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Design and Analysis of Grey Water Purifier for Agricultural Application

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***Abstract:** Increase in population in urban areas with lacking drinking water, there is a critical need to sort out the problems caused by the problems caused by energy and water as they are most common and essential part the human life. In this modern society the balancing of energy and adequate water supply with ergonomic surrounding is most important. These problems can short out by implementing Reverse osmosis (RO) system or by Conventional thermal distillation method. Utilising solar thermal energy membrane water distillation process represents a renewable energy and eco-friendly system. In ecologically perspective water demand in cities and urban areas are sorted by building environments in regions with a high correlation between water shortage and high solar rays. The main objective of this research is to treat the grey water with renewable energy system with cost effective manner.*
***Keywords:** Grey Water, Energy, Urban areas, Cities, residential building, management, Distillation process.*

I. INTRODUCTION

Desalination is a practical approach to get constant fresh water supply in the urban areas and Cities. Large scale of sea water is desalinated rapidly by implementing the use of Reverse Osmosis (RO) method and Conventional thermal distillation method [1]. Water and the energy are the most common and essential part of every living life on earth. In this modern world, adequate water and energy supply are prerequisite for economic progress [2]. The twin disaster of increasing global population and modern standards of living are destroying these two resources under colossal pressure [3]. Most technical solutions to these issues concentrate on either energy or water, neglecting the link between them or so called as energy-water nexus-a major consumer of both energy and water-Although the concept of tracking these both issues at once has started to gain the research interest in recent years. In urban residential building the management of energy and the water resource are inseparable [4].

In the most of countries the cities and the urban areas are the large consumers of the energy and water [5]. The World Health Organisation (WHO) gave an instance, they accounted for 95% of water consumption growth in United States between 1985 and 2005. Therefore, conservation of water and energy in buildings is a huge opportunity in realizing savings of these resource, with achieving the goals in green environmental building [6, 7]. The management of water resources concentrates on large [8], ergonomically centralized water supply and sewage disposal which has negative impact on the environmental impacts study conduct [9]. The guidelines released for safe use of wastewater, extraction and grey water provided by the world health organization (WHO) the grey water is said to be the easiest way to water treatment [10]. This is because the grey water has very significant volume of the water flow in households, has lot of enrich in nutrients and minerals which can be beneficial for irrigation, compared to drain water the grey water has less amount of pathogen content and it can reduce the demand for portable water. In this case there is low precipitation and high evaporation access augmentation of water supply with recycled water [11]. Indirect portable reuse can be planned or unplanned, planned indirect portable reuse utilizes the further water treatment. Unplanned portable reuse takes place through discharging treated wastewater into environmental which can used for minerals to soil [12]. Non-portable reuse is the most common water recycling system used in the urban areas. Such system is established in Tokyo, Fukuoka, and Japan [13], as well as Queensland in Australia [14]. A university student in Pretoria has done a study to adopt recycled water system from non-portable uses, most commonly it leads to less bills [15]. As discussed, a various practical study has the proof that recycling grey water in residential building in Urban areas is possible and environmentally friendly [15,16], and of utmost importance [17].

After implementing the efficiency measures, renewable energy (e.g., solar, wind and geothermal) provides a sustainable option for supplying energy and water to the necessity [18]. The requirements of better water management have rapidly increased because of shortage of pure water [19]. In particularly, residential domestic hot water (DHW) demand accounts for 12-20% total building energy consumption [20], with more than 97% of the total DHW is required at temperature of $\leq 40°C$ [21]. The world Health Organisation (WHO) Concludes that a person consumes 2 litre of drinking water per day is compulsorily required for a normal adult at normal condition [22].

Both water and Energy consumption are growing significantly with the expected increases of 27% (Water) [23] and 30% [Energy] [24] by the year of 2030. Rooftop solar thermal (e.g., evacuated tube and flat plate collectors) and solar photovoltaic systems have been widely used in the global to supply heat energy for domestic hot water and other energy needs. Various studies from different nations estimate that solar rooftop could potentially generate up to 20% of total building energy consumption, so there is still a lot of untapped resource which could be gained from rooftop solar technologies [27].

II. PRODUCT FEATURES AND DESCRIPTION

The idea is to treat the grey water from industries using a two-stage filtration setup. The pre-filter consists of a biological filter which will remove the larger particles. In post-filtration, the water will be stored in a metallic tank, insulated from scaling. Glass tubes, copper rods will generate heat using lens panels. The water starts boiling up, producing vapor that will be condensed on the upper cooler portion of the tank. The water collected internally using a partition will be mixed with needed minerals to get the mineralized water as per code IS 10500: 2012. The grey water produced from residential building or industry will be uplifted with pump to an overhead tank storing the water the product will have inbuilt storage tank with a limited capacity. The tank might be horizontally or vertically placed which will decided once the efficiency is determined. Tank will be attached with glass-ceramic tubes which will conduct heat which will be produced by a convex lens to the water hence boiling the water and produce vapor. The vapor get condensed at the top and water is in the purest form which can be extracted as distilled or drinkable water.

III. TARGET AUDIENCE

Water demand in India has been rapidly increasing due to several factors including combination of population growth, economic development, and change in consumption patterns etc. It’s estimated that water demand will continue to rise, and this will present important challenges for the future. This innovative model focuses on resolving this issue through water recycling and reuse, as well as an onsite residential treatment system that converts grey water into potable water that can be supplied by a common tank in residential areas, thereby adequate for fresh water with pollution [28]. The target audience for this respective model include apartments, stadiums, car manufacturing companies, raw material processers, brewery and carbonated beverage water industries, dairy industries, sugar mills and refineries, textile manufacturing, pulp and paper mills, the automotive and aircraft industries and even households for domestic purposes. It likewise intends to the reusable wastewater from private, business, and modern restroom sinks, bath shower depletes, and garments washing gear channels in the metropolitan networks [29].

IV. MODEL DEVELOPMENT

A. Modelled Purifier

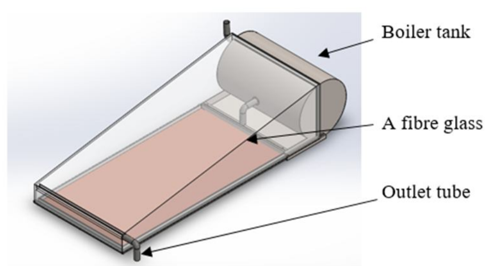

Figure-1: Grey Water Purifier

B. Competitive Advantage

Filters usually use electricity from the grid to power them, it cannot give the portable water, nor can it produce a waste that is highly toxic to the environment. The uniqueness of our project is treating the water by means of natural power and this system can give the same mineralized water for domestic purposes which will be highly useful for mankind. The water which is wasted by the industry will be treated with a naturally powered filter that will be compatible with both industrial and domestic grey water treatment which will completely remove the salt and chemical contents from water. The other industries which work on purification and conversation of grey water usually involve high-level power consumption. But in our solution, we would rather be utilizing the renewable energy available. As we are using Condensation process amount of the waste will be reduced. Comparing other existing solution, the proposed model will have the following advantages such as low electric consumption, high filtration efficiency, and easy installation economical, low self-maintenance, reusable and sustainable, usage of renewable resources for energy.

C. Social Impact

The solution proposed would be energy efficient and cost effective as it would be using renewable resources. By implementing this solution, we will be able to reuse the water in various means. As indicated by reviews, 9,087 billion cubic meters of water each year is polished off on the planet [30]. Whereas 19% of the water withdrawn is used by the industries which can be cut down by implementing this effective solution as the grey water which we get will be converted to the potable water in the end. We can also reduce the electricity consumption in industries where the electricity is consumed to withdraw the water from various freshwater bodies. Hence the public will be benefitted as there won't be any shortage of electricity and water.

D. Market Analysis

The demand for water in all sectors is expected to rise in the coming years as the world's population grows. Water scarcity resulted from a severe imbalance between water demand and water resource availability. With the rising populace and industrialization, it was normal that there would be an expansion in how much sewage and modern waste being produced. However, the country lacked the capacity to treat the current waste. According to survey, the water demand in India in 2025 is predicted to be around 910 billion cubic meters for irrigation, 73 billion cubic meters for Drinking water, 23 billion cubic meters for industrial purposes, 15 billion cubic meters for energy and 72 billion cubic meters for other purposes. Meanwhile the water demand in anticipated to increase in 2050 with the demand of 1072 billion cubic meters for irrigation, 102 billion cubic meters for drinking water, 63 billion cubic meters for industrial purposes, 130 billion cubic meters for energy and 80 billion cubic meters for other purposes. The direct competitors of our product are the industries which work on RO purification and the industries which converts grey water to distilled water. We can use several methodologies to market our plans like approaching the water demanding industries as it would an add on benefit for the industries as reusing the water would comparatively cost low than that of pumping out the fresh water using hi-tech technologies and high energy and other methodologies such as digital marketing etc. Our model has a wider opportunity to enter the market the requirement of fresh water is increasing day by day and the ground water level is decreasing exponentially. Most of the industries are set near freshwater bodies such as ponds and lakes as most of the processes involves the usage of fresh water and not the ocean/ sea water body as it would have more salt content which is not suitable for industrial processes. Our market volume is about 1,200 customers with a penetration rate of 60% and has a average value of ₹50. The calculated market value will be around ₹75,000. So, we expect a market size to double as the rate of wastage increases. This data is an assumed value. The targeted customer is the public every person is our customer giving them their own technology to reuse the water they waste every day. We there by target a small part as several 2,000 customers. The scalability of market in this technology is high as there is always moving of the technology of purification of water. The same market scalability will also increase because of the scarcity of water worldwide.

V. FINITE ELEMENT ANALYSIS STUDIES

A numerical tool for resolving physics and engineering issues is the finite element analysis (FEA). Useful for issues when analytical solutions are not possible due to complex geometry, loadings, and material properties

A. Material Properties

TABLE-1: Material Properties of Selected Materials

Physical Property	Stainless steel	Plain carbon steel	Copper alloy	Galvanized Steel
Density (kg/m^3)	7800	7800	8900	7870
Tensile strength (MPa)	513.613	399.826	394.38	356.9
Yield strength (MPa)	172.339	220.594	358.646	203.9
Thermal conductivity (w/mK)	18	43	390	-
Specific heat (J/kgk)	460	440	390	-

B. Meshing

One of the most crucial processes in carrying out an accurate simulation using FEA is meshing. A mesh is composed of elements that have node coordinate positions in space that might change depending on the element type that symbolize the geometry's shape.

TABLE-2: Meshing of the Design

Mesh type	Solid Mesh
Total Nodes	19187
Total Elements	10123
Maximum Aspect Ratio	164.33
Jacobian points for High quality mesh	16 Points
Element Size	16.4614 mm
Tolerance	0.823068 mm

C. Study Results

A general-purpose finite-element modelling tool called ANSYS is used to numerically solve a wide range of mechanical issues. These issues range from acoustic and electromagnetic issues to static/dynamic, structural analysis, heat transfer, and fluid issues. Ansys can be used in two different ways.

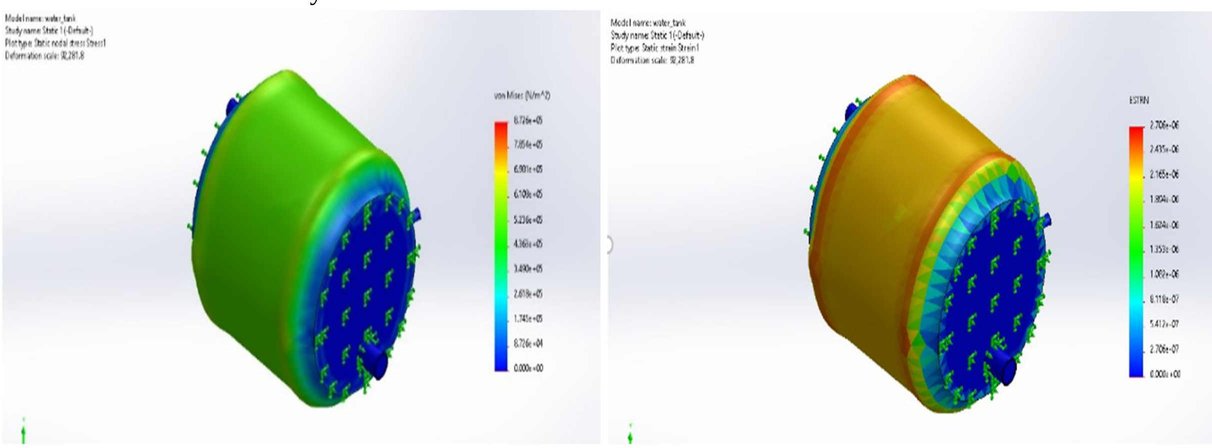

Figure-2: 2(a). Von mises Stress, 2(b) Resultant displacement of Water storage system

TABLE-3: FEA results of Stress and Displacement

Name	Type	Minimum	Maximum
Stress1	VON: von Mises Stress	0.000e+00N/m^2 Node: 1	8.726e+05N/m^2 Node: 16738
Displacement1	URES: Resultant Displacement	0.000e+00mm Node: 1	4.187e-04mm Node: 12487

TABLE-4: Resultant Forces

Selection set	Units	Sum X	Sum Y	Sum Z	Resultant
Entire Model	N	2.26156	7.90656e-05	-3.61204e-05	2.26156

VI. FUTURE SCOPE

Convert the grey water into drinkable water. To be designed in such a way it can be mounted at the top of the home. Reduce the time constraint for filtration. Make it suitable to resist climatic changes.

VII. CONCLUSIONS

Problem on purification of domestic waste water is identified through literature survey. Grey water is initially heated in order to remove bacteria and suitable minerals are added to make it drinkable. Without adding minerals it can be processed to the direct agricultural application. Design of the grey water purifier is designed with the help of SOLIDWORKS. Static Structural analysis of the designed purifier is done with the help of SOLIDWARKS SIMULATION. All the obtained results were tabulated and analyzed. Main aim of the idea is to reduce the risk factor of fresh water involved in agriculture.

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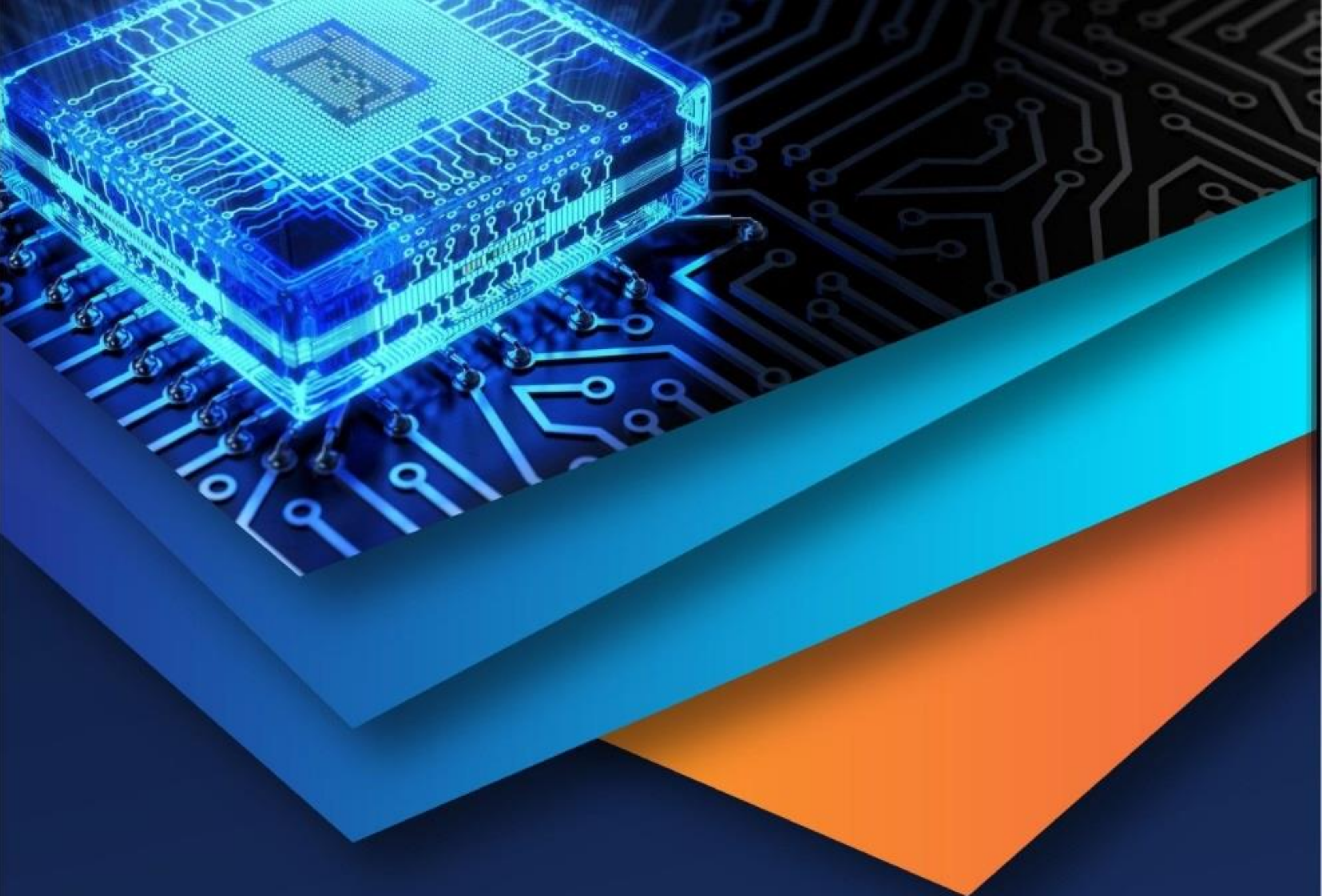

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