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An Innovative Approach to Soil Fertility Management for Soil Samples Collected from Villages Gurgaon, Haryana, India

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Abstract: The first and the foremost role of the soil, the living skin of the earth is that, it is the substrate for production of food and other goods contributing to the life on this planet. The holistic study of soil has been interesting in recognizing phenomena like soil formation, processes, properties and its functions. Soil analysis of a given region can provide important information about physical conditions, fertility status and chemical properties that affects the soil's for the growth of crop. The objective of the present study is to perform soil analysis of various soil samples collected from villages of Gurgaon, Sohna road and recommend various treatment and management techniques to improve the fertility and quality of soil to the farmers. The steps associated with soil testing included collection of soil samples from various regions, laboratory analysis for pH, electrical conductivity, organic carbon, phosphorous and potassium using STFR equipment, following the procedures prescribed in the soil testing kit. A variety of crop/plant type and combination of fertilizer recommendations and treatment procedures have been proposed in the light of various soil parameters observed and analysed. The study is likely to give judicious use of fertilizer and crop management reducing the use of chemical fertilizer in an environment friendly proposition to the farmers.
Keywords: Soil, pH, Electrical Conductivity, Organic carbon, Phosphorous, Potassium, Fertilizer

I. INTRODUCTION

The chief components of soil are Inorganic matter (40%), Organic matter (10%), Soil water (25%), Soil air (25%) approximately. The varying amount of these components give rise to different soil textures which are sometimes suitable and sometimes not for the growth of a plant. If not, then addition of suitable reagents like fertilizers is added and soil treatment is applied based on the actual condition of soil. The various parameters which decides the condition of soil are pH, Electrical Conductivity, Organic Carbon, presence of various metals like Potassium, Phosphorus etc. which can be measured for a given soil sample and hence can be used for the recommendation of certain compounds to improve the soil quality for good yields [1,2].

1) The main objective of soil testing is to know the amount of nutrients, pH, EC, OC etc. to judge the health of the various soil samples. The comparative analysis of various soil samples collected from villages of Gurgaon, region of Haryana using standard analytical techniques has been used to analyze the soil sample.
2) Measurement of the soil's acidity or alkalinity has been done on a scale of 0 to 14 (pH scale). Edible part of plants and herbs cultivated is in paramount when the pH of topsoil is lies in the range of 4.5 – 8. Therefore, this is imperative to measure pH and grow the plants according to the pH of soil and adjust the soil pH to a plant's requirements. Plant's nutrients must be dissolved in the soil solution in order for plants to absorb them, and the pH of soil affects the solubility of minerals. Depending on the pH of soil found using pH meter the category of crop cultivation and ideal fertilizer will be chosen and recommended and the corresponding treatment technique like liming or other additional supplements can be suggested.
3) In the soil, the Electrical Conductivity (EC) reading shows the level of ability, the soil water has to carry an electrical current and is a good indication of the amount of nutrients available for crops to absorb. EC level, that depends on individual soil conditions which if analyzed over time, gives a meaningful set of data based on the performance of crops and the changes that have been made to fertility program. Coarse sand to loamy soils have low salinity, loamy fine sand have slightly saline, slit loam and clay are moderately saline and clay soil EC vary from 0.2- 11.5 dS/m.
4) Organic Carbon (OC) is a measure of organic matter available in soil. It should not be less than 0.1% and should not be more than 1.5%. Bacteria grow properly if OC is in a proper limit.
5) The term 'available potassium' comprises both exchangeable and water soluble forms of the nutrient available in soil which are present in soil. The fixation of potassium (K) and entrapment at specific sites between clay layers tends to be lower under acid conditions. This situation is thought to be due to the presence of soluble aluminum that occupies the binding sites.

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6) Phosphorous is the major nutrient element associated with early maturity of crops particularly the cereals. Its deficiency causes marked reduction in plant growth and inferior quality.
7) In the light of observed results fertilizer/crop recommendation and various treatment/ management techniques has been suggested to improve the quality of soil.

II. MATERIALS AND METHODOLOGY

A. Requirements

A .Grinding with Mortar and Pestle

b. Sieving

c. Soil Samples

d. Weighing Machine

e. STFR Meter

f. Chemical reagents and Glass apparatus

Fig 1 Requirements for soil analysis

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B. Collection of Soil Samples

During sampling recently fertilised plots, spots near trees, compost piles and non- representative locations have been avoided. (Salt crusts on the surface of soils should be sampled separately). Once the area was chosen, sample was taken at various points of the field. The points were selected along a zig-zag path in the field. If the land was fertilised and if the straight-line path was chosen, then all the sampling points might fall in the fertilised band making the sample unrepresentative of the plot soil. For a real composite sample, care was taken that all soil cores must have equal volume and weight.

Any of the tools like auger, screw-type auger, post -hole auger, spade, or knife can be used for digging the plot. Spade or tube auger was convenient for hard or dry soil, while post-hole auger is useful for wet area. Using a spade, a V-shaped cut was made first up to a depth of 15 cm (plough -layer) and a slice of about 2cm thickness is removed. While taking a soil sample, only a soil volume was sampled (i.e. area multiply depth) and not mere area. Samples were collected from 3 or 4 well distributed spots after scrapping a surface a little. These were collected in a suitable container - a trough or bucket.

The sample collected were subjected to the following processes [1]:

1) *Sieving:* Passed the bulk soil sample through 6cm (4 meshes per inch) sieve by rubbing with fingers. Discarded the stones and gravels and bigger particles on the sieve.
2) *Drying:* Dried it in air at room temperature in shade (at about 25 degree Celsius and the relative humidity of 20-60%). Some analysis required fresh moist samples from the field and some needed -dried (100-110 degree Celsius) samples.
3) *Grinding and Sieving:* Broke up the bigger particles of soil by grinding lightly with a roller or with wooden pestle and mortar. Passed the heavy soils through a 2mm sieve before they get dried completely.
4) *Mixing:* Placed the sieved, dried and ground sample on piece of clean cloth. Grasped the opposite corners of the cloth and hold one corner down pulling the other across the sample. Repeated this in the reverse direction. Carried out the same procedure using the other two corners.
5) *Coining and Quarterning:* Partitioned the soil as follows. Kept the mixed soil at the centre of a clean paper. Made it into a cone. Flattened and divided it into two halves through the centre using a flat metal spatula. Then divided each half further into two halves. Separated the four portions. These are called 'quarters'. Discarded the two diagonally opposite quarters. Mixed the other two thoroughly and replied. Continued this fixed procedure until a sample of the size needed for replicate analysis in the laboratory is obtained. This technique minimises bias in the sampling.
6) *Storing:* Placed the quartered sample of soil in paper cartons using a polythene bag as an inner lining, or in an airtight glass jar with a screw cap. Labelled it properly with the location from where the soil is taken for sampling. (Table 1)

Table 1. Labelling of Soil samples from different locations

Sample No.	Place	Sample No.	Place
1.	Abhaypur	6.	Rehtoz
2.	Alipur	7.	Bhelpa
3.	Ghamroj	8.	Mahenwara
4.	Kherla	9.	Naya Gaon
5.	Damdma	10.	Garhi

C. pH Measurement

The pH of a soil considerably affects growth and development of plant predominantly because of the alteration in the availabilities of the vital elements like nitrogen, phosphorous, potassium and other micronutrients like copper, iron, manganese, molybdenum and zinc and aluminium. The activity of microbial population are also affected by pH as well as the activities of some type of pest chemicals/fertilizers applied to soil. If the pH of the soil is known suitable measure can be taken for its reclamation. The pH can be determined electrometrically using combined glass- calomel electrode and pH meter.[2]

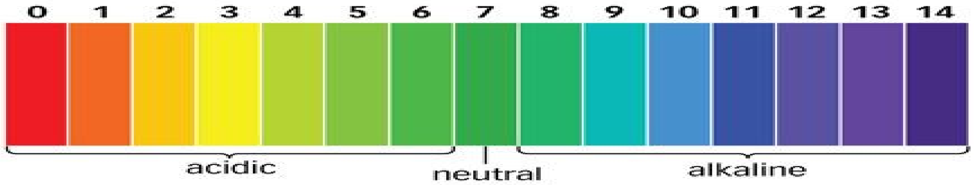

Fig 2 pH scale

D. Procedure for pH Measurement

First of all, for alluvial soil (12g) was weighed and taken with in a glass beaker and 24ml of demineralized water was added to it. For black soil (6g) of soil was taken and then dimneralized water (30 ml) was added. The solution was agitated for 2 minutes and then pH was measured as follows:

Set the STFR meter and pH was recorded by pressing the enter button. Then the electrode was put in pH 9 Standard buffer solution and calibrated it. Enter and then proceeded to standard pH 7 and was calibrated with pH 7 buffer solution and then proceeded to pH 4 standard buffer solution and was also calibrated with pH 4 buffer by dipping it in pH 4 buffer solution. The soil sample solution was taken and entered to note and observe the pH by dipping the electrode in suspension. Similar procedure was carried out for rest of the soil samples. Depending on the pH of collected soil samples it was rated as given below in the Table 2.The United States Department of Agriculture Natural Resources Conservation Service (USDANRC) has given the terminology to describe the status of soil into following categories [3]: .

Table 2. Value for pH and categories of various soils3

pH Value	Categories
< 3.5	Ultra acidic
3.5-4.4	Extremely acidic
4.5-5.0	Very strongly acidic
5.1-5.5	Strongly acidic
5.6-6.0	Modestly acidic
6.1-6.5	Marginally acidic
6.6-7.3	Neutral
7.4 -7.8	Marginally basic
7.9-8.4	Modestly basic
8.5-9.0	Strongly basic
>9.0	Very strongly basic

E. Effect of soil Acidity

1) Reduction in the amount of nutrients being recycled by soil micro-organisms (e.g. nitrogen supply may be reduced) as the growth of microorganisms is affected by the soil acidity.
2) Induced deficiencies of calcium, magnesium, sulphur, boron and molybdenum.
3) Limited ability of plants to use subsoil moisture.
4) Aluminium, Manganese, Iron may reach in toxic levels.
5) Acidity itself may cause damage to root hairs and affects moisture and nutrient uptake
6) Affect N-fixation by legumes.
7) Imbalance in microbial population, soil fungi predominates over bacteria.

F. Management of soil Acidity

Management of acid soils should be done by the alteration and manipulation of agricultural practices to develop optimum crop yield under acidic conditions. Liming can considerably improve the physical, organic and biological properties of soil. There can be significant improvement in the yield due to increased availability of several plant nutrients. In addition to liming, the present rational on acid soil management embodies integration of nutrient management practices with in situ soil moisture conservation technology, agro-forestry using a coordinated approach of crop production to meet the food and nutritional deficiency of the people. No doubt, liming technology is cost effective and can increase the crop yield, residue incorporation, minimum tillage, conservation agricultural practices can also increase the crop productivity in acid soil regions [4,7,8]

G. Farmer's Practices for Minimizing soil Acidification

1) Matching nitrogen fertilizer inputs to crop requirement.
2) Using particular forms of nitrogen fertilizer that cause less acidification.
3) Efficiently irrigating the area to minimize leaching.
4) Sowing early after fallow to ensure more rapid availability of available nitrogen.
5) Growing deep-rooting perennial species to take up nitrogen from greater depths.

H. Effects of soil Alkalinity on Crops

1) Iron deficiency
2) Manganese deficiency
3) Zinc and copper deficiency

I. Management of Alkaline soils can be Managed By

1) Use of gypsum
2) Leaching of salts
3) Scraping
4) Use of sulphur
5) Use of acidifying fertilizers
6) Green manuring

J. Procedure for EC Measurement

Put on the STFR meter and the enter button was pressed which showed the EC on the screen. Enter button was pressed to see the "put standard". The electrodes were washed with distilled water, dried and dipped into standard solution and then entered then go to sample menu by DOWN button and the electrode was dipped in the sample suspension and the enter button was pressed and then reading was taken after 2- 3 min. Similar procedure was carried out for rest of the soil samples. Observations are as follows (Table 3)

Table 3. Standard Electrical conductance values

EC(dS m^{-1}) at 25^0C	Degree of Salinity
< 0.40	Non saline
0.40-0.80	Very weakly saline
0.81- 1.20	slightly saline
1.20-2.50	Saline
2.50-5.70	Moderately saline
4.50-11.4	Strongly saline
9.0-15.0	Very strongly saline

K. Procedure for Organic Carbon Measurement

1) *Extraction and Color Development:* Took eleven glass beakers and marked them as B (for blank) and 1, 2, 3, 4, 5….10 for samples. 11 drops of distilled water were taken in a blank beaker by dropping bottle marked as DW and 0.4 g of soil were also taken in sample beaker. Added one vial OC1 followed by addition of one vial OC2 in all the beakers. Kept the beakers undisturbed for ½ an hr. In this half an hour extracting for potassium and phosphorus were prepared. After half an hour added 47 ml distilled water with the help of 50 ml measuring cylinder to all the beakers and mixed them with a glass rod. Another set of eleven glass beaker were taken and marked them as 1,2,3,4 ….11 and filtered the sample solutions. Readings of the blank solution was taken first followed by the readings of the sample solutions.

L. Procedure for Potassium Measurement

For Blank: Taken 2 mL of filtered blank solution in the test tube marked as KB from dropping bottle KB with the help of 2 ml syringe.

For Samples: Taken 1 ml of filtered blank solution in each of the sample test tube marked as K1, K2, K3, K4 …. K10 from dropping bottle KB with the help of 1 ml syringe. Then 1 mL filtered sample solution was taken in each of the sample test tube marked as K1, K2, K3, K4 …..K10 from respective dropping bottles marked as K1, K2, K3, K4 …..K10 with the help of 1 ml syringe. Syringe was washed with distilled water before each addition. Then added one vial of PT1 reagent, 11 drops PT2 reagents to all the test tubes, it was shaken lightly with cap closed. Waited for three minutes. Then added 5 drops of PT3 reagent quickly without disturbing the tube, waited for another 1 minute and then it was shaken slowly up and down three times with cap closed. Then added 1ml of PS2 reagent with 1 ml syringe and water was also added upto10 mL mark. It was shaken up and down three times and waited for another 5 minutes then finally readings were taken on the instrument.

M. Procedure for Phosphorous Measurement

Took eleven disposable 15 ml tubes, marked them as PB (for blank), P1, P2, P3, P4……P10 (for samples) and put them on test tube stand after rinsing with distilled water.

1) *For Blank:* Taken 2 mL of filtered blank solution in the test tube marked as PB from dropping bottle PB with the help of 2 ml syringe.
2) *For Samples:* Taken 2 mL of filtered sample solution in each of the sample test tube marked as P1, P2, P3, P4 …. P10 from respective dropping bottles marked as P1, P2, P3, P4 ….P10 with the help of 2 ml syringe. Syringe was washed with distilled water before each addition. Then added 5 drops of reagent PH1 plus 2 mL reagent PH2 (with 2 ml syringe) plus one mL reagent PH3 with 1 mL syringe to all the test tubes. Added distilled water up to 10 mL mark. Shook it and waited for 15 minutes after that readings were taken. Observation are summarized in table 6.

Table 4. Standard Soil Test Values categories for various types of soil

Organic Carbon (%)	Dose (kg Nitrogen /ha)	Available Phosphorous (kg P/ha)	Dose (kg P_2O_5/ha)	Available Potassium(kg P/ha)	Dose (kg K_2O/ha)
Low Below 0.20 0.21-0.40	 160 140	 Below 10 11-20	 80 60	 Below 100 101-150	 60 50
Medium 0.41-0.60 0.61-0.80	 120 90	 21-30 31-40	 45 30	 151-200 201-250	 40 30
High 0.81-1.0 Above 1.0	 75 60	 41-55 Above 55	 15 10	 251-300 Above 300	 20 0

III. RESULTS AND DISCUSSION

The extent of the soil's acidity or basicity is measured on a pH scale of 0 to 14. When soil pH falls below 6.0, nitrogen, phosphorus, and potassium are less available to plants; and when the pH rises above 7.5, iron, manganese, and phosphorus are less available. The observed pH values for all the soil sample falls in the modestly alkaline region.(Table 5)

Table 5. pH observed for different soil samples

Sample No.	pH	Nature of soil sample	Sample No.	pH	Nature of soil Sample
1.	7.99	Modestly basic	6.	8.16	Modestly basic
2.	8.06	Modestly basic	7.	7.30	Modestly basic
3.	8.12	Modestly basic	8.	7.67	Modestly basic
4.	8.15	Modestly basic	9.	7.31	Modestly basic
5.	8.16	Modestly basic	10.	6.89	Modestly basic

The farmers were growing Jawar, Bajra and Til in summer and Wheat and Mustard in winter, in addition to vegetables on a separate patch of lands. As per the earlier research few vegetables actually prefer acidic soil like radishes, potatoes and sweet potatoes, parsleys, peppers etc. Similarly, few plants and vegetables and alkaline soil lovers and some neutral soil lovers. The prescribed vegetables are Cabbage, Cauliflower, Cucumber, Sun flower, Beans etc (Table 6)

Electrical Conductivity is a very quick, simple and inexpensive method that farmers can use to check the health of their soils. In the soil, the Electrical Conductivity (EC) reading shows the level of ability the soil water has to carry an electrical current. Knowing soil's EC by electrical conductivity meter can allow us to make more educated farming decisions. However, a good soil EC level lies between somewhere above 200 µS/cm and 1200 µS/cm (1. 2 MS/cm). Any soils below 200 means there is not enough nutrients available to the plant and could perhaps show a sterile soil with little microbial activity. An EC above 1200 µS/cm may indicate too much high salt fertilizer or perhaps a salinity problem from lack of drainage so keeping your EC within this range. Also as EC changes over the growing season, an increase is observed as microbes are releasing more nutrients from the soil or a decrease as crops use up all the available nutrients.

Table 6. Observed conductance measurement for various soil samples

Sample No.	Electrical Conductance (dS m^{-1})	Nature of soil sample	Sampl e No.	Electrical Conductance (dS m^{-1})	Nature of soil sample
1.	1.16	Moderately saline	6.	0.992	Moderately saline
2.	1.10	Moderately saline	7.	1.20	Moderately saline
3.	1.06	Moderately saline	8.	1.11	Moderately saline
4.	1.04	Moderately saline	9.	0.79	Very slightly saline
5.	1.86	Moderately saline	10.	1.05	Moderately saline

Either way fertilizing is done accordingly. One would think that raising the pH through liming would increase fixation and reduce K availability; however, this is not the case, at least in the short term. Liming increases K availability, likely through the displacement of exchangeable K by Ca. Lower pH increases the solubility of Al, Mn , and Fe, which are toxic to plants in excess. A critical effect of excess soluble Al is the slowing or stopping of root growth. The observed values of all soil show that they are modestly saline.
The fixation of potassium (K) and entrapment at specific sites between clay layers tends to be lower under acid conditions. This situation is thought to be due to the presence of soluble aluminum that occupies the binding sites

Table 7. Summary of all additional parameters for the observed soil samples

Sample No.	OC(%)	P (kg/ha)	K(kg/ha)	Sample No.	OC(%)	P(kg/ha)	K(kg/ha)
1.	0.25	23.8	189	6.	0.52	28.3	110
2.	0.30	24.5	151	7.	0.46	25.9	123
3.	0.67	27.6	157	8.	0.54	26.5	180
4.	0.30	22.3	104	9.	0.57	27.1	190
5.	0.43	26.2	150	10.	0.35	23.4	120

A. Crop Recommendation

pH is significant since the amount of hydrogen ions /carbonate and bicarbonate ions present in soil's governs what plant nutrients are existing to vegetable/ herbs roots. The soil elements such as nitrogen, phosphorus, and potassium become accessible to plants when they are soluble in water or soil moisture. Most plant nutrients will become insoluble when the soil is either too acidic or too basic. Few vegetables, though, actually prefer acidic soil like radishes, potatoes and sweet potatoes, parsleys, peppers etc. Similarly few plants and vegetables are alkaline soil lovers and some neutral soil lovers.
Edible plants leaves, root, stem and other parts vegetation parts propagate greatest when the pH of soil is ideal for the plants being cultivated. It is essential to counterpart a plant to the soil pH or to regulate the soil pH to a plant's requirement.
Soil pH is the degree of the soil's acidity or alkalinity.. Most plants fully produce in the pH varying from 4.5 to 8.0. The pH of 5 is an indication of high acid content; a soil pH of 7.5 is an pointer of high alkaline content; a soil with pH of 7.0 is considered neutral. Table 8 below gives appropriate soil pH varieties for some broadly harvested crops as found in the USDA PLANTS Database. [3,6,7]

Table 8 – Selection of Various Crops on the Basis of pH

Acid Soil Crop- pH 4 - 5.5	Somewhat Acidic (pH 5.0-6.0)	Moderately Alkaline Soil Plants (pH of 6.0 to 7.0 or greater)	Very Acid to Alkaline Soil Tolerant Plants
Blueberry (4.5-5.0)	Apple (5.0-6.5)	Bean, lima (6.0-7.0) Beet (6.0-7.5) Broccoli (6.0-7.0)	Corn (5.5-7.5)
Potato (4.56.0)	Basil (5.5-6.5)	Cabbage (6.0-7.5) Cauliflower (6.0-7.5)	Eggplant (5.5-6.5)
Peanut (5.0-7.5)	Carrot (5.5-7.0)	Mustard (6.0-7.5)	Melon (5.5-6.5)
Blackberry (5.0-6.0)	Cauliflower (5.5-7.5)	Onion (6.0-7.0)	Cucumber (5.5-7.0)
Cranberry (4.0-5.5)	Cucumber (5.5-7.0)	Okra (6.0-7.5)	Garlic (5.5-7.5)
Raspberry (5.5-6.5)	Garlic (5.5-7.5)	Spinach (6.0-7.5)	Peanut (5.0-6.5) Squash, winter (5.5-7.0)
Parsley (5.0-7.0)	Radish (6.0-7.0)	Sunflower (6.0-7.5)	Pepper(5.5-7.0)
	Tomato (5.5-7.5)	Gourd (6.5-7.5)	Tomato (5.5-7.5)
	Turnip (5.5-7.0)	Watermelon (6.0-7.0)	Rutabaga (5.5-7.0)

B. Fertilizer Recommendation

As per the results observed using STFR instrument the fertilizers recommended are Diammonium Phosphate 65.2Kg/acr, Triple Super phosphate 120Kg/acr, Muriate of Potash 26Kg/acr, Urea and neem coated urea 125Kg/acr as the organic matter is low in these soil samples.

IV. CONCLUSION

Depending upon the observed values for various parameter of soil found using STFR meter the category of crop cultivation and ideal fertilizer on the can be recommended and the corresponding treatment technique like liming or other additional supplements to the soil will be recommended & corresponding treatment can be prescribed.. No treatment required as the pH has been observed to be slightly alkaline. The EC levels of the soil water is a good indication of the amount of nutrients available for crops to absorb. All the major and minor nutrients important for plant growth take the form of either cations (positively charged ions) or anions (negatively charged ions). EC level depends on individual conditions which should be analyzed over time, to give a meaningful set of data based on the performance of crops and the changes that have been made to fertility program. The combined results show that few soil are deficient in organic matter, phosphorous and potassium which can be compensated by the addition of judious amount fertilizer and crop rotation to minimize the contradictory effect of excess use of fertilizer. Neem coated urea is one of the best option in addition to biofertilizer. The study is likely to be useful for the poor farmers to provide them an alternate methods for their soil management in an eco friendly and sustainable manner.

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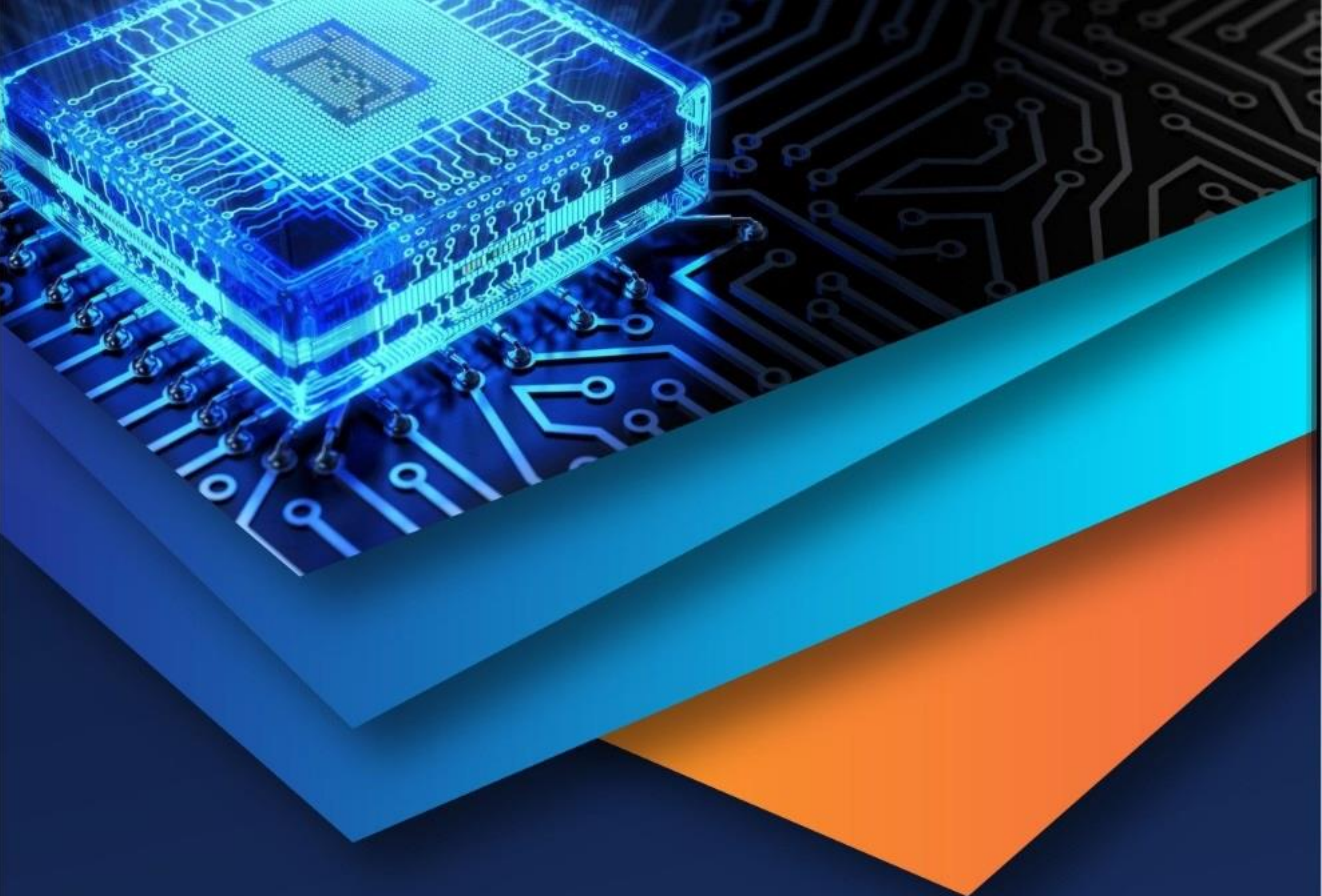

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