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Skill Development in Solid Waste Management

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Abstract

To have fast and sustainable growth power demand-supply gap can be linked only by consuming and spreading of renewable energy sources such as Solar, Wind, Biomass, Small Hydro, etc. Fossil fuels are fast depleting and pose an intolerable import bill while adding to the overall pollution. Municipal Solid Waste (MSW) has high potential of generating energy by utilizing various techniques. Training programmes are needed across India for development of skill, knowledge for effective and efficient utilization of MSW to meet rising energy demands in India.

1. Introduction

The consumption habits of modern consumer lifestyle are causing a huge worldwide waste problem. Having overfilled local landfill capacities, many first world nations are now exporting their refuse to third world countries. This is having a devastating impact on ecosystems and cultures throughout the world. Some alternative energy companies are developing new ways to recycle waste by generating electricity from landfill waste and pollution. Waste management is the "generation, prevention, characterization, monitoring, treatment, handling, reuse and residual disposition of solid wastes". There are various types of solid waste including municipal (residential, institutional, commercial), agricultural, and special (health care, household hazardous wastes, sewage sludge).The term usually relates to materials produced by human activity, and the process is generally undertaken to reduce their effect on health, the environment or aesthetics. Traditionally Landfill is used to dispose of waste generated. With the lack of space for new landfills, five technologies for waste to energy generation, namely bio-methanation, incineration, gasification/ pyrolysis, Refused Derived Fuel (RDF) and plasma arc gasification are playing an increasingly important role in waste management have been compared. Under “Swach Bharat Abhiyan” and “Ganga Bachao” program, it is necessary to develop such effective technologies which not only solves waste management problem but also provides us useful output such as electricity or cooking gas at an economical and highly efficient way. Above program also encourages the need of Shubham et al. (2015) [15] carried out optimal mixing of technology in rural area of Roorkee City, Uttarakhand and expand the energy potential and role of skill development. Skill development techniques, Programmes and workshops which can guide people, provide knowledge, and create awareness of the necessity of sanitation, methods of effective Waste Management for Rural and Urban Areas both and for all type of age people from childhood to old age.

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2. India Energy Challenges

The key task in India is to provide safe, reliable & eco-friendly energyfor rapid economic growth in keeping mind of global threat of climate change.
The present total Indian installed capacity is 281,423 MW, which includes thermal, hydel, nuclear, renewable [13].

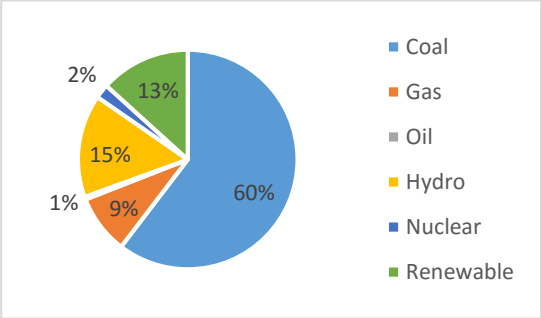

Fig: 1. Break-up of installed power generation capacity as on 30/11/2015 (Source:http://powermin.nic.in/power-sector-glance-all-india)

- At present the shortages are assessed to be in the range 2-10% in energy and 3-13% in peaking capacity from 2009-2015 [1].
- Instability of the grid is also a big challenge as on 30/31st July 2012 was a widespread grid failure across the northern and eastern regions. 600 million people were left without power or electricity for more than 6 hours those were connected to the grid.
- 45% of Rural India still don’t have access to electricity. Decentralized Solutions are necessary for the growth of electricity infrastructure.
- Over dependence on imported coal as domestic production lacks in meeting the demand and quality required.

3. Municipal Solid Waste Utilization for Generating Energy

Municipal Solid Waste, includes all new plant growth, residues and wastes, agricultural and forest residues, kitchen and city garbage, sewage etc. furthermore, To meet the

growing demand of energy, it is necessary to focus on efficient production and use of biomass resources to meet both traditional and high energy demand. The biomass production for fuel, food, fiber and fodder, requires sustainable land use and integrated planning approaches at all levels in the country. The estimated potential of various biomass resources is: Biomass energy 17,000 MW, Co-generation 8000MW and energy from waste [MSW, etc.] 1000MW. The generation of municipal solid waste (MSW) increases with socio-economic development of urban population. In an emerging economy like India, rapid population growth has further added to the intensity of waste generation. Uncontrolled dumping of wastes on the outskirts of towns and cities has created overflowing landfills, which have environmental impacts in the form of pollution to soil, groundwater, and air, and also contribute to global warming.

4. Literature Review

Dhere et.al. (2008) [1] studied the adverse impact of municipal solid waste on air and ground water due to the improper disposal of waste in Pune city. Waste material also impacts the soil quality as pointed out by Ahel et.al. (1998)[2], mainly by increasing the concentration of various hazardous elements of soil through municipal solid waste. Omofonmwan and Esiegbe (2009)[3] reported the ground water contamination due to the lechate contribution of the solid waste in metropolitan city of Nigeria. Zade and Noori (2008) [4] also described the adverse impact of solid waste in concerned areas. Mondal et.al (2010)[5] described the role of WtE to manage the solid waste problems. Therefore it appears that WtE can play an important role to minimize and manage the solid waste during the different festival and normal days at the study site and separation of the waste as Biodegradable and non-biodegradable at the point will be very helpful to manage the wastes material. Buenrostro et.al (2001)[6] classified municipal solid waste at the source that will be very useful to manage the waste especially for the developing countries.HM Zakir Hossin et.al (2014)[7] explained WTE technologies such as Biomethanation, pyrolysis and land gas recovery which can generate 186 MWh/day of electricity from 7765 Tonnes/day of waste to deal energy security problem in Bangladesh In Bangladesh 6 different corporations: Khulana City Corporation (KCC), Dhaka City Corporation (DCC), Chittagong City Corporation (CCC), Rajshahi City Corporation (RCC), Barisal City Corporation (BCC), Sylhet City Corporation (SCC) work for the collection, transportation, disposal and treatment of MSW and mentioned the composition analysis with quantity percentage of each corporation, total MSW generation in KCC, DCC, CCC, RCC, BCC, SCC was 595 Tonnes/day, 5340 Tonnes/day, 1315 Tonnes/day, 170 Tonnes/ day, 130 Tonnes/day, 215 Tonnes/day, respectively and electric power generation (KWh/day) from landfill process is 14328, 128160, 31560, 4080, 3120, 5160 respectively. Sieting Tan et.al (2014)[8] compared three WTE technologies i.e. incineration, landfill gas recovery and anaerobic digestion (AD) on environmental and economic basis which included includes transportation cost, carbon credit and sale of by-product of Taman Beringin, Malaysia landfill which can yield in 287% of increment in profit. CHG emission was checked on basis of Intergovernmental Pollution Climate Change (IPCC) guidelines. Incineration plants produced 1430 MW/day of heat and 480 MWh/day of electricity from 100 tonnes/day of waste. Hefa Cheng et.al (2007)[9]carried out methodology to study two incinerators of capacity each 250 tonnes/day having technology based on co-firing of MSW with coal in grate circulated fluidized producing 46.2 million KWh of electricity having calorific value of 3000-6700 KJ/Kg lower than developed countries of 8400-17000 KJ/Kg. In addition he calculated coal equivalent to MSW fuel ratio of 0.14, with saving of 0.2 million m3 landfill yearly. Sudhanshu Kaushik et.al (2011)[10] studied the MSW generation during Kumb Mela 2010 at famous temples of Haridwar City; Mansa Devi &Chandi Devi located at Shiwalik Foothills on seven days of Hindu festival which includes Makar sakranti, Magh Purnima, Mahashivratri, Chaitra Amavasya and Full moon days by recording observations of individual composition of MSW according to days. 7615.0 Kg of Waste was produced at Mansa Devi Site and approximately 5000 Kg of waste was produced at Chandi Devi Site. He observed that 64.7% was biodegradable waste and 12.3% was non-biodegradable at Mansa Devi hillock and at Chandi Devi hillock 62.7% of biodegradable and 10.2% of non-biodegradable. C Liamsanguan et.al (2007)[11] compared incineration, landfill & conventional power plants using Life Cycle Assessment (LCA) methodology and declared that incineration had higher advantages for global warming & photochemical ozone formation over conventional power plants but from acidification and nutrient enrichment aspect incineration was not suitable. He described landfill with gas collection and flaring systems were much favourable than incineration technology. In addition he compared conventional plant's energy content which was much higher than of Municipal Solid Waste (MSW) and also conventional power plants had higher efficiency than incineration plants. Dioxins emissions from incineration plants cause health issues. Khaiwal Ravindra et.al (2015)[12] interestingly defined complete transfer of waste to RDF plant can save 5451 tCO2 emission in Chandigarh and suggested new and better Municipal Solid Waste Management (MSWM) in which segregation of waste should be at source site only. Collection bin should be lifted every day irrespective of filled or partially filled. Special facilities of transportation during rainy season should be there to avoid rain water penetration. Carbon emission should be checked for storage, transportation, and disposal and processing site. Proper training of people involved in MSWM and their routine health check -up. Shubham et.al (2015) [14] carried out estimation of electrical energy from municipal solid waste utilizing waste to energy incineration technology of Roorkee City and suggested methods to improve the waste collection efficiency.

5. Municipal Solid Waste in Roorkee City

Roorkee is a city in Haridwar district, Uttarakhand that is spread over a flat terrain with the grand spectacle of Himalaya's ranges flanking it in the East and the North-east. It is on the banks of the Ganges canal on the national highway 58 (Delhi - Sri Badnrinath - Mana). The dominant

feature of the city is the Upper Ganges Canal which flows north-south and bisects the city. Also known for Roorkee Cantonment, one of the country's oldest, and the headquarters of Bengal Engineer Group (Bengal Sappers) since 1853. The city generates, on an average, about 250 MT of MSW per day. The major sources of MSW generation of the city are domestic, shops and commercial establishments, hotels, restaurants, dharamsalas and fruit and vegetable markets. Number of registered hotels, restaurants and dharamsalas in the city are 90, 50 and 52 respectively. In addition there are 3 fruit and vegetable markets. Out of which 1 market is excluded as it is not under Roorkee Nagar Palika Parishad [RNPP]. The MSW is composed of biodegradable (Vegetable waste, yard waste, paper waste, cotton clothes) and Non- biodegradable waste (Metal, stone, bricks, leather, plastic, Glass)

6. Scope of the Project

- Study of current Municipal Solid Waste Management (MSWM) in India.
- Study of current Municipal Solid Waste Management (MSWM) in Roorkee City.
- Estimate the Energy required by Roorkee City.
- Estimate the quantity of waste generated in Roorkee City.
- Estimate the waste generated administrative zone wise in Roorkee City.
- Theoretical Calculation of Energy potential from waste on basis of Literature Review.
- Collection of sample of wastes from landfill and city.
- Collection of water of sample from landfill near by side.
- Proximity & Ultimate Analysis of waste sample.
- Comparison of different Waste to Energy technologies i.e. Incineration, Bio-gasification, Bio-methanation, Pyrolysis.
- Calculation of potential of energy on basis of technology feasibility analysis.
- CFD simulation to improve incinerator.

7. Methods of Solid Waste Management

Studies and technologies prove that now waste is not a waste by proper assessment of chemical and physical composition suitable method of waste management can be very eco- friendly and profitable for humanity. Following are some traditional methods for solid waste management.

7.1. Recycling

Plastics& Paper are the most important recyclable material. Traditionally method follows with some rag pickers start collecting plastics and paper in early morning and at noon they washed the plastics and after drying them they sold it to a dealer. They usually work for more than 10 hours a day. This dealer sells this plastic to local plant where shredding and recycling is done. Paper is also recoverable material that ends up in the recycling industry. But in paper mills working with recyclable paper have to deal the problems of inherent impurities such as plastic, staples, stones and sand. The industry must have special processes and equipment to remove these from the paper before it is processed. Products like craft paper, card board or toilet paper are created. Paper can be recycled seven to eight times, each time, 22 trees are saved every tonne of recycled paper produced.

7.2. Composting

It is seen that in developing countries over 50% of the municipal waste is organic in nature. Organic waste usually has high moisture content and more likely suitable for composting and convert it to a rich organic fertilizer by biological natural aerobic process under controlled conditions. Various micro- organisms like bacteria, fungi etc. convert organic waste to smaller molecular substances by degradation. This process depends on various parameters such as oxygen percentage, moisture content, temperature, organic matter, micro-organism activity, etc. This technology is very traditional but recently percentage of Carbon, nitrogen, oxygen and moisture are inappropriate quantities due to pollution which greatly affects the compost. If these are not present in proper proportion then this process is greatly affected Composting method helps in the reduction of weight and volume of the organic waste.

7.3. Incineration

It is a process in which there is a controlled burning of waste at high temperature which reduces the volume as well as mass of the waste to considerable extent. This process removes water from the hazardous sludge from various industries and converts it into a non-burnable ash which can be used for various purposes like making fly ash bricks, boards, as an additive in cement industries etc. Incinerators need material like plastic, card boards etc. which have a good calorific value and these are considered as the material which mostly recyclers target and are livelihood of the rag pickers.

7.4. Land filling

Dumping of MSW is the most common and the cheapest way of waste management the Therefore around 60% of the world practices open dumping or land filling. Landfills are used for the disposal of wastes that cannot be recycled, composted, or incinerated. Landfills have been known to cause pollution in air and water and are a major source of greenhouse gases. These landfills are devoid of landfill gas (LFG) and leachate collection and treatment systems. Poor maintenance of these landfills renders them a threat to health and the environment rather than a solution to the problem of MSW management. Hence, landfilling should be used as a last resource and only when the first four components of integrated solid waste management have been exhausted.

8. Current Municipal Solid Waste Management practice in Roorkee

8.1. Collection of Municipal Solid Waste

Door to door, primary collection by engaging private sweepers. Waste is mostly collected through community bins/containers and road sweeping. Sweepers and sanitary workers engaged by the MSS sweep the streets. They accumulated the collected waste into small heaps and

subsequently loaded manually or mechanically onto the community containers/bins or directly loaded onto the solid waste transportation vehicles for onward transportation to the disposal site. Roorkee Nagar Palika Parishad (RNPP) presently utilizes the vehicles and equipment for transportation of solid waste.

8.2. Transportation of Municipal Solid Waste

RNPP maintains a low figure of vehicles for transportation and secondary collection of MSW from the various waste receptacles to the disposal sites. The vehicle contains TATA Ace, compactors, dumpers and tractor-trailers. Currently RNPP uses 10TATA Ace, 5 tractor trailer, 1 dumper and 3 compactor. These vehicles have duty for collection and transportation of waste from collection points to the landfills. Though the available transport volume is not adequate and make 4-5 trips per day per vehicle, due to operational inefficiency the available volume is not adequate even at four- five trips per day per vehicle. The situation has been worsened by poor management, no segregation & low awareness among people.

8.3. Disposal of MSW

In India, MSW from the urban areas is commonly disposed in the nearest available low-lying areas and wastelands on the outskirts of the city. Selection of these disposal sites depend solely on availability and not on scientific and socio-environmental criteria for a landfill. Open burning have highly impact on environment MSW is disposed in an uncontrolled manner and the daily cover material is not applied, although it is known that daily cover is necessary to abate odour, rodents and birds and to decrease site litter. At present RNPP disposes the solid waste of the city to one site located at the side of the national highway-74 at a distance of about 3 km from the city. In this site waste disposal is done by uncontrolled dumping village Saliar. Near Guru Ram Rai Public School which is located 500 meters from dumping site.

9. Problem Faced in Solid Waste Management by Roorkee

Today, Roorkee is experiencing the problem of solid waste management; this situation had been brought about by:

- Better and improving standard of living
- Growth of consumerism
- Population growth
- Increasing presence of substances in the municipal waste stream which are difficult to degrade/breakdown.
- Increasing industrial activities
- Poor public participation in finding solutions.
- Lack of recognition of solid waste as a problem demanding attention and action by the regulatory agencies.
- Shortage of space for disposal.

10. Waste Generated in Roorke City

Data is collected by weighing each vehicle throughout the day on weekends in each month. Then evaluated for the whole month. Variation is seen having highest in March and November.

These vehicles on average make 5 trips daily So total

MSW generated: 42.8*5 ≈ 214 MT

Table: 1. Vehicle Carrying MSW

S. No.	Vehicle Type	Amount of MSW (in MT)	Quantity of vehicles	Total (In MT)
1.	TATA Ace	1.6	10	16
2.	Tractor Trolley	2.5	5	12.5
3.	Compactor	3.1	3	9.3
4.	Dumper	5	1	5

11. Methodology

Roorkee City being under holy district Haridwar is a target place of the government to clean it under “Swach Bharat Abhiyan” and “Ganga Bachao” programme, so in order to be part of these programmes Roorkee city is selected for the work. Effective waste management has been a big challenge in most developing cities including Roorkee. Collection and sorting of municipal wastes at source in Roorkee with the hope of reducing the indiscriminate dumping of wastes has never been realized. Roorkee is also a big generation city of MSW as city comprises of Industrial Area & Colleges also. The population of Roorkee city as per the census 2011 is around 3 lakh. The study is conducted by collecting data from waste collection points of Roorkee city. The waste generation per day is around 200 tonne per day. The work represents study of current municipal solid waste management technique of Roorkee City and comparison of different Waste to Energy technologies. Relevant literature and information on the waste management practices in India was reviewed for conducting the present study. Key information was collected from the stakeholders through interviews and recorded office data for waste generation, transport and disposal. To validate or cross check the gathered information extensive field visits were made from the waste collection to the final disposal/processing sites to know the role of each element in waste management. Representative waste samples were also collected from different locations to get information about the physical composition of the waste.

12. Energy Potential

By considering Waste to Incineration technology theoretical estimation of Heat Energy is calculated by whole Roorkee city’s solid waste. Dulong’s formula needs to be applied. Heart

HV(KJ/Kg) = 338.2*C + 1442.8*(H-O/8) + 94.2*S

Where C, H, O and S are the % of these elements on dry ash free basis. Considering Literature Review taking percentage by Mass theoretical calculations are as follows:

C= 31.22, H= 8.17, O= 55.68, Sulphur very small so neglected. Applying to formulae we get Heat Energy Generated = 12260.69 kJ/kg

First, heat energy generated is used to calculate steam energy which is 70% of heat energy. Finally after steam energy calculation, net electric power generated by solid waste is calculated after accounting station service allowance and heat losses.Net electric power generation =

118582.55 kWh/day = 118.5 MWh/day. The above generated electricity is for one day and one day has 24 hours, so using this net electric power is calculated for per hour basis.

Net electric power generated = 118.5 MWh / 24h.

Net electric power generated = 4.9 MW≈ 5 MW.

13. Results and Discussion

Six objectives stated in work are accomplished by applying Dulong's formula to calculate net electricity generated. Dulong's formula is applied on WTE incineration technique. Incineration technique is chosen because it has many advantages over other techniques like the majority of wastes will burn without giving rise to noxious products of combustion (HCI, HF, SO_2 and NOx) in significant quantities, the volume and mass occupied by the waste is greatly reduced, it produces an effectively sterile ash residue etc. Total theoretical energy potential comes out to be 6 MW which is around enough for nearby rural areas. However in further work Sample will be collected from the site and proximate & ultimate analysis will done to calculate actual energy potential and CFD analysis will also be done to improve the performance of incineration plant. Further all the waste to energy technologies will be compared on technical, economic and environmental aspect. However the improper fate of solid wastes and mismanagement of sanitary system create disease supportive environment.

14. Conclusions

Due to the strong economic growth and urbanization in recent years, India faces many environmental challenges. In particular solid waste management in cities has been promoted as the big issue. Solid waste generation in Roorkee is increasing dramatically, mainly generated from households, buildings, commercial activities and other sources whose activities are similar to those of households and commercial enterprises such as wastes from offices, hotels, supermarkets, shops, institutions, and from municipal services such as street cleaning, etc. The main component of MSW is food waste which is a source of a very high potential of energy. Problems faced by this field is lack of comprehensive short and long term plan with municipal authorities to handle MSW in accordance with the MSW Rules, 2000. Majority of the municipal authorities do not have preparedness to set up waste processing and disposal facilities. There should be a proper trainings and awareness from worker to supervisor to managers to general public about effective and efficient waste management in order to accomplish "Swach Bharat" mission and target 'Zero Waste' for land filling.

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