

# Life Cycle Assessment of Solid Waste Management: A Preliminary Report on Waste to Energy Conversion for Dehradun City, India



Sonam Chaturvedi, Bikarama Prasad Yadav, Nihal Anwar Siddiqui, Sudhir Kumar Chaturvedi

**Abstract:** Energy management is a very important concept from the point of view of economics, as it explains the energy generated from various sources in various dimensions and ways such as alternating current, high, low or medium voltage, high and low amps, time-variant etc., all these combinations can be used in smart ways. It is used to decide the amount of energy which is required and then is stored for the long as well as short terms to avoid power cut and failure issues. The municipal solid waste (MSW) is also one of the major issues which mainly increases due to the urban population. The conventional dumping and treatment techniques for the MSW have some major ecological difficulties. In this paper, a preliminary report has been presented for the Waste-to-energy conversions. This study also identifies the potential of calorific value from the municipal solid waste generated in the capital city of Uttarakhand (Dehradun). All the related and relevant information are used to analyze energy penetration through proper literature reviews of different research papers and articles.

**Keywords:** Life Cycle Assessment, Solid Waste Management, SBM, NGT, Waste to Energy Conversion

## I. INTRODUCTION

The State of Uttarakhand also referred as "Dev Bhumi" was formed on ninth November 2000 as the 27th state of India. Uttarakhand State has a joined country and urban populace over a crore, of which the urban populace is around 30 per cent. The state all in all (urban and rural) is producing roughly 3000 metric huge amounts of strong waste each day of which the waste created by the urban zones is around 918 MTPD of MSW (Annual report CPCB, 2014-15). The complete urban

commitment builds two-overlap, considering the enormous coasting populace that visits the express each year. Of the waste created just 40-half is gathered and arranged, to a great extent informally. After the beginning of the JnNURM in the year 2005-06, a cognizant exertion from the State of Uttarakhand was started to logically deal with its civil strong waste. Committed strong waste administration (SWM) ventures were started in four towns of Uttarakhand for example. Dehradun, Haridwar, Haldwani and Nainital and as of now these undertakings are in a different phase of culmination. The necessities of coordinated SWM plan for the different ULBs have been for some time felt by the Policy Planners of the State of Uttarakhand. The experience picked up in setting up of the over four tasks have additionally constrained the Policy Planners to have a relook at the ways MSW is to be overseen in the hilly state [1], [5], [6]. Government of India has launched an ambitious "Swachh Bharat Mission"(SBM) which undertakes to make India a clean country by 02nd October 2019 when the country shall be celebrating the 150th birth anniversary of Father of Nation – Shri. Mahatma Gandhi Ji. The principle goal of SBM is to guarantee individual and network cleanliness concentrating on the logical administration and removal of metropolitan strong waste [8]. The National Green Tribunal (NGT), Principal Bench of Hon'ble Supreme Court of India, New Delhi has additionally been proactive right now has passed bearing to the State Government under the Petition No. 199 of 2014 Almitra H. Patel and Anr. Versus Association of India and Others to approach with a complete time-bound activity plan. The Tribunal has additionally proposed the State Government to consider the undertaking which had been maintained by the Tribunal in its judgment of Capt. Shopping centre Singh and Ors. Versus Punjab PCB and Ors. - Appeal No. 70 of 2012 dated 25/11/2014. Hon'ble NGT in OA No. 199 of 2014 (Almitra H. Patel Vs Union of India) on 5th February 2015 further coordinated that "the Central Pollution Control Board will present its autonomous remark comparable to detailing of a national arrangement concerning assortment and removal of a city strong waste as a National Policy to be received [10,11,12]. Let the CPCB likewise submit such proposition inside about fourteen days from today and put it on their sites so other State Board and State Government will likewise have a bit of leeway of that report and contemplate the equivalent while submitting status reports/recommendation as per this request.

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\* Correspondence Author

**Sonam Chaturvedi**, Ph.D Research Scholar, Department of HSE and Civil Engineering University of Petroleum and Energy Studies Dehradun-248007, India. Email: [sonam.dobriyal@gmail.com](mailto:sonam.dobriyal@gmail.com)

**Bikarama Prasad Yadav**, Associate Professor Department of HSE and Civil Engineering University of Petroleum and Energy Studies Dehradun-248007, India. Email: [bpyadav@ddn.upes.ac.in](mailto:bpyadav@ddn.upes.ac.in)

**Nihal Anwar Siddiqui**, Professor Department of HSE and Civil Engineering University of Petroleum and Energy Studies Dehradun-248007, India. Email: [nihal@ddn.upes.ac.in](mailto:nihal@ddn.upes.ac.in)

**Sudhir Kumar Chaturvedi**, Assistant Professor (SG), Department of Aerospace Engineering University of Petroleum and Energy Studies Dehradun-248007, India. Email: [sudhir.chaturvedi@ddn.upes.ac.in](mailto:sudhir.chaturvedi@ddn.upes.ac.in)

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" The CPCB in consistence with the said course turned out with an intriguing/demonstrative "Activity Plan for Management of Municipal Solid Waste" the proposals of the Hon'ble Tribunal and CPCB were appropriately fused in the said draft activity plan of the State [15].

The Ministry of Environmental and Forest, Government of India vide their Notification dated eighth April 2016 instituted "Strong Waste Management Rules, 2016" stipulating consistency criteria for isolation, assortment, stockpiling, transportation, handling and removal of metropolitan squander. As per the SWM Rules, 2016, the State Urban Development Department needs to set up a state activity plan/procedure on strong waste administration inside a time of the Rule warning [15,16].

In light to above and consistency with the previously mentioned bearings, the Urban Development Directorate, Government of Uttarakhand with dynamic discussion with all partners, for example, SPCB, ULBs and Department of Environment and Forests had before arranged draft State-Level Action Plan (2015) for the administration, dealing with and removal of city strong waste [18].

The said draft activity plan has been as needs being updated by UDD as per the - Solid Waste Management Rules, 2016 in meeting with GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit). This updated activity plan, in accordance with the SWM Rules 2016, comprehensively distinguishes the hole between the current civil waste age and its logical removal and the key techniques to fill the current hole by the year 2021. [20]

The said draft plan depends on multi year's projection, planned in a staged way to accomplish the set plans in next 4 years for example 2017-21. It likewise centres around the current continuous MSW activities, difficulties and imperatives before the Urban Local Bodies (ULB), give arrangements that are quantifiable, solid, practicable and economical dependent on strong examinations and investigation attempted by the State. [21,22,23]

This will assist the ULBs with opting for the best reasonable and demonstrated innovations for guaranteeing isolation, assortment, stockpiling, transportation, handling and logical removal of its metropolitan squanders as per the laid arrangements under the SWM Rules, 2016. The draft activity plan additionally features the assessed venture cost, which the ULBs will require throughout the following 10years and recommends the available resources to make these tasks monetarily self-continuing dependent on the rule of "Polluters to Pay". [25]

Last but not least, no endeavours to compelling SWM Rules consistency can be fruitful without the dynamic cooperation of the open themselves. The arrangement likewise imagines a segment devoted to the Capacity working of the ULBs and undertaking a broad IEC battle to develop among the open a "Metro Sense". Dehradun is the regulatory and administrative capital of Uttarakhand. [26]

It is encompassed by slopes and mountains and is well known for its scenic view and vacationer places. According to temporary reports of Census India, the populace of Dehradun in 2011 was 5, 78,420. Dehradun Municipal Corporation (DMC) is taken 0.4 Kg/day as normal per capita squander

age. As per DMC, a normal of 200-250 MT of waste is gathered every day.

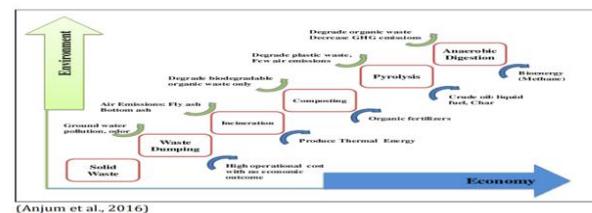
Source of waste generation includes Residential areas, Commercial areas and others. Table1.1 shows classification of the municipal solid waste.

**Table 1. Classification of MSW for Dehradun City, India (Chauhan et.al., 2018)**

S No	Source	Area covered	Typical waste generators	Type of solid waste
1.	Residential	All 60 wards	Single and multifamily dwellings	Food or yard wastes, paper, cloths, glass, metals, wood, plastics, E-wastes, household hazardous wastes etc.
2.	Commercial	Upper and lower clock tower	Hotels or Restaurants, sabzi mandi, markets, offices	Food wastes, paper and cardboards, glass, metals, wood, plastics etc.
3.	Others	Schools, colleges, institutes, hospitals, club etc.	ITBP, UPCL, Doon Hospital, Indresh Hospital, Sai Temple, Doon club	General wastes, medical wastes, food waste, hazardous wastes etc.
4.	Municipal services	Recreational areas, parks, gardens etc.	Street sweeping, Doon express park, Gandhi park	Dust, park or garden waste, waste from recreational areas.

## II. SOLID WASTE MANAGEMENT

It is a common practice adopted by the world to deal with their daily pile of waste generated. Several methods are used like incineration, waste to energy, decomposition, landfilling, etc. The most dangerous and harmful practices of all are landfills of solid waste. Landfills generate more diseases due to exposure to harmful gases such as methane and Co2 in the ratio of 90% and 10% other gasses. They spread health problems, water pollution as well as air pollution. Still, it is the most common practice being adopted by municipalities responsible for city-level waste management. Figure 1 shows the hierarchy of solid waste management practices. The top of the pyramid is the best option of management of solid waste and going down it shows the least favoured option of treatment.



**Figure 1. Solid waste management hierarchy for various technology.**

### Municipal Solid Waste Management Of Dehradun

Uttarakhand is also called as Herbal State in India. It has an abundance of natural resources which attracts most of the following industries such as Fast-moving Consumer Goods Companies, Pharmaceuticals, Trekking and Tourism companies, Information Communication Technology, Agro-based companies, Hydropower industries, Engineering Industries, Floriculture etc.

Dehradun is the capital of Uttarakhand. With a population of 500000.



Dehradun generated 291.840 metric tonnes of municipal solid waste per day. Government has many policies and projects to manage the waste. Organic waste is generated by low-level income groups of people such as wood, food waste, grasses, leaves etc. Paper waste, highly made by high-income level groups includes wrapping paper, books, magazine, newspaper, cardboards etc. The generation of waste is directly related to the income of people. With the increase in the level of income of a person, the paper waste increases positively. [31,32]

**Table 2. Current Estimates of Waste Composition [40]**

Income Level	Organic (%)	Paper (%)	Glass (%)	Metal (%)	Plastic (%)	Other (%)
Low Income	64	5	3	3	8	17
Lower Middle Income	59	9	3	2	12	15
Upper Middle Income	54	14	5	3	11	13
High Income	28	31	7	6	11	17

(Series & Papers, 2012)

As per the data collected by Nagar Palika Parisad, 2017 population count is about 500000, whereas waste generated per day is around 260.8 tonnes, with a capacity to generate approximately 10 MW of electricity per day, or in a month we can have 300 MW, and in a year, we will have 3.6 GW of power to fulfil the gaps of power cuts. Supplying the same to the Uttarakhand Power Corporation Limited will help in a substantial reduction of prices. Solid waste generation is directly proportionate with the number of populations in an area. As the population increase waste will also increase.

The entire municipality is developing on a very fast pace and along with the development of the city, the infrastructure and beautification of the city are vital. An efficient solid waste management system is to be essentially designed to avoid littering of the city and to avoid spreading [40, 33,35]

of epidemics. The lean waste management system is an innovative solution which deals with both minimizing the littering and increasing the efficiency of the waste collection system. The fact that the waste is not exposed to the public, adds to the aesthetics of the city.

Based on the fast growth rate of the city the higher capacity of the bins would also serve for the future needs of the city. Besides, the higher capacity bins will also ensure that the bins don't overflow during festival seasons when the waste generation is much higher than the average waste generation. Since the capacity of bins is more the municipality can reduce the frequency of collection which will help in reduction of operation, maintenance and transportation cost. With the installation of the "Lean waste management system," the municipality can ensure better hygiene conditions for their workers as they don't have to manually handle the waste which in turn leads to lesser hazardous working conditions and increased man-hours. The automated system ensures that the emptying of the bins is performed in a very short duration ensuring that no interference is caused to the traffic nor the pedestrians. Based on the waste generation data, ease of

access, and frequency of waste collection four types of semi-underground bins are proposed for "Lean Waste Collection System".

Proper waste management and disposal practices were proposed by the government and now comparatively better waste collection and processing systems are taken up. Vehicles of the waste collection have been increased and modernized (segregated blocks). Their size depends upon the income of the people of the area located. Still, 40% of the collected waste remain unutilized or unmanaged by the municipal authority. After a long wait, Dehradun got its first waste treatment plant at Shishambara, 20 km away from the city of Dehradun. [37,38,39]

### III. SAMPLE SURVEY IN DEHRADUN

To record the behaviour of the public towards the environment and understanding the treatment process of the solid waste management system in our society.

A small sample survey was conducted to get a better understanding of general public behaviour towards Waste Management. Systematic sampling approach was used to get the best result and a respective size of households were taken into consideration. In the systematic sampling, the sample population included all types such as students, household, employee, businessmen, senior citizens primarily.

As per the analysis, we get to know that out of the total households, 75% of them do not have any knowledge about policies of waste management in Uttarakhand. Government is taking various initiatives for proper waste management in Dehradun. About 85% of the household, still do not practise segregation of waste at home level and the majority reason lying behind is Lack of knowledge about Biodegradable and NonBiodegradable waste. And many states the reason, that it is not their responsibility to do segregation. General public produce wastes on their daily routine but aren't aware, where their generated waste goes. 60% of the public of sample aren't aware of the process of Composting of waste. And 35% do not know where their waste goes after they are thrown out. Through this survey, we get to know there is enough lack of awareness in people of Uttarakhand, about waste management. From the sample of selective households, about 55% hasn't ever heard about WASTE TO ENERGY method of disposal of waste.[27,28,29]

#### Present scenarios for waste management in Dehradun

Before shifting of Solid waste management department to the health department, the city was not having a proper door to door solid waste collection facilities. Households, mainly low income residing in the city dump their daily wastes on street, river or hills. Middle- or high-income groups appoint private sweepers monthly. Waste remains Discussion 20 untreated because of unavailability of treatment plants in Dehradun. Authority wasn't concerned about the processing of garbage Proper waste management and disposal practices were proposed by the government and now comparatively better waste collection and processing systems are taken up.



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**Table 3: Number of existing vehicles for waste management in Dehradun city [40]**

Type of vehicles	No. of vehicles
Tipper Lorries	4
Dumper Placer Lorries (Eicher & Tata)	7
Tractor Trolley	2
2 tractor containers	2
Big RCs	2
Small RC	1
TATA 709	1
JCB	2
Loader 710 (Scott)	2
Cattle Catcher (Mazda)	1
Mini RC	1
RC	1

Source – Nagar Nigam Dehradun

#### IV. RESULTS AND DISCUSSION

After a long wait, the Government of Uttarakhand got permission to install its first Waste to Energy plant. This plant is situated in Roorkee, having Ultra High-Temperature Hydrolysis Reaction plant. This treats the waste of 7 residential towns of Uttarakhand, converting 550 metric tonnes of municipal solid waste and commercial waste into electricity, per day.

The sample selection of the data has been performed in the city of Dehradun in terms of various age groups, occupation, rate of most environment risk, knowledge of composting wastes, disposal systems in Dehradun, waste management policies, rate of MSW wastes, and waste to energy processes. It's been observed that most of the citizens are not aware of the processes and the LCA is hindered in the city.

**Calculation of Calorific Value:** Calorific Value is defined as the total quantity of heat liberated from the complete combustion of a unit of weight in the presence of oxygen and air. Calorific value is measured in kcal/ kg. Due to the presence of heavy organic and moisture content in the waste, Incineration is the most common method used in India. Before the waste is used as a raw material for converting the input waste into energy as an output, it should be properly dry, such that there should not be any moisture in the waste, which can reduce the quantity of energy production. Sample of the waste after segregation should be weighed to get the quantity. Proximate Analysis is the analysis of moisture content, volatile matter content, ash content and fixed carbon content of the waste. The data collected as provided in Table 3.

Ultimate Analysis is the analysis of element-wise waste composition determining the composition of Carbon, Hydrogen, Oxygen, Sulphur as given in Table 4. For calculating Moisture content, a sample of waste is taken in a

dry and accurately weight crucible and heated up to 105 degrees for one hour. Moisture content in percentage is  $[(W-W_1)/W] * 100$ . Volatile content is taken in the platinum crucible and heated at 950 degrees for the next 7 minutes. Volatile Matter content percentage is  $[(W_1-W_2)/W] * 100$ . Ash content waste is heated at 700 – 750 degree until all carbon burns away and ash remains. Ash content percentage is  $(\text{Weight of crucible+ lid+ ash}) - (\text{weight of crucial+ lid}) / \text{weight of sample waste}$ . Fix Carbon percentage is  $100 - (\% \text{ moisture} + \% \text{ volatile} + \% \text{ ash content})$ .

W= weight of waste W1= Weight after heating W2= Weight after heating at 950 degrees.

**Table 4: Proximity Analysis [40]**

Parameters	Units	Result
Moisture	%	30.85
Volatile Matter	%	51.72
Ash	%	48.28
Fixed Carbon	%	9.8

**Table 5: Utility Analysis [40]**

Carbon	%	31.39
Hydrogen	%	2.65
Oxygen	%	13.50
Sulphur	%	0.72

Waste to Energy calculation Using Dulong's formula for calculating the heat energy generated from the sample waste used: Dulong Formula =  $338.2 * C + 1442.8 * (H - O / 8) + 94.2 * S$  C = Carbon H = Hydrogen O = Oxygen S = Sulphur So,  $338.2 * 31.39 + 1442.8 * (2.65 - 13.50 / 8) + 94.2 * 0.72$  Therefore, Heat value = 12011.58 kJ/kg Steam Energy includes 70% of heat energy. It will help in moving the turbine and generated electricity. (1 KW = 3600 kJ/h) Stream Energy =  $70\% * 12011.58 = 8408.106$  kJ/Kg In practice there is always a conversion efficiency of 31. 6% of heat input require =  $3600 / 31.6 \% = 11395$  kJ/ Kwh So the electric power generation = Stream Energy – Electrical Energy Discussion Paper No. 1, Feb 2019 26 =  $12011.58 / 11395 = 1.054109697$  Kwh/kg

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#### V. CONCLUSION

Waste to Energy is one of the best methods of disposal of waste without harming the environment and encouraging the Sustainable development of the Nation. Waste to Energy plant requires less space of land, in comparison to landfills. And, it is the most cost-effective method of reducing waste from society.



We generated energy in the form of gases, electricity, fuel etc., helping in reducing the energy crises in the society. This is one of the best renewable sources of energy which produce Electricity with sustainability.

The current solid waste management system of Uttarakhand is not very much effective or either directed towards clean environment. Uttarakhand is also having the huge footfalls of national as well as international tourist. The Tourism industry contains a major share in Uttarakhand. Solid waste generation in Uttarakhand is very uneven because there is high waste during trekking, camping, tour and travelling seasons. And as per the analysis, we can say that there is a positive relationship between the population of the towns and solid municipal waste generation. As the population increase, waste also increases. As per the estimates, Uttarakhand's major cities are capable to produce electricity from waste and fulfil the gap of demand and supply. Major cities such as Dehradun, Haridwar, Roorkee, Haldwani, Nainital, Tehri etc., help in contribution towards producing energy from waste.

Since long, Dumping was only the process, as used by the government of Uttarakhand, to settle everyday waste. Then, the Private Players' intervention changed the method of disposal of waste. The municipal corporation started selling waste to the private companies of New Delhi, which are involved in converting waste to energy. And that produced energy had been purchased by Uttarakhand Power Corporation Limited.

Proper guidance must be provided by the municipal corporation of Uttarakhand on how to segregate the waste and how to utilize such waste into other forms. Such as Uttarakhand produces large amounts of organic waste. That organic waste can be used through the composting method of disposal. Municipal corporation and many other agencies and NGO's must create awareness campaigns to educate the people about methods of segregation of waste at household basis, conduct various seminars in Colleges, School, Hospitals, Public places, Commercial offices, Industries etc. Proper education of Utilization of waste will help in reducing the waste and will take necessary care about Solid Waste Management.

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Aerospace Engineering from UPES, Dehradun. His are of interests are Aeronautical Engineering, Avionics, Remote Sensing, RADAR applications in Defence Technologies.

## AUTHOR PROFILE



### Mrs. Sonam Chaturvedi:

Mrs. Chaturvedi is currently persuing Ph.D in Environmental Sciences from University of Petroleum and Energy Studies (UPES), Dehradun. She has completed her B.Sc in ZBC and M.Sc in Organic Chemistry from Hemwanti Nandan Bahuguna University, Pauri Gardhwal. She was also associated with Drilling Fluid Lab at UPES since 2012 to 2015.



### Dr. Bikaram Prasad Yadav

Dr. Yadav is currently associated with the Department of HSE & Civil Engineering, UPES as an Associate Professor. He has complited B.Tech in Fire Safety Engineering from Cohin University of Science and Technology, Kochi, MBA in Safety Management from NIM, Mumbai. M.Tech and Ph.S in Health Safety & Environment from UPES, Dehradun. His area of interest are Construction Safety, Hazard Identification and Risk Assessment, Safety & Fire Audits, Fire Engineering (Industrial fire protection, Fire Safety in Buildings), Process Safety Management & Accident Investigation Analysis.



### Dr. Nihal Anwar Siddiqui:

Dr. Siddiqui is currently hoding the position of Professor and Program Director in the Department of HSE & Civil Engineering. He has completed his B.Sc. in Chemistry and M.Sc. in Environmental Sciences from Lucknow University. Ph.D in Enviornmental Biology from Awdesn Pratap University, Rewa. His area of interests are Environmental Science; Environmental Biology;Industrial safety ; Environmental Impact Assessment ; Safety Management, Occupational Health & Safety, Environmental Pollution, Env. Monitoring and control techniques. Dr. Siddiqui is also lead auditor for OHSAS 18001 and ISO 14001.



### Dr. Sudhir Kumar Chaturvedi

Dr. Chaturvedi is and Assistant Professor (SG) in the Department of Aerospace Engineering, UPES Dehradun. He has completed his B.E in Aeronautical Engineering from The Aeronautical Society of India, New Delhi. MS (by Research) in Ocean Engineering from IIT Madras, Chennai and Ph.D in