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Corn Steep Liquor Additive Aided Composting For Municipal Solid Waste and Evolution of Its Characteristics

R. Manju[1], S.Srikantaswamy[2], D.Shivakumar[3], K. Jagadish[4], M. R. Abhilash[5]
[1, 2 3, 5]*Department of Studies in Environmental Science, Manasagangothri, University of Mysore, Mysuru, 570006, India*
[4]*Department of Studies in Chemistry, Manasagangothri, University of Mysore, Mysuru, 570006, India*

Abstract: ***Composting is one of the best known processes for the biological stabilization of municipal solid organic wastes by transforming them into safer and more stabilized compost. The compost can be used as a source of nutrients and soil conditioner in agricultural field. Composting is gaining increased attention as an environmentally sound approach to manage organic waste especially in countries like India, where 45-50% of solid waste comprises of organic/green waste. Municipal solid waste contains bio degradable and non-biodegradable organic waste. Municipal Solid Waste Site of Mysore City was chosen for the present study. Different Organic Fraction of Municipal Solid Waste (OFMSW) was selected for research. Corn steep liquor was used as a source of additive. Organic additives were mixed at the rate of 10, 20, 30, 40, 50 and 60% of OFMSW inputs. Samples collected from different experimental set up were oven dried (100 -105˚ C), ground and used for chemical analysis. Physico-chemical parameters such as pH, moisture content, electrical conductivity, organic carbon, otal nitrogen & potassium, C:N ratio, phosphate, and ammonia were analysed periodically and optimum pH was observed between 7-8 and the pH values are relatively on higher side of OFMSW blended for 30% of total days samples. Similarly moisture content in the range of 22-24.37% was found as optimum. Physical parameters such as colour and odour were observed and an attempt was made to study the trace heavy metal concentrations present in the compost. These samples were compared with standard prescribed limits of Central Pollution Control Board for compost. With use of easy economical additives, the composting provides an effective for reutilizing organic wastes by converting them into compost for organic farming.***

Keywords: Physico-chemical, Municipal Solid Waste (MSW), Compost, Additives, Corn steep liquor, OFMSW.

I. INTRODUCTION

Solid waste management is a worldwide phenomenon that has been a major challenge all over the world. Mysore City is also not devoid of this problem [1].Modernization with respect to various factors like rapid industrialization, urbanization and population explosion led to generation of thousands of tonnes of Municipal Solid Waste (MSW) everyday [2].The MSW amount is expected to increase significantly in the near future. India on an average every day, generates 188,500 tonnes of MSWmore than 80% of which reaches open dumpsites where it results in damaging public health, deteriorating the environment, and causes climate change and other associated adverse effects[3-5]. Landfill space is hard to find in and around India's urban centres. Dumpsites in almost all cities are already handling more waste. Finding new landfills near cities is almost next to impossible due to various reasons. Composting is considered to be an obvious choice due to the high organic content (51%) in India. The management of MSW is going through a critical phase, due to the unavailability of suitable facilities to treat and dispose the larger amount of MSW generated daily in metropolitan cities [1]. Unscientific disposal causes an adverse impact on all components of the environment and human health. Management of solid waste reduces or eliminates adverse impacts on the environment and human health and supports economic development and improved quality of life [2]. Efforts are being made to safeguard the environment, by recycling different wastes and utilise them in value added applications. Due to the escalating growth in world population and large increase in waste production the generation of solid waste has become an increasingly important global issue over the last decade. The increase in solid waste generation poses numerous questions concerning the adequacy of conventional waste management systems and their environmental component [6].

Composting is one of the best-known processes, a hub of biochemical events that converts various components in organic waste into relatively stable humus like substances which can be used as a source of organic fertilizer and soil conditioners in various agricultural applications [7]. Mechanical–biological composting (MBC), rapid composting using accelerators, co-composting using additives, and microbial inoculums have made composting easy and opened up ventures and avenues for entrepreneurship in waste

management sector. Therefore the present study was undertaken to find out the prospects of additive based composting of MSWin Mysore city. Research in recent past has witnessed the application of additives to enhance the composting process [8]. Additives used can be enzymes, consortium of various microorganisms, minerals, readily available forms of carbon and nitrogen etc. The effects of chemical additives on composting of municipal solid waste, green waste, sludge etc. have been extensively studied by different researchers across the world[9]. Jagdish*et al*. (2012) studied the effect of additives such as jaggery, limestone and other surfactants on degradation of organic matter. All these previous works have highlighted the fact that additives could be favourable for composting process[3]. Corn steep liquor (CSL) which is a by-product of corn wet-milling has been used as important constituent of microbiology growth media and it has been used as cost effective source of nitrogen in the synthesis of bio plastics [10]and also as a component in organic bio stimulant [11]. However, CSL has not been explored so far as additive in solid waste composting.

II. MATERIALS AND METHODS

A. Study Area

Mysore city occupies a significant position in the larger context of southern part of the Karnataka State at 12'18 N latitude and 76'12' E longitude. Mysore city lies in a saucer shaped basin flaked by Chamundi Hills on the south east, the interfluent between two rivers Cauvery and Kabini. The city of Mysore is second largest city after Bangalore in terms of a growing urban hub in Karnataka. It is described as a Garden city and City of Palaces. The city is sprawling over an area of 128 sq km situated in an undulating surface. The city is second most populous city in Karnataka with a population of 887,446 according to 2011 census. These figures are expected to increase with years to come[12].The present study was carried out for the urban environment of Mysore using the MSW sample generated in the city. The municipal solid waste samples were collected from aerobic compost plant situated in Vidyaranyapuram, Mysore.

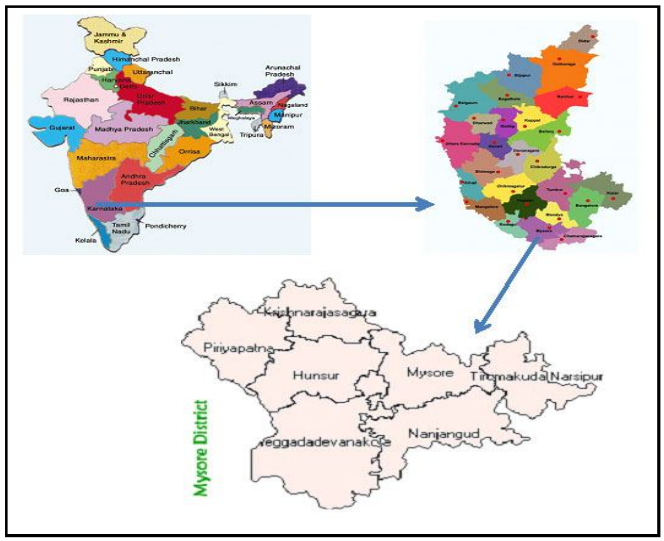

Fig 1: Study Area Map of Mysore city

B. Collection and processing of composting material

The solid waste consisting of various organic matter collected from the MSW Site was used as raw material for composting in the present investigation. Composting experiments were carried out at lab scale in 20 litre cement pots. Known weight (5 Kgs) of organics fraction of MSW (OFMSW) is added to each pot.Organic additive (corn steep liquor) is mixed at the rate of 10, 20, 30, 40, 50 and 60% of MSW inputs (5kg) respectively. The additives are mixed properly and temperature of the experimental set up was monitored frequently using a thermometer. The heaps were turned and mixed every 5th day to provide aeration. The excess water was drained out from the hole which is provided at the bottom of the pots. Three replicates were maintained and necessary care was taken to minimize the external disturbance affecting the composting process. The samples were drawn from pots at different stages of composting processes like 5, 10, 15, 20, 25 and 30 days. These samples were oven dried (100 -105˚ C), ground to 2 mm particle size and stored until further analysis.

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C. Analysis of compost samples

The collected degraded, dried and powdered compost samples were analyzed for various physicochemical parameters such as pH, bulk density, conductivity, moisture content, organic carbon, C:N ratio and total nitrogen, potassium and phosphate for analysis. pH of the compost was determined in aerated distilled water with 1:10 w/v ratio measured using pH meter (Saki *et al*., 2003). Particles and bulk densities by Pycnometric method-Bottle method, organic matter (%) content by Walkley-Black wet combustion method, electrical conductivity by instrument method 1:5 conductivity meter, moisture content (%) by gravimetric method. Phosphorousin the compost was determined through Olsen method, total nitrogen by Kjeldahl's method /phenol disulfonic acid method, total potassium by flame photometer (model no.). Total nitrogen in C/N ration were calculated by adding the three forms determined (organic, nitrate and ammonium) using standard procedures for analysis.

D. Statistical analysis

The data obtained from triplicate experiments were analysed using Origin Pro Software, version 8 with average standard deviation of <5%. Graphical representation was statistically interfaced with error bars.

III.RESULTS AND DISCUSSIONS

In the present study effect of additives on MSW has been studied. Organic additives chosen for the experiment are in semi liquid forms which are discarded as waste from food processing industry. The quantity and characteristics of solid waste vary from place to place; factors that influence the quantity and composition are the average income level based on the socio-economic groups. The composition of MSW in Mysore city has 55% organic material followed by 25% of plastic materials and 3% wood & wood products. This shows that MSW of Mysore city has good amount of bio degradable materials. The typical composition of municipal of solid waste of Mysore City is shown in Table-1.

Table 1: Composition of Municipal of Solid Waste of Mysore City

Item	Waste in %
Plastic	25
Paper	5
Clothes	4
Slipper	1
Bottles, broken plastic items	4
Glass	3
Wood and Wood products	3
Organic material	55
Total	100%

Table 2: Variation of different parameters involved in CSL based MSW composting for 30 days.

SI.No	Parameters	Unit	5 days	10 days	15 days	20 days	25 days	30 days	Recommended Standards
1	pH	-	18.45	7.97	7.42	7.83	7.65	7.48	6.5-7.5
2	Bulk density	g/cm3	0.8	0.5	0.6	0.4	0.2	0.1	<1.0
3	Conductivity	dsm^{-1}	1.4	1.4	3.3	1.6	2.2	2.1	<4 dsm^{-1}
4	Moisture Content	%	8.76	11.25	24.37	6.59	12.84	13.45	15-25%
5	Organic carbon	%	18.18	17.66	12.18	11.98	10.72	8.24	12-16%
6	Total Nitrogen	%	0.25	0.26	0.3	0.31	0.36	0.42	0.80%
7	Total Potassium	%	0.016	0.017	0.016	0.026	0.038	0.088	0.40%
8	C:N Ratio	%	24.5	33.95	18.44	37.97	39.97	40.42	<20
9	Total Phosphate	%	0.042	0.05	0.053	0.041	0.05	0.04	0.40%
10	Colour	-	Brown	Brown	Black	Black	Black	Black	Dark brown to black

The physico-chemical characteristics and the quality of the CSL additive based compost were characterized by analysing the parameters such as colour, odour, pH, moisture content, organic carbon, total nitrogen, potassium, phosphates and C:N ratio. Table 2 presents the results of effect of various composting parameters on CSL based composting.

A. Temperature

Temperature is one of the main parameters in composting,hence the effect of temperature on additive based composting was studied. Fig. 2 represents the temperature variation as observed in ambient and additive composting conditions which follows typical system exhibited by many additive based composting systems [13]. Three phases were observed during the process, where thermophilic phase was predominant which was witnessed from 3rd to 23rd days with maximum temperature of 68 °C on 15th day. Decline in temperature was observed from 23rd day and reached constant level with ambient temperature from 27th day. The extended duration of thermophilic phase may be attributed to the presence of sugars in corn steep liquor that might have boosted the microbial metabolism leading to increase in temperature. The high temperature aids in the destruction of weed seeds and also most of the pathogens [14].

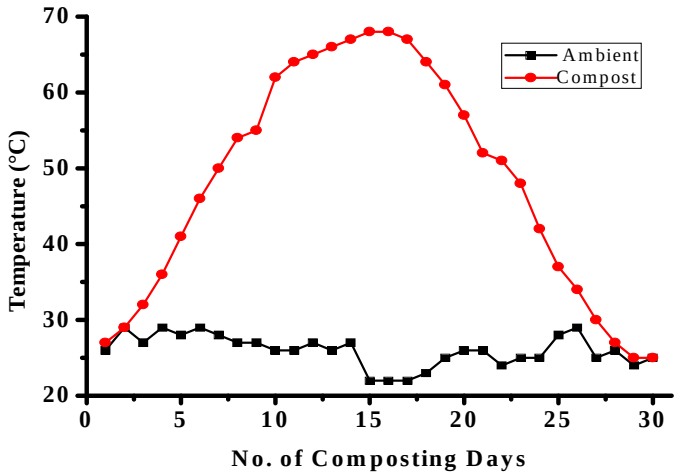

Fig.2. Effect of additive on temperature during composting

B. pH

pH gives a measure of acidic and basic nature of the compost.Fig.3illustrates the effect of pH on additive. There was fluctuation in pH values during the entire composting period. The pH range showed variation during different composting period ie 5th day (8.45), 10th day (7.97), 15th day (7.42), 20th da (7.86), 25thday(7.65), 30th day(7.48).The pH of the compost was found to be basic in nature during the initial days and was almost neutral during 15th- 20th day and was well within the permissible limits of FCO standards, 2009, signifying the applicability of this additive based compost as potential soil nutrient.

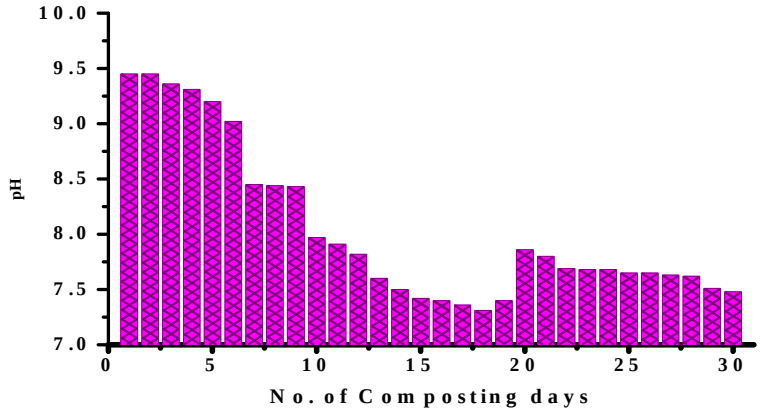

Fig. 3. Effect of additive on pH during CSL aided composting

C. Bulk density

Bulk density is a measure of weight per unit volume of a substance. High density materials possess lesser air spaces with higher occupation of fine pores with water. The bulk density in the present study ranges from 0.1 to 0.8 g cm^{-3} which is comparable to the standard.

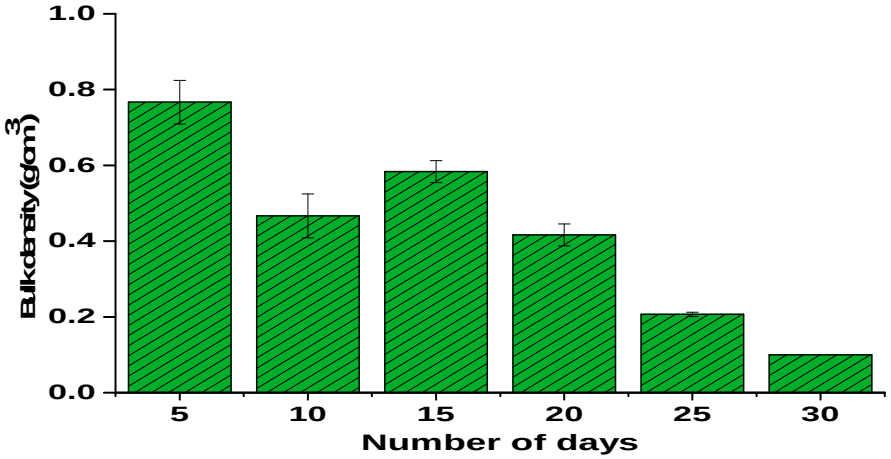

Fig. 4. Effect of additive on Bulk Density during CSL aided composting

D. Total Conductivity

The conductivity in CSL aided compost of 15th day was high and there was considerable decrease on either sides which may be due to high soluble salt content attributed to microbial activity and mineralization. The results are shown in Fig 5.

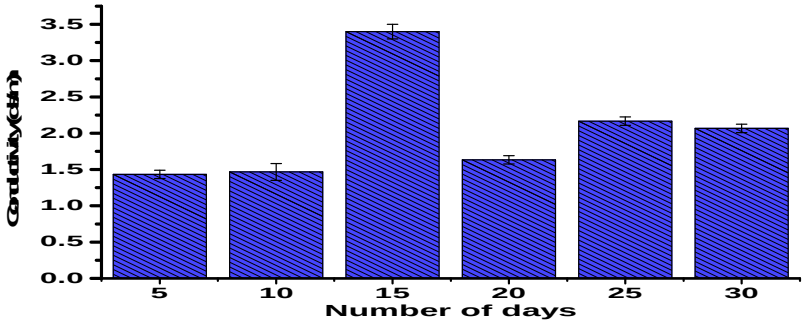

Fig. 5. Effect of additive on Total Conductivity during CSL aided composting

E. Moisture

Moisture content of composting mixture is vital component as it provides medium for transport of dissolved nutrients that aids in enhancement of enzymatic action and microbial respiration (Fig. 6)

F. Organic carbon

In the present study, the total organic carbon percentage varied from 18.24 to 8.24 %. The percentage organic carbon content was found to be decrease consecutively in all the stages of composting. The loss in percentage organic carbon content can be attributed to additive based composting. In comparison to the recommended standards obtained values were well within the stipulated limits (Fig.6).

G. Total nitrogen

Organic and inorganic forms of nitrogen in compost in a whole comprise of total nitrogen. The total nitrogen content in the compost diverges from 0.16 to 0.42% as shown in Table 2. This indicates faster rate of organic conversion. The incremental enhancement in

total nitrogen content during the composting can be accredited to decrease in carbon substrate due to decomposition of organic matter resulting in loss of CO_2(Fig.7).

H.Totalpotassium

Potassium is one of the essential soil nutrients that helps in plant growth and is highly soluble in waste. The insoluble potassium can be solubilised by the disintegration of waste. The concentration of potassium increases during the composting period. Concentration of potassium varies from 0.06 to0.088% in the present study as presented in table 2. There was overall increase in the availability of potassium in the compost which can be attributed to enhance organic decomposition due to the presence of additive in the compost (Fig.7).

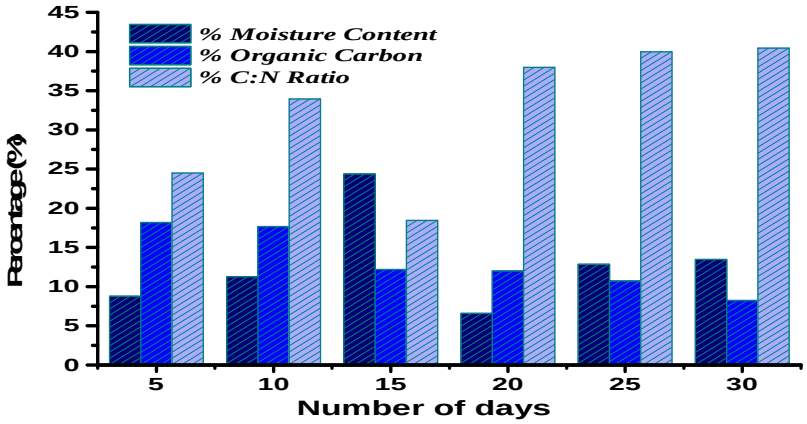

Fig.6: Effect of additive on moisture content, organic carbon and C:N ratio during CSL aided composting

I. C:N ratio

The results of effect of additive on C:N ratio during composting are presented in Table 2. The significant reduction in C:N ratio during 15th day of composting shows enhanced composting leading to the finished compost due to the addition of additive. The results obtained are well within the stipulated range of the recommended standard (Fig.6).

J. Total phosphate

Total phosphorous is one of the prominent plant nutrient among N, P, K that aids in plant growth. The concentration of total phosphorus in present study ranges between 0.04 to 0.053 % which is well within the stipulated range of recommended standard. There was gradual increase in total phosphorus content and generally higher in all the samples. Total phosphorus increases during various phases of composting and decreases due to humification. Similar observations were also noted in earlier studies.

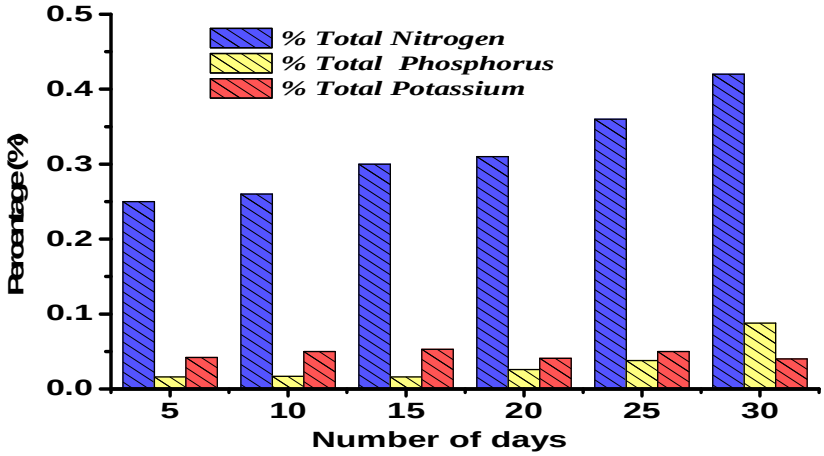

Fig.7 :. Effect of additive on total nitrogen, total phosphorus and total potassium during CSL aided composting

IV. CONCLUSIONS

The results of the present study indicated the scope of additives aided composting process. The corn steep liquor was used as an additive for the composting process for municipal solid waste of Mysore city in different proportions. Physical parameters like colour, odour, pH and moisture content were found to be under the permissible limits of the standards. The composted samples are rich in essential nutrients like nitrogen, phosphorous and potassium and it can be utilized for various purposes and considered as good fertilizer. This in turn reflected on the rate of organic matter degradation and quality of the finished compost as well. The present study highlights the significance of additive based composting for municipal solid waste.

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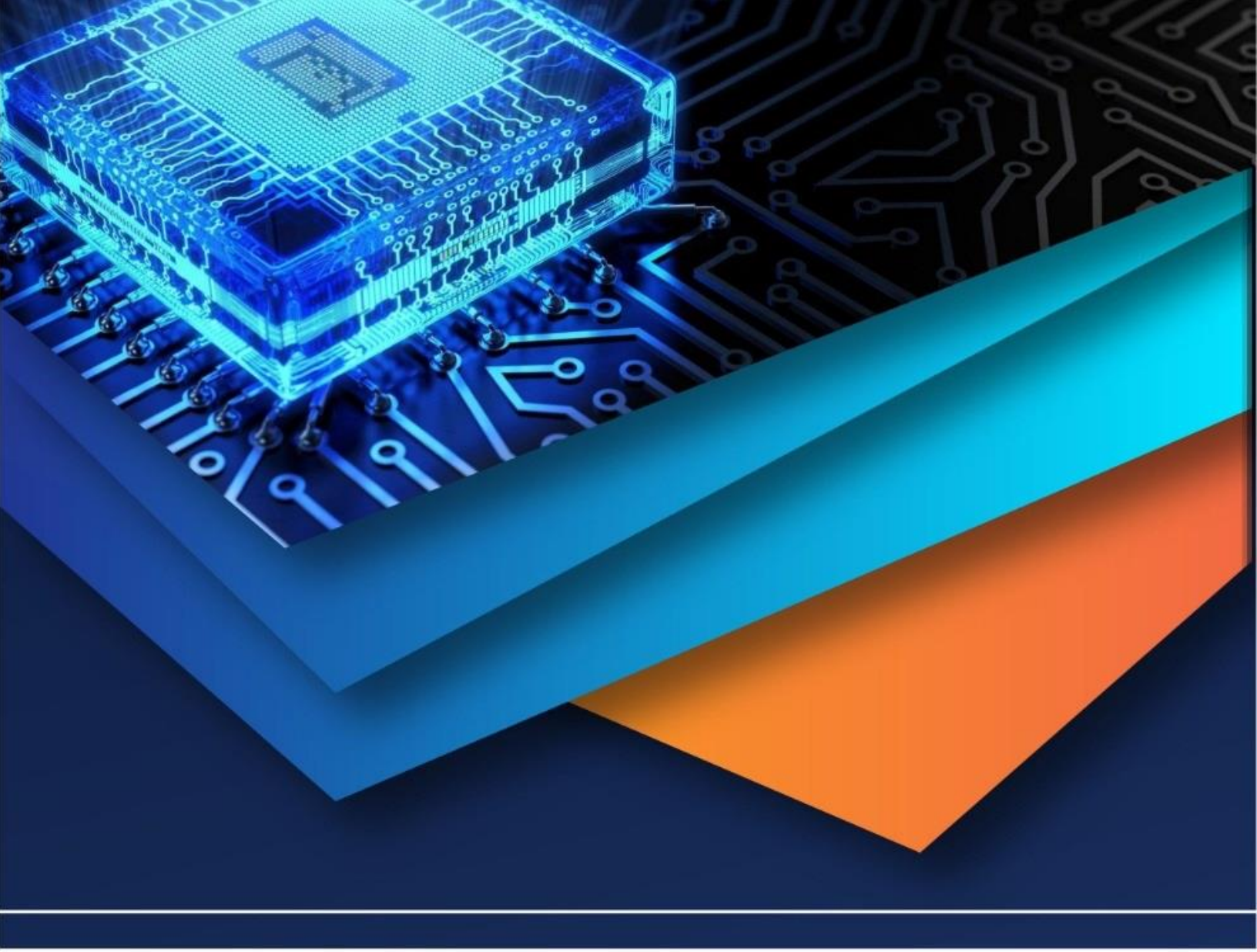

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