Review on Greywater Reclamation

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Abstract:- **Greywater recycling is a practise that is becoming more and more popular for water conservation and minimising the environmental effect of homes and buildings. Greywater can be treated and repurposed for non-potable uses including irrigation, toilet flushing, and laundry. Greywater is the wastewater produced by sources like sinks, showers, and washing machines. The significance of recycling greywater, its advantages, and the numerous greywater treatment methods are the main topics of the abstract. The abstract also discusses some of the potential drawbacks of recycling greywater, like upkeep costs and safety issues. Greywater recycling ultimately has the ability to drastically cut water usage, lessen the effects of droughts, and improve sustainable water management techniques.**

Keywords:- **Grey water, Recycling, Water conservation, Sustainable living ,Irrigation ,Plumbing ,Treatment systems.**

I. INTRODUCTION

Grey water is wastewater produced by home activities such as bathing, dishwashing, laundry, and cleaning. It is classified as "grey" because, unlike blackwater, it is not substantially polluted with organic waste or pathogens, but it may include trace amounts of soap, detergent, and other household chemicals. Grey water, as opposed to black water, which contains human waste from toilets, is relatively clean and can be reused for non-potable applications such as watering plants, flushing toilets, and cleaning. Grey water is a useful resource that can assist reduce fresh water demand and the strain on sewage treatment plants. By reducing the amount of water that needs to be pumped, treated, and delivered, grey water reuse can also promote energy conservation. But grey water should be adequately cleaned and disinfected before reuse to guarantee that it is suitable for the intended purpose and does not endanger human health or the environment. Ultimately, grey water is an important part of sustainable water management since it can help to create a more efficient and ecologically friendly water system.

II. WHAT IS GREY WATER?

According to WHO- The term "greywater" refers to untreated household wastewater, which has not been contaminated by toilet waste. It includes the water from bathtubs, showers, hand basins, laundry tubs, floor wastes and washing machines. It does not include waste from kitchen sinks, garbage disposal units or dishwashers.[1]

According to NSW Guidelines- greywater means waste water from washing machines, laundry tubs, showers, hand basins and baths from a greywater diversion device or by manual bucketing. It does not include waste water from a kitchen, toilet, urinal or bidet. [2]

Wastewater generated from bathing, washing, general cleaning, kitchen, maintenance of livestock, as well as from community stand posts, wells, hand pumps and other institutional areas, etc.[3]

III. SOURCES OF GREYWATER.

Greywater is the wastewater generated from various household activities, excluding toilet and kitchen wastewater. The primary sources of greywater include[4]

1. Bathroom sinks and showers: Greywater from bathroom sinks and showers typically contains soap, shampoo, and skin cells, among other contaminants.
2. Washing machines: Greywater from washing machines contains detergents, fabric softeners, and other laundry products.
3. Bathtubs: Greywater from bathtubs contains soap, shampoo, and skin cells, similar to bathroom sinks and showers.
4. Bathroom hand basins: Greywater from hand basins in bathrooms contains soap, toothpaste, and other dental products.

5. Air conditioning condensate: Greywater from air conditioning systems typically contains small amounts of dirt, dust, and other particles.
6. Spa or hot tubs: Greywater from spas or hot tubs contains disinfectants, such as chlorine or bromine, as well as other contaminants.
7. Aquarium water: Greywater from aquariums contains fish waste, uneaten fish food, and other aquatic debris.

IV. LITERATURE REVIEW

- Dhiman, et.al. [2022]- The author used Photocatalytic oxidation for treatment of organic matter. The process used UV lamp and titanium dioxide, hydrogen peroxide together to treat the grey water. The results indicated the pH of grey water was reduced by 6%. There is a significant drop in BOD value when gery water is treated with copper pellets The BOD value in the before treatment was 518 and 320 after treatment. A 12.4% reduction in COD value was recorded
- X.Y. Teh, P.E. Poh[2015]- The researcher used the activated sludge process along with disinfection using hydrogen peroxide. The Setup was tested for different HRT [Hydraulic Retention Time in Hours] to determine the optimum HRT. Three Sampling points were selected in the treatment process: Before treatment, between aerobic digestion and disinfection, and after disinfection. The treatment system was successful in removing 88% and 68% of TSS and COD respectively, with optimal operation settings determined to be 5 h of HRT.[16]
- Narges Shamabadi, Hasan Bakhtiari et.al.[2015]- The paper stated various reasons for the need for reuse of grey water. The paper characteristic limits of the treated grey water like BOD, COD, Turbidity based on its uses such as irrigation of green spaces and crops, flushing etc. The Paper also the treatment process used for treating grey water.[17]
- Adi Maimon, Eran Friedler et.al.[2014]- The authors collected samples from 34 houses in Israel presenting several treatment schemes CW - constructed wetland; RCW - recirculating constructed wetland; PT - primary treatment, and RAW - no significant treatment. The samples were tested for BOD5, TSS, PH, electrical conductivity and E. coli. Three factors were found to have an effect on water quality: the type of treatment, the skills of the system designer and whether kitchen effluent was included/excluded from the GW. The average E. coli count in GW treated by a professionally-designed system that exclude kitchen effluent resulted in acceptable risk under all exposure scenarios, even with no disinfection. [18]
- Simon Jabornig, Elisa Favero[2013]- The paper states experimentally how biofilm membrane bioreactors can be used for treatment of grey water. This process is a combination of Activated sludge process and membrane filtration process. The Moving biofilm oxidizes the organic matter and the membrane module filters it. The results were that A start-up with seed organism was not advantageous concerning degradation performance or membrane fouling .[19]
- Suzie M. Reichman, Adam M. Wightwick [2013]- The paper studied the effect of grey water on soil and plants grown in it. The plants selected were lettuce and radish. The water samples used were tap water, greywater from standard laundry detergent, greywater from low environmental impact laundry detergent. The sample with grey water showed the lowest biomass as compared to tap water. The use of greywaters from both the standard and eco detergents tested are likely to have negative impacts on plant growth and soil structure, if not immediately then as salts build in the soil from prolonged use.[20]
- B. Jefferson, A. Palmer et.al.[2004]- The authors stated the uses of grey water post treatment like irrigation of lawns at cemeteries, golf courses and college campuses, vehicle washing, fire protection, boiler feed water, concrete production and preservation of wetlands. A sample of 102 individuals of varying age, genders and washing application was taken from showers, baths, hand basins. The samples were tested for properties like BOD, COD, Turbidity, Presence of Nitrogen and Phosphorus and tabulated the results. The study revealed a deficiency of nitrogen and phosphorus as most of the nitrogen compound is are excreted in toilet bowl.[21]

- Odeh R. Al-Jayyousi [2003] -The author explained the need for the grey water reuse system with emphasis on how its effective can help in reducing the potable water need in arid and semi-arid regions. The greywater was characterized the greywater based on the place of origin and its contents. The various methods of treatment were mentioned. The UK's two stages method was explained which includes Coarse filtration plus Disinfection. The second method was membrane bioreactors [MBR] and biologically aerated filters [BAF], which was successfully implemented in Japan.[22]

V. CHARACTERISTICS OF GREYWATER

- pH: The pH scale measures how much free hydrogen and hydroxyl ions are present in the water relative to other ions. Any liquid's nature may be ascertained by its pH. [i.e., acidic, or alkaline]. As per the guidelines of National Institutes of Health, the pH of grey water should be within the range of 5 to 9.
- Turbidity: Like smoke in the air, turbidity is the opacity or blurriness of a liquid brought on by numerous small particles that are often imperceptible to the unaided eye. When light passes through a sample of liquid, the quantity of light that is scattered by the liquid's constituents is measured as it's optical feature. Turbidity is generally measured in NTU [Nephelometric Turbidity Unit]. Turbidity of any liquid is measured by using Turbidity meters also known as nephelometer. As per the guidelines of National Institutes of Health, greywater has been measured has been measured to have turbidity ranging from 19 to 444 NTU.
- Conductivity: Any liquid's conductivity may be used to determine how well it can carry an electrical current. Conductivity rises with salinity since soluble salts and other inorganic substances transmit electrical current. As per the guidelines of National Institutes of Health, the greywater dielectric strength ranges that have been observed between 14 and 3000 µS/cm.
- Oil & Grease: In water, typically wastewater, oil and grease refer to the amount of fats, oils, waxes, and other related elements present. Oil and grease can interfere with the organic life in waterbodies and leave unattractive coatings if these elements are not removed before processed wastewater is released. As per the guidelines of National Institutes of Health, the oil & grease should not be more than 7 mg/L.
- Biochemical Oxygen Demand [BOD]: The quantity of dispersed oxygen utilized by aerobic micro-organisms present on the organic matters found in a water sample at a particular temperature during a particular time frame is measured analytically as the biochemical oxygen demand. The BOD value is frequently used as a benchmark for the level of organic water contamination and is most frequently stated in milligrams of oxygen used per litre of specimen throughout 5 days of incubation at 20 °C.As per the guidelines of National Institutes of Health, the BOD5 of grey water ranges from 100 to 188 mg/L.
- Chemical Oxygen Demand [COD]: Chemical oxygen demand [COD] is the quantity of soluble oxygen required for the degradation of chemical organic substances present in water. When the amount of organic substance rises, COD rises as well. If inorganic substances that the oxidant [usually dichromate] may oxidize are present, it also rises. High quantities of decomposing plant debris, human waste, or industrial effluent are frequently seen in water with high COD. As per the guidelines of National Institutes of Health, the COD of grey water ranges from 250 to 375 mg/L.
- Total Suspended Solids [TSS]: Total suspended solid is the parched weight of undissolved colloidal matter in a water specimen that may be contained by a filter and evaluated using a filtering instrument termed a laminated glass crucible. As per the guidelines of National Institutes of Health, the TSS in grey water ranges from 100 to 283 mg/L.
- Total Dissolved Solids [TDS]: Total dissolved solid is a measurement of the total quantity of all dissolved both organic and inorganic elements, whether they are in the form of molecular, charged, or micro granular colloidal solids, in a liquid.

VI. REUSE OF GREY WATER

In India 80% of the total water supplied is converted to waste. Of the total waste generated, 62% becomes grey water which can be treated and later reused. [5] The grey water generated can be can be used for a number of daily operations depending upon the level of treatment given to it. The treated grey water can be used of flushing toilets, gardening landscaping, horticulture. [5] There could be a 10 to 20% reduction in the water requirement if it is used for toilet flushing. [6] The treated water used for gardening and horticulture should be made sure that it is free from salts. The grey water can increase the soil pH which would impact nutrient solubility and bioavailability. [7] Research on processing and reuse of grey water is promoted by developed countries like UK, USA, Canada, Japan, Germany, Israel, Sweden and Australia. Recently in the year 2021 India published a Manual for Grey water management under the Swachh Bharat mission.

VII. TREATMENT OF GREY WATER

The selection of the appropriate treatment technology depends on the quality of the greywater, the intended use of the treated water, and the local regulations. The treated water can be reused for non-potable purposes, such as toilet flushing, irrigation, and laundry.

The treatment can be accomplished by:

- Physical treatment
- Chemical treatment
- Biological treatment

A. Biological treatment

The breakdown of organics and their removal from solution in wastewater are the goals of biological treatment systems, which are "living" systems that rely on a combination of bacterial cultures. The most crucial stage of wastewater treatment is biological treatment. Sedimentation typically only removes 35–50% of BOD.[8] There are various Biological treatment methods which can be used for treatment of grey water. For low organically loaded grey water, the Membrane Bio Reactor, Rotating Biological Contactor, and Sequential Batch Reactor are effective. [9]

- Membrane Bio reactor: Simon Jabornig et.al[10] used a membrane bio filter in their experiment. This system consisted of a submersed permeate and back-flushing pump. Membrane bioreactors [MBRs] combine biological wastewater treatment methods like activated sludge with membrane processes like microfiltration or ultrafiltration. The results showed the following removal rates BOD_5- 95%, Turbidity- 99%, TSS- 98%. The COD removal rate was 64%.
- Rotating biological contactor: In the secondary treatment of wastewater after primary treatment, a rotating biological contactor, or RBC, is a biological fixed-film treatment method. The primary treatment procedure starts with the removal of grit, sand, and coarse suspended material through a screening process, then the suspended solids are settled. Friedler et al. [11] studied a low strength grey water treatment system, which consisted of RBC, sand filtration and chlorination.Total removal effectiveness ranged from 64% [COD] to 98% [turbidity], generating exceptionally low effluent BODt [2.3 mg/l] and turbidity [0.6 NTU] .COD removal was substantially lower than BODt removal [96%][11]
- Water hyacinth: B. D. Tripathi et.al used a three stage water hyacinth treatment process consisting of one water hyacinth stage then one algal stage and then finally another water hyacinth stage. The initial results for the untreated sample was - suspended solids 320 mg/L to BOD from 310 mg/L . After the final stage the suspended solid was reduced to 70.5 mg/L and BOD to 9.65 mg/L . [12]

The other methods effectively used such as constructed wetlands, aerated lagoons, trickling filter, activated sludge plant, oxidation ponds, soak pits could be used for the treatment of grey water.[13]

B. Physical treatment

The physical characteristics of greywater are influenced by a number of factors, including temperature, turbidity, electrical conductivity, and suspended particles, among others. Greywater typically ranges in temperature from 18 to 35 °C, and the relatively high temperature may come from warm water used for cooking and personal hygiene. These high temperatures could encourage undesired microbiological growth and precipitate some

carbonates like CaCO3 and other inorganic salts that are less soluble at high temperatures.[14]

Greywater that has undergone physical treatment has had impurities removed using filters and other physical techniques like sedimentation. Sedimentation is the process of allowing suspended particles to create sludge by allowing them to fall out of a liquid under the influence of gravity. [14]

Membrane filtration is used to remove bacteria, particle matter, and organic materials that might cause colour, taste, or odour, as well as components that can interact with disinfectants to produce disinfection by-products. [14]

C. Chemical treatment

Due to the presence of alkaline elements used in detergents, greywater with the majority of its sources coming from the laundry will typically have a high pH. Surfactants are the main chemical components present in greywater, which is produced as a result of cleaning or washing operations. Greywaters have been treated using a variety of chemical treatment techniques in an effort to reduce pollution and reuse water. Greywater typically has a pH in the range of 5-9. It greatly depends on the pH and alkalinity of the water supply.

Chemical coagulation-flocculation is a commonly used process for treating greywater, which is wastewater generated from household activities such as washing dishes, clothes, and bathing. The process involves the addition of chemical coagulants to the greywater, which react with the suspended particles and dissolved substances to form larger particles, known as flocs. These flocs are then removed through sedimentation or filtration, resulting in cleaner water that can be reused for non-potable purposes such as toilet flushing or irrigation. The efficiency of the coagulation-flocculation process depends on several factors, including the type and dosage of coagulant used, the pH of the greywater, the temperature, and the mixing intensity. Commonly used coagulants include alum [aluminum sulfate], ferric chloride, and polyaluminum chloride.[15]

VIII. CONCLUSION

Greywater recycling is a promising strategy to lower household water usage and lessen the effects of water scarcity. Households may conserve a lot of water, lower their water bills, and support the sustainable use of water resources by treating and reusing greywater. Greywater recycling can also increase the health of the soil, encourage plant development, and lessen the need for chemical fertilisers. To ensure their efficiency and safety, greywater recycling systems must be properly designed, installed, and maintained. Regulations and rules must also be followed while using treated greywater to avoid health concerns and environmental contamination. Overall, greywater recycling can be a successful water management approach, but for it to be fully utilized, it needs careful planning, education, and monitoring.

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