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A Study on Microplastic Pollution in Chennai and its Newer Advanced Removal Technologies

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Abstract: ***The threat posed by Micro plastic pollution has become an environment concern at a global level and particularly Chennai which is growing as a most popular industrialised city in India is affected at a larger level due to this pollution. This research paper is aimed at investigating the health impacts, sources and removal technologies of Micro plastic which is operational in Chennai with recommendations of newer and advanced technologies for the removal and elimination of the threat posed by Micro plastic. Studies have exposed that most of this pollutant has its source from industrial discharge, textile industry and domestic waste.***

This paper also emphasises on the harmful effects of Micro plastic on the human health like the induction of inflammation and endocrine disruption by its toxicity mechanism and various pathways through which people are exposed to this pollutant such as contaminated drinking water and seafood. A comparison between the conventional treatment methods and newer advanced technologies shows significant improvements in filtration of Micro plastic as observed in newer technologies which can be adopted in the city of Chennai to mitigate the problem of Micro plastic. The newly introduced Wasser 3.0 PE-X® technology is an innovative process which uses a filter less "clump and skim" procedure for the removal which has demonstrated high removal efficacy and more cost effective than the conventional methods being used and this paper also explores other emerging technologies like the membrane filtration and advanced oxidation processes. By studying these newer technologies this paper explores the practical application of these advanced removal technologies in the Chennai's water treatment plants, plastic manufacturing units and textile industries.

This research concludes by stressing the urgent requirement for adaptation of advanced Micro plastic removal technologies along with stricter regulations on plastic disposal and production more importantly organising frequently public awareness campaigns to combat this pervasive health and environmental threat in Chennai.

Keywords: 1) Micro plastics 2) Chennai 3) Water Pollution 4) Removal Technologies 5) Human Health Impact

I. INTRODUCTION

One of the most discussed environmental concerns in the recent times is the pollution caused by Micro Plastic which can be characterized by the presence of plastic particles which are smaller than 5mm in diameter. The origin of these particles is from the fragmentation of larger plastic debris which is present in the environment without degradation because of their physical properties. They also pose a threat to the aquatic ecosystem which indirectly poses a threat to the humans.

Chennai is a metropolitan city present in the state of Tamil Nadu in India which in the recent times has been experiencing rapid urbanization and industrialization and huge influx of people into this city where the administration has been facing challenges at various levels and the particular concern is with regard to the management of plastic waste which is the primary cause for Micro Plastic pollution. [9] Various investigations carried out by the experts has revealed that elevated concentrations of micro plastics are present across various water sources in Chennai.[4]

This paper aims to give a detailed analysis of the current status regarding Micro Plastic pollution in the Chennai water bodies including rivers, lakes and coastal region by analysis of existing research findings. Further this paper also analyses the harmful effects of Micro plastic on the human body, also a comparison between the conventional filtration process and newer technology is done to test the efficacy of newer technologies over conventional ones.

The Wasser 3.0 PE-X® technology is examined in detail and its practical usage is analysed. Finally the practical application of these advanced technologies in the relevant industrial sectors in Chennai is analysed which has provided insights into feasible solutions for the mitigation of this environmental challenge.

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II. PRESENCE AND SOURCES OF MICROPLASTICS IN CHENNAI'S WATER

1) Rivers: The studies which have been conducted in the Chennai Rivers have exposed higher levels of micro plastic pollution. When it comes to Adyar River an average of 0.4 particles per liter[9] and annually 11.6 trillion micro plastic particles are being let out in the Bay of Bengal. Another river which has shown elevated level is micro plastic is the cooum with an average of 195 particle per cubic meter and sediments to the value of 815 particles per Kg[12]. Research conducted in the Kosasthalaiyar River and its connected water bodies Ennore Creek and Pulicat Lake shows very high concentrations 79 items/liter in water, 121 items/kg in sediment which is followed by Kosasthalaiyar River itself with53 items/liter in water, 76 items/kg in sediment and then Pulicat Lake with31 items/liter in water, 41 items/kg in sediment. [67] The enormous levels of pollutants present in the Ennore Creek suggest downward transport and its close proximity to the coastal region contributes to accumulation raising concerns between freshwater and marine micro plastic.
2) Lakes: When it comes to lakes the Red Hills Lake is a important freshwater reservoir for the supply of drinking water to the city of Chennai research in this lake has revealed micro plastic concentration of 5.9 particle per litre in water samples and 27 particles per kilogram in sediment samples. [4] A very broader study which was conducted covering all the lakes showed that lakes present in the urban regions had higher micro plastic concentrations than the rural lakes; Chembarambakkam Lake tops the chart with highest levels of contamination among all the surveyed lakes. [22] The consistent findings of elevated Micro Plastic levels in urban lakes strongly suggests the improper disposal of plastic waste and runoff of pollutants to the water bodies causing contamination of freshwater sources.
3) Groundwater: The research which was conducted to investigate the groundwater quality in the areas of Kodungaiyur and Perungudi municipal solid waste dumpsites in Chennai has shown significant contamination of the micro plastics. The groundwater sample which was collected within 1 to 2 kms radius has revealed micro plastic particles of 2 to 80 per litre of water. [13] The samples which were collected in the Kodungaiyur landfill resulted in concentration of 22 particles per 150 millilitres. [13] The evidence of micro plastic contamination in ground water near this landfill shows that landfills act as direct pathways for micro plastics. This has an harmful effect on the people who use bore well for drinking water around these areas in Chennai and also acts as an potential transport of these pollutants to other water sources.
4) Coastal Areas: The Coromandel coast present near Chennai along the regions of Bay of Bengal has been observed to be a hotspot for micro plastic pollution with highest concentration seen in Kovalam. [22] The study which was conducted along the coastal regions of Marina beach has found concentrations ranging from 60 to 820 items per cubic meter in the water column, 60 to 1620 items per kilogram in wet sediment and 20 to 1540 items per kilogram in dry surface sediment samples[72] Major investigations around the coastal stretch of marina has revealed Micro plastic ranging from 23 to 155 items per liter in water samples and 37 to 189 items per kilogram in sediment samples. [22] These alarming levels of this pollutant around the river mouths suggest that there is heavy transfer of land based Micro plastic pollutants being transported to the marine ecosystem.
5) Primary Sources: The improper domestic waste water management is one of the major source of Micro Plastic pollution in Chennai's water caused mainly due to the use of single use plastics and their improper disposal which is discharged untreated or poorly treated into the sewage. [2] In the time periods around 2007 most of the solid waste in Chennai and waste water was directly released into the water bodies. Industrial sectors such as cosmetics, tanneries and thermal power plants are also major source of this pollutant as seen in the case of Adyar river were the industrial and domestic wastes were disposed. [9] The textile industry also releases pollutants like the micro fibers which is generated during manufacturing and during the washing of synthetic cloths. Fishing activities and coastal tourism where littering happens serves as additional source of pollution. The combined pollution by the textile, industrial sectors and also from domestic wastes intensifies the challenges to combat this pollutant.

III. HARMFUL EFFECTS OF MICROPLASTICS ON HUMAN HEALTH

1) Toxicity Mechanisms: Micro Plastics causes harm to the body by causing oxidative stress, inflammations, and can facilitate the absorption and transfer of harmful chemicals. [37] The particles in this pollutant which is tiny can act as a transporter for dangerous compounds like the bisphenol A and phthalates [34] which are prominently employed as additive in the manufacture of plastic. The compounds which are leaked into the environment can be absorbed by the human tissues by consumption or inhalation. [38] These particles when ingested by aquatic organisms enter the human food chain indirectly and pose a grave threat to the human health. [7]

2) Induction of Inflammation: Inhalation or ingesting of micro plastic would result in irritation of respiratory and digestive systems. [1] In vitro studies on human cell lines has indicated that bigger micro plastics is the cause for lung cells to inflame which indicates that toxicity mechanism depends on the size. [43] The presence of these pollutants in the human body for a longer time can cause long duration inflammations which can lead to failure of the immune system to eradicate them. This long duration inflammation can also lead to other complications such as neoplasia, development of abnormal tissues and various cancers. [37]
3) Disruption of the Endocrine System: Bisphenol A (BPA) and other phthalates are known chemicals which affect the endocrine system in the humans. [34] They disrupt the regular working of the hormone system in the body which could produce reproductive issues, increase in risk of cancers and abnormalities in development. [1] The study on mammalian biology has indicated that Micro plastics disrupt the hypothalamic-pituitary axis which is the primary reason for regulation of endocrine glands such as thyroid, ovaries and testis. The widespread exposure of these pollutants for the people in Chennai needs robust monitoring mechanism and redressal to this issue arising from these pollutants.
4) Entry Pathways in Chennai: It can be seen that micro plastics has been found in the drinking water sources in Chennai one such example would be the Red hills lake. [4] It is interesting to note that boiling water contaminated with this pollutant would lead to release of adsorption of heavy metals in to the water. [19] The consumers of sea food such as oysters, shellfish are said to be at high risk as these organisms ingest micro plastics. According to various studies done all over the state of Tamil Nadu people who consume fish and shellfish at an average quantity may consume hundreds and thousands of Micro Plastic particles every year. [22] In addition to these sources the particles are also suspended in the street dust of Chennai which has been inhaled by the general public. It can be seen that there are various pathways by which this pollutant enters the human body hence to properly address this issue and prevent further escalation a comprehensive plan to reduce micro plastic contamination across all channels is the need of the hour.

IV. COMPARISON OF MICROPLASTIC REMOVAL TECHNOLOGIES:

A. *Older Technologies*

When it comes to the conventional water treatment plants they are seen to have been following the process of coagulation, flocculation, sedimentation, and filtration using sand and gravel which is then disinfected. [18] In Chennai the sewage treatment plants use technologies such as moving bed bio film reactor (MBBR), Sequencing Batch Reactor (SBR) and membrane based bio reactors. For example the Koyambedu Wastewater treatment plant in Chennai uses Ultra filtration, reverse osmosis and gravity sand filters.[86]These kinds of methods could help in removal of significant portion of Micro plastic having efficiency from 20-90%. These methods also have their drawbacks like the chemicals used in the process which again pollutes the environment, the varying size of the micro plastic etc. The techniques like Coagulation and flocculation help in the removal but require constant addition of chemicals in the system this problems has lead to experts exploring the use of natural coagulants as a better alternative. [100] Despite removal there are large volumes of water with these pollutants being released daily. [52] The plants are not effectively filtering micro plastics. [101]

B. *Newer Technologies*

1) The latest innovative removal technology for Micro Plastic Wasser 3.0 PE-X® uses a filter free "clump & skim" procedure which is primarily based on agglomeration and water-induced chemical fixation.[49] Additions of Non toxic hybrid gels to the water results in the micro plastics to form clumps upon stirring it when results in popcorn like agglomerate which float when skimmed at ease[49]
2) The silica gels may be customized according to various pollutants and compositions of water. [49] Wasser 3.0 PE-X® has been reported to have an efficiency of 95+% removals for a variety of fluids and Micro Plastic accumulations. [49] Initial investigations revealed a reduction of 98.26% (TSS) and 97.92% (particle count) on an average. [75]This method is efficient against all kinds of polymer and prominent Micro pollutants. [49] Compared to existing technologies, Wasser 3.0 PE-X® is projected at 20+% reductions in investment costs and 75% lower expenses in operation which uses 50% less energy and requires no or very less maintenance since it operates without a filter in its mechanism. [49]
3) Membrane filtration technology is also emerging as an efficient one to combat the problem of micro plastic they follow the process of microfiltration, ultrafiltration, nanofiltration and reverse osmosis[15] by which it could remove efficiently and membrane bio reactors is expected to have a filtration rate of 99.9%. The challenges of membrane filtration include damage to the membrane and possible leaks from the filtration process. The efficiency and usage of technologies like advanced oxidation

process[57] is being investigated. Additional adsorption techniques using biochar and activated carbon are producing good results in the filtration process. [15]

4) Though these membrane technologies have higher effectiveness they are very expensive[17], Adsorption techniques also has its disadvantage when it comes to regeneration. [59] The use of Biological methods is also seen as the future in the pollutant cleaning process however its practical use needs to be tested before being implemented in the establishments. Wasser 3.0 PE-X® has emerged in the contemporary times as a technology which is balanced, cost effective and with better efficiency. [49]

Table 1: Microplastic Concentrations in Different Water Sources in Chennai

Water Source	Specific Location	Average Microplastic Concentration	Predominant Type	Key Findings
Rivers	Adyar River	0.4 particles/L	-	Discharges ~11.6 trillion particles annually into the Bay of Bengal [9]
Rivers	Kosasthalaiyar River	0.4 particles/L	-	Higher concentration in Ennore Creek (79 items/L water, 121 items/kg sediment) [9]
Rivers	Cooum River	195 particles/m³ (water), 815 particles/kg (sediment)	Fibers, Fragments	Blue and green colored microplastics most frequently observed [12]
Lakes	Red Hills Lake	5.9 particles/L (water), 27 particles/kg (sediment)	Fibers, Fragments, Films, Pellets	Common polymers: HDPE, LDPE, PP, PS [4]
Lakes	Chembarambakkam Lake	Highest concentration in urban lakes	Fibers	Part of a study across 39 urban and rural lakes in Tamil Nadu [22]
Groundwater	Near Landfills	2-80 particles/L	Nylon, Pellets, Foam, Fragments, Fibers/PVC, Polythene	Near Kodungaiyur and Perungudi dumpsites; up to 22 particles/150 ml near Kodungaiyur [13]
Coastal Areas	Coromandel Coast	Highest abundance	-	Identified as a hotspot, particularly Kovalam [22]
Coastal Areas	Marina Beach	60-820 items/m³ (water), 60-1620 items/kg (wet sediment), 20-1540 items/kg (dry sediment)	Filamentous (79% in wet sediment)	Filaments contained polyesters and fluoro-polymers; also polypropylene and polyethylene [72]

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Table 2: Comparison of Micro plastic Removal Technologies

Technology Type	Mechanism of Action	Reported Removal Efficiency (%)	Advantages	Disadvantages	Potential Applications in Chennai
Conventional Water Treatment	Coagulation, Flocculation, Sedimentation, Filtration	20-95	Widely implemented	Less effective for <20 µm particles	Existing water treatment plants
Wasser 3.0 PE-X®	Clump & Skim (agglomeration -fixation)	95+ (up to 98% in pilot)	High efficiency, all polymer types, lower cost, low energy, low maintenance	Relatively new technology	Water treatment plants, textile industries, plastic manufacturing
Membrane Filtration	Physical sieving	78-100 (Microfiltratio n) Up to 99.9 (MBR)	High efficiency, removes small particles	Potential fouling, higher cost, scalability challenges	Water treatment plants, industrial wastewater treatment
Advanced Oxidation Processes (AOPs)	Generation of reactive species (e.g., hydroxyl radicals)	Varies	Can break down microplastics	May produce byproducts, energy intensive	Industrial wastewater treatment
Adsorption	Binding to material surface (e.g., activated carbon, biochar)	Up to 100 (with biochar)	Can be cost-effective	Regeneration/c logging issues	Industrial wastewater treatment, tertiary treatment
Biological Methods	Natural trapping, degradation by organisms	Varies	Environmental ly friendly	Effectiveness and scalability need further research	Potential for integration in wastewater treatment

V. POTENTIAL INDUSTRIAL APPLICATIONS IN CHENNAI

1) Water Treatment Plants: The water treatment plants which are existing in Chennai could enhance their Micro Plastic removal efficiency by integrating advanced filtration methods like membrane bioreactor or by also adding tertiary filtration with smaller pore sizes.[15] By the implementation of innovative technologies such as Wasser 3.0 PE-X® as an addition to the existing purification systems could significantly reduce the discharge of Micro Plastics arising from these facilities.[49] The current infrastructure must be retrofitted with these advanced technologies as they are crucial for improving the quality of water which is treated and released into the environment.

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2) Textile Industries: One important sector which is known for the microfiber pollution is the textile manufacturing plants, these plants in Chennai could implement advanced filtration systems which can capture microfibers from waste water which is generated during the process of dyeing and finishing.[25]
The traditional method which includes coagulation followed by sand filtration
has shown some effectiveness in filtration process [81], the integration of Wasser 3.0 PE-X® would be the most viable and efficient solution from removing microfibers emitted by the textile industry before their discharge.[49]
The use of Zero Liquid Discharge (ZLD) technologies offer 100% water recovery and removes Micro Plastic as solid waste however this is a costly mechanism. [80]

3) Plastic Manufacturing Units: The Plastic manufacturing plants in Chennai can opt for advanced filtration mechanisms along with membrane filtration and electro coagulation for the removal of plastic pellets, fragments and powdered particles from the wastewater streams.[1] The implementation of Wasser 3.0 PE-X® could be a better option and cost effective method to achieve Micro plastic free production by removing plastic compounds from the water.[49]

4) The closed-loop manufacturing systems can also be adopted which can be useful to capture and reuse plastic particle which can reduce wastewater contamination.[17]

5) Other Industries: The cosmetic industry which emit Micro plastic as waste must be encouraged to use biodegradable alternatives[2] Further there must be proper waste management across all the industrial establishments for the prevention release of microplastics.[5] These establishments must adopt a comprehensive strategy to identify and address the sources of Micro Plastic across Chennai which when effectively implemented would be beneficial to both these industries and also the environment.

VI. CONCLUSION AND RECOMMENDATIONS

It can be concluded that the water bodies in Chennai are significantly contaminated with Micro Plastics from various sources which are potential risk to both the human health and environment. While there are conventional water treatment methods which offer removal to an extent their limitations particularly with regard to smaller particles urgently requires adoption of newer and more efficient technologies. Innovations like the Wasser 3.0 PE-X®, membrane filtration, advanced oxidation processes, and adsorption techniques can be seen as an efficient alternative with higher removal efficiency. Considering the problems this pollutant would cause in future it is recommended that Chennai adopts these emerging newer technologies at the earliest. The policy changes must be aimed at strictly controlling the plastic production and disposal including stricter enforcement of single use plastic bans. The industries must be frequently inspected for any violations and checked for their adherence to best practises in relation to the implementation of removal technologies in their waste water treatment plants. Awareness programmes must be conducted among the general public educating them about the dangers of Micro Plastics and ways by which they can avoid them as it is also vital to promote efficient waste management and reduce plastic consumption. Finally collaboration among industrial plant owners, general public and law makers is needed to effectively mitigate the menace of Micro Plastic pollution in Chennai for a sustainable future.

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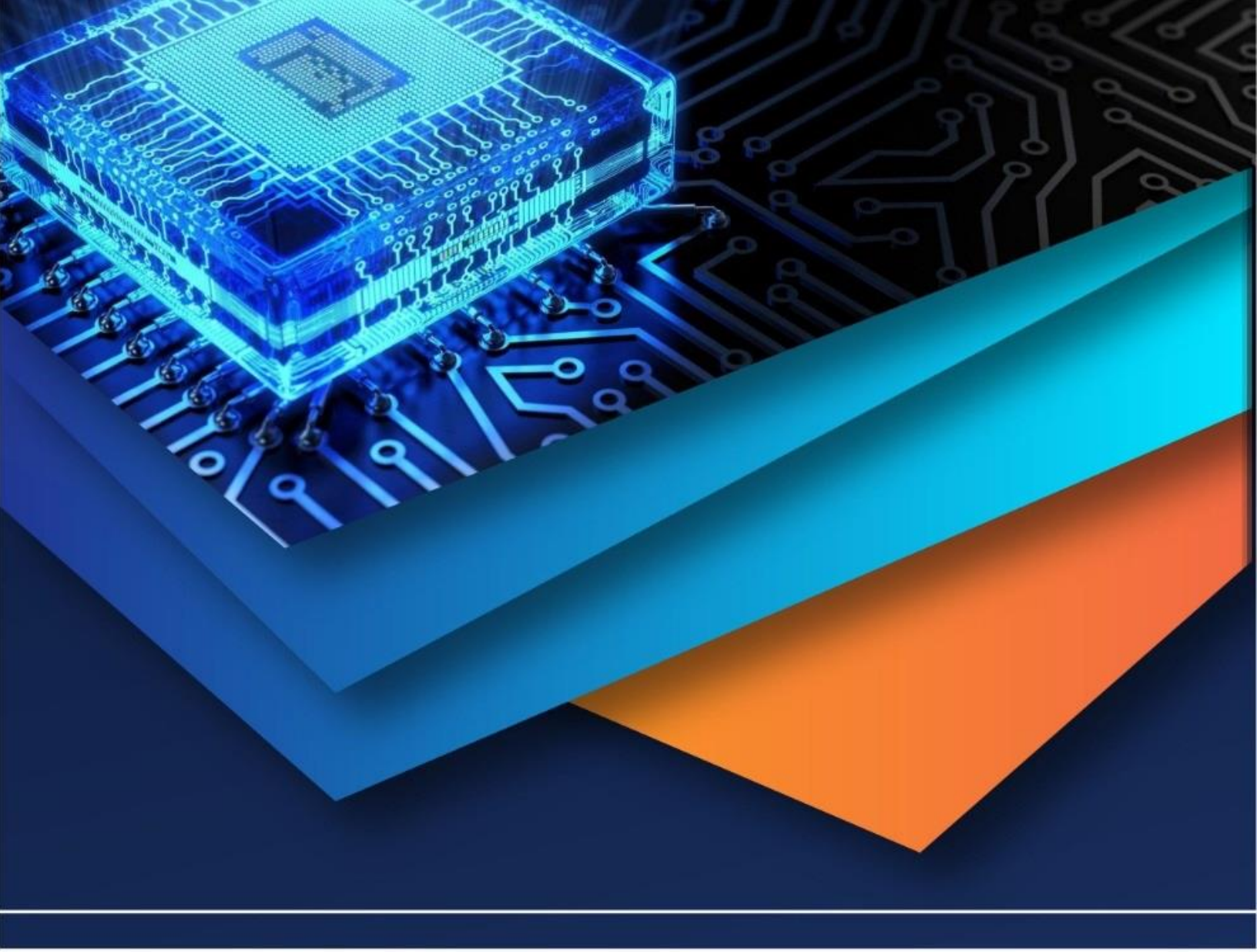

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