Municipal Solid Waste Management
Waste-to-Energy Technology: Plasma Pyrolysis

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Contents

Why ?

- Global climate change, world energy conflicts and energy source shortages due to fossil fuel uses.

- Because of uneven energy distribution in the world, a technology needs to be developed to serve as a secondary source of energy and mitigate energy crisis.

- Developing countries like India and China, the ratio of energy available to energy required is highly incompatible.

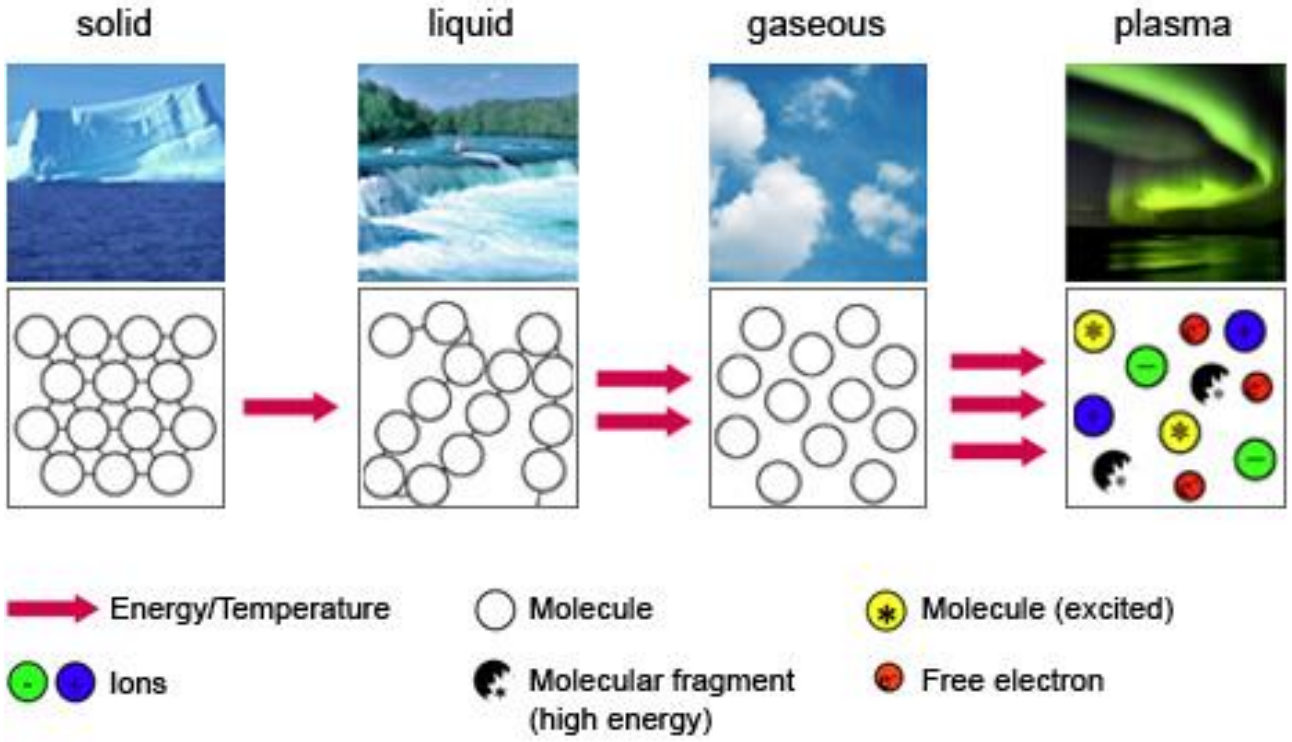
- World requirements for energy will increase by a factor of about six times by 2100.

Type of WtE

Kothari et al., 2010

Plasma

- **"Plasma"- an ionized gas discharge constituting electrons, ions, neutral atoms and molecules, radicals, UV, etc.**
- **The peculiar discharge composition has sparked research interest in various applications.**



Thermal (hot) Atmospheric pressure plasma discharges ($T_e \approx T_i \approx T_g$)

For waste decomposition

Plasma 4th state of matter

Why Plasma?

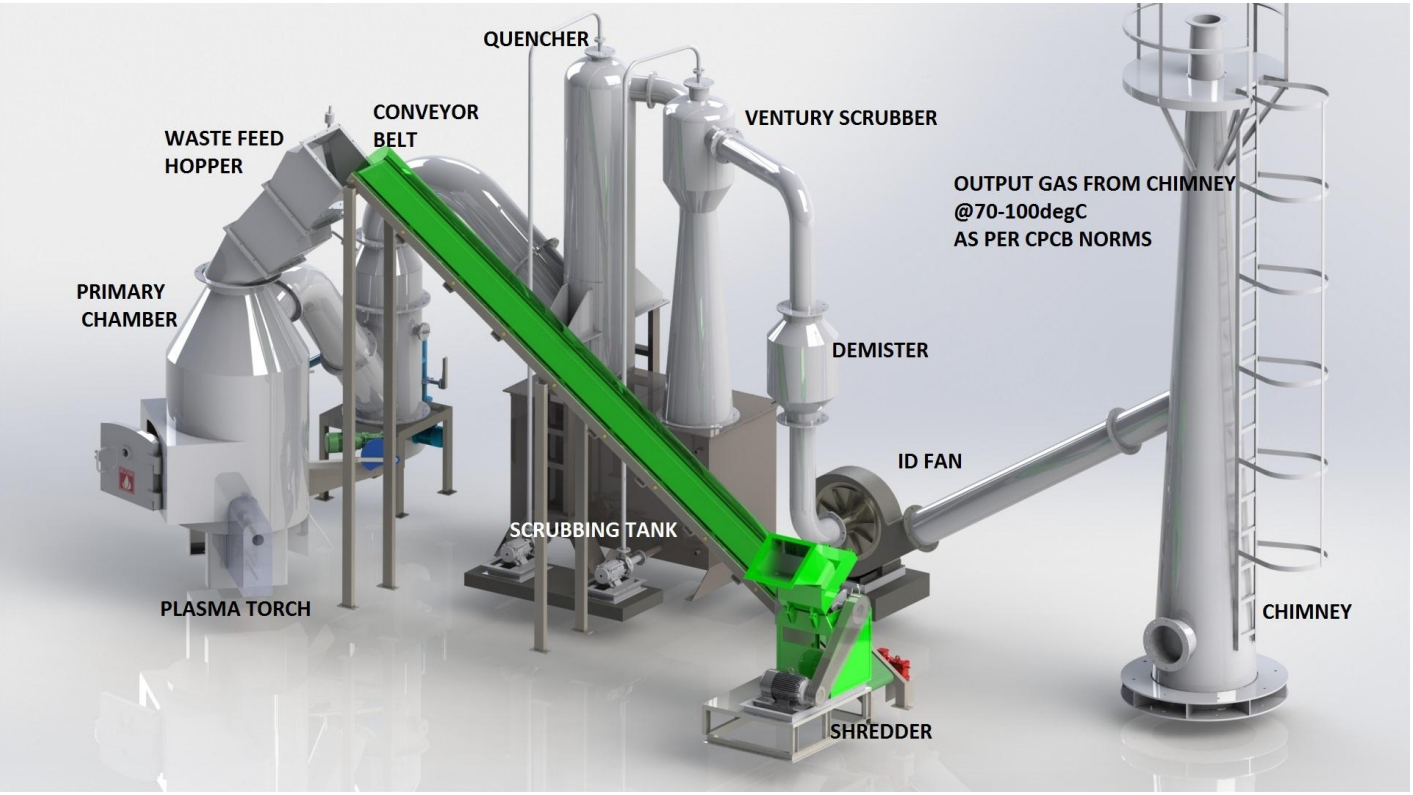
- Segregation of waste is not required
- Moisture content of the waste is not an issue
- No toxic gas (dioxins, furans, etc.) emission to the atmosphere due to high plasma temperature, thus no pollution
- Volume reduction of waste is > 90% (can be recovered land, very precious)
- Clean syn gas can be used for energy recover
- The inorganic stuff (glass, metal, silicates, etc.) will be melted and converted into dense, inert, non-leaching vitrified slag which can be used for interior decoration purposes & making vitrified blocks and grit for road construction.
- No survival of bacteria and viruses
- No health issues (no money can be spent)
- Potential to be economically viable

Outcome: A clean, eco-friendly technological solution for waste decomposition will be established with the conversion of waste to energy.

MSW Processing Plant

For Generation of Energy and Value-Added Products

PLASMA PYROLYSIS PLANT



Project Developer:
IIT Delhi (Satyananda Kar, DESE)

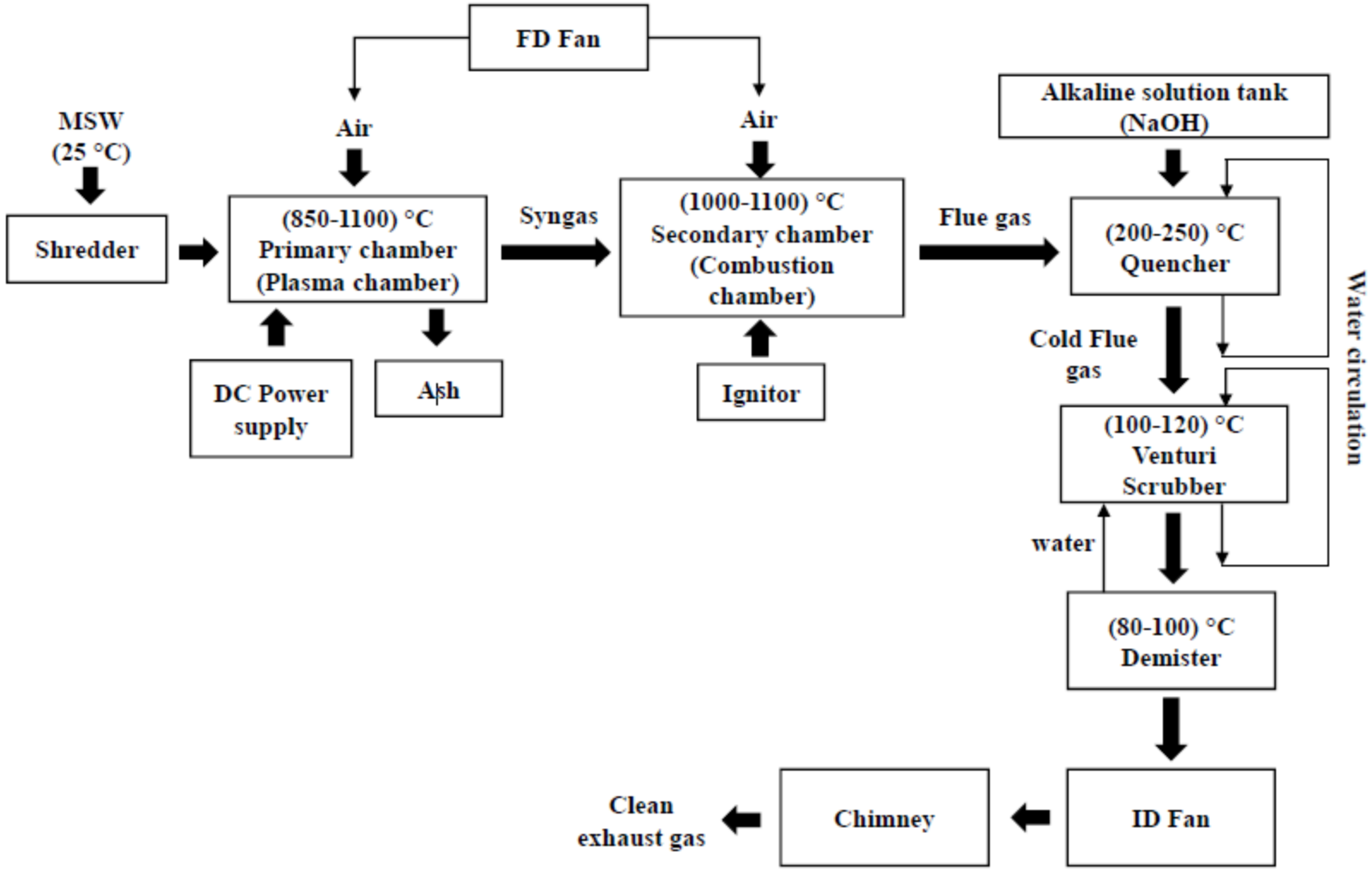
Capacity: 1.0 Ton/Day

Funded By:
Office of Principal Scientific Adviser to GoI

Location: Sudhara Technology Park, Jafrabad, Delhi

Status: Operating since November 30, 2021

Process Diagram



Plasma Pyrolysis of Municipal Solid Waste for syngas production

Municipal solid waste can be converted into syngas with the help of plasma pyrolysis technology with a very small percentage of ash (<10%) and volume reduction up to 95% without any harmful emissions. These produced syngas may be further used for electricity generation as well as alternative fuel for energy-intensive industries and the transportation sector.

Achievement:

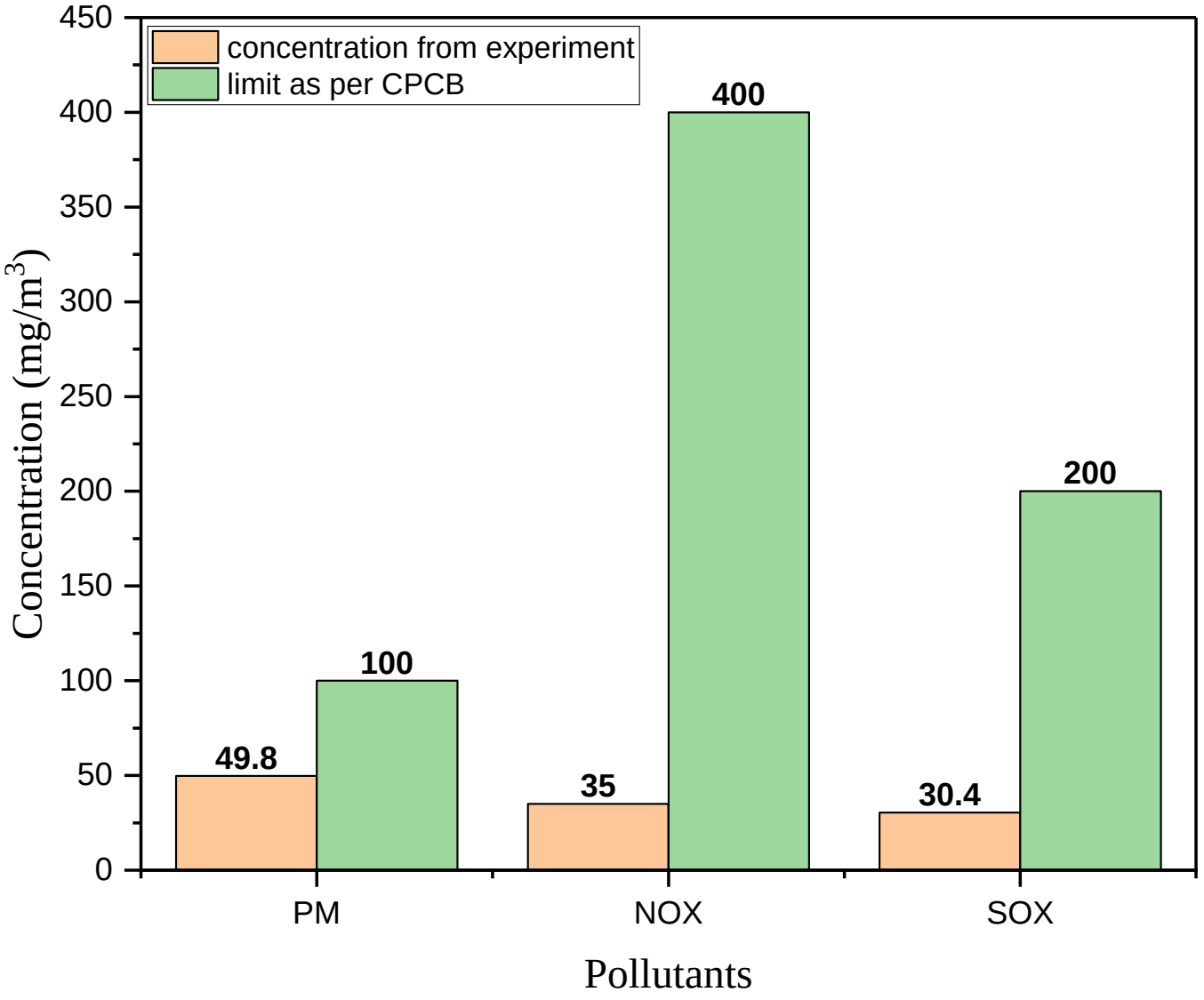
a) The exhaust gas sample was collected and tested for pollutant concentration and the result was found under the limitation of CPCB guidelines.

b) Samples of different waste composition is collected and tested for their optimized calorific value. The ***optimum calorific value was found to be 32 MJ/kg***

c) A sample of the exhaust gas from the chimney is collected in an online monitoring device and the testing report shows the ***availability of hydrogen gas and carbon monoxide***. These gases have high calorific value particularly hydrogen, which can be collected in further research and utilized for ***electricity generation***.

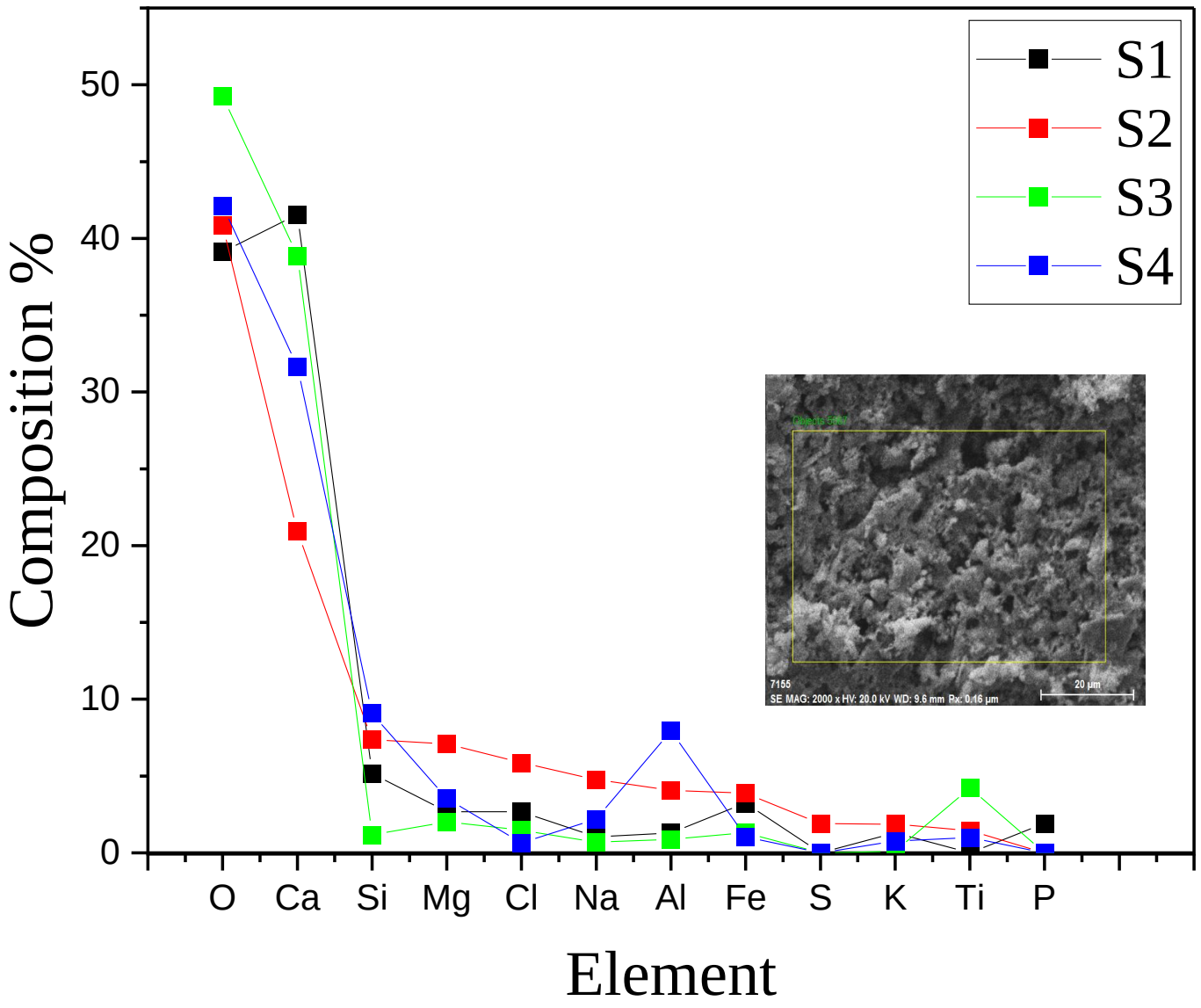
d) The **by-product** of waste treatment is ***bottom ash*** and after testing it is found to be ***nontoxic and carbonless***. The testing results are in **support of disposal in landfills** and might be used as ***raw material in the construction sector*** as well.

Stack emission sample test results for Jafrabad plasma pyrolysis plant



- The exhaust gas sample collected and tested for pollutants concentration and result found under the limitation of CPCB guidelines.
- The pollutants such as NO_X, SO_X, PM found 91.25 %, 84.8 %, and 66.8 % respectively and CO found 99.1 % less by volume.
- This testing and analysis show that the technology is capable of managing the MSW without any negative impact on environment and society.

Ash sample test results for jafrabad plasma pyrolysis plant



sample test result analysis:

- didn't get any hazardous material ***(B,V,Cr,As,Se,Sb,W,etc.)*** more information regarding the same confirmed after further testing like Inductively Coupled Plasma Mass Spectrometry (ICPMS).
- ***Cu is not available*** so it will not play the role of catalyst for dioxin and furans generation.
- ***Iron (Fe)*** quantity is less so it may also not act as a catalyst for gen. of dioxins and furans.
- we also haven't found any unburned carbon content (***carbonless***) in our ***ash sample***, which is a ***novelty*** compared to other technology.

➢ **Research and Testing of samples for the application of ash in construction is in progress.**

Fig. Elemental composition of bottom ash (Energy Dispersive Xray (EDX) analysis)

Plasma pyrolysis/gasifier vs Conventional gasifier

Sl. No.	Parameters	Plasma pyrolysis	Conventional gasifier	Reference
1.	Operation	In presence of oxygen	In presence of oxygen	-
2.	Capital investment	high	Relatively low	Young GC, 2010
3.	Operation and maintenance cost	high	low	-
4.	Net energy production potential (kWh/ton of MSW)	**816**	**685**	Young GC, 2010
5.	Syngas composition (%)	H_2 ≈ 40-45, CO ≈ 30-35	H_2 ≈ 15-25, CO ≈ 20-30	Bo Xiao, 2009; Janajreh I, 2013
6.	MSW mass reduction (wt. %)	90-99	80-85	
7.	Residue (ton/ton MSW)	0.18 (Vitrified slag/Ash)	0.2 (Ash)	Young GC, 2010
8.	Maximum moisture in produced fuel (%)	10	50	Munir M.T., 2019
9.	Output (Product gas)	Devoid of tars, heavy metals etc. – eco-friendly technology for treatment of waste	Product gas contains tars, heavy metals cam cause environmental damage	-
10.	Particulate emission (µg/Nm^3)	12.5	14.1	Wilson B, 2012
11.	HCl emission (µg/Nm3)	1-8	3-26	Munir M.T., 2019
12.	Hg emission (µg/Nm^3)	<0.0002	<0.007	Munir M.T., 2019
13.	Dioxins/furans emission (µg/Nm3)	<0.00925	Relatively more	Munir M.T., 2019
14.	Disposal of ash & production of vitrified slag	yes	no	Munir M.T., 2019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