iJRASET
International Journal For Research in Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 **Issue:** VIII **Month of publication:** August 2021

DOI: https://doi.org/10.22214/ijraset.2021.37295

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue VIII Aug 2021- Available at www.ijraset.com

Low Cost Multi Bed Filter for Rainwater Harvesting System in India

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Abstract: ***The project mainly focus on capturing rainwater and with basic treatment on passing it through layers of various filter media which helps to make this water fit for human household purposes and various domestic activities.***
The filter is made in various layers having smaller specific gravity media at the top and larger specific gravity media at the bottom . Similarly larger size media are placed at the top and smaller denser media are placed at the bottom.
The filter contains filtering medias such as granulated activated carbon made from coconut shells, ceramic earthenware clay pieces, coarse sand , Garnet sand and pebbles and gravels are used as a supporting layer.
Each layer is being separated by mesh and muslin cloth arrangement so as to hold layers above one another and does not allow filter medias to dislocate from one place to another. This multibed filter is being made as per economical point of view such that it uses natural filtering medias and constructed easily at very low cost.
This low cost multibed filter can filter down suspended solids, remove color ,taste and odor, lowers pH value, reduce alkalinity, total dissolved solids, concentration of chlorides, highly removes turbidity , lowers hardness in water, removes heavy metals such as mercury and other harmful elements as this filter contains activated carbon granules .
The filtered water can also be used for human consumption after disinfection.

I. INTRODUCTION

Water crisis in recent days for the purpose of domestic as well as industrial use is a major threat nowadays in emerging century . Even drinking water is not readily and sufficiently available in various regions across the whole country as well as in other parts of the world due to uneven distribution of rainfall as well as large demand of water in industrial and hydroelectric power generations. The water sources which can be a source of water is also polluted due to human activities.

Our country India is also facing acute water crisis problem and will also face more acute problems in near future until something is not done on national level to ensure water distribution and conservation on a large scale.

Due to increase in urbanization, the pucca buildings and structures are constructed nowadays and in every corner of the world which eventually lead to the lowering of ground water level as water can't be infiltrated to ground due to pucca structures and is drained to oceans and seas and lost in atmosphere. This lead to the loss in capacity of aquifers and eventually depleting ground water resource.

Since surface water is not readily and evenly distributed in every regions and also not suitable for domestic as well as industrial purposes, so ground water is a major source for water demand to be fulfilled and therefore there is a major need to be focussed on recharging ground water aquifers. The Rainwater Harvesting System is generally the system of augmentation of ground water resources by recharging ground water by artificial means which is obtained by rain and is diverted to percolate in ground not simply runoff to drains and seas or oceans. Due to depletion of ground water at a steady rate because of increasing demand and population, there is a need for recharging ground water so as to maintain the balance of supply of ground water to satisfy the demands. This captured rain water is allowed to be concentrate at certain storage tanks which can either be directly used for domestic purposes or can be used to increase the yield of ground water by artificially recharging ground water.

This method thus helps in capturing rain water which is the purest form of water and the wastage of this water is reduced as they directly flow through storm sewers and then to seas or oceans and rivers.

Since Ground water is a scarce resource nowadays as the water table is being depleted annually on a large scale therefore there shall be a keen step taken to overcome this adversity by using natural source of water i.e. rain by utilizing rain water to recharge ground water by proper mechanism globally on a large scale.

We know that rainwater is the primary source of water and is also the purest form of water so people need to aware about harvesting natural resource i.e. rain

Rainwater Harvesting and Conservation need to be well implemented where there is shortage of water supply and ground water and to regions where it falls.

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II. METHODS

A. *Surface Runoff Harvesting*

Generally in urban areas where there is a pucca structures constructed, these rainwater falling on surface is diverted to various recharging structures and contribute to groundwater resource.

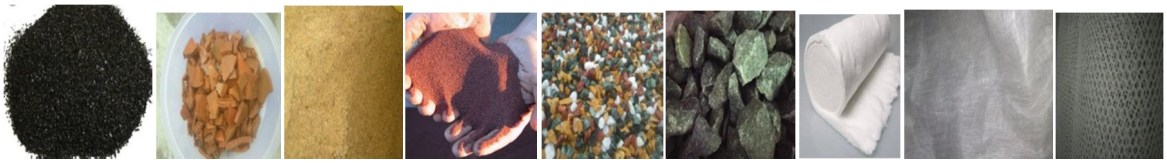
B. *Rooftop Rainwater Harvesting*

Rooftop Rainwater Harvesting is a mechanism of collecting and capturing rainwater where it falls on the surface so as to allow the rainfall water to be diverted and collected in the storage tank for various household and commercial purposes and conserve rain water .This rainwater is stored in artificial storage structures and is helpful in addition of groundwater table increment.

III. EXPERIMENTAL WORK

A. *Filter Materials*

1) *Granulated Activated Carbon:* Granulated Activated Carbon made from coconut shells is used in this filter. This helps in adsorption of taste and odor compounds or chemical contaminants, particularly organic chemicals. They also remove excess chlorine from water by converting them into chloride .
2) *Ceramic Pieces:* Ceramic pieces used in this filter are unglazed earthenware pottery waste products which gets broken due to various reasons. This ceramic unglazed earthenware pottery pieces when crushed to fine smaller pieces and having high void percent can capture suspended particles within its pores. This also acts as a barrier for bacteria and other pathogens and water borne cysts including E. Coli ,Salmonella,etc.
3) *Sand:* Sand used in this filter media are generally coarse sand which is used for making mortar in building construction. Sand captures particulates and suspended matter on there permeable surface layer by direct collision, vander wals force attraction, surface charge attraction and diffusion.
4) *Garnet Sand:* Garnet is chemically inert and non metallic mineral. They are well known for there hardness, durability and there chemical and abrasive resistance ,having larger specific Gravity which makes it Ideal material to be used in Multimedia filter .
5) *Pebbles and Gravel:* Pebbles and Gravel are generally used as a supporting layer for above filter medias . Pebbles can trap sediments and suspended particles by its physical means alone.
6) *Muslin Cloth:* Muslin cloth is woven cotton fabric which is used for separating layers of filter medias such as to hold the materials at their position.



GAC Ceramic Sand Garnet Sand Pebbles Gravel Cotton Muslin Cloth Mesh

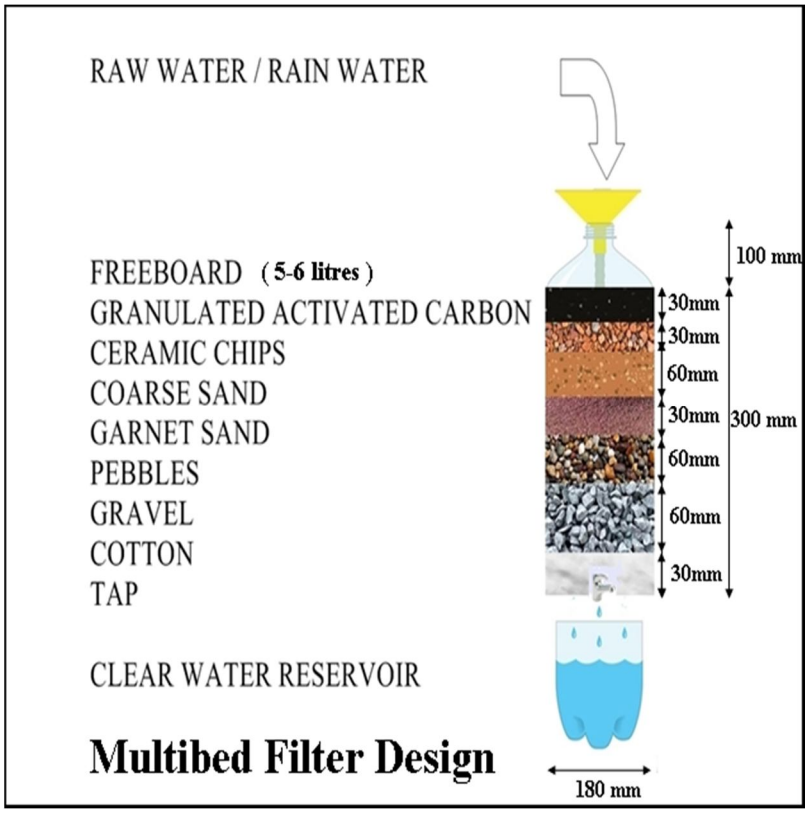
B. *Filter Media Properties*

S.No.	Media/ Materials	S.G.	Effective size (mm)	Depth of media(mm)	Quantity (kg)
1	Activated Carbon	0.45-0.8	4-8	30	0.5-1
2	Ceramic Chips	1.75-1.8	2-4	30	2-2.5
3	Coarse Sand	2.5-2.7	0.5-0.7	60	5-5.5
4	Garnet Sand	3.8-4.2	0.3-0.5	30	2.5-3
5	Pebbles	2.3-2.6	5-10	60	2-3
6	Gravel	2.7	20-40	60	8-10
7	Cotton	-----	--------	30	----------

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C. Multi Bed Filter Designing And Construction

FREEBOARD
GRANULATED ACTIVATED CARBON
CERAMIC CHIPS
SAND
GARNET
PEBBLES
GRAVEL
COTTON



All the materials were collected from local market. Sand, Gravel, Pebbles, etc. were washed and then sun dried.
GAC was also washed thoroughly so as to remove dust particles and its black color.
Ceramic unglazed earthenware broken pot was crushed into smaller pieces and was also washed. Garnet sand was also washed thoroughly.
Now the container was fitted with tap so as to ensure water filtering at the bottom.
Firstly cotton roll was placed at the bottom of the container of depth 30 mm layer by layer.
Secondly a mesh was placed and Gravel was laid upto depth 60 mm and was tampered and compacted so as achieve minimum void ratio.
Now again mesh was placed above gravel layer and pebbles were laid of depth 60 mm and was compacted heavily.
Then mesh was enrolled between muslin cloth and was placed above pebbles and Garnet sand was laid 30 mm over that muslin cloth.
Now again mesh was enrolled within muslin cloth and sand was filled upto 60 mm depth and was compacted also.
And same as below, ceramic crushed pieces was filled upto depth of 30 mm. Lastly mesh was placed above ceramic pieces and Activated Carbon Granules was laid over the top 30 mm layer. To ensure GAC does not float or bubbles up at the water surface mesh was placed above GAC layer and gravels were placed at the top.
The entry at container was also installed with mesh so as to remove large floating matters and particles.
The filter was firstly run with clear water so as to remove dust and other colors present in GAC and other filtering media layers.
The filter was then run with sample raw water so as to filter down suspended and particulate matters as well as removal of color, odor and taste. Rainwater is generally bacteria free as well as is generally soft, they generally contains sediments and other inorganic matters which get mixed from catchment areas.

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IV. TEST RESULTS

1) pH

Sample Details	Sample 1	Sample 2
Raw water	6	6.5
Filtered Water	7	7

pH result comparison

2) Color

Sample Details	Sample 1	Sample 2
Raw water	Yellow	Yellow
Filtered Water	Colorless	Colorless

Color result comparison

3) Total Alkalinity

Sample Details	Sample 1	Sample 2
Raw water	270 ppm	210 ppm
Filtered Water	220 ppm	170 ppm

Total Alkalinity result comparison

4) Total Hardness

Sample Details	Sample 1	Sample 2
Raw water	250 ppm	240 ppm
Filtered Water	230 ppm	230 ppm

Total Hardness result comparison

5) Turbidity

Sample Details	Sample 1	Sample 2
Raw water	5 NTU	4 NTU
Filtered Water	0 NTU	0 NTU

Turbidity result comparison

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BEFORE AFTER

Removal of Color, Turbidity and Total Suspoended Solids.

6) Total Dissolved Solids

Sample Details	Sample 1	Sample 2
Raw water	610 ppm	560 ppm
Filtered Water	540 ppm	490 ppm

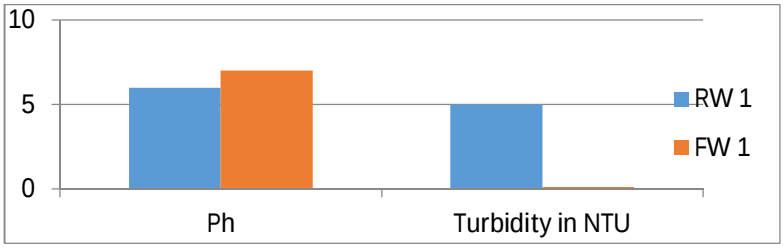
Total Dissolved Solids result comparison

7) Chloride Concentrations

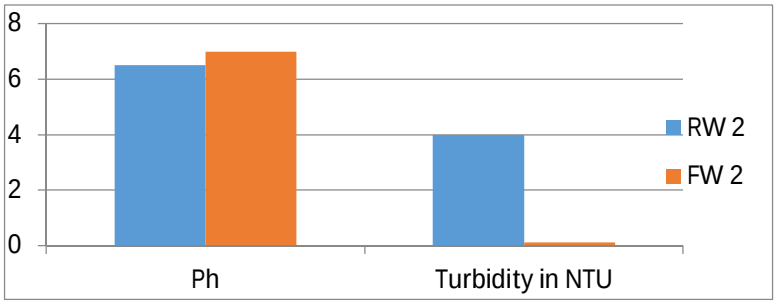
Sample Details	Sample 1	Sample 2
Raw water	80 ppm	90 ppm
Filtered Water	70 ppm	70 Pm

Chloride result comparison

V. COMPARISON OF RESULTS

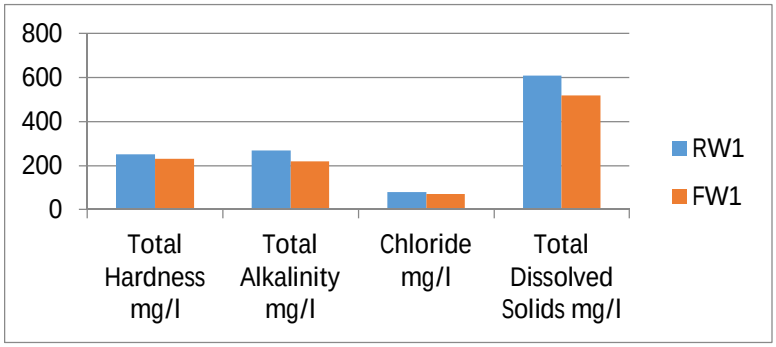


Graph 1- Raw water Ph and Turbidity test results

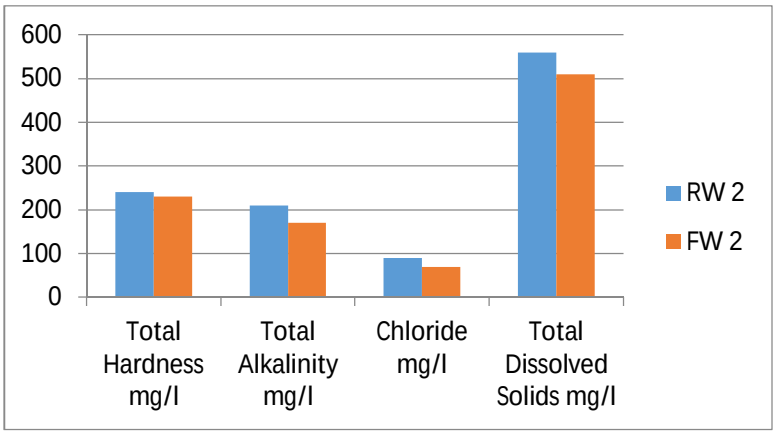


Graph 2- Filtered water Ph and Turbidity test results

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Graph 3- Raw water other test results



Graph 4- Filtered water other test results

VI. CONCLUSIONS

Our P.M. Mr. Narendra Modi recently launched Jal Shakti Abhiyan :Catch the Rain Campaign on occasion of World Water Day and calls for water security and effective water management as India's development and self-reliance is dependent on water security and water connectivity. He said that if India manages rainwater better , it will reduce the country's dependence on groundwater.

This project focus mainly on the capturing of rain water which is a renewable source of energy and nowadays water crisis problem leads to the economical use of water as well as saving it for human use.

Since rainwater is available freely in nature in rainy seasons, there shall be a need to store this rainwater and utilize it for human use as about large part of rainwater is flown through surface runoff to streams ,rivers ,lakes, etc and is mixed in seas and oceans.

The project mainly focus on capturing rainwater and with basic treatment on passing it through layers of various filter media which helps to make this water fit for human household purposes and various domestic activities.

The filter is made in various layers having smaller specific gravity media at the top and larger specific gravity media at the bottom . Similarly larger size media are placed at the top and smaller denser media are placed at the bottom.

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The filtered water can also be used for human consumption after disinfection.

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VII. FUTURE RESEARCH

This multibed filter can be used in residential areas and this treated rain water can be used directly for domestic purposes such as watering of lawns and gardens, washing of clothes and utensils, and for water closet as well as it can be used for bathing purposes.
In extreme conditions, this treated water can be consumed for drinking purposes after disinfection by chlorine in the clear water reservoir.
The collection of rainwater from roofs are collected by diverting the rainwater from roof pipes and drains to the rainwater storage tank of suitable capacity to collect rainwater .
This rainwater is stored and screens are installed at place of entry and the tank is then provided with pre chlorination process to ensure removal of bacteria and other micro organisms.
The water is allowed to settle so that the suspended particles are settled at tank bottom due to gravity.
Now the multibed filter are installed at certain elevated structures and water is then transferred to filter for treatment.
This treated water is then diverted to another clear water reservoir tank .
The excess stored rainwater is also used for recharging of ground water by making trenches of required and available area and depth and is filled with gravels and pebbles so as to allow water to percolate within ground for recharging aquifers.
Our P.M. Mr. Narendra Modi recently launched Jal Shakti Abhiyan :Catch the Rain Campaign on occasion of World Water Day
He calls for water security and effective water management as India's development and self-reliance is dependent on water security and water connectivity.
He said that if India manages rainwater better , it will reduce the country's dependence on groundwater.
Thus , if People get aware of harvesting this natural resource i.e. Rain ,water crisis can be reduced as well as ground water can be recharged effectively.
There shall be implementation of this roof top rain water harvesting scheme in every houses as well as ground water recharge structures are needed to be build at a larger rate so as to catch this rain water and helps in ground water recharging.
This multibed filter if being produced in bulk can greatly reduce its cost and is effective for single family dwellings such as to store and filter rain water and can be directly used in domestic and household activities as well as for drinking purposes if proper care in diverting rain water to storage tanks and disinfecting clear water reservoir tank.

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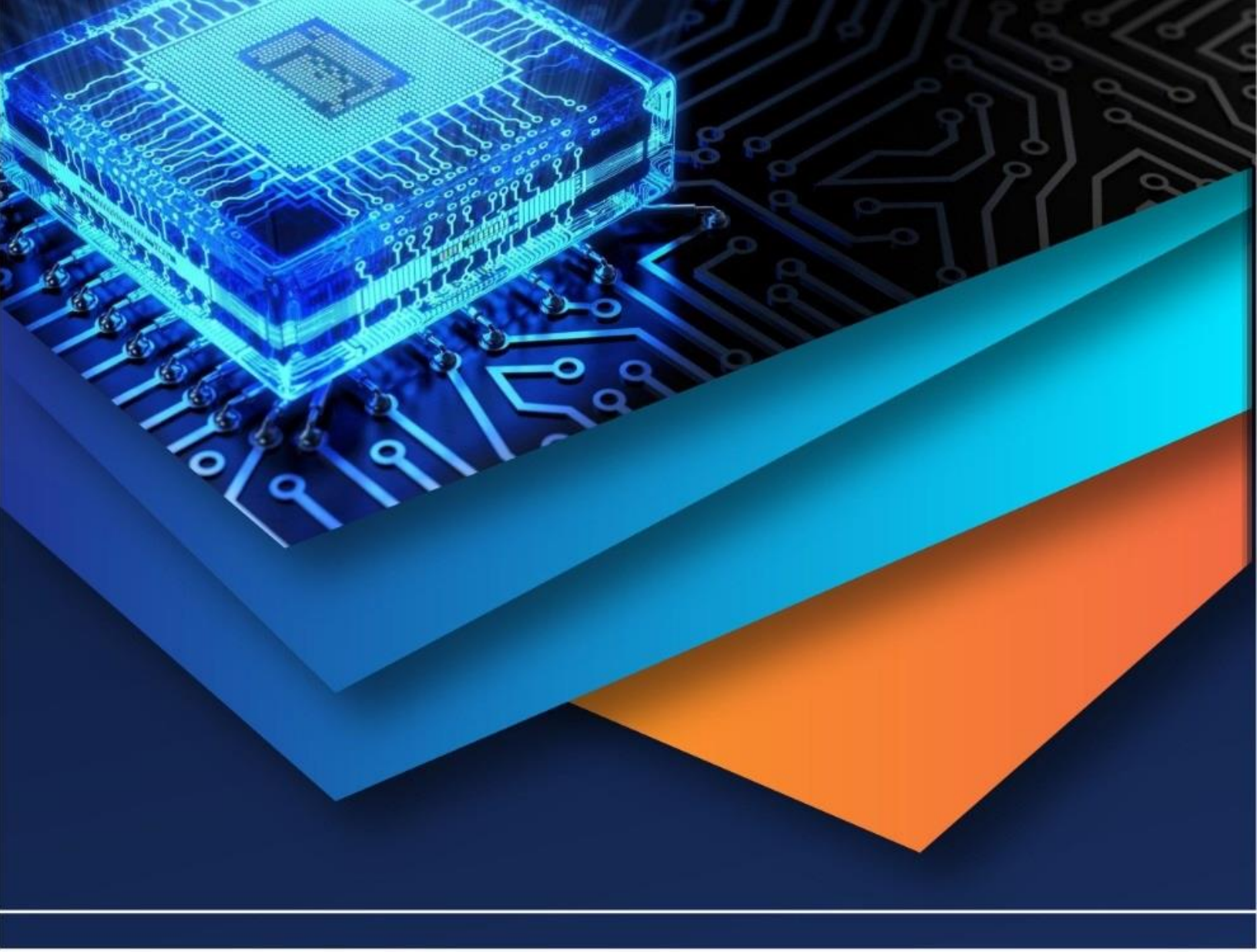
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