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A Literature Review on Integrated Approach for Grey Water Treatment

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Abstract: Water is critical for all life on the planet. Rapid industrialization and urbanization has caused India to face a water crisis since it has only 4 percent of the world's water resources. In order to resolve the crisis, India has to look for alternative water resources which may include rainwater harvesting, grey water and sewage reuse and desalination. Grey water is defined as waste water generated from the bathroom, laundry and kitchens. Nearly 70 percent of the water used in households results in grey water which can be treated using simple technology and reused. Reuse of grey water reduces the fresh water requirements and reduces the amount of sewage sent to treatment plants. An integrated approach is needed to manage the water and waste water treatment so that water supply is kept clean and waste water is recycled for beneficial use in agriculture and industry.

An integrated grey water treatment plant was developed to treat grey water generated in the Shrirampur gram panchayat area. The developed laboratory scale integrated model consist of screening, sedimentation, filter-I, filter-II, aeration and disinfection units, which is a combination of natural physical operations. The Shrirampur gram panchayat is one of the well-developed gram panchayat and bagged Vikas ratna Award at the hands of President of India in paryavaran santulit samruddha gram yojna. The area was divided in three zones for the present study. The major zones of the area such as Gokul Residency (Zone-I), Green Park-I (Zone-II) and Amar Nagar (Zone-III) were taken for the present study. The 564 random samples were collected from kitchen and bathroom considering sources of supply as tap water and borewell water in spring, winter and summer seasons. The overall performance of the laboratory scale integrated plant for treatment of kitchen and bathroom grey water considering source of supply as tap water & borewell water in spring, winter & summer season was excellent, producing very high quality effluents. The percentage removal efficiency of pollutant was found better for the sample collected in winter season than spring and summer seasons. The performance was showed in terms of reduction competency of water pollutants such as COD (84%), BOD (92%), Coliform (98%), TSS (87%), TDS (76%), Turbidity (64%) and Total hardness (70%). This treatment technology can be considered as a viable alternative to conventional treatment plant in rural region.

Keywords: Grey water, fresh water, waste water treatment, tap water and bore well water

I. INTRODUCTION

A. Background of the Study

Waste water generally is made of black water and grey water. Grey water also known as sullage, is non-industrial waste water generated from domestic processes such as washing dishes, laundry and bathing. Grey water comprises 50-80% of residential waste water. Grey water is distinct from black water in the amount and composition of its chemical and biological contaminants (from faces or toxic chemicals).

Grey water gets its name from its cloudy appearance and from its status as being neither fresh nor heavily polluted. Essentially, any water, other than toilet wastes, draining from a household is grey water. Although this used water may contain grease, food particles, hair and any number of other impurities, it may still be suitable for reuse. Reusing grey water serves two purposes: it reduces the amount of fresh water needed to supply a household, and reduces the amount of waste water entering sewer or septic systems.

Grey water is domestic waste water that is collected from dwelling units, commercial building and institutions of the community. It may include process waste water of industry (food, laundries etc.) as well as ground infiltration and miscellaneous waste liquids. It is primarily spent water from building water supply to which has been added to the waste effluent of bathrooms, kitchens and laundry.

Domestic waste water is the spent water from the kitchen, bathrooms and laundry. Many of the minerals and organic matter in the water serve as food for saprophytic micro-organism and hence the waste water is unstable bio degradable reduction of relative

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dependence on potable water usage is becoming a necessary facet of good water management. Many new or modified treatment processes are being investigated is an attempt to solve the serious water supply and waste water disposal problems of the growing population and its industries. Even with the application of the water reducing scheme, a large amount of the water reducing scheme, a large amount of water is still required and eventually, reuse of water may have to be practice. Therefore, several possible re-use of water schemes such as distillation and membrane techniques for complete reuse and biological oxidation, filtration and disinfection schemes for partial reuse have been considered.

B. Generation of Grey Water

Grey water comprises 50-80% of residential waste water (Amoah et al). Fig.1. Shows the various sources from which grey water is generated.

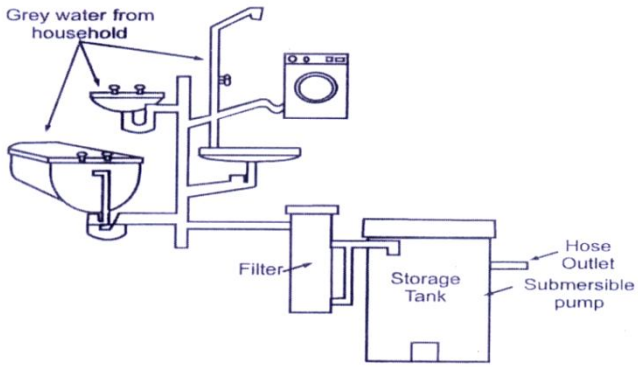

Fig. 1: Diagrammatic representation of household grey water generation

TABLE I WATER REQUIREMENT & GREY WATER GENERATION

Sr. No.	Description	Quantity of water (1 ppd)	Grey water generation Lppd
01	Bathing	12-18	12-18
02	Washing of clothes	8-12	8-12
03	Flushing of WC	5-10	--
04	Washing the floor	2-5	--
05	Washing of utensils	3-5	3-5
06	Cooking	5	--
07	Drinking	5	--
Total		40-60	23-35

IS 1172-1975 recommends a per capita water consumption of 135 ltr./day. The percentage of grey water generated from domestic use is shown in table II.

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TABLE II PERCENTAGE OF GREY WATER GENERATED

Sr. No.	Sources	% Grey Water
01	Bathing	55
02	Laundry	20
03	Washing of house	10
04	Washing of Utensils	10
06	Cooking	5
Total		100

C. Quantification of Grey Water

Determination of grey water generation and flow rate is the first requirement in the design of grey water, collection, treatment and reuse system. Following methods are proposed for quantification of grey water shown in table III.

TABLE III METHOD FOR QUANTIFICATION OF GREY WATER

Sr.No.	Method	Types
1	Direct Method	a) Water meter b) Bucket method
2	Indirect Method	a) Water consumption b) Type of uses

D. Composition of Grey water

TABLE IV
A TYPICAL QUALITATIVE COMPOSITION OF GREY WATER

Water source	Bacteria	Chlorine	Foam	Food particles	Hair	High pH	Nitrate	Odor	Oil & Greases	Organic smatter	Oxygen demand	Phosphate	Salinity	Soaps	Sodium	Suspended solids
Cloth washing			*			*	*		*		*	*	*	*	*	*
Washing of utensils	*		*	*		*		*	*	*	*			*	*	*
Bathing	*				*			*	*		*			*		*
Kitchen	*			*				*	*	*	*			*		*

E. Grey Water from Bathroom

Water used in hand washing and bathing generates around 50-60% of total grey water and considered to be the least contaminated type of grey water. Common chemical contaminants include soap, shampoo, hair dye, tooth paste and leaning products. It also has some fecal contamination through body washing.

F. Grey Water from Kitchen

Kitchen grey water contributes about 10 percent of the total grey water volume. It is contaminated with food particles, oils, fats and other wastes. It readily promotes and supports the growth of micro-organism. Kitchen grey water also contain chemical pollutants such as detergents and cleaning agents which are alkaline in nature and contain various chemicals.

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G. Grey Water Quality

The characteristics of house hold grey water can vary depending on the number of house hold occupants, their age, health status, tap water sources water usage patterns and household products used (such as Soaps, Shampoos, Detergents, Mouth wash, Tooth paste, Hair style, Shaving cream and body oils). The typical composition of grey water is shown in Table V.

TABLE V COMPOSITION OF GREY WATER

Sr. No.	Parameters	Unit	Grey Water (Ranges)
01	Suspended solids	Mg/l	45-330
02	Turbidity	NTU	22-200
03	BOD_5	Mg/l	90-290
04	COD	Mg/l	280-800
05	Oil & Grease	Mg/l	37-78
06	Coli form	Cu/100ml	0-500-10000
07	Total Dissolved Solid	Mg/l	126-175
08	Temperature	^{0}C	18-38
09	Nitrite	Mg/l	<0.1-0.8
10	Ammonia	Mg/l	<0.1-25.4
11	Total Kjeldahl Nitrogen	Mg/l	2.1-31.5
12	Total phosphorous	Mg/l	0.6-27.3
13	pH	--	6.6-8.7
14	Conductivity	mS/cm	325-1140
15	Sodium	Mg/l	29-230

H. Reuse of Grey Water

In many parts of the world, water scarcity is one of the most significant challenges to human health and environmental integrity. As the world's population grows and prosperity spreads. Water demands increase and multiply without the possibility for an increase in supply. Grey water uses can be toilet flushing, garden irrigation, outdoor uses, but also laundry and even showering. The treatment technique and the quality of the treated grey water will have to be adapted to the reuse purpose. The reuse and recycling of grey water has been practiced in several countries because of the obvious benefits in terms of fresh water saving and management.

I. Problems Associated

There has not being any record of illness caused by grey water to man grey water sky rockets in value during drought emergency and anywhere that other water sources are not available especially for irrigation but due the particles found in grey water as well as its chemical and biological properties it may be suggested that grey water could contain some properties which could cause dilapidation to plant growth and, or the soil. It was suggested that grey water from kitchen sink and dish washer should not be reused as these can contain heavy loads of organic materials, fats and caustic additives in high concentrations that are not readily broken down by soil organism. Soaps and detergents are components in grey water which could adversely affect plants the most. Relating to these facts, we decided to test for its properties (physical, chemical and biological) and then purify it to meet up to the standard for its reuse.

II. LITERATURE REVIEW

A general overview of previous research work on quantification, characterization & treatment of grey water and reuse for sustainable development.

A. *Glenda Emmerson (1998)* [9], suggested alternative source of water is grey water. Grey water is the water that goes down domestic bathroom and laundry drains. If this water is diverted for relatively safe applications such as garden irrigation, then a family can reduce their water usage by around 30-50 percent saving. Grey water reuse also offers environmental benefit but a caution should be exercised to avoid public health and the environment risk.

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B. *Peter L.M. Veneman et.al. (2002)* [19], investigated to grey water samples at five different commercial location in Massachusetts to quantify the variability and characteristics of grey water. The data indicated that the effect of different loading rates was statistically not significant, but that soil depth was. This seems to point to the fact that increasing the loading rates does not appear to have an adverse effect on treatment efficiency, but that decreasing soil depth does.

C. *Muttukumaran, et. al., (2003)*[17], presented a study a waste water treatment at panjappur and waste water reuse at srirangam. The waste water quality has been studied by taking samples and results were compared with FAO irrigation water quality standards. The authors suggested to utilize the treated waste water for growing greens, vegetables and for agriculture.

D. Jefferson, et.al. (2004) [4], reported Characterization of grey water that reveals a source water similar in organic strength to a low medium strength municipal sewage influent but with physical and biodegradability characteristics similar to a tertiary treated effluent.

E. *Friedler, et.al. (2005)[*7], presented a study of a pilot plant treating light greywater for seven flats. The pilot plant combines biological treatment (RBC) with physicochemical treatment (sand filtration and disinfection). The pilot plant produced effluent of excellent quality, meeting the urban reuse quality regulations, and was very efficient in TSS turbidity and BOD removal : 82 %, 98% and 96%, respectively. The COD removal was somewhat lower (70-75%) indicating that the greater may contain slowly-biodegradable organics. Fecal coli forms and heterotrophic reductions were very high (100% and 99.99%, respectively) producing effluent that also met drinking water standards.

F. *National Environmental Engineering Research Institute (NEERI) and UNICEF (2007)* [18], National Environmental Engineering Research Institute (NEERI) Nagpur and UNICEF Bhopal, Madhya Pradesh have developed, implemented and evaluated grey water reuse systems for small buildings (schools) in rural areas. NEERI has developed grey water treatment system as primary treatment (screening and equalization tank) followed by secondary treatment-I(gravel filter and sand filter) and secondary treatment-II(broken brick, charcoal, chlorination)for treatment of grey water at a tune of 1000-2000 l/day from hostels, schools and residential complexes . The drive for this technology was undertaken due to decreasing availability of water, lowering of groundwater table and increase in fluoride concentration in groundwater.

G. *Gideon Paul Winward, (2007)* [8], investigates pathogen removal through treatment and disinfection processes. Also the impacts of organic and particulate material in grey water on the efficiency of disinfection processes are investigated in depth.

H. *Dr. Mark Pidou et.al. (2007)* [6], reported a review of existing technologies and application collating a disparate information bas and comparing strength and weaknesses of different approaches. The best overall performance is observed within the scheme combining different type of treatment to ensure effective treatment of all the fractions.

I. *Sam Godfrey, et.al.(2009)* [22], presented grey water treatment and reuse system in residential schools in Madhya Pradesh, India and treated grey water used for toilet flushing and irrigating the food crops. In this study the cost-benefit analysis was undertaken for grey water reuse by considering internal and external costs and benefits. The analysis carried out indicates that the benefit exceeds the cost of the system.\

J. *Jonathan Glassman, et.al. (2009)*[12], suggested the design recommendation for the vertical intermittent sand filter in place of the current multi-media filter. The sand filter is easier to maintain than the existing multi-media filter because only the top layer of sand media in the filter has to be regularly replaced, compared to digging out and replacing all of the particle media in the drum.

K. *Bhausaheb L. Pangarkar, et.al . (2010)* [5], investigated the economical performance of the plant for treatment of bathrooms, basins and laundries grey water showed in terms of deduction competency of water pollutants such as COD (83%), TDS (70%), TSS *83%), total hardness (50%), oil and grease (97%), anions (46%) and captions (49%).The authors suggested that this technology could be a good alternative to treat grey water in residential rural area.

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L. *Vasudevan Rajaram et.al. (2010)* [27], presented an integrated approach to manage the water and wastewater treatment , concluded that every drop of wastewater in rural and urban India should be recycled for reuse. So that it does not contaminate our drinking water supplies and conserve scare water resources for satisfying the thirst of the entire population.

M. *Khatun et.al. (2011)[*2], reported characterization of grey water collected from different sources and different locations of Dhaka city. The author suggested an efficient, cheap and sustainable grey water treatment system for household and mosque. The treated grey water can be used for non-potable use such as irrigation, toilet flushing, car washing and aquifer recharging.

N. *Saroj B. Parjane et.al* (2011)[24], presented the finest design of laboratory scale grey water treatment plant, which is a combination of natural and physical operation such as primary settling with cascaded water flow, aeration, agitation and filtration, hence called as hybrid treatment process. The economical performance of the plant were investigated for treatment of bathroom, basins and laundry grey water. The author worked out cost benefit analysis of the system on the large scale and found more effective process in the rural region.

O. *Ukpong EC. et. al. (2012)*[26], reported to design and Construct a filter for grey water reuse for irrigation of not less than one hundred household. Laboratory tests were conducted on these samples and they reveals the presence of BOD, TSS, nitrate PH, coliform etc., whose values varies where compared with that of the parameters for standard irrigation water. The author suggested that the efficiency of the slow sand filter in the reduction a all the parameters was high due to their tangible nature which enable them to succumb surface forces of the filter media.

P. *Musfique Ahmed et. al. (2012)[*16], presented strategy of recycling Grey water separately from black water by using decentralized approach. The authors suggested that the recentralized system should be given priority for grey water recycling to reduce burden on centralized system and save transportation cost.

Q. *Amr M. Abdel-Kader (2012)* [3], reported that the treatment efficiency of the RBC system based on BOD removal was ranged between about 93.0% and 96.0%, and based on TSS removal was ranged between about 84.0% and 95.0% for all concentrations of influent grey water.

R. *Ruchi Mehta, et.al. (2012) [20],* shows the calculations for estimating the required area of land treat grey water generated from 20 house community by using vertical flow reed bed(VFRB).

S. *A.H.M. Faisal Anwar (2012)* [1], reveals that the reduction of capillary rise stops when the grey water concentration reaches towards the critical micelle concentration(280 mg/l)value.

T. *Javed Alam et.al. (2012)* [11], suggested the concept of using grey water in various possible fields and thus,making fresh water demand with in control. The use of grey water in India is in the stage of infancy.Though,various developed countries are already utilizing this new water potential after some preliminary treatments depending upon the type of use.

U. *Mohammad Hasan et.al. (2012)* [15], investigated a system involving a granular activated carbon(GAC) biofilm up flow expanded bed(UEB) reactor and slow down flow packed sand filter for treating mosque grey water. The fecal coli form, chemical oxygen demand (COD), total suspended solids (TSS), nitrate (No3) and ammonia as nitrogen were investigated under continuous flow operation using a hydraulic retention time (HRT) ranging from 1-6 hours. In this study the authors recommended to use HRT of 2 to 8 hr to remove physical, organic, chemical and microbial pollutants. This system is effective for treatment of grey water and includes low cost of operation and maintenance.

U. *S. Lambe et.al. (2013)[*10], reported that with increased population growth and development, there is a need to critically look at alternative approaches to ensure water availability. These alternative resources include rain water and bulk of a water used in household will emerge as grey water and contain some minerals, organic waste materials dissolved and suspended in it. The authors suggested to intercept this grey water at the household level, treat it so that it can be recycled for garden washing and flushing purposes.

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V. *Krishna Kumar O, et.al. (2013)[*14], suggested the grey water treatment by the process of bio-remediation, where dirt water from bathroom and sinks are treated using effective micro-organism solution and filtered by use of sand filter. The author concluded that by this method effective treatment of grey water form bathroom and basins can be achieved.

W. *Sahar Dalahmeh et.al. (2013)[*21], developed laboratory scale pine bark activated charcoal and sand filter evaluated as regards their pollutant removal and interaction between medium properties, greywater, microbial activity and bacterial community structure. The authors suggested that the organic matter content and surface hydraulic properties of the bark filters resulted in high BODs removal rates (95%-99%). Also charcoal had large specific are which provided the capacity for high removal of BOD (83%-97%).

X. *Sandeep Thakur, et.al., (2013)[*23], reported to reduce surface and ground water use in all sectors of uses and to substitute fresh water with alternative resources. The author suggested that Grey water recycling is the viable option that can be very useful in the water arid areas.

Y. *Kamal Rana et. al. (2014)[*13], presented some efficient, cheap and sustainable grey water treatment system for households the authors reviewed the processes to identify the best suited processes at household and community level. Septic tank, constructed wetlands and intermittent sand filter are identified as the most suitable processes for decentralized treatment due to the simple operation and maintenance facilities an well an cost effectiveness of the systems.

Z. *Shobha Kundu et. al. (2015)[*25], presented treatment system to treat and reuse grey water for gardening, toilet Flushing and street washing. The treatment system consists of natural process involving equalization cum sedimentation, Fitter bed consisting of sand aggregates and marbles. The author suggested that filtration increases DO concentration and other parameters decrease in grey water so as an to make it usable.

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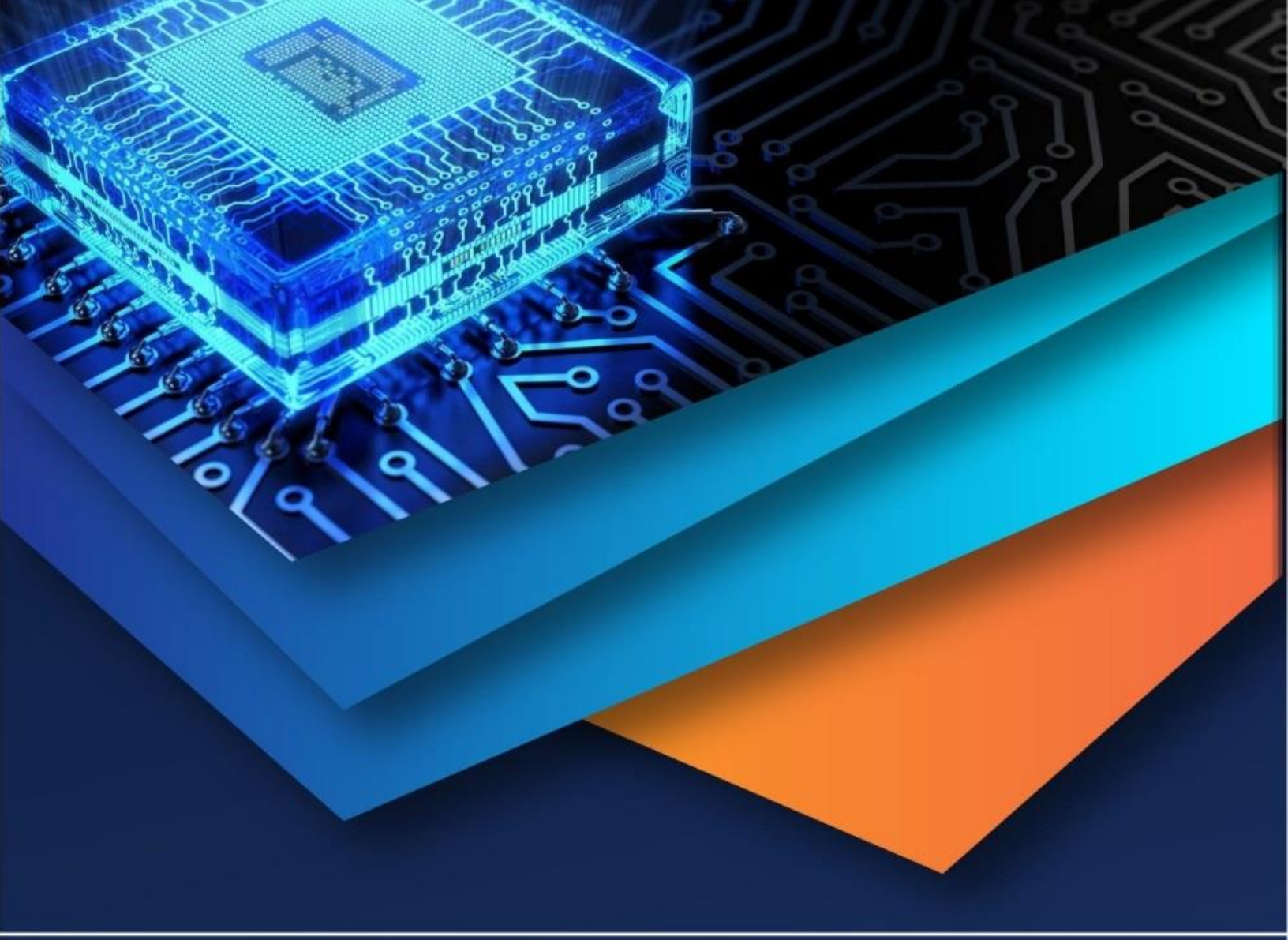

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