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Feasibility Analysis of Integrated Solid Waste Management in a Municipality Area

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Abstract: Waste generation includes processes whereby materials are disposed of or thrown away when it is determined that they are no longer valuable in their current state. The Solid Waste Management Rules, 2016 provide a definition of solid waste that includes treated biomedical waste (excluding biomedical waste and e-waste), battery waste, radioactive waste generated under local authorities, street sweepings, silt removed or collected from surface drains, horticulture waste, agriculture and dairy waste, and other non-residential wastes.

Solid Waste Management (SWM) is a vital service provided by Urban Local Bodies (ULBs) to its citizens to ensure a healthier environment, standard of living, health and sanitation facilities. Although an obligatory function, the SWM service has been an area of concern for urban centers of all sizes especially with changing patterns of lifestyle and behavior.

A typical SWM value chain comprises of the following steps:

- ***Waste generation and storage***
- ***Segregation, reuse, and recycling at the household level***
- ***Primary waste collection and transport to a transfer station or community bins***
- ***Street sweeping and cleansing of public places***
- ***Management of the transfer station or community bin***
- ***Secondary collection and transport to the waste disposal site/ processing facility***
- ***Processing of waste using appropriate technologies***
- ***Disposal of inert/ residual waste in landfills***

Recognizing the importance of solid waste management, the Government of Haryana has initiated steps to improve SWM in the state of Haryana by planning cluster based integrated solid waste management facilities. This task is entrusted with Directorate of Urban Local Bodies (DULB), Government of Haryana. According to the 2011 Census, there are 93 Urban Local Bodies (ULBs) in the state of Haryana, home to over 88 lakh people. The amount of MSW produced by these ULBs is approximately 5676 TPD, and by 2042, it is probably going to exceed 7,675 TPD. Thirteen clusters, consisting of shared treatment and disposal facilities, have been formed from the 93 ULBs. Setting up an integrated SWM system for every cluster has been suggested. Such a Analysis must be created with cost recovery mechanisms established for long-term viability and affordable service delivery guaranteed. It will also minimize its impact on the environment and maximize resource recovery.

Keywords: Solid waste management rules, Urban Local Bodies, Cluster based system, Integrated Solid Waste Management, IEC activity

I. INTRODUCTION

Role of Urban Local Bodies (ULBs)

According to the Indian Constitution, solid waste management (SWM) is a state topic. State governments are primarily in charge of making sure that suitable SWM practices are implemented in each state's cities and towns. SWM is a governmental topic, but it is essentially a municipal function, and as such, urban local governments are in full charge of carrying out this crucial task. The Constitution's 74th Amendment also calls for the urban municipal bodies to assume this duty.

Therefore, it is the duty and requirement of the nation's urban local governments to plan, create, run, and maintain the solid waste management system in their individual cities and towns. By choosing to establish treatment facilities and doorstep collection services with the private sector on acceptable terms and conditions, ULBs may encourage private sector participation in solid waste management. Standard concession agreements or formats may be drafted with legal assistance to ensure ULB interest protection

II. RESEARCH METHODOLOGY

INTRODUCTION

The amount of municipal solid trash generated in the state of Haryana is approximately 5676 tons per day (TPD), and if the rate of rise in per capita waste output is commensurate with the growth in urban population, this quantity is expected to exceed 7675 TPD by 2042. In an effort to give people access to a safe, clean, and healthy environment, the Directorate of Urban Local Bodies (DULB) has suggested establishing cluster-based integrated solid waste management facilities in the Haryana ULBs through a public-private partnership. The foundation for the SWM process in India has been established by the government through the Solid Waste Management Rules, 2016.

RESEARCH METHODOLOGY

Cluster-based MSW treatment plants have been proposed in Haryana based on many variables such free land pockets, existing treatment plants, and the best distance for transporting garbage. Karnal cluster is one such cluster comprising of Indri, Nilokheri, Taraori, Karnal, Gharaunda, Nissing, Thanesar, Shahabad, Ladwa, Kaithal, Kalayat, Rajound, Assandh, Pundri, CheekaPehowa, Ismailabad and Siwan ULBs. The cluster generates about 490 TPD of waste and the quantity is probably will rise to 738 TPD by 2027.

1) Infrastructure Assessment: Evaluate the existing MSW treatment and disposal infrastructure within the State of Haryana. This includes assessing the capacity and efficiency of Material Recovery Facilities (MRFs), composting plants, recycling centers, and sanitary landfill sites.
2) Centralized & Decentralized waste management
3) Data Collection: Gather information on population demographics, economic activities, and lifestyle patterns within the municipality. This includes population size, residential and commercial areas, industrial zones, and any specific waste-generating activities.
4) Waste Generation Assessment: Conduct surveys or studies to quantify the amount of MSW generated within the municipality. This involves estimating daily or annual waste generation per capita, as well as identifying any seasonal variations or trends in waste generation.
5) Composition Analysis: Analyze the composition of MSW to understand the types and proportions of different waste streams. This may include organic waste, recyclables (such as paper, plastics, metals, and glass), inert waste, and hazardous waste. The composition analysis helps in designing appropriate waste management strategies and facilities.
6) Waste Characterization: Determine the physical and chemical characteristics of MSW, including moisture content, density, calorific value, and potential for decomposition. This information is essential for selecting appropriate treatment and disposal methods, such as composting, recycling, or waste-to-energy processes.
7) Gap Analysis: Compare the estimated MSW generation rates and composition with the existing treatment capacity. Identify any gaps or deficiencies in infrastructure that may lead to inadequate waste management or environmental concerns.
8) Future Projections: Consider future population growth, urbanization trends, and changes in consumption patterns to forecast future MSW generation rates. Use these projections to plan for future infrastructure development and capacity expansion.
9) Policy and Planning Recommendations: Based on the findings of the assessment, develop policy recommendations and waste management plans to address the identified gaps and ensure sustainable MSW management in the State of Haryana
10) Sector-Specific Growth Factors: Estimate future MSW generation rates from each sector (domestic, commercial, industrial) using sector-specific growth factors. Consider factors such as population growth, economic development, and changes in consumption patterns to make accurate projections.
11) Treatment Capacity Assessment: Evaluate the treatment capacity of all functioning treatment plants within the state. This includes assessing the capacity of facilities such as Material Recovery Facilities (MRFs), composting plants, recycling centers, and sanitary landfill sites. Additionally, identify available land for installing new treatment plants to meet future demand.
12) Cluster Analysis: Define cluster boundaries based on a maximum distance of 50 km between ULBs. Analyze the distribution of ULBs within clusters to identify areas where waste management infrastructure may be lacking or insufficient.
13) Capacity Planning: Based on the assessment of MSW generation rates and treatment capacity, develop a capacity planning strategy to ensure that existing infrastructure can adequately handle future waste generation. This may involve investing in new treatment plants, expanding existing facilities, or implementing waste reduction and recycling initiatives to mitigate the need for additional capacity.

14) Policy Recommendations: Develop policy recommendations and waste management plans based on the findings of the analysis. These recommendations should aim to address gaps in infrastructure, promote sustainable waste management practices, and ensure compliance with regulatory requirement.

This may involve investing in new infrastructure, promoting waste reduction and recycling initiatives, and strengthening regulatory frameworks for waste management. By following this step-wise process, policymakers and urban planners can effectively assess the sufficiency of existing MSW treatment capacity and develop strategies to address current and future waste management challenges in the municipality. It sounds like you've gathered a comprehensive set of data and conducted a thorough analysis to assess the MSW generation and treatment capacity in the State of Haryana. Here's how you can proceed with the information you've gathered. By following these steps, you can effectively assess the sufficiency of existing MSW treatment capacity in the State of Haryana and develop strategies to meet future waste management needs

III. CLUSTER FORMATION

A. *Karnal Cluster Formation Approach*

There are three possible approaches for managing MSW: decentralized, centralized, or a combination of the two. Under each strategy, waste management services can be provided by the ULBs alone, in collaboration with the business community, or in conjunction with other local entities. In various Indian cities and towns, both decentralized and centralized systems are in use. A brief discussion of these two strategies has been provided below.

B. *Centralized approach*

The technology-driven centralized method to trash management, also known as integrated solid waste management, handles bulk wastes in a central processing plant. In terms of the MSW value chain, the implementing agency (the ULB or a private company) gathers waste from community or residential bins and delivers it to a processing plant in a centralized waste management system. After that, the wastes are processed to extract value using composting methods and/or waste-to-energy technologies like incineration, palletization, Refuse Derived Fuel (RDF), plasma gasification, and bio-methanation. These technologies, which convert garbage into electricity, are more prevalent in industrialized nations and have been used in a few waste management initiatives in India.

An Integrated Solid Waste Management System (ISWM) envisages provisioning of all aspects of waste management i.e. collection, transportation, processing and disposal of waste by one or two large entities. Application of state-of-the-art technologies, reaping economies of scale and ensuring commercial viability of projects are the main reasons for bundling up of all segments of the waste value chain. Moreover, coordination between the ULB and the private entity is relatively better in the ISWM framework when compared to a scenario where multiple entities are engaged in different segments of the waste management process.

C. *Decentralized Approach*

Decentralized trash management, with its reliance on Material Recovery Facilities (MRFs) scattered throughout communities, offers several advantages. By distributing waste management centers closer to the source of trash generation, transportation costs and emissions are reduced. Additionally, the involvement of small-scale entrepreneurs in operating these facilities promotes local economic development.

For-profit MRFs, owned by micro-entrepreneurs, play a vital role in this system. They utilize hand-held carts or small vehicles to collect and transport waste within the neighborhood, often employing informal workers for assistance. This approach not only addresses the issue of unemployment but also fosters community engagement and ownership of waste management initiatives. The segregation and processing of recyclable materials within MRFs contribute to resource conservation and environmental sustainability. Recyclables like metal, glass, and plastics can either be sold to recycling sectors or processed within the facility itself. Similarly, composting organic waste into nutrient-rich manure minimizes the volume of trash sent to landfills while promoting soil health and agricultural productivity.

In this decentralized framework, Urban Local Bodies (ULBs) play a crucial role in coordinating waste collection and transportation to sanitary landfill sites. By decentralizing waste management responsibilities, communities can achieve greater efficiency, sustainability, and inclusivity in handling their trash

The method trains homes on trash segregation and is based on door-to-door rubbish pickup. Material Recovery Facilities (MRFs) are established, with a daily treatment capacity of two to three tons of garbage, and each MRF serves about 1,000 households. The MRFs are for-profit businesses that hire unpaid health workers to handle trash collection and processing. Every RRC employs a pair of unpaid garbage workers who operate cycle carts equipped with masks, boots, gloves, and other safety gear to deliver door-to-door collection services every day.

The collected wastes are hauled to the MRFs, where organic waste is composted and manually separated.
The differences between the two approaches may be highlighted below:

Table 1: Centralized & decentralized waste management

Parameter	Centralized approach	Decentralized approach
Collection	Treating the combined waste at one location	Treating the waste at ward level. – Dry & Wet
Land required	Less number of sites, NIMBY syndrome restricted to few locations	More number of sites, Public opposition possible
Transportation	High	Less
Scale of economies	Scale of economies work in processing	Helps recycling of waste in trade lines
Disposal	More waste going to SLF SLF (as per the SWM Rules 2016 not more than 20% of the incoming Waste stream can be send to landfill)	Less waste going to SLF

The Both integrated and decentralized waste management systems have benefits and drawbacks, thus they can't be applied equally to ULBs in all shapes and sizes. Efficient solid waste management can be achieved through the use of both centralized and decentralized waste management systems, provided that they are implemented in appropriate situations. The topic of when to adopt the decentralized waste management model and under what circumstances to adopt the centralized model needs to be addressed because neither has been demonstrated to be better than the other on all parameters in all circumstances. The choice of a particular approach depends on several factors like financial and human resource capacity of the concerned ULB, socio-economic-cultural profile of city/town, status of service delivery, quantity and quality of waste generated, availability of land, among others.

IV. DATA COLLECTION

A. Basis of cluster formation

Understanding the quantity and composition of Municipal Solid Waste (MSW) is indeed crucial for effective waste management planning. The process typically involves several steps to assess the sufficiency of existing treatment capacity. Here's a step-wise process that might be followed:

1) Data Collection: Gather information on population demographics, economic activities, and lifestyle patterns within the municipality. This includes population size, residential and commercial areas, industrial zones, and any specific waste-generating activities.
2) Waste Generation Assessment: Conduct surveys or studies to quantify the amount of MSW generated within the municipality. This involves estimating daily or annual waste generation per capita, as well as identifying any seasonal variations or trends in waste generation.
3) Composition Analysis: Analyze the composition of MSW to understand the types and proportions of different waste streams. This may include organic waste, recyclables (such as paper, plastics, metals, and glass), inert waste, and hazardous waste. The composition analysis helps in designing appropriate waste management strategies and facilities.
4) Waste Characterization: Determine the physical and chemical characteristics of MSW, including moisture content, density, calorific value, and potential for decomposition. This information is essential for selecting appropriate treatment and disposal methods, such as composting, recycling, or waste-to-energy processes.
5) Infrastructure Assessment: Evaluate the existing MSW treatment and disposal infrastructure within the State of Haryana. This includes assessing the capacity and efficiency of Material Recovery Facilities (MRFs), composting plants, recycling centers, and sanitary landfill sites.
6) Gap Analysis: Compare the estimated MSW generation rates and composition with the existing treatment capacity. Identify any gaps or deficiencies in infrastructure that may lead to inadequate waste management or environmental concerns.
7) Future Projections: Consider future population growth, urbanization trends, and changes in consumption patterns to forecast future MSW generation rates. Use these projections to plan for future infrastructure development and capacity expansion.
8) Policy and Planning Recommendations: Based on the findings of the assessment, develop policy recommendations and waste management plans to address the identified gaps and ensure sustainable MSW management in the State of Haryana.

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This may involve investing in new infrastructure, promoting waste reduction and recycling initiatives, and strengthening regulatory frameworks for waste management.

By following this step-wise process, policymakers and urban planners can effectively assess the sufficiency of existing MSW treatment capacity and develop strategies to address current and future waste management challenges in the municipality.

Table 1: Population & waste generation details of Karnal Cluster

Location	Population 2011	Avg population 2020	Calculated waste gen (Per Capita as per CPHEEO) 2020 (TPD)	Avg population 2027	Calculated waste gen (Per Capita as per CPHEEO) 2027	Avg population 2042	Calculated waste gen (Per Capita as per CPHEEO) 2042
Karnal	302140	377829	170.02	447418	220.39	638649	381.84
Indri	17487	21024	6.31	24165	7.94	32345	12.89
Nilokheri	17938	19923	5.98	21575	7.09	25483	10.16
Taraori	25944	31279	9.38	36014	11.83	48343	19.27
Gharaunda	37816	47640	14.29	56722	18.63	81900	32.64
Nissing	17438	19598	5.88	21415	7.03	25779	10.28
Thanesar	155152	199763	79.91	241809	105.88	361950	192.36
Shahabad	42607	48405	14.52	53324	17.51	65278	26.02
Ladwa	28887	33875	10.16	38207	12.55	49112	19.58
Ismailabad	13,726	16110	4.83	18175	5.97	23351	9.31
Pehowa	52,579	74001	22.20	96076	31.55	168664	67.23
Kaithal	144915	188859	75.54	230595	100.97	351379	186.74
Kalayat	18660	21446	6.43	23816	7.82	29596	11.80
Rajound	17434	19594	5.88	21412	7.03	25776	10.27
Assandh	27125	32893	9.87	38047	12.49	51599	20.57
Pundri	33484	41792	12.54	49214	16.16	68790	27.42
Siwan	23882	27730	8.32	31104	10.21	39704	15.83
cheeka	38952	47881	14.36	56328	18.50	80401	32.05
Total	1055019	1316422	490.46	1559475	637.29	2241997	1115.70

B. Proposed Integrated Solid Waste Management Project

The amount and makeup of MSW produced in the ULB are crucial in identifying potential alternatives for collection, processing, and disposal. They depend on the number of people living there, demographic information, main activities in the town or city, economic levels, and way of life of the locals. Waste generation includes processes whereby materials are disposed of or thrown away when it is determined that they are no longer valuable in their current state. Different sources of solid waste are shown in Figure 1.The Local homes, businesses, shops, restaurants, lodging facilities, and medical facilities are the main producers of solid trash in the area. In addition to MSW, a large amount of biomedical waste (from the hospital industry) and e-waste are produced.

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Figure 1: Sources of MSW Generation

C. SCOPE OF WORK

The quantity and composition of SW generated in the ULB is essential for determining collection, processing and disposal options that could be adopted. They are dependent on the population, demographic details, principal activities in the city/town, income levels and lifestyle of the community. Waste generation encompasses activities in which materials are identified as no longer being of value (being in the present form) and are either thrown away or gathered together for disposal. The primary generators of solid waste are local households, commercial establishments, industries, markets, hotels, restaurants, and hospitals. Apart from SW, a lot of e-waste as well as bio-medical waste (hospital sector) is also generated

V. CONCLUSIONS

Thirteen cluster-based MSW treatment plants have been proposed in Haryana based on many variables such free land pockets, existing treatment plants, and the best distance for transporting garbage. Karnal cluster is one such cluster comprising of Indri, Nilokheri, Taraori, Karnal, Gharaunda, Nissing, Thanesar, Shahabad, Ladwa, Kaithal, Kalayat, Rajound, Assandh, Pundri, CheekaPehowa, Ismailabad and Siwan ULBs. The cluster generates about 490 TPD of waste and the quantity is probably will rise to 738 TPD by 2027 Thirteen cluster-based MSW treatment plants have been proposed in Haryana based on many variables such free land pockets, existing treatment plants, and the best distance for transporting garbage. Karnal cluster is one such cluster comprising of Indri, Nilokheri, Taraori, Karnal, Gharaunda, Nissing, Thanesar, Shahabad, Ladwa, Kaithal, Kalayat, Rajound, Assandh, Pundri, CheekaPehowa, Ismailabad and Siwan ULBs. The cluster generates about 490 TPD of waste and the quantity is probably will rise to 738 TPD by 2027

The overall project has been designed considering the year 2027 which accounts for the time taken in bid process management, bid finalization, construction & commissioning of the plant and year on year expansion in population growth and subsequently in waste generation quantity which will be approximately 638 TPD for Karnal (assuming 3% YOY increase in population and 300-450 g/capita waste generation). Accordingly, the cost estimation of collection, transportation as well as processing facility is considered for the year 2027.

The total capital expenditure of the project has been estimated to be 221.26.

Currently, the combined urban population of Karnal cluster has been estimated to be 1516422 which translates into solid waste generation quantity of 490 tons per day. Due to the unavailability of any waste processing plant in the cluster, the waste is currently dumped unscientifically in designated dumpsites. Moreover, some ULBs doesn’t have sufficient vehicles for collection and transportation of waste to the dumpsites which gives rise to roadside dumping and Garbage Vulnerable Points (GVPs). Therefore, an Integrated Solid Waste Management approach is needed in the cluster.

After thorough analysis of the waste generation quantity, waste characterization and current solid waste management scenario of the ULBs in the cluster, a waste to compost plant of 738 TPD capacity has been proposed for Karnal cluster.

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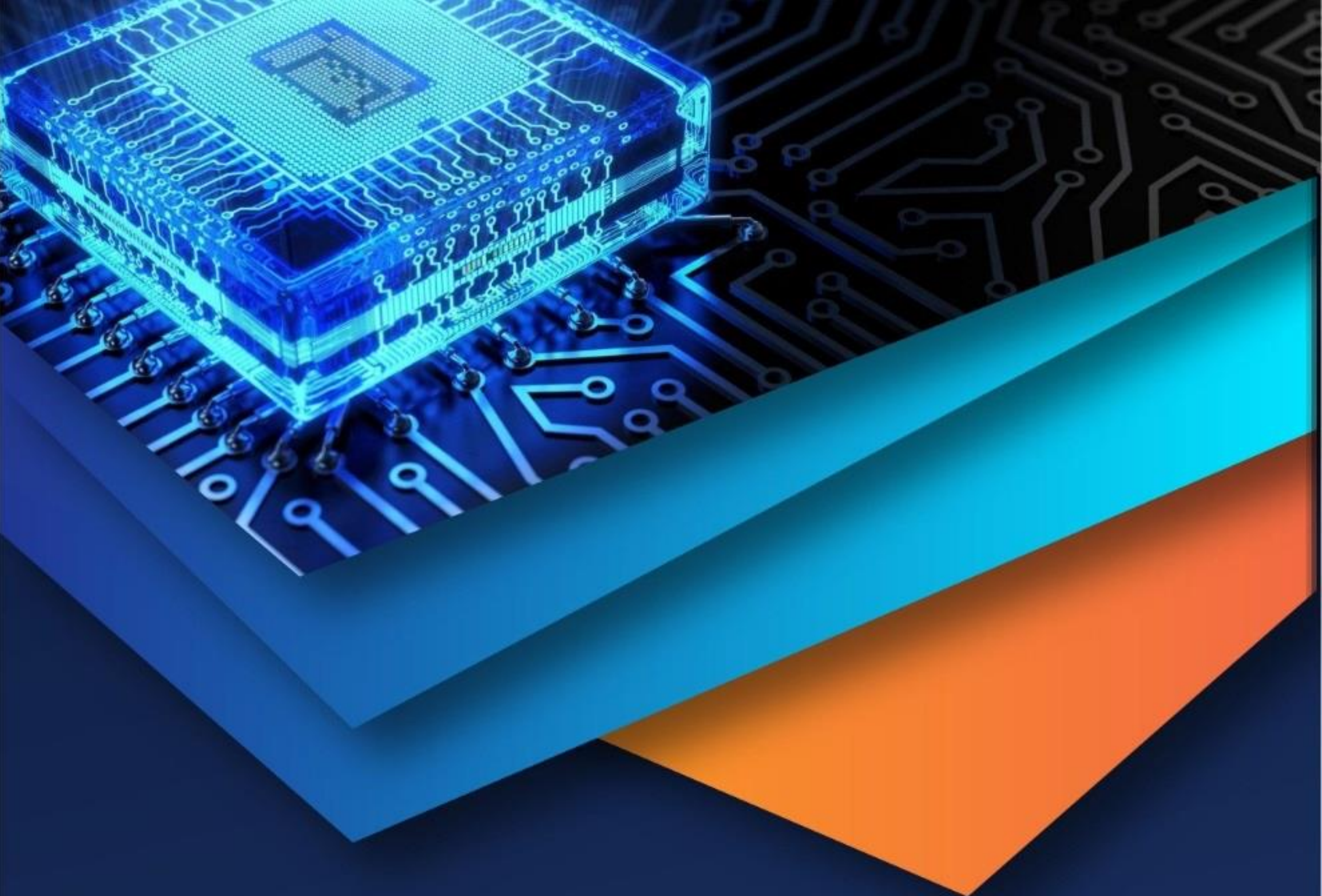

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