Development of an Integrated and Sustainable Model for Solid Waste Management in an Urban Environment

A. Jesudass, R.N. Kavya, M. Janani, M. Muthu Mithra

Abstract*: -*Waste management in the metropolis has become a challenging task as more intensified urbanization is happening at rapid rate. The urban local bodies without proper policies and management are finding hard to make a city clean and green. Improper waste management policies have resulted in severe health hazards among fellow human beings. Even soil, water and air are being polluted to greater extent due to carelessness in handling hazardous waste. Therefore, time has come to address the issues and gaps in waste management polices of urban local bodies through conducting studies on it. This study aimed at Developing an Integrated and sustainable model for waste management by studying the waste management practices of the Coimbatore city, an industrial district in the state of TamilNadu, India. The methodology involved is to collect the data on waste generation and its handling techniques from municipal body and after analysing the hindrances, a new model named "Decentralized model "has been proposed along with its advantages quantified in three pillars of sustainability namely social, environment and economy. Decentralized model is that in which the waste is handled near its source so that the transportation and huge landfilling is avoided which is major hindrance in Coimbatore city. The model has been designed considering all the parameters according to the population of particular neighbourhood under consideration and its costing has been done. The 3D rendering using google sketch up has been done to give the fellow researcher a good idea on how waste treatment plant shall be.

Index Terms*: *Waste, management, decentralization, sustainable, Coimbatore

I. INTRODUCTION

Solid waste management in growing Indian cities is huge task as country focuses on rapid economic growth which attracts industries which in turn attracts people that ends up in rapid urbanization. Concentrated development is the root source of problems in Indian cities.

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Attaining sustainability amidst rapid economic growth which ignores the environment which is depleted parallelly is quite debatable. About 50,000 towns are in India which are enveloped by 593 districts. Around 30 % of population lives in urban space. The forecasted population in urban space would increase by 40 % by 2030.Due to increased economic activity that increases the GDP in turn, waste generated also increased day by day to multifold. With 6 million tonnes of waste generated in 1947, it has increased to 48 million tonnes by 1997 with annual growth rate of 4.25 %. With forecasting tools and methods, it has been projected that it would rise upto 300 million tonnes by 2047.

A. *Coimbatore*

Coimbatore geographically located 11°1′6″N 76°58′21″E having a geographical area of 4732 sq. kms populated about 34 million people. In size and people, Coimbatore is third largest city in the state of TamilNadu. City was once famous for its textile mills making it a Manchester of south India. The city was built on the banks of Noyyal river which runs through and joins Cauvery. On other side, western Ghats provides a rain shadow that makes temperate climate in the city. Cotton cultivation was happening at greater rate because of the rich fertile black cotton soil which gave the name Manchester of South India. Small and medium scale industries manufacturing wet grinders, Motor pumps and automobile spare parts are also spread across the city.

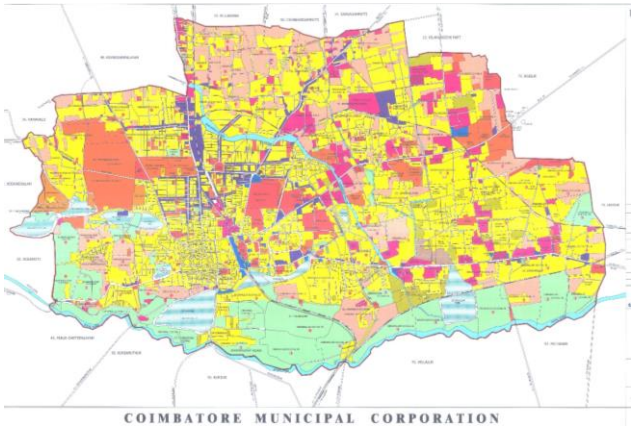

Fig I- Coimbatore City Map

II. METHODOLOGY

For this study, data on waste generation and its disposal methods has been obtained from waste management division of Coimbatore City Municipal Corporation, Coimbatore city. Data on population has been obtained from census report ,2011. For administrative purposes Coimbatore has been divided into hundred wards. Data on various zones and population in each zone have been derived from various government documents. For instance, population data which is available is from census report of 2011 in which Coimbatore has 75 wards. By Geometrical increase method, we have forecasted the population after which ward wise population is arrived. After which city has extended its boundaries, combined few smaller wards and splitted few bigger wards. So, from all the available government documents, we have extracted the data that we are in need which are validated at the endBrainstorming session with CCMC (Coimbatore city municipal corporation)officials, local experts , NGO's involved and academicians researching in waste management was conducted to identify the lags in the existing policies in handling waste of Coimbatore city, So that the proposed model shall come over such hindrances in framework.

III. RESULTS AND DISCUSSIONS

A. Waste generation

Waste generation and its handling methods has been obtained from CMCC through Right to Information act. On an average 1020 tonnes of solid waste is collected by corporation (which looks after 16 million) (exclusive of E-waste and medical waste) besides collection of C & D waste on an average of 100 tons of C & D waste daily. When the waste generated from all the categories are summed up, we get 1453 tonnes/ day. The categories include households, commercial establishments, restaurants, hospitals.

Table I- Main Sources of Solid waste in Coimbatore City

SI. No	Sources	Amount (Tonnes /day)
1	Municipal Waste	1000-1050
2	Construction and Demolition	100
3	Health care	1-3
4	Hazardous waste	300

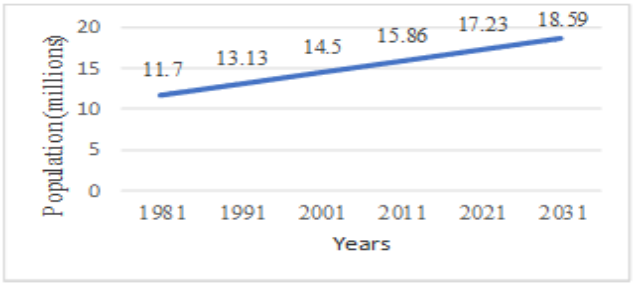

Fig II- Trend of Increasing Population in Coimbatore city

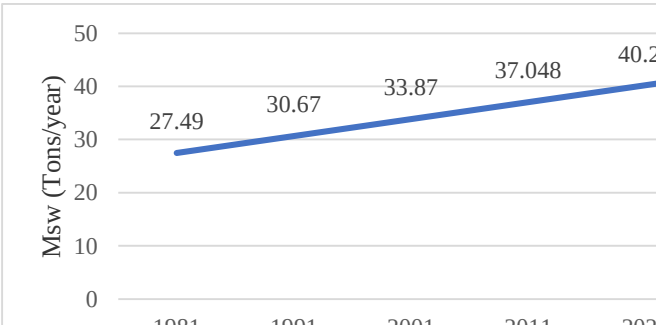

Fig III-Trend of MSW Generation in Coimbatore city

B. Waste Characterization

Broad portion of city waste in India is organic in nature (51%). The materials of recyclable nature are 17.5 % and the remaining portion 31% doesn't react i.e. inert in nature. The average calorific value of urban MSW is 7.3 MJ/kg (1,751 Kcal/kg) and the average moisture content is 47%. The figures show the physical composition of MSW in Coimbatore city, both dry and weight basis in percentage. From the figure it's pretty clear that food waste was the largest component in the msw both in dry 53% and wet 48 %.

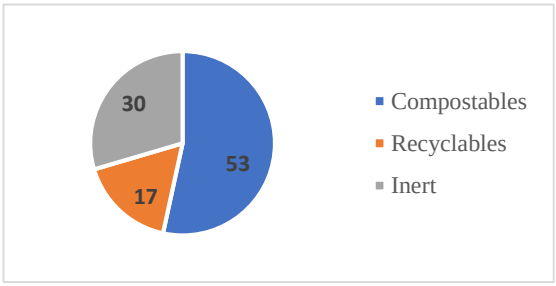

Fig IV- Composition- Physical -Dry weight

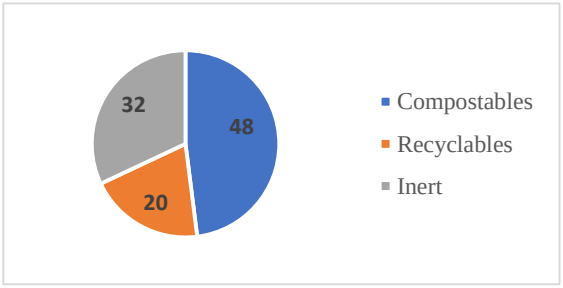

Fig V-Composition – Physical - Wet weight

C. Current MSW management practices

A good waste management practice involves efficient collection (segregation at source), sustainable transfer, storage, treatment (resource recovery) and disposal. The policy can be quantified or validated on three pillars of sustainability namely people, environment and economy.

Currently in Coimbatore, collection of solid waste involves from house hold community bins by means of push cart, from there to transfer stations by hydraulically operated vehicles and finally from there to waste processing plants at Vellalore. The methodology adopted for treating the solid waste is Windrow Composting, vermicomposting and Bio Methanation process.

Table II- Existing Methodologies to handle waste in Coimbatore

SI No	Methods	Capacity /land area	Location
1	Windrow Composting	600 TPD	Vellalore
2	Vermicomposting	100 TPD	Vellalore
3	Sanitary Landfill	25 Acres	Vellalore
4	Incineration Plant	Not Available	

On C&D waste, corporation has seventeen collection centres spread all over the city and made notified to the people that C & D waste shall be segregated into four streams Concrete, soil, steel, wood and plastics, bricks and mortar and shall be dropped at centres. Corporation shall collect the waste and recycle in its construction and debris recycling plant for which nominal charges are levied

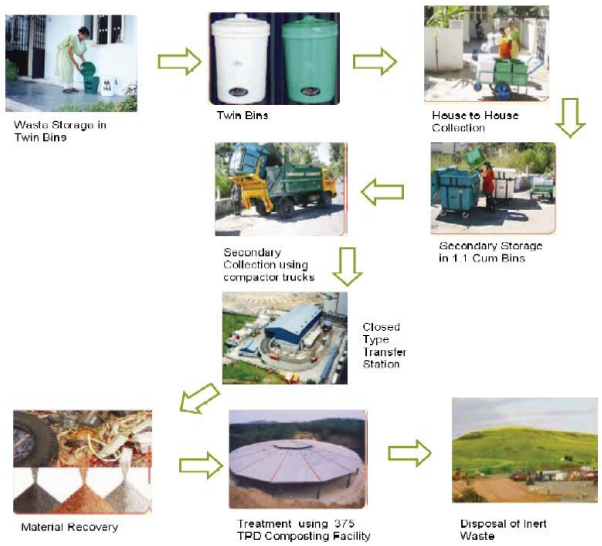

Fig VI- Existing waste management model in Coimbatore City

IV. DECENTRALIZED MODEL

Centralized model of waste management has been followed in the city of Coimbatore where in all the waste are been transported to Treatment plant located at Vellalore. The centralized model has various constraints such as it is capital and land intensive. As centralized model involves transporting of waste to a common treatment plant for e.g. Velallore in Coimbatore, resulting in higher fuel consumption. The decentralized model involves, dividing the urban space into various sub units of close to equal population or grouping to various categories , locating a treatment plant in sub units thereby reducing the transportation cost and huge landfill is avoided.There are 100 wards in Coimbatore which are divided into five administrative zones namely North, south, east, west and central. The idea of decentralized model is to handle the waste near the source itself i.e., in each ward, a waste treatment plant shall be constructed to handle the waste generated by the ward. The hundred wards of Coimbatore has been split into three categories depending on the population to design the waste treatment plant according to volume of waste to be handled

Table III- Different Categories (Grouping of Wards)

Category	Population	No of Wards
Category 1	<= 15000	6
Category II	15000<x<20000	65
Category III	>20000	29

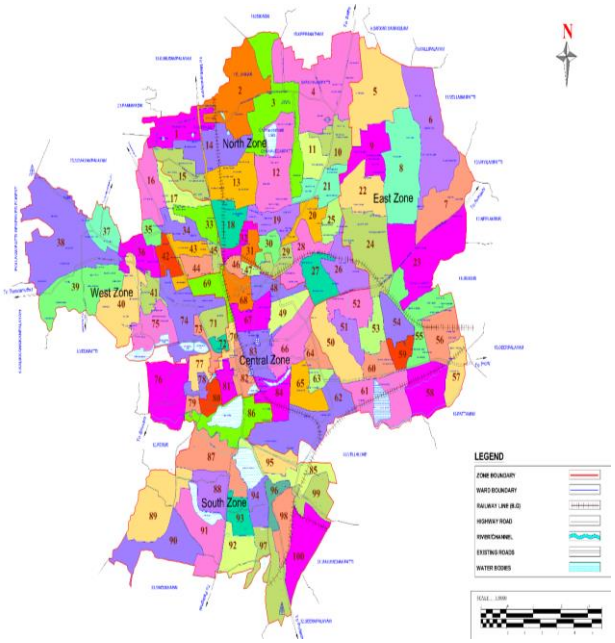

Fig. VII- Map of Coimbatore City showing 100 wards

A. *Waste treatment plant*

Every waste treatment plant shall have the following units

i. Separation unit
ii. Paper Recycling plant
iii. Medi waste treatment
iv. Plastic waste recycling unit
v. Open windrow composting unit
vi. Storage unit

B. *Design of Waste treatment Plant*

B.1.Composting Unit

The composting unit has been designed considering following parameters for all three categories of population.

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Table IV- Windrow Compost Unit Design

SI no	Design Parameters	Category 1- <15,000	Category 2- 15000-20000	Category 3->20000
1	Solid waste generation rate per person per day	0.64 kg/day	0.64 kg/day	0.64 kg/day
2	Solid waste generated per day	4311.5 kg/day	5830.89 kg/day	6870.41 kg/day
3	No' of days for composting	60 days	60 days	60 days
4	Assume the density of the waste	400 kg/m^3	400 kg/m^3	400 kg/m^3
5	Volume of waste generated per day	10.88 m^3/day	14.71 m^3	17.17 m^3
6	Assume depth of the heap	3 m	3 m	3 m
7	Area	494 m^2	650 m^2	650 m^2
8	Length and breadth (m)	4 x 5	4 x 5	4 x 5
9	No' of heaps	13	17	20

B.2.Paper Recycling Unit

Three paper recycling machines are available in the market depending on the volume of paper they can recycle per hour. Small sized machine can 20-100 kg of paper per hour, Medium sized machine can handle 70-250 kg and large one can recycle 100-500 kg per hour. Nearly 4-5 rupee is spent to buy 1kg of waste paper. Electric charges, water charge, transportation and other expenses will add upon. A total of at least Rs. 10 lakhs are required for the initial set up.

Table V-Plastic Recycling Unit

Sl.no	Title	Description
1	Machine adopted	TARA Medium paper recycling machine
2	Capacity	50.75 kg/day
3	Yield	7500 Kg/ Annum finished paper
4	Savings	Rs.50 lakh per annum
5	Capital cost	7.8 lakhs per unit

B.3.Plastic Recycling Unit

One of the biggest reasons for recycling plastic is its huge quantity. It has been observed that 60% of the waste accumulated by the municipal corporation is a plastic waste.

PET bottles and discarded broken plastic items are the plastics can be recycled. The energy savings that is calculated, when using a recycled plastic instead of manufacturing a fresh one amounts to nearly 70 percent.

Table VII-Plastic Recycling Plant

Sl.no	Title	Description
1	Machine adopted	TARA Medium Plastic recycling machine
2	Capacity	90 kg/day
3	Yield	576 Kg/ Annum
4	Savings	Rs.50 lakh per annum
5	Capital cost	6 lakhs per unit

B.4.Medi waste unit

Medical waste is waste that are generated from hospitals, clinics, dental clinics, testing laboratories etc., The waste can be categorized into following three a. Trace chemo, Biohazardous waste, pathological waste and pharmaceutical waste. That include removed organs from the body, infected tissues / bones, contaminated injection needles, used surgical instruments, gloves and any waste that is contaminated with blood. All the medical waste must be packed safely in separate bags. Incineration and Autoclaving is done followed by Shredding the medical waste and so sterilization happens.

B.5.Shredding Unit

First the waste is fed to the shredder where the waste is cut into small pieces which increases the surface area of the waste there by increasing the rate and quality of compost. Description of the shredder machine

Table VII- Shredding Unit

Sl.no	Title	Description
1	Machine adopted	Automatic waste shredder
2	Capacity	1000 kg/hr
3	Yield	3mm size waste pieces
4	Capital cost	70,000/- per unit

V. PLANS AND 3 D-MODELS

The plan and 3d models of all three type of waste treatment plant are given below It is sketched using google sketch up to give the reader an overall idea of how the waste treatment will look like. Three categories just vary in volume of organic waste to be handled accordingly with the population to be served. The number of heaps in windrow composting pit alone varies with different categories.

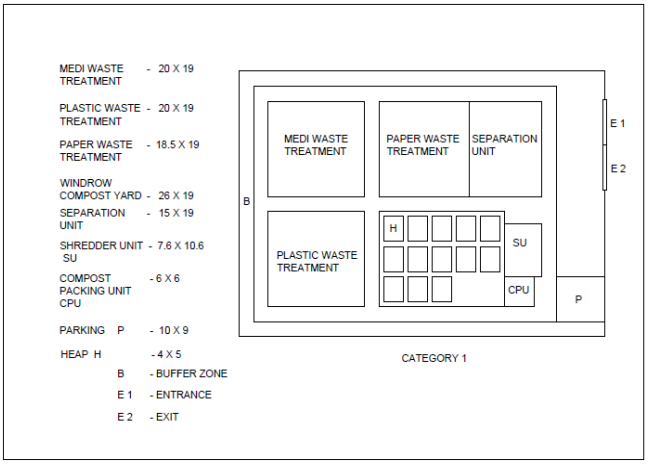

Fig. -VIII- Plan of Waste Treatment – Category 1

Fig. – IX- 3D model of Waste Treatment Plant- Category 1

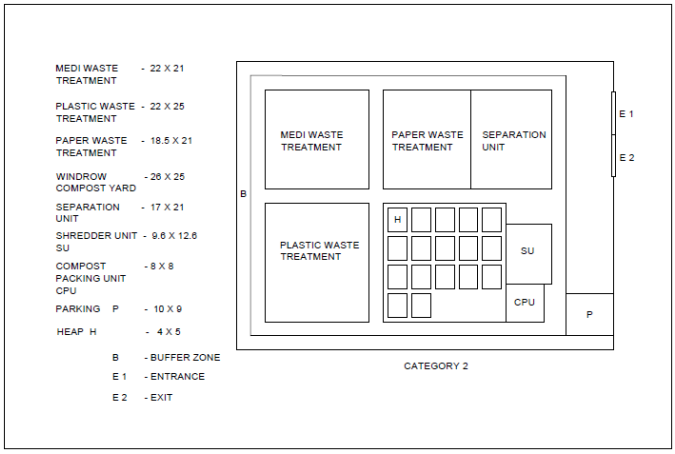

Fig. X- Plan of Waste Treatment plant – Category 2

Fig. 11- 3D Model of Waste Treatment plant – Category 2

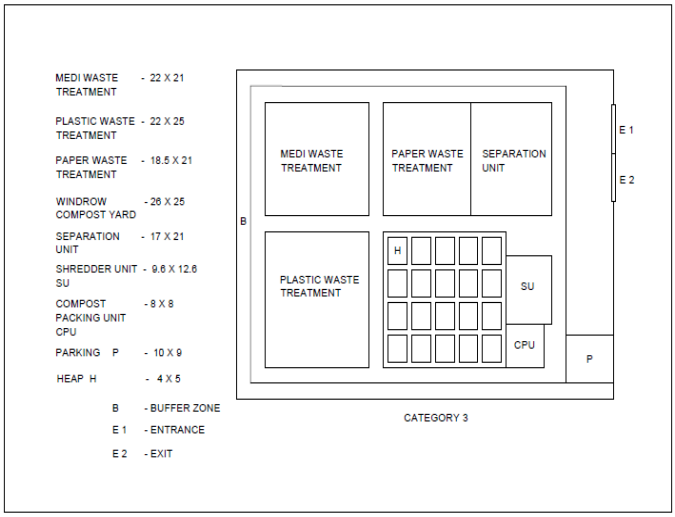

Fig.XI- Plan of Waste Treatment plant – Category 3

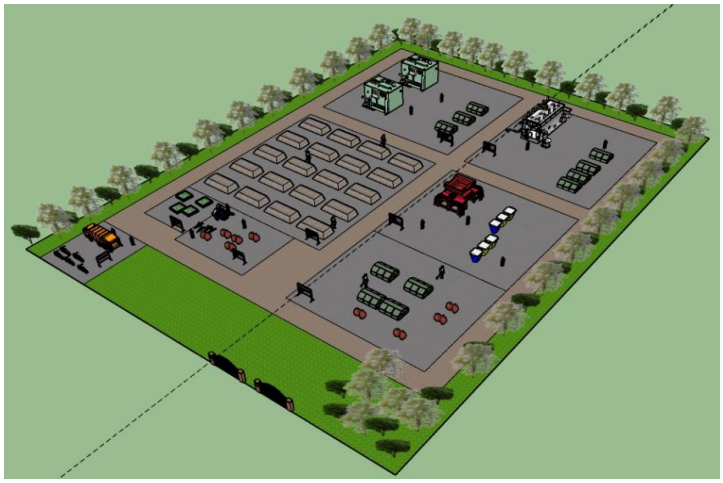

Fig .XII- 3D Model of Waste Treatment Plant- Category 3

VI. SELF MANAGING UNITS

The industries, institutions, apartments and any other source of waste from where the waste generated per day is more than or equal to 300 kg/day have to treat their waste my them self. This is the concept of decentralization, the waste treated at the source.

The concept behind this is the energy and cost required in the transportation and treatment can be saved when the waste is treated at the source. By making this self-managing units the transportation cost can be completely eliminated. Though the construction cost could be added but it could be much less compared to the transportation cost through the life time.

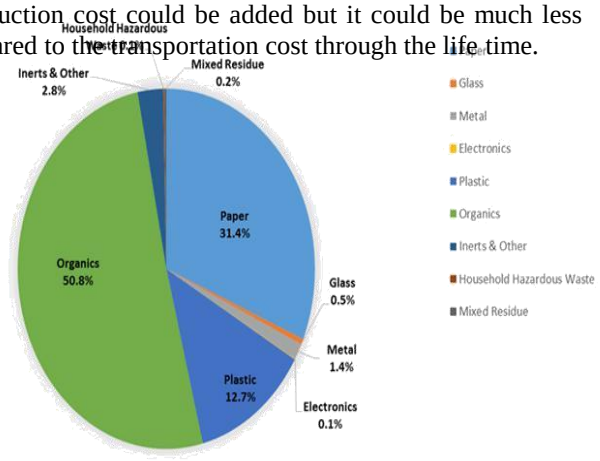

Fig.xii Waste Characterization- institution buildings

Table VIII-Design for Institution and Apartment for waste

Institution and apartments solid waste treatment (composting pit)		
1	Solid waste generation rate per person per day	0.05 kg/day
2	Solid waste generated per day	320kg/day
3	Total solid waste generated per year	116800kg/year
4	No' of days for composting	60 days
5	Assume the density of the waste	400 kg/m^3
6	Volume of waste generated	91.43m^3
7	Assume depth of the pit	3m
8	Installation cost	2lakhs
9	Net return	24000/month
10	Area	30.5m^2

Benefits of Decentralized Model

The benefits of adopting Decentralized model is quantified in all three pillars of sustainability namely Economy, Social and Environment. The advantages are listed out in the following table

Table 9- Benefits in terms of Sustainability

Unit	Environmental	Social	Economy
Windrow Composting Unit	Composting is a most sustainable way of handling organic waste. Compost is an excellent manure to plants as it is rich in nutritional value, Its N-P-K value is really good. It can replace the available chemical fertilizers, insecticides and pesticides which are toxic to environment and human beings too. Compost naturally improves the fertility of the soil thereby ecology is restored. The greenhouse gas emissions related to fertilizer production are avoided. There is significant reduction in the use of pesticides (avoiding emissions associated with their production).	Provides local level operation Institutional, neighborhoods Encourages volunteerism Encourages active lifestyles Employment for local unemployed people Encourages community gardening	Long life span of landfills Reduce or eliminate dumping costs Reduce or eliminate cost of buying compost Can reduce or eliminate other costs e.g. fertilizers Create employment
Paper Recycling Unit	EPA states seventeen trees , seven thousand gallons of water and four hundred and sixty three gallons of oil is being conserved by using one ton of recycled paper. Recovery rate in India: 3 million tons per year (20% of total waste produced Recovery rate in world countries: Germany recycles 73% of discarded paper, Sweden does 69%, Japan 60%, USA 49%. This shows the recovery rate in our country is much less Through the decentralization maximum of 90% of the paper used in the house hold could be recycled when proper segregation is achieved	The energy usage reduced to 60% By recycling, used and discarded paper is being made into a fresh usable paper. Waste to product is achieved. The energy saving is commendable as recycled paper instead of manufacturing a new one that consumes fossil fuel. Recycling aids in preserving natural resources and conserves natural ecology for the future generations. Thus, the living environment is made sustainable	The cost of paper will be less compared to the fresh paper There will be no shortage of paper

Plastic Recycling Unit	A study by franklin associates states nearly half of Green House emissions can be cut down if we use recycled PET bottles instead of fresh ones. Saves landfill spaces – 7.4 cubic years of landfill can be avoided if we recycle plastic waste generated in a city. Ensures sustainable use of resources Studies indicate by increasing the recycling rate of plastics by 25 percent , GHG emissions equivalent to one hundred and thirty one million gallons of gasoline can be cut down.	Amount of energy saved: 70% Provide better standard of living to the waste pickers through jobs with assured income	It is estimated that while trashing if 6 jobs are created for trashing 10,000 tonnes of waste, then recycling can give 36 jobs. Reduces the cost of production since the fresh raw material is not required. The energy required for the process of fresh raw material is reduced

VII. CONCLUSION

This study contributed to developing a model for a sustainable and an integrated waste management model for Coimbatore City. Transforming from centralized model to a decentralized model may make huge investments to build the necessary infrastructure arrangements for handling the waste, but in long run huge energy is conserved. Handling the waste in the neighbourhood makes people aware of efforts taken by government to handle the waste generated by them. Future studies may develop a mechanism to monitor and connect all the decentralized plants to have a integrated approach in waste management.

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