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Sewage Treatment of Self Sustainable E-Toilets Using Bio-Digester Method

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Abstract: ***Public sanitation is a cause of concern due to lack of hygienic sanitation infrastructure in the city. The effective use of information, communication and other engineering technologies has led to solve the major inherent issues of public sanitation such as lack of cleanliness and lack of adequate manpower support to manage the units. Electronic toilets have identified that the above issues are prevailing universally and this has a direct bearing on the health of communities. Hence E-toilet concentrates on the following areas where the outcomes shall be in the favour of providing sustainable solutions for above three critical issues. Design of the research is to develop sustainable solutions for the above cited areas, so that it can be used effectively in households, slums or in urban/semi urban locations and cities benefits the city dwellers and the large floating populations. E-toilet are easily adaptable and customizable to the demand of the respective communities. It focuses on a cost efficiency and sustainability. E-toilets provide sanitation that ensures a clean and hygienic environment while recovering recyclable components in a budget friendly (economic) way. To further consolidate, E-toilets focuses on Cleanliness, conversation, cost efficiency, modularity and Universality in our research output. This also covers the advantages of E-toilets in its effectiveness to reduce open defecation, minimizing the pollution and water borne diseases, and improvements in aesthetic value. The study involves the comparative analysis between E-toilet and Conventional toilet.***
Keywords: E-Toilets, Public Sanctity, Hygiene, Bio-digester, Cost Effective.

I. INTRODUCTION

E-toilet is an innovative technology for disposal of human waste in an eco-friendly manner by integrating convergence of electronics, mechanical, web-mobile technologies thereby controlling entry, usage, cleaning, exit, and remote monitoring capabilities with multiple revenue options. Although much advancement has been seen and heard of; in technologies as well as public infrastructure, the sanitation sector still remains weak. In most cases, the public provision provided for sanitation is also not being used effectively by the public as the facilities lack proper hygiene and cleanliness. Another facet which is also seen to contribute significantly towards the deteriorating sanitation system is the lack of appropriate maintenance, insufficient manpower to maintain the units and the unscientific waste disposal methods. E-toilet system is a modular, prefabricated public bio-toilet made of appropriate material suitable to the local conditions and is integrated with user-friendly electronic interfaces. These are sophisticated unmanned, automated smart toilets having remote monitoring facilities, by integrating electrical, mechanical and GPS technology. Toilets are provided with bio digester tanks for hygienic decomposition of soil waste and discharging environment safe effluent as per norms. The effective use of Information, Communication and other Engineering technologies has led to solve the major inherent issues of public sanitation such as lack of cleanliness and lack of adequate manpower and support to manage the units. E-toilet offer utmost cleanliness, sustainability, ease of maintenance and better sanitation.

II. LITERATURE REVIEW

1) *Vinod M.S, Bincy Baby:* The authors provide an extensive solution for affordable toilets which are often an obstacle due to the costs and functions which needs to be addressed. The three critical issues which are termed by the author are a) Cleanliness b) conservation of resources and c) sustainability of toilets. If the issues of the sanitations are not taken into consideration than it could affect the health of the population. Hence, we concentrate on the following areas where the outcomes shall be in favour of providing sustainable solutions for above three critical issues. Design of the research is to develop sustainable solutions for the above cited areas, so that it can be used effectively in households, slums or in urban/semi urban locations and cities benefits the city dwellers and the large floating populations. Hence the universality of our solutions is the most important outcome of our research. He also proposes modular solutions so as to make the toilet easily adoptable and customizable to the demand of the

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respective regions, while focusing on a cost effective, sustainable, and affordable solution. His Research directions to provide affordable sanitation that ensures a clean and hygienic environment while recovering recyclable components. To further consolidate we focus on Cleanliness, conversation, cost effective, modularity and Universality in our research output.

2) *Vijay Bhopal, Nicola Greene, Abhi Bhaargava:* This paper gives the solution of commercialisation of the Nano Membrane Toilet in low income Urban residential areas. Considering that the NMT is a new, high-tech product, a business modelling approach suited the aim to explore ways to understand the target customers and characterise some potential distribution and sales models. This was completed by some basic financial modelling, based on thorough review of existing literature and sanitation delivery models, as well as interviews with key players to support results. This case study was done to illustrate how a preliminary business model option could be developed for this new toilet in typical urban and semi-urban areas.
3) *J. Geetha, S. Sampath Kumar:* In the most developing countries the open defecation to the way of life the habit of open defecation is inseparably integrated in the day to day eye of the people especially in the rural areas and urban slums of India. The practice is considered as most serious environmental bizarre (WHO Fact Sheet, 2014). It is harder to bend the minds of people with regard to open defecation, which they feel that they practice over many generations. This paper is an attempt to bring out the awareness level and practices of 10 randomly selected households from 60 panchayats of Namakkal Perambalur and Padukkoctal Districts of Tamil Nadu on open defecation. The study show that open defecation and its attendant medical problems were component in the community with nobody even bothering to do anything to overcome it. While open defecation was in practice many women especially mothers did not know how to dispose of their children's faces safely.

III.METHODOLOGY

A. *Features of E-toilets*

1) The built form gives a simplistic, pleasant unitised look to each toilet block. Body is built up of metal sheet with finish suitable for the local climatic conditions. The external finish is weather proof.
2) The external wall and roof of the toilet cubicle is fully watertight and weather proof. The roof of the toilet blocks is so designed that no water accumulation takes place. Internal finish and assemblies of the toilet are fully water and leak proof.
3) Each toilet cubicle is fitted with a Coin validator system for entering the toilet. Occupancy indicator with LED display shall be provided outside the toilet.
4) Smart features like Pre-Flush, Auto flush and automatic platform cleaning mechanism (to clean the toilet before and after usage) are provided. In-built water tanks with LED indicators showing water level are provided.
5) Display boards with instructions in Hindi, English and Kannada will be written for the aid of the user. Such display boards will be distinctly visible during night hours.
6) GPS Connectivity will help in monitoring the health status of the unit from a remote location.
7) In case of sudden power outage or water discontinuation, Power and water backup for its users are required.
8) Each toilet is provided with a bio digester tank, suitable for maintenance free processing of the solid waste. The bio digester tank will be dosed with suitable microbial solution in specific intervals to keep the tank fully functional throughout its service life.

B. *Working of E-toilets*

1) The unit may have an Indian style closet or a western style Water Closet (WC), health faucet, lights, status display and instruction boards, etc. An PVC water tank is fitted on top of the toilet unit for storage and supply of water required for the toilet usage and maintenance. This tank is fitted with an LED indicator showing water level.
2) There will be a display light outside the toilet unit, which shows whether the unit is “Occupied” indicated with Red light or “Unoccupied” indicated with Green light. The user will be able to enter and close the door manually, similar to a conventional toilet.
3) The entry to the toilet cubicles will be controlled through a coin insert mechanism. On dropping the desired coins, the door will be automatically unlocked for using the toilet.
4) Upon entering the toilet, the indoor light and exhaust fan will be switched on automatically. Pre-flush system will wet the closet initially. Toilet flush can be activated using a manual flush cock provided inside the toilet. Even if the user forgets to flush after usage, the system will automatically flush after the exit. Exit from the unit is completely manual. An automatic floor cleaning mechanism will also be provided through which the floor will be cleaned automatically. The floor cleaning will be activated either through a push switch or it may be programmed to function after a specified usage.

5) The E-Toilets, though must integrate several electronic technologies for its smooth operations, should not provide any complex electronic interface for the user. The electronic systems should be utilized for effective management of such toilets.
6) The E-Toilets is connected to an anaerobic bio-digester of 2000 litre capacity which will be sufficient for up to 200 defecations per day.
7) The bio digester is of anaerobic type with six (6) compartments followed by disinfection. The compartments have polygrass mats for protection of bacteria on side partition walls. The bio digester will be fitted with a ball valve or bypass arrangement.
8) Bio Digesters are cylindrical/ rectangular structures with the provision of inlet for human waste and outlet for Biogas and Odourless, Harmless Fertile Water produced by bacteria digesting the Human Manure.
9) The discharge from the bio toilet shall meet the desired level after chlorination.
10) The discharged water from the toilets will be connected to the nearest drainage/sewage network.

C. Sewage Treatment

Sewage of E-toilet can be connected to as follows: -

1) Anaerobic Bio-Digester
2) Existing Sewer Line
3) Septic Tank

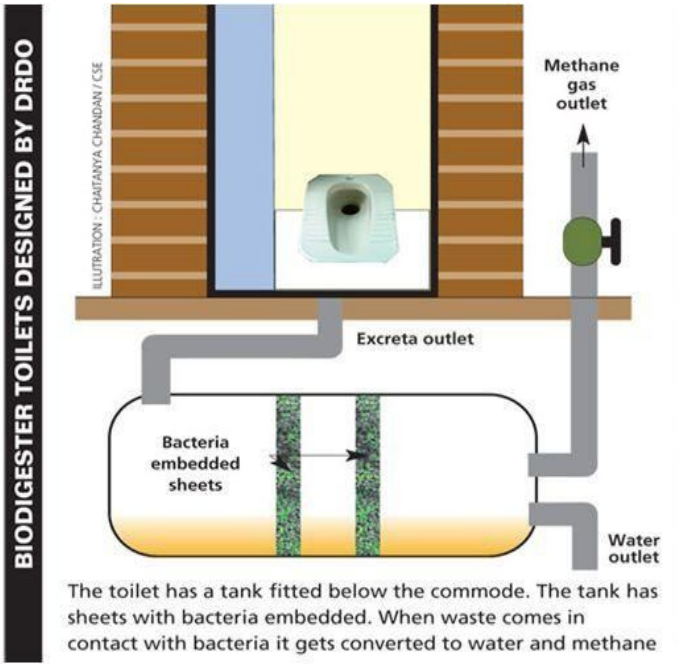
D. Anaerobic Bio-Digester

Anaerobic Bio Degradation involves degradation of human waste without the use of oxygen in a closed container. There are four processes that are carried out during anaerobic decomposition in bio digesters: -

1) Hydrolysis – Breaking down of large organic polymers to simpler monomers.
2) Acidogenesis - Simple monomers converted to volatile fatty acids.
3) Acetogenesis - Acetate converted into CH4 and CO2 while H2 consumed.
4) Methanogenesis - Volatile fatty acids converted to acetic acid, CO2 and H2.

E. Structure of Bio-Digester

1) The Tank of Bio toilet is cylindrical/ rectangular with provision of inlet for human waste and outlet for Biogas and water.
2) Night soil degradation occurs through microbial reaction which converts it into biogas and odourless water. 3.
3) The gaseous effluent (methane) is either continuously let off to the atmosphere or can be collected to be used for various energy incentive activities like cooking (viable for large scale projects).



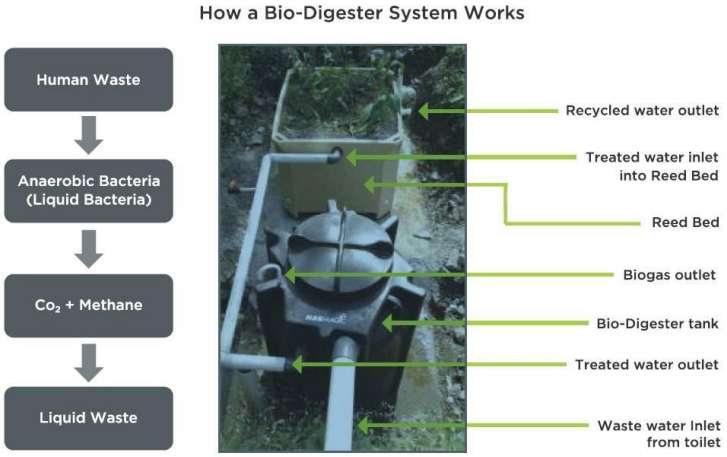
F. Working on Bio-Digester

1) An anaerobic bio-digester completely works in the absence of the oxygen. By imbedding the anaerobic bacteria also known as liquid bacteria.

2) Firstly, the waste water is supplied to the bio-digester tank, where it gets mixed with anaerobic bacteria and gets converted into Co2 and methane gas.

3) Residual liquid waste which is nothing but the water gets passed through the reed bed where this water gets treated for further uses.

4) The methane gas obtained from this process can be used for the cooking purpose and the treated water can be used for gardening, washing, flushing and many other purposes.



G. Quality of Treated Water From E-Toilets

Table 1: - Quality for waste water discharged from bio-digester tank

Parameter	MOEF Standards(A)
BOD, mg/L	30
SS, mg/L	100
TN, mg/L	100
Dissolved P, mg/L	5
Total Residual Chlorine mg/L max	1.0

H. Comparison between E-Toilets and conventional Toilet

Sr. No.	Toilet Feature	E-Toilet	Conventional Toilet
1.	Composition	Smart Toilet	Normal Toilet / Septic Tank
2.	Space	More usable space inside toilet and the digester consumes 1/3 of septic tankand soak pit	3 times the space used forsmart bio toilet
3.	Aesthetics	Better aesthetics due to interior and exterior finish inprefabrication	Depends on workmanship
4.	Ease of Construction	Easy to transport and install	Construction is time consuming and cannot betransported
5.	Hygiene	Better hygiene due to automatic cleaning	Dependent on manual cleaning
6.	Technology	Smart systems for entry flushing, cleaning.	No smart technology

7.	End Product	Water & biogas, Odorless waste, free for environmentdischarge	Sludges & Nitrates, Not safefor discharge due to presence of pathogens
8.	Waste Emptying	Not Required	Quarterly
9.	Maintenance for digesters	No Maintenance for 50 years	Annually
10.	Decomposition	99%	30%
11.	Environmental eco friendly	Green Material used as fullyrecyclable	Brick and mortar are notfully recyclable
12.	Water usage	Less due to recycle of treatedwaste water for flushing	More
13.	Use of Alternative Energy sources	Solar panels may be used topower the toilets	Conventional Electricity isused
14.	Cost	Around 5 lakhs	Around 1 Lakhs
15.	Ease of use	Newer Technology	Familiar technology
16.	Usage Limit	Around 100 uses per day	No such usage limit
17.	Theft	Possibility of theft when not placed in place	No Risk
18.	Possibility of Breakdown	More moving parts and dependent on electricity. Morechances of Breakdown. Hence Has to be properlyused	Clogging and lack of cleanliness are the only realreasons for breakdown

I. Environmental and Social Impact

1) Air quality
2) Noise Quality
3) Water Quality
4) Land Environment
5) Socio-economic impacts
6) Potential environment impact matrix

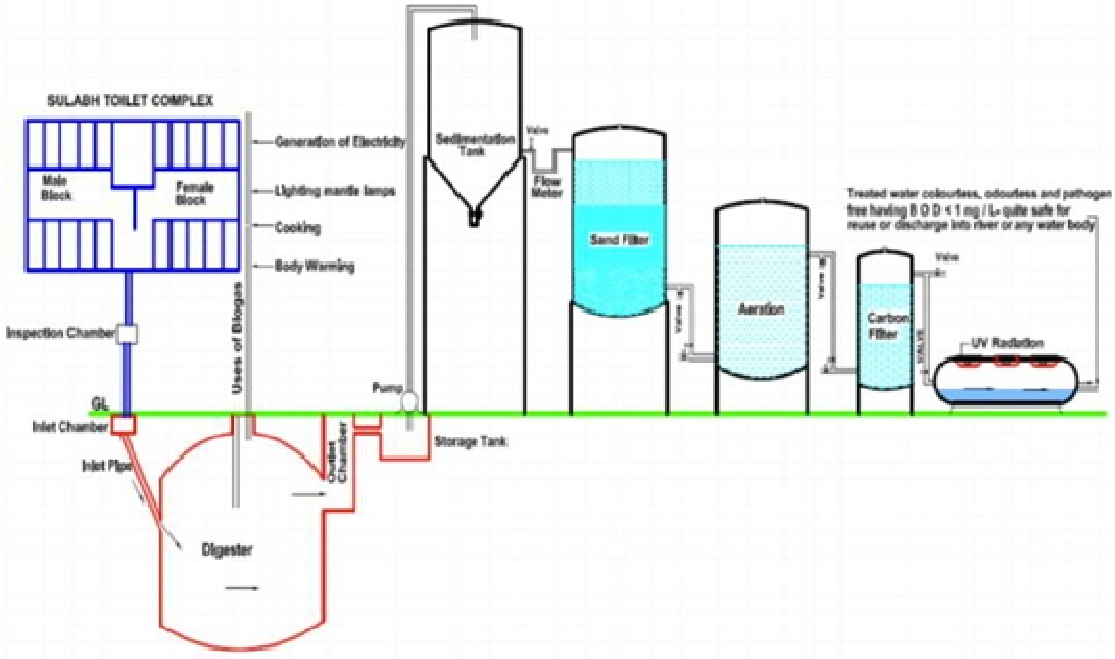
J. Case Studies

1) *Case Study On E-Toilet at Nigdi, Pimpri Chinchwad:* Public sanitation for all has remained the most difficult, exclusive challenge for the PCMC. The inherent huge costs, absence of dependable labour, unattractive job profile, unpleasantness of wastes and the ever-increasing population has had its share in making sanitation a highly neglected and challenging aspect. Supply and Installation of E-Toilets is one of the projects identified under smart city. It is located at Nigdi, Pune. It is a good initiative taken by the HPCL, India. It is the first E-toilet in PCMC. It started from 19 feb,2019 and was inaugurated by the Commissioner of PCMC. It is owned by HPCL, India. The cost of an e-toilet is around 5 lakhs. The wastage is connected to the sewer line. The feedback after use is good by the consumer. In PCMC further scope to implement more E-toilets in more quantity.

2) *Case Study On E-Toilet at Hubli-Dharwad:* Hubli and Dharwad are twin cities in the state of Karnataka and are referred as Hubli-Dharwad. Public sanitation for all has remained the most difficult, elusive challenge. The inherent huge costs, absence of dependable labour, unattractive job profile, unpleasantness of wastes and the ever increasing population has had its share in making sanitation a highly neglected and challenging aspect. Supply and Installation of E-Toilets is one of the projects identified under the smart city proposal of Hubli-Dharwad. In 2018, Around 16 number of E-toilets will be installed in Hubbell and Dharma. The per piece cost is around 8 lakhs. These E-toilet are with anaerobic bio-digester STP in which water is reusable

3) *Case Study on Bio-digester At Shirdi, Maharashtra:* An NGO called Sulabh International Academy of Environmental Sanitation (SIAES) designs and builds toilet-to-methane systems that serve small or large-scale communities. Their large-scale system is a “toilet complex” with a biogas generator attached in the town of Shirdi in Nasik District of Maharashtra. The toilets are pay for

use and the complex has 120 WCs, 28 special toilets and other wash facilities that are attached to the bio digestion system and, because the site is used by a steady stream of religious pilgrims, they see 30,000 to 50,000 visitors every day. The complex was built both as a way to get rid of public health hazards from human faeces, and as a way to generate electricity that lights the site and, in other applications of this NGO's technology, to use methane as cooking fuel and for heating water. The toilet complex requires substantial investment, but the total cost of the biogas facility is undetermined. Because this NGO produces a variety of latrine-to-methane options, the costs vary based on construction. According to Sulabh, to build the toilet system, it costs Rs 70,000 - 1 lakh per seat, including facilities of the seat, bathroom, urinal, sink, room of the caretaker and store room. If there is attachment of a biogas plant, it is an additional Rs 1.5 lakhs. The effluent is used as fertilizer, as it contains nitrogen (5.5%), potassium (2.4%) and phosphate (4.2%). However, to get it to a usable state there is significant infrastructure and technology deployed to ensure that the effluent is "free from odour, colour and pathogens and lowering its Biochemical Oxygen Demand (BOD) around 10 mg/l only." In particular, the system uses sedimentation and filtration through sand and activated charcoal as well as through ultraviolet rays. With this system, the effluent can either be used as an excellent fertilizer or put into bodies of water without harmful impact. Depending on the scale of bio digestion, the Sublah system is able to generate amounts of methane gas that range from fuelling one cook stove for one hour per day (family-sized bio digester) to electrifying an entire park area (as in the case of a fully integrated toilet complex).



4) *Case Study on Bio-digester At Kerala:* Biotech is a consultancy organization that works specifically on managing organic waste and the production of energy from it. Between 2004 and 2007, the organization served approximately 48,000 by building 12,000 small, home-use bio digesters and 200 bio digesters for institutions. In suburban regions, there is demand for hygienic disposal mechanisms for households, institutions and municipalities. The implementation of bio digesters allows for the management of organic waste and wastewater at source, and produces methane gas for cooking, heating, and electricity generation. A cubic foot-sized household bio digester costs about Rs 15,000, with government subsidy available of up to 60%. According to Biotech, an average family can pay back a contribution to the cost of the plant in about three years through savings in LPG use. For institutional use, the integrated waste management systems cost around RS 50 lakhs and Biotech charges an annual operating fee to run the bio digester. Methane gas to generate electricity, an effluent that can be used/sold as fertilizer, hydrogen sulphide that must be scrubbed. According to Biotech, the manufacturing, installation and maintenance of bio generators from their organization has generated an estimated 13 individual work days for each domestic plant, 55 days for each institutional plant and 80 days for each waste to energy plant.

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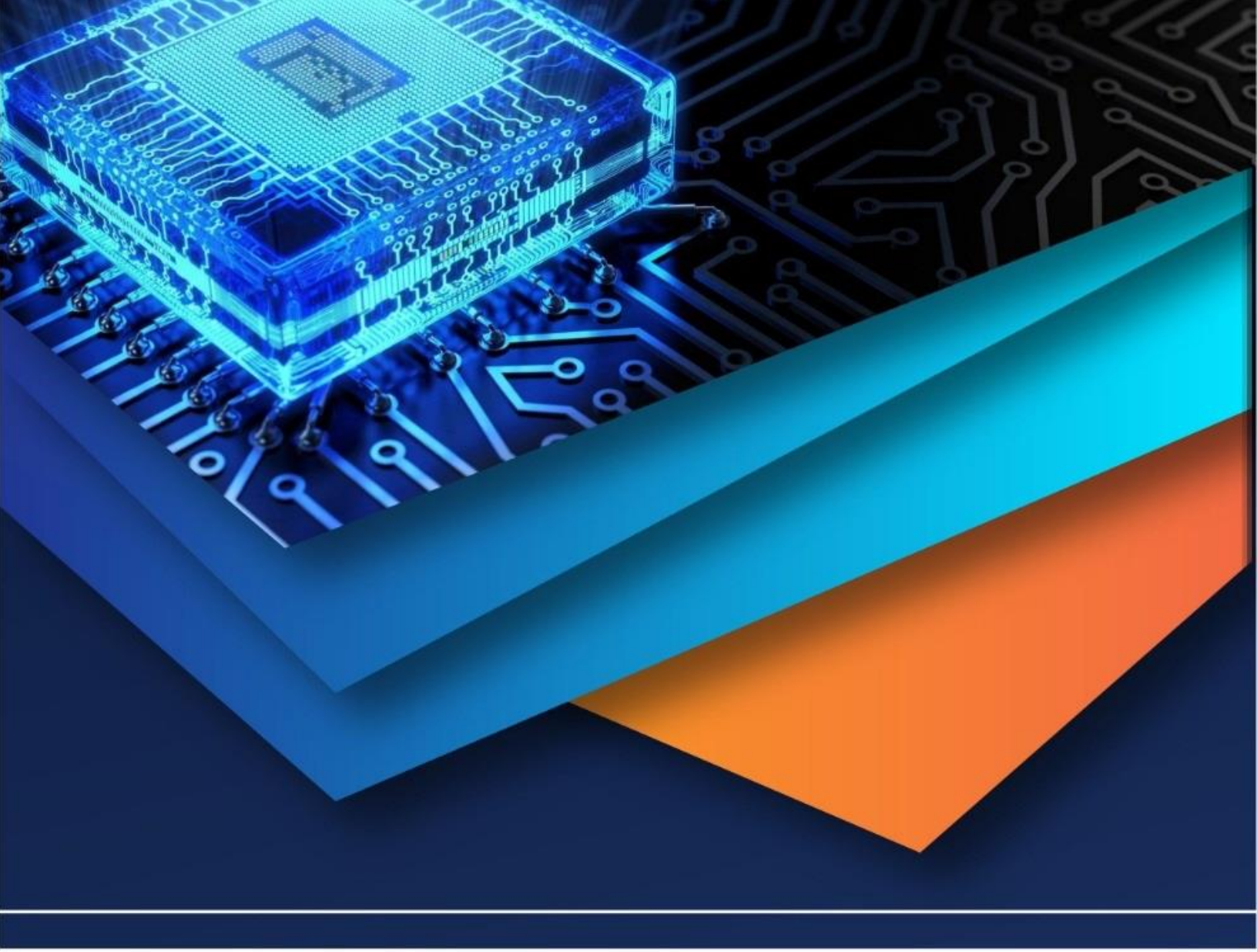


IV. CONCLUSIONS

1) The E-toilet project will have positive impacts on the socio-economic environment of the area.
2) The E-toilet fosters a cleaner, more hygienic environment for the citizens and commuters by encouraging the use of public sanitation facilities and hence reducing the practice of open urination and defecation.
3) Wastes that arise from the toilets shall be digested in a smart bio digester tank or shall be directed to the nearest sewer.
4) Noise produced from vehicular movement and construction activities can be curbed to a minimum by making use of noise shields for machinery, carrying out maintenance of vehicles, and by restricting construction activity to day time.
5) Regular monitoring of air, water and noise parameters shall be carried out to keep a check on routine compliance of statutory requirements.
6) The proponent strongly believes in the concept of sustainable development and understands the impacts as identified above from the proposed project and will take all measures to mitigate such negative impact and also lay emphasis on the implementation of the Recommendations of the Environmental Management Plan in true spirit.
7) E-toilet fulfil all the criteria of Good public sanitation. There is a lot of scope for the implementation of more number of E-toilet in urban and semi urban areas.

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