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An Overview of Numerous Techniques for Groundwater Pollution Risk Zone Assessment

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Abstract: Water plays a significant part in our everyday lives, meeting our daily needs. There is a significant loss of soil as well as groundwater as opposed to previous days. The objective of this research is to achieve groundwater contamination vulnerability assessment using
Different techniques such as GIS techniques (overlay and index method), statistical methods and mathematical models, but main ly discussed in this study DRASTIC Method has been explained which was developed by United States Environmental Protection Agency (USEPA). Further the most commonly used methods are overlay and index analysis all over the world.
To promote data collection and spatial analysis, the assessment of susceptibility to groundwater contamination should be carried out using computer programs based on Geographical Information System (GIS).
Keywords: Groundwater, GIS techniques, DRASTIC Method, Overlay and Index method, Statistical method, mathematical models.

I. INTRODUCTION

Groundwater constitutes a natural source of fresh water, mainly used for consumption and communal purposes. Groundwater pollution risk is mainly related to hydro geological factors, that is, vulnerability of groundwater to pollution and anthropogenic factors related to the land, among others. When the areas of high groundwater pollution risk are indicated, appropriate preventative measures can be undertaken.

Risk can be characterized as the likelihood of an unexpected occurrence resulting in, among others, negative effects. High probabilit y, i.e. high risk of contamination, can only be accomplished when a highly sensitive area has a high probability of contamination ex posure. In fact, the likelihood will be quantitatively calculated as a percentage of between 0 and 100 percent.

Reliable quantitative evaluation of groundwater pollution risk, however, is difficult because it depends on several variables, some of the hardly observable factors, and so evaluations of groundwater pollution risk are typically qualitative rather than quantitative. Mo st groundwater contamination risk assessments focus on the danger that arises from only one particular source of pollution, such as n itrates from Agricultural fertilization, waste disposal sites or even land-use associated with biofuel.

Aimed at a final, accurate risk assessment of groundwater contamination, researchers also concentrate on the result of this riskassess ment's uncertainty assessment. Locally measured concentrations of nitrate are typically taken as an indication of current groundwate r quality depletion. In this way, actual facts are related to a strictly abstract probability of occurrence of an unexpecd incident.

The approach to rising groundwater contamination risk assessment's degree of uncertainty is generally achieved by validating the data and factors that influence this risk. As a result of the validation, researchers adjust the primarily agreed original methodof as sessing groundwater's intrinsic vulnerability to contamination, typically by altering the weights of the selected factor

Or adding additional factors or parameters that affect this risk. In this way (i) there is a deliberate or accidental change from the intrinsic vulnerability assessment to a specific one and (ii) the result obtained by the changed method of groundwater pollution risk assessment is closer to the measurements of the current concentrations of specific compounds, typically nitrates, but as a result it is an assessment of groundwater-pollution-related compounds.

Risk rather than an evaluation of the total risk of groundwater contamination arising from any possible feature. When assessing the risks when large areas, it is impossible to determine the effect of all potential points or local sources that are only of local signifi cance. Generally these sources are aggregated into categories.

The presented work aimed at a qualitative assessment of groundwater pollution risk using the groundwater's intrinsic susceptibility t o contamination and possible effects of forms of land use in the study field. To carry out this risk assessment, qualitative classificati ons have been suggested regarding the possible effect of major forms of land use on groundwater quality and ground water contamination risk.With the goal of improving the universality of the adopted approach and classifications, the research iscon cerned with evaluating the overall risk of pollution and not risks directly related to selected compounds, such as nitrates, andthe sele cted field of study was one where hydrogeological conditions and types of land use are typical of European plains.

Another objective was the presentation and analysis of the spatial relationships between the obtained result of the groundwater pollution.Risk assessment and the main factors taken into account in this risk assessment.

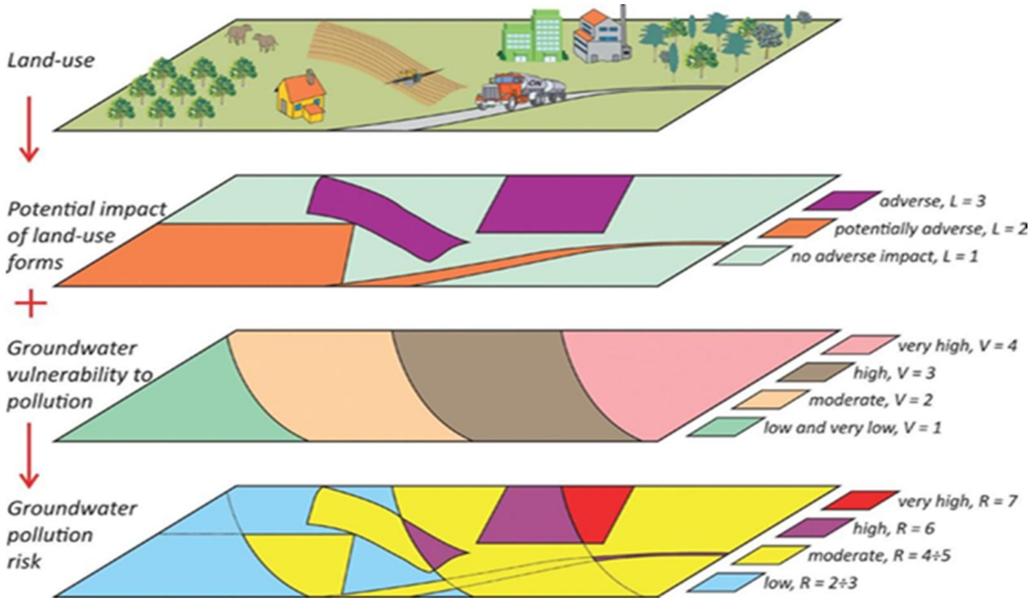

Fig. 1: Conceptual Model of Groundwater Pollution Risk Assessment
(Source – Duda. R et.al, 2020)

Where;
L = Potential impact of land use forms.
V = Vulnerability of Groundwater to pollution.
R = Rate of Risk.

II. METHODOLOGY

Ground water vulnerability assessment methods:

A. GIS Techniques in Mapping Ground Water Contamination

1) GIS is a hardware and software framework used for spatial data collection, retrieval, visualization and analysi
2) Spatial features are stored in a coordinate system (latitude / longitude, state plane, UTM, etc.), which describes a particular plac e on the planet.
3) Spatial features are associated with the descriptive attributes in tabular form. Spatial data and related attributescan then be stack ed together in the same coordinate system for mapping and analysis.
4) Where possible contaminating sources were known, the danger map was extracted from the threat chart, the hazard chart.
5) Pollutants from ordinary human activities (farming, forestry, industry) or from occasional sources enter aquifers. Consequentl, the conservation of groundwater in many countries is a prior environmental issue.

a) *Vulnerability Map:* Three categories of deterministic models were combined with GIS to simulate pollution from NPS: regression models overlay and index models and transient models.
b) *The Hazard Map:* In the mapping of the groundwater contamination risk, the hazard should be defined as the 'source of dange'a nd the 'layer' of the hazard is represented by the spatial distribution of the potential contamination sources. The hazard map is r eplaced by the DCI (Danger of Contamination Index) index. Practices impacting groundwater systems include: forestry, general agriculture, farming, industrial activities and other sources as landfills, waste disposal etc.
c) *Overlay and Index Method:* Overlay and index method (the GAO report calls these methods of "parameter weighting"), combine maps of parameters considered to beimportant in thetransport of pollutants. Each parameter has a range of possible values, indicating the degree to

Whichthe groundwater in a region is covered or left vulnerable by that parameter. For several such schemes, for Example, depth of the groundwater appears considered more fragile than deep, with shallow water. The simplest overlay Systems define areas where susceptibility parameters overlap, for example shallow groundwater and sandy soils. More sophisticated systems assign statistical ratings based on multiple criteria. DRASTIC (Aller, et al. 1987) is the most common of these methods to use as a scoring system based on seven hydrogeological characteristics.

B. Mathematical Model

1) Statistical models and estimation can be used in long-term groundwater management planning.
2) Models of groundwater are useful methods for studying the fluid existence of water and subsurface transport of pollutants.

Processbased mathematical models such as PRZM, GLEAMS, and LEACHM can predict the fate and transportationof pollutants fro m known sources with remarkable accuracy in a localized area by applying fundamental physical principles to predict the flow of w ater into porous media and the actions of chemical constituents carried by that water

These models allow for identification of threats to the safety of groundwater supplies in the hands of experienced experts with relev ant site specific information, and can play an important role in planning remediation efforts. Unlike

Other predictive methods for groundwater quality, mathematical models predict fluctuations in pollutants from groundwater pollution.

a) The GAO found that none of the techniques used by state agencies are statistical process models (GAO, 1992). Theyare not co mmonly used for regional groundwater risk research.
b) Models' biggest downside is the amount of input data required to run them. The quantity of data is rather high and it is rare to fi nd an aquifer where all the input data is required torunthem. The quantity of data is quite large and it is rare to find an aquifer where all the data used to run the model has been measured.
c) Integrated vulnerability maps and land use maps were used by Farjad et al (2012), while Nobre et al.(2007) used a combination of vulnerability assessment, modeling and fuse logic.Wang et al .(2012) developed a risk assessment approach for groundwate r pollution which integrated hazards, intrinsic vulnerability and groundwater value.
d) Usually, random parameters are chosen in mathematical models and the model is run based on those parameters. To get distribu tion of an unknown probabilistic agent, this simulation is repeated several times over. The cumulative probability distribution function of the observed variable must be calculated in order to generate therandom sample. The probability (P) of interest varia ble (X) increase or decrease from any quantity (x) may be Associated to the function of cumulative probability distribution.
e) A probability distribution function was required after generating 5000 outputs for each cell to construct a pollution probability map for the aquifer. Specific probability distribution functions have been tested using HYFRAN software, such as lognormal, average, Halphen, Weibull, Gumbel, generalized extreme value, generalized Pareto, exponential, Pears on type 3, and gamma.

C. Statistical Methods

The primary method to contamination to groundwater supplies is primarily the Statistical Methods. The key contamination of groundwater is created from the different waste factories such as lead, nitrate, phosphate, raw sludge disposal, land filling chromium etc.Using the key component analysis (PCA)/factor analysis (FA), hierarchical cluster analysis (HCA), correlation coefficient and h ealth risk analysis to identify the specific source of emissions, the data collected will be viewed.

1) The deciding factor in assessing the existence of the soil and groundwater by means of air pollution, the release of effluent, the use of agricultural chemicals such as pesticides.Some of the factors responsible for low groundwater quality are agricultural pra ctices, unplanned municipal growth and inadequate hydrochemical
expertise.Highlevel methodology and a powerful method that combines the use of various multivariate statistical techniqus (Principal Component Analysis (PCA), Factor Analysis (FA), Cluster Analysis (CA) and Analysis Correlations that assist in the study. Understanding nuanced water quality details and periodic investigation zone status.
2) Multivariate statistical methods for distribution and correlation between the parameters studied are applied to ground water data. Important descriptive statistical parameters, e.g. scale, mean, standard deviation, kurtosis, and skewing for both seasons were treated. Study of the coefficient of correlation and multivariate measures such as PCA and CA is carried out.

Many factors, such as soil properties, contaminant properties, soil hydraulic cooling, and crop management affect the aquifer assets. Knowing the groundwater flow mechanism would allow for a better assessment of potentially significant factors affecting the groun dwater resource’s intrinsic susceptibility and vulnerability. The emphasis of this review is on soils and the position in attenuating contaminants before they reach the groundwater table.

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Depending on the data accessibility this method is very useful in the concept of defining the pollution vulnerability assessment.

a) Drastic Method

- Designed by USEPA.
- Based on hydrogeological criteria, provides a framework for determining the susceptibility to contamination of groundwater supplies.
- Provides a method for evaluating an area based on established conditions without the need for site-specific, comprehensive pollution data.
- Provides a cheap tool for finding areas needing further investigation.

b) Key Assumptions Made

- Contamination occurs at the ground surface.
- The contaminant enters the saturated zone.
- The contaminant travels with water, at the same rate as water.
- The method will be applied to no greater than100acres.
- The aquifer is unconfined (the method can be modified for a confined aquifer).
- The dominant pollutants are not pesticides (the method can be modified to include pesticides).

c) Parameters Used in the Index: The name DRASTIC is taken from the initial letters of the seven parameters used to evaluate the intrinsic vulnerability of aquifer systems. The following symbols are used in the computation of DRASTIC vulnerability index:

D: Depth of Groundwater.
R: Net Recharge.
A: Aquifer Media.
S: Soil Media.
T: General Topography or Slope.
I: Vadose Zone.
C: Hydraulic Conductivity of the Aquifer.

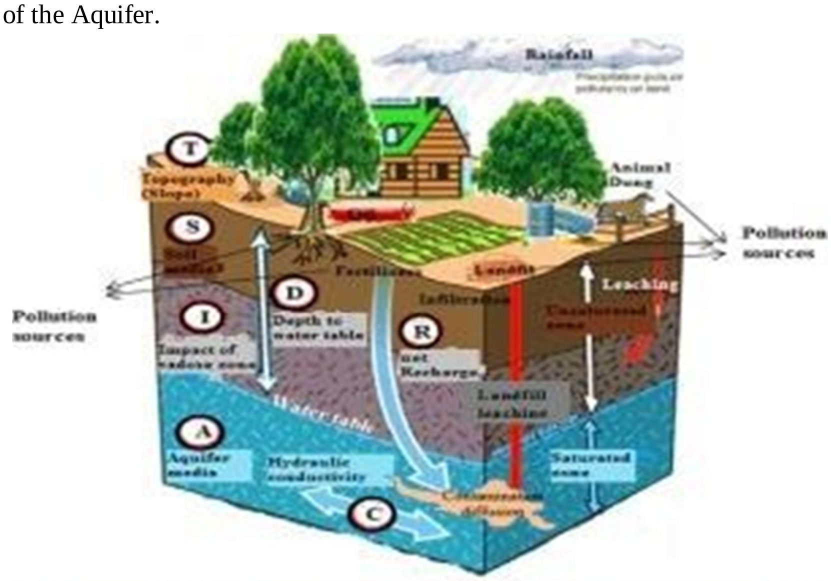

Fig. 2: DRASTIC Model
(Source-ScienceDirect.com)

The DRASTIC Method Governing Equation: Each parameter is assigned a rate and a weight.

DRASTIC Index = Dr × Dw + Rr ×Rw + Ar × Aw + Sr × Sw + Tr ×Tw + Ir × Iw + Cr× Cw

r = the rating for the parameter.

w = an assigned weight for the parameter.

d) *The DRASTIC index can be further divided into four categories:* Medium, moderate, elevated and very high. Every category represents the inherent potential of an aquifer to get polluted. The higher DRASTIC index number tells one another the greater potential for relative pollution risk. The DRASTIC index is quantitative and dimensionless, depending on an aquifer's geological and hydrogeological characteristics. Every DRASTIC parameter was expressed in the form of the matic layer .Using Arc GIS .All generated maps were used to assess intrinsic groundwater.
e) *Depth to groundwater (D):* "The depth from the ground to the water table in an unconfined aquifer and to the bottom of the enclosed aquifer sheet". Parameter D (Depth of water table) value was obtained using data from the pumping test. The higher the water levels are, the Longer it takes for the pollutant to enter the groundwater table, in general. The ranking scor es range from 1 to 3 according to DRASTIC classification.
f) *Net Recharge (R):* "The cumulative volume of water added to the surface of the ground and absorbed into the aquifer." Net regeneration is the amount of water that is infiltrating into the ground and entering the water table. The map integratesavailable features such as slope, soil permeability and rainfall, which are critical for calculating the portion recharge. Soil permeability was calculated on the basis of soil quality, average research area rainfall was used as the charge index and the final recharge value was calculated and the ratings were allocated.
g) *Aquifer media (A):* "Consolidated or unconsolidated rock (such as sand , gravel, and limestone) that acts as an aquifer" The movement of groundwater in the aquifer medium is critical in deciding the time for attenuation processes, such as sorption, reac tivity, and dispersion, along with the amount of effective surface area of materials with which the contaminant may come into c ontact within the aquifer. The migrations of contaminants are strongly influenced by fracturing, porosity, or by interconnected.
h) *Soil Media (S):* "The highest portion of the vadose system with substantial biological activity. "Soil is generally known as the Earth's upper weathered region that reaches 1.8 m or less. Soil has a major impact on the amount of recharge which allows infilt ration into the water table and thus movement of pollutants.
i) *Topography (T):* "The variation of the ground surface in slope and slope" Topography is known as the variation of the slope and slope of the ground surface. Topography helps monitor the run off or accumulation of contaminants on the soil. Higher groundwater contamination potential will be associated with slopes which provide a greater opportunity for pollutants to infiltrate.
j) *Impact of Vadose Zone (I):* "The region which is unsaturated or discontinuously saturated above the water table" The vadose zone refers to the region above the water table, which is unsaturated and its form defines the material's attenuation c haracteristics including the usual soil horizon and rock above the water table gravel, gravel-sand, clay-sand And clay is called study area Vadose.
k) *Hydraulic Conductivity (C):* "Aquifer materials' ability to transmit water" Hydraulic conductivity is characterized as the capacity of aquifer materials to transmit water and is determined by the quantity and interconnection of void spaces withi n the aquifer that may occur as a result of intergranular porosity, fracturing and/or bedding plane test data and a geological hydr aulic conductivity chart.
l) *DRASTIC Index*: The DRASTIC index, a measure of the potential for emissions, is determined by summing the ranking and weights products ofall seven parameters as discussed above. Through the computed DRASTIC index, areas which are mor Likely to be potential for emissions can be defined. The index of vulnerability ranges from 64 to 150 and is divided into three gr oups: 64-80, 80 to 120 and 120 to 150 corresponding to low, medium and high vulnerability.
m) *Weights are fixed in the methodology.*

Parameter	Weight
Depth to Water	5
Net Recharge	4
Aquifer Media	3
Soil Media	2
Topography	1
Impact of the Vadose Zone Media	5
Hydraulic Conductivity of the Aquifer	3

So the governing equation becomes:

DRASTIC Index = 5 Dr + 4 Rr + 3 Ar + 2Sr + Tr + 5 Ir + 3 Cr

Table 1. Comparisons of different Techniques

Comparison Parameters	GIS Techniques [Overlay Index method]	Statistical Method	Mathematical Model
Basic Methodology	Making maps like vulnerability map and hazard map	Find out the statistical parameters by different methods like PCA,CA	Combination of different methods like GIS method , PRZM, GLEAMS
Data required	Less	More than GIS	Maximum data
Approach	Simple	Medium	Toughest
Time consuming	Less	Lesser	Maximum
Accuracy	Less	Less	Maximum
Application	Use full for larger area	Smaller than GIS method	Use full for small area

III. CONCLUSIONS

Ground water pollution is a very relevant topic in present scenario nearly 70% of the world is covered by water, only 2.5% of it is fresh water. In present scenario, we over use and over consumption of water through manmade activities, industrial activities, agriculture activities, transport activities etc. Due to these problems various techniques for the groundwater pollution risk zone assessment is required and hence we have discussed these techniques in our study according to their study area and data required.

In OVERLAY AND INDEX METHOD, maps of the parameters influencing the transport of pollutants from the surface to Ground water are obtained and combined, and an index value is then assigned to those parameters; the results are a Vulnerability targeted spatially. In STATISTICAL METHOD, real water quality data are proportional to spatial variables and involve a significant amount of Site defined.

In MATHEMATICAL MODEL, the fate and transport of pollutants from known sources can be predicted with remarkable precision in a localized area by applying simple physical principles to predict the flow of water in porous media and the Chemical component conduct borne by the water.

According to our study GIS based DRASTIC Method is more applicable because of less data required, use full for larger area, less time required, and its approach is simple. So this method is more applicable than other method.

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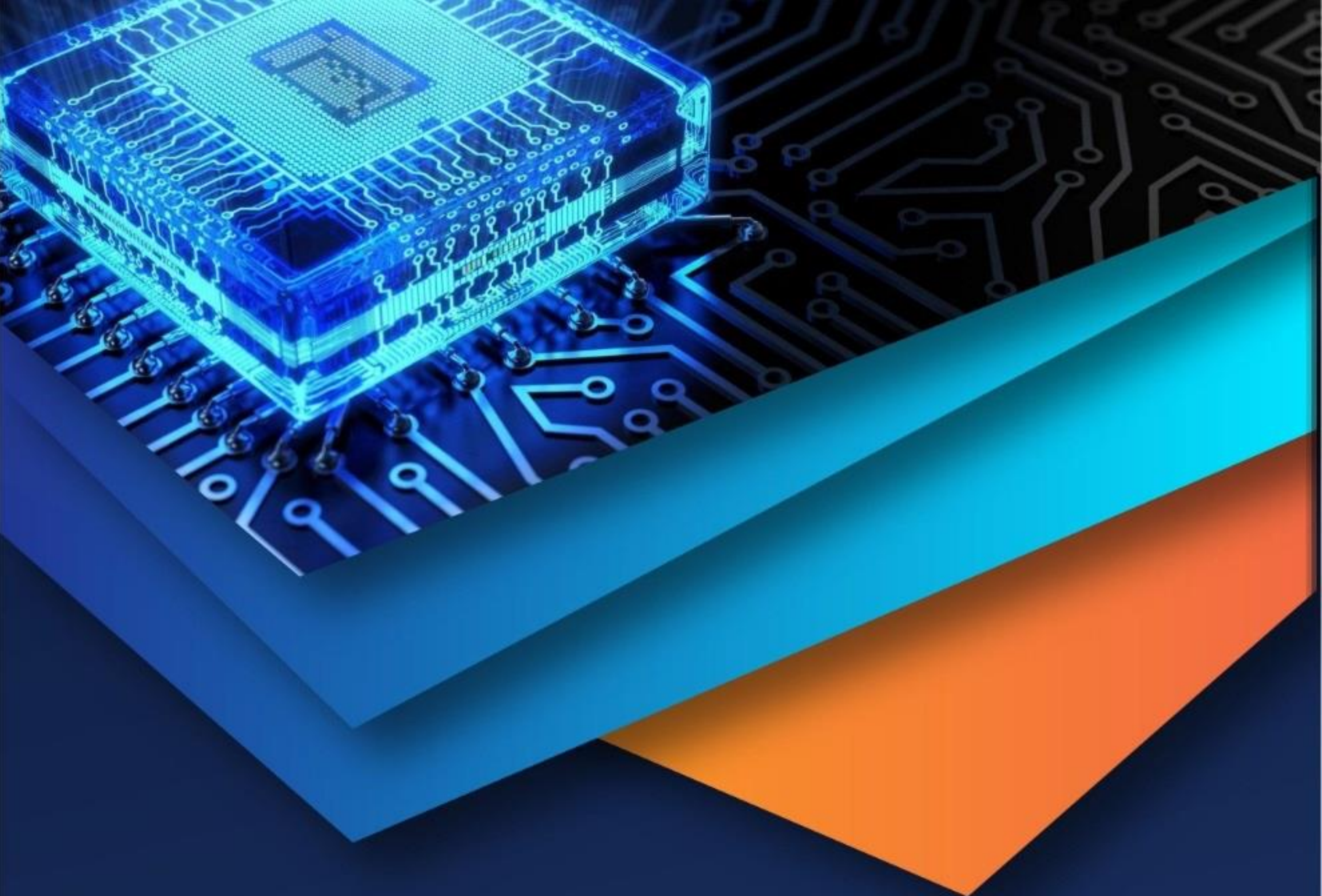

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