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Performance and Evaluation of Sewage Treatment Plant Based on MBBR and EBB Technologies

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Abstract: The rapid expansion of modern housing and industrialization around the cities has polluted environment. This trend was observed in many developed countries in the beginning of nineteenth century which resulted in the contamination of air, water, soil etc. with pollutants. If the pollutants are released in the environment and left untreated they would cause serious diseases in both humans and animals. Large scale pollution of water bodies around the globe became a major problem due to release of industrial and domestic waste directly in water streams. To prevent the leaching of pollutants in the ground water scientist developed various methods of wastewater treatment based on the hazardous chemicals and microorganisms, which were present in the untreated water. Modern sewage treatment plants were installed in big cities to treat the water released from households. Most STPs were designed based on the stringent criteria to check the pollutants levels in the treated water so that when it is released or recycled it is safe to the environment. Modern day STP plants have a high cost of operation due to huge power consumption. In order to reduce the pollutant levels in the wastewater this study was conducted using a Eco Bio Block (EBB) techniques with aeration and without aeration. A comparison of EBB was also carried out with MBBR technique. Our results show that when EBB technique was applied with aeration it is effective in reducing pollutant levels in the wastewater akin to MBBR. In addition, we tested the EBB without aeration and found that the treated waste water has relatively low levels of BOD, COD and turbidity, suggesting that the treated water can be utilized for landscaping and horticulture activities. Overall, the outcomes from this study are encouraging to adopt EBB in smaller towns and in small housing societies to treat the wastewater prior to release.
Keywords: Sewage treatment plant, Eco Bio Block, Moving Bed Biofilm Reactor, Wastewater, Aeration

I. INTRODUCTION

Recycling and treatment of waste water has become an important task for municipal corporations around the globe. Industrialization of cities has augmented the pollution of water bodies; as a result demand for large scale wastewater treatment plant has increased. In the past decades, the key challenge is to prevent the contamination of water by biological and chemical agents[1].Wastewater discharged from the households and other public utilities is polluted with hazardous substances, and it has a negative impact on human health and the environment [1]–[4]. Before discharging, waste water must go through a treatment plant to remove its contaminants. We can reduce the environmental pollution and its impact on the human health by treating wastewater using modern day large scale treatment plants, which are equipped with latest technologies [56]. The treatment plants processing the urban effluents and wastewater must meet the required quality standards set by the appropriate authority prior to the release of such water back to the environment [7]. Modern day waste treatment plants carry out primary treatment of waste water to remove organic content. The secondary treatment uses biological approaches to metabolize the organic matter present in the waste by bacteria [8]. Tertiary treatment is applied to eliminate pathogens. Most STPs use aerobic digestion for the elimination of organic matter. The popularly used aerobic processes are the activated sludge, oxidation ditch, trickling filter, and aerated lagoons. In recent years, high operational cost of electricity in aerobic plants led to a shift in anaerobic treatment using alternate approaches [9]–[11]. The goal of the primary, secondary and tertiary treatment in the STP is to eliminate or remove organic matter, solids, contaminants, disease-causing microorganisms and other toxins from the treated wastewater. The purpose of this study is to assess the performance of sewage treatment plants (STP) in the IISER Mohali campus using two new technologies e.g., EBB and MBBR [12]–[16].

Pipraiya A. et al., in [17] discussed that Sewage Treatment Plants (STPs) are effective units to reduce wastewater loads from environments. The moving bed bio film reactor (MBBR) concept was invented in Norway during the 1980s, in response to an agreement signed by eight European nations to reduce nitrogen loadings to the North Sea.

In the MBBR plant plastic based carriers are used to provide a surface for bacterial growth. Minhs M and Bakshi S in [18] did comparisons of three main technologies such as Moving Bed Biological Reactor (MBBR), Sequencing Batch Reactor (SBR), and Soil Bio Technology (SBT). The idea behind this study was to suggest ways to implement wastewater treatment keeping in view the parameters like, space, cost for setting up a plant, operation and maintenance cost, power requirement and quality of sludge produced at the given place. In Indian scenario problem of pollution is wide spread. In recent years we have become aware about it because of the enhanced education in masses and wide spread pollution of water bodies all over the country. Ministry of Environment & Forests (MoEF) mandated legislation was passed in 1986. This led to the initiation of concerted efforts from different stake holders to install water treatment plants for both industry and municipal waste. The methods used to treat waste water involved huge consumption of energy which in turn produces more pollutants in the environment.

The need of the hour is to devise technologies, which produces no or little waste but at the same time are able to mitigate the impact of wastewater on the environment. Eco Bio Block (EBB) Technology is a Japanese invention and has been recommended by Japan International Cooperation Agency (JICA) to the government of India and has been approved by Central Pollution Control Board (CPCB) and Ministry of Environment & Forests (MoEF) for used as a media in Sewerage and Sewage treatment plants. This technique is also being used in many cities of the world and it has showed great promising results especially in sewage treatment. Eco Bio Block can be used to clean the water in open drains, ponds, lakes, sewage treatment plants and in effluent treatment systems.

II. METHODOLOGY

For performance evaluation of the sewage treatment plant, samples collected at various stages i.e., at inlet level raw sewage from preliminary stage and outlet level in the secondary treated water tank-outlet. The sampling technique that followed is called grab sampling. Samples were collected in April and June 2022.For testing the quality of untreated and treated wastewater samples, standard procedures were followed as per the recommendation of APHA. For each parameter three-four samples were taken into account for testing. Wastewater is consists of both liquid and solid organic matter (containing <1% solids in it), it is generally discharged by domestic residences, commercial units, industrial plants, agriculture, and allied sectors of economy. To understand the role of pollutant and impact of treatment on water, respectively, quality parameters were measured before and after wastewater treatment. The parameters that we analysed in this study are as follows: Turbidity, pH, Biological oxygen demand, and Chemical oxygen demand.

A. pH

pH was measured using the pH meter. pH refers to molar concentration of H^+ ions in a solution. It generally varies from 0 to 14. The pH of wastewater sample was measured using pH paper strips and a pH meter. The probe of the pH meter was cleaned with distilled water and wiped with a tissue paper. Later the electrode was immersed in the sample until the reading got stabilized.

B. Biological Oxygen Demand

Biological Oxygen Demand(BOD) is the dissolved oxygen amount, which is used by the heterotrophic microbes. We used OxiToP method for BOD estimation. This method works on the principle that a decrease in the oxygen levels in a reactor causes a definitive pressure difference that can be measured with a pressure sensor and translated into mg/L of BOD. We took the 250ml sample bottles fitted with the instrument and added two drops of nitrification inhibitor. Two pellets of NaOH was added prior to putting the cap back on the OxiTop instrument and it was set to zero.

C. Chemical Oxygen Demand

Analysis of organic matter in a wastewater sample is important to check the quality of water. The Chemical Oxygen demand (COD) is the amount of oxygen consumed during the oxidation of all organic matter by a chemical agent in a strong acid medium. The COD analysis is an easy, quick and inexpensive method to determine the amount of total organics in a wastewater/water sample. It is based on the amount of oxygen consumed by the oxidation of total organic matter using the Closed Reflux Colorimetric Method (5220 D in APHA). To measure the COD, sonicate the sample, add 3.5 ml H_2SO_4 and 1.5 ml digestion solution. Transfer the 2.5 ml solution into a glass ampule. Ampules were put into COD digester for 2 hours at 150^{o}C. OD was checked at 600nm to determine the COD. COD concentration was determined after drawing the calibration curve.

D. Turbidity

Turbidity is the measurement of clarity or cloudiness of water sample. Suspended solids and dissolved coloured material lead to an increase in turbidity. It was measured by a turbidity meter.

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III. RESULTS AND DISCUSSION

To evaluate the performance of EBB treatment using aeration, values of pH, BOD, turbidity and COD were measured. A comparison of untreated sample with that of treated one revealed following results. The pH of the sampled water prior to the treatment was 7.3 whereas after treatment the pH was 7.5(Figure 1 and Table 1). The BOD of the sampled water before the treatment was 230 mg/l but when checked after treatment BOD was reduced to 23 mg/L. We measured the 358 mg/L COD in inlet whereas after treatment it was reduced to 46.7mg/L. A similar trend was observed in turbidity as well. EBB STP fitted with aeration was able to reduce BOD 90%,COD 87% and turbidity 97% (Figure 1; Table 1). Thus, EBB coupled with aeration is very effective in bringing down pollutants in the treated water and this also meets the effluent discharge standard.

TABLE I
PHYSICAL AND CHEMICAL ANALYSIS OF STP EQUIPPED WITH EBB (75 KLD WITH AERATION SYSTEM)

Date of Sampling	1. pH		2. BOD(mg/I)		3. COD(mg/l)		4. Turbidity (NTU)	
	IN	OUT	IN	OUT	IN	OUT	IN	OUT
April 2022	7.3	7.4	260	25	363	44	235	6
April 2022	7.2	7.5	230	23	360	51	175	5.9
June 2022	7.3	7.5	255	25	351	45	240	8
Maximum	7.3	7.5	260	25	363	51	240	8
Minimum	7.2	7.4	230	23	351	44	175	5.9
Average	7.3	7.5	248.3	24.3	358.0	46.7	216.7	6.6
% Removal			90		87		97	

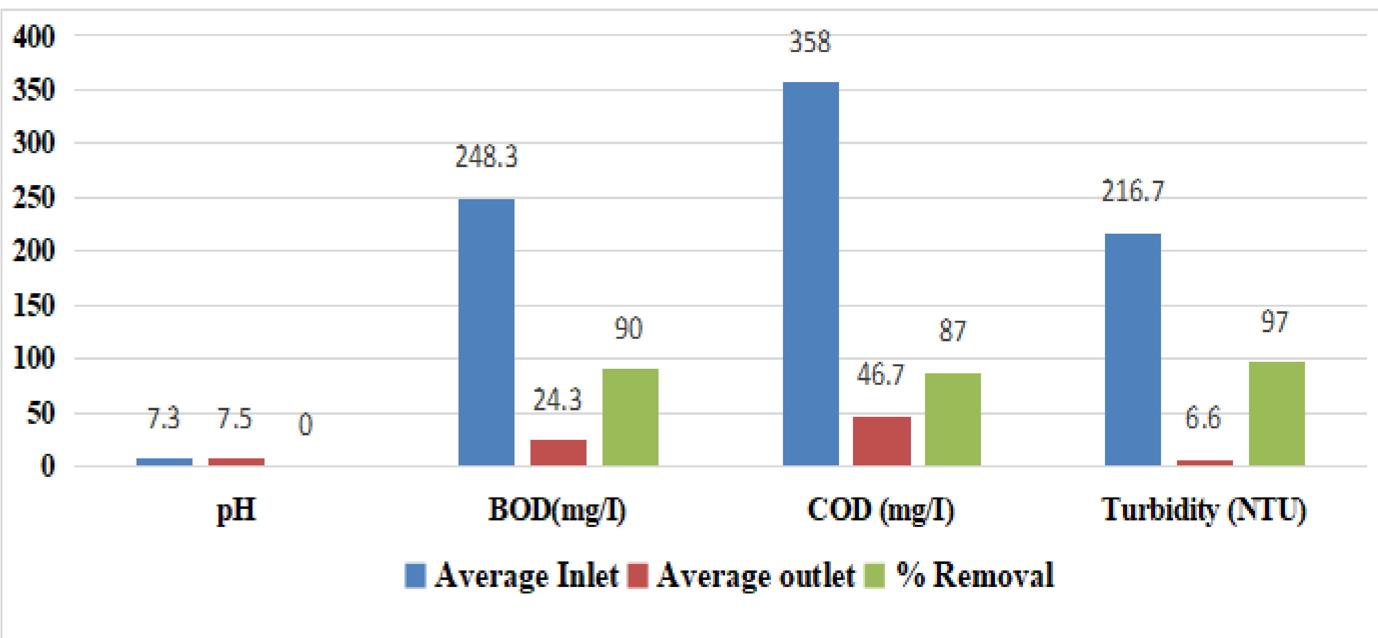

Figure 1. A comparison of pH, BOD, COD and turbidity in a 75 KLD STP with aeration

The pH in MBBR STP with aeration varies from 7.2 to 7.3 in the inlet prior to treatment whereas after treatment it was found in the range of 7.4 to 7.5 (Figure 2; Table 2). The average BOD was measured to 248.3 mg/l in the inlet but after treatment it was reduced to 27.7mg/l. Similarly, COD was measured to 358 mg/l in the inlet while after treatment it was found 51.3 mg/l. Average turbidity was 216.7 NTU in the inlet which was reduced to 9.5 NTU after treatment. A significant reduction in pH, BOD, COD and turbidity was noticed in MBBR aeration system.

TABLE III

Physical and Chemical analysis of STP equipped with MBBR (80KLDwith aeration system).

Date of Sampling	1. pH		2. BOD(mg/I)		3. COD(mg/I)		4. Turbidity (NTU)	
	IN	OUT	IN	OUT	IN	OUT	IN	OUT
April 2022	7.3	7.5	260	28	363	49	235	9
April 2022	7.2	7.4	230	29	360	58	175	9.5
June 2022	7.3	7.4	255	26	351	47	240	10
Maximum	7.3	7.5	260	29	363	58	240	10
Minimum	7.2	7.4	230	26	351	47	175	9
Average	7.3	7.4	248.3	27.7	358.0	51.3	216.7	9.5
% Removal			89		86		96	

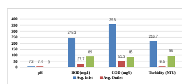

Figure 2. Comparison of pH, BOD, COD and turbidity in a 80 KLD EBB plant fitted with aeration system.

EBB STP operated without aeration showed a significantly reduced efficacy in removing BOD (inlet 285 mg/l, outlet 116.7 mg/l), COD (inlet 397 mg/l, outlet 139 mg/l) and turbidity (inlet 249.3 mg/l, outlet 44.3 mg/l).Although pH did not vary significantly, however, a 59% reduction in BOD, 65% in COD and 82% in turbidity was observed (Figure 3, Table 3). The water discharged from this plant can be used for the purpose of landscaping and gardening

TABLE IIIII

PHYSICAL AND CHEMICAL ANALYSIS OF STP WITH EBB (75 KLD WITHOUT AERATION SYSTEM).

Date of Sampling	1. pH		2. BOD (mg/I)		3. COD (mg/I)		4. Turbidity (NTU)	
	IN	OUT	IN	OUT	IN	OUT	IN	OUT
April 2022	7.3	7.4	280	110	384	135	251	27
April 2022	7.4	7.4	300	130	443	157	260	65
June 2022	7.2	7.4	275	110	364	125	237	41
Maximum	7.4	7.4	300	130	443	157	260	65
Minimum	7.2	7.4	275	110	364	125	237	27
Average	7.3	7.4	285.0	116.7	397.0	139.0	249.3	44.3
% Removal			59		65		82	

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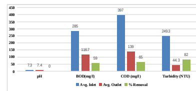

Figure 3. A comparison of pH, BOD, COD and turbidity in EBB without aeration.

When percentage removal was subjected to a comparison for EBB and MBBR techniques. It was noticed that both methods are suitable and meet the permissible value as per NGT guidelines (Figure 4, Table 4). Based on results obtained it is concluded that EBB and MBBR (with aeration) are quite effective in reducing the BOD, COD and turbidity of outlet water. Both techniques are effective in treating wastewater (Figure 4, Table 4). It is obvious from the data that we can use the EBB treated water for irrigation, flushing and landscaping purposes similar to MBBR. The use of EBB makes plants very compact but at the same time show good efficiency. The results show that EBB and MBBR technique are useful for resident societies, moderate size institutions and small towns looking for their own solutions of waste water treatment. EBB blocks can be reused and recycled easily. In contrast, in MBBR, plastic media form the treatment unit, and it would cause pollution from the plastic beads. The simple design of EBB blocks allow easy wash and reuse whereas MBBR does not offer this advantage.EBB blocks can easily be fixed by good quality thick rope or stainless wire in the bioreactors. However, MBBR does not allow such fixing arrangement directly in the bioreactor.

TABLE IVV

A COMPARISON OF PHYSICAL AND CHEMICAL PARAMETERS IN EBB & MBBR (WITH AERATION SYSTEM)

S. No.	Date	EBB ((75 KLD outlet with aeration system)								MBBR (80 KLD outlet with aeration system)							
		pH		BOD(mg/I)		COD(mg/I)		Turbidity (NTU)		pH		BOD(mg/I)		COD(mg/I)		Turbidity (NTU)	
		IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT
1	April 2022	7.3	7.4	260	25	363	44	235	6	7.3	7.5	260	28	363	49	235	9
2	April 2022	7.2	7.5	230	23	360	51	175	5.9	7.2	7.4	230	29	360	58	175	9.5
3	June 2022	7.3	7.5	255	25	351	45	240	8	7.3	7.4	255	26	351	47	240	10
Maximum		7.3	7.5	260	25	363	51	240	8	7.3	7.45	260	29	363	58	240	9.5
Minimum		7.2	7.4	230	23	351	44	175	5.9	7.2	7.4	230	26	351	47	175	9
Average		7.3	7.5	248.3	24.3	358	46.7	216.7	6.6	7.3	7.4	248.3	27.7	358	51.3	216.7	9.5
% Removal				90		87		97				89		86		96	

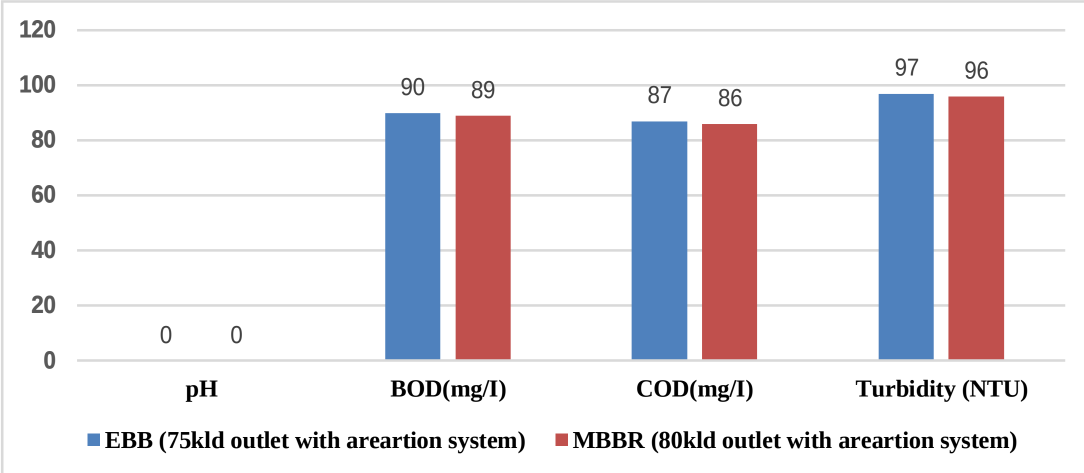

Figure 4. A comparison of MBBR and EBB with aeration system

Modular size EBB blocks are available in different sizes and in various shapes in the market i.e., 100*100*60mm, 90mm*90mm*80m, 390 mm*190mm*90 mm, 390mm*290mm*60mm etc. Therefore, one can choose them depending upon the requirement in the water body where they would be placed, such as, lake, pond, and river. The same does not applies to MBBR, and despite its efficacy it does not offer same level of flexibility as observed in EBB.

This is possible because in EBB environment friendly microorganism embedded in the porous volcanic concrete block to wastewater while MBBR relies on plastic media. The modular design of EBB system can be easily shifted to other places. It can easily be fitted with plumbing work, electrical work etc. on the R.C.C platform as per requirement like MBBR.

Although in practice skilled person is required to keep the daily record of meter reading to register electricity consumption in units. Reading parameters of water before and after treatment and routine check-up similar to MBBR plant is required in EBB. In EBB sludge recycling is low, and hardly there is a requirement to do the same.EBB STP operated without aeration suggests that percentage removal of BOD, COD and turbidity does not meet NGT guidelines.

IV. CONCLUSIONS

EBB blocks with different porous sizes and microbes are more effective in waste water management. To explore the cost effectiveness and efficiency for different classes of polluted water further research is required. Since there is huge requirement of waste treatments in developing countries like India. To reduce the cost and improve effectiveness of treatment further research is required.

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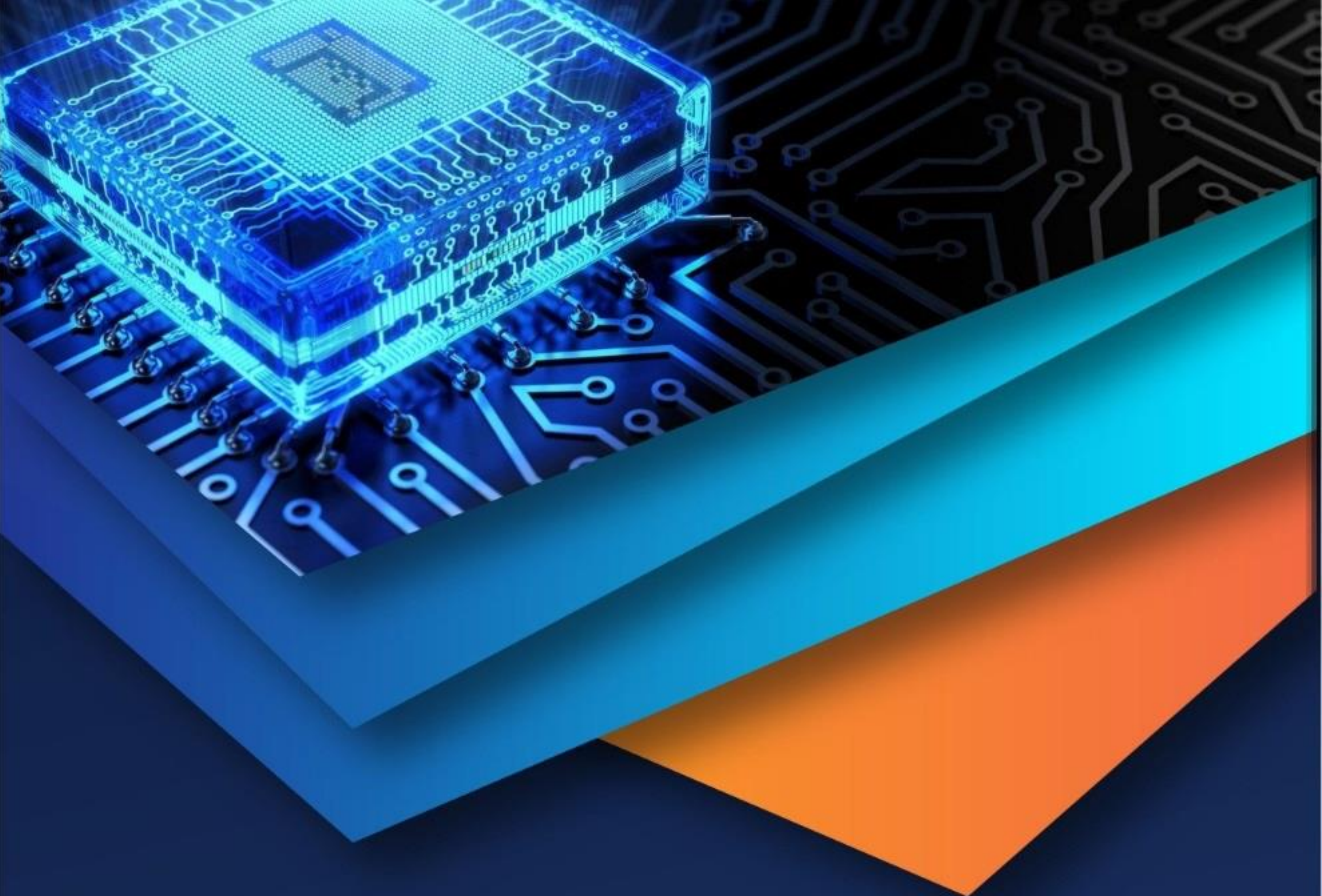

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