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Generation of Electricity Using Solid Waste Management in Krishnagiri Municipalty

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ABSTRACT
The electricity sector in India supplies the world's 6th largest energy consumer, accounting for 3.4% of global energy consumption by more than 17% of global population. About 65.34% of the electricity consumed in India is generated by thermal, 21.53% by hydroelectric power plants, 2.70% by nuclear power plants and 10.42% by Renewable Energy Sources. More than 50% of India's commercial energy demand is met through the country's vast coal reserves. The country has also invested heavily in recent years in renewable energy utilization, especially wind energy. Four major economic and social drivers characterize the energy policy of India: a rapidly growing economy, increasing household incomes, limited domestic reserves of fossil fuels and the adverse impact on the environment of rapid development in urban and regional areas. Meanwhile, the rural areas are struggling with a chronically tight supply of electrical power. In order to properly manage the changing conditions, knowledge and estimation of the available resources and applying their relation with the population is of utmost importance. The paper deals with extraction of such information with the help of spatial techniques. This paper deals with estimation of the amount of solid waste generated by a part of the Krishnagiri city using spatial techniques. Solid waste management is one of the most essential functions in a country to achieve a sustainable development. In India, it has been one of the least prioritized functions during the last decades. The most common ways to treat waste in India today are open dumping and uncontrolled burning. These methods are causing severe environmental pollution and health problems. India is one of the world’s largest emitter of methane gas from waste disposal. Since methane is a strong greenhouse gas, even small emissions have large impact on the climate. Like most municipalities in India, COK has experienced difficulties keeping in pace with last decades’ industrialization, resulting in insufficient collection of municipal solid waste and over burdened dumpsites. Another consequence of the rapid industrialization is the increased demand for electricity. Today there is not enough installed capacity of power stations in Krishnagiri to meet this demand, leading to daily power cuts. This project will give an overview of the current waste used to generate electricity situation in Krishnagiri and analyze whether Hydro air Tectonics should build this combustion unit or if they should sell the generated RDF to industries. The result will be presented in a case study. The garbage has several nutrients and hence can be advantageously processed to produce many bye products and end products viz. gas, electricity and also organic manure which is highly suited for organic farming.
KEYWORDS: Hydroelectric Power Plants, Cropping Intensity, Krishnagiri , Environmental Pollution . Rapid Industrialization.

I. INTRODUCTION

Rapid economic growth has created a growing need for dependable and reliable supplies of electricity, gas and petroleum products. Due to the fast paced growth of India's economy, the country's energy demand has grown an average of 3.6% per annum over the past 30 years. In India, the typical rate of population increase is about 23% and in the urban areas is about 35%. Rate of increase of the solid waste generated is 1.3% annually.

The amount of municipal solid waste generation by 2025 is expected to be 750 Gms / capita per day, which presently ranges from 200 to 500 Gms / capita per day. Thus, if this scenario continues, there are bound to be serious problems for waste disposal especially in the urban areas. Electricity can be produced by burning "municipal solid waste" (MSW) as a fuel. MSW power plants, also called waste to energy (WTE) plants, are designed to dispose of MSW and to produce electricity as a by-product of the incinerator operation.

The term MSW describes the stream of solid waste ("trash" or "garbage") generated by households and apartments, commercial establishments, industries and institutions. MSW consists of everyday items such as product packaging, grass clippings, furniture, clothing, bottles, food scraps, newspapers, appliances, paint and batteries. It does not include medical, commercial and industrial hazardous or radioactive wastes, which must be treated separately. Burning MSW can generate energy, while reducing the volume of waste by up to 90 percent.

The solid waste disposal system deals with the collection and proper disposal or recycling of the solid wastes. The disposal techniques may include land filling, burning, composting etc. Presently, the major portion of the solid waste in Krishnagiri is collected from households using the ghanta gadi / trucks or the community bins in the form of containers, dumper buckets etc.

This collected solid waste is then dumped at the transfer stations, from where it is taken to the dumping grounds or for other further processing. About 30% of it is recycled and small amount is also converted into compost. Major portion of the remaining is filled in the dumping grounds. But for the land filling techniques, a large area of land is required. The present dumping grounds are now getting saturated. They also pose health hazards to the people living in the surrounding areas due to the unhygienic conditions.

The solid wastes also need to be treated within lesser time, because it cannot be piled up. The present practices in Krishnagiri expect the residents to segregate the solid wastes at the individual level. This practice can be put to use for efficiently processing the solid waste can be converted into usable energy.

II. STUDY AREA

The Krishnagiri district has a prehistoric importance. Archeological sources confirm the presence of habitats of mankind during Paleolithic, Neolithic and Mesolithic Ages. Various rock paintings and rock carvings of Indus Valley civilization and Iron Age seen in this district support the historical significance of this district. Krishnagiri region is a part of the ancient Kongu Nadu and Cheracountry.

Historically it was ruled by Kongu and Chera rulers. Later the region came under Cholas, Pallavas, Gangas, Nulambas, Hoysalas, Vijaya Nagar and Bijapur emperors, Wodeyars of Mysore and Nayaks of Madurai. This region of Krishnagiri served as "Gateway of Tamil Nadu" and the protective barrier for Southern region defending onslaughts from barriers with motives of imperialism and exploitation. Krishnagiri Fort become the first and forth most defensive place. The majestic fortress built on Krishnagiri hill by the Vijaya Nagar Emperors, stands as testimony still now.

The "Mango of Krishnagiri", Dr. C. Rajagopalachari, who hailed from a small village in this district rose to the highest position in the nation as the first Governor General of independent India, leader of the Congress Party, and as Chief Minister of Tamil Nadu. The historical importance and potential growth in education, economy and tourism of present Krishnagiri made it necessary to create a separate district. Krishnagiri was formed as 30th district by the Government of Tamil Nadu. Krishnagiri district was carved out of Dharmapuri district on 9 February 2004 with five taluks and ten block

2.1 SOLID WASTE

Residual Municipal Solid Waste (MSW) is waste that is household or household like. It comprises household waste collected by local authorities, some commercial and industrial wastes e.g. from offices, schools, shops etc that may be collected by the local authority or a commercial company. Legislation limits (by implication1) the amount of mixed MSW that can be sent to landfill. One of the guiding principles, now enshrined in law, for European and UK waste management has been the concept of a hierarchy of waste management options, where the most desirable option is not to produce the waste in the first place (waste prevention) and the least desirable option is to dispose of the waste with no recovery of either materials and/or energy.

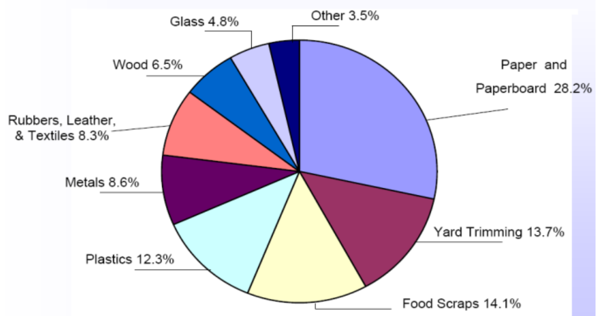

Fig no 2. 1 Solid waste

Between these two extremes there are a wide variety of waste treatment options that may be used as part of a waste management strategy to recover materials (for example furniture reuse, glass recycling or organic waste composting) or generate energy from the wastes .There are a wide variety of alternative waste management options for dealing with MSW to limit the residual amount left for disposal to landfill. (Fig no 2. 1)

2.1.1 Objective

The aim with this project is to do a feasibility study about the possibility to recover energy from MSW in Krishnagiri, with focus on combustion. In order to evaluate the feasibility for building a combustion unit, the current waste and electricity situation in Krishnagiri as well as the future MSW treatment plans are analyzed. This information will be used to formulate a case study, in which the following questions are answered:

- Should there be mass burning of MSW or only combustion of the burnable fraction of the MSW (RDF)?

- Who should process the waste and which methods should be used?
- Where the plant should be situated?
- Should there be co-incineration with another fuel? In that case, which fuel is suitable for co-incineration?
- Which technology should be used for combustion and what type of flue gas treatment should be used?
- Which type of energy should be recovered?

When the case is formulated the technical and financial viability are analyzed. The possible energy extracted from the plant is determined as well as the plant cost

2.2 Expected result of the study

The study will result in an informative and analysing report of the current and future MSW situation in Krishnagiri. It is meant to serve as informative material for those people interested in learning more about the MSW and electricity situation in Krishnagiri as well as guidelines for future MSW management.

2.3 Limitations

- MSW stands for the largest part of the waste generated in Krishnagiri and causes difficult problems for the municipality. Therefore, the focus will be on energy recovery from MSW and not other waste types.
- Energy recovery from MSW can be achieved through different technologies such as biomethanation, gasification and combustion. Due to the fact that combustion has been proven successful in many developed countries and that it is an efficient method to reduce the volume of the waste, this study will focus on energy recovery from combustion.
- In the case study, only the technical and financial viability will be covered. The environmental gains from improving the waste situation in Krishnagiri will not be evaluated, except from the carbon dioxide reductions, which will result in Certified Emission Reductions (CERs) and thereby give financial revenues.

2.4 Description of the current and future waste and electricity situation in Krishnagiri

In this section the current and future waste and electricity situation in Krishnagiri is described. To be able to get an overview of the waste and electricity situation, several interviews with companies, institutions and governmental actors involved in solid waste management in Krishnagiri were made.

Krishnagiri Municipality is currently managing the solid waste generated from the town with the existing vehicles and labor. In krishnagiri the waste is not collected properly and the waste in not sorted out in the proper stream. The service is not up to the expectation and the present system has many shortcomings.

Therefore a strategy has been devised to implement a solid waste management plan effectively in krishnagiri municipality.

The information about future MSW management in Krishnagiri was given by the company Hydro air Tectonics, since they are going to take care of at least half of the generated MSW in Krishnagiri in the near future. A study visit to one of Hydroair Tectonics MSW treatment plants in Ichalkaranji, together with interviews and work at their head office in Mumbai made it possible to thoroughly analyse their treatment methods.

2.5 Setting up a waste-to energy plant

This chapter gives an overview of the regulations and support systems that need to be considered when setting up a waste-to-energy plant in India. The information is given by interviews.

2.6 The case for MSW incineration in Krishnagiri

In this chapter, the case study is presented and the technical and financial viability is analysed. The presentation of the case is based on analysis of the information given in the sections above.

In the technical viability analyses, the potential energy that can be extracted from the plant is calculated. The methods used for the calculations are based on literature studies and known equations. In the technical viability analysis it is assumed that the company Hydroair Tectonics and the industry Orchid Chemicals & Pharmaceuticals Ltd will cooperate and exchange energy/fuel. Therefore this section is based on data from these two companies. Furthermore, standard values from Borlänge Energy’s waste-to-energy facility are used.

In the financial viability analysis, an estimation of the maximum plant cost for the project is made, in order for the project to be profitable. The calculations are based on the possible revenues from the plant and on the alternative costs for not building the plant. These data were obtained from interviews and Internet sources.

III. Solid Waste Management And Electricity Production In Krishnagiri

3.1 General

Krishnagiri experiences tropical climate during the summer. Summer is generally warm and dry. Monsoon season brings substantial amount of rainfall to this region and Krishnagiri experiences a long monsoon. Winters are generally pleasant and comfortable. This is the best time to visit the place. There are three distinct seasons that can be seen in

Krishnagiri. Summer is from the months of March to June.

During this time temperatures are warm and mercury rise up to around 38°C and dipping a minimum of 32°C. April and May are generally the hottest months of the year and the heat could be uncomfortable. Monsoon season is from the months of July to November. During this time temperatures are mild and pleasant. Heavy rainfall can be expected in short intervals.

Monsoon season is also a good time to visit as there are breaks in the rainfall. Approximately 25 industries located in this district process mangoes. Much of the population in this district is employed through mango cultivation directly and other labour class benefit through employment in mango processing units. There are about 150 mango nurseries which produce mango saplings in and around 'Santhur Village' .

The district exports mango based products worth over ₹8 billion. Under the horticulture development program, government owned horticulture farms are functioning here. Through these units, about 300,000 fruit saplings are produced and distributed under different schemes. Apart from production and export, Krishnagiri also hosts Mango exhibition every year which is the unique in its kind in line with the annual exhibition held at New Delhi.

3.2 Solid waste generation

The solid waste in Krishnagiri can be divided into the following categories: industrial waste, agricultural waste, hazardous waste, bio-medical waste, e-waste, construction and demolition waste and MSW.

A study performed in 1996 by Krishnagiri Metropolitan Development Authority (KMDA) in collaboration with the World Bank shows that the residences are the largest generator of solid waste in Krishnagiri, which can be seen in Table 2.

Table 3.1 Solid waste generation sources in Krishnagiri.

Solid waste generation source	[%]
Residences	68
Commercial buildings	14
Restaurants, Hotels, Schools and other	11
Markets	4
Hospitals and Clinics (collected separately)	3
Total	100

3.2.1 Industrial Waste

Industrial waste is unwanted material from an industrial operation. It may be liquid, sludge, solid or hazardous waste. One of the largest industrial areas in Krishnagiri is called Manali and is situated in the northern suburb in the Tiruvallur district. Major chemical industries are situated in this area, particularly petrochemical industries.

No figures exist about how much industrial waste is generated every day in Krishnagiri. The industries are themselves responsible for taking care of their waste. The industries often have private scrap dealers collecting their recyclable waste. The scrap dealers buy the waste from the industries and sell it to manufacturing industries that recycle the material.

3.2.2 Agricultural Waste

Agricultural waste is waste produced as a result of various agricultural operations. It includes manure, harvest waste and other wastes from farms, poultry and slaughter houses. Within the ten zones of Krishnagiri there is no land for agricultural purposes. Yet in the nearby districts in Tamil Nadu there are areas used for agricultural operations. The interesting crops for cultivation here are paddy, ground nut, prosopis juliflora and sugarcanes.

In Tamil Nadu there are agricultural waste-to-energy projects from combustion, gasification and biomethanation. There are nine combustion power plants, that together stand for 109 MW. There is one gasification plant (1 MW) and two biomethanation plants; one that uses vegetable waste (0.25 MW) and one that uses poultry litter waste (4 MW).

Figure shows a 0.25 MW biomethanation plant that was set up at the Koyembedu wholesale market complex in September 2005. Around 100 tons of vegetable waste reaches the plant every day. The plant is unique in India in the way that it produces electricity only from vegetable waste, no leather or other animal waste.

3.2.3 Hazardous Waste

Hazardous waste is waste that can cause significant damage to environment and human health if it is not treated properly.

During a long period of time the industries in Krishnagiri disposed their hazardous waste together with the MSW on roadsides and in low-lying areas, as there was no infrastructure available. As an attempt to solve this problem the Supreme Court created the Hazardous Waste Handling Rules 1989, which forced the state governments to provide infrastructure such as landfills for disposal and treatment of hazardous waste.

For fifteen years Tamil Nadu Government violated these rules allowing industrial expansion without taking any measurements for the hazardous waste generated. The proposal from Tamil Nadu

Pollution Control Board (TNPCB), to establish common treatment storage and disposal facility for hazardous waste, became a difficult issue because of the public opinion that the nearby land and the groundwater would be polluted. Threatened by pressure from the Supreme Court, the Tamil Nadu Government finally selected Gummidipoondi in the Tiruvallur district for the treatment site.

3.2.4 Bio-Medical Waste

Bio-medical waste means any waste, which is generated during the diagnosis treatment of immunization of human beings or animals in research activities or in the production or testing of medication.

Bio-medical waste is waste generated from healthcare centres. The 528 hospitals in Krishnagiri city generate about 12 000 kg of bio-medical waste per day. It is considered hazardous firstly for its potential for infection and secondly for its ingredients of antibiotics, cytotoxic drugs, corrosive chemicals and radioactive substances.

According to the Bio-Medical Waste (Management and Handling) Rules, 1998, bio- waste needs to be treated in certain facilities. Two sites were chosen by TNPCB for location of common treatment and disposal of biomedical waste from hospitals in Krishnagiri and the nearby districts. They are situated in Thenmelpakkam and Chennakuppan in the Kancheepuram district. The main processes in these facilities are incineration and autoclaving.

3.2.5 E-Waste

E-waste is the informal name of electronic products nearing the end of their useful life. Products such as mobile phones, computers, refrigerators etc fall under this category.

E-waste contains over a thousand different substances, many of which are toxic to environment and human health. One of the primary sources of e-waste in Krishnagiri is computer waste from the many western IT companies which have been established in the southern parts of the city.

Today there are no specific guidelines or environmental laws for e-waste in India. Since it is considered both “hazardous” and “non-hazardous” it falls under the Hazardous Waste Management Rules, 2003. Thus, the creation of new guidelines for handling e-waste is in progress by the Central Pollution Control Board (CPCB), which most likely will be transformed into environmental laws later.

TNPCB has authorized seven e-waste recycling industries, which receive e-waste scrap from industries in Tamil Nadu. They use mechanical tools to break the scrap and then manually segregate it into different components for recycling. The scrap is segregated into plastic components, glass, ferrous and non-ferrous material. Some of the components are not suitable for this process and are therefore exported to reprocessing facilities in Belgium, Singapore, Hong Kong, China and Taiwan for metal recovery.

However there are informal scrap dealers and recyclers in residential areas in Krishnagiri and in the outskirts of the city. With small tools and crude methods they manually sort out valuable materials from the scrap. In order to segregate aluminium from the e-waste they often burn the waste, which causes toxic air pollution.

3.2.6 Construction and Demolition Waste

Construction and demolition waste is waste from building materials debris and debris resulting from construction, re-modelling, repair and demolition operations.

Every day Krishnagiri city generates 10MT of construction and demolition waste. There are a few sites identified by the COK, where the generators of this waste can dump their waste, as well as collect the waste if they want to use the material for landfilling etc. This system does not work perfectly and it exists unauthorized dumping of construction debris along certain roads.

3.2.7 Municipal solid waste

MSW includes residential and commercial waste generated in a municipal area, excluding industrial hazardous waste but including bio-medical waste.

Low-income countries like India produce approximately 0.4-0.9 kg waste per person and day, while the waste generation rate in high-income countries ranges from 1.1-5 kg per person and day. The average waste generation in Krishnagiri is estimated to be 585 gram per person and day, which is the highest per capita generation of all cities in India.

The population in Krishnagiri 2008 was 71,323 according to KMDA and the total amount of solid waste collected per day was 3400 tons. Zones 10 and 5 are the largest zones by area but zones 5 and 8 generate the highest amount of waste which is shown in Figure.3.1

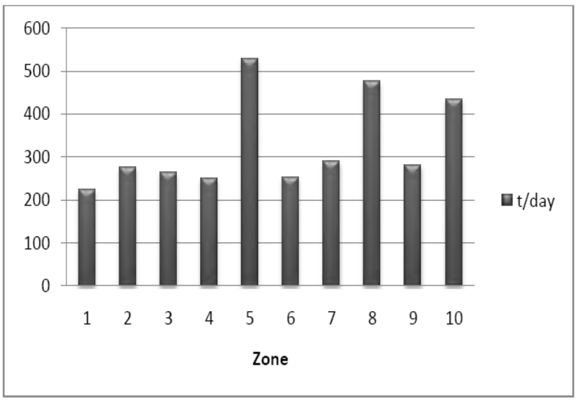

Figure 3.1 Zone wise garbage removal in Krishnagiri.

3.3 Municipal solid waste management in Krishnagiri

The following text will explain the role of the governmental actors and the different aspects of MSWM in Krishnagiri.

3.3.1 Governmental actors responsible for SWM

In India it is the local bodies that have the overall responsibilities for SWM in each city. Unfortunately, the municipal laws regarding SWM do not have adequate provision do deal effectively with the problems of solid waste in India today.

3.3.1.1 The Ministry for Environment and Forest

The principle activities of the Ministry for Environment and Forest (MoEF) consist of protection of the environment in the form of legislations. This includes conservation of flora, fauna, forest and wildlife as well as control and prevention of pollution. MoEF created the Municipal Solid Waste (Management and Handling) Rules, 2000.

Figure illustrates the Municipal Solid Waste (M&H) Rules, 2000, in the form of Schedule (I-IV). Below each schedule there are specifications, standards and procedure descriptions how MSW should be handled. The responsibility for the implementation of the Municipal Solid Waste (M&H) Rules, 2000, lies within every municipality. (Figure.3.2)

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

Figure 4.2 The Municipal Solid Waste (M&H) Rules, 2000.

3.3.1.2 Central Pollution Control Board

Central Pollution Control Board (CPCB) is together with the State Pollution Control Boards responsible for the implementation and review of the standards and guidelines described in the Municipal Solid Waste (M&H) Rules, 2000. They shall make sure that the monitored data will be in compliance with the standards specified under Schedules II, III and IV. In Tamil Nadu it is the Tamil Nadu Pollution Control Board (TNPCB), which has the responsibility on state level.

CPCB advises the Central Government on any matter concerning the improvement of the quality of air and prevention and control of air and water pollution. If a company wants to set up a facility that will cause pollution, it needs to get clearance from CPCB.

3.3.1.3 The Ministry of New and Renewable Energy

The Ministry of New and Renewable Energy (MNRE) is responsible for both renewable energies and new fossil fuel technologies. Its main objectives regarding MSW management are

- To accelerate the promotion for MSW-to-energy projects
- To create favourable conditions with financial regime, to develop and demonstrate the viability of recovering energy from waste
- To realize the available potential of MSW-to-energy by the year 2017

Tamil Nadu Energy Development Agency (TEDA) implements The Ministry of New and Renewable Energy’s (MNRE’s) goals and visions on state level. They encourage research and development on renewable energy sources and implement such projects within Tamil Nadu as well as distribute subsidies to the projects.TEDA promotes mainly four renewable energy sources: wind, biomass, solar energy and energy recovery from waste.

3.3.1.4 The Ministry of Urban Development

The Ministry of Urban Development (MoUD) created the solid waste management manual, which serves as guidelines for the municipalities to handle their work more efficiently. It also provides the municipalities with technical guidelines on aspects of solid waste management.

The urban local bodies, which are responsible for the SWM in each city, often lack adequate knowledge and expertise to deal efficiently with the problems of waste management. As an attempt to improve the situation, the MoUD decided in 1998 to create a solid waste management manual. The manual serves as guidelines for the urban local bodies to handle their work more efficiently.

According to the solid waste management manual, the best method to deal with waste in India is to adapt the “hierarchy of waste management”. This method is known throughout the world as a sustainable solution for the growing problem of solid waste. Figure.3.3 shows the hierarchy as it is described in the solid waste management manual.

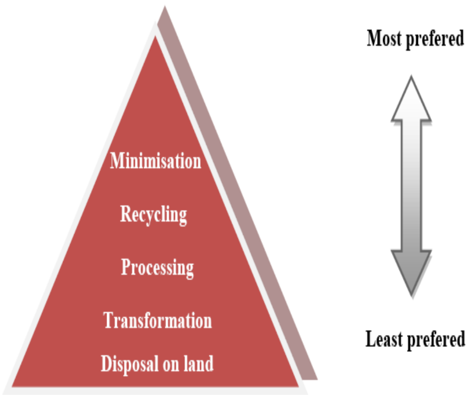

Figure 3.3 Hierarchy of waste management.

1. Waste minimisation/reduction at source means that the waste is prevented from entering the waste stream by the means of reusing products and using less material for manufacturing them.
2. Recycling means the act of sorting out recyclable materials like plastic, glass, metals and paper from the waste and reprocessing them into new products.
3. Waste processing includes biological and thermal processing and can result in useful products like energy and compost.
a) Biological processing includes composting and biomethanation.
b) Thermal processing includes combustion, pyrolysis and gasification.
4. Waste transformation (without recovery of resources) is for example combustion without energy recovery. Mechanical decomposition and autoclaving fall under this category.
5. Disposal on land (landfilling) should be the solution only if the waste cannot be treated with the four previous methods. The landfills should be designed to minimize the impact on the environment.

IV. FUTURE MSW-TO-ENERGY IN KRISHNAGIRI

The problems that Krishnagiri Corporation has been facing during the last years regarding solid waste management and electricity production have become more manifest today than ever. The two dumpsites in Krishnagiri, Kodungaiyur and Perungudi, are overfilled with waste and the residents in Tamil Nadu are getting tired of planning their daily routines after the announced and unannounced power cuts.

This, together with stricter regulation from the government has made Krishnagiri Corporation more actively work towards changing the situation. This chapter will describe future MSW management in Krishnagiri. In the sections where the source is not given, the facts are based on Hydroair Tectonics internal documents.

4.1 Hydroair Tectonics

Recently, the company Hydroair Tectonics Ltd from Mumbai has signed a contract with Krishnagiri Corporation to take care of the waste going to Perungudi dumpsite. An area of 30 acres is provided by the COK at Perungudi dumping ground. In return the company needs to pay a royalty fee to the COK of Rs. 15/ton ($0.31/ton) of MSW.

4.1.1 The processing plant

The company will set up an integrated MSW treatment plant at Perungudi dumping ground in Krishnagiri, which is going to process 1400 tons of MSW every day. It is going to be two segregation units, each processing 700 tons of MSW per day. M/S Shiram Energy Systems Ltd is an associate for this project. They have implemented the 6 MW processing plant in Hyderabad which has been operating successfully since 2003.

The MSW will be segregated into the following fractions: recyclables, inert material, compostable fractions and burnable waste. The segregation is made both manually and mechanically. The incoming waste is initially weighted on a weight bridge, tipped on a tipping ground and then processed according to figure.4.1

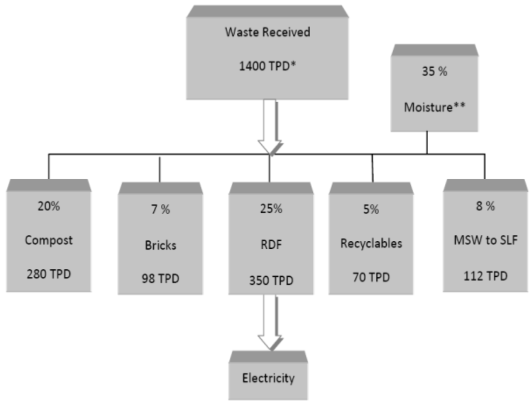

Figure 4.1 Estimated flowchart of the processing of waste at Perungudi dumpsite in Krishnagiri.

The compostable and inert components are segregated and processed to compost and bricks respectively. The burnable material is separated and chopped to Refuse Derived Fuel (RDF) which can be used in a boiler to produce electricity. Most of the recyclable components will be segregated and sold to scrap dealers, for resale value.

Larger inert components and other waste that is not suitable for recycling or biological processing will be put on a sanitary landfill. More than one third of the waste received at the plant consists of moisture. Leachate water will be collected and processed in a treatment plant.

4.1.1.1 Compliance with the Municipal Solid Waste (M&H) Rules, 2000

The technology used will meet the requirements of The Municipal Solid Waste (M&H) Rules 2000, in line with the following rules:

- Biodegradable Waste will be processed by composting only.
- Compost or any other end products will comply with standards as specified in Schedule-IV of The Municipal Solid Waste (M&H) Rules, 2000.
- Land filling shall be restricted to non-biodegradable, inert waste and other waste that are not suitable either for recycling or for biological processing.

4.1.2 MSW to products

A large part of the financial income of the plant will be revenues from selling the products generated from the segregation process. The products are recyclables, compost, RDF and bricks. If Hydroair Tectonics builds a unit for burning RDF with energy recovery in the future, the primary product will be electricity.

The following text will give a short description of the manufacturing process of the products and the segregation process, based on facts from the existing plant in Ichalkaranji.

4.1.2.1 Compost

When the large stone blocks and recyclables have been sorted out manually from the waste at the tipping ground, the segregation of the compostable fraction starts. The MSW is fed into a drum machine with holes measuring 80 mm in diameter. The compostable fraction, mixed with the inert material, passes through the holes. The remaining waste makes up the burnable fraction, which is going to be processed to RDF. The segregation unit is shown in figure.4.2.

Figure 4.2 Segregation unit for separation of the organic and inert components.

The compostable fraction mixed with inert material is used for aerobic composting in windrows. The waste is processed for 35 days with regular stir and mixing with bio- culture, which accelerates the degradation, as seen in figure.4.3

Figure 4.3 Bioculture is sprayed on the windrows.

- The processed waste is passed on to the second mechanical segregation step, which is a drum machine with holes measuring 20 mm in diameter. The larger fractions of inert material will be separated and sent to a sanitary landfill or to a stone crusher.
- The remaining waste will continue to the next segregation step, which is based on gravity separation. Air is added from below and the inert fraction with higher density is separated from the compostable fraction.
- The final segregation step, before the compostable fraction can be used as compost, is the magnetic separator which separates small components of metals from the organic fraction.
- The compost is packed in plastic bags, as illustrated in figure, and sold to farmers as soil conditioner or organic fertiliser. (Figure.4.4)

In Schedule-IV of The Municipal Solid Waste (M&H) Rules, 2000 there are standards specified for the maximum amount of heavy metals that is allowed in compost for the purpose of using it as fertilizer.

There are also standards for pH value and C:N ratio. A sample taken on the 6th of June 2008 from the compost produced at Hydroair Tectonics' segregation plant in Ichalkaranji shows that the standard values were not exceeded. The values can be seen in table.4.1

Figure 4.4 The compost ready to be sold to farmers.

Table 4.1 Standard values of compost in India and specific values from the compost produced in krishnagiri.

Physical characteristics	Standard	Ichalkaranji
C : N ratio	20 – 40	27.35
pH	5.5 – 8.5	6.54
Heavy metals	Should not exceed (mg/kg)	mg/kg
Arsenic	10	BDL
Cadmium	5	0.22
Chromium	50	0.19
Copper	300	90
Lead	100	BDL
Mercury	0.15	BDL
Nickel	50	BDL
Zinc	1000	212

4.1.2.2 RDF

The larger fractions of MSW, which are separated in the first segregation step, consist of larger stone blocks and burnable waste such as paper, plastic, textiles, COKonut shells, rubber etc. The large inert fractions and the recyclable plastic and metals are sorted out manually and the remaining burnable waste is passed on to a mechanical separation unit.

Air is added from below and the heavy non-combustible material, such as glass and inert material are separated from the light combustible fractions. Finally, the combustible material is mechanically crushed and chopped into a small fluffy fraction. The RDF processing machinery is illustrated in figure.5.5

Figure 5.5 The RDF processing machinery.

Figure 5.6 Bailed RDF fluff.

The result is called RDF fluff .(Figure.5.6)and can be used as fuel in a boiler for electricity generation. Alternatively it can be sold to energy demanding industries as a substitute for coal.

For the purpose of storing and transportation, the RDF fluff can be bailed as seen in figure, or processed further to briquettes or pellets. If it is going to be sold directly to the market further processing of RDF fluff is preferable.

In table 5.1 the range of specific characteristics of RDF fluff is shown.

Characteristics	Range [%]
Moisture	10 - 30
Ash Content	20 - 30
Volatile Matter	50 - 65
Fixed Carbon	12 - 15
Mineral matter	20 - 30
Carbon	20 - 30
Hydrogen	3 - 5
Nitrogen	1 - 1.5
Sulphur	0.2 - 0.3
Oxygen	20 - 25

The higher and lower heating value for RDF.given in Table 5.2 and Characteristics of RDF fluff and pelletsare given in Table 5.3

Table 5.2 The higher and lower heating value for RDF.

RDF	LHV (Hi)		HHV (Hs)	
	MWh/ton	kcal/kg	MWh/ton	kcal/kg
Lower limit	2.0	1684	2.2	1905
Higher limit	3.1	2705	3.7	3152

Table 5.3Characteristics of RDF fluff and pellets.

Product	Fluff	Pellets
Shape	Irregular	Cylindrical
Size	25 x 25mm to 150 x 150mm	8 mm to 25 mm in diameter
Bulk density	0.02-0.03 MT/m3	0.6 to 0.7 MT/m3

4.1.3 Sanitary landfill

A sanitary landfill will be made at the dumpsite. The waste going to the landfill is restricted to certain inert material and other unusable waste and will stand for less than 8 percent of the incoming waste. Compactors will be used to arrange the waste in thin layers and to achieve high density of the waste. To minimize the run off to the ground water, the sanitary landfill will have a sealing system consisting of sheets made of plastic material and soil layer with low permeability.

The site will be provided with a leachate collection and removal system, which will be explained in the next section. Sand, silt and soil, which are separated during the segregation steps, are going to be used as earth cover to prevent infiltration. A cover of 10 cm is provided daily and an intermediate cover of 40-64 cm during monsoon.

4.1.4 Leachate treatment

A large part of the waste is moisture, which will result in runoff from the plant, in the form of leachate water if it is not collected. The leachate from the project facility and sanitary landfill site will be collected through a drainage layer, a perforated pipe collector system and a sump collection area.

It is carried to collection tanks and later on to a treatment plant. At the plant, the leachate will be treated so that it can meet certain standards as specified in the Schedule-IV of The Municipal Solid Waste (M&H) Rules, 2000. These are illustrated in table.5.4

Table 5.4 Standard for leachate treatment.

Parameter	Standards (Mode of Disposal)		
	Inland surface water	Public sewers	Land disposal
Suspended solids, mg/l, max	100	600	-
Dissolved solids (inorganic) mg/l, max.	2100	2100	-
pH value	5.5 - 9.0	5.5 - 9.0	-
Ammonium nitrogen (as N), mg/l, max.	50	50	-
Total nitrogen (as N), mg/l, max.	100	-	-
Biochemical oxygen demand (3 days at 27 deg C) max.(mg/l)	30	350	100
Chemical oxygen demand, mg/l, max.	250	-	-
Arsenic (as As), mg/l, max	0.2	0.2	0.2
Mercury (as Hg), mg/l, max	0.01	0.01	-
Lead (as Pb), mg/l, max	0.1	1.0	-
Cadmium (as Cd), mg/l, max	2.0	1.0	-

V. CONCLUSION

Both energy from waste and recycling and composting efforts are a win-win-win for the INDIA. EfW generates clean electricity, decreases greenhouse gases that would have been emitted from landfills and fossil-fuel power plants, and pairs well with increased recycling rates in states. Recycling and composting reduces trash that is destined for the landfill that would have emitted greenhouse gases while decomposing, saves energy that would have been used for the production of a virgin material, and decreases the need to mine for raw materials, which will preserve our natural resources. Doing so will ultimately reduce emissions that cause climate change.

Waste to energy solves the problem of MSW disposal while recovering the energy from the waste materials with the significant benefits of environmental quality, increasingly accepted as a clean source of energy. Research and technology development focusing on corrosion phenomena, flue gas control, fly ash management and beneficial reuse of residues will further drive the growth of WTE industry.

WTE incineration needs to be implemented to make greater contribution in supplying renewable energy in Bangladesh, while helping solving the country's MSW management problem in the coming decade. The challenge of MSW disposal and the demand for alternative energy resources are common in many developing countries.

Experimentally a 5-10 MW power plant may be installed based on the quality and current generation of solid wastes in RCC. It can also be considered as a Waste Management Plan rather than as an Electricity Generation Project as the technology can lead to a substantial reduction in the overall waste quantities requiring final disposal, which can be better managed for safe disposal in a controlled manner while meeting the pollution control standards.

In addition, power produced from the WTE activity can reduce the costly natural resources "fossil fuel" utilization in power generation. It is expected that the experience on the development of WTE in Bangladesh can offer some helpful lessons to other developing counties.

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