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Plastic Waste Characterization in Municipal Solid Waste: A Case Study of Nagar Palika Chitrakoot (Uttar Pradesh)

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Abstract: Plastics are used in a greater number of applications in worldwide and it becomes essential part of our daily life. In Indian cities and villages people use the plastics in buying vegetable as a carry bag, drinking water bottle, use of plastic furniture in home, plastics objects use in kitchen, plastic drums in packing and storage of the different chemicals for industrial use, use plastic utensils in home and many more uses. After usage of plastics, it will become part of waste garbage and create pollution due to presence of toxic chemicals and it will be spread diseases and give birth to uncontrolled issues in social society. In current scenario consumption of plastic waste increasing day by day and it is very difficult to manage the plastic waste. There are limited methodologies available for reutilization of plastic waste again. Such examples are recycling, landfill, incineration, gasification and hydrogenation. In this paper we will review the existing methodologies of utilization of plastic waste in current scenario.

Keywords: Plastic Waste, Plastic Utilization Technologies, Sustainable Waste Management

I. INTRODUCTION

Plastic items are widely used in everyday life, ranging from applications in greenhouses, coating, and wiring, to packaging, films, covers, bags, and containers. Consequently, a considerable amount of plastic solid waste (PSW) is found in the final stream of municipal solid waste (MSW).

Thermoplastics account for nearly 80% of total plastic consumption and are used for conventional plastic applications, such as packaging, as well as non-plastic applications, such as fibres and coatings (Al-Salem et al., 2009). With the rapid development of the social economy, the demand for electronic products has increased significantly. Simultaneously, product lifespans have shortened, leading to the early obsolescence of many electronic devices. In fact, WEEE is one of the fastest-growing waste streams in municipal solid waste (Yang et al., 2013). Moreover, overall MSW generation continues to rise due to population growth and the persistence of a “throwaway culture” in many parts of the world. The ability of landfills to manage increasing waste volumes is limited, owing to the space required and the resulting pollution of soil, water, and air (Gug et al., 2015.Advantages of plastics include corrosion resistance, flexibility, and low production costs. However, the rapid growth of plastic waste generation has posed new environmental challenges. Post-consumer plastic products, including polypropylene (PP), polyethylene (PE), polyethylene terephthalate (PET), and high-density polyethylene (HDPE), form a considerable fraction of MSW—typically 5–15% by weight and 20–30% by volume (Saleem et al., 2015). These gases can be used for heating, lighting, and electricity generation (Chiemchaisri et al., 2010). In the last few years, biodegradation of plastic waste has acquired and given substantial importance as there is increased pressure for the safe management of plastic waste (Sen & Raut, 2015).

Landfilling is undesirable due to its high cost and the poor biodegradability of plastics, while incineration, although widely practiced, is expensive and generates emissions that often exceed acceptable levels (Lin, 2009). With the rapid growth of the automobile sector, the demand for diesel is increasing, thereby depleting petroleum reserves. In this context, waste plastic oil offers a viable substitute for diesel and has also been applied in marine engines, where blending with heavy oils reduces viscosity and improves engine performance (Mani et al., 2011).

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A. Aims & Objectives

1) To quantify monthly plastic waste generation and its proportion in total MSW for the year 2024.
2) To analyse seasonal variations and the impact of awareness campaigns on plastic waste trends.
3) To evaluate potential technological pathways for plastic waste utilization.
4) To propose an integrated plastic waste management model aligned with policy guidelines and sustainable practices.

B. Study Area

Chitrakoot Dham (Karwi), classified as a Nagar Palika, is geographically situated at 25°12′49″N latitude and 80°51′36″E longitude. As per the 2011 Census of India, it had a recorded population of 95,894. Increased human activity contributes to a notable rise in plastic waste, especially from packaging materials, disposable items, and household plastic. The region's waste is collected daily and transported to the municipal disposal site, where basic segregation and dumping occur.

II. METHODOLOGY

Monthly data on total MSW generation and plastic waste composition were collected and compiled for the year 2024. The data was obtained from municipal records, waste audits, and physical characterization studies at the disposal site. Plastic waste was segregated, weighed, and expressed both in absolute terms (tons) and as a percentage of the total MSW generated monthly.

A. Monthly Plastic Waste Generation

Month	Total Waste (Ton)	Plastic (Ton)	% Plastic of Total Waste
January	444.87	53.12	11.94%
February	426.24	50.74	11.90%
March	438.21	52.05	11.87%
April	408.15	50.88	12.47%
May	455.06	66.69	14.66%
June	423.84	64.89	15.31%
July	369.10	46.86	12.70%
August	372.62	47.64	12.79%
September	403.00	48.47	12.03%
October	410.03	45.88	11.19%
November	385.40	45.88	11.90%
December	463.60	51.53	11.11%

Table 1: Table: Monthly Trends of Total Waste, Plastic Waste, and Percentage Share of Plastic in Karwi, Chitrakoot (2024)

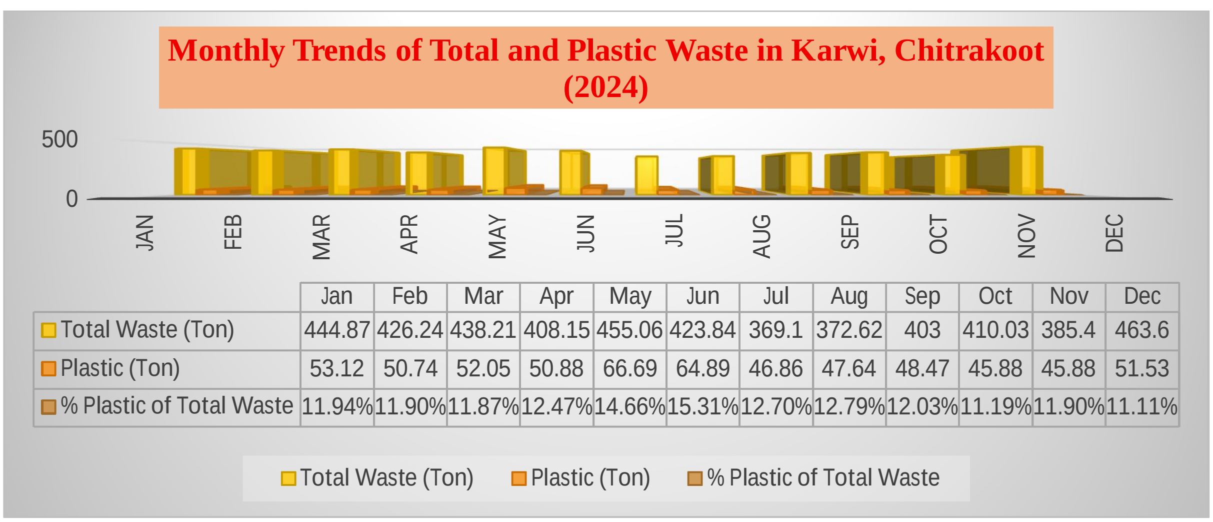

Figure 1.1: Monthly Trends of Total and Plastic Waste in Karwi, Chitrakoot (2024)

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B. Trend Analysis

The plastic waste generation shows a steady monthly presence in the MSW stream, with peaks during the summer months (May–June) possibly due to increased consumption and tourism. The highest plastic content was observed in June (15.31%), while the lowest was in December (11.11%).

On average, plastic contributed approximately 12.7% to the total MSW generated monthly. The initiative conducted under Aarambh 6.0 and Yuma 4.0 from 12–31 July 2024, focused on cleanliness, transparency and promoting a plastic-free urban environment. Nagar Palika Parishad officials with support from local leaders visited marketplaces to distribute cloth bags and biodegradable leaf plates as alternatives to single-use plastics.

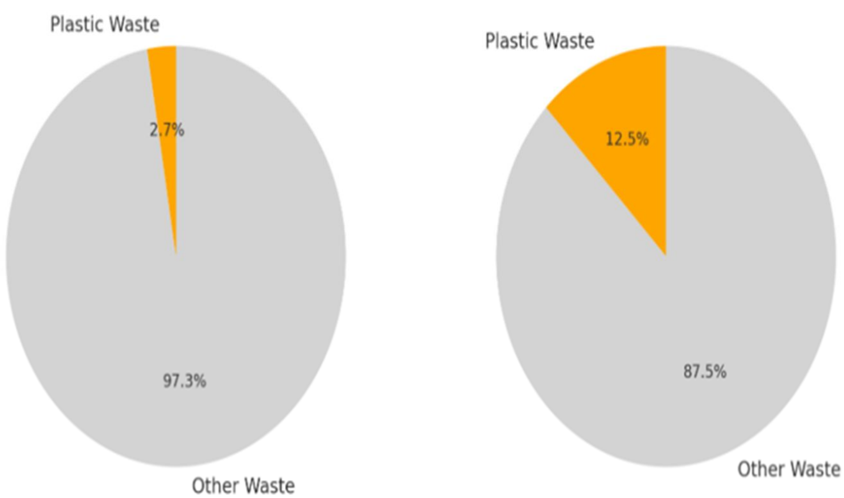
In addition, the campaign emphasized awareness and education encouraging vendors and residents to reduce polythene dependency and adopt sustainable practices.

(a)In 2010, plastic waste in Nagar Palika Chitrakoot (b) In 2024, plastic waste in Nagar Palika Chitrakoot

III. PLASTIC WASTE UTILIZATION PATHWAYS

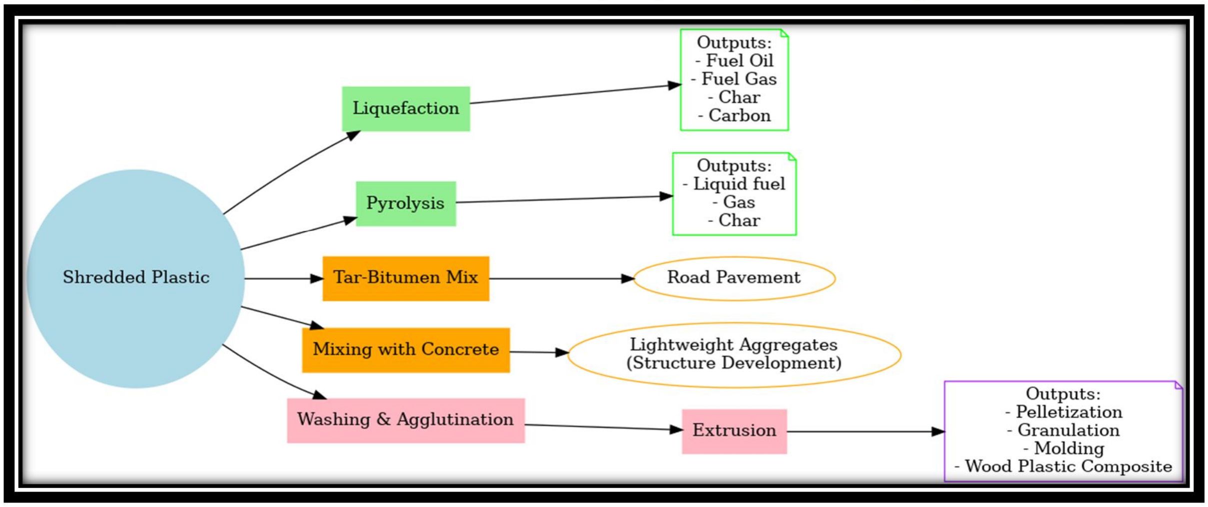
Plastic waste can be processed through different technological routes after shredding, leading to the recovery of fuels, materials, and construction applications.

1) Liquefaction – Shredded plastic can undergo liquefaction to produce fuel oil, fuel gas, char, and carbon. This process is effective in converting waste plastic into energy-rich products, suitable for energy recovery and industrial use (Lin, 2009).
2) Pyrolysis – Pyrolysis is another thermochemical method where plastics are decomposed in the absence of oxygen to produce liquid fuels, gaseous products, and char. It is considered one of the most promising options for waste-to-fuel conversion due to its ability to recover valuable hydrocarbons (Miskolczi et al., 2009).



3) Tar-Bitumen Mix – Shredded plastics can be incorporated into bitumen for road pavement applications. Studies have demonstrated that plastic-bitumen mixtures improve pavement durability, reduce rutting, and enhance resistance to water damage, thereby contributing to sustainable road construction (Vasudevan et al., 2010).
4) Mixing with Concrete – Plastics can also be used as lightweight aggregates in concrete production, enhancing structural development while reducing the consumption of natural aggregates. This approach provides an alternative utilization of plastic waste in construction materials (Frigione, 2010).
5) Washing, Agglutination**, and Extrusion** – Cleaned and agglutinated plastic can be subjected to extrusion, resulting in products such as pellets, granules, moulded goods, and wood-plastic composites. This recycling method allows plastics to be reintroduced into the production cycle, reducing the need for virgin plastic materials (Hopewell et al., 2009).

Flow Chart: Plastic Waste Recycling and Utilization Pathways



IV. PROPOSED MODEL OF PLASTIC WASTE MODEL

Plastic waste has become a significant concern in Chitrakoot Karwi, where it now constitutes nearly 12–15% of the total municipal solid waste. The proposed plastic waste management model for Chitrakoot (Karwi U.P.) emphasizes segregation at source, followed by separate collection and transportation of plastic waste to Material Recovery Facilities (MRFs) for sorting and processing. Recyclable plastics are directed towards recycling and value addition, while compostable alternatives are promoted to reduce dependence on single-use plastics. Non-recyclable fractions are managed through safe disposal methods such as co-processing or secured landfills. The model is supported by policy enforcement under Plastic Waste Management Rules and strengthened through community participation and awareness programs, creating an integrated, sustainable system for plastic waste reduction and management.

V. SALIENT GUIDELINES ON PLASTICS IN THE CONTEXT OF CHITRAKOOT (KARWI, U.P.)

Together, these guidelines form a comprehensive set of technical, managerial, and regulatory instruments that support the sustainable management of plastic waste, ensuring environmental safety while promoting recycling and biodegradability. Plastic waste management in Chitrakoot (Karwi, U.P.) can be improved by aligning local practices with national and international standards. ISO 17088:2012 provides specifications for compostable plastics, offering a pathway to reduce non-biodegradable waste. Recycling and recovery are guided by IS 14534:1998 and ISO 15270:2013, relevant to the Material Recovery Facilities (MRFs) already operational in Chitrakoot, though their efficiency is limited. Effective segregation, emphasized in IS 14535:1998 and the ICPE Newsletter (2005), remains a key challenge as plastics are often mixed with organic waste. Policy frameworks such as the CPHEEO Manual on Solid Waste Management (2001) and the Plastic Waste Management Rules (2011, amended 2015) provide regulatory direction, but weak enforcement and low community participation hinder outcomes in Karwi. On the technical side, biodegradability testing standards like ISO 10210:2012 and ISO 14855:2012 outline robust methods for assessing plastic degradation under various conditions, though they remain largely unimplemented locally.

Overall, strengthening segregation at source, enhancing recycling infrastructure, and exploring compostable alternatives—within the framework of these guidelines—can significantly improve Chitrakoot's plastic waste management system.

Sl.	Title	Guidelines / Specifications
1.	Specifications for compostable plastics	ISO 17088:2012
2.	Guidelines for Recycling of Plastics	IS 14534:1998
3.	Guidelines for the recovery and recycling of plastics waste	ISO 15270:2013
4.	Sorting and Segregation of plastics	IS 14535:1998 and ICPE Newsletter Vol 6, Issue 2, 2005
5	Manual on Solid Waste Management (2001), CPHEEO, Ministry of Urban development, GoI, New Delhi.	MSWM, 2001
6.	Plastic Waste (Management & Handling) Rules, 2011	2015
7.	Methods for the preparation of test samples used in the determination of the ultimate aerobic and anaerobic biodegradability of plastic materials in an aqueous medium, soil, controlled compost or anaerobic digesting sludge.	ISO 10210:2012
8	Method for the determination of the ultimate aerobic biodegradability of plastics, based on organic compounds, under controlled composting conditions by measurement of the amount of carbon dioxide evolved and the degree of disintegration of the plastic at the end of the test.	ISO 14855:2012

Table :1.2 Guidelines and Specifications Related to Plastic Waste Management

VI. CONCLUSION

The study of plastic waste generation in Chitrakoot (Karwi, U.P.) during 2024 highlights the increasing contribution of plastics to the municipal solid waste (MSW) stream, averaging 12–15% of the total waste generated monthly. Seasonal variation was evident, with the highest proportion of plastic waste recorded in June (15.31%), likely driven by increased consumption patterns and tourism, and the lowest in December (11.11%). This demonstrates that plastic has become a consistent and integral fraction of MSW, demanding systematic management interventions. The trend analysis further emphasizes the effectiveness of awareness campaigns such as Aarambh 6.0 and Yuma 4.0, which promoted cloth bags, biodegradable plates, and reduced dependence on polythene. These initiatives underscore the importance of community participation and behaviour change alongside technical interventions. Plastic waste utilization pathways—including pyrolysis, liquefaction, incorporation into bitumen, mixing with concrete, and extrusion into new products—provide multiple opportunities for resource recovery, energy generation, and sustainable construction. However, the success of these technologies depends on reliable segregation, proper collection, and the availability of processing infrastructure. The proposed plastic waste management model for Chitrakoot integrates source segregation, dedicated collection, Material Recovery Facilities (MRFs), recycling, and safe disposal of non-recyclables. Supported by regulatory frameworks such as the Plastic Waste Management Rules and guided by technical standards (e.g., ISO 17088:2012, ISO 15270:2013), the model presents a practical pathway to address the growing challenge of plastic pollution. Nevertheless, weak enforcement, limited efficiency of MRFs, and insufficient public participation remain critical barriers. Strengthening segregation at source, improving recycling infrastructure, and promoting compostable alternatives are essential to achieving sustainable outcomes. Aligning local practices with national and international standards, while simultaneously enhancing awareness and governance, will enable Chitrakoot to transition towards a circular economy for plastics, thereby reducing environmental impacts and ensuring long-term urban sustainability.

REFERENCES

[1] Al-Salem, S. M., Lettieri, P., & Baeyens, J. (2009). Recycling and recovery routes of plastic solid waste (PSW): A review. Waste Management, 29(10), 2625–2643.

[2] Bureau of Indian Standards. (1998a). IS 14534: Guidelines for recycling of plastics. New Delhi: BIS.

[3] Bureau of Indian Standards. (1998b). IS 14535: Guidelines for segregation of plastics. New Delhi: BIS.

[4] Bureau of Indian Standards. (2012). ISO 17088: Specifications for compostable plastics. New Delhi: BIS.

[5] Bureau of Indian Standards. (2012a). ISO 10210: Methods for biodegradability testing of plastics. New Delhi: BIS.

[6] Bureau of Indian Standards. (2012b). ISO 14855: Determination of ultimate aerobic biodegradability of plastic materials under controlled composting conditions. New Delhi: BIS.

[7] Bureau of Indian Standards. (2013). ISO 15270: Plastics—Guidelines for recovery and recycling of plastics waste. New Delhi: BIS.

[8] Central Public Health & Environmental Engineering Organisation (CPHEEO). (2001). Manual on municipal solid waste management. Ministry of Urban Development, Government of India.

[9] Chiemchaisri, C., Charnnok, B., & Visvanathan, C. (2010). Recovery of plastic wastes from dumpsite as refuse-derived fuel. Waste Management, 30(11), 2029–2034.

[10] Frigione, M. (2010). Recycling of PET bottles as fine aggregate in concrete. Waste Management, 30(6), 1101–1106.

[11] Government of India. (2011). Plastic Waste (Management and Handling) Rules, 2011. Ministry of Environment and Forests, New Delhi.

[12] Government of India. (2015). Plastic Waste Management Rules, 2015 (amendment). Ministry of Environment, Forest and Climate Change, New Delhi.

[13] Gug, J., Cacciola, D., & Sobkowicz, M. J. (2015). Processing and properties of a solid energy fuel from municipal solid waste (MSW) and recycled plastics. Waste Management, 35, 283–292.

[14] He, P., Chen, L., Shao, L., Zhang, H., & Lu, F. (2015). Municipal solid waste (MSW) landfill: A source of microplastics? – Evidence of plastics in leachate. Waste Management, 38, *14–24*.

[15] Hopewell, J., Dvorak, R., & Kosior, E. (2009). Plastics recycling: Challenges and opportunities. Philosophical Transactions of the Royal Society B: Biological Sciences, 364(1526), 2115–2126.

[16] Indian Centre for Plastics in the Environment (ICPE). (2005). Newsletter on plastics and environment. Mumbai: ICPE.

[17] Lin, Y.-H. (2009). Thermal and catalytic degradation of waste plastics. Energy Sources, Part A: Recovery, Utilization, and Environmental Effects, 31(20), 1806–1812.

[18] Mani, M., Subash, C., & Nagarajan, G. (2011). Performance, emission and combustion characteristics of a DI diesel engine using waste plastic oil. Applied Thermal Engineering, 31(5), 273–278.

[19] Miskolczi, N., Bartha, L., Angyal, A., & Valkai, I. (2009). Thermal degradation of municipal plastic waste for production of fuel-like hydrocarbons. Polymer Degradation and Stability, 94(4), *659–665*.

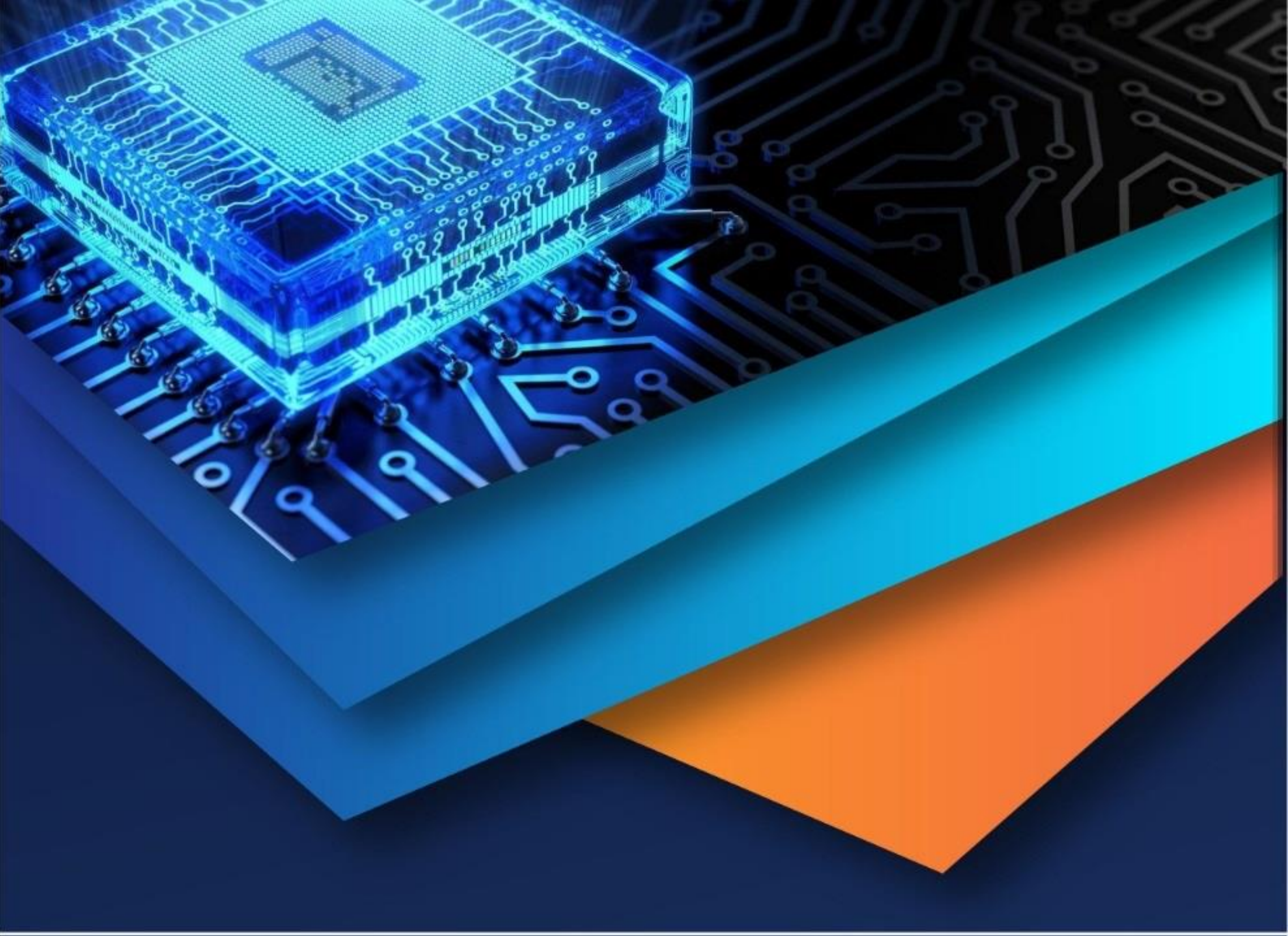
[20] Saleem, J., Riaz, M., & Park, J. (2015). Waste to energy: A solution for municipal solid waste management and sustainable energy in developing countries. Renewable and Sustainable Energy Reviews, 51, 182–196.

[21] Sen, S. K., & Raut, S. (2015). Microbial degradation of low-density polyethylene (LDPE): A review. Journal of Environmental Chemical Engineering, 3*(1)*, 462–473.

[22] United Nations Environment Programme (UNEP). (2009). *Recycling* – From e-waste to resources. UNEP, Sustainable Innovation and Technology Transfer Industrial Sector Studies.

[23] Vasudevan, R., Sekar, A. R. C., Sundarakannan, B., & Velkennedy, R. (2010). A technique to dispose waste plastics in an ecofriendly way–Application in construction of flexible pavements. Construction and Building Materials, 25(6), 3070–3075.

[24] Yang, J., Li, W., & Song, Z. (2013). Global e-waste generation and management. *Waste* Mnagement & Research, 31(12), 1189–1192.



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