Solid Waste Management in Kottayam Town

Project No.195 / 99

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INTRODUCTION AND OBJECTIVES OF THE STUDY

Kottayam Municipality is a town located in the south central part of Kerala state. It has more than fifteen thousand families as residents and a host of business and office / bank establishments and educational institutions. It is the head quarters of Kottayam District; hence it has a large floating population also. As a result of all these factors, a lot of solid waste is generated in the town.

The solid waste being generated is now dumped in a yard at Vadavathoor, about five kilometers from the heart of the town. During the 1950s and the '60s the yard was used as a compost-manufacturing yard, since at that time the solid waste contained only organic, putreceable matter. But later on, as a result of the change in the contents of the waste, composting became difficult and no effective processing was introduced, resulting in just dumping of the waste. At times the garbage is burnt, resulting in the pollution of the surrounding areas. So it is clear that the existing system of solid waste management is totally unscientific and unhygienic.

The system of collection of waste itself is not efficient. This old town has comparatively narrow roads and lanes. The Municipality has arranged to collect the waste with the help of community bins. As the number of bins is insufficient and not properly located, the wastes get scattered and also remains in the open for days. The situation creates pollution and a lot of inconvenience to the public. The situation is conducive for the spreading of various diseases.

The authorities do think of various ways to tackle the problem, but lack of an effective system based on the conditions prevailing in the town, is a real handicap. No measure has been taken to revamp the whole system of Solid Waste Management. The project now conducted provides information and suggestions for establishing an effective Solid Waste Management system for Kottayam town. A scheme for the processing of the solid waste can also be drafted out from the findings of the study done. If the authorities take a bold decision, the problem of waste management can be solved with the help of the public. The processing can also generate very useful products, especially organic fertilizer for agriculture, in the form of compost.

OBJECTIVES OF THE STUDY

1. To assess qualitatively and quantitatively the solid waste being generated in the town.

2. To examine the existing system of solid waste management, in large and small quantities – their merits and demerits.

3. To conduct studies on possible solid waste disposal systems – with special emphasis on recycling or conversion into useful products, in a small scale, locally.

4. To create awareness among the residents to process the waste locally itself, forming local self-help groups, if possible.

5. To establish pilot projects for the local level management of solid wastes.

6. To conduct studies on the use of earthworms for vermicomposting.

7. To make studies on the adaptation and the required conditions for the various worms for use in vermicomposting.

8. To examine the possibilities of recycling of wastes like plastics, glass, metals, etc.

Workshop on Research Methodology

The *Kerala Research Program on Local Development* held a four-day workshop on Research Methodology from 3rd to 6th September 1999. Attending the Workshop on Research Methodology had been a very informative and supporting experience for the subscribers like myself who were not properly exposed before, to socio-economic research methodology. The sessions gave sufficient knowledge on collection of data, analysis of data and the conclusions to be drawn from them [1, 2, 3]. Thanks to this program, the procedure for the research project could be efficiently drawn up.

The Research Project Work started in September 1999. The studies mostly progressed steadily. But, cooperation from the municipal officials was much less than expected; hence in the initial stages there was great difficulty for secondary data collection. Then, we conducted personal interactions with the authorities and also with the public, thereby winning their confidence to support the study.

During the studies, we have observed that a few people were non-cooperative; this may be due to ignorance about the project. Majority of the population expect that the results of the research work would be utilized effectively. The public does feel the need for a sustainable, viable and effective system for the management of the solid wastes in the town. They are ready to put in their maximum cooperation, in this regard.

It also became clear from the interaction with the people that they have no clear idea on how the wastes are to be processed, either on a small scale or on a large scale. Therefore, we feel the dire need to provide awareness, and even training to the people on the various scientific and effective processes of solid waste management. The data collected during the project has also indicated the need for such an integrated management system.

METHODS USED IN THE STUDY

The project "Solid Waste Management in Kottayam Town" was done in two phases.

Phase I consisted of a detailed study for assessing the **quality** and **quantity** of solid wastes generated in Kottayam Town [12, 13, 25, 35,36,37].

Phase II was an Action Research for the disposal of the solid waste by way of processing, recycling / reuse, at local level without the need for transportation and massive disposal [9, 10, 11, 14, 16, 17, 19, 21, 22, 34].

To avoid delay in studies, both phases were being carried out simultaneously.

PHASE I

Phase I of the project consisted of the following studies:

(a) Collection of Secondary Data from the Municipal Office, related to the total wastes being generated, the variety of wastes, the method of disposal, and the problems faced.

(b) Collection of primary data on the quantity of solid wastes generated from various sources through the statistical sampling technique; the sources included houses, hotels, hospitals, hostels, business establishments, markets, workshops, etc.

(c) Primary data on the existing disposal methods.

(d) Classification of wastes based on the primary data to enable the study of most effective methods for disposal of the wastes, or conversion into useful products, including methods of recycling.

PHASE II

The Phase contained the following:

(a) Awareness campaigns regarding the local level processing of wastes.

(b) Experiments on the recycling of plastics – types of plastics and experiments on the miscibility of plastics and hence the recycling into new products.

(c) Vermicomposting experiments using various varieties of earthworms to study their ability and to determine the conditions required for efficient vermicomposting.

(d) Establish "local level solid waste processing units" on an experimental basis for vermicomposting.

FINDINGS AND OBSERVATIONS

PHASE I

The existing Secondary data were obtained from the Municipal Office, Health Inspectors, Municipal Ward Councilors, and the Personnel-in-Charge of NIRMAL-2000, the district project of Kerala Health, Hygiene and Sanitation Mission.

To obtain the details of the wastes being generated, the following information were collected and consolidated:

(1) Total area of the Town **: 16.44 sq. km**

(2) Total Population **: 63,155**

(3) Density of population **: 3,841 / sq.km.**

(4) Total number of houses **: 15,322**

(5) Residential area : 90%
Commercial and industrial area : 10%

(6) Computed total waste generated as per the Municipal records:

(i) Domestic : 28.00 tons

(ii) Commercial (Market) : 9.00 tons

(iii) Hospital and Clinics : 2.00 tons

Total : 39.00 tons

The data obtained on the total waste generated is only an approximation, which was used for various purposes by the Municipality. The officials themselves did not accept this as reliable information. Hence, the data on the solid waste are not accepted. In addition, according to the new approach in solid waste management the classification is to be based on the processing technique to be employed.

TABLE I

Kottayam Municipal Area

Wards, Number of Houses and Population

Ward No.	Name of Ward	No.of houses	Population
1	Eranjal	370	2620
2	Manganam	360	1664
3	Devalokam	515	2323
4	Kanjikuzhy	526	2222
5	Muttambalam	538	2577
6	Holy Family	648	3371
7	Convent	429	2264
8	Railway station	518	1995
9	Hospital	605	1683
10	Civil station	524	1465
11	M.D.Seminary	618	1543
12	Cathedral	518	1370
13	Kodimatha	475	1477
14	Vayaskara	494	1654
15	Union Club	495	1332
16	Nagampadam	516	2019
17	Thirunakkara	600	1915
18	Kurisupally	406	980
19	Pazhaya Seminary	537	1569
20	Thaliyilkotta	461	1610
21	Thirumala	350	1351
22	Valiyakunnumpuram	401	1862
23	Puthenangadi	458	2012
24	Boay Jetty	440	1849
25	Sastam Kovil	374	2292
26	Ambalakkadavu	504	2419
27	Thazhathangady	427	2538
28	Karapuzha	419	2877
29	Pulinakkal	357	1130
30	Veloor	485	2137
31	Parappadom	557	2275
32	Kanjiram	397	2760
	Total	**15322**	**63155**

Institutions and establishments in the town also generate the solid wastes. The quantity and quality of solid wastes generated by these establishments has also been assessed. For this purpose, we collected the details of existing establishments. The details of the establishments are provided in TABLE II. The data were collected from representative establishments according to statistical sampling methods: three to four percent of each category was taken up for collecting data.

TABLE II

Kottayam Municipal Area

Details of Business Establishments and Industries

Sl.No.	**Type of establishment**	**Total No.**
1	Bakery	296
2	Provision stores	408
3	Medical Stores	152
4	Petty shops	250
5	(a) Factory, (b) Flour mill, (c) Printing press	296
6	Beauty parlor	57
7	Cold storage, chicken sellers	123
8	Workshops	295
9	Stationery	383
10	Textiles	288
11	Hotels	265
12	Hardware	855
13	Lodge	79
14	Jewelers	34
15	Photo Studios	24
16	Vegetables & Fruits	132
17	Theatres	6
18	Dairy (*Chapra*)	6
19	Hospitals & Clinics	14
	Total	**3963**

In addition, there are hostels belonging to two colleges and boarding houses for six schools. There are seven ladies' hostels also.

Observations on the difficulties of collection of solid wastes

The existing system of Solid Waste Management necessitates an efficient system for collection of wastes from every nook and corner of the town [10, 11, 12]. The interaction with the Health Inspectors revealed some important difficulties faced in the collection of the solid wastes. One most important specific problem being observed is that of the roads, lanes and gullies. Due to the special conditions of these, the collection of the wastes is very difficult. Hence we had to look into this aspect of the problem. This led to a study on the details of the existing **roads**. TABLE III provides the details of the roads in Kottayam town.

The second hindrance pointed out by the health staff was topographical feature of the town. Hence, this was also considered. Therefore, a relief map of the town had to be prepared.
(Appendix 1)

Existing system of Solid Waste Management

The total quality of solid waste generated, according to the municipal records is given as:

1. Domestic : 28.00 tons
2. Commercial - market : 9.00 tons
3. Hospitals and Clinics : 2.00 tons

Total : 39.00 tons

Combined per capita generation ~ 0.62 kg/ head.

The classification of wastes into the above three varieties, still in records, is based on the older concept of collection and dispersal in the dump yard – a concept developed in the 1940s and 50s. At that time, there had been no problem of plastic wastes. Even now, there is found to be no plans for recycling or reuse of wastes, except for some rag pickers. Hence, we felt the need for a thorough study to ascertain the wastes with view to recycle, reprocess or reuse. The classification should be based on this aim. Therefore, wastes were classified into various types based on this concept.

The collection and disposal system of the Municipality

Municipality practices communal storage for collection and disposal; the infra structure consists of:

(a) 64 numbers of concrete / metal bins of 0.4 cubic metre size
(b) 14 numbers of metal dumpers of capacity approximately 2 cubic metres
(c) Old lorries : 2
(d) Tractors : 2
(e) Tripper lorries : 2
(f) Dumper placers : 2

The manpower in the health department:

(a) Sweepers : 69
(b) Sanitation workers : 69
(c) Drivers : 5
(d) Helpers : 1

Additional temporary workers (CLR workers) are engaged on daily wages according to need.

(Junior Health Inspectors, Health Inspectors and Health Officers are the personnel in charge).

The expenditure for the solid waste management (1997 – '98): Rs. 1.88 crores (40% of the revenue expenditure).

The storage capacity of community bins is grossly inadequate - fly tripping and open throwing is very common.

Solid wastes from large hotels in the center of the town are collected directly by the workers.

Primary collection vehicles employed are box type handcarts with two number crew; tractors with trailer, or trucks are used for transportation to the dumping site.

Most of the metal tanks / metal bins are now damaged / rusted. Many have been removed from their locations due to complaints of the public or due to some other inconvenience.

There are only open roadside transfer stations; transfer is done manually.

Existing System of Disposal of Solid Waste

The solid wastes are dumped (said to be land filling!) in a site of 4.5 acres, about 5 kilometers away from the town, in the nearby panchayat; this will be set fire at times. Some rag pickers collect portions of the dumped wastes. There is no daily cover provided for the waste disposal.
There is complaint from the local people and the Panchayat authorities regarding the pollution caused by the dumping yard. Within a short time the protest can turn into direct action by the people against dumping of wastes.

OBSERVED AND EXPECTED CONSEQUENCES

Pollution: Soil, water and air get polluted, especially from the dumping area. Since the wastes are not cleared every day, even the collection bins become the center for pollution.

Diseases: Many bacterial and viral communicable diseases spread very easily; allergy related diseases are also on the increase.

Wastage: Reusable, recyclable and processable materials are wasted.

Hindrance to traffic: Due to the accumulated wastes on roads, traffic is affected – in the town roads are very narrow – pedestrians are the most affected due to lack of space.

The Packed wastes: Wastes packed in plastic carry bags are creating a lot of nuisance. These get scattered and also block drainages.

The mixed up wastes: In the early days of the municipality (1940s to 1970s), the wastes were practically putreciable only, which were converted into compost and was sold to farmers. But now the solid waste collected contains putreciable materials, plastics, paper, glass, metals, construction materials, etc., which makes classical composting practically impossible.

Condition of the roads: Most of the roads are very narrow; so, even placing bins for waste collection is not practicable. As a result, effective collection of wastes does not take place in most of the regions. The Health Inspectors express their helplessness in this regard.

Relief of the town: The town has high hills and very low lands – this makes the roads to have ups and downs - the steepness of the roads also create difficulty in the collection and transportation of wastes.

Study on details of the roads in Kottayam Town

Observing that the road conditions play a very important role in the collection and transportation of solid wastes, it was decided to have a clearer picture of the roads in the town with special reference on the width.

TABLE III A and TABLE III B provide the details on the nature of majority of roads in Kottayam.

TABLE III -

Kottayam Municipal Area.

DETAILS OF ROADS

1) National Highways	**: Nil.**
2) State Highways (M.C. Road)	**: 3.9 km.**
3) Main District Roads (PWD)	**: 3.7 km.**
4) Other District Roads (PWD)	**: 33.5 km.**
Total	**: 41.1 km.**

The PWD roads have widths from 10 to 20 meters only.

TABLE III B. Breadth wise distribution of Municipal roads, along with their average lengths.

Breadth of road/lane (m)	**Number**	**Total length (m)**	**Average length (m)**
13	1	300	300
12-13	nil	-	-
11-12	2	400	200
10-11	2	1,163	581.5
9-10	7	1,917	274
8-9	8	1,717	215
7-8	8	1,737	217
6-7	22	7,472	340
5-6	48	133,291	2777
4-5	126	29,754	236
3-4	187	32,729	175
2-3	128	13,122	103
1-2	83	6,055	73
Grand Total	**622**	**229,157**	-
Total, less than 6m.wide	**572**	**214,931**	-
Total, less than 5m.wide	**524**	**81,640**	-

The residential houses are mainly located along the sides of these narrow roads / lanes having less than 5m width. Therefore, the collection by using the community collection spots cannot work effectively in the residential regions of the town. The residents carry the wastes to the waste bins placed in the broader roads, which are far away from the houses; this will create a tendency to pack the wastes in plastic carry bags. Also, the wastes are being thrown into any open space near the house.

Topography of the town

The town is situated in the middle belt and is hilly in character. The main roads are through the heights and much of the residential areas fall in the lower regions. Sometimes, the steepness will be about 10m against a length of 50m roads.

Narrowness and steepness of roads make the sweeping and collection of wastes, as well as transportation, very difficult. As a result, the municipal health workers are not covering most of the residential regions.
(Appendix 1).

PRIMARY DATA ON THE QUANTITY AND QUALITY OF WASTES BEING GENERATED.

The information being used by the municipal authorities, as in any other local government office, contains the total quantity of wastes, and probably a classification based on the general source; in this case, **domestic, market** and **hospital,** a classification of the 1940's and 50's. The wastes generated during those periods were *organic in nature* and hence *putreceable*.

But the past decade saw a total change in the quality as well as quantity of wastes. There had not been any effective study based on the various types of materials now being included in the municipal solid waste. The modern trend in solid waste management is that of **"4Rs"** – *Reduce, Reuse, Recycle and Reprocess* - and so the wastes are to be classified accordingly, on the basis of the expected method of management of the waste material itself. Hence, the waste processing should start with segregation at the point of origin; then the segregated wastes should, as much as possible, be processed there itself, or to be collected for processing elsewhere [9, 12, 25].

The data was, therefore, collected on the basis of classification considering the expected processing or recycling involved. Worldwide, various classifications are being used in the solid waste management [35, 36].

In our case also, we collected the data with maximum segregation. The various types are:

(1) Putreceable / organic,
(2) Paper,
(3) Plastics,
(4) Glass,
(5) Metals / metallic,
(6) Clothes, leather, wooden materials,
(7) Construction / demolition materials,
(8) Medicines, poisonous materials,
(9) Any other (to be specified).

(The questionnaire is attached, in which the above numbers are used as codes).

Data sheets were prepared for the collection of the data.

Information on the existing method of disposal was also being collected through the data sheets. The codes and the corresponding methods of disposal included are:

(1) Municipal waste bin / dust bin / dumper,
(2) Dumping into open area nearby,
(3) Using as manure or converting into manure,
(4) Land filling,
(5) Recycling, processing
(6) Burning / incineration,
(7) Dumping into nearby canal / stream, river
(8) Dumping into drainage,
(9) Burying (without purpose for converting into manure),
(10) Vermicomposting / composting,
(11) Used as fodder.

Personal opinion on the most effective solid waste management, class wise, was also included in the questionnaire.

PRIMARY DATA ON DOMESTIC SOLID WASTES

Type of sampling : Random, Cluster

Total Number of Houses : 15,322.

Number of Houses Sampled : 516.

Period of Measurement and Mode : One Week; Every Day.

Containers Provided : Four containers, for Putreceables, Paper, Plastic, and other recyclables.

[The total number of houses in the municipality is 15,322. A 3% sampling requires about 460 houses. For the sampling, geographically 292 clusters of 50 – 60 households were identified and numbered. Out of these 10 were selected at random for each group of wards 1-10, 11-21 and 22-32, the eastern, middle and western regions, taking the lots for 3, 4, and 3 clusters, respectively, in each region, which gave a total of 516 houses].

GENERATION OF DOMESTIC SOLID WASTES, PER DAY

(1) Organic, Putreceable Wastes	: 12.1 tons (84%)
(2) Paper and Packing Paper Materials	: 1.3 tons (9%)
(3) Plastics	: 0.7 ton (5%)
(4) Others	: 0.3 ton (2%)
TOTAL	**: 14.4 TONS**

EXISTING METHODS OF DISPOSAL OF DOMESTC WASTES

1. Depositing in the Municipal Waste Bins	: 3.8 tons (26.4%)
2. Dumping in Open spaces, including roadsides	: 3.6 tons (25.0%)
3. Used as Manure / Converted into Manure	: 1.1 tons (7.6%)
4. Land filling	: 0.5 ton (3.4%)
5. Used for Recycling, processing	: 0.9 ton (6.2%)
6. Burning	: 0.4 ton (2.8%)
7. Dumping in Rivers, Ponds and Canals	: 3.5 tons (24.3%)
8. Dumping into Drainages	: 0.5 ton (3.5%)
9. Burying	: 0.1 ton (0.7%)
10. Vermicomposting, composting	: TRACES ONLY.
11. Used as Fodder	: TRACES ONLY.

PRIMARY DATA ON SOLID WASTES FROM MARKETS

Total Number of Major Markets with slaughter house	:1 Only
Total Number of Minor Markets	:1 Only

GENERATION OF SOLID WASTES PER DAY

Major Market

Vegetable wastes	: 4.6 tons
Paper	: 0.5 ton
Plastic	: 0.2 ton
Slaughter house wastes	: 1.0 ton
Total	: 6.3 tons

Minor Market

Vegetable wastes	: 0.8 tons
Paper	: 0.3 ton
Plastic	: 0.2 ton
Total	: 1.3 tons

TOTAL from markets : 7.6 TONS

EXISTING METHODS OF DISPOSAL

There are two dumpers in the central market area and one in the other minor market. But the wastes get scattered all around. The waste is collected by the municipality sanitation workers, transported by trucks and dumped in the Dumping Yard. The collection is done during weekdays, but not every day, and no clearance done on holidays; sometimes for up to five days these remain in the dumper or on the roadside.

Municipal collection : 6.6 tons

The animal wastes (1 ton) are of two types: the ones used for further processing and the non-processable.

The skin (0.30 ton) is being sent for leather tanning, and the bones (0.35 ton) for making the fertilizer 'bone meal'; a total of 0.65 ton of the waste is reprocessed.

Used for processing : 0.65 ton

The remaining intestines and other wastes (0.35) are now being used as feed in pig farms.

Fodder : 0.35 ton

TOTAL : 7.6 tons

PRIMARY DATA ON SOLID WASTES FROM INSTITUTIONS AND BUSINESS ESTABLISHMENTS

There are 3963 institutional and business establishments in the town, (TABLE II). In addition, there is Government offices, banks, schools, colleges, and religious centers, like churches, temples, mosques, and halls. Most of the offices and banks now produce paper wastes, mainly due to the use of computers; their weight is small, but bulky in nature. Similarly, the shops selling provisions, stationery articles and household items also generate less massive but bulky paper and plastic packing materials. A good quantity of these is plastic coated paper, card or hard board.

The schools and colleges dispose off the waste in their own compounds. The wastes are mainly burnt, since these consist of paper, plastic and dry leaves. Laboratory chemicals generated in the college and higher secondary schools are drained indiscriminately into the drainages which sink into the soil or drains into the natural sources of water, which may even be used for drinking purpose.

Most of the hostels also dispose off their wastes in their own compounds. The same is true of school boarding houses also.

A very precarious spot of waste accumulation is the railway station. Plastic and paper are the main culprits. A part of the waste gets collected into the municipal collection system; the remaining gets dumped in the nearby wasteland.

PRIMARY DATA ON SOLID WASTES FROM ESTABLISHMENTS

Type of sampling : Random, category wise

Total Number of Establishments : 3963.

Number Sampled : 143

Period of Measurement and Mode : One Week; Every Day.

GENERATION OF SOLID WASTES, PER DAY

(1) Organic, Putreceable Wastes : 19.8 tons (64.7%)

(2) Paper and Packing Paper Materials : 3.3 tons (10.7%)

(3) Plastics : 1.9 ton (6.2%)

(4) Glass	: 0.9 ton (2.9%)
(5) Metals and metallic	: 2.2 tons (7.2%)
(6) Cloth, leather, etc.	: 0.8 ton (2.3%)
(7) Others	: 1.7 tons (5.5%)
TOTAL	**: 30.6 TONS PER DAY**

EXISTING METHODS OF DISPOSAL

1. Depositing in the Municipal Waste Bins	: 14.7 tons (48.0%)
2. Dumping in Open spaces, including roadsides	: 5.2 tons (17.0%)
3. Used as Manure / Converted into Manure	: 0.9 ton (2.9%)
4. Land filling	: 1.4 ton (4.6%)
5. Used for Recycling, processing, reprocessing	: 1.6 tons. (5.2%)
6. Burning	: 1.7 tons (5.5%)
7. Dumping in Rivers, Ponds and Canals	: 1.2 tons (3.9%)
8. Dumping into Drainages	: 0.8 ton (2.6%)
9. Burying	: 0.5 ton (1.6%)
10. Vermicomposting, composting	: TRACES ONLY.
11. Used as Fodder	: 2.6 tons (8.5%)

TOTAL QUANTITY OF WASTES FROM ALL SOURCES

(1) Organic, Putreceable Wastes	: 38.3 tons	(73%)
(2) Paper and Packing Paper Materials	: 5.4 tons	(10.2%)
(3) Plastics	: 3.0 ton	(5.8%)
(4) Glass	: 0.9 ton	(1.8%)
(5) Metals and metallic wastes	: 2.2 tons	(4.1%)
(6) Cloth, leather, etc.	: 0.8 ton	(1.5%)
(7) Others	: 1.7 tons	(3.3%)

GRAND TOTAL : 52.3 TONS PER DAY.

EXISTING METHODS OF DISPOSAL

1. Depositing in the Municipal Waste Bins	: 25.1 tons (49.9%)
2. Dumping in Open spaces, including roadsides	: 8.8 tons (16.7%)
3. Used as Manure / Converted into Manure	: 2.0 ton (3.8%)
4. Land filling	: 1.9 ton (3.6%)
5. Used for Recycling, reprocessing, processing	: 3.15 tons (4.7%)

6. Burning	: 2.1 tons (4.0%)
7. Dumping in Rivers, Ponds and Canals	: 4.7 tons (8.6%)
8. Dumping into Drainages	: 1.3 ton (2.5%)
9. Burying	: 0.6 ton (1.1%)
10. Vermicomposting	: TRACES ONLY.
11. Used as Fodder	: 2.95 tons (4.9%)
GRAND TOTAL	**: 52.3 TONS**

PHASE II

Phase II of the project, as proposed, consisted of the experiments related to the processing of the Solid Wastes in the beginning.

The solid wastes are to be effectively sorted out into different types, which can be processed, recycled, or disposed of by a single process.

There are various techniques or processing technologies available for the different kinds of wastes. But, there is a need to identify the most suitable one for the specific waste and for the location. The possibility of using the product obtained is also to be taken into account.

THE TESTS ON PROCESSING OF PLASTICS

The solid waste now very common in every area is the plastic. We normally consider plastic as a single entity, though a variety of observable forms are known.

Plastic materials are not easily degraded in the environment; at the same time they create environmental problems when thrown out into the soil or into the water sources. Burning of plastics is not suggested, since, if burnt, they produce poisonous gases, and many of them do not burn properly, also leaving behind harmful solid products. So the best way is to recycle the plastic materials.

When we consider the real situation, plastic materials are to be in cleaned form, and those plastics that can be remolded, may be mixed and collected together. The discussions with the public clearly exposed their inability in identifying the variety as in the scientific classification. This indicates the need to provide awareness to them, on the classification or grouping of plastics by providing the name of the source, like, ‘milk cover’, carry bags, water bottle, cover used for edible oils, bottles for edible oils, plastic cups, etc.

The polymers being used for various purposes are: high-density polythene, low-density polythene, polypropylene, polystyrene, polyvinyl chloride, polymethylmethacrylate, etc. To collect them in the respective group of the material will be very difficult. The general term 'Plastics' is used to describe materials composed of carbon chain macromolecules similar to cellulose (paper). Plastics are used for a variety of end uses. These include plastic carry bags, milk containers, water bottles, soft drink bottles, shampoo bottles, etc, as well as synthetic fabrics. TV and computer housings, furniture, automobile parts (including tires), and water resistant packing materials are also now made from long lasting plastic materials.

The effort to recycle plastics has taken on new dimensions in the 1990's. General estimations are that, in urban areas 80% of plastic come from residential sources, 20% from commercial and industrial sources. About 28% of plastics that are discarded are in durable products (appliances, furniture, etc.), about 25% are in unendurable products (plastics, cups, bags, etc….) and 45% are in containers and other packaging.

In the recycling process, plastics are typically chipped, washed, and heated to produce pellets or flakes that can be manufactured into secondary products.

Some mixed plastic items can be separated into their component resins, but in general, plastics must be separated before they are put into a secondary manufacturing process.

In India six plastics account for over 75% of all plastic sales. These are: low-density polyethylene (LDPE), polyvinyl chloride (PVC), high-density polyethylene (HDPC), polypropylene (PP), polystyrene (PS), and polyethylene-terephthalate (PET).

In the case of the plastic wastes, there is no method of separation, now. If plastics are to be recycled, each plastic must be separately collected, or those miscible plastics, which have nearby melting or softening temperatures may also be collected together. But the consumers cannot identify the very many plastic items. So we collected the common waste materials.

Altogether 40 samples could be obtained. The softening / melting temperatures (T_m) were found for these samples, by thermo gravimetric analysis (TG) combined with differential thermal analysis (DTA). The measurements were taken at Rubber Research Institute of India, Puthuppally, Kottayam.

Plastic wastes were collected in three sets depending on the physical similarity observed, and few samples from each set were used for the TG analysis. (Appendix 1).

Set 1

(1) Mineral water bottle	-	appendix 2.fig.1
(2) Disposable tumbler	-	appendix 2.fig.2
(3) Oil cans	-	appendix2.fig.3
(4) Container jar (pet jar)		
(5) Disposable Tiffin container		
(6) Tooth paste tube		
(7) Light shade		

Set 2

(1) Carry bag – thick white	-	appendix 2.fig.4
(2) Carry bag – thick red		
(3) Carry bag – thin black	-	appendix 2.fig.5
(4) Carry bag – thin green	-	appendix 2.fig.6
(5) Transparency sheet	-	appendix 2.fig.7

Set 3

(1) Lid of flask	-	appendix 2.fig.8
(2) ‘Ujala’ container	-	appendix 2fig.9
(3) Shampoo bottle	-	appendix 2.fig.10
(4) Edible oil (Parachute) container		
(5) Glycerin bottle		

The **thermo gravimetric analysis** data indicate the melting / softening temperature, T_m, of the samples and also the temperatures at which these burn out. The reprocessing can be carried out at a temperature close to T_m of the material. The T_m of plastics taken as samples from various groups are as given in Table IV:

TABLE IV

Sample material	Melting/softening temperature, T_m, degree Celsius	Fig. Number, Appendix 2.
Mineral water bottle	397	Fig.1
Disposable tumbler	320	Fig.2
Oil can	438	Fig.3
Carry bag - thick white	378	Fig.4
Carry bag - thin black	248	Fig.5
Carry bag - thin green	248	Fig.6
Transparency sheet	437	Fig.7
Lid of flask	440	Fig.8
'Ujala' container	450	Fig.9
Shampoo bottle	297	Fig.10

These figures clearly show the need for the collection of plastic materials separately. Those having nearby softening temperatures can be mixed together. For example, oil can, transparency sheet, and lid of flask and 'ujala' container can be mixed together; similarly mineral water bottle and carry bag - thick white - may be processed together.

The study also clearly indicates the need for identification marks to be included on plastic materials. In the developed countries the plastic materials are numbered according to the material.

The numbers, for example, can be given for the most common six polymers:

#1. Polyethylene terephthalate (PET)
#2. High-density polyethylene (HDPE)
#3. Polyvinyl chloride (PVC)
#4. Low-density polyethylene (LDPE)
#5. Polypropylene (PP)
#6. Polystyrene (PS).

If recycling of plastics is to be effectively carried out, the manufacturers should initially identify the material with the help of a similar scheme. The governments, both central and states, should enact laws for the introduction of the system. Re-cycling will then become easier and more effective.

Local governments and interested entrepreneurs or NGO's can develop and implement projects for the recycling of plastics. If the quantity obtained in one town is not sufficient for an economically viable processing unit, regional units can be set up for processing the plastics from four or five cities.

EXPERIMENTS IN VERMICOMPOSTING.

Drawing conclusions from literature, it is understood that vermicomposting can be of great importance in treating the decomposable organic / domestic wastes. Hence, experiments on the same are of prime importance; experiments were conducted to determine the adaptability of the available earthworms and to find out the possibility of any local species that can be used effectively for the composting.

In view of the magnitude of problem to be solved, I have made linkages with Department of Zoology, University of Agricultural Sciences, Gandhi Krishi Vignan Kendra Campus, Bangalore, and 'Association for Promotion of Organic Farming', Bangalore. The Department of Zoology, UAS, Bangalore has been doing pioneering research work on vermicomposting. Association for Promotion of Organic Farming is organizing seminars and symposia, and also publishing books, on organic farming for which vermicomposting plays a very vital role. I visited the

research center three times, in August, October and December 1999, to obtain practical experience in vermicomposting. Dr. Radha Kale and Dr. Kubra Bano are the pioneers in the field of vermicomposting; they were doing research work in this field from 1979 on wards.

Work done in vermicomposting

The experiments were conducted on the basis of the information gathered from literature and from observations (as trained by the experts). Five concrete tanks of 2'8" x 2'3" x 2' dimensions have been made for the vermicomposting experiments. About 100 animals of *Eudrilus Eugeniae* and *Perionyx excavatus* species were brought from the University of Agricultural Sciences, Bangalore. These were cultured in the tanks using the domestic waste. The worms were introduced on 8th January 2000 into the 12-day old waste. This had to be kept, with occasional mixing for 10 - 12 weeks.

Experiments using local worms

In an attempt to identify local worms, which can be of use in vermicomposting, we collected some worms in our locality, close to a marshy field. We could identify the following worms:

(1) *Megascolex cochinesis*,
(2) *Megascolex travencorensis*,
(3) *Pontoscolex scorethrurus* and
(3) *Perionyx excavatus.*

The local *P. excavatus* is also found to be useful for vermicomposting.

The putreceable wastes can be converted into very useful vermicompost through the use of earthworms, with any quantity from a few kilograms to about 70 tons per day. Up to 70kg of domestic waste could be composted inside the concrete tank. For smaller quantities, flowerpots of 10 – 20 liters capacity were used.

Therefore, for local level small mass processing, vermicomposting is most suitable. Though the composting takes a long period of about 10-12 weeks, there is practically no capital investment; not much space also needed.

AVAILABILITY OF WORMS FOR VERMICOMPOSTING

The most widely used *Eudrilus eugeniae* is being collected from culturing centers now. Since, the locally available *Perionyx excavatus* is also useful for composting, these may be collected from the local farmlands.

The Technique

Earmark a small area of 1m by 1m in a well-shaded patch of land where earthworm castings are found. Sprinkle slurry made of about 500g jaggery and an equal amount of fresh cow dung mixed with 15 to 20 liters of water, over this area. Over this, wet pats of cow dung are to be scattered. Then a layer of moistened rice straw should be spread over it. The whole area is then covered with a jute sack. Regular watering should continue for a period of 20 to 25 days, taking care to avoid water stagnation. When the cover is removed there will be a large number of worms, mainly *P. excavatus* in the surface layers of the cow dung and straw. There will be other varieties also in this layer, depending on the location. **All these varieties will be useful for vermicomposting.**

ADVANTAGES OF VERMICOMPOST

The nutrient status of vermicompost is found to be the following:

1. Organic Carbon	9.15 to 1798%
2. Total Nitrogen	0.5 to 1.5%
3. Available Phosphorus	0.1 to 0.3%
4. Available Potassium	0.15 to 0.56%
5. Calcium and Magnesium	22.67 to 47.6 Mec / 100g.
6. Copper	2.0 to 9.5 ppm.
7. Iron	2.0 to 9.5 ppm.
8. Zinc	5.7 to 11.5 ppm.
9. Sulphur	128.0 to 548.0 ppm.

In addition to these major nutrients and trace elements, which help in the growth of plants, the vermicompost is known to be rich source of plant growth promoting substances such as *auxins* and *cytokinins.*

CONCLUSIONS AND RECOMMENDATIONS

The total quantity of waste being generated is 52.3 tons per day in Kottayam Town; the earlier estimations gave a value of 39.0 tons. The wastes consist of all the various types, putreceable, recyclables and others. The method of disposal is observed to be primitive and unhealthy. All the wastes are mixed together at the time of collection and these are never segregated.

The total length of municipal roads and lanes is 229.2 km., the total number of roads being 622. Out of these, 572 roads having a total length of 214.9 km have only less than 6 meters width, and 524 roads with less than 5 meters width have 81.6 km total length. The residential houses are along these narrow lanes. The lanes are so narrow that there is no sufficient space to place the collection bins. Even if placed, it creates great inconvenience for pedestrians and creates traffic problems in these roads.

It is observed that effective collection of wastes do not take place in these areas where larger quantities of waste is being generated.

The topography of the town, as shown in the relief map in Appendix 1, clearly indicates the nature of the land. As a result, collection and transportation of waste become very difficult. This leads to pollution, and creates much difficulty to the public.

The modern concept is to consider the waste as materials as raw materials. The different types of materials should not get mixed up if effective processing is to be done. The system of collection and transportation should also be with the view of reprocessing, recycling or reusing. In this respect we put forward the following suggestions.

SUGGESTIONS FOR IMPROVING COLLECTION AND TRANSPORTATION.

The following suggestions are put forward for the collection of solid wastes in the town:

1. Community collection containers can be placed in major waste generating points like, markets; but the wastes must get segregated before collection, and different types of wastes must get collected separately, i.e., putreceable, recyclable, reusable, etc., should be specifically separated. (Color-coding of containers can be used for distinguishing the various types). Plastic materials are to be separated according to the melting points and collected separately. Necessary containers with proper lid to avoid littering are to be used. The containers should have the necessary capacity for holding the wastes of one day.

2. Daily removal of waste must be done. In the case of domestic putreceable wastes, mechanized vehicles would be needed for the collection.

3. Transportation should also be litter-proofed. Waste from the smaller containers may be transferred into larger containers, without mixing up the different types. Another way of transportation can be with the help of container carrying trucks, which can take the containers after placing a new empty one in its place.

4. All shops, hotels and other public service establishments should have their own containers for each type of waste they generate. They will have to make necessary arrangements to dump the wastes in the collection containers or, where the quantity is large, directly to the transporting vehicle.

5. Segregated putreceable solid wastes from households are to be collected from the doorsteps, everyday; plastics, paper, glass, metals, etc, shall be collected for processing once in a week. At the same time, citizens should be encouraged to convert the putreceable wastes into vermicompost or into biogas in their own premises for their own use.

6. Putreceable solid waste must undergo bacterial or worm composting; if local composting centers can be developed, transportation can be minimized. In Kottayam we have not found any municipal land available for such local processing. But the Municipality can take steps for establishing such centers.

7. Effective awareness campaign must be held to make the public know about their responsibility in dealing with the waste generated by them.

PROCESSING OF SOLID WASTES

The most important matter to be dealt with in the problem of Urban Solid Waste Management is the processing of these wastes. As indicated earlier, the principle is based on the various techniques that can be made use of for the processing. Also, there is the need for effective conversion into useful products without causing any pollution or inconvenience to the public. So, it goes without saying that **the segregation of the materials at origin is a must for the effective processing.**

In this regard, the authorities should even enact necessary rules and regulations to make this segregation effective.

There must be effective systems for the collection of the segregated wastes according to the final processing method. Putriceable waste must be collected and removed daily. Other wastes may be removed or collected in the interval of three to five days. Also, the transportation systems must be made more scientific.

SUGGESTIONS ON LOCAL LEVEL COMPOSTING OF PUTRECEABLE WASTES

The major part of domestic wastes (84%) is putreceable. This waste is not easily collected due to the topographical factors and the road conditions, as detailed before. Under such circumstances, measures are to be taken for the local level processing of these wastes. Institutions like colleges, schools, and hostels can also make arrangements for the same.

Those households having space can adopt vermicomposting for the processing of their waste, while those who do not have sufficient space should adopt a community level processing system. Flats having 10 or more families can construct concrete tanks for vermicomposting, the size depending on the number of people.

The principle adopted for vermicomposting to be provided in the form for demonstration classes is given in Appendix 3.

In the case of residential households having very limited space, as we have done in our experimental set up, flowerpots of seven or more liter capacity can be used instead of tanks.

Another possible processing is the bacterial gasification or biogas generation using the putreceable wastes. The gas thus generated can be used as fuel in the ordinary gas burners.

The persons should adopt whichever method is convenient and acceptable to them.

THE TECHNIQUE OF VERMICOMPOSTING

Whether in a **tank** or in a **flowerpot**, the principle and the methods used for vermicomposting are the same. The technique involves the following steps:

1. Set-up a tank / flowerpot box or a flowerpot in a shady place to protect it from rain, and secure the container from ants and rodents, by keeping a pot dish underneath containing water and keep a good cover to prevent the entry of insects, pests and flies. The container should have proper drainage at the bottom to prevent accumulation of water in it. Also, avoid too much light to pass into the container.
2. Keep a layer of coconut husk or sand, (one or two pieces of husk or two-inch thick sand layer is sufficient) at the bottom of the container.
3. Collect and dump the wastes into the container; the waste can be all those in the house as well as leaves and paper. Kitchen wastes including egg-shell and fish bone, can be included; but avoid too much of chilly and oils. If these are present take care to add some waste newsprint paper also. Let the container be fully filled with the wastes.
4. If available, mix some cow-dung or its slurry with the wastes. Or else make the contents wet by adding some water – but no need for too much water.
5. Cover the surface with 2 to 2.5 cm thick soil paste; make 2cm diameter holes about 30 cm apart to provide needed aeration. Instead of soil or mud, torn and wet newspaper can be used. Spread the paper pieces on the surface to form a layer of about 1 to 1.5 cm thick and sprinkle water to keep it wet. This layer will prevent the evolution of foul smelling gases.
6. Leave the mass without disturbance for two weeks. When continuously collecting household wastes, the daily wastes can be added and covered with wet newspaper pieces until the container is filled up; then leave it for at least ten days. During these days the temperature of the contents may reach 70^{o} C and if any worm is present it will die.

7. Release selected variety of worms (*Eudrilus eugeniae* or *Perionyx excavatus*) on the surface at the rate of 1000 to 2000 per square meter. Worms on their own enter the organic matter through the holes or cracks on the surface or through the paper pieces. See that the mass is sufficiently wet, but not too much soaked in water.
8. Leave the container with the worms for 8 to 10 weeks, depending on the quantity of the waste and the density of worms; if the quantity of worms is comparatively small longer time is needed.
9. Collect the compost, (where needed after removing the mud-pack) along with the worms.
10. Make a small pyramid of this manure on the floor and leave for 8 to hours.
11. Slowly pushing and spreading the manure from the top, separate worms that move down and form a cluster at the base.
12. These worms are re-introduced into a new container having the prepared waste.
13. The separated manure / compost will have small worms, cocoons and some unfed materials. Dry this material in shade for 2 to 3 days and pass through 3mm sieve to get the worms, cocoons and unfed matter separated from the vermicompost.
14. The worms and cocoons are used for composting.

Dissemination program on "Solid Waste Management in Kottayam Town"

The dissemination programme was held on 13th January 2001, at Aiswarya Hotel, Kottayam, under the auspices of KRPLLD Kottayam Study Circle and Kottayam Municipality. 130 persons including Municipal Council, Zillah, Block and Gram Panchyat Members participated. Later with the launching of the 'Kottayam – Kumarakom Ecocity Programme' the planning has been taken up by the agency, 'Ecosmart', and they accepted the suggestions for solid waste management as part of the Ecocity programme.

As a result, the Municipality and the Ecocity implementing agency have decided to make plans for Solid Waste Management in line with the suggestions evolved. Afterwards, the Municipal Council decided to popularize the local level waste management techniques.

Segregation at the origin, collecting the wastes separately for processing and implementation of effective environment friendly processes for Reuse, Recycling and Reprocessing on the basis of the suggestions put forward, have been accepted by the Municipality and 'Ecosmart', which outlined the waste management plan.

Awareness / Popularization Programs Conducted and Meetings held

1) 22nd October 1999, 11 a.m.: 2 hour awareness lecture on "Solid Waste Management", YMCA Hall, Kottayam; audience: School Teachers of Kottayam Sub-district; number of participants: 60.
2) 3rd November 1999, 11:a.m.: Meeting for discussing strategies on 'NIRMAL-2000', Kerala Health Sanitation Mission Programmed at Nirmal-2000 Office, Kottayam.
3) 7th December 1999; 3:p.m. Baselius College Popular Science Forum Meeting for preparing "Wall Hangers' for Hotels, related to the Nirmal-2000 Program; number of participants: 70.
4) 13th December 1999, 1:30 p.m.; Seminar on Solid Waste Management, Wards 1-5, Panachikadu Panchayat, at Govt. LPS, Paruthumpara, Kottayam; number of participants: 80.
5) 23rd December 1999, 2:00 p.m.: Seminar on Solid waste Management, Wards 6-10, Panachikadu Panchayat, Cooperative Bank Auditorium, Kolladu, Kottayam; number of participants: 35.
6) 5th January 2000, 2:00 p.m.: Seminar "Clean and Green Environment", Sponsored by STEC, Govt. of Kerala, St. Peter's Higher Secondary School, Perumpanachy, Changanasserry, Kottayam; number of students participated: 350.

IMPLEMENTATION OF LOCAL LEVEL SOLID WASTE MANAGEMENT

After interactions with people through Ward Sabhas and Local Self Help Groups, some persons have taken initiative to establish vermicomposting on a local level basis. C.N.I.Lower Primary School, near Chalukunnu, Kottayam took initiative to construct a tank for vermicomposting, for which we supplied *Eudrilus eugeniae* worms for composting. The composting program is now progressing.

On 5th December 2001, an awareness workshop was conducted at Assumption College, Changanasserry, on Solid Waste Management under the auspices of the Botany Department and M.G. University. After conducting the classes I have given them the worms, about 1000 of the animals, for establishing a vermicomposting unit. At present the composting unit is progressing with the wastes from the campus.

Five families, in and around Kottayam Town, have received worms from our unit for establishing vermicomposting units for their residential wastes.

The Municipality is planning to establish, at present, bacterial composting system for the waste processing. But in due course, they will try to implement vermicomposting on the large scale. We are now involved in discussions to implement the system.

Soon the Municipality will start an awareness campaign for encouraging local processing of solid wastes. We are now preparing the necessary literature in the form of brochures, posters, and notices to create awareness among the public.

As a member of the District level committee for the Clean Kerala campaign, I am now involved in preparing various waste management schemes for the district as a whole. In this respect we are preparing plans for the cleaning and solid waste management in different areas like hotel / restaurant, shopkeepers, business establishments, and also residential houses in consultation with the respective associations / organizations, the peoples' representatives, and the officers in the local government bodies. The project is continuing slowly but successfully.

RESEARCH RELATED ACTIVITES

Courses and programs attended and conducted.

(1) Attended Thematic Workshop on 'Health, Quality of Life and Environment', conducted by KRPLLD, at Centre for Development Studies, Thiruvananthapuram, 8th to 9th April 1999.

(2) Participated in the Workshop on 'Research Methodology', conducted by KRPLLD at Kerala Institute for Local Administration, Trissur, 3rd to 6th September 1999.

(3) Attended the Appraisal Workshop on 'Health, Sanitation and Indigenous Medicine', conducted by KRPLLD at Centre for Development Studies, Thiruvananthapuram, 18th to 20th November 1999.

(4) Attended 'KRPLLD Circle Meeting', 15th January 2000, Kottayam.

(5) KRPLLD Kottayam circle meeting -10am to 2pm, 15th January 2000- Hotel Aiswarya, Kottayam.

(6) Resource person for seminar on 'Clean and Green Environment' organized by department of science and technology, government of Kerala, at St.Peter's higher secondary school, Perumpanachy, Changanachery, Kottayam- 2.00– 3.30 pm, 5th February 2000: number of participants – 350.

(7) KRPLLD Kottayam Circle meeting and presentation of the progress of the work: 10am-4pm; 19th February 2000.

(8) Key - note address at the annual meeting of Energy Conservation Society Pathanamthitta.

(9) Special training for the Research Assistants on data collection for the solid waste generation: 21st March 2000.

(10) Resource Person for one day seminar on "Energy and Environment' organized jointly by 'Manaviyam' (Kerala government program) and Energy Conservation Society; 3-4pm, 28th March 2000, Baselius College Auditorium, Kottayam; Number of participants: 90.

(11) Discussion with Health inspectors of Kottayam Municipality on the state of Solid Waste Management, along with the research assistants; 2-3.30 pm, 29th March 2000.

(12) Class on 'Environmental protection' for 'Prathibha Sangamam' camp for selected high school students at Njaliakuzhy, Kottayam; Number of participants ; 60.

(13) Class on 'Environmental Protection' for 'Prathibha Sangamam' camp for upper primary school students of Kottayam District; 11-10 am to 1.00 pm, 28th April 2000, N.S.S. High School, Njaliakuzhy, Kottayam; Number of participants; 62.

(14) Visited Kerala Agricultural University Campus at Kumarakom, Kottayam to observe and study vermicomposting techniques: 4th April 2000.

STUDY TRIPS

(1) Personal visit to establish linkage with Department of Zoology, College of Basic Sciences and Humanities, University of Agricultural Sciences, GKVK Campus, Bangalore; 26-28 August 1999.

(2) Trip to the Zoology Department, University of Agricultural Science for obtaining details on vermicomposting- discussions, observation and practical training in vermicomposting, 28th and 29th October 1999.

(3) Trip to GKVK Campus for further studies and to obtain worms, E. eugeniae and also to identify the locally available worms, 27th to 30th December 1999.

(4) Trip to IRTC, Mundoor, to study about the vermicomposting technique being developed at the center; also visited the composting yard of Chalakkudy Municipality, which is being done as a research project of IRTC – 20th December 2000.

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(38) Dr.A. Mohanakrishnan, Er.A. Ebenezer (2000), *Environmental benefits and bio-energy – An overview*, Proceedings of the All India Seminar on Solid Waste Management for Towns: Conducted by The Institution of Engineers (India), Palaghat, Kerala; 20th February 2000.

Appendix 1

Kottayam Municipal Area

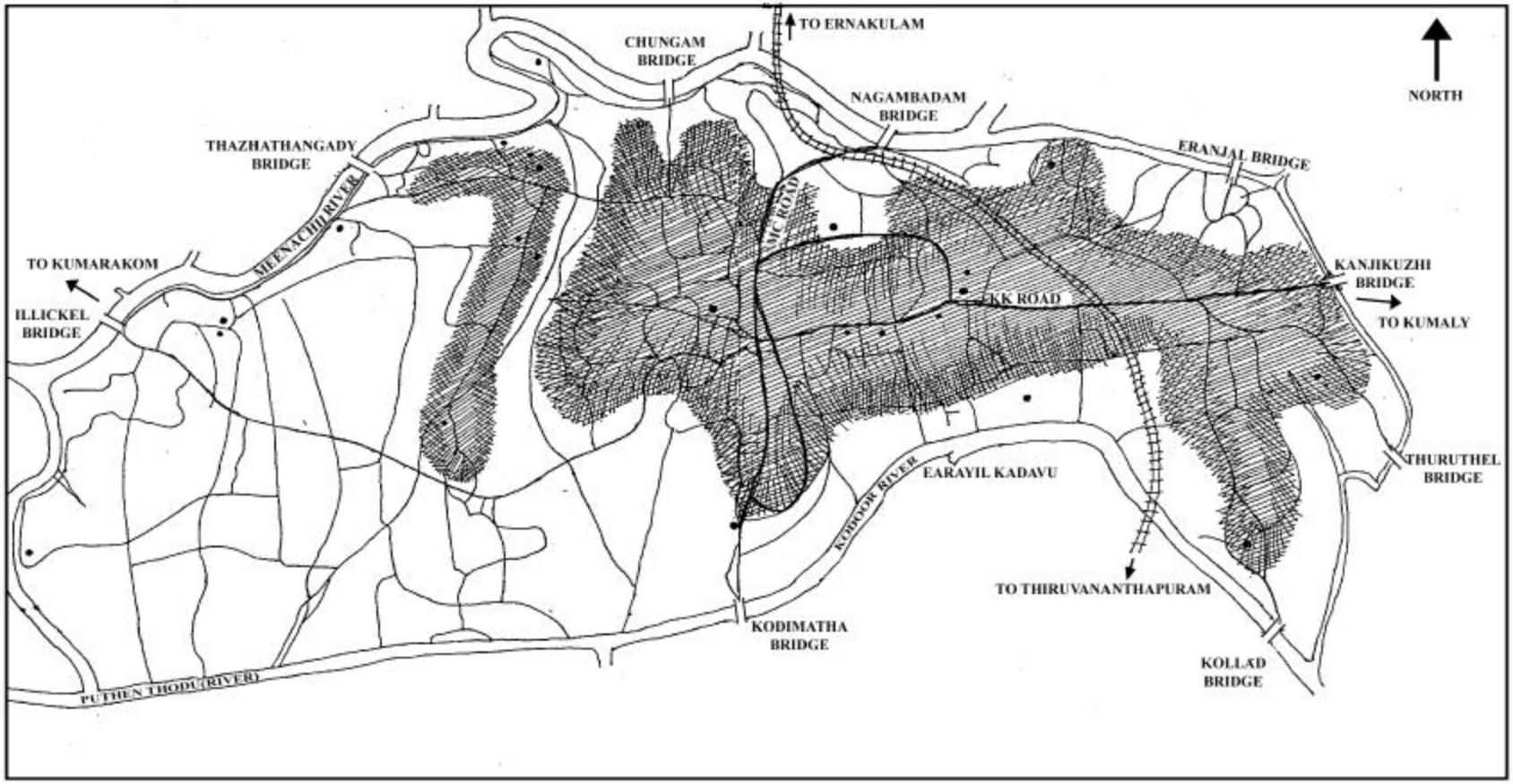
RELIEF MAP

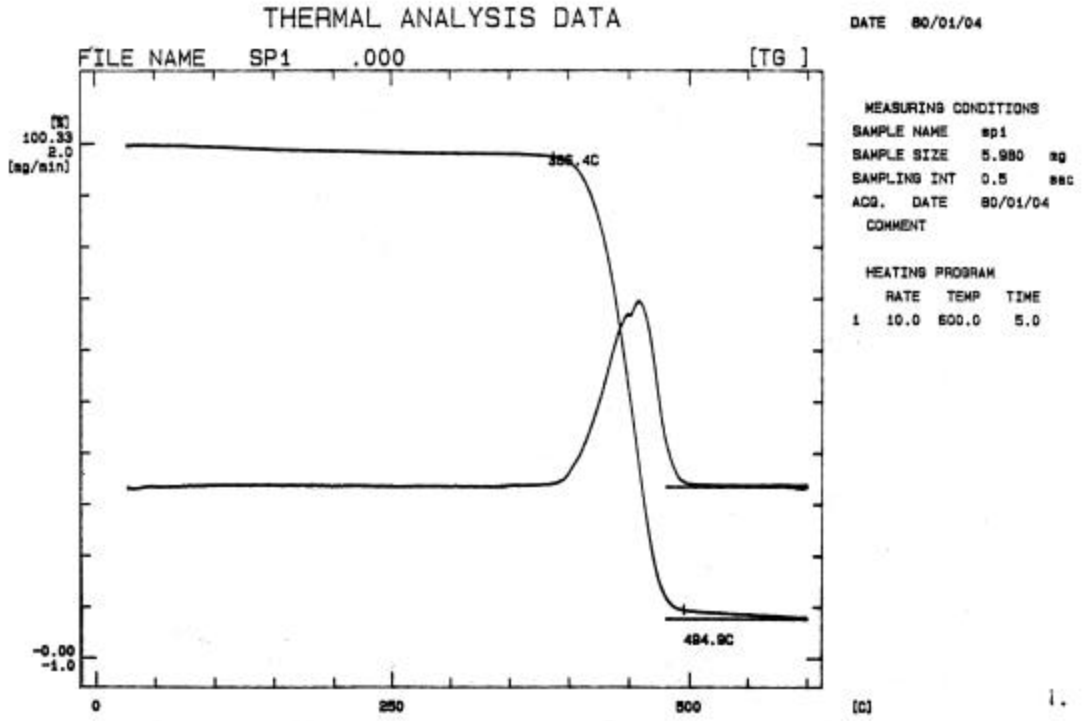
Appendix 2

Kottayam Municipal Area

THERMOGRAVIMETRIC CURVES OF SELECTED PLASTIC WASTE MATERIALS.

RELIEF MAP OF KOTTAYAM TOWN (NOT TO SCALE)

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[mg/min]
-0.00
-1.0
0
250
500
[C]
386.4C
484.9C
MEASURING CONDITIONS
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SAMPLING INT 0.5 sec
ACQ. DATE 80/01/04
COMMENT
HEATING PROGRAM
RATE TEMP TIME
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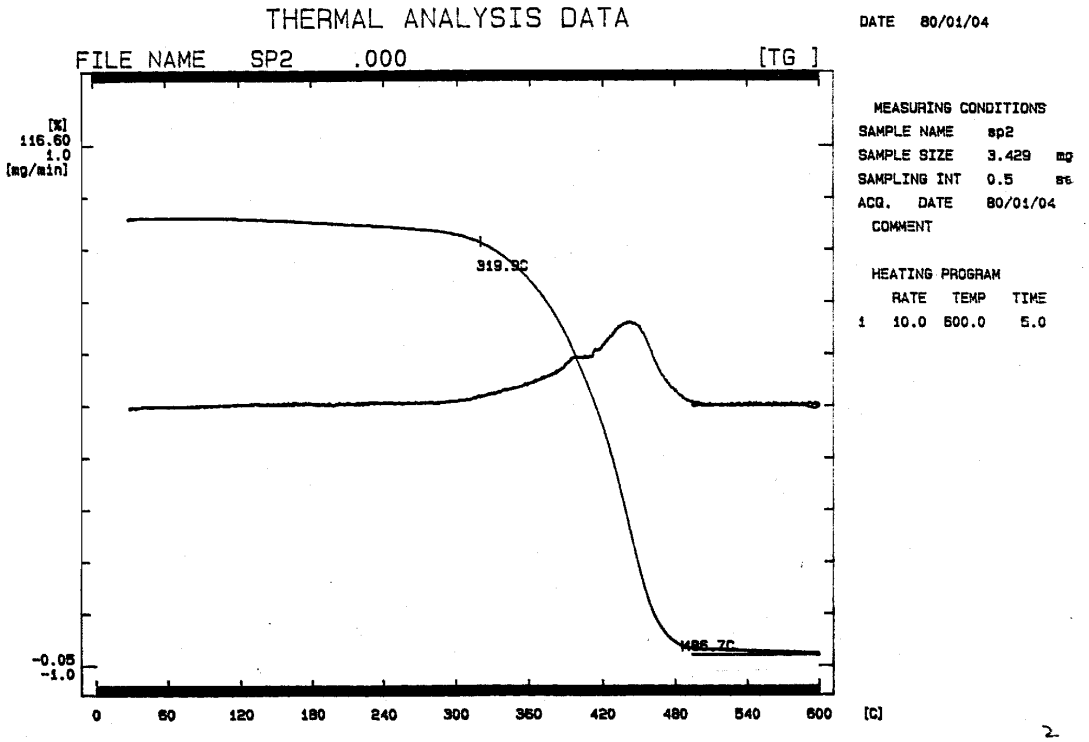
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1.0
[mg/min]
319.9C
486.7C
-0.05
-1.0
0 60 120 180 240 300 360 420 480 540 600 [C]
MEASURING CONDITIONS
SAMPLE NAME sp2
SAMPLE SIZE 3.429 mg
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COMMENT
HEATING PROGRAM
RATE TEMP TIME
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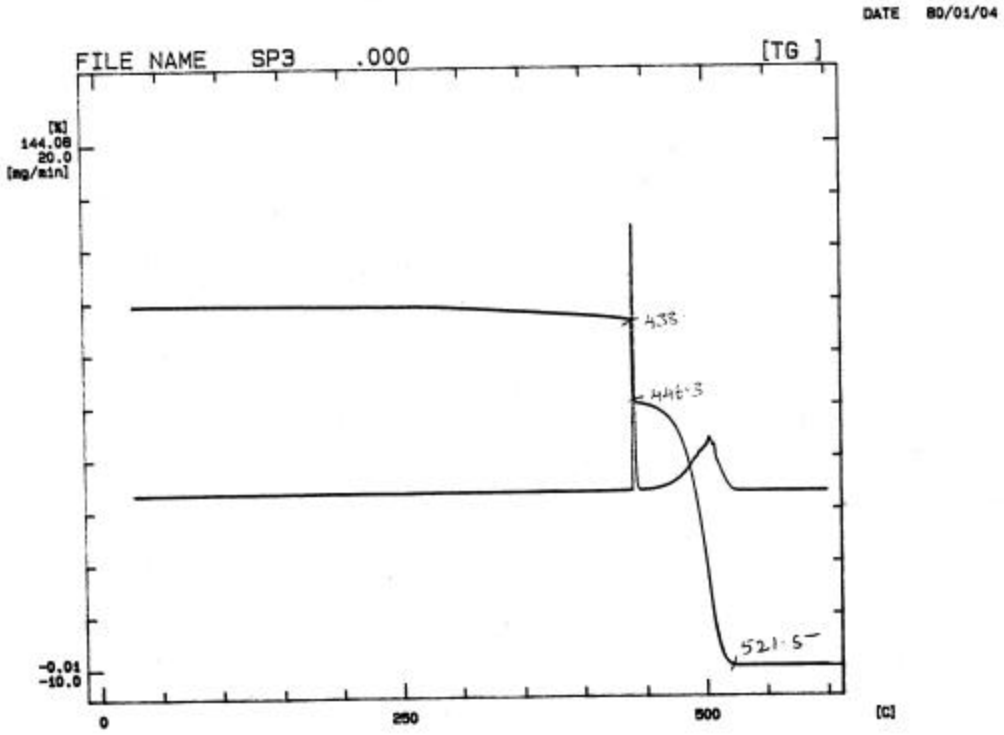
2.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20.0
[mg/min]
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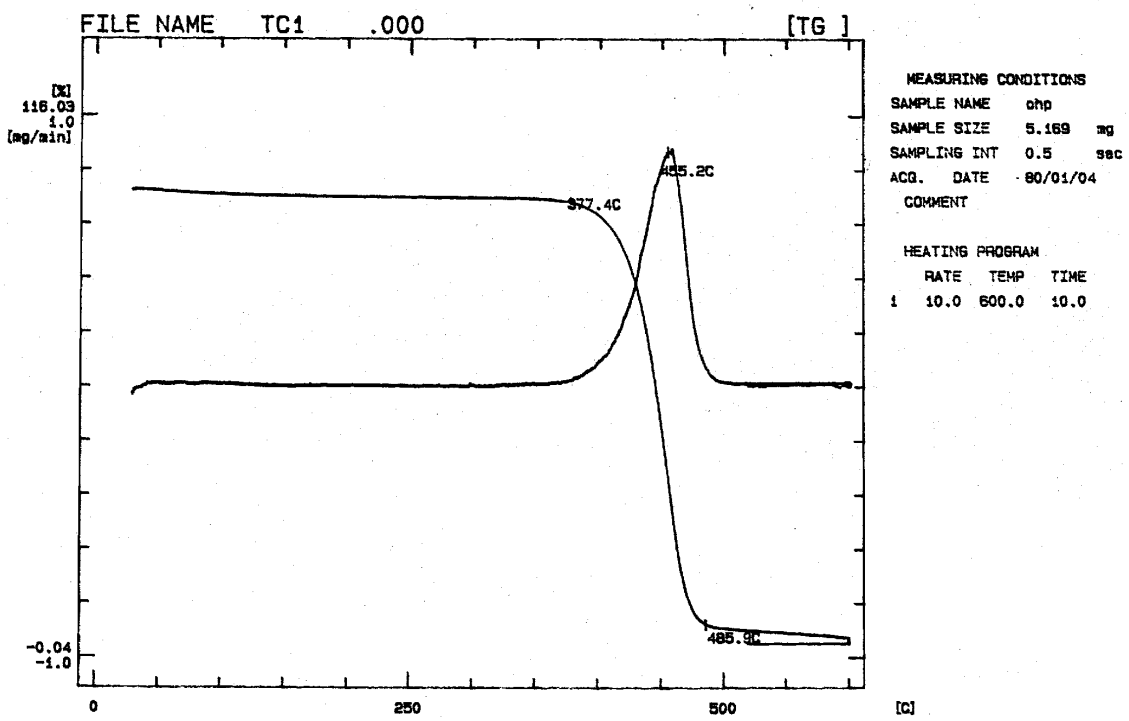
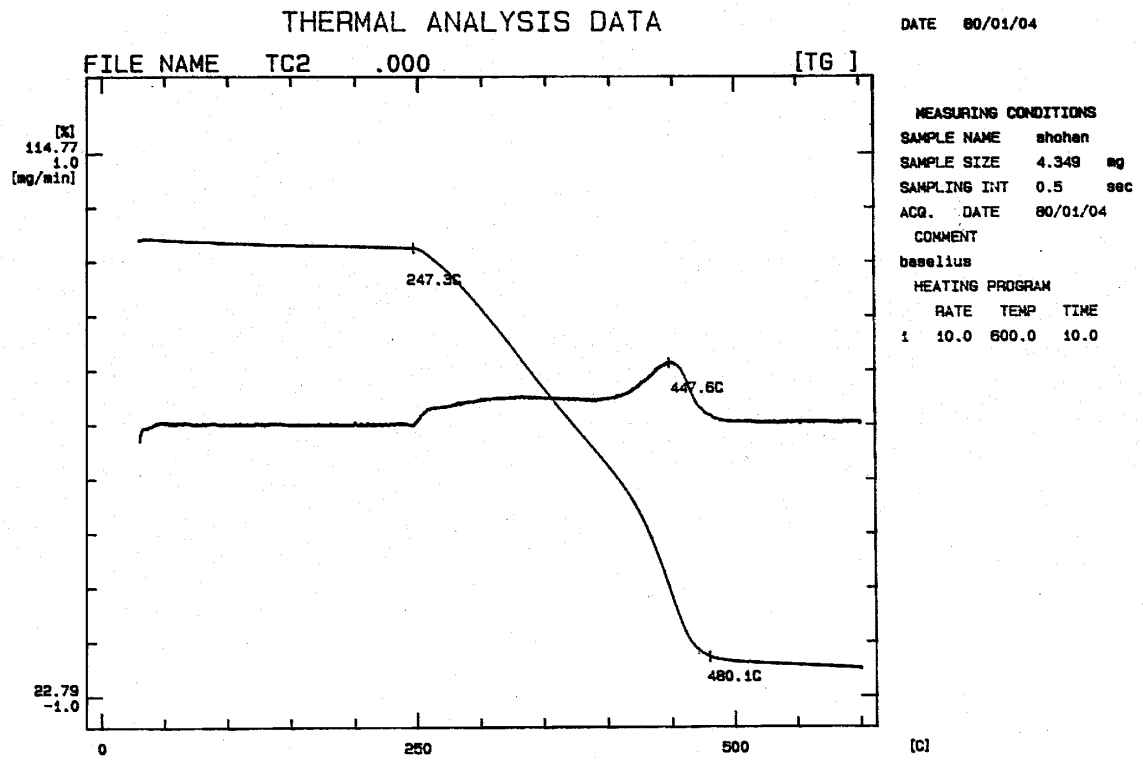
448.3
521.5
-0.01
-10.0
0 250 500 [C]

3.

THERMAL ANALYSIS DATA

DATE 80/01/04




THERMAL ANALYSIS DATA
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[mg/min]
22.79
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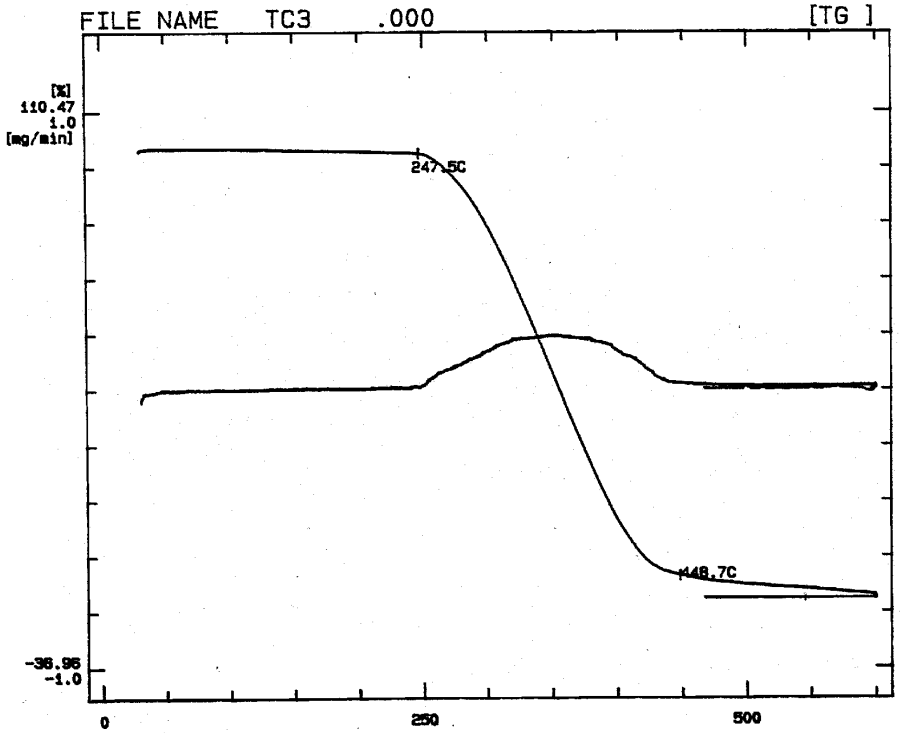
247.3C
447.6C
480.1C
0
250
500
[C]
MEASURING CONDITIONS
SAMPLE NAME shohan
SAMPLE SIZE 4.349 mg
SAMPLING INT 0.5 sec
ACQ. DATE 80/01/04
COMMENT
baselius
HEATING PROGRAM
RATE TEMP TIME
1 10.0 600.0 10.0

THERMAL ANALYSIS DATA

DATE 80/01/04

FILE NAME TC3 .000 [TG]



MEASURING CONDITIONS

SAMPLE NAME	a6	
SAMPLE SIZE	2.713	m
SAMPLING INT	0.5	s
ACQ. DATE	80/01/04	

COMMENT

basalius

HEATING PROGRAM

	RATE	TEMP	TIME
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THERMAL ANALYSIS DATA

DATE 80/01/04

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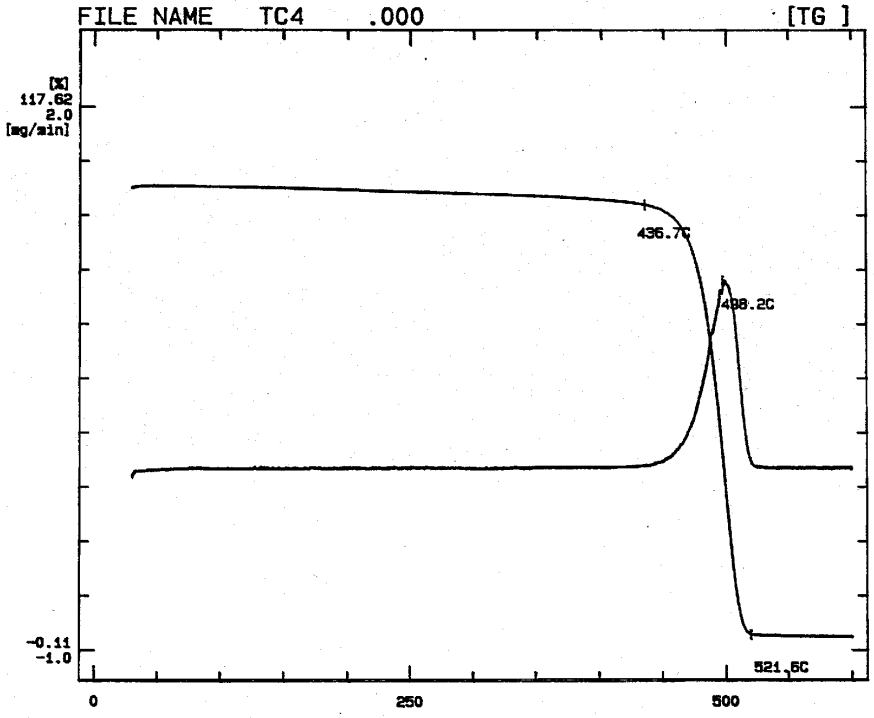


MEASURING CONDITIONS

SAMPLE NAME	a2	
SAMPLE SIZE	4.247	mg
SAMPLING INT	0.5	sec
ACQ. DATE	80/01/04	

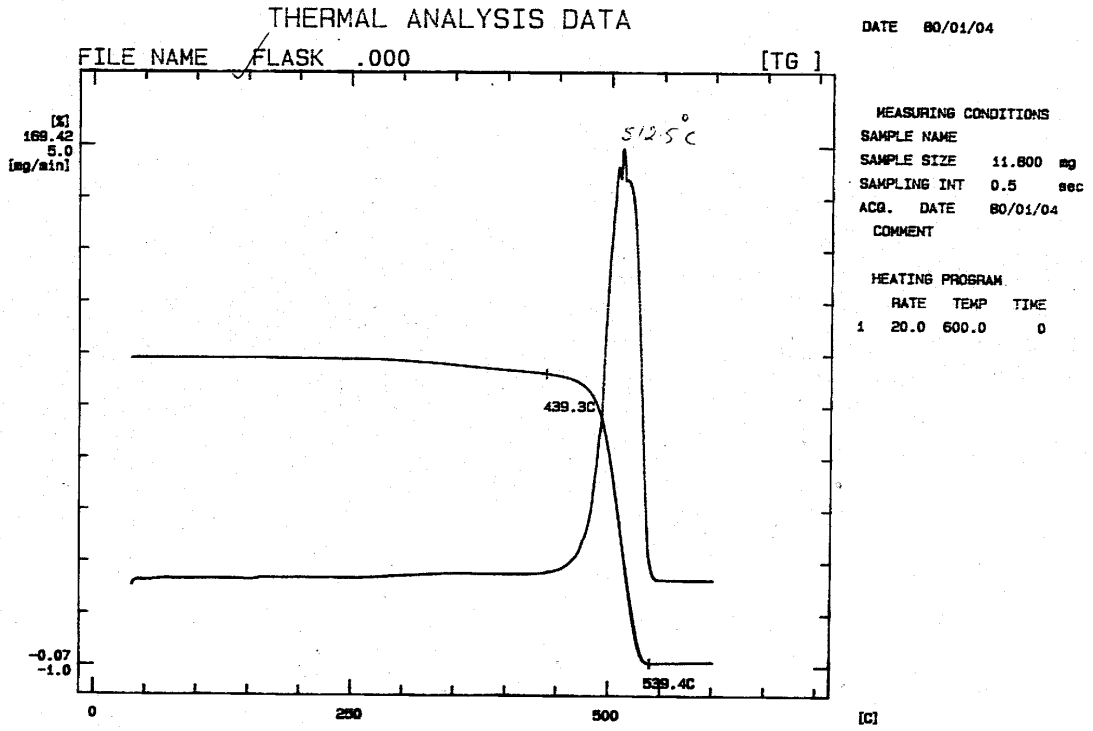
COMMENT

baselius

HEATING PROGRAM

	RATE	TEMP	TIME
1	10.0	600.0	5.0

3.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[%]
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[mg/min]
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539.4C
-0.07
-1.0
0
250
500
[C]
MEASURING CONDITIONS
SAMPLE NAME
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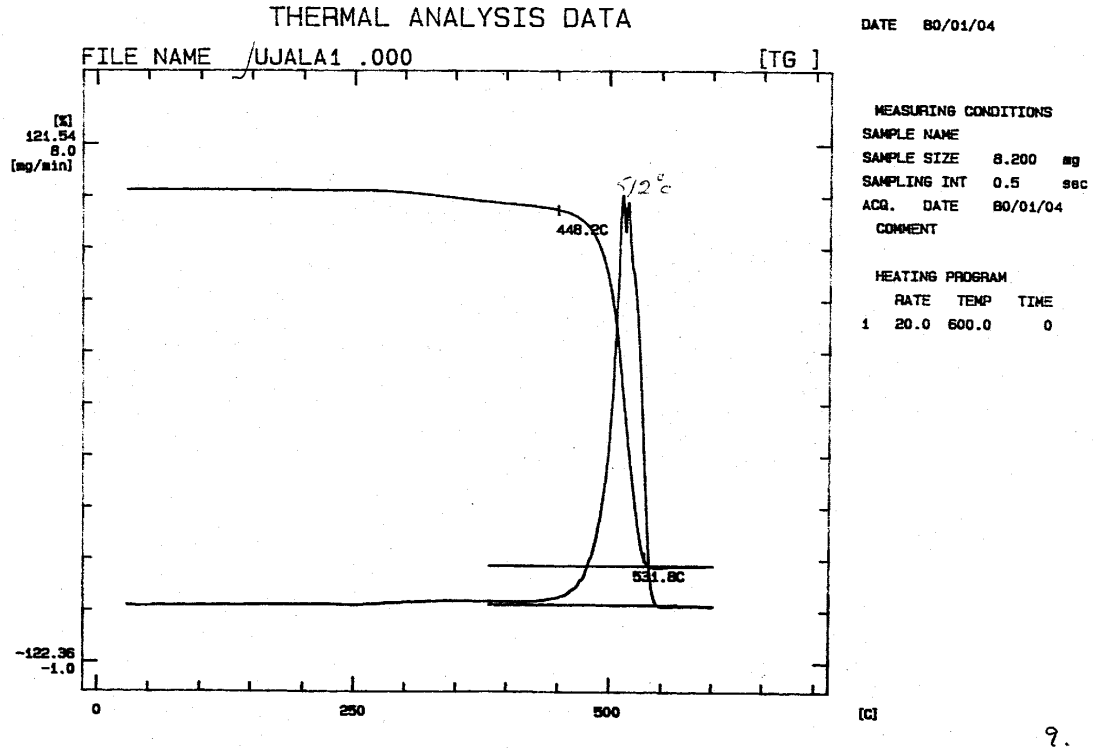
ACQ. DATE 80/01/04
COMMENT
HEATING PROGRAM
RATE TEMP TIME
1 20.0 600.0 0

8.


THERMAL ANALYSIS DATA
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DATE 80/01/04
[%]
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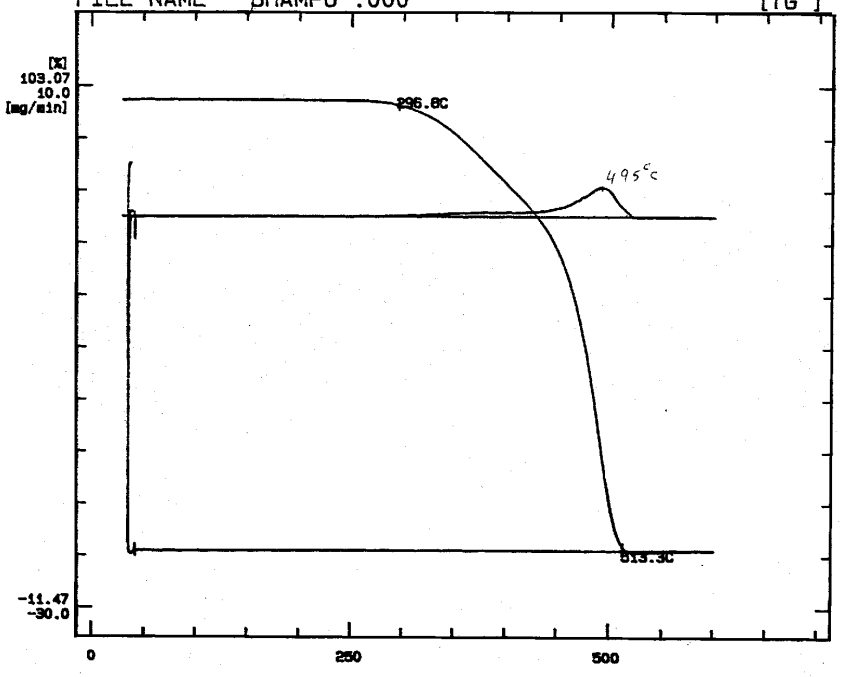
8.0
[mg/min]
512°C
448.2C
531.8C
-122.36
-1.0
0
250
500
[C]
MEASURING CONDITIONS
SAMPLE NAME
SAMPLE SIZE 8.200 mg
SAMPLING INT 0.5 sec
ACQ. DATE 80/01/04
COMMENT
HEATING PROGRAM
RATE TEMP TIME
1 20.0 600.0 0

9.

THERMAL ANALYSIS DATA

DATE 80/01/04

FILE NAME SHAMPO .000 [TG]



MEASURING CONDITIONS

SAMPLE NAME

SAMPLE SIZE 8.730 mg

SAMPLING INT 0.5 sec

ACQ. DATE 80/01/04

COMMENT

HEATING PROGRAM

	RATE	TEMP	TIME
1	0	0	0

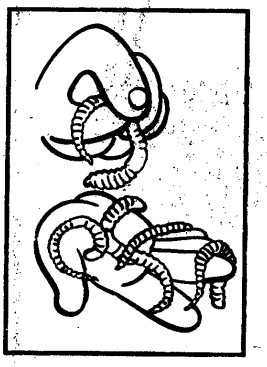
VERMICOMPOSTING TO ABATE POLLUTION
AND
FOR MAINTAINING SOIL PRODUCTIVITY

I

1. How to proceed?

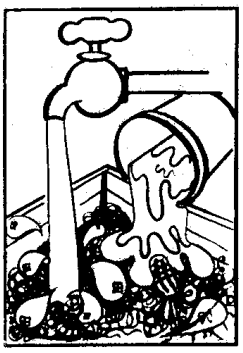
2. Organic waste is no constraint.

3. Possibility to utilise the solid organic waste from urban areas,agro-based industries and agricultural land.

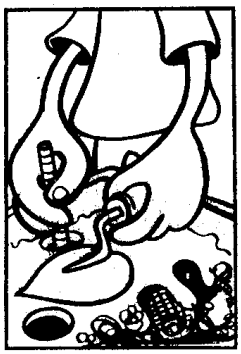


4. Selected species of earthworms to convert these waste into manure(*Eudrilus eugeniae, Eisenia fetida, Perionyx excavatus*)

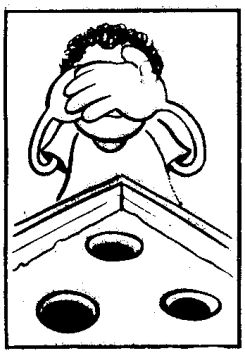
5. Collection of waste available from the surroundings into a box or tank.



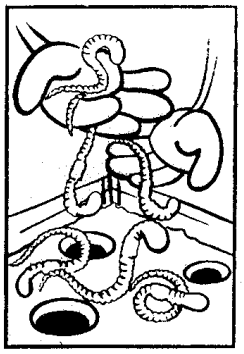
6. The material is mixed with cowdung or slurry



7. Plaster the surface with 2.5cm thick soil paste. Make 2 cm diameter holes 30cm apart to provide needed aeration

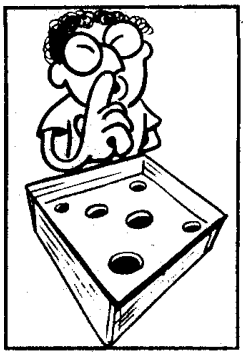


8. Leave the same without disturbing for two weeks.



9. Release earth worms on the surface at the rate of 1000 to 2000 per sq. mtrs

10. Worms, on their own enter the organic matter through the holes and cracks on soil surface



11. For six weeks there is no need to pay any attention.

12. Remove the mud pack, collect the compost along with worms.

13. Make a small pyramid of this manure on the floor and leave for 6 to 8 hrs.

14. Worms that move down and form a cluster at the base are separated by slowly pushing and spreading the manure from the topl.

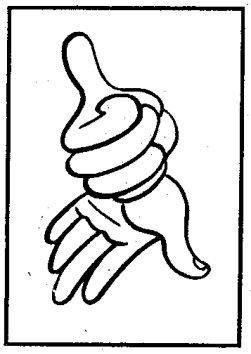
15. These worms are re-introduced into fresh waste to continue the process.

16 The separated manure will have small worms, cocoons and some unfed materials.

17 By drying this in shade for 2 to 3 days and passing through a 3mm sieve small worms, cocoon and unfed matter are separated from vermi - compost or worm cast.

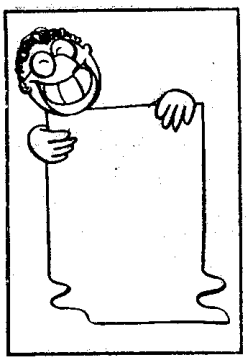
18 These worms add to the population to increase the production of compost.

19 When number of worms keep increasing, adults can be harvested to prepare animal feed and to provide opportunity for new generations to establish.



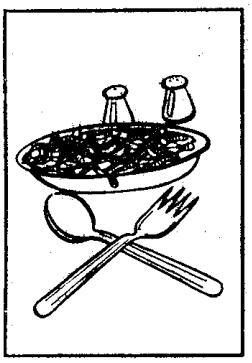
20 How good is the vermicompost?

21 **It is an aerobically derived manure from any available organic waste in a short time, with or without the cowdung.**



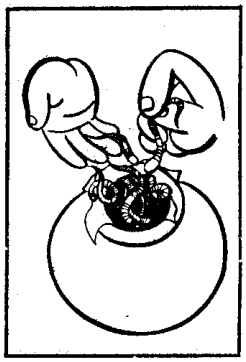
22 **The following is the nutrient status of the vermicopost.**

1. Organic Carbon %9.15 to 17.98
2. Total Nitrogen %0.5 to 1.5
3. Available Phosphorus %0.1 to 0.3
4. Available Potassium %0.15 to 0.56
5. Calcium and Magnesium Mec/100g 22.67 to 47.6
6. Copper (PPM) 2.0-9.5
7. Iron (PPM) 2.0-9.5
8. Zinc (PPM) 5.7-11.5
9. Sulphur (PPM) 128.0-548.0

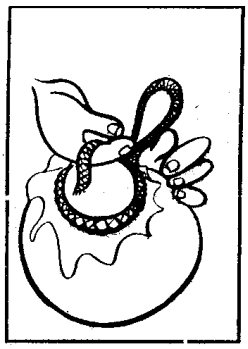


II

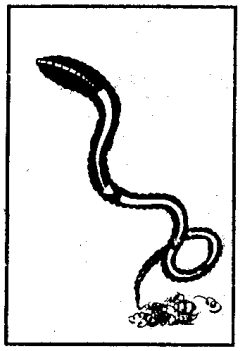
23 **Preparation of worm meal**



24 **Collect the fully grown worms and put them into a narrow mouthed vessel lined with several layers of wet cloth or paper**

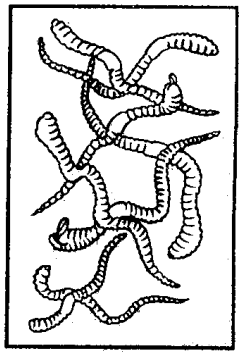


25 Tie the mouth of the vessel with a wet cloth to avoid escaping of worms.

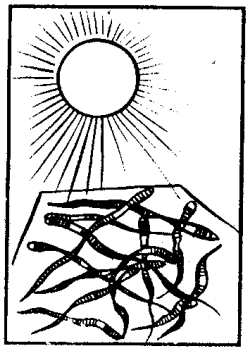


26 By two days all the waste collected in the gut of worms is cleared.

27. Worms are washed in 1% salt water to narcotise.



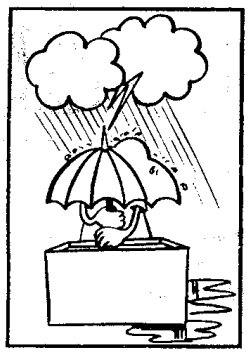
28 Narcotised worms are spread on a cloth or plastic sheet in shade for drying .



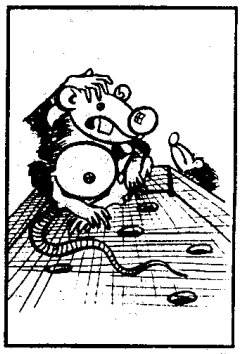
29. When partially dried, the same is further dried in hot sun or oven till they become crisp

30 Crisp worms ground into powder is the worm meal which is used as an ingredient in animal feed.

II 31 What precautions to be taken in earthworm cultivation?



32. Protection from rain to avoid water stagnation in culture tanks.



33 To use mesh covers to protect from rodents.

34 To apply some waste oil around the edges of the tank to protect from ants.

Appendix 3

THE TECHNIQUE OF VERMICOMPOSTING.