutional refuse	:	0.05 to 0.2 kg/capita/day

If industrial solid waste is included in municipal refuse for collection and/or disposal purposes, from 0.1 to 1.0 kg/capita/day may be added at the appropriate step where the municipality must estimate service delivery requirements. These generation rates are subject to considerable site-specific factors and are required to be supported by field data.

3.4.3 Relation between Gross National Product (GNP) and Municipal Solid Waste Generation

The consumption of raw materials and finished product by the community is directly proportional to the Gross National Product (GNP) of the country. Since the solid waste quantities are directly proportional to the quantity of material consumed the increase in per capita solid waste quantities would be directly proportional to the per capita increase in GNP. Table 3.6 shows the relation between GNP and expected generation of municipal solid waste, based on the study conducted by the United Nations in 1995.

Table 3.6: Relation between GNP and Expected Generation of Municipal Solid Waste

Sl. No.	Country	During the year 1995			During the year 2025		
		GNP Per Capita (US$)	Urban Population (% of Total)	Urban MSW Generation (kg/capita/day)	GNP Per Capita (US$)	Urban Population (% of Total)	Urban MSW Generation (kg/capita/day)
Low Income		**490**	**27.8**	**0.64**	**1,050**	**48.8**	**0.6-1.0**
1	Nepal	200	13.7	0.50	360	34.3	0.6
2	Bangladesh	240	18.3	0.49	440	40.0	0.6
3	Myanmar	240	26.2	0.45	580	47.3	0.6
4	Vietnam	240	20.8	0.55	580	39.0	0.7
5	Mangolia	310	60.9	0.60	560	76.5	0.9
6	India	340	26.8	0.46	620	45.2	0.7
7	Lao PDR	350	21.7	0.69	850	44.5	0.8
8	China	620	30.3	0.79	1,500	54.5	0.9
9	Sri Lanka	700	22.4	0.89	1,300	42.6	1.0
Middle Income		**1,410**	**37.6**	**0.73**	**3,390**	**61.1**	**0.8-1.5**
10	Indonesia	980	35.4	0.76	2,400	60.7	1.0
11	Philippines	1,050	54.2	0.52	2,500	74.3	0.8
12	Thailand	2,740	20.0	1.10	6,650	39.1	1.5
13	Malaysia	3,890	53.7	0.81	9,400	72.7	1.4
High Income		**30,990**	**79.5**	**1.64**	**41,140**	**88.2**	**1.1-4.5**

14	Republic of Korea	9,700	81.3	1.59	17,600	93.7	1.4
15	Hong Kong	22,990	95.0	5.07	31,000	97.3	4.5
16	Singapore	26,730	100	1.10	36,000	100	1.1
17	Japan	39,640	77.6	1.47	53,500	84.9	1.3

(1 US$ = 40 INR)

Source: "What a Waste", Solid Waste Management in Asia, Urban Development Sector Unit, East Asia and Pacific Region, October, 1998

3.4.4 Rate of Increase Based on Experience in Other Cities

If data from other cities having registered similar pattern of development in the past is available, it can be used. However, data from other similar cities on rate of increase in per capita per day of solid waste may not be readily available. Due to difference in socio-economic factor, migration of population, industrialisation and waste quantities, a comparison of increase in per capita waste of one Indian city with that of comparable cities in other developing countries will also not be applicable.

3.4.5 Seasonal Variations

Seasonal variations in waste quantities must be accommodated by the management system. They arise from seasonal factors with respect to both climate, cultural and religious events. During monsoon, the waste becomes wet and heavy and total tonnage increases. Quantities of solid waste may also increase during cultural and religious festivals. Climate affects the generation of vegetative waste (yard and garden) or plant growth responds to favorable temperatures and soil to autumn while in tropical areas, where temperatures are always favorable, maximum growth is in the season of rainfall. At the end of the growth season (autumn dry season) leaves may comprise a significant proportion of the solid wastes.

3.5 Physical Characteristics

3.5.1 Density

A knowledge of the density of a waste i.e. its mass per unit volume (kg/m3) is essential for the design of all elements of the solid waste management system viz. Community storage, transportation and disposal. For example, in high-income countries, considerable benefit is derived through the use of compaction vehicles on collection routes, because the waste is typically of low density. A reduction of volume of 75% is frequently achieved with normal compaction equipment, so that an initial density of 100 kg/m3 will readily be increased to 400 kg/m3. In other words, the vehicle would haul four times the weight of waste in the compacted state than when the waste is uncompacted. The situation in low-income countries is quite different: a high initial density of waste precludes the achievement of high compaction ratio. Consequently, compaction vehicles offer little or no advantage and are not cost-effective.

Significant changes in density occur spontaneously as the waste moves from source to disposal, as a result of scavenging, handling, wetting and drying by the weather, vibration in the collection vehicles. The values shown in Table 3.7 reflect densities at the pick-up point.

Table 3.7: Density of Municipal Solid Wastes in Some Cities

Sl. No.	City	Density (kg/m^3)
1	Bangalore	390
2	Baroda	457
3	Delhi	422
4	Hyderabad	369
5	Jaipur	537
6	Jabalpur	395
7	Raipur	405

Source: Solid Waste Management in Developing Countries INSIDOC, 1983
N.B.: The above figures may be taken as indicative and actual field measurements must be made while designing solid waste management schemes for towns and cities.

3.6 Chemical Characteristics

A knowledge of chemical characteristics of waste is essential in determining the efficacy of any treatment process. Chemical characteristics include (i) chemical; (ii) bio-chemical; and (iii) toxic.

Chemical: Chemical characteristics include pH, Nitrogen, Phosphorus and Potassium (N-P-K), total Carbon, C/N ratio, calorific value.

Bio-Chemical: Bio-Chemical characteristics include carbohydrates, proteins, natural fibre, and biodegradable factor.

Toxic: Toxicity characteristics include heavy metals, pesticides, insecticides, Toxicity test for Leachates (TCLP), etc.

The waste may include lipids as well.

3.6.1 Classification

A knowledge of the classes of chemical compounds and their characteristics is essential in proper understanding of the behaviour of waste as it moves through the waste management system. The products of decomposition and heating values are two examples of the importance of chemical characteristics. Analysis identifies the compounds and the percent dry weights of each class. The rate and products of decomposition are assessed through chemical analysis. Calorific value indicates the heating value of solid waste. Chemical characteristics are very useful in assessment of potential of methane gas generation. The various chemical components normally found out in municipal solid waste are described below. The product of decomposition and heating values are two examples of the importance of chemical characteristics. Analysis identifies the compounds and the per cent dry weight of each class.

(i) Lipids:

Included in this class of compounds are fats, oils and grease. The principal sources of lipids are garbage, cooking oils and fats. Lipids have high calorific values, about 38000 kcal/kg, which makes waste with a high lipid content suitable for energy recovery processes. Since lipids in the solid state become liquid at temperatures slightly above ambient, they add to the liquid content during waste decomposition. They are biodegradable but because they have a low solubility in waste, the rate of biodegradation is relatively slow.

(ii) Carbohydrates:

Carbohydrates are found primarily in food and yard waste. They include sugars and polymers of sugars such as starch and cellulose and have the general formula $(CH2O)X$. Carbohydrates are readily biodegraded to products such as carbon dioxide, water and methane. Decomposing carbohydrates are particularly attractive for flies and rats and for this reason should not be left exposed for periods longer than is necessary.

(iii) Proteins:

Proteins are compounds containing carbon, hydrogen, oxygen and nitrogen and consist of an organic acid with a substituted amine group $(NH2)$. They are found mainly in food and garden wastes and comprise 5-10% of the dry solids in solid waste. Proteins decompose to form amino acids but partial decomposition can result in the production of amines, which have intensely unpleasant odours.

(iv) Natural Fibres:

This class includes the natural compounds, cellulose and lignin, both of which are resistant to biodegradation. They are found in paper and paper products and in food and yard waste. Cellulose is a larger polymer of glucose while lignin is composed of a group of monomers of which benzene is the primary member. Paper, cotton and wood products are 100%, 95% and 40% cellulose respectively. Since they are highly combustible, solid waste having a high proportion of paper and wood products, are suitable for incineration. The calorific values of oven dried paper products are in the range 12000 – 18000 kcal/kg and of wood about 20000 kcal/kg, which compare with 44200 kcal/kg for fuel oil.

(v) Synthetic Organic Materials (Plastic):

In recent years, plastics have become a significant component of solid waste accounting for 5-7%. Plastic being non-bio-degradable, its decomposition does not take place at disposal site. Besides, plastic causes choking of drains and environmental pollution when burnt under uncontrolled condition. Recycling of plastics is receiving more attention, which will reduce the proportion of this waste component at disposal sites.

(vi) Non-combustibles:

Materials in this class are glass, ceramic, metals, dust, dirt, ashes and construction. Non-combustibles account for 30-50% of the dry solids.

3.7 Conclusion

No rational decisions on municipal solid waste system are possible until data of composition and quantity of solid waste are available. The method and capacity of storage, the correct type of collection vehicle, the optimum size of crew and the frequency of collection depend mainly on volume and density of wastes. Climate also has some influence. The disposal method may be dependent on the type of material recycled, organic content of waste, which could be composted, and the combustible material, which could be a source of energy.

CHAPTER 4
THE PLANNING AREA

4.1 INTRODUCTION

Durgapur is an industrial metropolis in the state of West Bengal, India, located about 160 km from Kolkata. It was a dream child of the great visionary Dr. Bidhan Chandra Roy, the second chief minister of the state. The well laid out industrial township was designed by Joseph Allen Stein and Benjamin Polk. It is home to the largest industrial unit in the state, Durgapur Steel Plant, one of the integrated steel plants of Steel Authority of India Limited. Alloy Steels Plant of SAIL is also located here. There are a number of power plants, chemical and engineering industries. Some metallurgical units have come up in recent years.

Durgapur is located at 23.48°N 87.32°E. It has an average elevation of 65 m (213 ft). Durgapur is situated on the bank of river Damodar, just before it enters the alluvial plains of Bengal. The topography is undulating. The coal-bearing area of the Ranigunj coalfields lies just beyond Durgapur, although some parts intrude in to the area. The area was deeply forested till recent times, and some forests are still there, standing witness to its wild past.

Solid Waste Management is one of the important obligatory functions of not only urban local bodies but also of rural local bodies. But this essential service is not efficiently and properly performed by the local bodies of West Bengal, resulting in many health and sanitation problems. It is observed that lack of financial resources, institutional weakness, improper selection of technology, transportation systems and disposal options, public's apathy towards environmental cleanliness and sanitation have made this service unsatisfactory.

The fundamental objective of Solid Waste Management program is to minimize the pollution of the environment as well as utilizing the waste as a resource. These goals should be achieved in a way that is financially sustainable, i.e. using methods that can be afforded by the community over the long term and with minimum risk to the persons involved.

In the context of epidemiological transition in West Bengal, solid wastes pose a major concern. Though to some extent, there has been a tremendous improvement in the field of total sanitation, particularly household sanitation, which has contributed to the drastic decrease in the incidence of diarrhoeal diseases, the social sanitation including the waste disposal is a contributor to the emerging infectious and new diseases. When we consider the solid waste management scenario of West Bengal, we can see that the exact quantity of waste generated in West Bengal is not totally known except for certain micro level studies conducted in different towns and municipalities. The rapid urbanization and consumerism makes it a tedious process and due to this, the composition of wastes also varies.

4.2 TYPES OF SOLID WASTE FOUND IN DURGAPUR MUNICIPAL CORPORATION (DMC)

a) Ashes and residues: Materials remaining from the burning of wood, coal, coke and other inflammable wastes in institutions, homes, stores, industrials and municipal facilities for the purpose of heating and cooking and above all the remains of combustible wastes are categorized as ashes and residues. These materials are generally composed of fine powdery materials, cinders, and small amounts of burned and partially burned materials.

b) Rubbish: This comprises of various kind of flammable and inflammable materials of households, institutions of commercial activities etc. The combustible rubbish includes the materials such as paper, cardboard, furniture parts, textiles, rubber, leather wood etc. Non-combustible rubbish consists of glass, broken crockery, plastic, discarded tins, aluminium cans and materials made of ferrous and non-ferrous materials.

c) Demolition and construction waste: Waste from demolished buildings and other structures are classified as demolition waste. Waste from the construction, remodeling and repairing of individual residences, housing complexes, multi storied flats, commercial buildings etc. are classified as construction wastes which includes stones, concrete, bricks, plaster and plumbing.

d) Industrial process wastes: It consists of the solid and semi-solid wastes coming from industrial plants. The specific characteristics of these wastes vary depending on the nature of the manufacturing process.

e) Municipal wastes: Wastes such as street sweeping materials, roadside litter, litter from municipal dustbins, dead animals and abandoned vehicles. Municipal waste includes rubbish, trash and almost all types of waste.

f) Food waste: Food wastes are the residues of various kind of foods like fruit, vegetable, animal product resulting from handling, preparation and eating of foods.

g) Other waste: Besides the above-mentioned types of wastes many other kinds of biodegradable and non-biodegradable wastes are found coming from different sources like hospital, market, pathological lab etc. The biodegradable waste consists of all carbonaceous wastes and non-biodegradable waste includes inorganic wastes and non-degradable polymeric organics like certain types of plastics.

4.3 SOURCES OF SOLID WASTE GENERATED IN DURGAPUR

a) Waste from residential areas: The waste generated from residential areas is generally named as domestic waste. This kind of waste varies a lot based on the socio-economic conditions and cultural situations. In developed residential areas where gas or electricity is used for cooking, the waste generated will be less compared to the low-income residential areas where wood or charcoal is used as fuel. Paper, cardboard, tin and bottles are found to be more in prosperous settlements and in commercial areas.

b) Waste from shops/vegetable/ fruit market: The wastes generated from the shops, vegetable and fruit market consists of polythene, paper, dried plantain leaves etc. Most of the wastes coming from shops and vegetable or fruit market are degradable in nature which is used for wrapping agricultural goods.

c) Waste from hospital/ nursing home/medical stores: Hospital, nursing homes and medical stores have a great contribution on solid waste generation at DMC. Different kind of solid wastes like unused medicine, saline bottles, medicine cover are generated some of which are non-degradable.

d) Waste from Hotels/Restaurants/Eating stalls: Hotels and Restaurants generate both degradable and non-degradable waste. The domestic type waste generated will be large in quantity and hence to be removed daily. They can be provided with separate bins for waste collection.

e) Waste generated by street hawkers: Street food vendors and hawkers generate large quantities of waste particularly food waste and plastic paper plates.

f) Waste from Slaughter Houses/ Fish markets: Slaughterhouses and fish markets generate highly putrescible matter. They decay very fast and are the main reason for the malodors near these premises. No paper collection or removal is practiced and hence the waste rots in the premises itself.

4.4 STATUS OF SOLID WASTE GENERATION IN DURGAPUR

The total quantity of solid waste generated in West Bengal is not estimated accurately. A study conducted at Durgapur City Corporation by the Department of Civil Engineering, NIT Durgapur shows that a total of 224 tonnes of solid waste is generated per day from various sources. The sample survey conducted at 43 wards showed that among these 224 tonnes, 181 tonnes of solid waste are from households. The wastes are mainly generated by shops and commercial establishments, hotels, hospitals and clinical laboratories of the City generate both infectious and non-infectious wastes, which comes to about 2-3 tonnes per day.

The other sources of waste generated in the City are offices, educational institutions, marriage halls, slaughterhouses etc.

A detailed study has also been conducted by the same group on the informal sector involving collection of non-degradable waste like plastics, paper, metals and glasses. During the study they identified more than 500 rag pickers who were involved in collection of non-degradable waste directly from the sources or from the waste dumps. They sell these wastes to the wholesale waste collectors who transport these materials to Durgapur for recycling. The physical characteristics of the waste generated in Durgapur City Corporation shows that 50% of the waste generated are organic substances, which are suitable for composting. Thus, from the detailed study and similar other studies in City Corporations, they inferred that a total of 250-350 tonnes of solid wastes are generated per day in almost all Corporation areas.

4.5 PRESENT STATUS OF SOLID WASTE MANAGEMENT IN DURGAPUR

In spite of the availability of a number of proven technologies, the local self-government institutions are not in a position to implement any, because of various socio-political and techno-economic issues. Hence, majorities of the Municipalities, Towns and Panchayats are still in need of small-scale waste treatment units. Solid waste management rose as a problem for public recently and before that no one considered this. The main constraints in implementing proper solid waste management programme are lack of political will and solid waste management was never given priority in the agenda of any political party. Difficulty in acquiring sites for waste management is another problem faced by many authorities and local self- government institutions. Lack of faith in the success of the solid waste management programme was another problem and this still remains in Durgapur Corporation.

Present system of waste management in West Bengal, including large and small municipalities include depositing in Municipal waste bins or Dumper Placer Containers, dumping in open spaces and roadsides, burning, burying, dumping in the drainages, dumping in ponds and canals. Some quantity of the wastes generated are recycled and converted to manure. Only a few municipalities and Panchayats in West Bengal have dump yards. Most of the dump-yards are now having been converted into compost yards.

The compost yard near Bidhan Nagar is an example for this. Even land filling exists in certain parts of West Bengal, but due to urbanisation, lack of space and as most of the low lying areas are converted to residential areas, land filling by authorities is negligible. Earlier days quarry sites were also used as land filling areas, but now-a-days they are also seen abandoned. Hence when we consider the present waste management system, open dumping in dump yards without any processing is followed in almost all areas.

Durgapur is one of the first Corporations of West Bengal State beside Kolkata, though now several have been added. It has a naturally undulated geographical feature and is a highly well planned industrial urbanised spots on a serenely rural base. The existing arrangements for solid waste management in most of our urban centers are highly unsatisfactory and subject a considerable part of our population to serious health risk. Durgapur City Corporation, has 43 wards with an area of 154.2 sq. km. Consequent to the increase in the area, the population under it, has increased, and along with that the responsibilities of the Corporation authorities and the expectation of the citizens. Unless all who live in the City find-tune themselves to improve the upkeep of the City, there is no doubt that the City will wilt under the enormous pressure it is subjected to from all sides.

Solid waste is generated in each and every household, small and big establishments, hotels, market places, hospitals etc. The lifestyle of the people of Durgapur has undergone an enormous change. The large open areas surrounding the houses are lost. Having houses at elevated places has been given up and living in multi-storied flats is well accepted. Hotels have mushroomed and patronized. Roadside eating places have increased in numbers. Markets have become big, crammed up and unsustainable. New and make shift unofficial markets have spread all along the urban as well as rural areas. Meat stalls and poultry have multiplied. Lodgings and hostels for men and women have increased.

All these contribute a great deal to the quantity of solid waste generated. Thus, disposal of solid waste is a major headache of Durgapur Corporation. Solid waste without plastics and glass when digested is a very good bio-fertilizer and the people who knew its value still go in for bio-compost.

In earlier days, small quantities of solid waste used to be collected in bullock carts and now huge trucks carrying a minimum of 4 tonnes are needed for transporting solid wastes. With nook and corners of the City occupied for residential and business purposes such places are essential by the public. But solid waste is continuing to be generated even by the resenting public.

In such a situation, proper collection methodology and appropriate technology to dispose of the solid waste, fully understanding its fertilizer value will of the people involved namely the generators of the waste, the transporters, and personnel managing the storage yards, and the technologists who operate the plant should act in unison and dedication to achieve success.

During the last few years many good actions have been initiated by the City Corporation though found fault with by many. Collection of solid waste from Dumper Placer Container (DPC), transporting them to transit points and hence transporting to the dumping is a major task. The waste collected from different streets are brought together and dumped along with the immense quantity of solid waste generated in two main markets in Durgapur City, namely, City Center, and Benachity. These market areas are the transit points for the transportation of the waste to the compost plant. The quality of this waste is such that it is wet and putrefies fast thus generating mal odour and subhuman condition for handling.

It is a common sight in Durgapur City that the people using DPC are seen tampering and even burning them when transportation is delayed. Since the waste is degradable, they decay fast and attract flies and other vectors. When the drainage channels are cleaned the solid waste are removed and kept on roadsides rather than dumping it into dustbins. These wastes again fill in the channel during the next rain. On the whole the process started by the Corporation is on the right lines but needs to be thoroughly streamlined. Healthy Corporation should pour in from all quarters. Residents Associations can do immense help in managing solid waste disposal by educating, creating awareness among public and extending a helping hand to the public in stopping the unhealthy and indiscriminate practices of waste dumping which creates nuisance to all.

Unlike other Municipalities and Corporations in West Bengal, the Durgapur Corporation has a well established and planned centralised solid waste management plan for managing the garbage generated in Durgapur City.

Sl. No.	Item	Details
1	Area	154.2 sq. km
2	Population	493405 (as in 2001 census)
3	Population density	3200
4	Literacy rate	75%
5	No. of wards	43
6	Total quantity of waste generated per day	250 MT
7	Disposal site	Bidhannagar

The Durgapur City Corporation is responsible for collection, transportation, management and disposal of the garbage generated within the city limits. For this, the authorities have provided a network of several Dumper Placer Containers in different parts of the city. Households and establishments including hospitals/ nursing homes, hotels, restaurants etc. are required to deposit their waste in these bins, for subsequent collection and transportation to the compost plant at Bidhannagar. Silt from drains and construction wastes are collected along with the garbage for disposal. Substantial quantities of wastes are also generated from the slaughterhouses and poultry farms. But no proper segregation, collection and disposal of these wastes are carried out in Durgapur Corporation. Hence these wastes are also mixed along with the city waste and carried for disposal.

4.6 SOLID WASTE COLLECTION

4.6.1 Primary collection of solid waste

The primary collection of solid waste is done fully with man power. For primary collection there are several no of workers with specific work scheduled. The primary collection includes the following activities-

1. Sweeping in different areas for collecting the garbage.
2. Storing the garbage in the specific bins.
3. Door to door collection the garbage.

The workers perform the above mention activities by using the following implements- brooms, baskets (bamboo and aluminium), brushes, iron plate, containerized push carts, tricycles and rotor-mould wheeled bins as shown in Figure 4.1. All the implements are supplied from Durgapur Municipal Corporation. One of the most important achievements of DMC is the introduction of Tricycle which stands as a wonder tool for better collection of MSW at door steps.

Figure 4.1: Daily collection of Household garbage in DMC
(Source: Waste Inventory in West Bengal 2009)

4.6.2 Secondary collection

Secondary collection is the transfer of solid waste from street to transfer stations and from transfer stations to disposal sites. For these activities there are engaged several numbers of heavy vehicles like dumper and lorries and light vehicles like tractor, van, chhota-hathi etc. with specific route scheduled for each and every vehicle for each trip.

Figure 4.2: Large collection containers in AMC
(Source: Waste Inventory in West Bengal 2009)

However, this process is followed mostly but silt from open drains across the project area is disposed at the same roadside collection points where the rest of the household and commercial waste is temporarily deposited. This is a widespread practice, which further compounds the problem by spoiling the quality of the waste – the feedstock for the plants. It not only creates foul smell for the residents of the area but also provides a very unpleasant view of the streets where they are deposited as shown in figure 4.3 and figure 4.4.

Figure 4.3: Silt from drains dumped with solid wastes

Figure 4.4: Dumping of Wastes together

4.7 WASTE DISPOSAL

Majority of the waste generated is disposed in open dumps and areas, which threat public health and environmental quality. The collected mixed waste is transported to dumping area by truck and dumped on open land without any processing. It causes obnoxious odour and fly formation. The Rag picker collects usable materials. They also involve in burning of waste to collect the valuable materials. The ambient air will thus contain higher values of PM, SO_2 and NOx. This problem results in public agitation against dumping of MSW in this site. Ground water contamination in the area can also occur due to leaching from the dumping site. In a nut shell, the existing practice poses greater challenges to the public health, environment and aesthetic value of the state.

Conventional Methods of Waste Disposal

The conventional methods of waste disposal are as follows:

- ✓ Open Dumping
- ✓ Open Burning and Incineration
- ✓ Sanitary Landfill

4.7.1 Open Dumping

- Disposal of solid waste by dumping in open areas, dumped from vehicles along roadsides, and/or dumped late at night
- Oldest and most common way of disposing solid waste in developing countries
- Still in use wherever land is available without regard to safety, health hazards and aesthetic degradation
- Refuse is spread over a large area
- No maintenance

Fig 4.5: Open Dumping of Municipal Solid Waste

Open dumps pose the following health, safety, and environmental threats:

- ➢ Fire and explosion
- ➢ Inhalation of toxic gases
- ➢ Injury to children playing on or around the dump site
- ➢ Disease carried by mosquitoes, flies, and rodents

- Contamination of streams, rivers and lakes
- Contamination of soil and groundwater
- Contamination of drinking water
- Damage to plant and wildlife habitats
- Decrease in the quality of life to nearby residents and the local community

Open dumps create a public nuisance, divert land from more productive uses, and depress the value of surrounding land. An open dump is an illegal waste disposal site and should not be confused with a permitted municipal solid waste landfill or a recycling facility. If allowed to remain, open dumps often grow larger, and may attract dumping of both solid and hazardous wastes.

4.7.2 Open Burning & Incineration

- Incineration is a waste treatment process that involves the combustion of solid waste at 1000°C
- Waste materials are converted into ash, flue gas, and heat
- The ash is mostly formed by the inorganic constituents of the waste and gases due to organic waste
- the heat generated by incineration is used to generate electric power

Fig 4.6: Open burning of plastic waste and agricultural waste

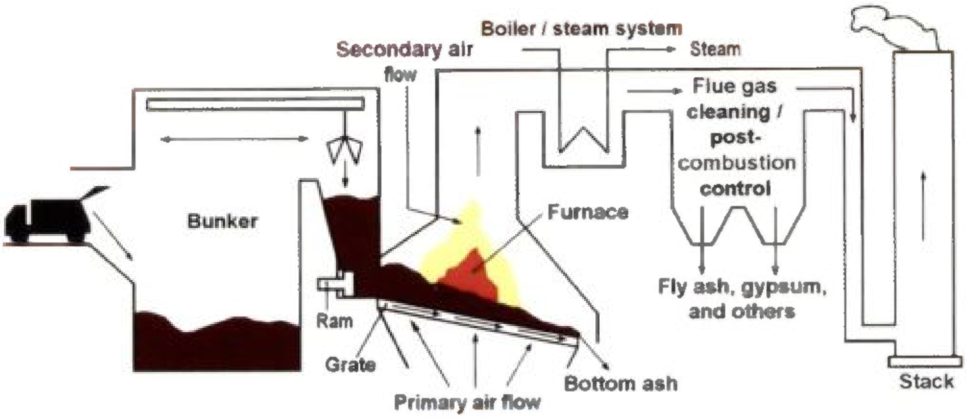


Fig 4.7: Schematic of Incineration Plant

The major disadvantages of the system are

- The air pollution controls required in incineration plants are extremely expensive. Very often up to one half of the costs of a plant are due to air pollution control facilities. As the laws can change and maybe require updates in the air pollution controls this could lead to much higher costs in the future.
- Energy, produced by means of waste incineration is not likely to be practical for small communities. Therefore, incineration plants have be situated in areas where the district heating network can easily be connected to very many households.
- Incinerators are costly to construct, operate and regulate. Stringent emissions for incinerators increase the cost of construction, operation and maintenance.
- The extremely high technical standards of the plants require skilled workers, which leads to the facts that rather high wages have to be paid.
- The chemicals that would be released into the air could be strong pollutants and may destroy ozone layer
- The residues from the flue gas cleaning can contaminate the environment if they aren't handled appropriately and therefore they must be disposed of in controlled and well operated landfill to prevent groundwater- and surface pollution.

4.8.3 Sanitary Landfill

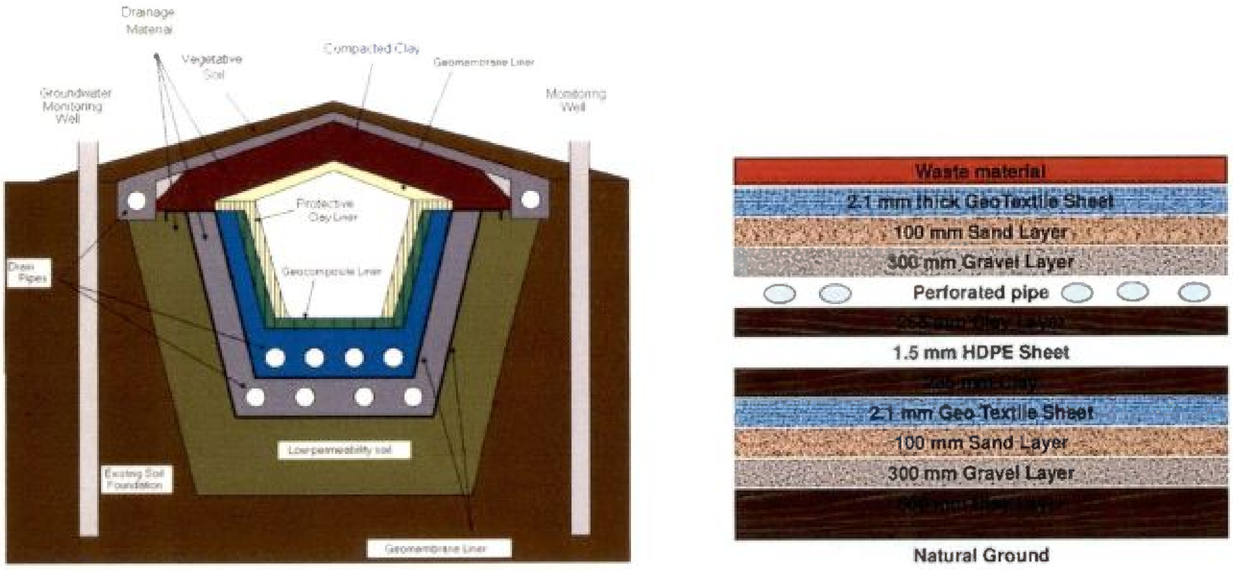


Fig 4.8: Schematic of a Sanitary Landfill

The major disadvantages of the system are

- The site will look ugly while it is being used for landfill
- Leachate (Toxic liquid) is generated due to decomposition of waste in the landfill which contains acid, heavy metals and other toxic elements which can contaminate ground water resources
- Dangerous gases are given off from landfill sites that cause local air pollution and contribute to global warming
- Local streams could become polluted with toxins seeping through the ground from the landfill site
- Methane gas is generated in waste mass which travels underground in cracks of rocks if not pumped out and accumulates in nearby areas (foundation of buildings) which may cause explosion if not taken out
- Once the site has been filled it might not be able to be used for redevelopment as it might be too polluted

CHAPTER 5

NOVEL SOLID WASTE DISPOSAL TECHNIQUES: A CSIR-CMERI INNOVATION AND DEVELOPMENT

5.1 SOLID WASTE DISPOSAL TECHNIQUES DEVELOPED BY CSIR-CMERI

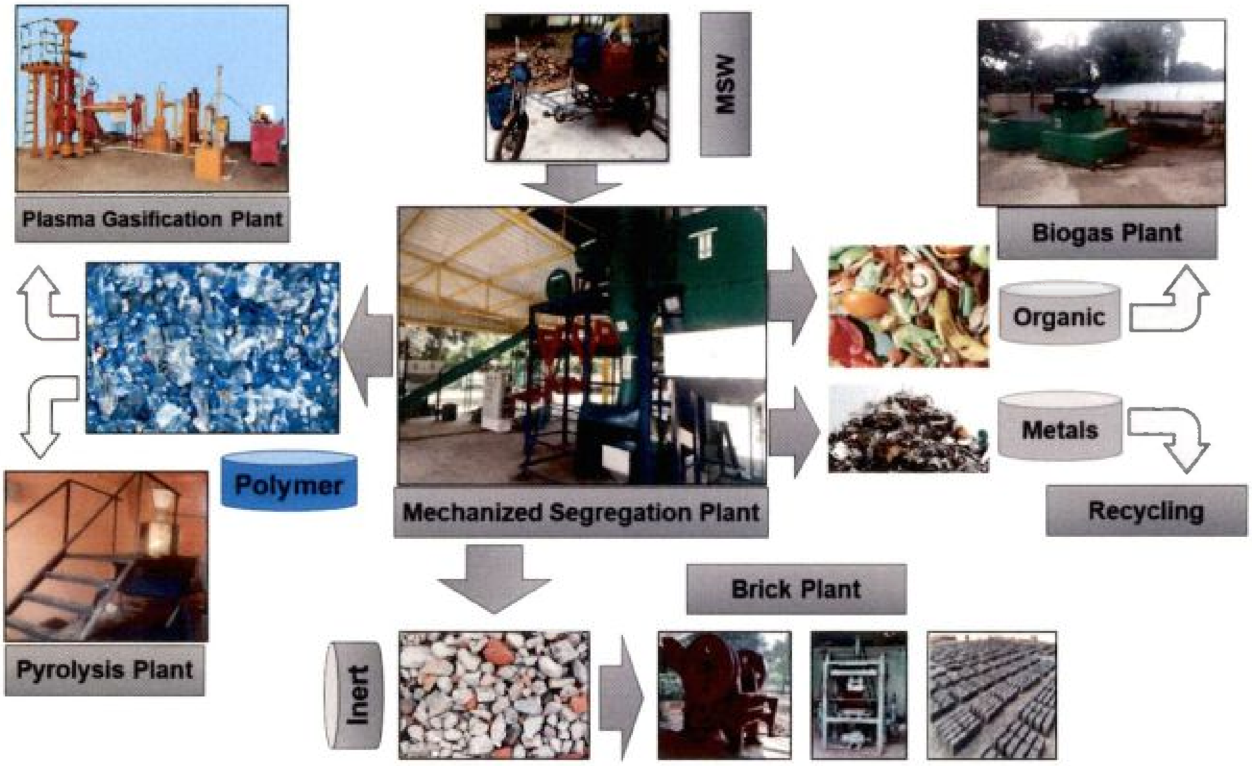


Fig 5.1: Zero Waste Colony Model developed by CSIR-CMERI

5.2 MECHANIZED SEGREGATION OF LIVE MUNICIPAL SOLID WASTE

The waste is being classified into two categories a) live waste and b) dead waste. The classification is based on collection of waste. The wastes which are being collected daily by the municipalities are termed "Live Waste". The wastes which have been dumped over the years at the landfill site are being termed as "Dead Waste". CSIR-CMERI has developed mechanized segregation system for both live and dead waste into different components.

The segregation process starts with dumping of solid waste material into a bin directly from the dumper carrying the materials. The segregation system should be capable of segregating metallic waste (metal body, metal container etc.), biodegradable waste (foods, vegetables, fruits, grass etc.), non-biodegradable (plastics, packaging material, pouches, bottles etc.) & inert (glass, stones etc.) wastes.

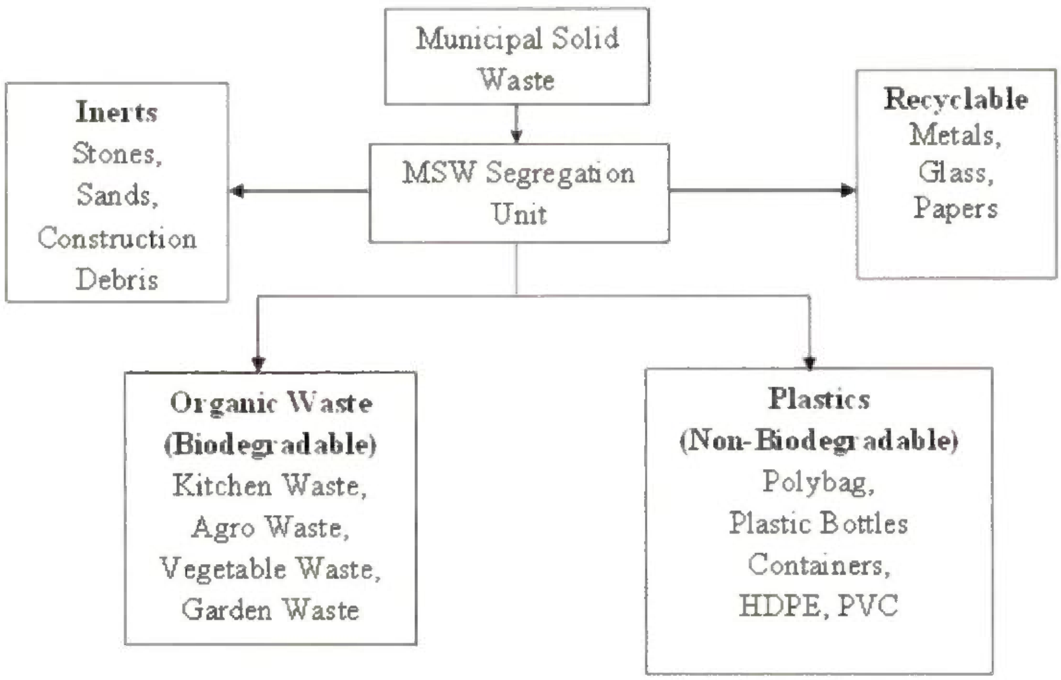


Fig 5.2: Process layout of Segregation System for Live Waste

The Municipal Solid Waste contains a high amount of moisture. The high moisture content will reduce the efficiency of mechanical sorting, consequently making it unfavourable for beneficial utilization. Hence, a pre-treatment is required before mechanized segregation of waste. The MSW is passed over a horizontal roller conveyor where it is exposed to hot air (55-60°C). The dried material is passed over a rotary magnetic drum separator where the iron components (Fe) separate out which are collected in a hopper for reuse. The rest of the material are passed over an Eddy Current Separator where non-ferrous metallic parts (Al, Cu) are separated out. The remaining waste are sent to the Air Separation Unit where the lighter particles (Plastics, paper) and heavy mass (biomass) are being separated. The lighter objects (Plastics, paper) can be directly fed into the shredder. The shredded material will be sent to polymer waste pyrolysis unit using a vibratory chute for pyrolysis. The segregated biomass can be utilized for production of biogas in the bio-methanation unit through a waste grinder. A mechanized segregation unit of capacity 50 kg/h developed at CSIR-CMERI is as shown in Fig. 5.3

Fig 5.3: Mechanized Segregation Unit for Live Waste at CSIR-CMERI (Capacity: 50 kg/h)

5.3 MECHANIZED SEGREGATION OF DEAD MUNICIPAL SOLID WASTE

The segregation system should be capable of segregating metallic waste (metal body, metal container etc.), fines (degraded organic waste), non-biodegradable (plastics, packaging material, pouches, bottles etc.) & inert (construction debris, stones etc.) wastes. The process flow of mechanized segregation unit for dead waste developed at CSIR-CMERI is shown in Fig. 5.4.

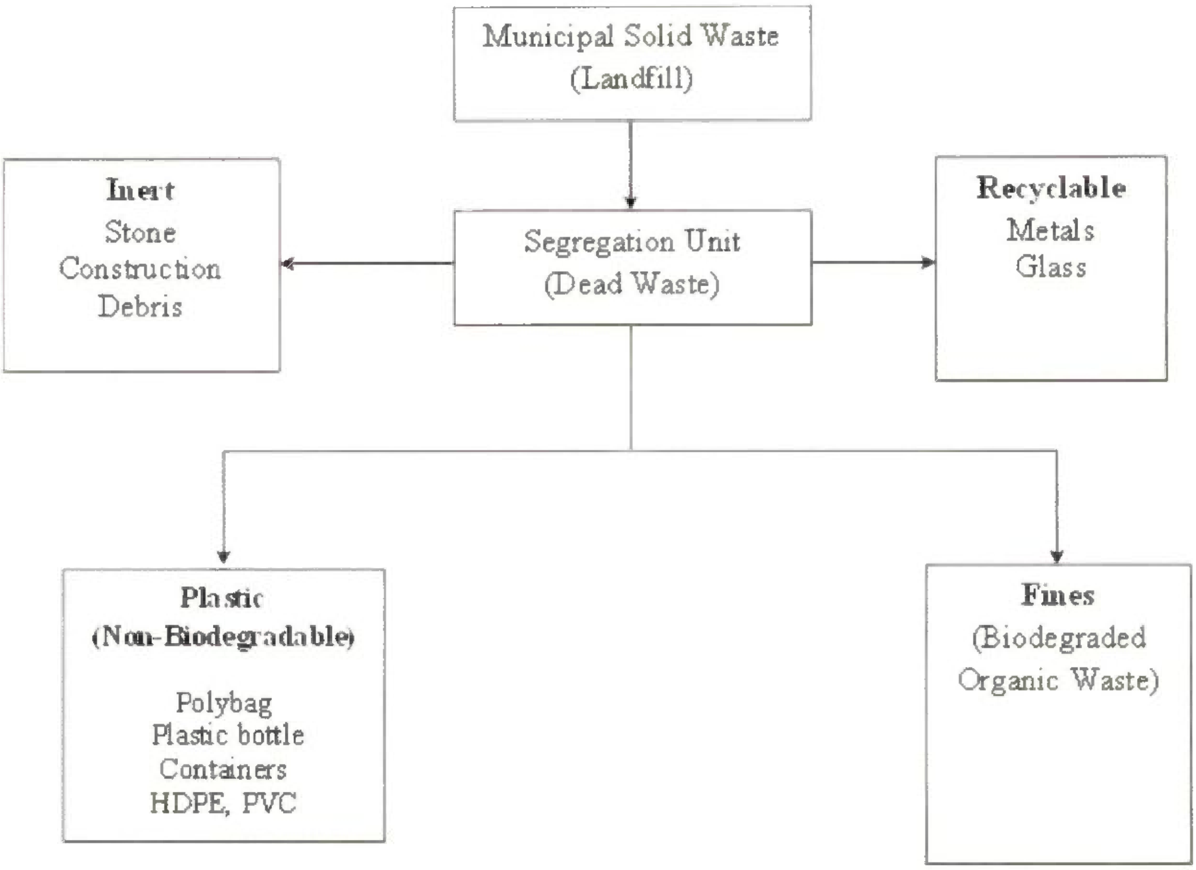


Fig 5.4: Process layout of Segregation System for Dead Waste

A mechanized segregation unit of capacity 50 kg/h developed at CSIR-CMERI is as shown in Fig. 5.5

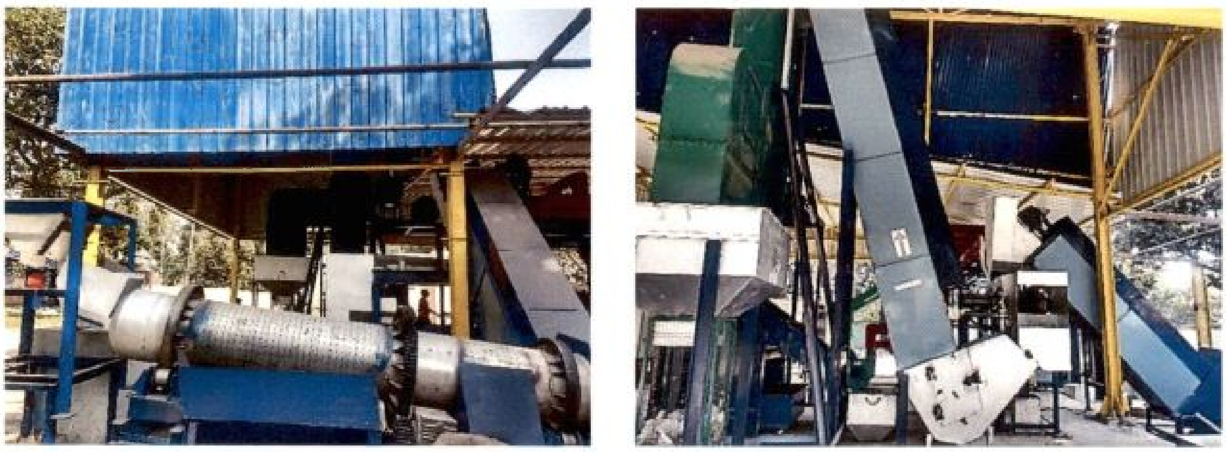


Fig 5.5: Mechanized Segregation Unit for Dead Waste at CSIR-CMERI (Capacity: 100 kg/h)

5.4 DISPOSAL OF PLASTIC WASTE UTILIZING HIGH TEMPERATURE PLASMA

In this relevance plasma arc technology is effective, eco-friendly, most efficient and less explored technology for proper disposal of mountain of solid waste material generated on daily basis. In this method electrical ionization between two electrode cathode and anode at low voltage and high current is being used to treat the waste at a temperature as high as ~3000°C. The electric ionization will be carried out through low voltage (30-50 V) & high current (300-400 A) between two electrodes. The temperature shall be raised as high as ~3000°C during the ionization process. The chances of generation of carcinogenic gases at such elevated temperature are remote. The output gas will be mainly CO, H_2, hydrocarbons and CO_2. This CO & H_2 enriched sys-gas has high calorific value. The product gas after passing through the plasma treatment is made to pass through the carbon sieves (REDOX reactor). This will help to convert carbon from the sieve and oxygen to form CO. Catalytic converter shall be used to convert any traces of hydrocarbon into CO and H_2. Catalyst like Nickel can be used for this purpose. The gas is then cleaned in cyclone separator and scrubber. Then cooled in the condenser. This CO & H_2 enriched sys-gas has high calorific value. This gas will be primarily stored into a gas holder and will be used for generation of electricity after combustion into gas engine. The layout of the proposed plant is as follows: The process layout has been shown in Fig. 5.6 and the Plastic disposal unit of 25 kg/hr capacity developed at CSIR-CMERI has been shown in Fig. 5.7.

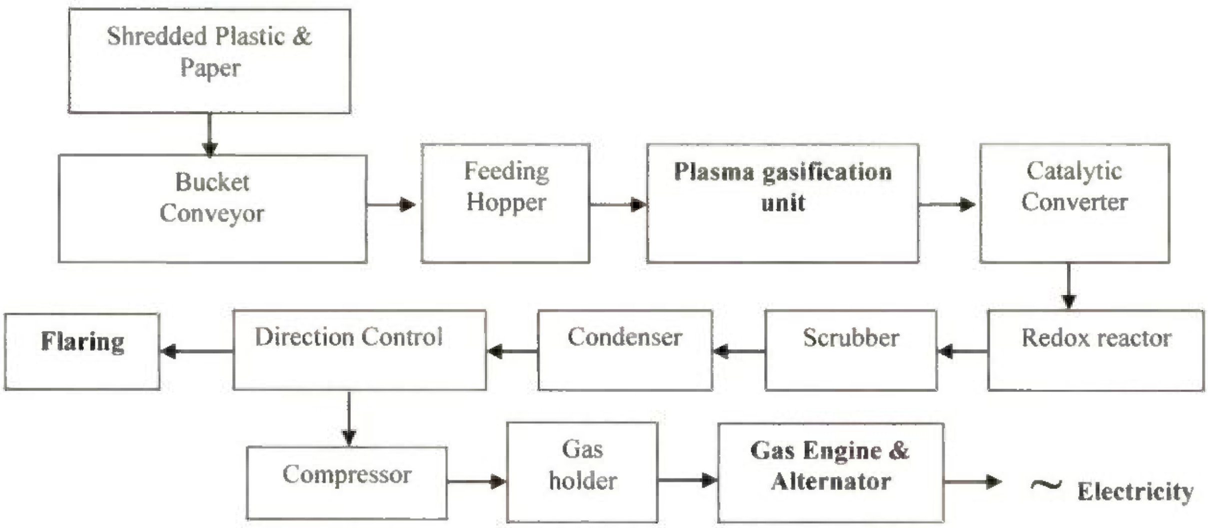
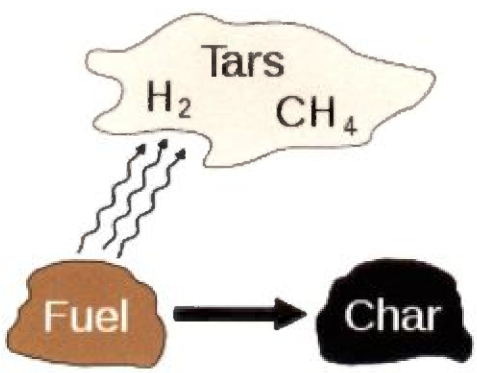


Fig 5.6: The process layout of Plasma Gasification Unit

Fig 5.7: Plastic Disposal Unit at CSIR-CMERI (Capacity: 25 kg/hr)

5.5 DISPOSAL OF PLASTIC WASTE THROUGH PYROLYSIS

Pyrolysis is the thermal degradation of waste in the absence of air to generate gas often termed syngas), liquid (bio oil) and solid (char, mainly ash and carbon). The plastic wastes are heated at a temperature of about 450° to 600°C in the absence of oxygen and broken down to simpler substances forming oils, carbon after condensation. The pyrolysis oil is being termed as Petro Alternate Fuel (PAF), which can be used in industrial boilers, generators, or can be further refined into diesel. The process of pyrolysis has been shown in Fig. 5.8 and the 20 kg/batch pyrolysis plant developed by CSIR-CMERI has been shown in Fig. 5.9.



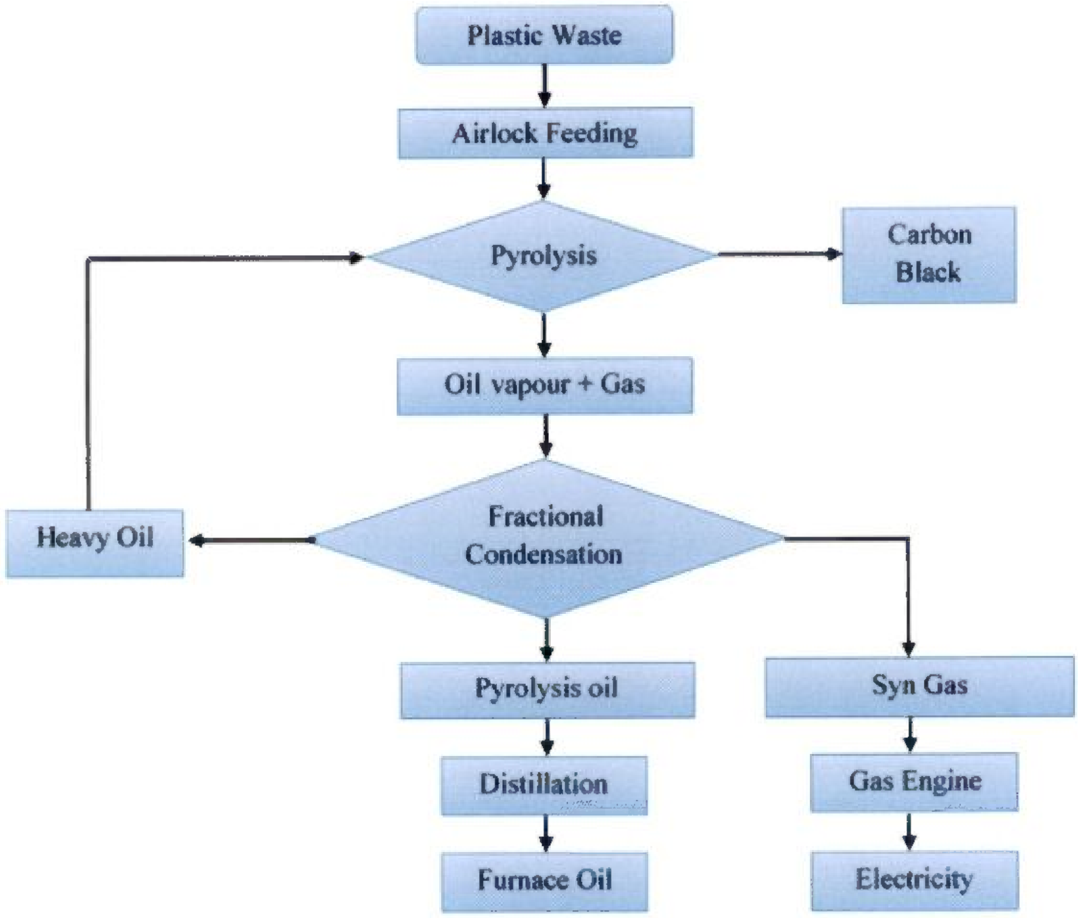


Fig 5.8: Schematic Process Layout for Plastic Pyrolysis

Fig 5.9: Polymer Waste Pyrolysis Unit at CSIR-CMERI (Capacity: 20 kg/batch)

The major components of the polymer waste pyrolysis plant include the following:

i) Reactor

The reactor is the heart of the pyrolysis system. It consists of a reaction vessel and a furnace which is insulated on the outside with ceramic wool and cladded. The heating system consists of an oil purification unit, oil pumping unit and monoblock burners for oil and gas.

The reactor is fed with raw material and catalyst mixed in a certain proportion.

The furnace is heated so that the temperature inside the reactor is in a temperature range where catalytic decomposition takes place depending on various feedstocks. The reactor also has the provision for nitrogen purging to create inert environment to allow the process to happen in the absence of oxygen.

ii) Gas Receiver

The syngas from the catalytic degradation comes out of the reactor and is cleaned using a receiver where the heavier carbon particles and long chain hydrocarbons condense and flow back to the reactor and the lighter fraction is taken to the multi-layer catalytic tower. The syngas velocity also decreases in the cyclone due to which the gas gets more residence time in the catalytic tower and subsequent line.

iii) Catalytic Tower

The catalytic tower is used to purify the syngas using catalyst in the vapour phase. Unwanted components like H_2S, SO_X, NO_X etc. can be removed using appropriate catalyst, if required.

iv) Condenser

Shell and tube condenser is used to cool the syngas from the reactor to liquid Petro alternate fuel.

v) Anti-Flashback Device

The uncondensed clean gas is then passed through a tank that is partially filled with water. The gas bubbles out to the next line of components. The water ensures that the gas that bubbles out cannot go back to the previous line of components.

vi) Scrubber

The gas and oil after getting fired in the furnace is cleaned by passing it through a wet alkali packed bed scrubber. The flue gas is cleaned, cooled and filtered to remove the particulate matter from the flue gas.

vii) Chimney

The cooled flue gas is vented to the atmosphere through the chimney.

viii) Flaring System

It is dangerous to vent exhaust gas (C1 to C4) without any safety measures. In this process, it is transferred first through the safety device and then burnt in the burner or Flare system.

ix) Distillation

The same machine can be used to distill the Petro Alternate Fuel (PAF) to high quality diesel with some changes.

5.5.1 Advantages of polymer waste pyrolysis process

The pyrolysis system demonstrates:

• Stable operation for a broad range of waste quality;

• Emissions from the system are well below the limit values;

• Flexibility in design and operation achieved by a modular design;

• Effective initial waste volume reducing;

• Efficient recovery of the materials and energy from the process;

• Low operational costs; no supplementary external fuel supply for the normal operation, i.e. significant reduction of running costs.

The pyrolysis system is designed for treatment of variety of different wastes such as municipal solid waste (MSW), sewage and oil sludge, automotive shredder residuals (ASR or car fluff), e-waste, rubber and tyres, medical waste, plastics, agricultural waste, as well as cleaning of the contaminated soil. Dozens of the commercial pyrolysis facilities for treatment of different feedstocks were designed and built so far.

The pyrolysis facility can operate as stand-alone waste-to-energy plant as well as the part of big power plants. In the last case the pyrolysis process thermally treats the waste and generates fuel, namely pyrolysis gas and pyrolysis char. These fuels are then co-fired in the power plant boiler unit. Pyrolysis process in this configuration disposes waste, simultaneously replacing part of the fossil fuels, consumed by the power plant.

5.6 BIO-METHANATION FOR BIODEGRADABLE WASTE

The potential of kitchen wastes to be used as substrates for biogas production can achieve the goals of developing a sustainable technology for waste management, producing renewable energy and reducing greenhouse gas emissions. A complex microbiological process lies behind the efficient production of biogas. The organic waste treated in the biogas process represents the substrate for various microorganisms. The more varied the composition of the organic material, the more components are available for growth, and thus the greater diversity of organisms that can grow. The various microbial groups are involved in the flow of carbon from complex polymers to methane-based model. Biogas is a mixture of Methane, Carbon Dioxide, Water vapour, Ammonia etc. generated from the anaerobic digestion of biomass. The methane will be enriched through scrubbing the dust, CO_2. The enriched methane gas will be used as fuel gas for cooking purpose in the kitchen and also in fuel cell for generation of electricity. Moreover, after anaerobic digestion, the spent slurry becomes excellent organic manure which is highly rich in N P K content. This manure can be used in cultivation after drying. The process flow has been described in Figs. 5.10 & 5.11 and the 10 cu. m capacity biogas plant developed at CSIR-CMERI has been shown in Fig. 5.12

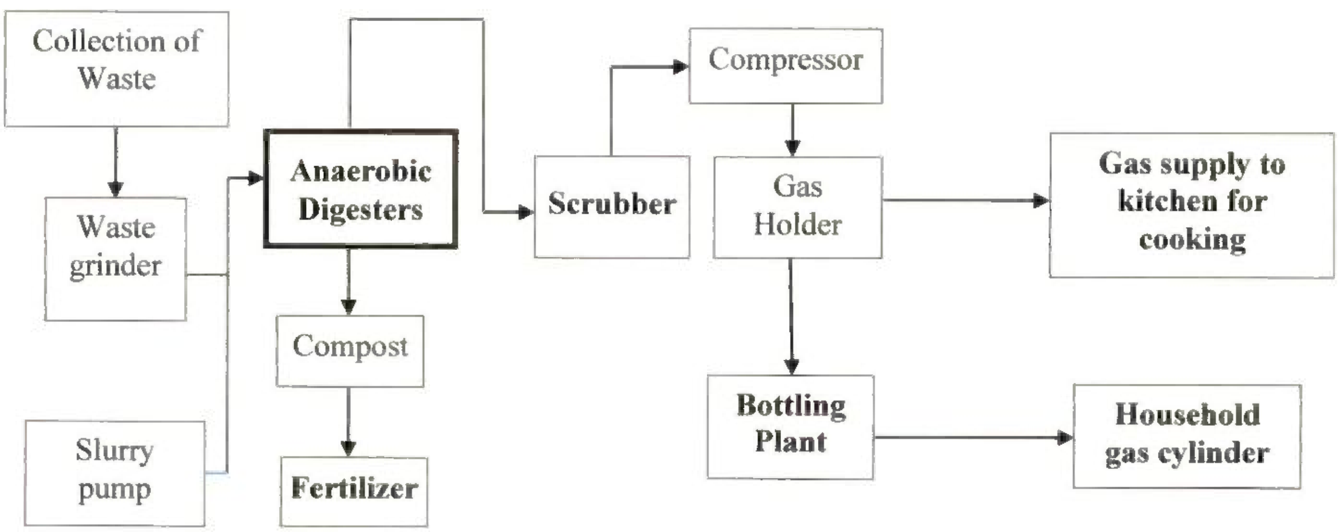


Fig 5.10: The Process Layout of Bio-methanation Unit

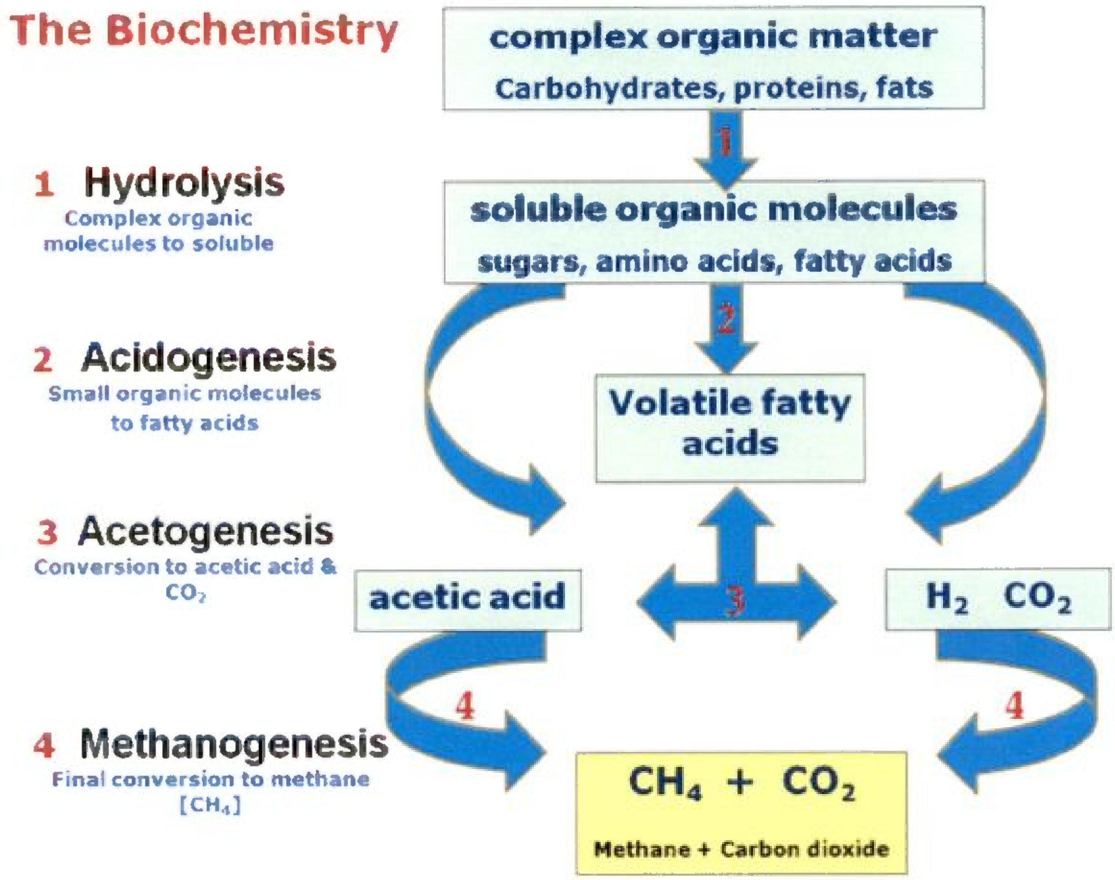


Fig. 5.11: The Anaerobic Digestion Process of Bio-Degradable Waste

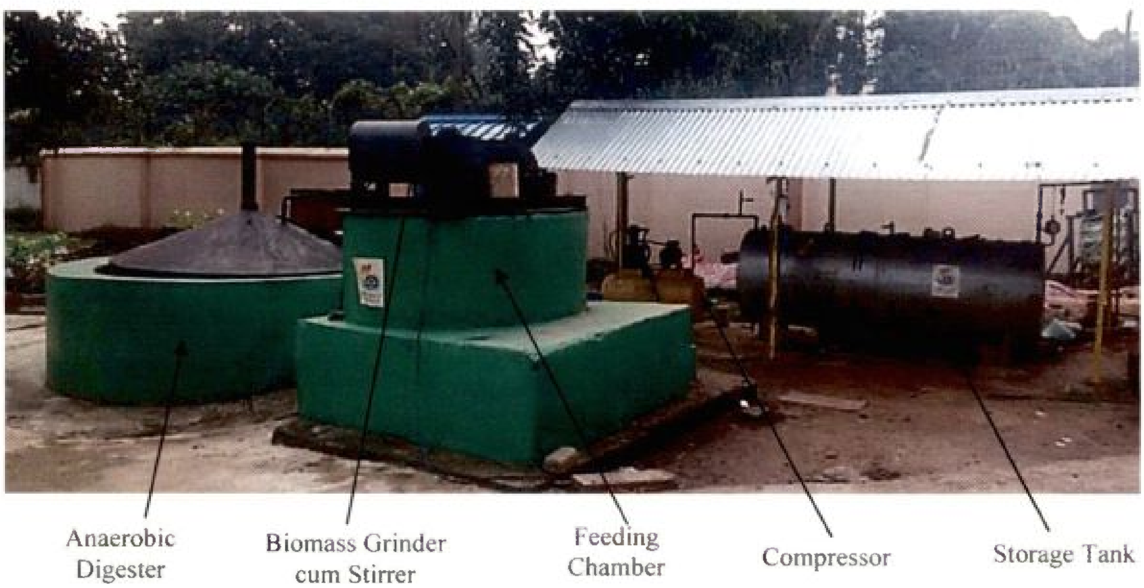


Fig. 5.12: Bio-methanation Unit of 10 cum capacity at CSIR-CMERI

5.4 UTILIZATION OF CONSTRUCTION & DEMOLITION WASTE

Safe and effective disposal of solid waste is the greatest challenge of the era. The management of MSW is going through a critical phase, due to non-availability of suitable facilities to treat and dispose larger amount of MSW, generated daily in metropolitan cities. The major portion of the waste generated is the construction debris (C&D). The composition of C&D waste can vary depending on age of building being demolished / renovated or the type of buildings being constructed. C&D waste generation figures for any region fluctuate as it depends largely on the type and nature of construction / demolition activities.

The construction debris is collected and crushed into a crusher. Then different sized gravels which are coming out from the segregation unit are mixed with this slag. Then 10-15% cement is mixed with the materials for punning. Now, these materials are mixed thoroughly in a dry state for proper mixing. Water is added to the dry mixture in a suitable proportion. The prepared mixture is then filled in the die of a mould cavity. Then it is being pressed. Moulding gives a definite shape to the mixture. Finally, the prepared bricks are tested for engineering properties. The ready bricks are being used as construction materials. The process of brick making has been shown in Fig. 5.13 and the plant at CSIR-CMERI has been shown in Fig. 5.14

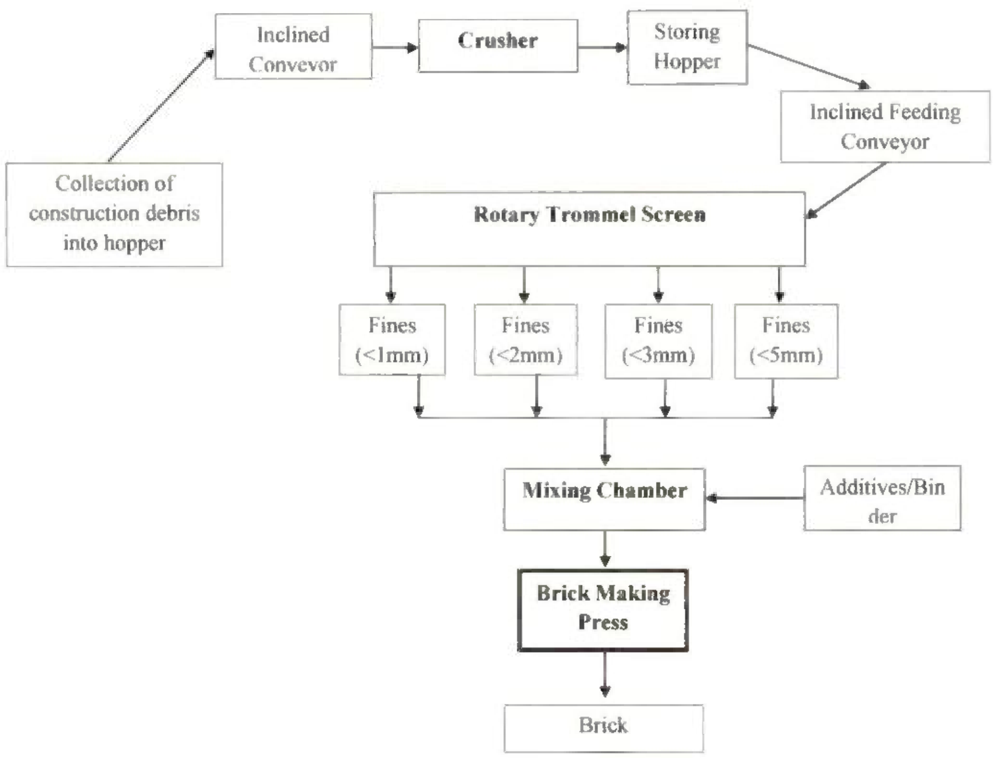


Fig. 5.13: Brick Making Process from Construction & Demolition Waste

10

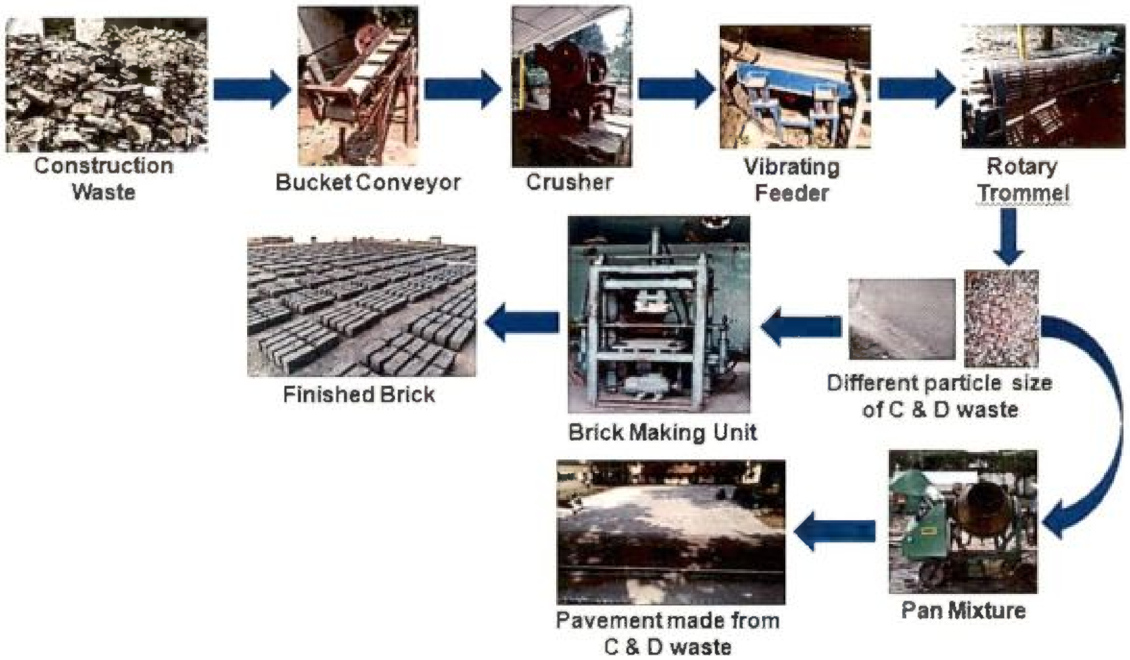


Fig 5.14: Utilization of Construction & Demolition Waste at CSIR-CMERI

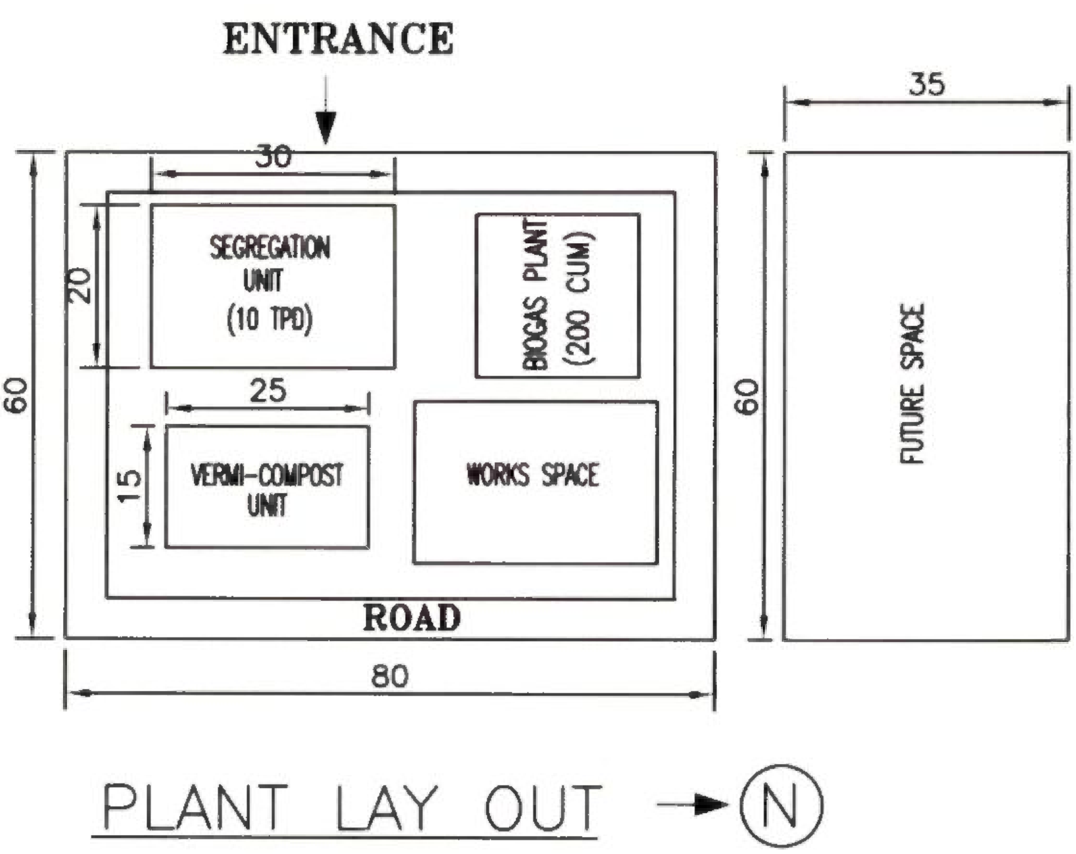
Advantages:

The advantages of the system are as follows

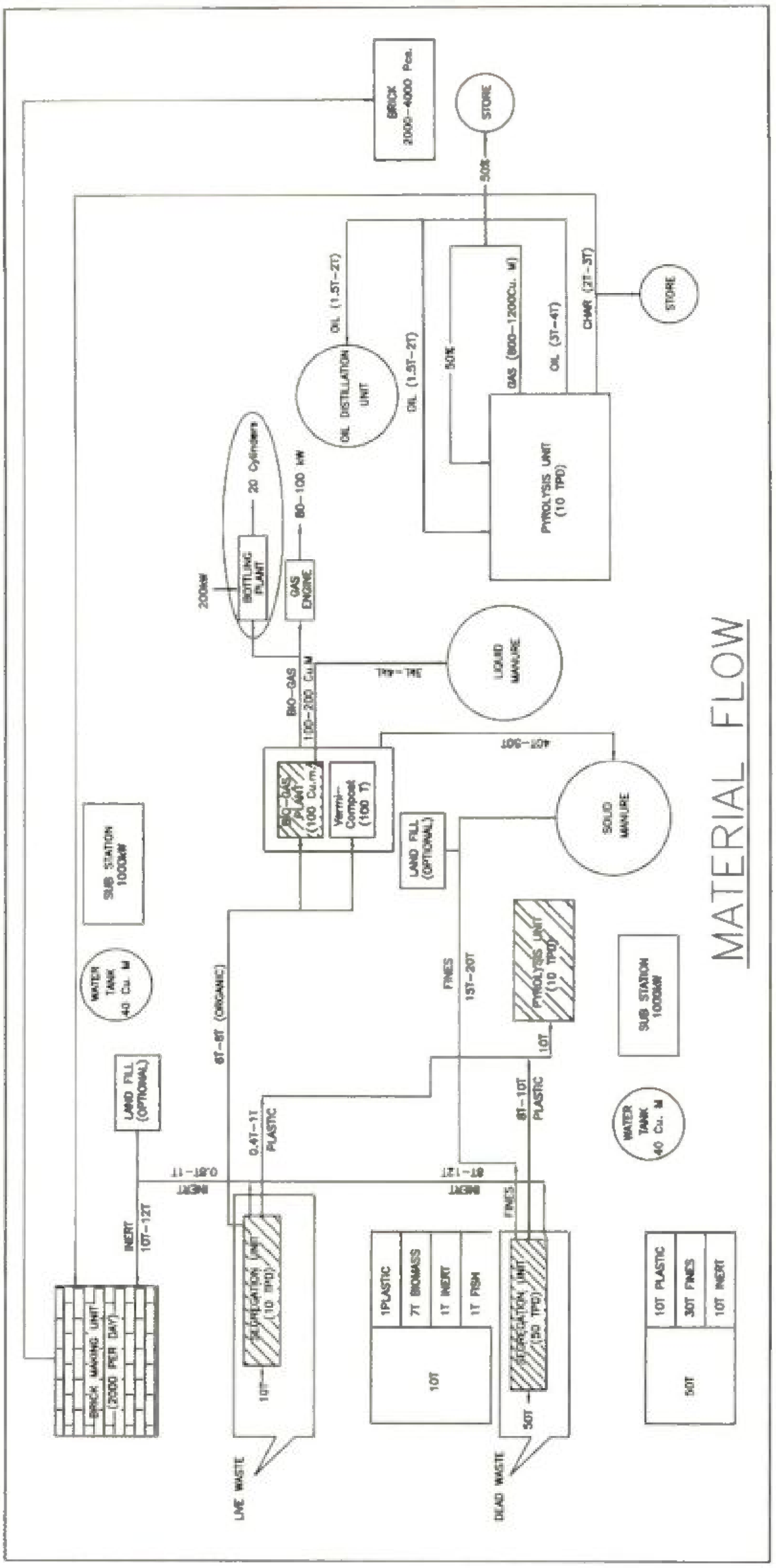
- Integrated & mechanized system for disposal of both bio-degradable & non-biodegradable waste;
- Eco-friendly disposal of municipal solid waste with zero level toxin emission;
- Utilization of generated bio-gas for house hold purpose in economic way;
- Utilization of organic manure generated from bio-methanation plant for agricultural purposes;
- Utilization of construction debris for generation of value added products.

CHAPTER 6
PROJECT DETAILS

6.1 Proposed plant layout for disposal of 10TPD MSW



All dimension is in meter (m)


MATERIAL FLOW
LIVE WASTE
DEAD WASTE
SEGREGATION UNIT (10 TPD)
SEGREGATION UNIT (50 TPD)
BRICK MAKING UNIT (2000 PER DAY)
BRICK 2000-4000 Pcs.
LAND FILL (OPTIONAL)
WATER TANK 40 Cu. M
SUB STATION 1000kW
BIO-GAS PLANT (100 Cu.m)
Vermi-Compost (100 T)
BIO-GAS 100-200 Cu.M
BOTTLING PLANT
20 Cylinders
GAS ENGINE
80-100 kW
200kW
LIQUID MANURE
SOLID MANURE
PYROLYSIS UNIT (10 TPD)
OIL DISTILLATION UNIT
STORE
1PLASTIC
7T BIOMASS
1T INERT
1T FISH
10T
10T PLASTIC
30T FINES
10T INERT
50T

6.2 Scope of work

6.2.1 Durgapur Municipal Corporation

- Providing developed land (80 m×60 m) with boundary wall for establishing set-up of Municipal Solid Waste disposal system (Perimeter: 280 m & Height: 2 m);
- Approach road for the site;
- Necessary electrical connection up to substation at site for operation of plant;
- Necessary water connection up to tank at site;
- Providing insurance, electricity and water for running the plant at no cost;
- Collection of waste from different sites under DMC and providing them at the proposed site;

6.2.2 CSIR-Central Mechanical Engineering Research Institute

- Necessary civil and electrical works at the proposed site for installation of 10 TPD Integrated Municipal Solid Waste Disposal system for Live Waste;
- Design, development, installation & commissioning of 10 TPD live mechanized segregation system to separate Municipal Solid Waste into biodegradable & non-biodegradable components;
- Design, development, installation & commissioning of 1000 kg/day Polymer waste pyrolysis plant for further processing of polymer waste from segregation plant, in an eco-friendly way;
- Design, development, installation & commissioning of 50 ton composting plant;
- Design, development, installation & commissioning of 200 cum biogas plant for processing of biodegradable waste from segregation plant;
- Design, development, installation & commissioning of 300 kg/hr cum briquette plant
- Sale of by-products consisting of pyrolysis oil and char from polymer waste pyrolysis plant;
- Sale of by-products consisting of biogas, solid and liquid manure from biogas plant;
- Sale of recyclables consisting of metals from segregated live waste;
- Sale of by-products consisting of briquette and compost;
- After commissioning, Operation & Maintenance for subsequent two years, renewed annually.

6.3 Duration of the Project:

The total duration of the project is 18 months (1.5 years) after handover of site by DMC.

6.4 Milestone Activities & Duration

Sl. No.	Activities Description	0-3 months	3-6 months	6-9 months	9-12 months	12-15 months	15-18 months		18-30 months	30-42 months
1	**Handover of proposed site after Site Clearance (scope of DMC)**									
2	Necessary civil, Structural and electrical works							Handing Over	Operation & Maintenance	
3	Desing & Engineering									
4	Purchase & Procurement									
5	Fabrication of Equipment									
6	Installation of Segregation Unit (10TPD Live)									
9	Installation of Biogas Plant (200 cum)									
10	Installation & Commissioning of 300 kg/hr briqutte plant									
11	Installation of compost (50 ton)									
12	Trial Run & Commissioning									

6.5 Estimated Cost: (INR in Lakh)

Capital Expenditure (A):

Option-1: Considering Stand-alone Project

Sl No	Description	INR in Lakh	Remarks
1	Works & Services	150	
2	Equipment	920	
	Sub Total	1070	
	GST (@18%)	193	
	Sub-Total	**1,263**	

Option-2: Considering additional project along with 50 TPD *i*MSWDS

Sl No	Description	INR in Lakh	Remarks
1	Works & Services	150	
2	Equipment	750	
	Sub Total	900	
	GST (@18%)	162	
	Sub-Total	**1,062**	

Recurring Cost / per year (B)

Sl. No.	Description	INR in Lakh	Remarks
a	Chemicals & Consumables	8	Annexure-A
b	Other Res. Expenditure	15	Annexure-B
c	Manpower	31	Annexure-C
d	Contingencies	2	
	Sub-Total	**56**	

6.6 Cost Benefit Analysis

Total Waste: 10 TPD (Live waste)

Economic life span of the plant: 15 years

A. Capital Cost

Option-1: Considering Stand-alone Project

The details of the capital costs are as follows

Sl. No.	Description	Size / Capacity	INR in Lakh	Remarks
a	Land	5,000 sq. m	-	To be provided by DMC at no cost
b	Plant and Equipment			
i	Installation of mechanized segregation plant	10 TPD Fresh waste × 1 Nos.	500	
ii	Installation of Biogas Plant	100 cum × 2 Nos.	150	
iii	Installation of Gas Engine	4 Nos. 15 kVA	30	
iv	Installation of compost facility	50 ton	40	
v	Installation of Briquette facility	150 kg/hr × 2 Nos.	30	
vi	Installation of Pyrolysis Plant	1000 kg/ batch	150	
	Procurement of vehicles for operation at site	Tractor – 2 No.	20	
c	Civil, Structural & Electrical Works	As required	180	
	Sub-total		**1,100**	

Option-2: Considering additional project along with 50 TPD *i*MSWDS

The details of the capital costs are as follows

Sl. No.	Description	Size / Capacity	INR in Lakh	Remarks
a	Land	5,000 sq. m	-	To be provided by DMC at no cost
b	Plant and Equipment			
i	Installation of mechanized segregation plant	10 TPD Fresh waste × 1 Nos.	500	
ii	Installation of Biogas Plant	100 cum × 2 Nos.	150	
	Installation of Gas Engine	4 Nos. 15 kVA	30	
iii	Installation of compost facility	50 ton	40	
iv	Installation of Briquette facility	150kg/hr × 2 Nos.	30	
v	Installation of Pyrolysis Plant	500 kg/ batch	--	(Included in Proposal of *i*MSWDS of 50TPD Dead Waste)
vi	Procurement of vehicles for operation at site	Tractor – 1 No.	--	(Included in Proposal of *i*MSWDS of 50TPD Dead Waste)
c	Civil, Structural & Electrical Works	As required	180	
	Sub-total		**930**	

B. Recurring Cost / per year

Sl. No.	Description	INR in Lakh	Remarks
a	Chemicals & Consumables	8	Annexure-A
b	Other Res. Expenditure	15	Annexure-B
c	Manpower	31	Annexure-C
d	Contingencies	2	
	Sub-total	**56**	

C. Revenue Generation/ per year

Sl. No.	Description	Revenue/Yr (INR in Lakh)	Remarks
a	Pyrolysis plant	20	Annexure-D
b	Biogas plant	25	Annexure-E
c	Recyclables/Compost/Briquette	12	Annexure-F
	Sub-total	**57**	

Annexure-A

Budget for Chemicals & Consumables

Sl.	Component	Amount (₹ in Lakh)
1	Fuel (Diesel)	5
2	Utilities, Consumables & Miscellaneous Supplies	3
	Total	**8**

Annexure-B

Budget for Other Research Expenditure

Sl.	Component	Amount (₹ in Lakh)
1	Repair and Maintenance of plant machinery	6
3	Plant and Office Running Expenses	1
5	Quality check	2
6	Miscellaneous	1
7	TA/DA	5
	Total	**15**

Annexure-C

Budget for Manpower

Sl.	Position	Nos.	Salary	Amount (Rs)
1	Supervisor	1	20,000	20,000
2	Operator	3	20,000	60,000
4	Unskilled Labour	15	10,000	1,50,000
			Sub Total	2,10,000
		Overhead @ 25%		52,500
		Total (per month)		2,62,500
				31,50,000

Annexure-D

Revenue Generation from Pyrolysis Plant, Capacity: 1000 kg/day

Sl	Description	Quantity/ day (kg)	Annual Quantity (ton)	Price (₹)/kg	Annual (₹)
1	Fuel oil (20% yield)	200	60	30	18,00,000
2	Carbon (25% yield)	250	75	3	2,25,000
3	Gas (30-40%)				
				Total Sale (₹)	**20,25,000**

Annexure-E

Revenue Generation from Biogas Plant, Capacity: 200 cum

Sl	Description	Quantity/day	Unit	Annual Quantity	Unit Rate (₹)	Amount (₹)
1	Biogas	200	cum	60,000	24	14,40,000
2	Sale of Liquid Manure	2,000	INR/L	6,00,000	1	6,00,000
3	Sale of Compost/ Solid Manure	800	INR/Kg	2,00,000	2.5	5,00,000
					Total Sale (₹)	**25,40,000**

Annexure-F

Revenue Generation from sale of recyclable items

Sl	Parameter	Average %	Quantity/day (kg)	Unit rate/ kg	Per annum
1	Metals, Glass	2.0%	100	10	**3,00,000**

Revenue Generation from compost

Sl	Item	Rate (₹)	Production/day	Amount/day (₹)	Amount/yr (₹)
1	Compost	4.25/kg	600	2,550	**7,65,000**

Revenue Generation from Briquette

Sl	Item	Rate (₹)	Production/day	Amount/day (₹)	Amount/yr (₹)
1	Briquette	5/kg	100	500	**1,50,000**

Detail Project Report

on

Design, Development, Installation and Commissioning of Integrated Municipal Solid Waste Disposal System (iMSWDS)

SUBMITTED TO

Durgapur Municipal Corporation
City Center, Durgapur-713216

BY

Diamond Jubilee
60 Years
1958-2017
CSIR-CMERI

CSIR-CENTRAL MECHANICAL ENGINEERING RESEARCH INSTITUTE

(A Constituent Establishment of CSIR, Govt. of India)

M.G. Avenue, Durgapur-713209, West Bengal

(July, 2018)

Preface

The management of municipal solid waste in India has surfaced or continued to be a severe problem not only because of environmental and aesthetic concerns but also because of the enormous quantities generated every day. Even though only 31% of Indian population resides in urban areas, it generates a gigantic 1,43,449 metric tonnes per day of municipal solid waste, as per the Central Pollution Control Board (CPCB), 2014-15 and these figures increase every day with an increase in population. To further add to the problem, the total number of towns (statutory and census) in the country have also increased from 5,161 in 2001 to 7,936 in 2011, thus increasing the number of municipal waste generation by 2,775 within a decade.

The management of municipal solid waste is one of the main functions of all Urban Local Bodies (ULBs) in the country. All ULBs are required to meticulously plan, implement and monitor all systems of urban service delivery especially that of municipal solid waste. With limited financial resources, technical capacities and land availability, urban local bodies are constantly striving to meet this challenge.

With the launch of the flagship programme by the Government of India, Swachh Bharat Mission in 2014 that aims to provide basic infrastructural and service delivery with respect to sanitation facilities to every family, including toilets and adopting the scientific methods to collect, process and disposal of municipal solid waste. The mission focuses on quality and sustainability of the service provision as well as emphasizing on the commitment on every stakeholder to bring about a visible change in society.

The three most popular options for processing and disposing of MSW are:

- Converting it into compost
- Converting it to energy
- Sanitary landfill

Converting MSW into Compost

In this method, the waste is exposed to anaerobic microbes, like bacteria, which break down the organic matter in the absence of oxygen to form biogas (mixture of methane and carbon dioxide) and compost (solid and liquid residual). Biogas can be used as fuel for cooking or for generator to convert it to electricity. The liquid slurry can be used as organic fertilizer.

Converting Municipal Solid Waste to Energy (WTE)

In this process thermal breakdown of MSW in high temperature environment is done to reduce MSW into a slag and syngas. The syngas can be used in gas engines/ gas turbines to generate electricity, steam or other such forms of energy. Waste to energy generates clean, reliable energy from a renewable fuel source, thus reducing dependence on fossil fuels.

Both these methods (Converting MSW into compost and Converting MSW into energy) have environmental benefits compared to third method disposing of MSW in landfills. Both the methods would reduce the quantity of wastes and generate a substantial quantity of energy which in turn reduce pollution of water and air, thereby offering a number of social and economic benefits. Some of the strategic and financial benefits from implementation of both the methods are:

- **Government Incentives** - The government of India already provides significant incentives for appropriate dispose of MWS, in the form of capital subsidies and feed in tariffs. With concerns on climate change, there are more chances of increased incentives by government.
- **Co-product Opportunities** - Depending on the technology/route used for energy recovery, eco-friendly and "green" co-products such as charcoal, compost, nutrient rich fertilizer or bio-oil can be obtained.
- **Job Opportunities** - With distributed waste management, new opportunities emerge for companies to provide support services. Every machine, required to dispose-off MSW, opportunities of maintaining, servicing, or taking care of it emerge. In other words, the technology will boost job opportunity. To add further this could be significant international expansion possibilities for Indian companies, especially expansion into other Asian countries.

The present project proposal aims to develop novel technologies that are innovative to extract wealth out of waste. The major technological interventions proposed are:

➢ Design & development of mechanized segregation system to separate Municipal Solid Waste into biodegradable & non-biodegradable components;

➢ Design & development of safe, environment friendly process for disposal of polymer waste utilizing pyrolysis;

➢ Design & development of biogas plant for disposal of biodegradable waste.

The major advantages of the proposed technologies include:

➢ Minimization of Landfill option, which is becoming crucial due to the continuously reducing space for sanitary landfills;

- Lowering environmental footprint through significant reduction in quantities of air pollutants;
- Reducing dependence on imported oil by using pyrolysis oils from waste polymers which are low priced;
- Use of pyrolysis gas generated from polymer waste pyrolysis plant to run gas engines/turbine and produce electricity;
- Environment friendly disposal of biodegradable waste through generation of Biogas which will definitely support the dwindling energy resources. The gas can be used for as fuel in the kitchen or for power generation;
- Generation of high quality, weed free manure from biogas plant which is an excellent soil conditioner. This is very important for replenishing organic carbon in the undernourished soil after years of agriculture;
- Downstream employment generation for the rural/urban poor.

CONTENT

CHAPTER 1
INTRODUCTION

1.1 PREAMBLE

Over the years, there has been a continuous migration of people from rural and semi-urban areas to towns and cities. The proportion of population residing in urban areas has increased from 10.84% in 1901 to 25.70% in 1991. The number of class I cities has increased from 212 to 300 during 1981 to 1991, while class II cities have increased from 270 to 345 during the same period. The increase in the population in class I cities is very high as compared to that in class II cities. The uncontrolled growth in urban areas has left many Indian cities deficient in infrastructural services such as water supply, sewerage and municipal solid waste management.

Most urban areas in the country are plagued by acute problems related to solid waste and become a tenacious problem. It is not uncommon to find 30-50% of staff and resources being utilized by Urban Local Bodies for these operations. Despite this, there has been a progressive decline in the collection and disposal of municipal solid waste including hospital and industrial wastes, as well as measures for ensuring adequacy of environmental sanitation and public hygiene. In many cities nearly half of solid waste generated remains unattended, giving rise to insanitary conditions especially in densely populated slums which in turn results in an increase in morbidity especially due to microbial and parasitic infections and infestations in all segments of population, with the urban slum dwellers and the waste handlers being the worst affected.

Solid Waste Management is a part of public health and sanitation, and according to the Indian Constitution, falls within the purview of the State list. Since this activity is non-exclusive, non-rivaled and essential, the responsibility for providing the service lies within the public domain. The activity being of a local nature is entrusted to the Urban Local Bodies. The Urban Local Body undertakes the task of solid waste service delivery, with its own staff, equipment and funds. In a few cases, part of the said work is contracted out to private enterprises.

There is lack of community awareness either about the likely perils due to poor waste management or the simple steps that every citizen can take which will help in reducing waste generation and promote effective management of solid waste generated. The degree of community sensitization and public awareness is low. There is no system of segregation of organic, inorganic and recyclable wastes at household level.

It is estimated that the total solid waste generated by 300 million people living in urban India is 38 million tonnes per year. The disposal of municipal solid waste is one of the pressing problems of city life, which has assumed great importance in the recent past. With the growing urbanization as a result of planned economic growth and industrialization, problems are becoming acute and call for immediate and concerted action. The proper disposal of urban waste is not only absolutely necessary for the preservation and improvement of public health but it has an immense potential for resource recovery.

It is estimated that about 1,45,000 MT of Municipal Solid Waste is generated daily in the country. Per capita waste generation in major cities ranges from 0.20 kg to 0.60 kg. Generally, the collection efficiency ranges between 70 to 90% in major metro cities whereas in several smaller cities the collection efficiency is below 50%. It is also estimated that the Urban Local Bodies spend about Rs.500 to Rs.1500 per ton on solid waste for collection, transportation, treatment and disposal. About 60-70% of this amount is spent on street sweeping of waste collection, 20 to 30% on transportation and less than 5% on final disposal of waste, which shows that hardly any attention is given to scientific and safe disposal of waste. Landfill sites have not yet been identified by many municipalities and in several municipalities, the landfill sites have been exhausted and the respective local bodies do not have resources to acquire new land. Due to lack of disposal sites, even the collection efficiency gets affected.

Very few Urban Local Bodies in the country have prepared long term plans for effective Solid Waste Management in their respective cities. For obtaining a long term economic solution, planning of the system on long-term sustainable basis is very essential.

1.2 PROBLEMS BEING FACED BY URBAN LOCAL BODIES

Barring a few progressive municipal corporations in the country, all other local bodies suffer due to non-availability of adequate expertise and experience; thereby the solid waste is not properly handled resulting into creation of environmental pollution and health hazards. As mentioned earlier, these local bodies lack technical, managerial, administrative, financial resources, adequate institutional arrangements. Similarly, Defense, Railways, CPWD and several Government of India Organizations/Undertakings having large establishments in the cities and towns lack the technical knowhow of managing urban solid waste. It is, therefore, very necessary to provide proper guidance in the Urban Local Bodies/Government

Agencies/Establishments referred above, to make them efficient in managing the solid waste generated in their respective areas/cities/towns.

1.3 NEED OF THE PROJECT

Looking to the existing SWM system, the Ministry of Environment & Forest has notified Municipal Solid Waste (Management & Handling) Rules 2016 under the Environment Protection Act 1986. According to these rules, all the municipal authorities were expected to improve solid waste management practices in terms of aforesaid rules by December, 2003. But, the situation did not improve as expected for want of adequate technical know-how and lack of human and financial resources.

It has been estimated that the average daily waste generation from Durgapur is around 250 TPD. With the projected population as 647,361 in the year 2020, it is estimated that 275 tons of MSW would be generated in the year 2020. Currently, the waste is being collected, transported and disposed at Shankarpur a dumping yard without any scientific processing, giving an ugly face to the city. These practices attract a lot of objection in view of open dumping of MSW and obnoxious odour and fly formation in the open dump yard. These practices also pose greater risk of ground water contamination due to percolation. According to World Health Organization (WHO) nearly five million people die due to disease caused by faulty disposal system and poor collection practices of waste over the years. As per the report of WHO, there are twenty two diseases which are directly related to improper management of solid waste. The rodent and vector insects transmit various diseases like dysentery, cholera, plague, typhoid, infective hepatitis and other. haphazard disposal of

In order to protect the public health and environment, it is need of the hour to find a suitable method for MSW disposal. Therefore, the present project has been undertaken to assess the existing SWM system, identify the gaps of the existing system and propose plan for eco-friendly disposal of solid waste. After evaluating various options available for MSW disposal and assessing factors like land availability, calorific value of MSW, paucity of land for Land Fill etc., it is suggested that disposal of MSW through technologies developed by CSIR-CMERI which include mechanized segregation of waste, utilization of the segregated bio-degradable waste and polymer waste are the most ideal ways for eco-friendly disposal of MSW at Durgapur.

CHAPTER 2

PRINCIPLES OF MUNICIPAL SOLID WASTE MANAGEMENT

2.1 INTRODUCTION

Management of municipal solid waste involves (a) development of an insight into the impact of waste generation, collection, transportation and disposal methods adopted by a society on the environment and (b) adoption of new methods to reduce this impact.

2.1.1 Solid Waste Generation

Municipal Solid Waste (MSW) is the trash or garbage that is discarded day to day in a human settlement. According to MSW Rules 2000, MSW includes commercial and residential wastes generated in municipal or notified areas in either solid or semi-solid form excluding industrial hazardous wastes but including treated bio-medical wastes. Waste generation encompasses activities in which materials are identified as no longer being of value (being in the present form) and are either thrown away or gathered together for disposal. Municipal Solid Waste consists of the following kinds of waste.

Fig 2.1: Sources of MSW Generation

The other kinds of waste found in urban settlements are:

1) Industrial or Hazardous Waste,
2) Bio-Medical or Hospital Waste, and
3) E-Waste

The Industrial hazardous waste is managed through Hazardous Waste (Management and Handling) Forth Amendments Rules 2010. Hazardous waste is typically identified with properties of *ignitability, corrosivity, reactivity and toxicity*. Hence urban local bodies must ensure that industrial waste in their command area does not get mixed with the municipal solid waste stream, failing which will result in economic losses (as hazardous waste treatment costs much higher than the municipal solid waste) and health & safety hazards (Contaminants like heavy metals, chromium, mercury, etc. when found in the municipal waste stream will contaminate the compost produced by the city. When farmers buy the compost it will indirectly affect the food chain) while treating such wastes.

According to the Hazardous Waste Management Rules 2010, the onus of managing and treating hazardous waste lie with the waste generator, and the urban local body has to ensure that such waste does not contaminate municipal waste stream in their area of authority.

A society receives energy and raw material as inputs from the environment and gives solid waste as output to the environment. In the long-term perspective, such an input-output imbalance degrades the environment.

2.1.2 Environmental Impact of Solid Waste Disposal on Land

When solid waste is disposed off on land in open dumps or in improperly designed landfills (e.g. in low lying areas), it causes the following impact on the environment:

(a) ground water contamination by the leachate generated by the waste dump
(b) surface water contamination by the run-off from the waste dump
(c) bad odour, pests, rodents and wind-blown litter in and around the waste dump
(d) generation of inflammable gas (e.g. methane) within the waste dump
(e) bird menace above the waste dump which affects flight of aircraft
(f) fires within the waste dump
(g) erosion and stability problems relating to slopes of the waste dump
(h) epidemics through stray animals
(i) acidity to surrounding soil and release of greenhouse gas

2.1.3 Objectives of Solid Waste Management

The objectives for solid waste management are:

- Maximize resource recovery / minimal emissions;
- Minimize impact on environment, human intervention, space requirement, impact on health hazard;
- No waste visibility;
- Elimination of MSW's inherent hazards:
  - Obnoxious odours
  - GHG emissions
  - Disease vectors and transmissions
  - Ground water contamination
  - Attracting stray animals & birds
  - Unhygienic & visually ugly site
- Making a clean & hygienic smart city

2.2 PRINCIPLES OF MUNICIPAL SOLID WASTE MANAGEMENT

Municipal Solid Waste Management involves the application of principle of Integrated Solid Waste Management (ISWM) to municipal waste. ISWM is the application of suitable techniques, technologies and management programs covering all types of solid wastes from all sources to achieve the twin objectives of (a) waste reduction and (b) effective management of waste still produced after waste reduction.

2.2.1 Waste Reduction

It is now well recognized that sustainable development can only be achieved if society in general, and industry in particular, produces 'more with less' i.e. more goods and services with less use of the world's resources (raw materials and energy) and less pollution and waste. The government is committed to reducing the amount of waste.

2.2.2 Effective Management of Solid Waste

Effective solid management systems are needed to ensure better human health and safety. They must be safe for workers and safeguard public health by preventing the spread of disease. In addition to these prerequisites, an effective system of solid waste management must be both environmentally and economically sustainable.

- Environmentally sustainable: It must reduce, as much as possible, the environmental impacts of waste management.
- Economically sustainable: It must operate at a cost acceptable to community.

Clearly it is difficult to minimize the two variables, cost and environmental impact, simultaneously. There will always be a trade off. The balance that needs to be struck is to reduce the overall environmental impacts of the waste management system as far as possible, within an acceptable level of cost.

An economically and environmentally sustainable solid waste management system is effective if it follows an integrated approach i.e. it deals with all types of solid waste materials and all sources of solid waste. A multi-material, multi-source management approach is usually effective in environmental and economic terms than a material specific and source specific approach. Specific wastes should be dealt within such a system but in separate streams. An effective waste management system includes one or more of the following options:

(a) Waste collection and transportation.

(b) Resource recovery through sorting and recycling i.e. recovery of materials (such as paper, glass, metals) etc. through separation.

(c) Resource recovery through waste processing i.e. recovery of materials (such as compost) or recovery of energy through biological, thermal or other processes.

(d) Waste transformation (without recovery of resources) i.e. reduction of volume, toxicity or other physical/chemical properties of waste to make it suitable for final disposal.

(e) Disposal on land i.e. environmentally safe and sustainable disposal in landfills.

2.2.3 Functional Elements of Municipal Solid Waste Management

The activities associated with the management of municipal solid wastes from the point of generation to final disposal can be grouped into the six functional elements: (a) waste generation; (b) waste handling and sorting, storage, and processing at the source; (c) collection; (d) sorting, processing and transformation; (e) transfer and transport; and (f) disposal.

Waste Generation: Waste generation encompasses activities in which materials are identified as no longer being of value (in their present form) and are either thrown away or gathered together for disposal. Waste generation is, at present, an activity that is not very controllable. In the future, however, more control is likely to be exercised over the generation of wastes. Reduction of waste at source, although not controlled by solid waste managers, is now included in system evaluations as a method of limiting the quantity of waste generated.

Waste Handling, Sorting, Storage, and Processing at the Source: The second of the six functional elements in the solid waste management system is waste handling, sorting, storage, and processing at the source. Waste handling and sorting involves the activities associated with management of wastes until they are placed in storage containers for collection. Handling also encompasses the movement of loaded containers to the point of collection. Sorting of waste components is an important step in the handling and storage of solid waste at the source. For example, the best place to separate waste materials for reuse and recycling is at the source of generation. Households are becoming more aware of the importance of separating newspaper and cardboard, bottles/glass, kitchen wastes and ferrous and non-ferrous materials.

On-site storage is of primary importance because of public health concerns and aesthetic consideration. Unsightly makeshift containers and even open ground storage, both of which are undesirable, are often seen at many residential and commercial sites. The cost of providing storage for solid wastes at the source is normally borne by the household in the case of individuals, or by the management of commercial and industrial properties. Processing at the source involves activities such as backyard waste composting.

Collection: The functional element of collection includes not only the gathering of solid wastes and recyclable materials, but also the transport of these materials, after collection, to the location where the collection vehicle is emptied. This location may be a material processing facility, a transfer station, or a landfill disposal site.

Sorting, Processing and Transformation of Solid Waste: The sorting, processing and transformation of solid waste materials is the fourth of the functional elements. The recovery of sorted materials, processing of solid waste and transformation of solid waste that occurs primarily in locations away from the source of waste generation are encompassed by this functional element. Sorting of commingled (mixed) wastes usually occurs at a materials recovery facility, transfer stations, combustion facilities, and disposal sites. Sorting often includes the separation of bulky items, separation of waste components by size using screens, manual separation of waste components, and separation of ferrous and non-ferrous metals.

Waste processing is undertaken to recover conversion products and energy. The organic fraction of Municipal Solid Waste (MSW) can be transformed by a variety of biological and thermal processes. The most commonly used biological transformation process is aerobic composting. The most commonly used thermal transformation process is incineration.

Waste transformation is undertaken to reduce the volume, weight, size or toxicity of waste without resource recovery. Transformation may be done by a variety of mechanical (ex. shredding), thermal (ex. incineration without energy recovery) or chemical (ex. encapsulation) techniques.

Transfer and Transport: The functional element of transfer and transport involves two steps: (i) the transfer of wastes from the smaller collection vehicle to the larger transport equipment and (ii) the subsequent transport of the wastes, usually over long distances, to a processing or disposal site. The transfer usually takes place at a transfer station.

Disposal: The final functional element in the solid waste management system is disposal. Today the disposal of wastes by landfilling or uncontrolled dumping is the ultimate fate of all solid wastes, whether they are residential wastes collected and transported directly to a landfill site, residual materials from Materials Recovery Facilities (MRFs), residue from the combustion of solid waste, rejects of composting, or other substances from various solid waste-processing facilities. A municipal solid waste landfill plant is an engineered facility used for disposing of solid wastes on land or within the earth's mantle without creating nuisance or hazard to public health or safety, such as breeding of rodents and insects and contamination of groundwater.

2.3 HIERARCHY OF WASTE MANAGEMENT OPTIONS

Current thinking on the best methods to deal with waste is centered on a broadly accepted 'hierarchy of waste management' (arrangement in order of rank) which gives a priority listing of the waste management options available. The hierarchy gives important general guidelines on the relative desirability of the different management options. The hierarchy usually adopted is (a) waste minimization/reduction at source, (b) recycling, (c) waste processing (with recovery of resources i.e. materials (products) and energy), (d) waste transformation (without recovery of resources) and (e) disposal on land (landfilling).

The highest rank of the ISWM hierarchy is waste minimization or reduction at source, which involves reducing the amount (and/or toxicity) of the wastes produced. Reduction at source is first in the hierarchy because it is the most effective way to reduce the quantity of waste, the cost associated with its handling, and its environmental impacts.

The second highest rank in the hierarchy is recycling, which involves (a) the separation and sorting of waste materials; (b) the preparation of these materials for reuse or reprocessing; and (c) the reuse and reprocessing of these materials. Recycling is an important factor which helps to reduce the demand on resources and the amount of waste requiring disposal by landfilling.

The third rank in the ISWM hierarchy is waste processing which involves alteration of wastes to recover conversion products (e.g., compost) and energy. The processing of waste materials usually results in the reduced use of landfill capacity.

Transformation of waste, without recovery of products or energy, may have to be undertaken to reduce waste volume (e.g. shredding and baling) or to reduce toxicity. This is usually ranked fourth in the ISWM hierarchy.

Ultimately, something must be done with (a) the solid wastes that cannot be recycled and are of no further use; (b) the residual matter remaining after solid wastes have been pre-sorted at a materials recovery facility; and (c) the residual matter remaining after the recovery of conversion products or energy. Landfilling is the fifth rank of the ISWM hierarchy and involves the controlled disposal of wastes on or in the earth's mantle. It is by far the most common method of ultimate disposal for waste residuals. Landfilling is the lowest rank in the ISWM hierarchy because it represents the least desirable means of dealing with society's wastes.

It is important to note that the hierarchy of waste management is only a guideline.

2.4 WASTE MINIMISATION

Waste minimization or reduction at source is the most desirable activity, because the community does not incur expenditure for waste handling, recycling and disposal of waste that is never created and delivered to the waste management system. However, it is an unfamiliar activity as it has not been included in earlier waste management systems.

To reduce the amount of waste generated at the source, the most practical and promising methods appear to be (i) the adoption of industry standards for product manufacturing and packaging that use less material, (ii) the passing of laws that minimize the use of virgin materials in consumer products, and (iii) the levying (by communities) of cess/fees for waste management services that penalize generators in case of increase in waste quantities.

Modifications in product packaging standards can result in reduction of waste packaging material or use of recyclable materials. Minimization of use of virgin raw materials by the manufacturing industry promotes substitution by recycled materials.

Sorting at source, recycling at source and processing at source (e.g. yard composting) helps in minimizing waste.

One waste management strategy used in some communities in developed countries is to charge a variable rate per can (or ton) of waste, which gives generators a financial incentive to reduce the amount of waste set out for collection. Issues related to the use of variable rates include the ability to generate the revenues required to pay the costs of facilities, the administration of a complex monitoring and reporting network for service, and the extent to which wastes are being put in another place by the generator and not reduced at source.

2.5 RESOURCE RECOVERY THROUGH MATERIAL RECYCLING

Material recycling can occur through sorting of waste into different streams at the source or at a centralized facility. Sorting at source is more economical than sorting at a centralized facility.

2.5.1 Sorting at Source

Sorting at source (home sorting) is driven by the existing markets for recyclable materials and the link between the house holder and the waste collector. The desirable home sorting streams are:

(a) Dry recyclable materials e.g. glass, paper, plastics, cans etc.,

(b) Bio-waste and garden waste,

(c) Bulky waste,

(d) Hazardous material in household waste,

(e) Construction and Demolition waste, and

(f) Commingled MSW (mixed waste).

At present recycling of dry recyclables does take place at the household level in India. However, source separation and collection of waste in streams of (b), (c), (d) and (e) has to be developed in most cities.

2.5.2 Centralized Sorting

Centralized sorting is needed wherever recyclable materials are collected in a commingled (mixed) state.

Hand sorting from a raised picking belt is extensively adopted in several countries.

Mechanized sorting facilities using magnetic and electric field separation, density separation, pneumatic separation, size separation and other techniques are used in some developed countries. Such facilities are usually prohibitively expensive in comparison to hand sorting.

In India, centralized sorting is not adopted. However, some intermediate sorting does occur after household wastes reach kerbside collection bins (dhalaos) through ragpickers. There is a need to formalise this intermediate sorting system or develop a centralized sorting facility to minimize recyclable materials reaching a waste processing facility or a landfill.

2.5.3 Sorting Prior to Waste Processing or Landfilling

Home sorting and centralized sorting processes normally recover most of the recyclable materials for reuse. However, a small fraction of such materials may escape the sorting process. Sorting is also undertaken just prior to waste processing, waste transformation or landfilling to recover recyclable materials. In a landfill, sorting may be carried out by ragpickers immediately after spreading of a layer of waste. In waste processing or transformation centres, manual sorting or size separation is usually undertaken.

Wherever manual sorting is adopted, care must be taken to ensure that sorters are protected from all disease pathways and work in hygienic conditions.

2.6 RESOURCE RECOVERY THROUGH WASTE PROCESSING

Biological or thermal treatment of waste can result in recovery of useful products such as compost or energy.

2.6.1 Biological Processes

Biological treatment involves using micro-organisms to decompose the biodegradable components of waste. Two types of processes are used, namely:

(a) Aerobic processes: Windrow composting, aerated static pile composting and in-vessel composting; vermi-culture etc.

(b) Anaerobic processes: Low-solids anaerobic digestion (wet process), high-solids anaerobic digestion (dry process) and combined processes.

At present recycling of dry recyclables does take place at the household level in India. However, source separation and collection of waste in streams of (b), (c), (d) and (e) has to be developed in most cities.

In the aerobic process the utilizable product is compost. In the anaerobic process the utilizable product is methane gas (for energy recovery). Both processes have been used for waste processing in different countries – a majority of the biological treatment process adopted world-wide are aerobic composting; the use of anaerobic treatment has been more limited.

In India, aerobic composting plants have been used to process up to 500 tons per day of waste.

2.6.2 Thermal Processes

Thermal treatment involves conversion of waste into gaseous, liquid and solid conversion products with concurrent or subsequent release of heat energy. Three types of systems can be adopted, namely:

(a) Combustion systems (Incinerators): Thermal processing with excess amounts of air.

(b) Pyrolysis systems: Thermal processing in complete absence of oxygen (low temperature).

(c) Gasification systems: Thermal processing with less amount of air (high temperature).

Combustion system is the most widely adopted thermal treatment process world-wide for MSW. Though pyrolysis is a widely used industrial process, the pyrolysis of municipal solid waste has not been very successful. Similarly, successful results with mass fired gasifiers have not been achieved. However, both pyrolysis and gasification are emerging as viable alternatives in the present.

To be viable for energy recovery through thermal processing, the municipal solid waste must possess a relatively high calorific value. In the MSW generated in developed countries, presence of significant quantity of paper and plastics yields a high calorific value of the MSW (typically above 2000 kcal/kg) which makes it suitable for thermal processing. In Indian MSW, the presence of high quantities of bio-degradable matter results in a low calorific value of the MSW (typically less than 1000 kcal/kg). In its mixed form, such waste may not be suitable for thermal processing. However, removal of inerts from Indian MSW as well as development of combustion system for low-calorific value wastes can result in a reversal of this position in the future.

2.7 WASTE TRANSFORMATION (WITHOUT RESOURCE RECOVERY) PRIOR TO DISPOSAL

At the end of all sorting processes, biological processes and thermal processes, the non-utilizable waste has to be disposed off on land. Prior to this disposal, waste may need to be subjected to transformation by mechanical treatment, thermal treatment or other methods to make it suitable for landfilling.

2.7.1 Mechanical Transformation

Sorting of waste may be undertaken to remove bulky items from the waste. Shredding of waste may be undertaken for size reduction to enable better compaction of waste.

2.7.2 Thermal Transformation

In regions where land space is very scarce (e.g. islands), waste with low calorific value may be subjected to combustion without heat recovery to reduce the volume of waste requiring disposal on land. Combustion transformation processes are similar to those discussed in Section 2.6.2.

2.8 DISPOSAL ON LAND

Waste is disposed off on land in units called landfills which are designed to minimise the impact of the waste on the environment by containment of the waste. Usually three types of landfills are adopted. Landfills in which municipal waste is placed are designated as "MSW Landfills" or "Sanitary Landfills". Landfills in which hazardous waste is placed are designated as "Hazardous Waste landfills". Landfills in which a single type of waste is placed (e.g. only construction waste) are designated as "Monofills".

2.9 COMPONENTS OF MUNICIPAL SOLID WASTE MANAGEMENT SYSTEM

Currently, in India, source separation and collection of dry recyclables is fairly well developed at the household level, commercial centers and institutional areas. These recyclable are further removed by ragpickers at various intermediate stages. Central sorting, whether manual or mechanized, is not adopted.

Source separation of bio-waste, construction and demolition waste as well as polymer waste is rarely done; consequently, most of the waste collected is a mixture of these components. Such mixed waste is rarely suitable for biological processing or thermal processing as it has high content of inert material, low calorific value and indeterminate mixing of hazardous elements (such as insecticides, paints, batteries etc.) at the micro level.

In some cities, good quality bio-waste is collected from fruit and vegetable markets and subjected to biological processing (aerobic) to produce compost. Such processing plants help reduce the quantity of waste reaching landfills.

Thermal processing of mixed municipal waste has not been successful in India. Biological processing of mixed municipal waste yields low quality compost which may have contaminants in excess of permissible limits.

Biological processing becomes viable once construction and demolition waste and hazardous waste streams are isolated from the bio-waste stream. Thermal processing of waste becomes viable only if sufficient high calorific value components (such as paper, plastic) are present in the waste.

Waste segregation and recovery of energy from segregated waste in an eco-friendly way is usually not a major component in an integrated municipal waste management system at present. However, compaction of raw solid waste before it proceeds the landfill site is the most common route of waste disposal undertaken by local bodies for reduction of landfill area.

CHAPTER 3
COMPOSITION AND QUANTITY OF SOLID WASTE

3.1 INTRODUCTION

The information on the nature of wastes, its composition, physical and chemical characteristics – and the quantities generated are basic needs for the planning of a Solid Waste Management system.

3.1.1 Terminology and Classification

In the literature, it is observed that various authors have used different terminology to describe the nature of wastes. In this text, 'composition' refers to the limited list of components or constituents, such as paper, glass, metal, plastic and garbage, into which an aggregate of municipal waste may conveniently be separated. 'Characteristics' on the other hand, refers to those physical and chemical properties, which are relevant to the storage, collection, treatment and disposal of waste such as density, moisture content, calorific value and chemical composition. In addition to these general terms, there are a number of more specific terms which, for greater clarity, must also be defined. A comprehensive list of definitions is therefore presented later in this chapter. Some terms, like 'domestic waste' and municipal waste refer to the sources of the wastes, while others, such as 'garbage', 'street waste' and 'hazardous waste', indicate the types of wastes.

3.1.2 Variations in Composition and Characteristics

An examination of the composition and characteristics of wastes in different parts of the country underscores the profound influences of national income, socio-economic conditions, social developments and cultural practices, and thereby focuses attention on the importance of obtaining the data locally.

Since different kinds of solid waste management system are designed for the future as well as the present, careful consideration should be given to changes that may occur during the design life of a system. Changes are inevitable, occur at an increasingly rapid rate in response to the increasing pace of social and technological development and the nature and extent of such changes cannot be predicted with accuracy. A built-in flexibility in the waste management system hence becomes essential. Nevertheless, it is possible to identify some of the factors that are likely to cause changes in waste composition and characteristics, which will enable planners to make reasonable judgements about the future.

3.2 DEFINITIONS AND CLASSIFICATION OF SOLID WASTES

In order to plan, design and operate a solid waste management system, a thorough knowledge of the quantities generated, the composition of wastes and its characteristics are essential. As a first step, a proper definition of the terms is necessary to avoid the general confusion that is common in the usage of these terms.

3.2.1 Definitions

There are many terms, which relate to the types and sources of wastes and these too must be defined. Based on the source, origin and type of waste a comprehensive classification is described below:

(i) Domestic/Residential Waste:

This category of waste comprises the solid wastes that originate from single and multi-family household units. These wastes are generated as a consequence of household activities such as cooking, cleaning, repairs, hobbies, redecoration, empty containers, packaging, clothing, old books, writing/new paper, and old furnishings. Households also discard bulky wastes such as furniture and large appliances which cannot be repaired and used.

(ii) Municipal Waste:

Municipal waste includes wastes resulting from municipal activities and services such as street waste, dead animals, market waste and abandoned vehicles. However, the term is commonly applied in a wider sense to incorporate domestic wastes, institutional wastes and commercial wastes.

(iii) Commercial Waste:

Included in this category are solid wastes that originate in offices, wholesale and retail stores, restaurants, hotels, markets, warehouses and other commercial establishments. Some of these wastes are further classified as garbage and others as rubbish.

(iv) Institutional Waste:

Institutional wastes are those arising from institutions such as schools, universities, hospitals and research institutes. It includes wastes which are classified as garbage and rubbish as well as wastes which are considered to be hazardous to public health and to the environment.

(v) Garbage:

Garbage is the term applied to animal and vegetable wastes resulting from the handling, storage, sale, preparation, cooking and serving of food. Such wastes contain putrescible organic matter, which produces strong odours and therefore attracts rats, flies and other vermin. It requires immediate attention in its storage, handling and disposal.

(vi) Rubbish:

Rubbish is a general term applied to solid wastes originating in households, commercial establishments and institutions, excluding garbage and ashes.

(vii) Ashes:

Ashes are the residues from the burning of wood, coal, charcoal, coke and other combustible materials, for cooking and heating in houses, institutions and small industrial establishments. When produced in large quantities at power generating plants and factories these wastes are classified as industrial wastes. Ashes consist of a fine powdery residue, cinders and clinker often mixed with small pieces of metal and glass.

(viii) Bulky Wastes:

In this category are bulky household wastes which cannot be accommodated in the normal storage containers of households. For this reason they require special collection. In developed countries bulky wastes are large household appliances such as cookers, refrigerators and washing machines as well as furniture, crates, vehicle parts, tyres, wood, trees and branches. Metallic bulky wastes are sold as scrap metal but some portion is disposed of at sanitary landfills.

(ix) Street Sweeping:

This term applies to wastes that are collected from streets, walkways, alleys, parks and vacant lots. In the more affluent countries manual street sweeping has virtually disappeared but it still commonly takes place in developing countries, where littering of public places is a far more widespread and acute problem. Mechanized street sweeping is the dominant practice in the developed countries. Street wastes include paper, cardboard, plastic, dirt, dust, leaves and other vegetable matter.

(x) Dead Animals:

This is a term applied to dead animals that die naturally or accidentally killed. This category does not include carcass and animal parts from slaughterhouses which are regarded as industrial wastes. Dead animals are divided into two groups, large and small. Among the large animals are horses, cows, goats, sheep, hogs and the like. Small animals include dogs, cats, rabbits and rats. The reason for this differentiation is that large animals require special equipment for lifting and handling during their removal. If not collected promptly, dead animals are a threat to public health because they attract flies and other vermin as they putrefy. Their presence in public places is particularly offensive and emits foul smell from the aesthetic point of view.

(xi) Construction and Demolition Wastes:

Construction and demolition wastes are the waste materials generated by the construction, refurbishment, repair and demolition of houses, commercial buildings and other structures. It mainly consists of earth, stones, concrete, bricks, lumber, roofing materials, plumbing materials, heating systems and electrical wires and parts of the general municipal waste stream, but when generated in large amounts at building and demolition sites, it is generally removed by contractors for filling low lying areas and by urban local bodies for disposal at landfills.

(xii) Industrial Wastes:

In the category are the discarded solid material of manufacturing processes and industrial operations. They cover a vast range of substances which are unique to each industry. For this reason they are considered separately from municipal wastes. It should be noted, however, that solid wastes from small industrial plants and ash from power plants are frequently disposed of at municipal landfills.

(xiii) Hazardous Wastes:

Hazardous wastes may be defined as wastes of industrial, institutional or consumer origin which, because of their physical, chemical or biological characteristics are potentially dangerous to human and the environment. In some cases although the active agents may be liquid or gaseous, they are classified as solid wastes because they are confined in solid containers. Typical examples are: solvents, paints and pesticides whose spent containers are frequently mixed with municipal wastes and become part of the urban waste stream. Certain hazardous wastes cause explosions in incinerators and fires at landfill sites. Others, such as pathological wastes from hospitals and radioactive wastes, require special handling at all time. Good management practice should ensure that hazardous wastes are stored, collected, transported and disposed off separately, preferably after suitable treatment to render them innocuous.

(xiv) Sewage Wastes:

The solid by-products of sewage treatment are classified as sewage wastes. They are mostly organic and derive from the treatment of organic sludge from both the raw and treated sewage. The inorganic fraction of raw sewage such as grit is separated at the preliminary stage of treatment, but because it entrains putrescible organic matter which may contain pathogens, must be buried / disposed off without delay. The bulk of treated, dewatered sludge is useful as a soil conditioner but invariably its use for this purpose is uneconomical. The solid sludge therefore enters the stream of municipal wastes unless special arrangements are made for its disposal.

3.2.2 Classification

Because of the heterogeneous nature of solid wastes, no single method of classification is entirely satisfactory. In some cases it is more important for the solid waste specialist to know the source of waste, so that classifying wastes as domestic, institutional or commercial, for example, is particularly useful. For other situations, the types of waste, garbage, rubbish, ashes, street waste is of greater significance because it gives a better indication of the physical and chemical characteristics of the waste. The principal classification is given in Table 3.1. The first three types, garbage, rubbish and ashes are those which make up the bulk of municipal wastes, derived principally from households, institutions and commercial areas. These wastes pose the most alarming/serious problems in urban areas.

Table 3.1: Classification of Solid Wastes

TYPES OF SOLID WASTE	DESCRIPTION	SOURCES
Food waste (garbage)	Wastes from the preparation, cooking, and serving of food. Market refuse, waste from the handling, storage, and sale of produce and meats and vegetable	Households, institutions and commercial such as hotels, stores, restaurants, markets, etc.
Rubbish	**Combustible** (primary organic) paper, cardboard, cartons, wood, boxes, plastics, rags, cloth, bedding, leather, rubber, grass, leaves, yard trimmings **Noncombustible** (primary inorganic) metals, tin cans, metal foils, dirt, stones, bricks, ceramics, crockery, glass bottles, other mineral refuse	
Ashes and Residues	Residue from fires used for cooking and for heating buildings, cinders, clinkers, thermal power plants.	
Bulky waste	Large auto parts, tyres, stoves refrigerators, others large appliances, furniture, large crates, trees, branches, palm fronts, stumps, flotage	
Street waste	Street sweepings, Dirt, leaves, catch basin dirt, animal droppings, contents of litter receptacles, dead animals	Streets, sidewalks, alleys, vacant lots, etc.
Dead animals	Small animals: cats, dogs, poultry etc. Large animals: horses, cows etc.	
Construction & demolition waste	Lumber, roofing, and sheathing scraps, crop residues, rubble, broken concrete, plaster, conduit pipe, wire, insulation etc.	Construction and demolition sites, remodeling, repairing sites

Industrial waste & sludges	Solid wastes resulting from industry processes and manufacturing operations, such as food processing wastes, boiler house cinders, wood, plastic and metal scraps and shaving, etc. Effluent treatment plant sludge of industries and sewage treatment plant sludges, coarse screening, grit & septic tank	Factories, power plants, treatment plants, etc.
Hazardous wastes	Hazardous wastes: pathological waste, explosives, radioactive material, toxic waste etc.	Households, hospitals, institution, stores, industry, etc.
Horticulture Wastes	Tree-trimmings, leaves, waste from parks and gardens, etc.	Parks, gardens, roadside trees, etc.

Source: Solid Waste Management in Developing Countries by Bhide & Sunderasan, INSDOC April, 1983

3.3 Composition and Characteristics

The composition and characteristics of municipal solid wastes vary throughout the world. Even in the same country it changes from place to place as it depends on number of factors such as social customs, standard of living, geographical location, climate etc. MSW is heterogeneous in nature and consists of a number of different materials derived from various types of activities. Even then it is worthwhile to make some general observation to obtain some useful conclusions.

- The major constituents are paper and putrescible organic matter;
- Metal, glass, ceramics, plastics, textiles, dirt and wood are generally present although not always so, the relative proportions depending on local factors;
- The average proportion of constituents reaching a disposal site(s) for a particular urban area changes in long term although there may be significant seasonal variations within a year.

For these reasons an analysis of the composition of solid waste, for rich and poor countries alike, is expressed in terms of a limited number of constituents. It is useful in illustrating the variations from one urban center to another and from country to country. Data for different degrees of national wealth (annual per-capita income) are presented in Table 3.2.

Waste composition also varies with socio-economic status within a particular community, since income determines life-style – consumption patterns and cultural behaviour.

Table 3.2: Patterns of Composition, Characteristics and Quantities

	Low Income Countries (1)	**Middle Income Countries (2)**	**High Income Countries (3)**
Composition: (% by weight)			
Metal	0.2-2.5	1-5	3-13
Glass, Ceramics	0.5-3.5	1-10	4-10
Food and Garden waste	40-65	20-60	20-50
Paper	1-10	15-40	15-40
Textiles	1-5	2-10	2-10
Plastics/Rubber	1-5	2-6	2-10
Misc. Combustible	1-8	-	-
Misc. Incombustible	-	-	-
Inert	20-50	1-30	1-20
Density (kg/m^3)	250-500	170-330	100-170
Moisture Content (% by wt)	40-80	40-60	20-30
Waste Generation (kg/cap/day)	0.4-0.6	0.5-0.9	0.7-1.8

(1) Countries having a per capita income less than US$360 (1978 prices)
(2) Countries having a per capita income US$360-3500 (1978 prices)
(3) Countries having a per capita income greater than US$3500 (1978 prices)

Source: Holmes, J: Managing Solid Waste in Developing Countries.

Several conclusions may be drawn from this comparative data:

- The proportion of paper waste increases with increasing national income;
- The proportion of putrescible organic matter (food waste) is greater in countries of low income than those of high income;
- Variation in waste composition is more dependent on national income than geographical location, although the latter is also significant;
- Waste density is a function of national income, being two to three times higher in the low-income countries than in countries of high income;
- Moisture content is also higher in low-income countries; and

- The composition of waste in a given urban center varies significantly with socio-economic status (household income).

3.3.1 Characteristics of Municipal Solid Waste in Indian Urban Centres

National Environmental Engineering Research Institute (NEERI) has carried out extensive studies on characterisation of solid waste from 43 cities during 1970-1994. The average characteristics have been presented in Tables 3.4 and 3.5. The paper content generally varies between 2.9 to 6.5% and increases with the increase in population. The plastics, rubber and leather contents are lower than the paper content, and do not exceed 1% except in metropolitan cities. The metal content is also low, viz. less than 1%. The low values are essentially due to the large scale recycling of these constituents. During a study in Bombay (1993-94), samples were collected both at the source as well as disposal sites to ascertain the extent of recycling. The paper is recycled on a priority basis while the plastics and glass are recycled to a lesser extent. The biodegradable fraction is quite high, essentially due to the habit of using fresh vegetables in India. The high biodegradable fraction also warrants frequent collection and removal of solid waste from the collection points. The ash and fine earth content of Indian municipal solid waste is high due to the practice of inclusion of the street sweepings, drain silt, and construction and demolition debris in municipal solid waste. The proportion of ash and fine earth reduces with increase in population due to improvements in the road surfaces. Percentage of inert material increases with the increase in population may be due to fast than construction and demolition waste find its way into the municipal solid waste disposal stream. High ash and earth content increases the density of municipal solid waste which are between 350 and 550 kg/m^3 in Indian cities.

The chemical characteristics indicate that the organic content of the samples on a dry weight basis ranges between 20 to 40%. The nitrogen, phosphorus and potassium content of the municipal solid waste ranges between 0.5 to 0.7%, 0.5 to 0.8% and 0.5 to 0.8% respectively. The calorific value ranges between 800-1000 kcal/kg. Knowledge of the chemical characteristics is essential in selecting and designing the waste processing and disposal facilities.

Ragpickers are observed to be more active in bigger cities. They prefer to remove paper, plastics, rags and packaging and such other material, which is light and also have a high calorific value. The remaining waste hence tends to have a higher inert content and a lower calorific value.

The demolition activity is observed to increase with population leading to increased inert content and reduced organic content in MSW.

Table 3.3: Physical Characteristics of Municipal Solid Wastes in Indian Cities

Population Range (in million)	Number of Cities Surveyed	Paper	Rubber, Leather and Synthetics	Glass	Metals	Total compostable matter	Inert
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	0.35	0.32	40.04	48.38
1.0 to 2.0	9	4.71	0.71	0.46	0.49	38.95	44.73
2.0 to 5.0	3	3.18	0.48	0.48	0.59	56.67	49.07
> 5	4	6.43	0.28	0.94	0.80	30.84	53.90

All values in table 3.3 are in percent, and are calculated on net weight basis
Source: Background material for Manual on SWM, NEERI, 1996.

Table 3.4: Chemical Characteristics of Municipal Solid Wastes in Indian Cities

Population Range (in million)	No. of Cities Surveyed	Moisture %	Organic matter %	Nitrogen as Total Nitrogen %	Phosphorus as P_2O_5 %	Potassium as K_2O %	C/N Ratio	Calorific value* in kcal/kg
0.1-0.5	12	25.81	37.09	0.71	0.63	0.83	30.94	1009.89
0.5-1.0	15	19.52	25.14	0.66	0.56	0.69	21.13	900.61
1.0-2.0	9	26.98	26.89	0.64	0.82	0.72	23.68	980.05
2.0-5.0	3	21.03	25.60	0.56	0.69	0.78	22.45	907.18
> 5	4	38.72	39.07	0.56	0.52	0.52	30.11	800.70

All values, except moisture, are on dry weight basis.
* Calorific value on dry weight basis
Source: Background material for Manual on SWM, NEERI, 1996.

3.4. Quantities

The information regarding waste quantity and density coupled with waste generation rate (by weight), is important while assessing the payload capacity of the collection equipment. It is possible to estimate the number of vehicles required for the collection and transportation of waste each day.

While per capita waste generation is a statistic, which is necessary for indicating trends in consumption and production, the total weight and volume of wastes generated by the community served by the management system are of greater importance in planning and design. As in all other aspects of data collection for the planning and design phases, data on waste generation, weight and volume should be collected by each authority for application in its own area of operation.

3.4.1 Per Capita Quantity of Municipal Solid Waste in Indian Urban Centres

The quantity of waste from various cities was accurately measured by NEERI. On the basis of quantity transported per trip and the number of trips made per day the daily quantity was determined. The quantity of waste produced is lesser than that in developed countries and is normally observed to vary between 0.2-0.6 kg/capita/day. Value upto 0.6 kg/capita/day are observed in metropolitan cities (Table 3.6). The total waste generation in urban areas in the country is estimated to be around 38 million tonnes per annum.

Forecasting waste quantities in the future is as difficult as it is in predicting changes of waste composition. The factors promoting change in waste composition are equally relevant to changes in waste generation. An additional point, worthy of note, is the change of density of the waste as the waste moves through the management system, from the source of generation to the point of ultimate disposal. Storage methods, salvaging activities, exposure to the weather, handling methods and decomposition, all have their effects on changes in waste density. As a general rule, the lower the level of economic development, the greater the change between generation and disposal. Increases in density of 100% are common in developing countries, which mean that the volume of wastes decreases by half.

Table 3.5: Quantity of Municipal Solid Waste in Indian Urban Centres

Population Range (in million)	No. of Urban Centres (sampled)	Total population (in million)	Average per capita value (kg/capita/day)	Quantity (tonnes/day)
< 0.1	328	68.300	0.21	14343.00
0.1-0.5	255	56.914	0.21	11952.00
0.5-1.0	31	21.729	0.25	5432.00
1.0-2.0	14	17.184	0.27	4640.00
2.0-5.0	6	20.597	0.35	7209.00
> 5	3	26.306	0.50*	13153.00

* 0.6 kg/capita/day generation of MSW observed in metro cities
Source: Background material for Manual on SWM, NEERI, 1996.

3.4.2 Estimation of Future per Capita Waste Quantity

For purposes of project identification, where an indication of service level must be estimated and data from the project preparation stage have not yet been developed, the following municipal refuse generation rates are suggested:

Residential refuse : 0.3 to 0.6 kg/capita/day

Commercial refuse : 0.1 to 0.2 kg/capita/day

Street sweepings : 0.05 to 0.2 kg/capita/day

Institutional refuse : 0.05 to 0.2 kg/capita/day

If industrial solid waste is included in municipal refuse for collection and/or disposal purposes, from 0.1 to 1.0 kg/capita/day may be added at the appropriate step where the municipality must estimate service delivery requirements. These generation rates are subject to considerable site-specific factors and are required to be supported by field data.

3.4.3 Relation between Gross National Product (GNP) and Municipal Solid Waste Generation

The consumption of raw materials and finished product by the community is directly proportional to the Gross National Product (GNP) of the country. Since the solid waste quantities are directly proportional to the quantity of material consumed the increase in per capita solid waste quantities would be directly proportional to the per capita increase in GNP. Table 3.6 shows the relation between GNP and expected generation of municipal solid waste, based on the study conducted by the United Nations in 1995.

Table 3.6: Relation between GNP and Expected Generation of Municipal Solid Waste

Sl. No.	Country	During the year 1995			During the year 2025		
		GNP Per Capita (US$)	Urban Population (% of Total)	Urban MSW Generation (kg/capita/day)	GNP Per Capita (US$)	Urban Population (% of Total)	Urban MSW Generation (kg/capita/day)
	Low Income	**490**	**27.8**	**0.64**	**1,050**	**48.8**	**0.6-1.0**
1	Nepal	200	13.7	0.50	360	34.3	0.6
2	Bangladesh	240	18.3	0.49	440	40.0	0.6
3	Myanmar	240	26.2	0.45	580	47.3	0.6
4	Vietnam	240	20.8	0.55	580	39.0	0.7
5	Mangolia	310	60.9	0.60	560	76.5	0.9
6	India	340	26.8	0.46	620	45.2	0.7
7	Lao PDR	350	21.7	0.69	850	44.5	0.8
8	China	620	30.3	0.79	1,500	54.5	0.9
9	Sri Lanka	700	22.4	0.89	1,300	42.6	1.0
Middle Income		**1,410**	**37.6**	**0.73**	**3,390**	**61.1**	**0.8-1.5**
10	Indonesia	980	35.4	0.76	2,400	60.7	1.0
11	Philippines	1,050	54.2	0.52	2,500	74.3	0.8
12	Thailand	2,740	20.0	1.10	6,650	39.1	1.5
13	Malaysia	3,890	53.7	0.81	9,400	72.7	1.4
High Income		**30,990**	**79.5**	**1.64**	**41,140**	**88.2**	**1.1-4.5**

14	Republic of Korea	9,700	81.3	1.59	17,600	93.7	1.4
15	Hong Kong	22,990	95.0	5.07	31,000	97.3	4.5
16	Singapore	26,730	100	1.10	36,000	100	1.1
17	Japan	39,640	77.6	1.47	53,500	84.9	1.3

(1 US$ = 40 INR)

Source: "What a Waste", Solid Waste Management in Asia, Urban Development Sector Unit, East Asia and Pacific Region, October, 1998

3.4.4 Rate of Increase Based on Experience in Other Cities

If data from other cities having registered similar pattern of development in the past is available, it can be used. However, data from other similar cities on rate of increase in per capita per day of solid waste may not be readily available. Due to difference in socio-economic factor, migration of population, industrialisation and waste quantities, a comparison of increase in per capita waste of one Indian city with that of comparable cities in other developing countries will also not be applicable.

3.4.5 Seasonal Variations

Seasonal variations in waste quantities must be accommodated by the management system. They arise from seasonal factors with respect to both climate, cultural and religious events. During monsoon, the waste becomes wet and heavy and total tonnage increases. Quantities of solid waste may also increase during cultural and religious festivals. Climate affects the generation of vegetative waste (yard and garden) or plant growth responds to favorable temperatures and soil to autumn while in tropical areas, where temperatures are always favorable, maximum growth is in the season of rainfall. At the end of the growth season (autumn dry season) leaves may comprise a significant proportion of the solid wastes.

3.5 Physical Characteristics

3.5.1 Density

A knowledge of the density of a waste i.e. its mass per unit volume (kg/m3) is essential for the design of all elements of the solid waste management system viz. Community storage, transportation and disposal. For example, in high-income countries, considerable benefit is derived through the use of compaction vehicles on collection routes, because the waste is typically of low density. A reduction of volume of 75% is frequently achieved with normal compaction equipment, so that an initial density of 100 kg/m3 will readily be increased to 400 kg/m3. In other words, the vehicle would haul four times the weight of waste in the compacted state than when the waste is uncompacted. The situation in low-income countries is quite different: a high initial density of waste precludes the achievement of high compaction ratio. Consequently, compaction vehicles offer little or no advantage and are not cost-effective.

Significant changes in density occur spontaneously as the waste moves from source to disposal, as a result of scavenging, handling, wetting and drying by the weather, vibration in the collection vehicles. The values shown in Table 3.7 reflect densities at the pick-up point.

Table 3.7: Density of Municipal Solid Wastes in Some Cities

Sl. No.	City	Density (kg/m^3)
1	Bangalore	390
2	Baroda	457
3	Delhi	422
4	Hyderabad	369
5	Jaipur	537
6	Jabalpur	395
7	Raipur	405

Source: Solid Waste Management in Developing Countries INSIDOC, 1983

N.B.: The above figures may be taken as indicative and actual field measurements must be made while designing solid waste management schemes for towns and cities.

3.6 Chemical Characteristics

A knowledge of chemical characteristics of waste is essential in determining the efficacy of any treatment process. Chemical characteristics include (i) chemical; (ii) bio-chemical; and (iii) toxic.

Chemical: Chemical characteristics include pH, Nitrogen, Phosphorus and Potassium (N-P-K), total Carbon, C/N ratio, calorific value.

Bio-Chemical: Bio-Chemical characteristics include carbohydrates, proteins, natural fibre, and biodegradable factor.

Toxic: Toxicity characteristics include heavy metals, pesticides, insecticides, Toxicity test for Leachates (TCLP), etc.

The waste may include lipids as well.

3.6.1 Classification

A knowledge of the classes of chemical compounds and their characteristics is essential in proper understanding of the behaviour of waste as it moves through the waste management system. The products of decomposition and heating values are two examples of the importance of chemical characteristics. Analysis identifies the compounds and the percent dry weights of each class. The rate and products of decomposition are assessed through chemical analysis. Calorific value indicates the heating value of solid waste. Chemical characteristics are very useful in assessment of potential of methane gas generation. The various chemical components normally found out in municipal solid waste are described below. The product of decomposition and heating values are two examples of the importance of chemical characteristics. Analysis identifies the compounds and the per cent dry weight of each class.

(i) Lipids:

Included in this class of compounds are fats, oils and grease. The principal sources of lipids are garbage, cooking oils and fats. Lipids have high calorific values, about 38000 kcal/kg, which makes waste with a high lipid content suitable for energy recovery processes. Since lipids in the solid state become liquid at temperatures slightly above ambient, they add to the liquid content during waste decomposition. They are biodegradable but because they have a low solubility in waste, the rate of biodegradation is relatively slow.

(ii) Carbohydrates:

Carbohydrates are found primarily in food and yard waste. They include sugars and polymers of sugars such as starch and cellulose and have the general formula (CH2O)X. Carbohydrates are readily biodegraded to products such as carbon dioxide, water and methane. Decomposing carbohydrates are particularly attractive for flies and rats and for this reason should not be left exposed for periods longer than is necessary.

(iii) Proteins:

Proteins are compounds containing carbon, hydrogen, oxygen and nitrogen and consist of an organic acid with a substituted amine group (NH2). They are found mainly in food and garden wastes and comprise 5-10% of the dry solids in solid waste. Proteins decompose to form amino acids but partial decomposition can result in the production of amines, which have intensely unpleasant odours.

(iv) Natural Fibres:

This class includes the natural compounds, cellulose and lignin, both of which are resistant to biodegradation. They are found in paper and paper products and in food and yard waste. Cellulose is a larger polymer of glucose while lignin is composed of a group of monomers of which benzene is the primary member. Paper, cotton and wood products are 100%, 95% and 40% cellulose respectively. Since they are highly combustible, solid waste having a high proportion of paper and wood products, are suitable for incineration. The calorific values of oven dried paper products are in the range 12000 – 18000 kcal/kg and of wood about 20000 kcal/kg, which compare with 44200 kcal/kg for fuel oil.

(v) Synthetic Organic Materials (Plastic):

In recent years, plastics have become a significant component of solid waste accounting for 5-7%. Plastic being non-bio-degradable, its decomposition does not take place at disposal site. Besides, plastic causes choking of drains and environmental pollution when burnt under uncontrolled condition. Recycling of plastics is receiving more attention, which will reduce the proportion of this waste component at disposal sites.

(vi) Non-combustibles:

Materials in this class are glass, ceramic, metals, dust, dirt, ashes and construction. Non-combustibles account for 30-50% of the dry solids.

3.7 Conclusion

No rational decisions on municipal solid waste system are possible until data of composition and quantity of solid waste are available. The method and capacity of storage, the correct type of collection vehicle, the optimum size of crew and the frequency of collection depend mainly on volume and density of wastes. Climate also has some influence. The disposal method may be dependent on the type of material recycled, organic content of waste, which could be composted, and the combustible material, which could be a source of energy.

CHAPTER 4
THE PLANNING AREA

4.1 INTRODUCTION

Durgapur is an industrial metropolis in the state of West Bengal, India, located about 160 km from Kolkata. It was a dream child of the great visionary Dr. Bidhan Chandra Roy, the second chief minister of the state. The well laid out industrial township was designed by Joseph Allen Stein and Benjamin Polk. It is home to the largest industrial unit in the state, Durgapur Steel Plant, one of the integrated steel plants of Steel Authority of India Limited. Alloy Steels Plant of SAIL is also located here. There are a number of power plants, chemical and engineering industries. Some metallurgical units have come up in recent years.

Durgapur is located at 23.48°N 87.32°E. It has an average elevation of 65 m (213 ft). Durgapur is situated on the bank of river Damodar, just before it enters the alluvial plains of Bengal. The topography is undulating. The coal-bearing area of the Ranigunj coalfields lies just beyond Durgapur, although some parts intrude in to the area. The area was deeply forested till recent times, and some forests are still there, standing witness to its wild past.

Solid Waste Management is one of the important obligatory functions of not only urban local bodies but also of rural local bodies. But this essential service is not efficiently and properly performed by the local bodies of West Bengal, resulting in many health and sanitation problems. It is observed that lack of financial resources, institutional weakness, improper selection of technology, transportation systems and disposal options, public's apathy towards environmental cleanliness and sanitation have made this service unsatisfactory.

The fundamental objective of Solid Waste Management program is to minimize the pollution of the environment as well as utilizing the waste as a resource. These goals should be achieved in a way that is financially sustainable, i.e. using methods that can be afforded by the community over the long term and with minimum risk to the persons involved.

In the context of epidemiological transition in West Bengal, solid wastes pose a major concern. Though to some extent, there has been a tremendous improvement in the field of total sanitation, particularly household sanitation, which has contributed to the drastic decrease in the incidence of diarrhoeal diseases, the social sanitation including the waste disposal is a contributor to the emerging infectious and new diseases. When we consider the solid waste management scenario of West Bengal, we can see that the exact quantity of waste generated in West Bengal is not totally known except for certain micro level studies conducted in different towns and municipalities. The rapid urbanization and consumerism makes it a tedious process and due to this, the composition of wastes also varies.

4.2 TYPES OF SOLID WASTE FOUND IN DURGAPUR MUNICIPAL CORPORATION (DMC)

a) Ashes and residues: Materials remaining from the burning of wood, coal, coke and other inflammable wastes in institutions, homes, stores, industrials and municipal facilities for the purpose of heating and cooking and above all the remains of combustible wastes are categorized as ashes and residues. These materials are generally composed of fine powdery materials, cinders, and small amounts of burned and partially burned materials.

b) Rubbish: This comprises of various kind of flammable and inflammable materials of households, institutions of commercial activities etc. The combustible rubbish includes the materials such as paper, cardboard, furniture parts, textiles, rubber, leather wood etc. Non-combustible rubbish consists of glass, broken crockery, plastic, discarded tins, aluminium cans and materials made of ferrous and non-ferrous materials.

c) Demolition and construction waste: Waste from demolished buildings and other structures are classified as demolition waste. Waste from the construction, remodeling and repairing of individual residences, housing complexes, multi storied flats, commercial buildings etc. are classified as construction wastes which includes stones, concrete, bricks, plaster and plumbing.

d) Industrial process wastes: It consists of the solid and semi-solid wastes coming from industrial plants. The specific characteristics of these wastes vary depending on the nature of the manufacturing process.

e) Municipal wastes: Wastes such as street sweeping materials, roadside litter, litter from municipal dustbins, dead animals and abandoned vehicles. Municipal waste includes rubbish, trash and almost all types of waste.

f) Food waste: Food wastes are the residues of various kind of foods like fruit, vegetable, animal product resulting from handling, preparation and eating of foods.

g) Other waste: Besides the above-mentioned types of wastes many other kinds of biodegradable and non-biodegradable wastes are found coming from different sources like hospital, market, pathological lab etc. The biodegradable waste consists of all carbonaceous wastes and non-biodegradable waste includes inorganic wastes and non-degradable polymeric organics like certain types of plastics.

4.3 SOURCES OF SOLID WASTE GENERATED IN DURGAPUR

a) Waste from residential areas: The waste generated from residential areas is generally named as domestic waste. This kind of waste varies a lot based on the socio-economic conditions and cultural situations. In developed residential areas where gas or electricity is used for cooking, the waste generated will be less compared to the low-income residential areas where wood or charcoal is used as fuel. Paper, cardboard, tin and bottles are found to be more in prosperous settlements and in commercial areas.

b) Waste from shops/vegetable/ fruit market: The wastes generated from the shops, vegetable and fruit market consists of polythene, paper, dried plantain leaves etc. Most of the wastes coming from shops and vegetable or fruit market are degradable in nature which is used for wrapping agricultural goods.

c) Waste from hospital/ nursing home/medical stores: Hospital, nursing homes and medical stores have a great contribution on solid waste generation at DMC. Different kind of solid wastes like unused medicine, saline bottles, medicine cover are generated some of which are non-degradable.

d) Waste from Hotels/Restaurants/Eating stalls: Hotels and Restaurants generate both degradable and non-degradable waste. The domestic type waste generated will be large in quantity and hence to be removed daily. They can be provided with separate bins for waste collection.

e) Waste generated by street hawkers: Street food vendors and hawkers generate large quantities of waste particularly food waste and plastic paper plates.

f) Waste from Slaughter Houses/ Fish markets: Slaughterhouses and fish markets generate highly putrescible matter. They decay very fast and are the main reason for the malodors near these premises. No paper collection or removal is practiced and hence the waste rots in the premises itself.

4.4 STATUS OF SOLID WASTE GENERATION IN DURGAPUR

The total quantity of solid waste generated in West Bengal is not estimated accurately. A study conducted at Durgapur City Corporation by the Department of Civil Engineering, NIT Durgapur shows that a total of 224 tonnes of solid waste is generated per day from various sources. The sample survey conducted at 43 wards showed that among these 224 tonnes, 181 tonnes of solid waste are from households. The wastes are mainly generated by shops and commercial establishments, hotels, hospitals and clinical laboratories of the City generate both infectious and non-infectious wastes, which comes to about 2-3 tonnes per day.

The other sources of waste generated in the City are offices, educational institutions, marriage halls, slaughterhouses etc.

A detailed study has also been conducted by the same group on the informal sector involving collection of non-degradable waste like plastics, paper, metals and glasses. During the study they identified more than 500 rag pickers who were involved in collection of non-degradable waste directly from the sources or from the waste dumps. They sell these wastes to the wholesale waste collectors who transport these materials to Durgapur for recycling. The physical characteristics of the waste generated in Durgapur City Corporation shows that 50% of the waste generated are organic substances, which are suitable for composting. Thus, from the detailed study and similar other studies in City Corporations, they inferred that a total of 250-350 tonnes of solid wastes are generated per day in almost all Corporation areas.

4.5 PRESENT STATUS OF SOLID WASTE MANAGEMENT IN DURGAPUR

In spite of the availability of a number of proven technologies, the local self-government institutions are not in a position to implement any, because of various socio-political and techno-economic issues. Hence, majorities of the Municipalities, Towns and Panchayats are still in need of small-scale waste treatment units. Solid waste management rose as a problem for public recently and before that no one considered this. The main constraints in implementing proper solid waste management programme are lack of political will and solid waste management was never given priority in the agenda of any political party. Difficulty in acquiring sites for waste management is another problem faced by many authorities and local self- government institutions. Lack of faith in the success of the solid waste management programme was another problem and this still remains in Durgapur Corporation.

Present system of waste management in West Bengal, including large and small municipalities include depositing in Municipal waste bins or Dumper Placer Containers, dumping in open spaces and roadsides, burning, burying, dumping in the drainages, dumping in ponds and canals. Some quantity of the wastes generated are recycled and converted to manure. Only a few municipalities and Panchayats in West Bengal have dump yards. Most of the dump-yards are now having been converted into compost yards.

The compost yard near Bidhan Nagar is an example for this. Even land filling exists in certain parts of West Bengal, but due to urbanisation, lack of space and as most of the low lying areas are converted to residential areas, land filling by authorities is negligible. Earlier days quarry sites were also used as land filling areas, but now-a-days they are also seen abandoned. Hence when we consider the present waste management system, open dumping in dump yards without any processing is followed in almost all areas.

Durgapur is one of the first Corporations of West Bengal State beside Kolkata, though now several have been added. It has a naturally undulated geographical feature and is a highly well planned industrial urbanised spots on a serenely rural base. The existing arrangements for solid waste management in most of our urban centers are highly unsatisfactory and subject a considerable part of our population to serious health risk. Durgapur City Corporation, has 43 wards with an area of 154.2 sq. km. Consequent to the increase in the area, the population under it, has increased, and along with that the responsibilities of the Corporation authorities and the expectation of the citizens. Unless all who live in the City find-tune themselves to improve the upkeep of the City, there is no doubt that the City will wilt under the enormous pressure it is subjected to from all sides.

Solid waste is generated in each and every household, small and big establishments, hotels, market places, hospitals etc. The lifestyle of the people of Durgapur has undergone an enormous change. The large open areas surrounding the houses are lost. Having houses at elevated places has been given up and living in multi-storied flats is well accepted. Hotels have mushroomed and patronized. Roadside eating places have increased in numbers. Markets have become big, crammed up and unsustainable. New and make shift unofficial markets have spread all along the urban as well as rural areas. Meat stalls and poultry have multiplied. Lodgings and hostels for men and women have increased.

All these contribute a great deal to the quantity of solid waste generated. Thus, disposal of solid waste is a major headache of Durgapur Corporation. Solid waste without plastics and glass when digested is a very good bio-fertilizer and the people who knew its value still go in for bio-compost.

In earlier days, small quantities of solid waste used to be collected in bullock carts and now huge trucks carrying a minimum of 4 tonnes are needed for transporting solid wastes. With nook and corners of the City occupied for residential and business purposes such places are essential by the public. But solid waste is continuing to be generated even by the resenting public.

In such a situation, proper collection methodology and appropriate technology to dispose of the solid waste, fully understanding its fertilizer value will of the people involved namely the generators of the waste, the transporters, and personnel managing the storage yards, and the technologists who operate the plant should act in unison and dedication to achieve success.

During the last few years many good actions have been initiated by the City Corporation though found fault with by many. Collection of solid waste from Dumper Placer Container (DPC), transporting them to transit points and hence transporting to the dumping is a major task. The waste collected from different streets are brought together and dumped along with the immense quantity of solid waste generated in two main markets in Durgapur City, namely, City Center, and Benachity. These market areas are the transit points for the transportation of the waste to the compost plant. The quality of this waste is such that it is wet and putrefies fast thus generating mal odour and subhuman condition for handling.

It is a common sight in Durgapur City that the people using DPC are seen tampering and even burning them when transportation is delayed. Since the waste is degradable, they decay fast and attract flies and other vectors. When the drainage channels are cleaned the solid waste are removed and kept on roadsides rather than dumping it into dustbins. These wastes again fill in the channel during the next rain. On the whole the process started by the Corporation is on the right lines but needs to be thoroughly streamlined. Healthy Corporation should pour in from all quarters. Residents Associations can do immense help in managing solid waste disposal by educating, creating awareness among public and extending a helping hand to the public in stopping the unhealthy and indiscriminate practices of waste dumping which creates nuisance to all.

Unlike other Municipalities and Corporations in West Bengal, the Durgapur Corporation has a well established and planned centralised solid waste management plan for managing the garbage generated in Durgapur City.

Sl. No.	Item	Details
1	Area	154.2 sq. km
2	Population	493405 (as in 2001 census)
3	Population density	3200
4	Literacy rate	75%
5	No. of wards	43
6	Total quantity of waste generated per day	250 MT
7	Disposal site	Bidhannagar

The Durgapur City Corporation is responsible for collection, transportation, management and disposal of the garbage generated within the city limits. For this, the authorities have provided a network of several Dumper Placer Containers in different parts of the city. Households and establishments including hospitals/ nursing homes, hotels, restaurants etc. are required to deposit their waste in these bins, for subsequent collection and transportation to the compost plant at Bidhannagar. Silt from drains and construction wastes are collected along with the garbage for disposal. Substantial quantities of wastes are also generated from the slaughterhouses and poultry farms. But no proper segregation, collection and disposal of these wastes are carried out in Durgapur Corporation. Hence these wastes are also mixed along with the city waste and carried for disposal.

4.6 SOLID WASTE COLLECTION

4.6.1 Primary collection of solid waste

The primary collection of solid waste is done fully with man power. For primary collection there are several no of workers with specific work scheduled. The primary collection includes the following activities-

1. Sweeping in different areas for collecting the garbage.
2. Storing the garbage in the specific bins.
3. Door to door collection the garbage.

The workers perform the above mention activities by using the following implements-brooms, baskets (bamboo and aluminium), brushes, iron plate, containerized push carts, tricycles and rotor-mould wheeled bins as shown in Figure 4.1. All the implements are supplied from Durgapur Municipal Corporation. One of the most important achievements of DMC is the introduction of Tricycle which stands as a wonder tool for better collection of MSW at door steps.

Figure 4.1: Daily collection of Household garbage in DMC
(Source: Waste Inventory in West Bengal 2009)

4.6.2 Secondary collection

Secondary collection is the transfer of solid waste from street to transfer stations and from transfer stations to disposal sites. For these activities there are engaged several numbers of heavy vehicles like dumper and lorries and light vehicles like tractor, van, chhota-hathi etc. with specific route scheduled for each and every vehicle for each trip.

Figure 4.2: Large collection containers in AMC
(Source: Waste Inventory in West Bengal 2009)

However, this process is followed mostly but silt from open drains across the project area is disposed at the same roadside collection points where the rest of the household and commercial waste is temporarily deposited. This is a widespread practice, which further compounds the problem by spoiling the quality of the waste – the feedstock for the plants. It not only creates foul smell for the residents of the area but also provides a very unpleasant view of the streets where they are deposited as shown in figure 4.3 and figure 4.4.

Figure 4.3: Silt from drains dumped with solid wastes

Figure 4.4: Dumping of Wastes together

4.7 WASTE DISPOSAL

Majority of the waste generated is disposed in open dumps and areas, which threat public health and environmental quality. The collected mixed waste is transported to dumping area by truck and dumped on open land without any processing. It causes obnoxious odour and fly formation. The Rag picker collects usable materials. They also involve in burning of waste to collect the valuable materials. The ambient air will thus contain higher values of PM, SO_2 and NOx. This problem results in public agitation against dumping of MSW in this site. Ground water contamination in the area can also occur due to leaching from the dumping site. In a nut shell, the existing practice poses greater challenges to the public health, environment and aesthetic value of the state.

Conventional Methods of Waste Disposal

The conventional methods of waste disposal are as follows:

- ✓ Open Dumping
- ✓ Open Burning and Incineration
- ✓ Sanitary Landfill

4.7.1 Open Dumping

- Disposal of solid waste by dumping in open areas, dumped from vehicles along roadsides, and/or dumped late at night
- Oldest and most common way of disposing solid waste in developing countries
- Still in use wherever land is available without regard to safety, health hazards and aesthetic degradation
- Refuse is spread over a large area
- No maintenance

Fig 4.5: Open Dumping of Municipal Solid Waste

Open dumps pose the following health, safety, and environmental threats:

- Fire and explosion
- Inhalation of toxic gases
- Injury to children playing on or around the dump site
- Disease carried by mosquitoes, flies, and rodents

- Contamination of streams, rivers and lakes
- Contamination of soil and groundwater
- Contamination of drinking water
- Damage to plant and wildlife habitats
- Decrease in the quality of life to nearby residents and the local community

Open dumps create a public nuisance, divert land from more productive uses, and depress the value of surrounding land. An open dump is an illegal waste disposal site and should not be confused with a permitted municipal solid waste landfill or a recycling facility. If allowed to remain, open dumps often grow larger, and may attract dumping of both solid and hazardous wastes.

4.7.2 Open Burning & Incineration

- Incineration is a waste treatment process that involves the combustion of solid waste at 1000°C
- Waste materials are converted into ash, flue gas, and heat
- The ash is mostly formed by the inorganic constituents of the waste and gases due to organic waste
- the heat generated by incineration is used to generate electric power

Fig 4.6: Open burning of plastic waste and agricultural waste

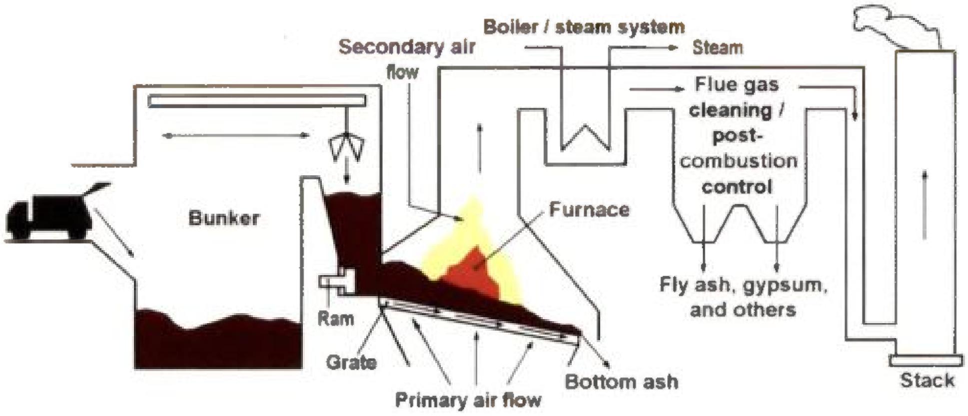


Fig 4.7: Schematic of Incineration Plant

The major disadvantages of the system are

- The air pollution controls required in incineration plants are extremely expensive. Very often up to one half of the costs of a plant are due to air pollution control facilities. As the laws can change and maybe require updates in the air pollution controls this could lead to much higher costs in the future.
- Energy, produced by means of waste incineration is not likely to be practical for small communities. Therefore, incineration plants have be situated in areas where the district heating network can easily be connected to very many households.
- Incinerators are costly to construct, operate and regulate. Stringent emissions for incinerators increase the cost of construction, operation and maintenance.
- The extremely high technical standards of the plants require skilled workers, which leads to the facts that rather high wages have to be paid.
- The chemicals that would be released into the air could be strong pollutants and may destroy ozone layer
- The residues from the flue gas cleaning can contaminate the environment if they aren't handled appropriately and therefore they must be disposed of in controlled and well operated landfill to prevent groundwater- and surface pollution.

4.8.3 Sanitary Landfill

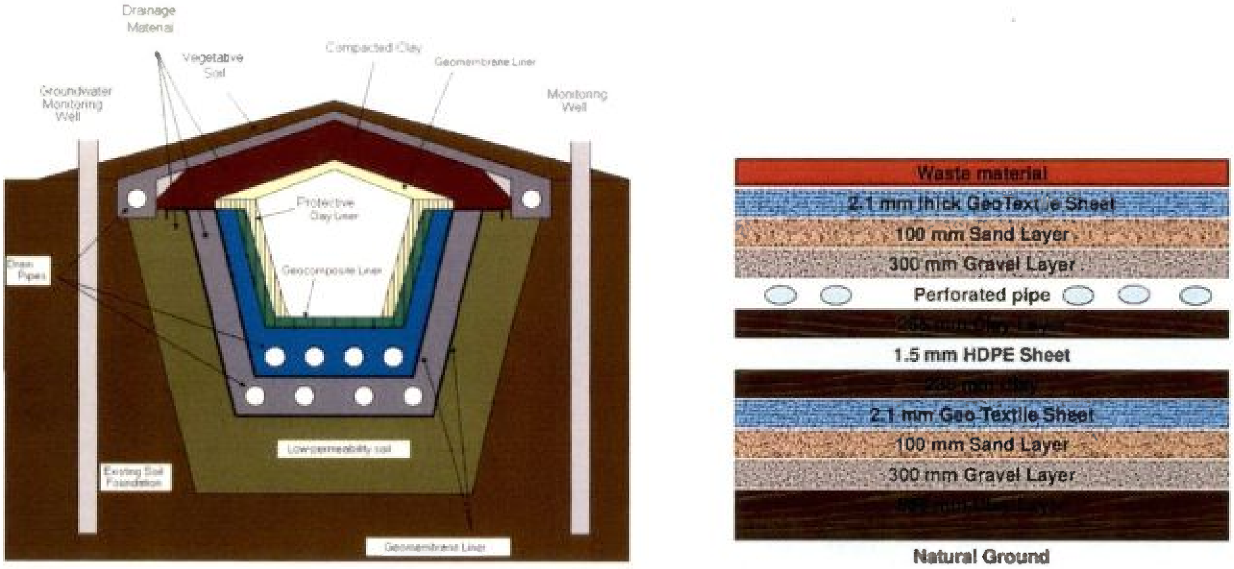


Fig 4.8: Schematic of a Sanitary Landfill

The major disadvantages of the system are

- The site will look ugly while it is being used for landfill
- Leachate (Toxic liquid) is generated due to decomposition of waste in the landfill which contains acid, heavy metals and other toxic elements which can contaminate ground water resources
- Dangerous gases are given off from landfill sites that cause local air pollution and contribute to global warming
- Local streams could become polluted with toxins seeping through the ground from the landfill site
- Methane gas is generated in waste mass which travels underground in cracks of rocks if not pumped out and accumulates in nearby areas (foundation of buildings) which may cause explosion if not taken out
- Once the site has been filled it might not be able to be used for redevelopment as it might be too polluted

CHAPTER 5

NOVEL SOLID WASTE DISPOSAL TECHNIQUES: A CSIR-CMERI INNOVATION AND DEVELOPMENT

5.1 SOLID WASTE DISPOSAL TECHNIQUES DEVELOPED BY CSIR-CMERI

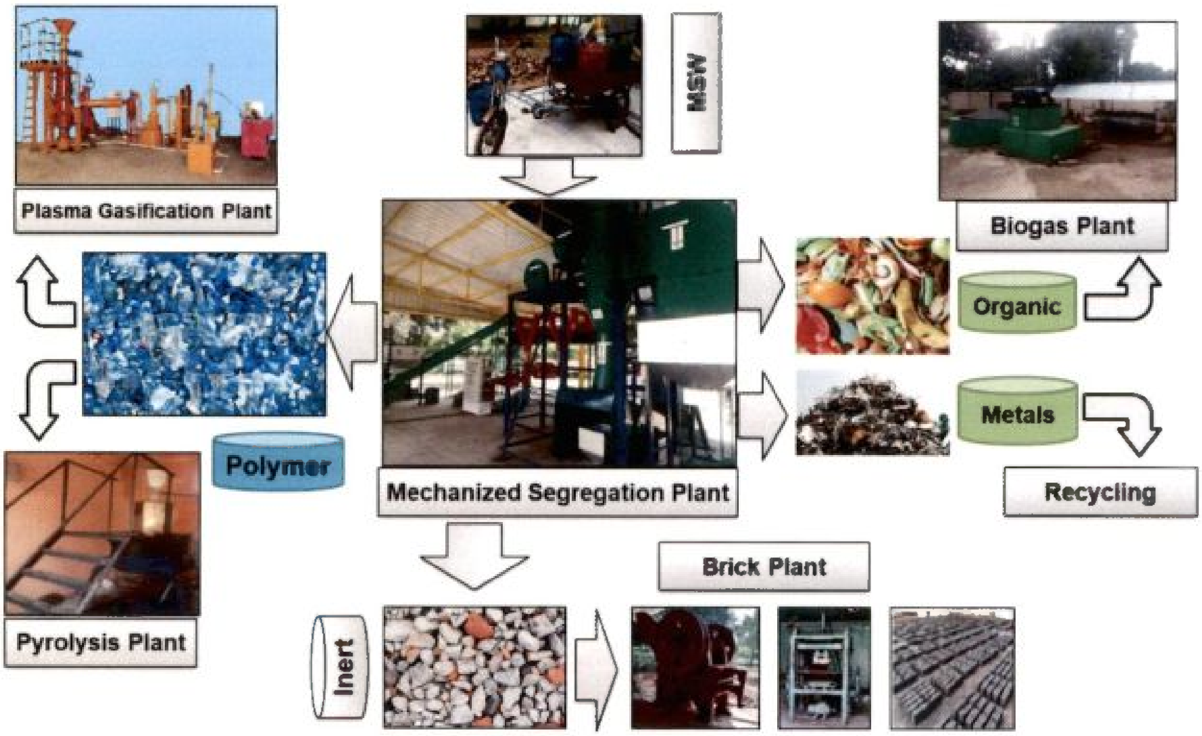


Fig 5.1: Zero Waste Colony Model developed by CSIR-CMERI

5.2 MECHANIZED SEGREGATION OF LIVE MUNICIPAL SOLID WASTE

The waste is being classified into two categories a) live waste and b) dead waste. The classification is based on collection of waste. The wastes which are being collected daily by the municipalities are termed "Live Waste". The wastes which have been dumped over the years at the landfill site are being termed as "Dead Waste". CSIR-CMERI has developed mechanized segregation system for both live and dead waste into different components.

The segregation process starts with dumping of solid waste material into a bin directly from the dumper carrying the materials. The segregation system should be capable of segregating metallic waste (metal body, metal container etc.), biodegradable waste (foods, vegetables, fruits, grass etc.), non-biodegradable (plastics, packaging material, pouches, bottles etc.) & inert (glass, stones etc.) wastes.

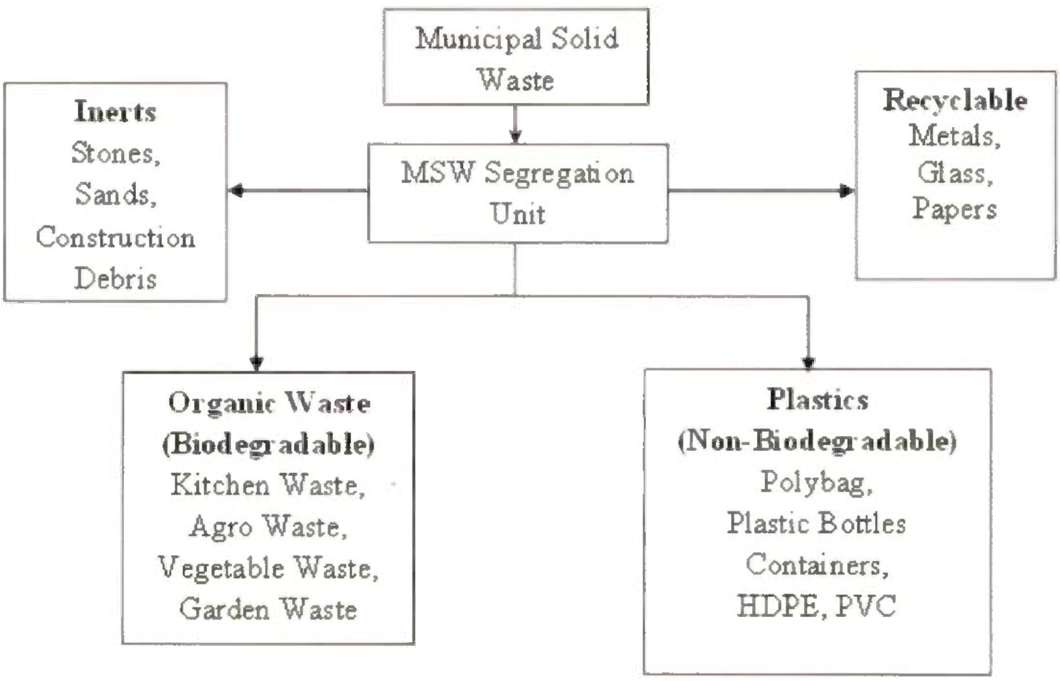


Fig 5.2: Process layout of Segregation System for Live Waste

The Municipal Solid Waste contains a high amount of moisture. The high moisture content will reduce the efficiency of mechanical sorting, consequently making it unfavourable for beneficial utilization. Hence, a pre-treatment is required before mechanized segregation of waste. The MSW is passed over a horizontal roller conveyor where it is exposed to hot air (55-60°C). The dried material is passed over a rotary magnetic drum separator where the iron components (Fe) separate out which are collected in a hopper for reuse. The rest of the material are passed over an Eddy Current Separator where non-ferrous metallic parts (Al, Cu) are separated out. The remaining waste are sent to the Air Separation Unit where the lighter particles (Plastics, paper) and heavy mass (biomass) are being separated. The lighter objects (Plastics, paper) can be directly fed into the shredder. The shredded material will be sent to polymer waste pyrolysis unit using a vibratory chute for pyrolysis. The segregated biomass can be utilized for production of biogas in the bio-methanation unit through a waste grinder. A mechanized segregation unit of capacity 50 kg/h developed at CSIR-CMERI is as shown in Fig. 5.3

Fig 5.3: Mechanized Segregation Unit for Live Waste at CSIR-CMERI (Capacity: 50 kg/h)

5.3 MECHANIZED SEGREGATION OF DEAD MUNICIPAL SOLID WASTE

The segregation system should be capable of segregating metallic waste (metal body, metal container etc.), fines (degraded organic waste), non-biodegradable (plastics, packaging material, pouches, bottles etc.) & inert (construction debris, stones etc.) wastes. The process flow of mechanized segregation unit for dead waste developed at CSIR-CMERI is shown in Fig. 5.4.

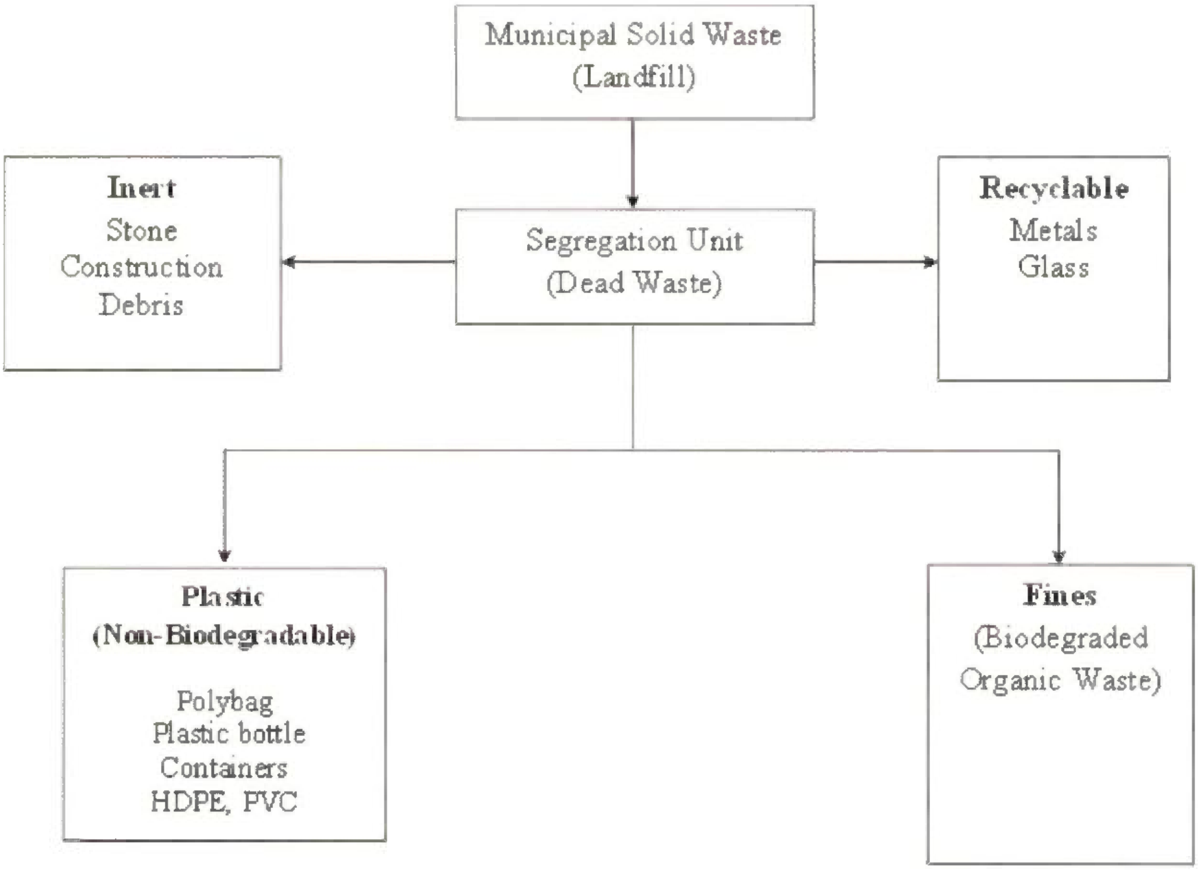


Fig 5.4: Process layout of Segregation System for Dead Waste

A mechanized segregation unit of capacity 50 kg/h developed at CSIR-CMERI is as shown in Fig. 5.5

Fig 5.5: Mechanized Segregation Unit for Dead Waste at CSIR-CMERI (Capacity: 100 kg/h)

5.4 DISPOSAL OF PLASTIC WASTE UTILIZING HIGH TEMPERATURE PLASMA

In this relevance plasma arc technology is effective, eco-friendly, most efficient and less explored technology for proper disposal of mountain of solid waste material generated on daily basis. In this method electrical ionization between two electrode cathode and anode at low voltage and high current is being used to treat the waste at a temperature as high as ~3000°C. The electric ionization will be carried out through low voltage (30-50 V) & high current (300-400 A) between two electrodes. The temperature shall be raised as high as ~3000°C during the ionization process. The chances of generation of carcinogenic gases at such elevated temperature are remote. The output gas will be mainly CO, H_2, hydrocarbons and CO_2. This CO & H_2 enriched sys-gas has high calorific value. The product gas after passing through the plasma treatment is made to pass through the carbon sieves (REDOX reactor). This will help to convert carbon from the sieve and oxygen to form CO. Catalytic converter shall be used to convert any traces of hydrocarbon into CO and H_2. Catalyst like Nickel can be used for this purpose. The gas is then cleaned in cyclone separator and scrubber. Then cooled in the condenser. This CO & H_2 enriched sys-gas has high calorific value. This gas will be primarily stored into a gas holder and will be used for generation of electricity after combustion into gas engine. The layout of the proposed plant is as follows: The process layout has been shown in Fig. 5.6 and the Plastic disposal unit of 25 kg/hr capacity developed at CSIR-CMERI has been shown in Fig. 5.7.

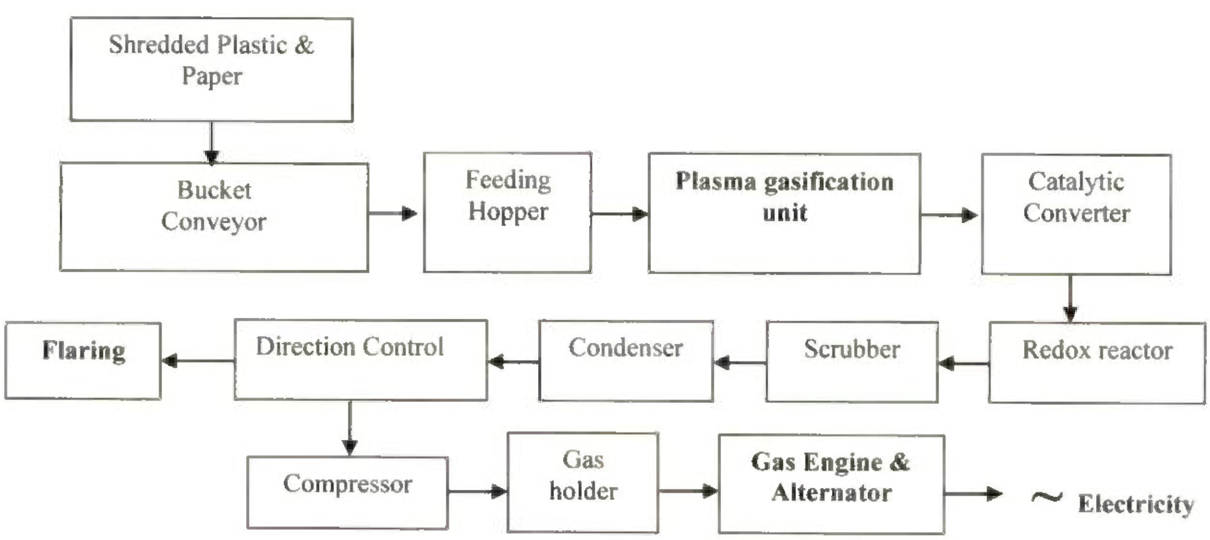
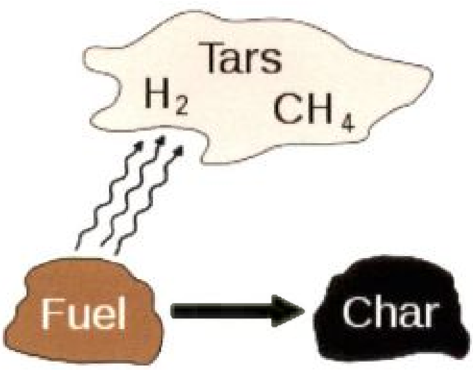


Fig 5.6: The process layout of Plasma Gasification Unit

Fig 5.7: Plastic Disposal Unit at CSIR-CMERI (Capacity: 25 kg/ hr)

5.5 DISPOSAL OF PLASTIC WASTE THROUGH PYROLYSIS

Pyrolysis is the thermal degradation of waste in the absence of air to generate gas often termed syngas), liquid (bio oil) and solid (char, mainly ash and carbon). The plastic wastes are heated at a temperature of about 450° to 600°C in the absence of oxygen and broken down to simpler substances forming oils, carbon after condensation. The pyrolysis oil is being termed as Petro Alternate Fuel (PAF), which can be used in industrial boilers, generators, or can be further refined into diesel. The process of pyrolysis has been shown in Fig. 5.8 and the 20 kg/batch pyrolysis plant developed by CSIR-CMERI has been shown in Fig. 5.9.



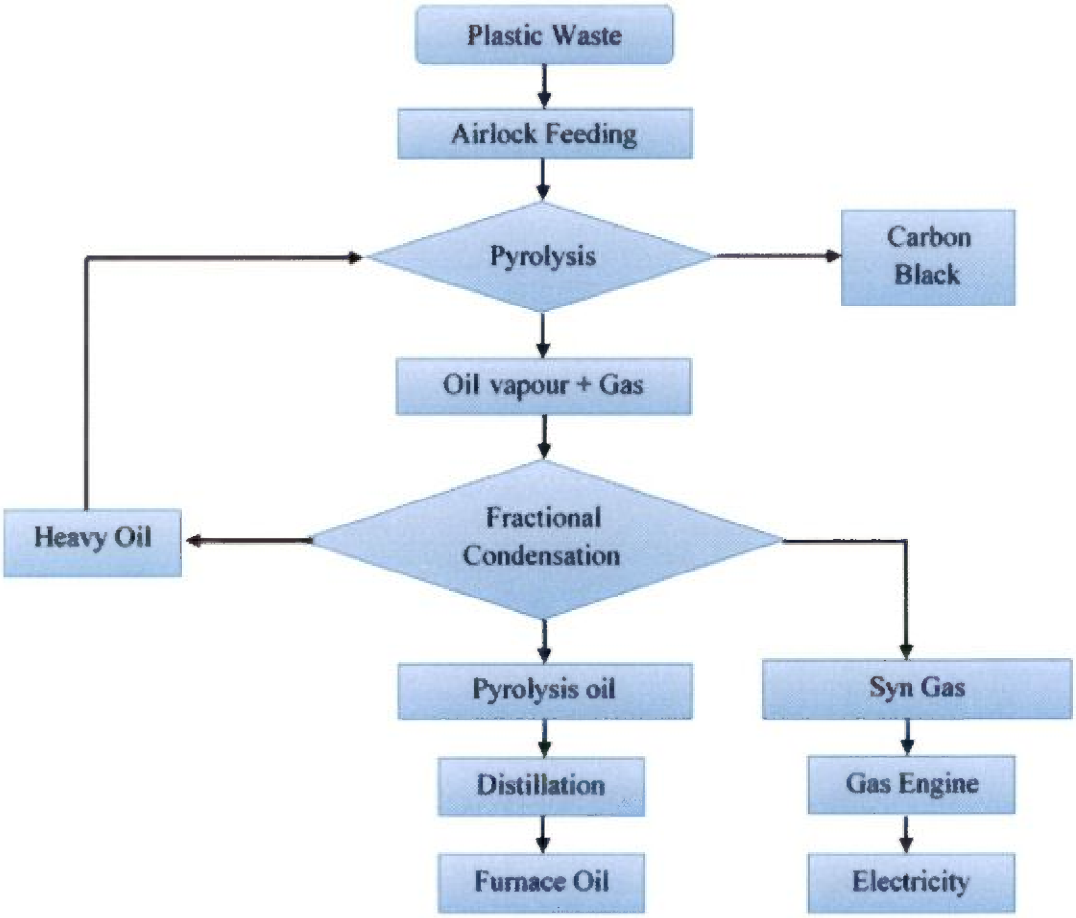


Fig 5.8: Schematic Process Layout for Plastic Pyrolysis

Fig 5.9: Polymer Waste Pyrolysis Unit at CSIR-CMERI (Capacity: 20 kg/batch)

The major components of the polymer waste pyrolysis plant include the following:

i) Reactor

The reactor is the heart of the pyrolysis system. It consists of a reaction vessel and a furnace which is insulated on the outside with ceramic wool and cladded. The heating system consists of an oil purification unit, oil pumping unit and monoblock burners for oil and gas.

The reactor is fed with raw material and catalyst mixed in a certain proportion.

The furnace is heated so that the temperature inside the reactor is in a temperature range where catalytic decomposition takes place depending on various feedstocks. The reactor also has the provision for nitrogen purging to create inert environment to allow the process to happen in the absence of oxygen.

ii) Gas Receiver

The syngas from the catalytic degradation comes out of the reactor and is cleaned using a receiver where the heavier carbon particles and long chain hydrocarbons condense and flow back to the reactor and the lighter fraction is taken to the multi-layer catalytic tower. The syngas velocity also decreases in the cyclone due to which the gas gets more residence time in the catalytic tower and subsequent line.

iii) Catalytic Tower

The catalytic tower is used to purify the syngas using catalyst in the vapour phase. Unwanted components like H_2S, SO_X, NO_X etc. can be removed using appropriate catalyst, if required.

iv) Condenser

Shell and tube condenser is used to cool the syngas from the reactor to liquid Petro alternate fuel.

v) Anti-Flashback Device

The uncondensed clean gas is then passed through a tank that is partially filled with water. The gas bubbles out to the next line of components. The water ensures that the gas that bubbles out cannot go back to the previous line of components.

vi) Scrubber

The gas and oil after getting fired in the furnace is cleaned by passing it through a wet alkali packed bed scrubber. The flue gas is cleaned, cooled and filtered to remove the particulate matter from the flue gas.

vii) Chimney

The cooled flue gas is vented to the atmosphere through the chimney.

viii) Flaring System

It is dangerous to vent exhaust gas (C1 to C4) without any safety measures. In this process, it is transferred first through the safety device and then burnt in the burner or Flare system.

ix) Distillation

The same machine can be used to distill the Petro Alternate Fuel (PAF) to high quality diesel with some changes.

5.5.1 Advantages of polymer waste pyrolysis process

The pyrolysis system demonstrates:

• Stable operation for a broad range of waste quality;

• Emissions from the system are well below the limit values;

• Flexibility in design and operation achieved by a modular design;

• Effective initial waste volume reducing;

• Efficient recovery of the materials and energy from the process;

• Low operational costs; no supplementary external fuel supply for the normal operation, i.e. significant reduction of running costs.

The pyrolysis system is designed for treatment of variety of different wastes such as municipal solid waste (MSW), sewage and oil sludge, automotive shredder residuals (ASR or car fluff), e-waste, rubber and tyres, medical waste, plastics, agricultural waste, as well as cleaning of the contaminated soil. Dozens of the commercial pyrolysis facilities for treatment of different feedstocks were designed and built so far.

The pyrolysis facility can operate as stand-alone waste-to-energy plant as well as the part of big power plants. In the last case the pyrolysis process thermally treats the waste and generates fuel, namely pyrolysis gas and pyrolysis char. These fuels are then co-fired in the power plant boiler unit. Pyrolysis process in this configuration disposes waste, simultaneously replacing part of the fossil fuels, consumed by the power plant.

5.6 BIO-METHANATION FOR BIODEGRADABLE WASTE

The potential of kitchen wastes to be used as substrates for biogas production can achieve the goals of developing a sustainable technology for waste management, producing renewable energy and reducing greenhouse gas emissions. A complex microbiological process lies behind the efficient production of biogas. The organic waste treated in the biogas process represents the substrate for various microorganisms. The more varied the composition of the organic material, the more components are available for growth, and thus the greater diversity of organisms that can grow. The various microbial groups are involved in the flow of carbon from complex polymers to methane-based model. Biogas is a mixture of Methane, Carbon Dioxide, Water vapour, Ammonia etc. generated from the anaerobic digestion of biomass. The methane will be enriched through scrubbing the dust, CO_2. The enriched methane gas will be used as fuel gas for cooking purpose in the kitchen and also in fuel cell for generation of electricity. Moreover, after anaerobic digestion, the spent slurry becomes excellent organic manure which is highly rich in N P K content. This manure can be used in cultivation after drying. The process flow has been described in Figs. 5.10 & 5.11 and the 10 cu. m capacity biogas plant developed at CSIR-CMERI has been shown in Fig. 5.12

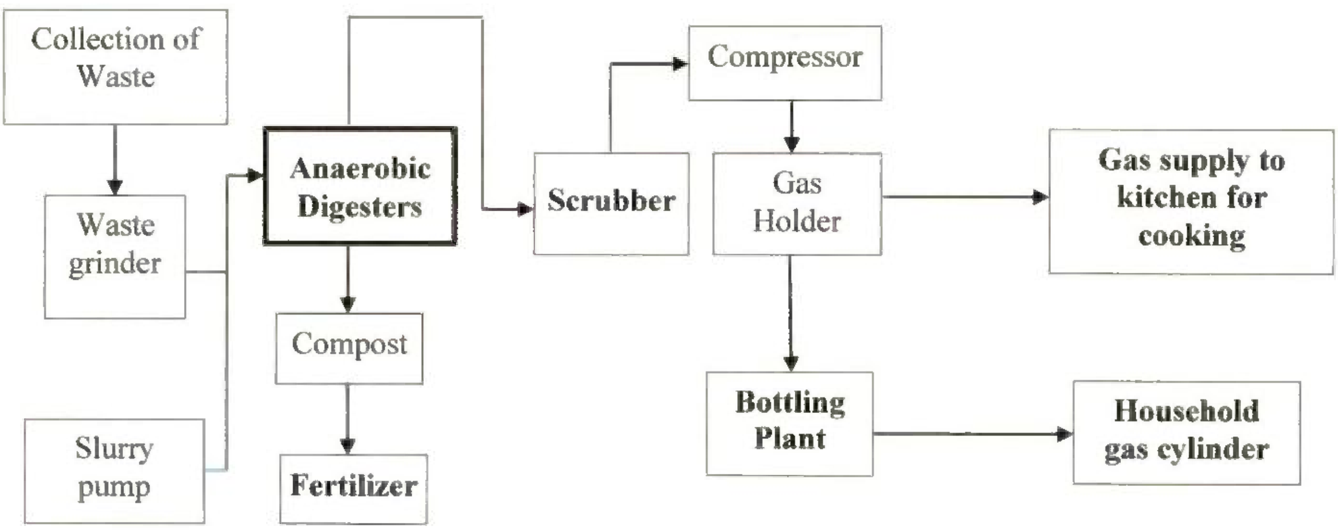


Fig 5.10: The Process Layout of Bio-methanation Unit

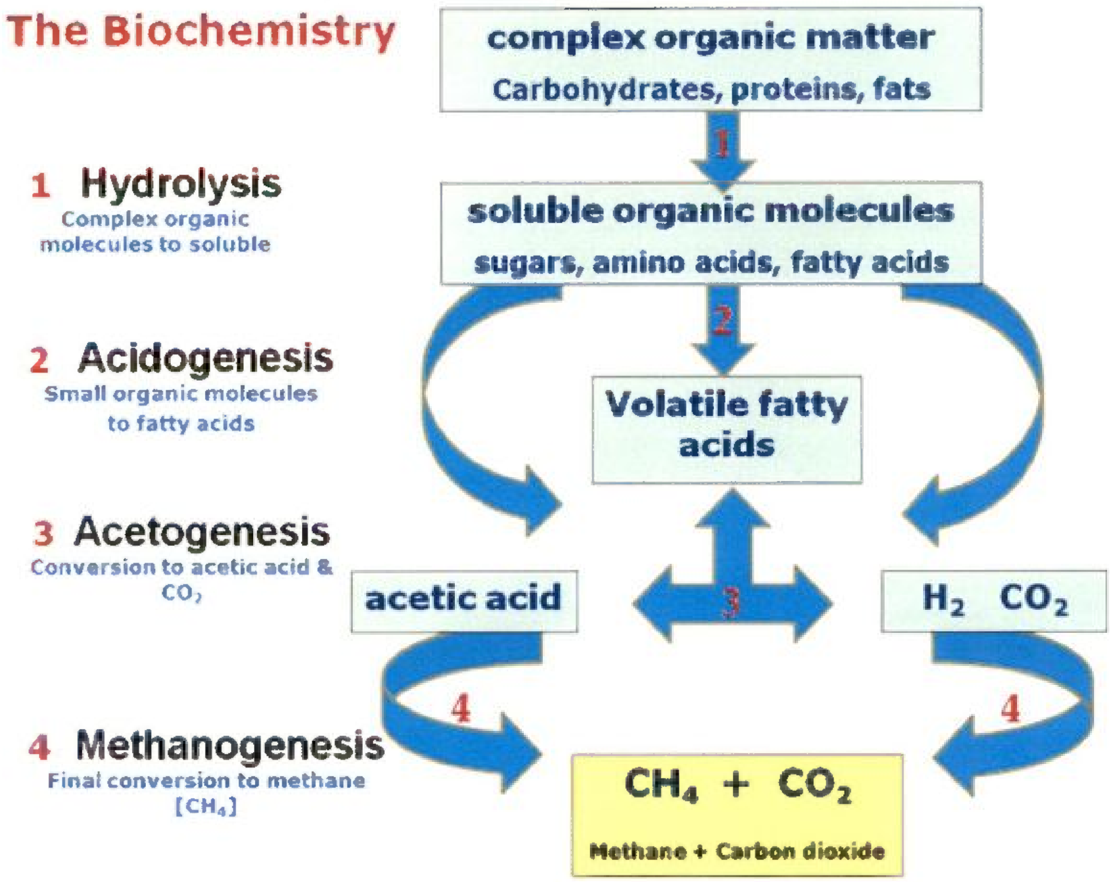


Fig. 5.11: The Anaerobic Digestion Process of Bio-Degradable Waste

Fig. 5.12: Bio-methanation Unit of 10 cum capacity at CSIR-CMERI

5.4 UTILIZATION OF CONSTRUCTION & DEMOLITION WASTE

Safe and effective disposal of solid waste is the greatest challenge of the era. The management of MSW is going through a critical phase, due to non-availability of suitable facilities to treat and dispose larger amount of MSW, generated daily in metropolitan cities. The major portion of the waste generated is the construction debris (C&D). The composition of C&D waste can vary depending on age of building being demolished / renovated or the type of buildings being constructed. C&D waste generation figures for any region fluctuate as it depends largely on the type and nature of construction / demolition activities.

The construction debris is collected and crushed into a crusher. Then different sized gravels which are coming out from the segregation unit are mixed with this slag. Then 10-15% cement is mixed with the materials for punning. Now, these materials are mixed thoroughly in a dry state for proper mixing. Water is added to the dry mixture in a suitable proportion. The prepared mixture is then filled in the die of a mould cavity. Then it is being pressed. Moulding gives a definite shape to the mixture. Finally, the prepared bricks are tested for engineering properties. The ready bricks are being used as construction materials. The process of brick making has been shown in Fig. 5.13 and the plant at CSIR-CMERI has been shown in Fig. 5.14

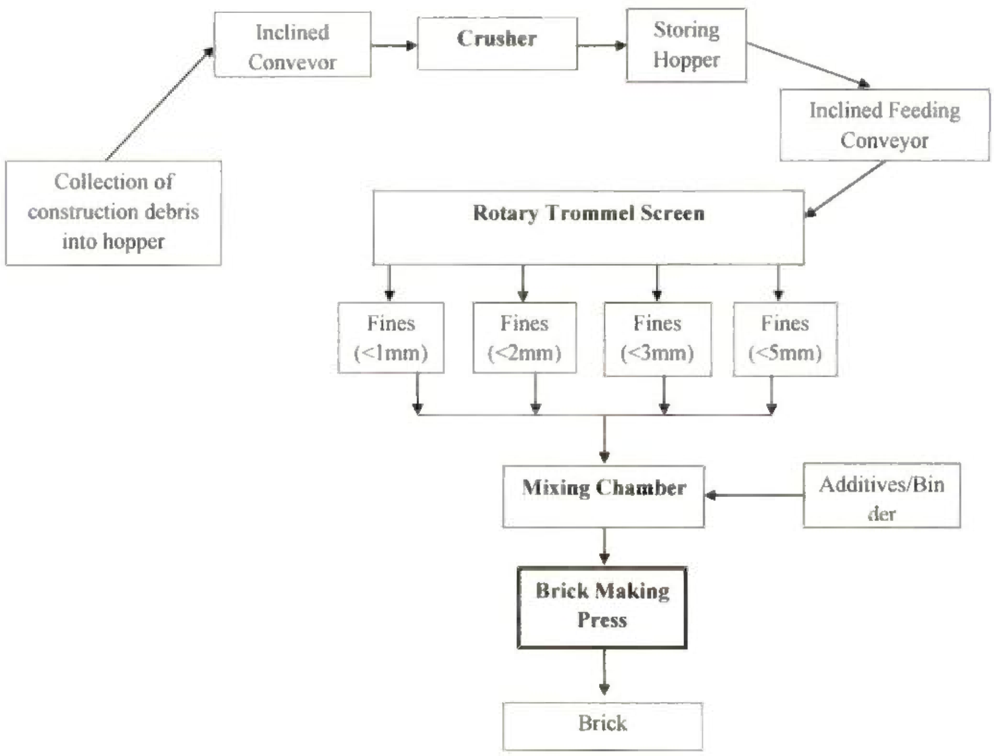


Fig. 5.13: Brick Making Process from Construction & Demolition Waste

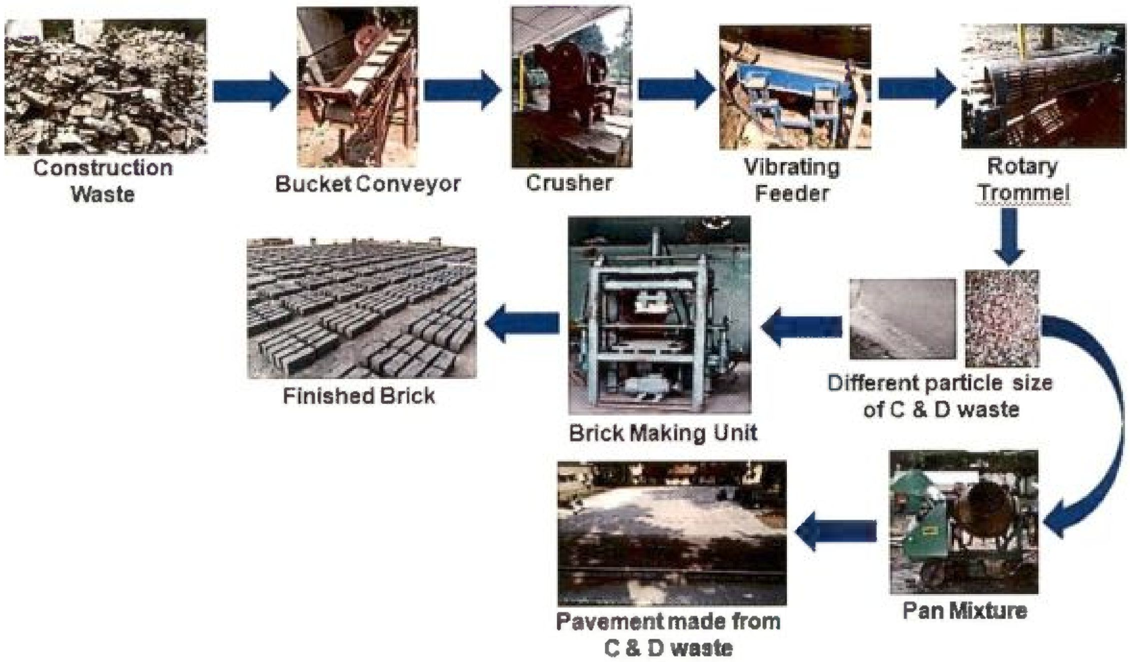


Fig 5.14: Utilization of Construction & Demolition Waste at CSIR-CMERI

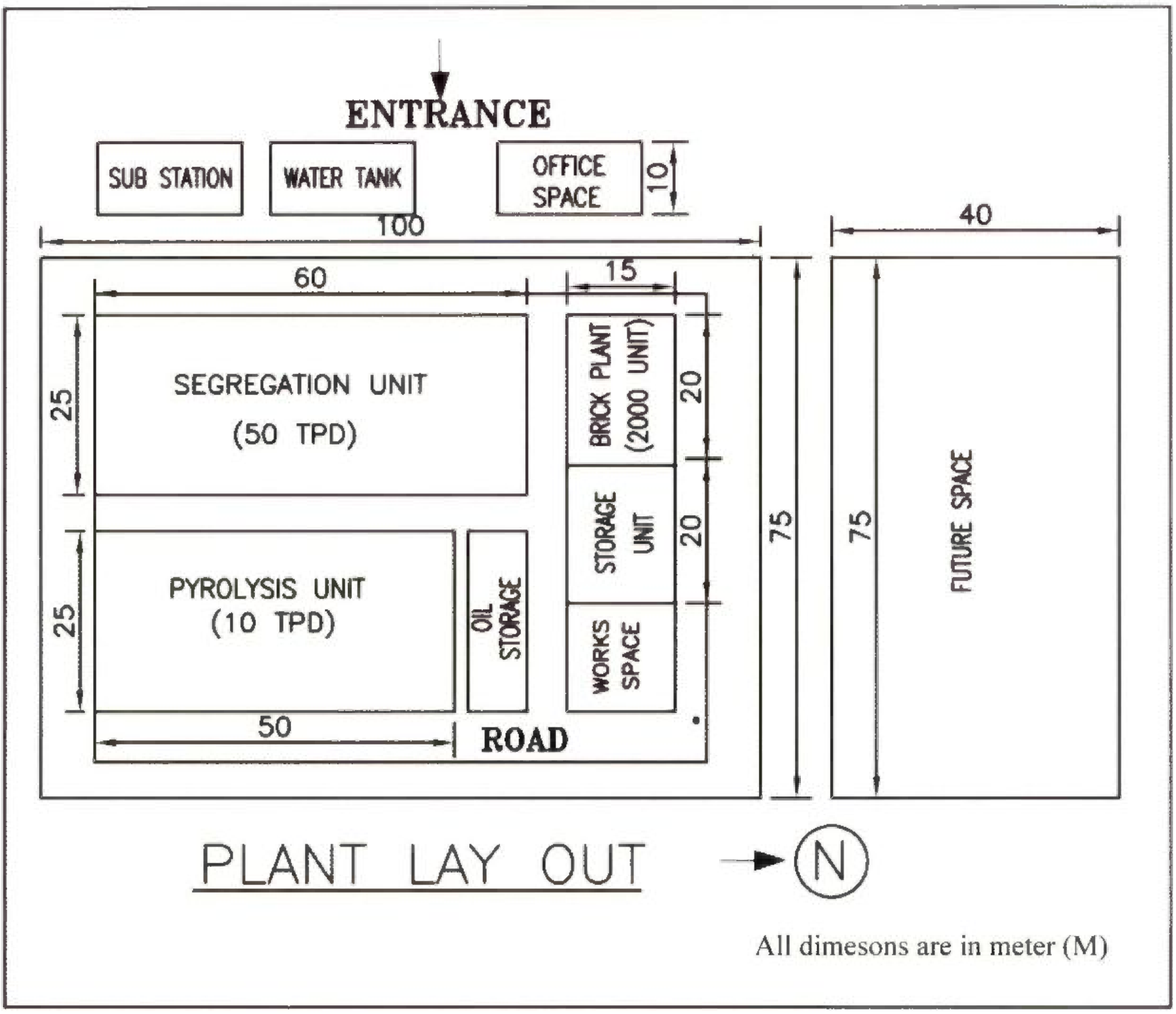
Advantages:

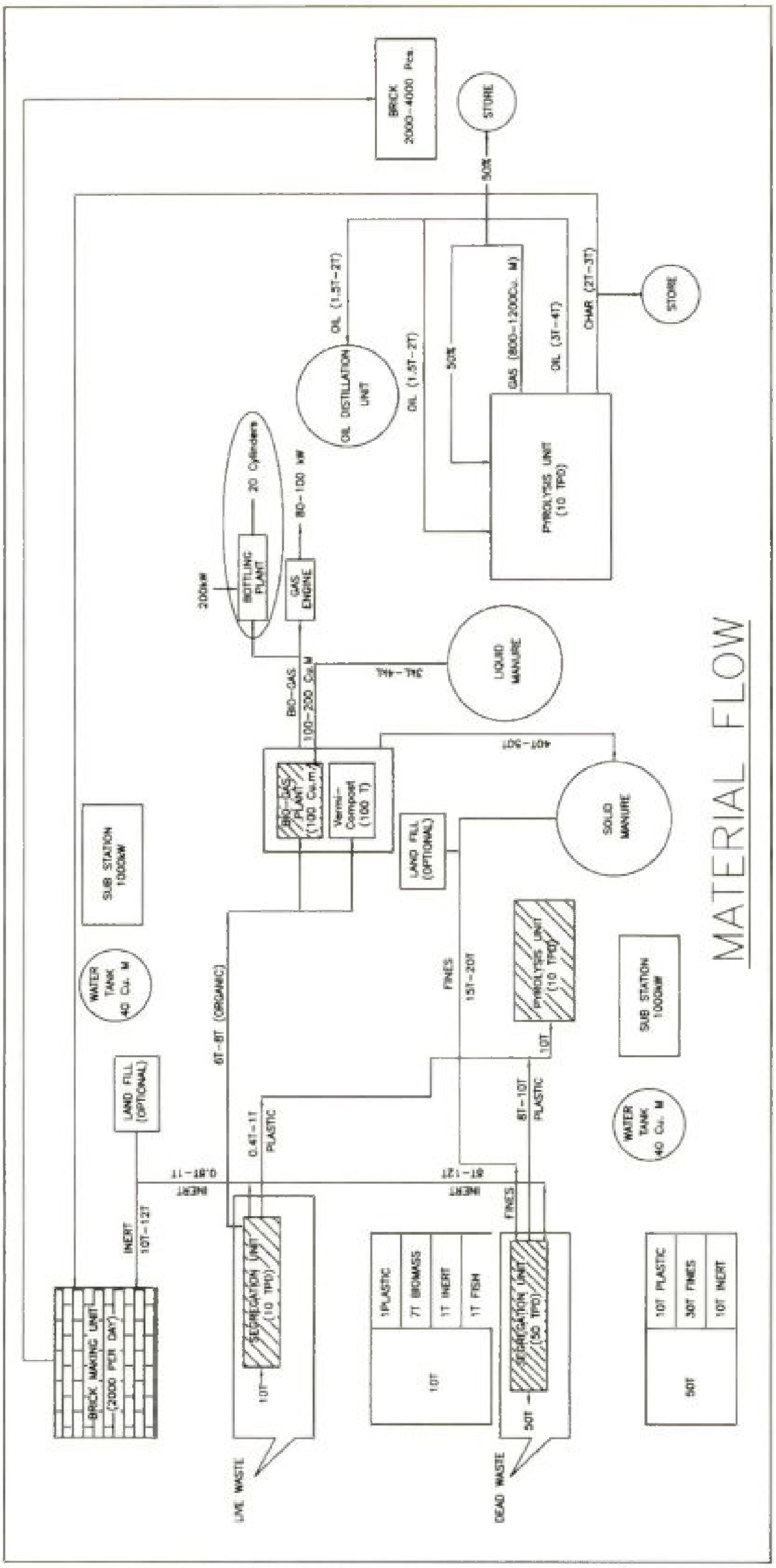
The advantages of the system are as follows

- Integrated & mechanized system for disposal of both bio-degradable & non-biodegradable waste;
- Eco-friendly disposal of municipal solid waste with zero level toxin emission;
- Utilization of generated bio-gas for house hold purpose in economic way;
- Utilization of organic manure generated from bio-methanation plant for agricultural purposes;
- Utilization of construction debris for generation of value added products.

CHAPTER 6
PROJECT DETAILS

6.1 Proposed plant layout for disposal of 50 TPD Dead MSW




MATERIAL FLOW
LIVE WASTE
DEAD WASTE
SEGREGATION UNIT (10 TPD)
SEGREGATION UNIT (50 TPD)
BRICK MAKING UNIT (2000 PER DAY)
BRICK 2000-4000 Pcs.
LAND FILL (OPTIONAL)
WATER TANK 40 Cu. M
SUB STATION 1000kW
BIO-GAS PLANT (100 Cu.m.)
Verni-Compost (100 T)
BIO-GAS 100-200 Cu.M
BOTTLING PLANT
GAS ENGINE
20 Cylinders
80-100 kW
200kW
LIQUID MANURE
SOLID MANURE
PYROLYSIS UNIT (10 TPD)
OIL DISTILLATION UNIT
STORE
OIL (1.5T-2T)
OIL (3T-4T)
CHAR (2T-3T)
GAS (800-1200Cu. M)
50%
6T-8T (ORGANIC)
0.4T-1T PLASTIC
8T-10T PLASTIC
INERT 10T-12T
INERT 0.8T-1T
INERT 6T-12T
FINES 15T-20T
40T-50T
10T
50T
1PLASTIC
7T BIOMASS
1T INERT
1T FISH
10T PLASTIC
30T FINES
10T INERT

6.2 Scope of work

6.2.1 Durgapur Municipal Corporation

- Providing land (100 m×75 m) with boundary wall for establishing set-up of Municipal Solid Waste disposal system (Perimeter: 350 m & Height: 2 m);
- Development of space including dismantling of the existing plant, in case the proposed site is not acquired for commencement of the project;
- Approach road for the site;
- Collection of waste from different sites under DMC and providing them at the proposed site;
- Sale of by-products consisting of pyrolysis oil and char from polymer waste pyrolysis plant;
- Sale of recyclables consisting of metals from segregated dead waste;
- Necessary electrical connection up to substation at site for operation of plant;
- Necessary water connection up to tank at site;
- Providing electricity and water for running the plant at no cost;
- Insurance of movable & immovable properties;

6.2.2 CSIR-Central Mechanical Engineering Research Institute

- Necessary civil and electrical works at the proposed site for installation of 50 TPD Integrated Municipal Solid Waste Disposal system for Dead Waste
- Design, development, installation & commissioning of 50 TPD mechanized segregation system to segregate Municipal Solid Waste
- Design, development, installation & commissioning of 10 TPD Polymer waste pyrolysis plant for further processing of polymer waste from segregation plant
- Design, development, installation & commissioning of 2000 brick/day brick plant
- After commissioning, Operation & Maintenance for subsequent two (2) years, renewed annually.

6.3 Duration of the Project:

The entire project will be implemented in eighteen months (1.5 year) from the date of handover of site and completion of civil and electrical work.

A. The proposed activities are:

Sl. No.	Item	Type	Capacity	Qty
1	Preparation of site including necessary civil and electrical works	-	-	As per approved drawing
2	Segregation system	Dead Waste	50 TPD	1 No.
3	Pyrolysis plant	Polymer waste	10 TPD	1 No.
4	Brick Plant	Inert/Construction Debris	2000/day	1 No.

6.4 Milestone Activities & Duration:

Sl. No.	Activities Description	0-3 months	3-6 months	6-9 months	9-12 months	12-15 months	15-18 months		18-30 months	30-42 months
1	**Handover of proposed site after Site Clearance (scope of DMC)**							Handing Over	Operation & Maintenance	
2	Necessary civil, Structural and electrical works									
3	Desing & Engineering									
4	Purchase & Procurement									
5	Fabrication of Equipment									
6	Installation of Segregation Unit (50TPD-Dead)									
7	Installation of Pyrolysis Plant (10TPD)									
8	Installation of Brick Plant (2000 nos/day)									
9	Trial Run & Commissioning									

6.5 Estimated Cost: (INR in Lakh)

Capital Expenditure (A)

➢ **Option-1: Considering procurement of vehicles under the scope of CMERI**

Sl	Description	INR in Lakh	Remarks
1	Works & Services (incl. solar roof)	800	
2	Equipment	1,675	Annexure-A
	GST (@18%)	446	
	Sub-Total (A)	**2,921**	

➢ **Option-2: Considering procurement of vehicles under the scope of DMC**

Sl	Description	INR in Lakh	Remarks
1	Works & Services (incl. solar roof)	800	
2	Equipment	1,550	Annexure-A
	GST (@18%)	423	
	Sub-Total (A)	**2,773**	

Recurring Cost / per year (B)

Sl	Description	INR in Lakh	Remarks
a	Chemicals & Consumables	30	
b	Other Res. Expenditure	75	
c	Manpower	75	
d	Contingencies	10	
	Sub-total	**190**	

6.6 Cost Benefit Analysis

Total Waste: 50 TPD (Dead waste)

Economic life span of the plant: 15 years

A. Capital Cost

➢ **Option-1: Considering procurement, operation and maintenance of vehicles under the scope of CMERI**

Sl No	Description	Size / Capacity	INR in Lakh	Remarks
a	Land	7,500 sq. m	-	To be provided by DMC at no cost
b	Plant and Equipment			
i	Segregation plant	50 TPD Dead waste	1000	
ii	Pyrolysis Plant	10 TPD	400	
iii	Brick Making Plant	2000 Bricks × 1 Nos.	150	
iv	Vehicles for operation	Tractor – 6 Nos. JCB – 3 Nos. Office Vehicle- 1No.	125	
v	Civil, Structural & Electrical Works	As required	600	
vi	Solar Installation		200	
	Sub-total		**2,475**	

➢ **Option-2: Considering procurement, operation and maintenance of vehicles under the scope of DMC**

Sl No	Description	Size / Capacity	INR in Lakh	Remarks
a	Land	7,500 sq. m	-	To be provided by DMC at no cost
b	Plant and Equipment			
i	Segregation plant	50 TPD Dead waste	1000	
ii	Pyrolysis Plant	10 TPD	400	
iii	Brick Making Plant	2000 Bricks × 1 Nos.	150	
iv	Vehicles for operation	Tractor – 6 Nos. JCB – 3 Nos. Office Vehicle- 1No.	--	To be provided by DMC
v	Civil, Structural & Electrical Works	As required	600	
vi	Solar Installation		200	
	Sub-total		**2,350**	

A. Recurring Cost / per year

Sl	Description	INR in Lakh	Remarks
a	Chemicals & Consumables	30	Annexure-B
b	Other Res. Expenditure	75	Annexure-C
c	Manpower	75	Annexure-D
d	Contingencies	10	
	Sub-total	**190**	

B. Cash Flow / per year

Sl	Description	Unit/Nos.	Revenue/Yr (INR in Lakh)	Remarks
a	Pyrolysis plant	2	200	Annexure-E
b	Recyclables & Fines	1	40	Annexure-F
	Subtotal		**240**	

Annexure-A

Budget for Permanent Equipment

- **Option-1:**

Sl.	Description	Size / Capacity	Amount (₹ in Lakh)
1	Segregation Plant	50 TPD Dead waste	1000
2	Pyrolysis Plant	10 TPD Polymer waste	400
3	Brick Making Plant	2000 Nos/day	150
4	Vehicles for operation at site	Tractor – 06 Nos. JCB – 03 Nos. Office Vehicle- 1No.	125
		Total	**1,675**

- **Option-2:**

Sl.	Description	Size / Capacity	Amount (₹ in Lakh)
1	Segregation Plant	50 TPD Dead waste	1000
2	Pyrolysis Plant	10 TPD Polymer waste	400
3	Brick Making Plant	2000 Nos/day	150
4	Vehicles for operation at site	Tractor – 06 Nos. JCB – 03 Nos. Office Vehicle- 1No.	--
		Total	**1,550**

Annexure-B

Budget for Chemicals & Consumables

Sl.	Component	Amount (₹ in Lakh)
1	Fuel (Diesel)	20
2	Utilities, Consumables & Miscellaneous Supplies	10
	Total	**30**

Annexure-C

Budget for Other Research Expenditure

Sl.	Component	Amount (₹ in Lakh)
1	Repair and Maintenance of plant machinery	35
2	Plant and Office Running Expenses	5
4	Quality check	5
5	Miscellaneous	5
6	TA/DA	25
	Total	**75**

Annexure-D

Budget for Manpower

Sl.	Position	Nos.	Salary	Amount
1	Supervisor	2	20,000	40,000
2	Operator	8	20,000	1,60,000
3	Mechanic	2	15,000	30,000
4	Helper	4	10,000	40,000
5	Tractor Driver	4	15,000	60,000
6	Security Guard	2	10,000	20,000
7	Unskilled Labour	15	10,000	1,50,000
			Sub Total	5,00,000
			Overhead @ 25%	1,25,000
			Total (per month)	6,25,000
				75,00,000

Annexure-E

Revenue Generation from Pyrolysis Plant (10 Ton/day)

Sl	Description	Quantity/ day (kg)	Annual Quantity (ton)	Price (₹)/kg	Annual (₹)
1	Fuel oil (20% yield)	2,000	600	30	1,80,00,000
2	Carbon (25% yield)	2,500	750	3	22,50,000
3	Gas (30-40%)				
				Total Sale (₹)	**2,02,50,000**

Annexure-F

Revenue Generation from sale of recyclable items

Sl	Parameter	Average %	Quantity in TPD	Unit rate/ ton	Per annum
1	Metals, Glass	1.0%	0.2	20,000	6,00,000

Revenue Generation from fines

Sl	Item	Rate (₹)	Production/day	Amount/day (₹)	Amount/yr (₹)
1	Fines	1/kg	10,000	2,000	30,00,000

Tangible Benefits for DMC:

- Treatment of 50 TPD MSW leading to Clean City
- Recovery of Land: 1.0 acre/year (if no further dumping is ensured)
- Revenue Generation from Treatment of MSW

Sl. No.	Revenue	Unit/Nos	Revenue/Unit (Rs in Cr)	Revenue/ Yr (Rs in Cr)
1	Pyrolysis Plant	1	2.0	2.0
2	Recyclable, Fines		0.4	0.4
			Total	2.4

- Employment Generation

Sl. No.	Item	Nos.
1	Direct Manpower in operation of Plant	40
2	Downstream Employment for selling of By-Product	10
	Total	50