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An Assessment of Groundwater Quality in Coastal Taluks of Tiruvallur Districts in Tamil Nadu, India

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Abstract: ***Increase in population and landuse changes near the coastal region have affected the coastal environment. Industrialization thrived and population boomed, and groundwater was deemed to be a very important resource for their subsequent functioning. The consequent over extracting of groundwater has totally compromised the quality of ground water. Sea water intrusion has also grown to be a major issue in the Coastal Taluks of Tiruvallur district which has in turn, affected the Agricultural Cultivation and livelihood of many farmers and residents. A total of 37 groundwater samples were collected and the water quality assessment had been carried out by evaluating the physicochemical parameters, in order to analyze the degree of damage done to the quality of groundwater . The ionic dominance for the major cations and the anions were in the order of EC, pH, TDS, Na+ > Ca^{2}+ > Mg^{2}+ > K and Cl^{-} > $HCO3^{-}$ > $SO4^{2-}$ > Fl^{-} > CO3, respectively. Most of the samples analyzed were above the standard guidelines set by BIS and WHO. Geographical Information System (GIS) was used to analysis the spatial variation of chemical content in the ground water. The quality of the water was evaluated using Piper Diagram and also by correlation method. The results revealed that most of the samples are not suitable for irrigation. Based on these parameters, groundwater had been assessed and was not suitable for drinking and irrigation purpose.***

Keywords: Groundwater Quality, GIS, Anions, Cations, Correlation and Piper Diagram.

I. INTRODUCTION

In India, extraction of groundwater has started to increase with the advent of industrialization and population expansions. Hence, the quality of groundwater is deteriorating due over extraction. Groundwater, being the major freshwater resource after glaciers and polar ice in the world, plays an important role in socio-economic life of the people in Tamil Nadu for domestic and agricultural activities. The suitability of groundwater for different purposes depends upon its intrinsic quality which is influenced by inputs from the atmosphere, soil and rock weathering, as well as from anthropogenic activities. Due to lack of proper awareness, public ignorance of environmental issues, indiscriminate disposal of increasing anthropogenic wastes, unplanned application of agrochemicals, and discharges of improperly treated sewage have resulted in the deterioration of surface and subsurface water (Singh and Hasnain 1998; Mitra et al. 2007;Kumar et al. 2008; Ishaku 2011; Ewusi et al. 2013; Kalpana and Elango 2013). One has almost forgotten that, The value of groundwater lies not only in its widespread occurrence and availability but also in its consistent good quality (Rajmohan et al. 2000; UNESCO 2000).

Parameters	Max	Min	Mean	WHO Guideline value (2004)	BIS 2012
Electrical Conductivity (µS/cm)	8370	400	2584.32	1500	-
Ph	7.3	5.8	6.8	6.5 - 8.5	6.5 - 8.5
TDS (mg/l)	4191	212	1417.54	1500	500 - 2000
Calcium (mg/l)	384	34	129.02	200	75 - 200
Magnesium (mg/l)	316	19	63.27	150	30 - 100
Sodium (mg/l)	1051	12	314.45	200	200 - 400
Potassium (mg/l)	227	0	20.05	12	-
Carbonate (mg/l)	0	0	0	-	-
Bicarbonate (mg/l)	702	61	366.4	500	-

Chloride (mg/l)	2233	46	509.86	600	250 - 1000
Sulphate (mg/l)	702	14	193.43	250	200 - 400
Fluoride (mg/l)	1.7	0	0.36	1.5	1.0 - 1.5

Table: 1 Comparison of analytical results with International (WHO) and National standards (BIS)

The high population density along the banks of major rivers and coastal areas is attributed to the easy availability of water. The search for ground water has also began along the alluvial tracts of rivers and coastal areas. The semi consolidated and unconsolidated sediments along the coastline helped mankind to go in for deeper groundwater exploration during the first half of the last century. As the exploration advanced towards deeper horizons, problems like salinity hazard, salt water intrusion, land subsidence and so on, brought about complications to the situation. The abnormal increase in population and the modern livelihood demand more water, which has pressurized the coastal aquifers.

A. Study Area

Tiruvallur district is an administrative district in Tamil Nadu. The district has a mixture of urban and rural characteristics. The Eastern and Southern part of Tiruvallur district is dominated by urban characteristics. The Northern part of the district is strongly influenced by the Andhra culture due to its position. Tiruvallur District has total of 13 taluks of which only two taluks of coastal region has been selected for the research. Ponneri taluk is a taluk of Tiruvallur district of the Indian state of Tamil Nadu. According to the 2011 census, the taluk of Ponneri had a population of 385,620 with 193,043 males and 192,577 females. Tiruvottiyur Taluk, is located at 13.16°N 80.3°E. It is an esplanade located on the shores of Bay of Bengal.

B. Material & Methods

Water samples were collected from bore wells as well as wells that were dug and Handpumps, using clear acid-washed polyethylene bottles. Thirty seven groundwater samples were collected for analyzing the chemical parameters. GIS interpretation techniques were used to show the spatial variation of ground water. Piper Diagram and Correlation techniques were also used to show the quality of ground water.

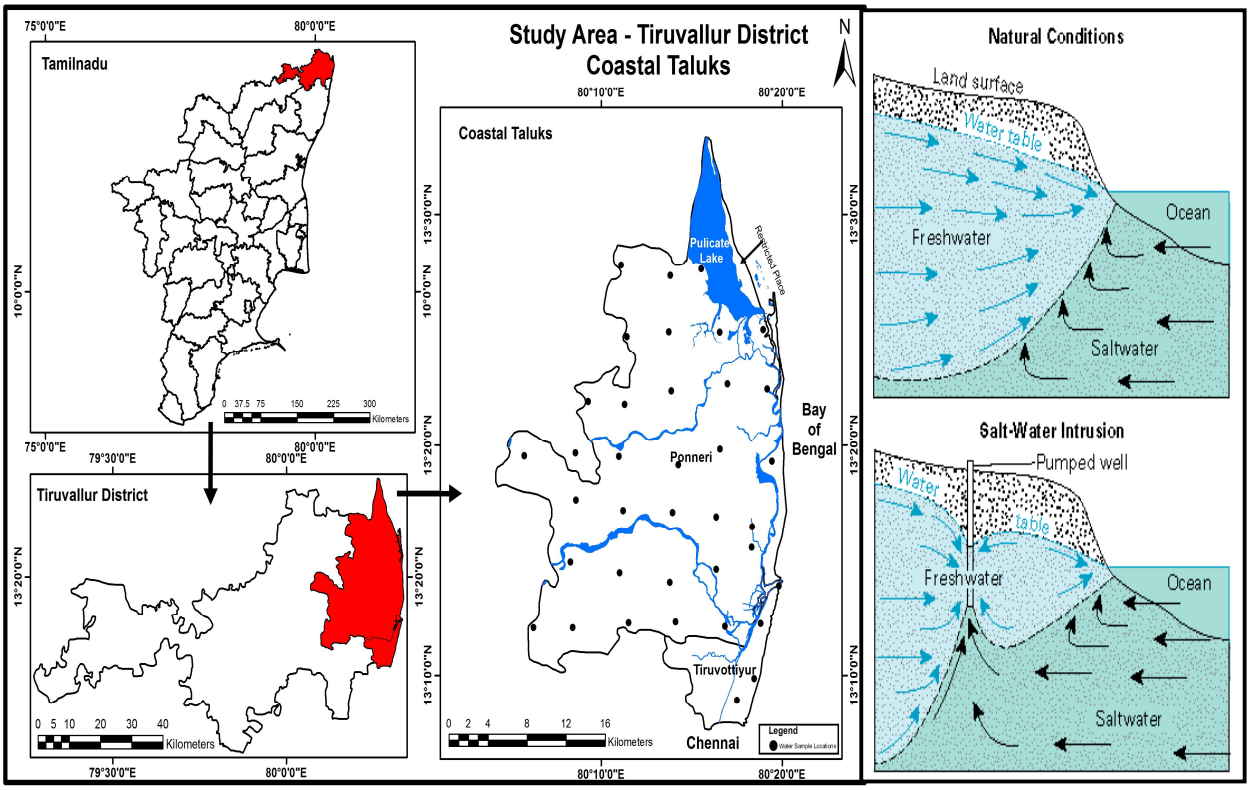

Figure: 1 Study Area

Figure: 2 Extraction of fresh water near Coastal Area (USGS)

Image: 1 (Samples Collection in field)

II. RESULT AND DISCUSSION

Selected physicochemical parameters of groundwater samples were analyzed and the descriptive statistics of the analyzed parameters are presented in Table 1. The results are compared with the World Health Organization recommended maximum permissible limits and BIS standards.

The electrical conductivity in the groundwater ranged from 400 to 2370 µS/cm and the mean value is 2584.32 µS/cm. Higher **EC** values are observed in the southern and eastern parts of the coastal region, due to the emergence of the Ennore port and Cement factories near the sample area. Figure 3 shows the spatial distribution of EC values, which keeps increasing as one keeps moving from east to west. It is indicating the flow direction and can be considered as a premonition of the sea water Intrusion. The large variations in EC are mainly attributed to anthropogenic activities and also to the geochemical processes that occur in this region. EC generally increases along a groundwater flow path because of the combined effects of evaporation, ion exchange, and topographic conditions (Toth 1999). The data in Table 1 show that pH in groundwater ranges from 5.8 to 7.3 and the average value is 6.8. The lowest pH (5.8) is found in the south western part and the highest value (7.3) is found in the sample station 20, which falls within the permissible limit. Spatial distribution of pH is shown in Fig. 2. The permissible range of pH for drinking and agricultural purposes is 6.5–8.5 (BIS 2012). Majority of the samples fall within the permissible limit. The spatial distribution (Fig. 3) of TDS also shows similar variation like EC, and the values range from 212 to 4191 mg/l and mean is 1417.54 mg/l. The TDS concentration basically depends on the different ions present in water. The calcium and magnesium ions in waters are generally used to classify the suitability of water.

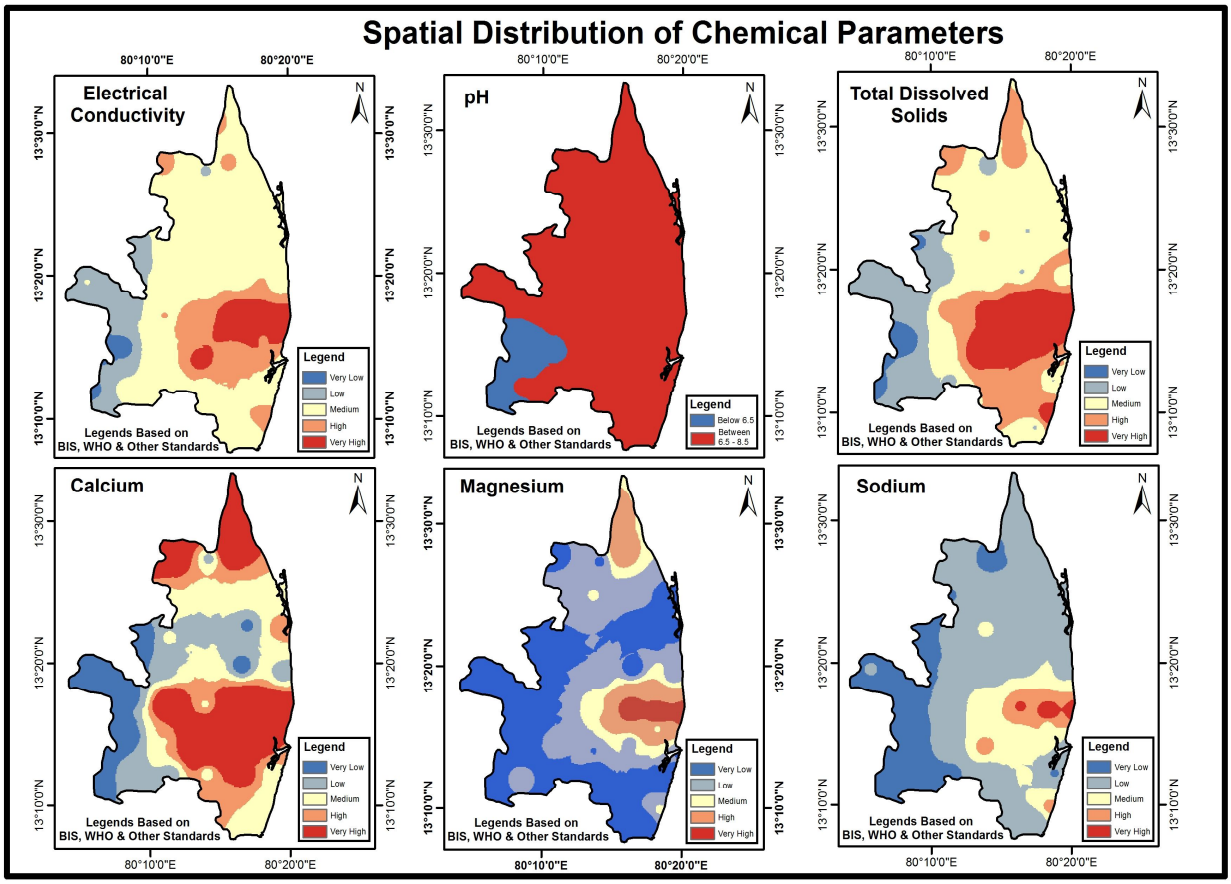

Figure: 3 Spatial Variation of Chemical Parameters in Ponneri & Tiruvottiyur Taluks

A. Cations

Calcium in the study area varies from 34 to 384 mg/l. High level of Ca is found in central and Southern parts of the study area and the lowest level of Ca is in the western parts. Magnesium varies from 19 to 316 mg/l, the region around Ennore port has the highest Mg level and remaining regions have extremely low levels of magnesium. Higher concentration of Sodium (Na), is observed near port area and near Minjur town. Potassium (K), ranges from 0mg/l to 227 mg/l.

B. Anions

Concentration of Carbonate is "0" in the study area. The higher concentration of HCO3 (Bi Carbonate) ranges from 61 to 702 mg/l. The chloride (Fig 4) ion is the most predominant natural form of the element chlorine and is extremely stable in water. The chloride in groundwater may come from diverse sources such as weathering, leaching of sedimentary rocks and soil, domestic and municipal effluents (Sarath Prasanth et al. 2012). Chloride varies from 46 to 2233 mg/l. ICMR and BIS have the prescribed 250 mg/l as the maximum permissible value. If the chloride value exceeds 300 mg/l and the major cation is sodium, then the water becomes salty (Ravi sankar and Poongothai 2008). Nearly 27% of Cl is found within the Acceptable Limit, 62% falls in the permissible limit and 10 % of the sample falls above the relaxation limit.

The data in Table 1 show that Sulphate (SO4) of the groundwater ranges from 14 to 702 and the average value is 193.43 mg/l, the distribution of sulfate in aquifers varies throughout the study area. Since it is soluble (easily dissolved) in water, sulfate is found at highly concentrated levels in many aquifers and in surface water (MPCA 1999). Sulphate, Nearly 70% of the sample is within the acceptable limit, 16 % of the samples are within the permissible limit and 14% of the sample falls above the relaxation limit, which are found in the southern parts and in the proximity of the port area. The content of fluoride is within the permissible limit and ranges from 0 to 1.7 mg/l, except for one sample ,which is above the permissible limit and is found in the southern part of the study area. As per the standard level of water quality, majority of the samples fall out of the permissible zone. The spatial distribution of all the anions and cations is shown in the Figs. 3 & 4. The spatial distribution of major ions of groundwater samples clearly shows the flow of ground water from South East to West and North Western directions, which leads to sea water intrusion. In the south of

study area, the Chennai Corporation has initiated a plan for city expansion which will eventually hamper the Tiruvottiyur region. As per this study, nearly 51% of the ground water is found to be highly hazardous and not fit for drinking.

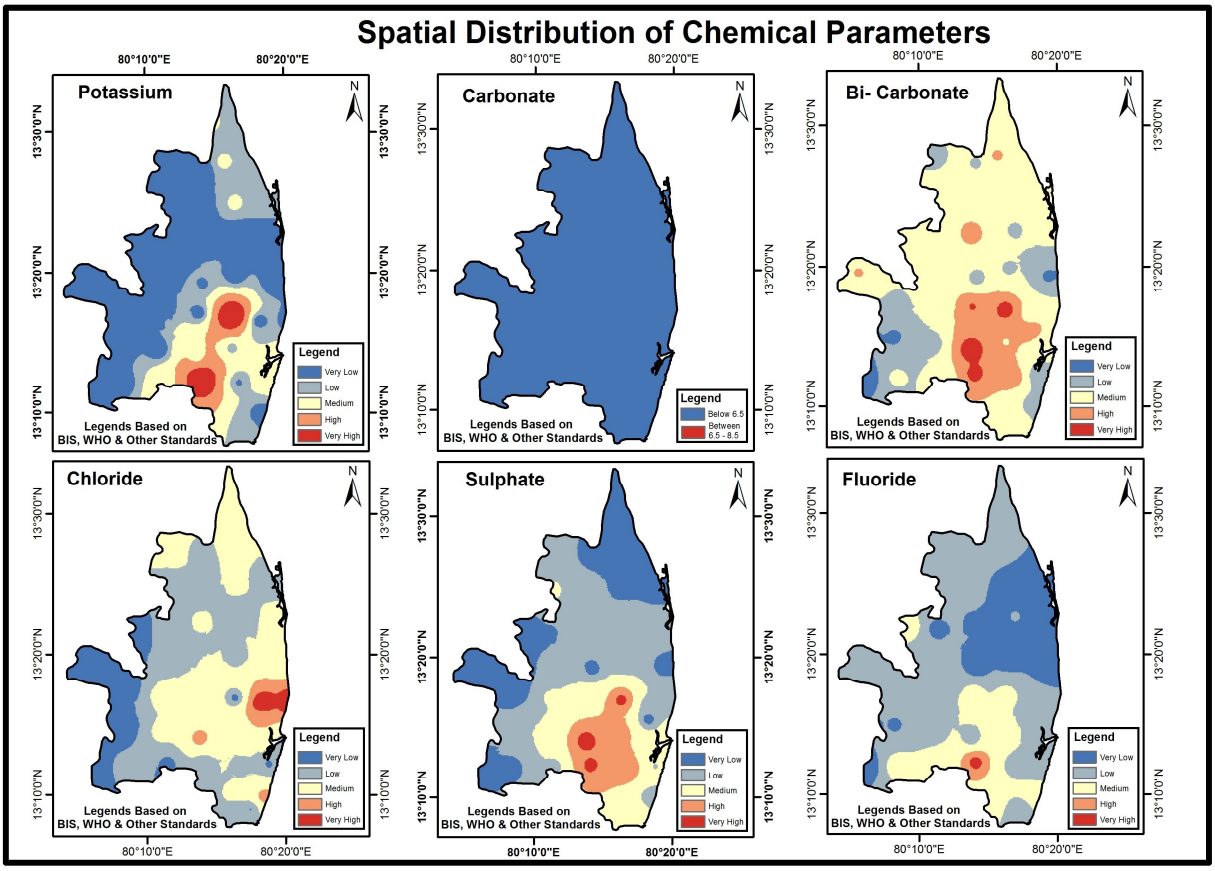

Figure: 4 Spatial Variation of Chemical Parameters in Ponneri & Tiruvottiyur Taluks

C. Hydro chemical facies

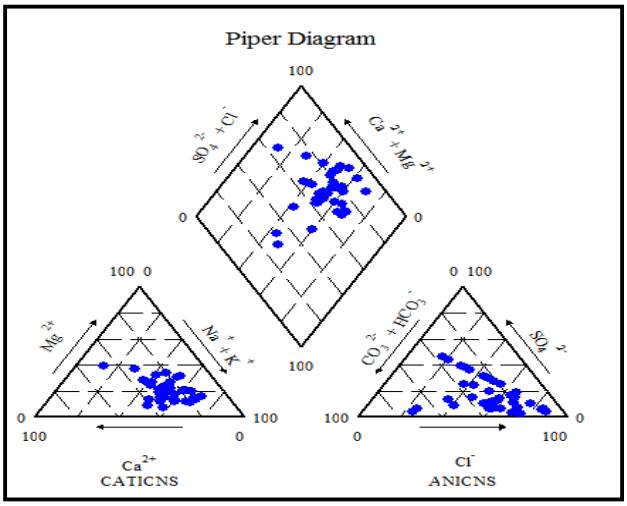

Table: 5 Piper Diagram

The geochemical evolution of groundwater can be easily understood by plotting the concentrations of major cations and anions in the Piper trilinear diagram (Piper, 1953). The cations and anion fields are combined to show a single point in a diamond-shaped field, from which inference is drawn on the basis of hydrogeochemical facies. The results are plotted on a Piper's diagram (Fig. 5).

The piper plots shows that most of the water falls into the field of NaCl (sea water), few stations falls into mixed CaMg. This plot shows that alkalis (Na and K) exceed the alkaline earth (Ca and Mg) and Cl exceeds other anions.

D. Statistical analysis

	EC	pH	TDS	CA	MG	NA	K	CO3	HCO3	CL	SO4	Fl
EC	1											
Ph	0.34	1										
TDS	0.96	0.3	1									
CA	0.76	0.3	0.8	1								
MG	0.85	0.34	0.73	0.48	1							
NA	0.95	0.28	0.96	0.67	0.75	1						
K	0.41	0.23	0.28	0.28	0.39	0.28	1					
CO3	0	0	0	0	0	0	0	1				
HCO3	0.54	0.5	0.53	0.52	0.35	0.5	0.53	0	1			
CL	0.75	0.17	0.85	0.62	0.56	0.79	-0.12	0	0.19	1		
SO4	0.48	0.9	0.48	0.56	0.2	0.44	0.66	0	0.66	0.07	1	
Fl	0.14	0.16	0.13	0.66	0.1	0.1	0.59	0	0.46	-0.08	0.49	1

Table: 2 Correlation coefficient of Coastal taluk

The correlation coefficient is commonly used to measure the relationship between two variables. It is a measure to exhibit how well one variable predicts the behavior of the other (Lee et al. 2003). The results show that (Table 2), among the cations, Na has positive correlation with Mg, and for the other cations there is no significant correlation but, in the case of anions, SO4 has significant correlation with HCO3. HCO3 and K have positive correlation with SO4, and positive correlation exists between Ca and Cl, and F.

III. CONCLUSION

This study provides significant information on groundwater quality in the coastal taluks of Tiruvallur district, Tamilnadu, India. Based on EC, around 75% of ground water is unsuitable for drinking and irrigation purposes. Some major ions in groundwater are within permissible limits for drinking, except in a few places which are nearer to the sea coast. Spatial distribution of chemical parameters clearly indicates that, a large amount of water has been extracted by industries and Ennore Port, which has worsened the quality of water. Spatial distribution map of EC, TDS, Ca, MG and Na clearly indicates that the sea water, moving toward inland, has affected many croplands and is unfit for drinking. Sea water intrusion has become a serious problem in the study area, mainly during the summer. The result of hydro chemical facies reveals that the type of water contains a mixture of NaCl and CaMg. During statistical analysis, the results show that the Na has significant correlation with MG and SO4 has significant correlation with HCO3. Majority of agri land have been affected and left barren due to increasing salinity in the ground water. This interpretation will of a great help to water resource managers in order to solve environmental problems in the society for developing agriculture in India.

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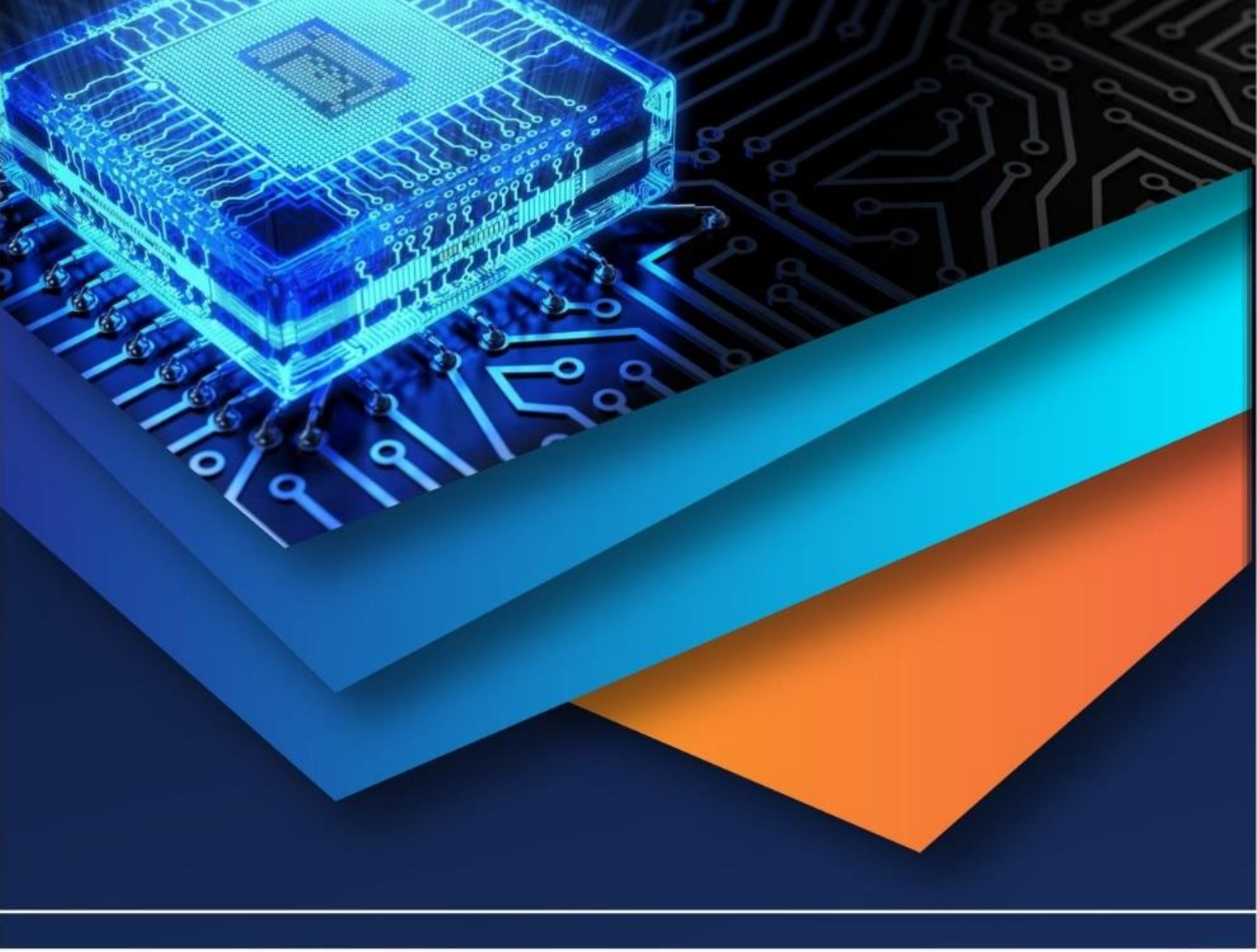

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