iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 Issue: IV Month of publication: April 2025

DOI: https://doi.org/10.22214/ijraset.2025.69146

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue IV Apr 2025- Available at www.ijraset.com

A Study on Waste Management at Langadiyawas Landfill, Jaipur: Feasibility of Plasma Arc Gasification

Rohit Soni[1], Zubbair Ahemed khan[2], Megha Sharma[3], Sonam Kumawat[4], Shyam Singh Tanwar[5], Deepak Kumar Bairwa[6]
[1, 2]Assistant Professor, [3, 4, 5, 6]Student, Department of Civil Engineering, Sri Balaji College of Engineering and Technology, Jaipur, Rajasthan, India

Abstract: The landfill situation in Langadiyawas, located in Jaipur, Rajasthan, faces issues relating to an excess of municipal solid waste (MSW) generation, improper dumping, and environmental damage. Its excess waste breakdown has resulted in waste production of 500 tonnes a day which leads to the Langadiyawas dump site as the primary disposal site. In turn, the overcapacity of landfills has resulted in groundwater pollution, air quality deterioration, and methane gas release. An incineration facility to convert waste to energy (WTE) is planned to be built by the Jaipur Municipal Corporation (JMC) on site, however, Plasma Arc Gasification (PAG) proves to be a cleaner and more efficient source. The goal of this study is to assess the viability of PAG implemented in Langadiyawas, focusing on the ineffectiveness of the current waste management systems and establishing a test case for the city. This research investigates the use of Plasma Arc Gasification (PAG) as an alternative strategy for effective waste management for Jaipur. With the capacity to destroy municipal solid waste (MSW) with the most extreme temperatures available (3000-10000ºC), PAG also creates syngas (composed out of hydrogen and carbon monoxide) and vitified slag while generating clean energy. In comparison to traditional incineration, PAG yields much lower emissions of pollutants such as carbon dioxide, dioxins, furans, and guarantees the destruction of almost all waste material.

The assessment examines the progress on Langadiyawas landfill with respect to its waste breakdown, site capacity, and ecological impact. Moreover, it assesses waste's energy potential in Jaipur estimating that over 1,100 MWh of energy could be generated by plasma arc gasification (PAG) of 1,556 tonnes of waste processed daily, which is expected to be enough to supply power to over 110,000 homes.[7] In addition, PAG has substantial profit margins, including carbon credits, creation of jobs, and sales from other remains, including synthetic oil and construction grade slag.[9]

Keywords: Langadiyawas Landfill, Jaipur, Waste-to-Energy, waste management, plasma arc gasification.

I. INTRODUCTION

A. Background

Being one of the most developing capital cities of India, Jaipur has around 3.51 million people in the urban areas. On average, Jaipur produces a lot of Municipal Solid Waste (MSW) daily, which is estimated between 1700-2000 tons. There has been a rise of economic growth as well as urbanization which has increased the population, and this, in turn, has increased the amount of waste that needs to be dealt with. At present, the Jaipur Municipal Corporation (JMC) has to primarily deal with the challenge of solid waste management through landfilling, which is the predominant significant disposable method.

The site of Langadiyawas waste Landfill has been serving Jaipur for waste dumping for twenty years approximately. It is 21 km to the East of Jaipur. Langadiyawas has overfilled recently too much waste is dumped there resulting in pollution and is affecting the city in a negative manner. The Local water sources are getting polluted such as water resources, the area's methane gas as well as toxic gas emissions are negatively impacting the region while also causing land degradation. People in these regions suffer from various health issues due to the organic matter that is decomposed.

In order to mitigate these issues, JMC has sought to develop an incineration waste-to-energy plant at Langadiyawas, which will attempt to convert 1,000 tonnes of waste per day into 12 MW of electricity. However, conventional incineration comes with prohibitive costs due to the carbon emissions produced, the poisonous ash created, and the discontentment from health and environmental activists. These factors also suggest the need for more advanced waste treatment processes - smaller in scale, more efficient, and cleaner, like PAG.

B. Research Objectives

1) Analyze the current scenario of waste within the Langadiyawas landfill.
2) Assess the possible environmental and health concerns from the already established waste disposal techniques.
3) Examine the viability.

II. CURRENT SCENARIO OF LANGADIYAWAS LANDFILL

A. Location and Capacity

Langadiyawas landfill, which is located 21 km from the heart of Jaipur, is the most important dumping yard for municipal waste and covers more than two hundred acres.

B. Waste Composition at Langadiyawas

In accordance with the studies concerning urban waste in India, it is estimated that Jaipur's composition in MSW is:

Waste	composition
Organic Waste (Biodegradable)	49-55%
Plastics	9-13%
Paper & Cardboard	10.3-12%
Metals & Glass	6-7.5%
Construction & Inert Waste	15-18%

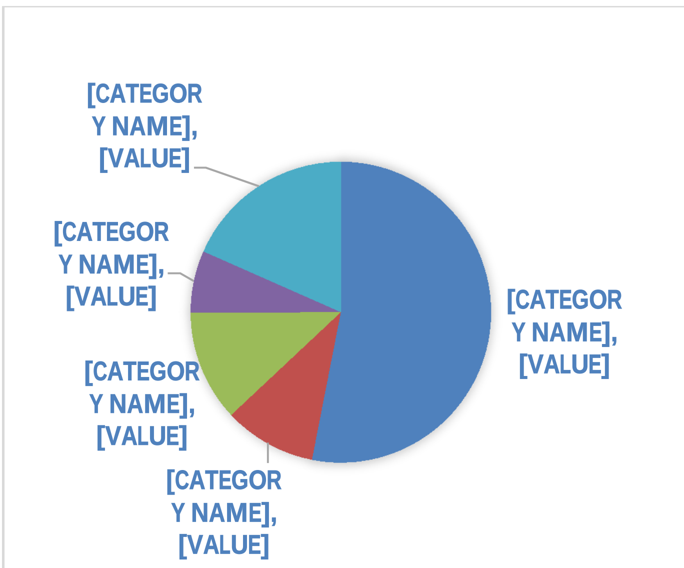


Fig. 1 Waste Composition

C. Environmental Challenges

1) Leachate Pollution: Polluted waste effluent that contains toxic materials infiltrates the groundwater and has an impact on nearby villages.
2) Air Quality: Emission of methane and carbon dioxide further enhances the global warming problem and leads to a wide variety of arising respiratory diseases.
3) Landfill Space Availability: Other methods need to be sought after because the landfill is full.
4) Medical Hazards: Poor health management of the waste results in higher incidence of illnesses like respiratory tract infections and diseases transmitted by vectors.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue IV Apr 2025- Available at www.ijraset.com

III. PLASMA ARC GASIFICATION: A SUSTAINABLE ALTERNATIVE

A. *Technology Overview*

Waste is treated via an innovational technique called Plasma Arc Gasification (PAG) which includes the usage of high temperature plasma torches a.k.a 3000-10000 degrees. The wastes becomes syngas (which is a combination of carbon monoxide and hydrogen) and inert slag.[2]

Process Flow

1) Waste Soring and Drying – Takes away unprocessable materials.
2) Plasma Arc Gasification – Waste is converted to syngas via plasma torches.
3) Syngas steam recovery – The produced syngas is used to create electricity or biofuels.
4) Non-Toxic Slag Recovery – Vitrified non-toxic slag is used in construction.

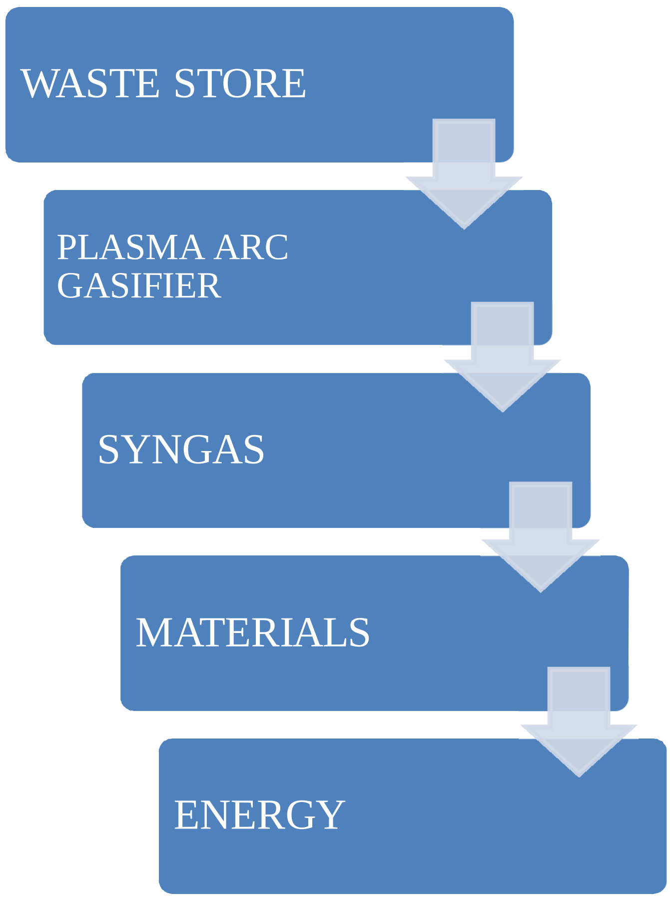


Fig. 3 Process Flow

B. *How Plasma Arc Gasification Works*

1) *Waste Feedstock Processing*

The process starts with the pre-treatment of waste, where materials like municipal solid waste (MSW), industrial refuse, or even hazardous waste are shredded and dried to optimize processing. Unlike conventional landfills that let waste pile up for years, PAG actively reduces waste volume while recovering energy.[10]

2) *Plasma Gasification Chamber*

Inside the reactor, a plasma torch, powered by an electric arc, generates extreme heat, breaking down organic and inorganic compounds into simpler molecules. Unlike conventional combustion, this process occurs in an oxygen-starved environment, preventing the formation of toxic dioxins and furans.

3) Production of Syngas

The key output of PAG is syngas, a mixture of carbon monoxide (CO) and hydrogen (H_2). This gas can be cleaned and used as a fuel for electricity generation, biofuel production, or even hydrogen extraction. This turns waste into a renewable energy source instead of a pollutant.

4) Formation of Inert Slag

The inorganic components of waste (like metals and minerals) melt into a glass-like, non-toxic slag. This material can be safely used in construction, reducing the need for natural resources while keeping harmful waste out of landfills.

IV. COMPARING INCINERATION WITH PLASMA ARC GASIFICATION

Plasma arc gasification is much sustainable then other such as incineration process Comparing Incineration and plasma arc gasification.[4]

Feature	Plasma arc Gasification	Incineration (WTE)
Energy efficiency	71-80%	24.5-30%
Emissions	Minimal CO_2, no dioxins	High CO_2, toxic dioxins
Byproducts	Inert slag (usable)	Toxic ash (landfill required)
Landfill reduction	Up to 93.5%	~24% residual waste
Cost & Maintenance	High initial cost, lower long-term maintenance	Moderate cost, high pollution control costs

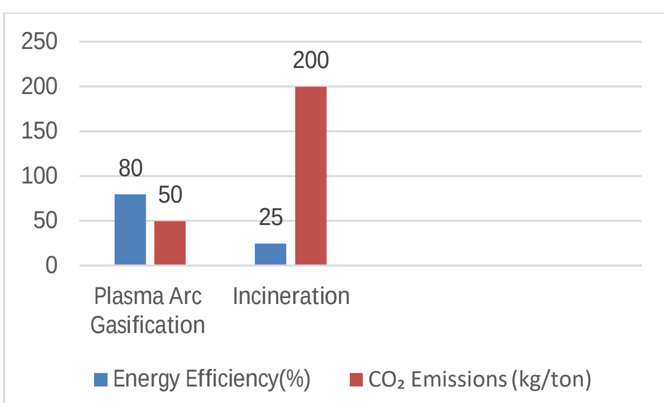


Fig. 2 Comparison of Plasma Arc Gasification and Incineration

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue IV Apr 2025- Available at www.ijraset.com

A. *Comparing Plasma arc Gasification with other waste Management Techniques*

Comparing other techniques with Plasma Arc Gasification. Plasma Arc Gasification reduce more waste than other techniques.[6]

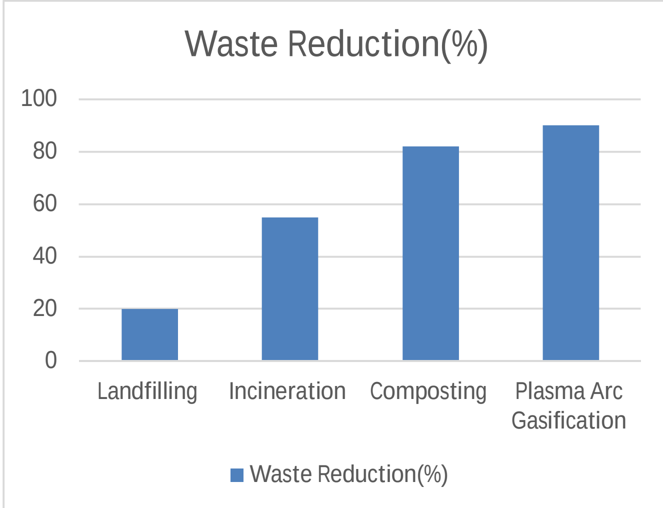


Fig. 3 Waste Reduction

B. *Energy Potential of Jaipur's Waste via Plasma Arc Gasification*

1) Average Muncipal waste generated daily in Jaipur: 1200–1400 MT
2) Average energy value (Calorific value) of mixed MSW: ~6–12 MJ/kg
3) Convert waste energy into syngas: ~51-60.5%

Jaipur can produce 21–26 MW of electricity each day from its waste by using the Plasma Arc Gasification system.
This amount of power could meet the daily electricity needs of nearly 20,500 homes in India (based on Indian average daily consumption).
This will make this approach not just a solution for waste management but also produce energy and become an energy alternative.

C. *Feasibility Analysis for Jaipur*

These are the feasibility analyses for Jaipur:

1) Technical Feasibility

A successful waste-to-energy plant depends on the nature of the waste composition, energy content, and infrastructure suitability. Jaipur's waste type is favorable for the adoption of PAG.

2) Economic Viability

Capital Investment: ₹500–750 crore as a preliminary estimate for a PAG plant.

3) Revenue Generation:

- Syngas can be sold as electricity to the grid.
- Vitrified slag can be marketed for construction purposes.[8]
- Government incentives and carbon credits may offer financial assistance.

4) Environmental Feasibility

Reduction in Landfill Dependence

- PAG can treat 80–90% of MSW, thus lessening landfill burden.[5]
- Waste diversion can add 10–14 years to the life of Langadiyawas landfill.

Air & Water Pollution Control

- Methane Emissions Reduction: PAG obliterates methane emissions, thus lowering Jaipur's carbon footprint.
- Prevention of Leachate: Landfill seepage of leachate into groundwater can be minimized.
- Particulate Emissions Reduced: Sophisticated gas cleaning systems in PAG avoid toxic gas emission.

D. Infrastructure Needs

Jaipur's waste collection system comprises door-to-door collection, transfer stations, and centralized landfilling. In order to incorporate PAG, the following infrastructure changes are required:

- Pre-sorting & Segregation Facilities – To pre-separate organic and high-calorific-value waste prior to gasification.
- Plasma Reactor Installation – Installation of a 5–10 MW PAG facility at Langadiyawas.
- Syngas Utilization System – For the production of electricity or synthetic fuel.
- Byproduct Management System – For treating vitrified slag to be used for construction work.[8]

E. Implementation Strategy for Jaipur

1) Stakeholder Involvement
   - Government: Jaipur Municipal Corporation, Rajasthan Pollution Control Board.
   - Private Sector: Investment by waste-to-energy companies.
   - Public participation: Public awareness campaigns and segregation of wastes.

2) Policy and Regulatory Framework
   - Alignment with Swachh Bharat Mission and National Solid Waste Management Rules 2016.
   - Compliance with Ministry of Environment, Forest and Climate Change (MoEFCC) guidelines.

3) Financial Model
   - Public-Private Partnership (PPP) for funding.
   - State government incentives for clean energy projects.
   - Foreign investment and technology collaboration with different groups.

4) Infrastructure and Logistics
   - Site selection for a 5–10 MW Plasma Gasification plant near Langadiyawas.
   - Integration with waste segregation and collection systems.

V. CHALLENGES AND LIMITATIONS

1) High Initial Investment

PAG entails a large capital outlay, which poses financial feasibility issues.[3]
Solutions: Government subsidies, private investment, and foreign funding.

2) Technological Adaptation

Technical expertise in India is limited for implementing PAG.[3]
Solutions: Training programs and partnerships with foreign PAG companies.

3) Public Acceptance

Resistance owing to absence of awareness of the technology.
Solutions: Policy incentives and educational campaigns.

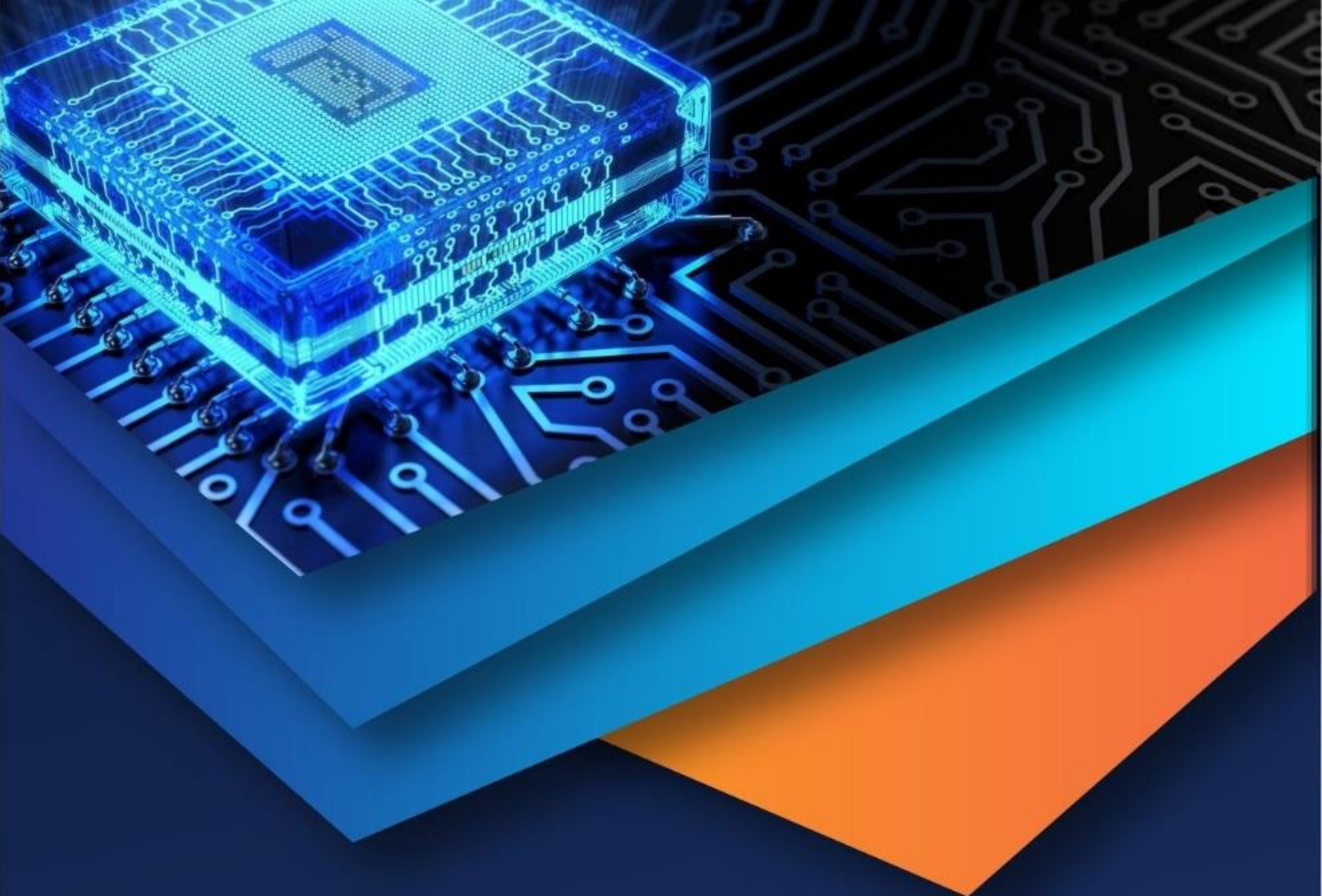
VI. CONCLUSION

Langadiyawas landfill crisis necessitates an immediate and sustainable solution to waste management. Plasma Arc Gasification provides a workable alternative that has the potential to minimize landfill dependence, produce clean energy, and reduce environmental effects. The analysis of feasibility indicates that the implementation of PAG in Jaipur is economically and technically feasible with adequate funding, regulatory encouragement, and stakeholder participation. This study suggests adopting a phased-in approach, first with a pilot project, followed by a complete waste-to-energy plant. Such successful implementation will make Jaipur a model city for sustainable solid waste management for India.

REFERENCES

[1] Jaipur Municipal Corporation - Waste Management Data (2024).
[2] Environmental Benefits and Challenges of PAG:
Mihai, F.-C., & Ingrao, C. (2021). Assessment of Plasma Arc Gasification for Municipal Waste Management: A Sustainable Approach? Sustainability, 13(4), 1957.

[3] The Langadiyawas Landfill: Challenges and Opportunities Sharma, R., & Jain, S. (2019). International Journal of Environmental Studies, 76(5), 742-755.
[4] Comparison of Plasma Gasification with Incineration: Janajreh, I., Adewuyi, K., & El-Halwagi, M. (2013). Plasma arc gasification of municipal solid waste: A review of process performance and conversion efficiency. Energy, 42(1), 975-987.
[5] General Plasma Arc Gasification Technology:
Yeddu, S. R., & Basu, P. (2013) Plasma gasification of municipal solid waste. Applied Energy, 108, 686-694.
[6] Plasma Gasification Process: Modeling, Simulation, and Comparison with Conventional Technology Fabry, F., Rehmet, C., Rohani, V., & Fulcheri, L. (2013). Waste Management, 33(3), 710-718.
[7] Environmental Impact Assessment of Plasma Gasification of Municipal Solid Waste Arena, U. (2012). Waste Management, 32(4), 625-639.
[8] Plasma-Arc Technology for the Thermal Treatment of Chemical Wastes Li, Y., Huang, Z., Xu, Y., & Sheng, H. (2009). Environmental Engineering Science, 26(4), 789-795.
[9] Application of PAG in Sustainable Waste Management: Heberlein, J., & Murphy, A. B. (2008). Thermal plasma waste treatment. Journal of Physics Applied Physics, 41(5), 053001.
[10] Plasma Gasification of Municipal Solid Waste Mountouris, A., Voutsas, E., & Tassios, D. (2006). Journal of Hazardous Materials, 123(1-3), 120-126.



10.22214/IJRASET

INDEX COPERNICUS 45.98

IMPACT FACTOR: 7.129

TOGETHER WE REACH THE GOAL

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY