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An Exploratory Investigation of Grey Water Using an In-Pipe Filtration Treatment Technology

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Abstract: *Although considerable research has been conducted on greywater treatment and reuse, several important gaps remain that limit its large-scale and practical implementation. Most existing studies emphasize individual treatment techniques such as filtration, biological processes, or chemical methods, while limited attention has been given to the development of integrated systems that combine efficiency, affordability, and simplicity. This creates a challenge in identifying solutions that are both technically effective and suitable for widespread use, particularly in residential and rural settings. Another critical gap lies in the variability of greywater characteristics. The quality and composition of greywater differ significantly depending on factors such as household activities, water usage patterns, socio-economic conditions, and geographic location. However, many treatment systems are designed based on fixed parameters, which may not perform effectively under varying conditions. This lack of adaptability reduces the reliability of existing systems in real-world applications. Furthermore, there is insufficient research focusing on the long-term performance, durability, and maintenance requirements of greywater treatment systems. While several pilot-scale studies demonstrate promising results, their sustainability over extended periods and under continuous operation is not well documented. Issues such as clogging, efficiency degradation, and operational costs require more detailed investigation. In addition, social acceptance and user awareness remain underexplored areas, especially in developing regions. The success of greywater reuse systems largely depends on public perception, willingness to adopt, and proper usage practices. However, limited studies address behavioral and socio-cultural aspects influencing adoption. Therefore, there is a clear need for further research to develop adaptable, cost-effective, and sustainable greywater treatment solutions that consider technical, environmental, and social dimensions for successful implementation.*

Keywords: Greywater, Reuse, Standards, Treatment Technologies, Water scarcity

I. INTRODUCTION

Increasing global water scarcity has made the management of freshwater resources a critical challenge, particularly in densely populated regions such as Maharashtra, India. Rapid urbanization, population growth, and excessive groundwater extraction have significantly increased water demand across domestic, agricultural, and industrial sectors. In this context, greywater reuse and rainwater harvesting have emerged as sustainable alternatives to conserve potable water.Greywater, which constitutes approximately 55–75% of total household wastewater, includes water generated from kitchens, bathrooms, laundry, and wash basins, excluding toilet waste. Due to its relatively low contamination level compared to blackwater, greywater can be treated and reused for non-potable purposes such as irrigation, toilet flushing, and groundwater recharge. Filtration plays a vital role in greywater treatment, with materials such as sand, gravel, coal, and brick fragments commonly used. Among various techniques, vertical sand filtration is recognized as a simple and cost-effective method.

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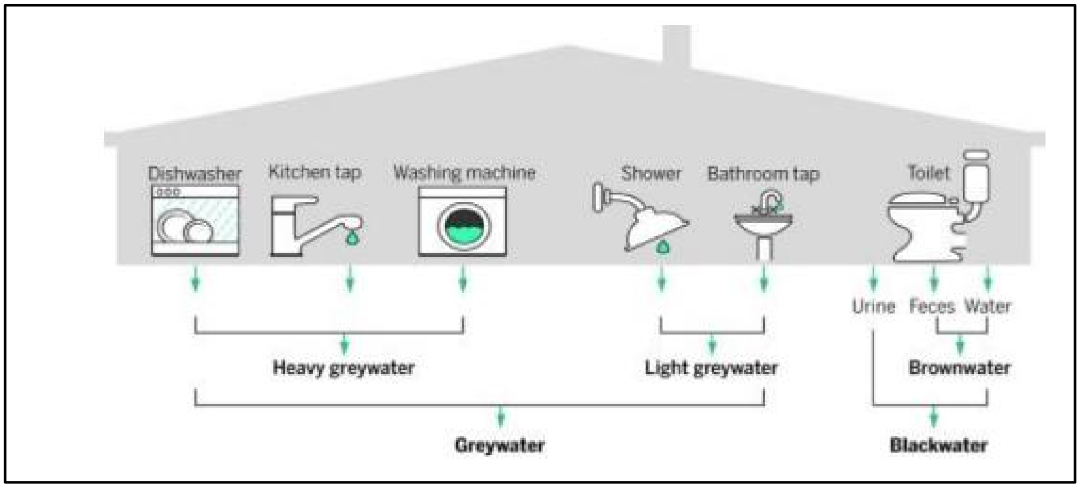

Figure No. 1: Collection of greywater

The characteristics of greywater vary depending on household activities, water usage patterns, and chemical products used. It typically contains organic matter, suspended solids, oils, detergents, and microorganisms. Therefore, proper physical and chemical analysis is essential before reuse to ensure safety and efficiency. Studies have shown that decentralized greywater treatment systems, particularly in-house filtration units, can significantly reduce pollutants such as chemical oxygen demand (COD), biochemical oxygen demand (BOD), and total suspended solids (TSS), achieving removal efficiencies exceeding 85%.

Furthermore, decentralized treatment systems offer advantages such as reduced infrastructure requirements, lower operational costs, and immediate reuse potential. However, concerns related to pathogen presence, system maintenance, and variability in greywater composition must be addressed. Overall, greywater recycling presents a viable solution to mitigate water scarcity, reduce freshwater consumption, and promote sustainable water management practices, especially in developing regions.

II. LITERATURE REVIEW

Antoine morel [2005] has carried out study on proper greywater management comprising of collection, treatment and reuse and/or disposal. Prevents humans of being in contact with it and limits pathogen transfer. A sound treatment also has positive effects on the nearby water bodies, since it limits the input of nutrients and thus eutrophication. Greywater management is not only a precondition for clean and healthy living conditions, it also has a great potential for reuse.

Agunwambaj.c., ukpong e. C. [2012], in his research has suggested, the project is to design and construct a filter for grey water reuse for irrigation of not less than one hundred (100) household. To achieve this objective, samples were collected from one hundred households within the University of Nigeria, Nsukka campus and its environs. Laboratory tests were conducted on these samples and they revealed the presence of BOD, TSS, nitrate, PH, Coli form etc, whose values varies when compared with that of the parameters for standard irrigation water. Filtration plays a very important role in grey water treatment. A filter usually consists of a layer of sand or crushed coal supported on a bed of gravel. The sand used in the filters must be hard and resistant to chemical attack and free from dirt such as clay or dust. The sand could be coarse (0.4-2.0mm), medium (0.3-1.8) or fine (0.25-1.50mm).

Andreasandreadakis,c.Noutsopoulos [2015]Suggestwed Greywater characteristics are highly variable and depend on the living standards, the activities, the income and the habits of the residents. The application of biological greywater treatment systems presents some difficulties especially in the case of a seasonal use of a household, due to the intermittent production of greywater on an hourly basis, the low presence of nutrients in greywater and the need to manage the sewage sludge produced. According to the sampling protocol a total number of 60 samples were collected

(3 residencies, 5 samples for each residence, 4 sampling campaigns). Samples were analyzed for conductivity, total solids (TS), total and volatile suspended solids (TSS, VSS), total and soluble COD, BOD, and heavy metal content.

H. M. Faisal anwar [2014]In this paper, studied surfactant-rich laundry greywater is used to investigate the changes of different soil properties such as, hydraulic conductivity, pH, Electrical Conductivity (EC) and pressure-saturation relationship. A series of soil column (composed of several PVC rings) experiments was conducted under unsaturated condition for different greywater concentration. In each experiment, pH, EC and hydraulic conductivity were measured. Soil hydraulic conductivity depends on the type of soil, porosity and configuration of the soil pores. Saturated hydraulic conductivity data for sequential leaching of soil with tap water and laundry greywater. Hydraulic conductivity increases steadily with greywater concentration.The experiments were performed for different greywater concentrations under unsaturated condition.

Antoine Morel [2006] suggested greywater management must unconditionally be seen as one part of the whole environmental sanitation package, it should also include solid waste and excreta management, surface water drainage as well as hygiene education aspects. These are all equally important components in an effective environmental sanitation programmed. to increase the sanitation coverage in low and middle-income countries typically give low priority to proper management of greywater. It is often assumed that by implementing latrines the issue of inadequate sanitation is extensively mitigated. Greywater is then still discharged without adequate treatment into the environment, be it through open drains, sewer systems or in an uncontrolled way.

III. NEED OF STUDY

India continues to face recurring water scarcity issues, particularly during summer seasons, despite receiving substantial monsoon rainfall. Rapid urbanization, population growth, and inefficient water management practices have intensified the imbalance between water supply and demand. Major cities such as Bengaluru have already experienced severe water shortages, highlighting the urgent need for sustainable water management solutions.A significant proportion of domestic water, nearly 70%, is utilized in activities such as cooking, bathing, and laundry, resulting in the generation of greywater. However, this relatively less contaminated wastewater is often discharged along with sewage, placing additional burden on sewage treatment plants and leading to the wastage of a valuable resource. Greywater recycling presents an effective approach to address this issue by treating and reusing wastewater for non-potable purposes such as toilet flushing, gardening, car washing, and firefighting.

Studies have demonstrated that greywater reuse can reduce household water consumption by up to 50–70%, resulting in substantial savings in water usage and cost. Additionally, decentralized greywater treatment systems can minimize infrastructure load, reduce groundwater extraction, and enhance water sustainability at the household and community levels.Despite its proven benefits, the adoption of greywater recycling in India remains limited due to lack of awareness, inadequate infrastructure, and absence of simple, cost-effective treatment systems. Therefore, this study aims to explore efficient greywater treatment methods and promote sustainable water reuse practices, contributing to improved water security and environmental conservation.

IV. OBJECTIVE

1) To design a demonstration setup for an in-pipe filtering system.
2) To investigate the grey water that has been treated.
3) Using grey water recycling to alleviate water scarcity
4) To provide a low-cost, small-space, and low-maintenance grey water treatment system.
5) To qualification of grey water of multi-storey building.
6) To proposed planning for pipeline network or membrane filter system for multi-storey building

V. METHODOLOGY

Basically methodology based on three parts :

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1. Studyof current scenario ofGrey water.
2. Development of Model for In-pipe filtration treatment system.
3. Examine the performance of In-pipe filtration on the basis of different parameters.

In building generally two pipeline networks are available. One for domestic use of clean water and another for sewerage. Underground large tank in buildings is available to store clean water coming from the municipality. Another tank is available on the rooftop of the building. Water is pumped out from ground tank to rooftop tank by means of mechanical pump. Another tank on the rooftop is available for fire purposes. Domestic water tank's water is used for daily operation. Such as in washing, in cleaning, in flushing etc. Generally the capacity of the domestic water tank is 18000 liters. While the capacity of a fire water tank is 20000 liters for 11 storey buildings. In daily operation, the diameter of a pipe coming out of a domestic water tank is 75 mm. The water will be used in flushing, gardening by reusing greywater using the building's pipeline network. In our project there are two types of pipelines used in the pipeline network. One for domestic water and the other for flushing water. There are two types of sewage pipelines provided in this pipeline network. One for Greywater and the other for Black Water. Underground two tanks will be provided. One of these will be used as domestic water storage and the other tank will be used to store treated greywater. And three tanks will be built on the terrace. These include a domestic water tank, another flushing water tank, and a third fire water tank. Greywater means bathing, kitchen, laundry, washbasin that drains wastewater.

Purify the greywater collected from the greywater pipeline with help of the MBR system and then storing it in an underground greywater tank. Emptying treated water in a flushing water tank by pumping treated greywater. Flushing water tank will be used only in gardening, flushing water, etc. Domestic water tank's water will be used in bathing, kitchen, laundry, wash basin, etc. We compared sand filter and Membrane bio reactor for greywater treatment.

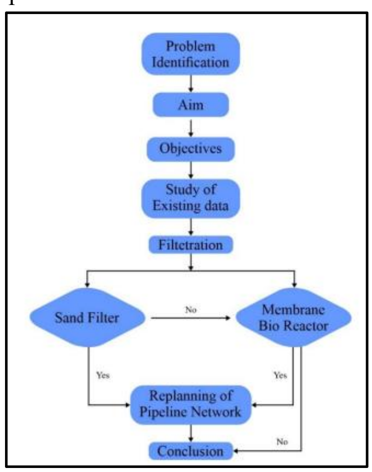

Figure no 2: Methodology

VI. RESULT AND DISSCUSSION

It was observed that the head needed for graywater to gravity flow from the storage tank to the disinfection tank in the updated system is 39 inches. This means that unless the normal operating level of graywater in the storage tank is at or near the overflow line, graywater will not gravity flow to the treatment system. On most days, the system was operating at the overflow line and graywater was still able to flow to the treatment system. However, during periods of low participantactivity such as weekends, the graywater supply in the storage tank was often below the overflow line and therefore may have remained stagnant for longer than 24 hours, possibly resulting in higher strength graywater requiring a larger chlorine dose to treat to levels ensuring the safety of participating participant. Figure 6.1 is a schematic showing the amount of head required in the storage tank. The issues associated with the amount of head required are also related to the residence time of untreated graywater in the storage tank, discussed below

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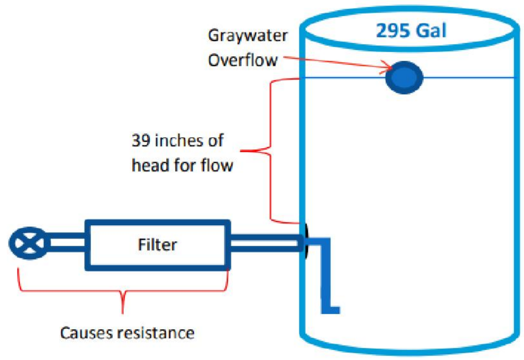

Figure 3 Schematic of Head Requirements in Graywater Storage Tank

The graywater reuse system was designed to process 300 GPD, and during the research phases was forced to process this amount by 'flushing' every hour for four minutes (less frequently during the night) through the use of automatic flush timers. The 300-gallon storage tank and corresponding processing rate were decided upon by assuming a maximum occupancy on the first-floor of 28 participants. The system was designed to account for peak operational demands consisting of all 28 participants flushing a toilet once in a one-hour period. It has since been learned that the maximum occupancy on the first-floor is 25 participants due to one single occupancy room and one show room. Occupancy in the remaining 12 rooms varies from year to year, although all 12 rooms are designed for double-occupancy. Additionally, flow meter readings from the first operational period show a processing average of 91 GPD, indicating that the amount of flushes per participantper day is lower than the theoretical assumptions used to operate the demonstration system on automatic flush timers. A flow rate of 91 GPD is approximately equivalent to each of the 17 participating participants flushing four times per day. A lower storage volume would be ideal due to the lower than expected use of graywater for toilet flushing.

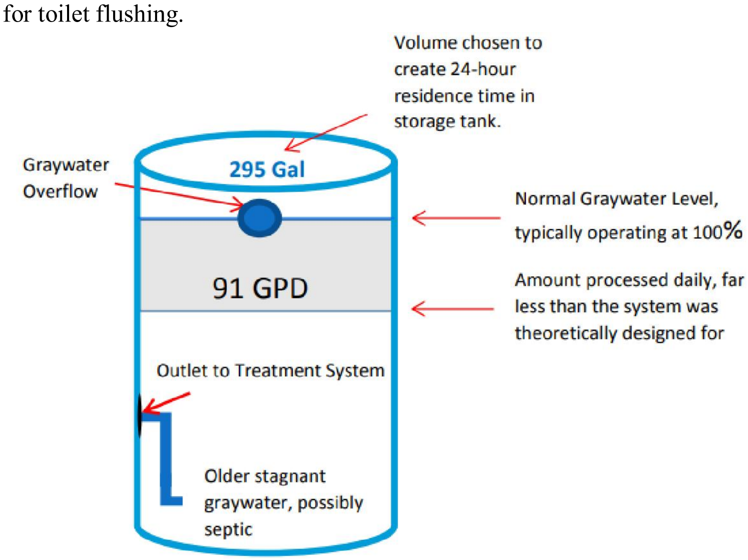

Figure 4 Schematic of Graywater Storage Tank Concerns

Upon completion of the spring 2014 semester, participating participant were given a survey to reflect upon their experience with the graywater reuse system for toilet flushing at Aspen Residence Hall. When asked their opinion of the overall experience, the majority of participant stated they were somewhat satisfied, whereas 2 participants stated they were very unsatisfied and would not participate again. Additionally, participant were asked if they would recommend using non-potable water for toilet flushing to others

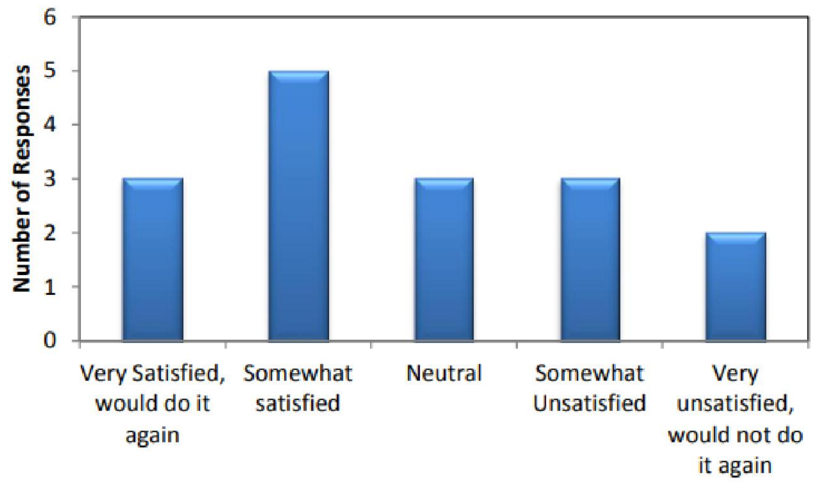

Figure 5 Satisfaction levels of Non-potable Water Use for Toilet Flushing

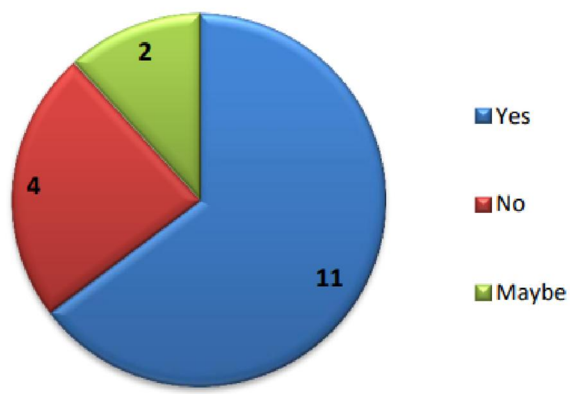

Figure 6 Number of students who would recommend non-potable water to others in an effort to preserve potable water supplies

survey results show that the majority of students feel the main difference between toilet flushing with municipal water and non-potable water is the odor (Figure 6.5). Due to the instances of unexpected foul odors, these results were anticipated.

Grey water generation

Average members in house – **4**

Daily water consumption per capita per day – **200 lit**

Daily grey water generation per capita per day – **150 lit.**

Daily generation of grey water in house – **600 lit.**

B. Grey water sampling for test

1. 1000 ml of grey water collected from house.

2. Sample is stored in plastic bottle for 4^0 C temperatures.

3. Performed following test in laboratory to find out **pH, TSS, BOD5, E- coli.**

Sr.No	Parameters	Results
1	pH	9.5
2	TSS	208 NTU
3	BOD5	180 mg/lit
4	E.Coli	3.4 x 10^3 CFU/100 ML

Table 1. Results

REFERENCES

[1]. Abdel-Shafy, H. I., El-Khateeb, M. A., & Shehata, M. (2014). Greywater treatment using different designs of sand filters. Desalination and Water Treatment, 52(28–30), 5237–5242. https://doi.org/10.1080/19443994.2013.813007

[2]. Al-dulaimi, G. (2017). IMPROVING WASTEWATER QUALITY FROM SEPTIC TANK SYSTEM BY USING A IJCIET. (December 2013).

[3]. Jyoti, J., Alka, D., & Jitendra Kumar, S. (2013). Application of Membrane-Bio-Reactor in WasteWater Treatment: A Review. International Journal of Chemistry and Chemical Engineering.

[4]. Parjane, S. B., & Sane, M. G. (2011). Performance of grey water treatment plant by economical way for Indian rural development. International Journal of ChemTech Research.

[5]. Manna Sahoo, S. (2018). Treatment of Gray Water for Reusing in Non-potable Purpose to Conserve Water in India. International Journal of Applied Environmental Sciences, 13(8), 703–716.

[6]. Shelar, P. A. B., Kalburgi, M. S. M., Kesare, M. N. D., &Kushwah, S. U. (2019). Research Paper on Treatment of Grey Water using Low Cost Technology for Kushvarta Kund Water. (May), 7768–7774.

[7]. World Water Development Report (WWDR). Water for People, Water for Life; The United Nations Educational, Scientific and Cultural Organization: Paris, France, 2003.

[8]. Coalition for Environmentally Responsible Economies (CERES). Water Scarcity & Climate Change: Growing Risks for Businesses & Investors; CERES: Boston, MA, USA, 2009.

[9]. Gross, A.; Wiel-Shafran, A.; Bondarenko, N.; Ronen, Z. Reliability of small scale greywater treatment systems and the impact of its effluent on soil properties. Int. J. Environ. Stud. 2008, 65, 41–50.

[10]. Water Resources Agency Ministry of Economic Affairs. 2014. Available online: http://www.wra.gov.tw/ct.asp?xItem=30421&ctNode=1967 (accessed on 16 April 2016). (In Chinese)