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Disambiguation of Municipal solid waste to Syngas in Ujjain District by Plasma Gasification Technique

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Abstract – The Municipal solid waste generated in developing countries like India is about 1.6Lakh metric tons per day which leads to 0.53Kgs/day per household as we considered that India has 302.4 million households. Out of this number only 65% of the waste is treated and rest is left un-treated and dumped in local areas as it is in cities. [20]

In 2014 on the birthday of the Father of nation a nationwide program is been launched which is Swachh Bharat Mission. This program helps to alter the mindset of every Indian, results that hills of the waste to start reducing as the people start the use of 4 "R"'s of the Solid Waste Management. [21]

In this paper we are discussing the Solid Waste Management of municipal areas of Ujjain city area, Tarana city area, Khachroad city area, Badnagar city area, Mahidpur city area and Nagda city area total comprises of a population of about 7,45,153 people. The generation of Municipal solid waste of these areas is about 356 Tons/day giving us average of 0.48Kg/day per capita waste of the area. [15] Here we also segregate the waste and find out the composition of the type of waste generated in the area also a proposal of plasma treatment is been done to reduce the incinerator and Landfill Loads.

Key – Words – Swachh Bharat Mission, wastelands, incinerator, Landfill, Kg/day per capita waste, un-treated waste, 4 "R"'s of the Solid Waste Management.

Introduction – India is a very big country with a population of more than 1.4 Billion people. Since a developing nation the waste generation should be high but due to nature of us Indians we take the Reuse and Recycle too personally and try to use the things in every possible way thus reducing a significant amount of Solid Waste. In older days only one bin was there in which all types of waste is been dumped. [18]

Fig – 01 – Single bin of UMCC

But as we grow up to the new India and a new India is been formed, the number of bins are increased from 1 to 6 now a days. The bins are identified by colors so that they can be distinguished from distances and the segregated waste is been put in them. The 6 bins of different colors are –

Fig – 02 – Bins now a days

1. **Green bin for glass materials**
2. **Purple bin for Papers and cardboards**
3. **Yellow bin for Plastics**
4. **Brown bin for Putrescible**
5. **Red for Metals and Sharps**
6. **Black for Non-Recyclable materials**

Still the waste is been hand segregated by workers in many areas without any safety measures. Various people have their food earnings by this waste segregation and they do this every day for living.

Fig – 03 – Poor do waste segregation for living.

Fig – 04 – Poor selling waste after segregation for their living

Fig – 05 – Waste management company people waste segregation

Materials and Methods - There are many methods of waste disposal, especially –

- **Incineration/combustion -** Separation of toxic organic materials released from anatomical wastes is a thermal process used for 2-3 seconds at a temperature of about 850°C to 1600°C. . Until the incinerator smokes, the heat can be used to generate electricity. It contains carbon dioxide, carbon dioxide, oxygen, nitrogen, carbon monoxide, nitrogen oxides, sulfur oxides and other small particles and must be passed through a wet cloth to reduce pollution. [10]
- **Autoclave -** The autoclave can be thought of as a large steam generator. It works at 121°C and sterilizes many of its products. By working at low temperature for 15-20 minutes, it allows all materials to be sterilized and used again for the same or different people.

The size of the autoclave depends on the size and working capacity of the hospital. There are three types of a. Gravity Autoclave B. Vacuum autoclave c. Retort Autoclave In the retort autoclave, this autoclave can maintain high temperature and the required time is as short as 5 minutes, so it is now used in hospitals. [10]

- **Microwaves -** an expensive but environmentally friendly technology for rapid processing of biomedical waste. This process is cheaper and more environmentally friendly than incineration or pyrolysis. The technology is based on the generation of radio frequency, which increases the pressure and temperature in the matrix to kill bacteria. As the temperature rises to 300 °C, pressure and vibrations cause the volume to expand rapidly, reaching a large value. [10]
- **Hydro-clave -** Internal vessels made of high-pressure steel. For large hydrodynamic boilers, the feed is from the top of the cylinder, the outlet is from the bottom of the cylinder, and for small hydrodynamic boilers, and both are at the top. Hydro-sterilizers work the same as autoclaves, but they are more efficient and faster, they create wastewater and reduce waste by breaking it down into smaller pieces. [10]
- **BC Plasma Pyrolysis -** Plasma pyrolysis is a high temperature process used to convert organic matter into synthetic fuel. There is a jelly flickering with a torch and it is called Plasma. The product also goes to the charged plates. The current between the anode and the cathode is very large, which has a positive effect on the debris, called the plasma arc. High blood pressure can be reached due to the poor quality of the system. 1200 °C. When the hot gas leaves the system, the gas can be used as fuel to generate electricity, and the syngas can be stored and used elsewhere as needed. [10]
- **Chemical Methods -** Processing of various liquid hospital wastes using various chemicals. Adhesive decontamination is easily done using chemicals (Dalal Parag, 2012). Depending on the biomedical waste, chemicals such as chlorine, sodium hydroxide and calcium oxide are used. [10]

Recommendation - Among all operating methods, here we show plasma pyrolysis, also known as PAG, Plasma Arc Gasification. Plasma is known as the fourth state of matter. Plasma is hot, electrically charged ions that can conduct an electric current. Plasma technology is indispensable for our chemical engineers working with heat in many applications. [1] Artificial plasmas are created from gaseous dielectrics. The friction of this gas with the arc deforms the ions into electrons and causes the temperature to rise up to 5000°C. Although plasma technology is not confused with brushing and incineration of garbage, plasma gasification does not burn garbage in a low flame like a flame. Incinerator [23]

In plasma arc gasification, the arc carburetor sends a high voltage through two electrodes, creating an electric field between them. The highly inert gas is then passed from the power source to a sealed container (called a plasma converter). The temperature inside the arc can reach 14,000 °C (25,000 °F), hotter than the surface of the Sun. [2] At high temperatures, most solids turn into gases made up of simple elements with complex molecules split into individual atoms. Plasma arc gasification byproducts include syngas, which is a mixture of hydrogen and carbon monoxide. [16] Waste, including plastic, contains large amounts of hydrogen and carbon monoxide, and conversion of these materials to syngas can be more than 99 percent. Before the syngas can be converted into electricity, pollutants such as hydrogen chloride must be removed. [3] Once cleaned, the syngas can be burned as gas, some of which is gasified by a powerful plasma arc, and the remainder is sold to power companies, which often use it to generate fire electricity. [17] Slag is an obsidian-like residue that is free of impurities, including heavy metals such as mercury and cadmium, and can be used to make bricks and synthetic stone. The waste heat from this process can be used to generate energy and electricity. [4] The composition of the wastewater can affect the performance of the gasification process. Mineral-rich waste, such as metal and waste products, produces the most valuable product, syngas, but less slag, but more slag. Therefore, a preliminary wastewater analysis may make sense in some cases. Plasma arc gasification is more efficient if deposits can be removed before they enter the gasifier. [24]

Plasma Gasification Benefits has developed plasma gasification systems for the treatment of municipal and municipal solid waste (MSW) for the past ten years and has recently explored the paper application of plasma technology in coal gasification. [5] They believe their technology could demonstrate that coal can be used to reduce atmospheric pressure. Plasma combustion reactors can be adapted to existing power plants and/or installed in new plants with the following advantages over pulverized coal power and/or gaseous carbon dioxide. :

- More food consumption, coal, coal dust, mining waste, lignite and other fuels (such as biomass and MSW) can be used No oxygen plant required
- Very (> 90%) • High conversion (> 99%)) organics for syngas (syngas)
- Syngas does not contain tar; Air blast design for syngas gas turbine operation after gas cleaning
- No coke, ash or carbon residue; only usable glassy slag is produced
- Nitrogen oxides (NOx), sulfur oxide (SOx) particles, etc.

According to the new EPA source emission standards for

- Higher thermal efficiency
- Lower carbon dioxide (CO2) emissions
- Lower investment and operating and maintenance (O&M) costs [7]

According to WPC estimates, only 2% to 5% of the energy input from the plasma torch in gasification is the total in the feed 80% of the energy output can be recovered in the produced syngas. The evaporator is heated by a plasma torch system near the bottom of the reaction vessel. In the gasifier, the organic feedstock (coal, municipal waste, car chopper waste, biomass, etc.) is fed into a

vertical reactor vessel at atmospheric pressure. [8] The gasifier is lined with refractory materials or external water cooling, and refractory materials are used only at low melting point. In the lower part of the carburetor, air enriched with superheated oxygen is supplied in the stoichiometric amount necessary for evaporation. [6] The amount of air supplied is such that the upwardly flowing gas has a low superficial velocity and allows direct introduction of non-briquetted/unpowdered feed material into the reactor. [9] Additional air and/or steam can be provided at various levels of the gasifier to aid pyrolysis and gasification. The temperature of the synthesis gas exiting the top of the gasifier is kept above 1,000°C. At this temperature, tar formation ceases. [11] Gasification is performed at very high temperatures by a plasma torch system at the bottom of the gasification vessel. High operating temperatures break down coal and/or noxious and toxic constituents into their elemental constituents; dramatically increase the kinetics of the various reactions taking place in the gasification zone, and convert organic matter into hydrogen (H2) and carbon monoxide. Convert to (CO).)) [25]

Advantages The main advantages of plasma torch technology in waste disposal are: [22]

- Avoiding landfills and no harmful emissions of toxic waste
- Potential production of vitrified slag that can be used as construction material
- Combustible syngas for electricity and heater Biomass waste treatment or chemicals for synthesis into fuels. [14]
- Production of value-added products (metals) from slag
- Safe means of destruction for medical waste and many other hazardous wastes Avoids formation of dioxins and furans common in incinerators. [12]
- Air emissions are cleaner than landfills and similar to those from incinerators.

Disadvantages The main disadvantages of plasma torch technology in waste treatment are: [22]

- Operating costs are higher than incineration.
- Wet feeding reduces synthesis gas production and increases energy consumption.
- Net energy production is low or even negative when all energy inputs are taken into account. [13]
- Regular and limited maintenance.

Results – The area we have taken is a vast area of Ujjain district comprising of the Ujjain city Municipal area, Tarana city area, Khachroad city area, Badnagar city area, Mahidpur city area and Nagda city areas. Not taken Ghatiya city areas as the authorities there are unresponsive and non cooperative too.

All these areas combine to give a huge population of 7,45,153 people (according to Censes 2011 as censes 2021 not done due to COVID-19 pandemic) generating about 356 Tons/day Municipal solid waste which comes to be 0.48Kg/day per capita waste to be average which is thrown out of the houses for Solid Waste Management. [19]

Table – 01 – Population wise waste generation per capita per day

S. No.	Municipal Area	Population	MSW per day in Tons	Per capita waste in Kg/day
1.	Ujjain	515215	226	0.42
2.	Tarana	24908	14	0.56
3.	Khachroad	34191	16	0.47
4.	Badnagar	36438	17	0.47
5.	Mahidpur	34362	18	0.52
6.	Nagda	100039	65	0.65
		745153	356	0.48

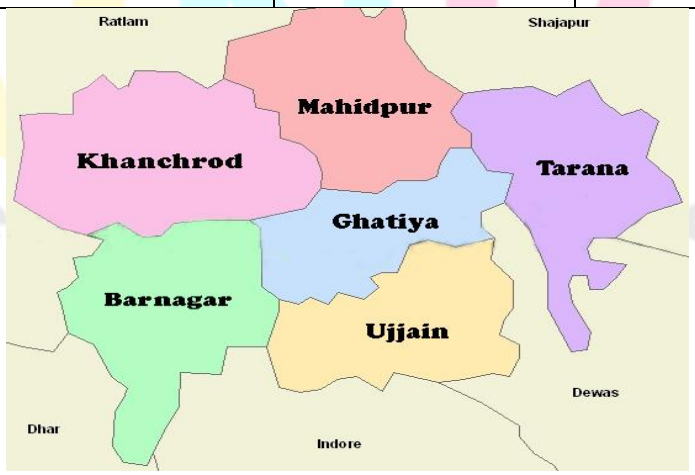

Fig – 06 – Ujjain District Map

These wastes we get from table 1 are taken in collection centers of respective municipalities and then are hand segregated.

Fig – 07 – Hand segregation at area

We in this paper divide the waste in about 10 types and is been segregated as per type it is given in below table in percentage wise –

Table – 02 – Percentage wise waste segregated per capita per day

S. NO.	Types of Waste	Ujjain	Tarana	Khachroad	Badnagar	Mahidpur	Nagda
i.	Putrescible waste	63	65	64	55	61	49
ii.	Plastic waste	12	13	13	16	13	13
iii.	Textile waste	5	4	4	7	6	9
iv.	Paper waste	3	3	3	5	4	2
v.	Metal waste	5	6	5	7	4	1
vi.	Glass waste	1	1	2	2	2	1
vii.	Toxic Waste	1.5	3	2	2	2	11
viii.	Bio-Medical Waste	4.5	3	3	3	5	7
ix.	Electrical appliance waste	2	1	2	1	1	2
x.	Chemical waste	3	1	2	2	2	5

Conclusion – Contrary to the classical belief of incinerator or landfill the plasma technology is very dominant and game changer in the field of Environment Management. We had developed the process to acquire fly ash and bottom ash for plasma, leading us to make bricks. Just one big disadvantage of Plasma Gasification is large initial capital cost. This became larger as plentiful land is available in India for dumping. Still the production of Syngas help us a bit and also landfill residue is reduced to minimum we can say we are talking the technology of the future. The hazard treatment of Plasma Gasification is of efficiency more than 95% for both organic and inorganic materials make our statement strong that we are talking the technology of the future.

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