Greywater Management System – Biodegradation, Benefits and Challenges

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Table of Contents

Introduction

Freshwater bodies play a vital role in sustaining biodiversity on the face of the earth. These resources maintain the natural balance of the environment and support the existence of species. However, the antagonistic effect of the climate crisis and other anthropogenic causes have rapidly dwindled the extent and the number of freshwater bodies globally. Given that 71% of the earth is covered with water, only a small but significant percentage (of 0.5%) forms the available freshwater source[1]. The water demand is estimated to rise by at least 55% between 2000 to 2050[2]. Scientists and researchers worldwide are occupied extensively to alleviate the stress on water resources and shield the freshwater bodies to prevent their disappearance and desertification. However, most of these techniques make the water more artificial and unaffordable to the common man. The effective and operative means to overcome the water crisis involves water recycling and reuse. Several conventional, energy-intensive, wastewater treatment plants are functional throughout the world involving varied technologies. Nevertheless, these are majorly sewage-based plants employed for the safe introduction of treated effluent in the aquatic bodies with minimal reuse applicability.

Water scarcity prevailing in India

International Water Management Institute predicts a severe water scarcity in India by 2025[3]. The availability of per capita surface water in India has been decreasing and will witness a drastic reduction by the year 2050. The water scarcity and its availability to the consumers are consistently increasing in major states of India, including Uttar Pradesh, Madhya Pradesh, Bihar, Jharkhand, Haryana, Karnataka, Gujarat, Maharashtra, Rajasthan, Andhra Pradesh, Telangana and Odisha. A report by World Bank predicted a zero-ground water level in a minimum of 21 cities in India by 2030. An acute crisis is faced in many Indian metros including Delhi and Bengaluru. The present scenario of water scarcity in India must act as a wake-up call for society and a motivational factor to shift to more sustainable and renewable sources of water. We are in such a fragile situation where any unstainable or unexercised utilization of water is not acceptable. Therefore, a major transition to the greywater recycling system has gained significant momentum for the conservation and management of sustainable water.

Defining greywater

Domestic wastewater contains a blend of water from the toilets and non-toilet sources. Traditionally, the domestic wastewater generated passes through the sewers to the

Sr. No.	Parameters	Values
1.	pH	6.3 – 8.1
2.	Suspended Solids	40 – 340 mg/L
3.	Turbidity	15 – 270 NTU
4.	BOD	47 mg/L – 466 mg/L
5.	Total coliforms	10^6 – 10^8 CFU/100 mL
6.	Nitrogen	2 – 23 mg/L
7.	Phosphorus	0.1 – 0.8 mg/L
8.	Sulphate	< 0.3 – 12.9 mg/L
9.	Conductivity	325 – 1140 mS/cm
10.	Hardness	15 – 50 mg/L
11.	Sodium	60 – 250 mg/L
12.	Chloride	9 – 18 mg/L
13.	Oil and grease	8.0 – 78 mg/L

Kitchen wastewater comprises elevated levels of TSS, oil, grease and BOD whereas, the bathing water and laundry water contains higher COD, phosphorus and xenobiotics.

The common detergents **utilized** in India consist of 40% Sodium tri Poly Phosphate which surges the phosphate and sodium ion concentration, affecting the reuse of laundry water.

treatment site. However, a very imperative component of domestic wastewater with a great potentiality of being effectively reused is "Greywater". Greywater is defined as low strength effluent generated from household sources such as a bathroom, laundry, and kitchen, not originated from the toilet or urinals. The separation of greywater from the sewage system substantially reduces the volume of sewage to be treated and its associated costs.

The water requirement per capita for an average Indian household where sewerage is present records to 135 lpcd of which 70 – 90 L will be generated as greywater. *In situ* treatment and recycling of the greywater involves low cost, simple technology which could be a stand-alone facility for each household or a community treatment plant.

Characteristics of greywater

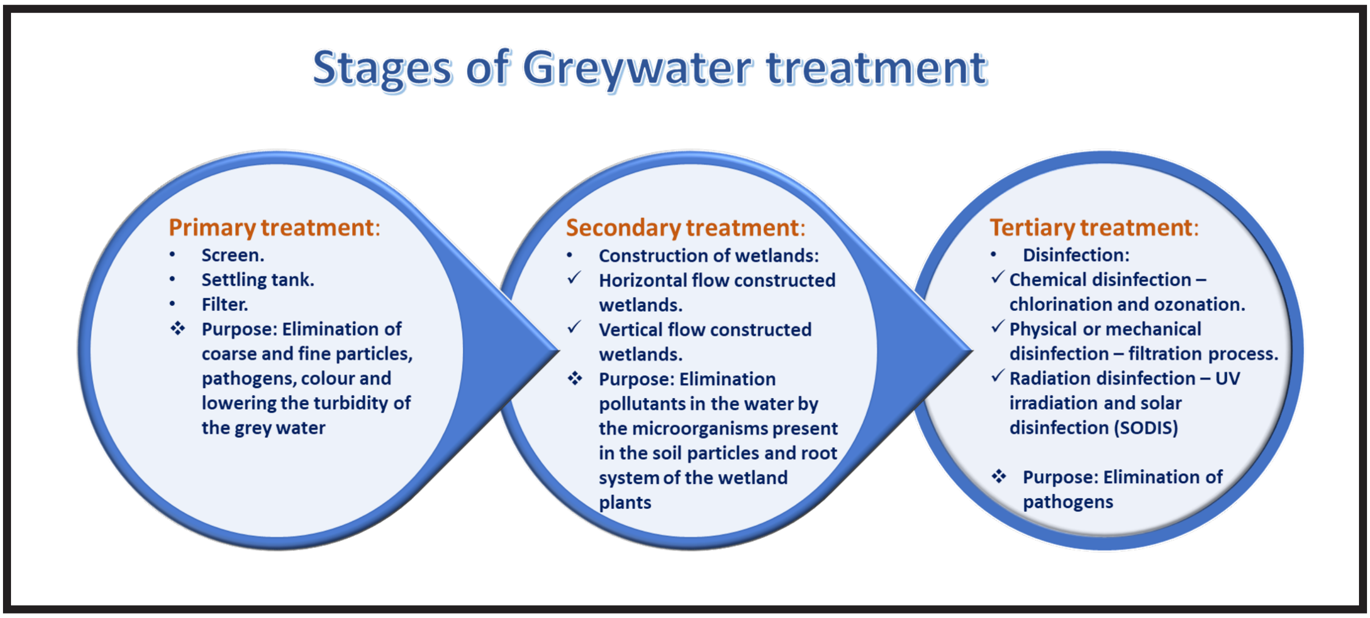
The formulation of the greywater varies widely and relies on the lifestyle, sanitation and hygiene practices followed by the house inmates. The range of values of different parameters of the grey water is referenced as underneath[4,5,6].

The problem statement

In addition to the grave issue of rapid reduction in freshwater resources, greywater generation also imposes several social and environmental threats if not treated well. Greywater though considered less organically burdened as compared to sewage, comprises various detrimental components. Apart from the compounds already mentioned in the table above, the greywater includes detergents, soaps, shampoos, hair, skin, toothpaste, shaving foams, bubble bath, cosmetics, oil and grease. These damaging components easily penetrate the environment if untreated or poorly treated greywater is dumped into the aquatic body. The high load of nutrients in the greywater makes it an ideal source for building up harmful algal blooms at its dumping site. This subsequently causes ecological contamination and proves toxic to aquatic life. Likewise, the untreated greywater upon reaching the soil hampers the permeability of the soil. The oily and fatty component of greywater gets absorbed by the soil, making it water-resistant and thereby, diminishing the soil's water-retaining capacity which negatively impacts the crops. Furthermore, the phosphates and salts occurring in untreated greywater change the characteristics of soil by altering its pH and converting fertile soil into dry soil. This calls for a well-established and effective greywater treatment technique to evade any possible environmental pollution.

Greywater treatment overview

An effective greywater treatment begins with appropriate plumbing and color-coded pipelines. A decent method of capturing the greywater involves the utilization of dual plumbing with the provision of a valve guiding the greywater into the sewer when needed.



The basic three stages of treatment involve primary, secondary, and tertiary treatment. These stages sequentially treat the greywater and make it viable for reuse applications. The figure below depicts the major treatment stages with their related processes.

Microbial degradation of greywater

The principle underlying the microbial degradation of wastewater involves the utilization of metabolic substances such as microbial enzymes for oxidizing the pollutants into simpler compounds, thereby backing up the efficient recycling of the greywater. Biodegradation act as natural waste management and recycling system. Highlighting the importance of the biodegradation process largely contributes towards a healthy environment and healthy human lives.

The list of various compounds and the probable microorganisms for their biodegradation are mentioned under:

a) **Biodegradation of hair and skin present in grey water:**

   The microbes producing keratinase enzymes[7] (Keratin is a structural protein present in hair and the epidermal skin) – *Bacillus, Pseudomonas, Nesterenkonia, Stenotrophomonas, Chryeobacterium, Streptomyces, Fervidobacterium, Vibrio, Lysobacter, Xanthomonas, Microbacterium, Bacillus lincheniformis, Kocuria, Bacillus subtilis.*

b) **Biodegradation of Sodium dodecyl sulphate (SDS):** (one of the principal surfactants presents in detergents, shampoos and utilized as a foaming agent in shaving foams, toothpaste and bubble bath)

   The microbes producing enzymes such as Alkyl-sulphatases, Dehydrogenases etc[8] – *klebsiella oxytoca, Klebsiella liquifasciens, Pantoea agglomerans, Comamonas terrigena, Enterobacter cloacae, Enterobacter liquifasciens, Vibrio, E-coli, Flavobcterium, Shigella, Citrobacter, Citrobacter baakii, Bacillus cereus.*

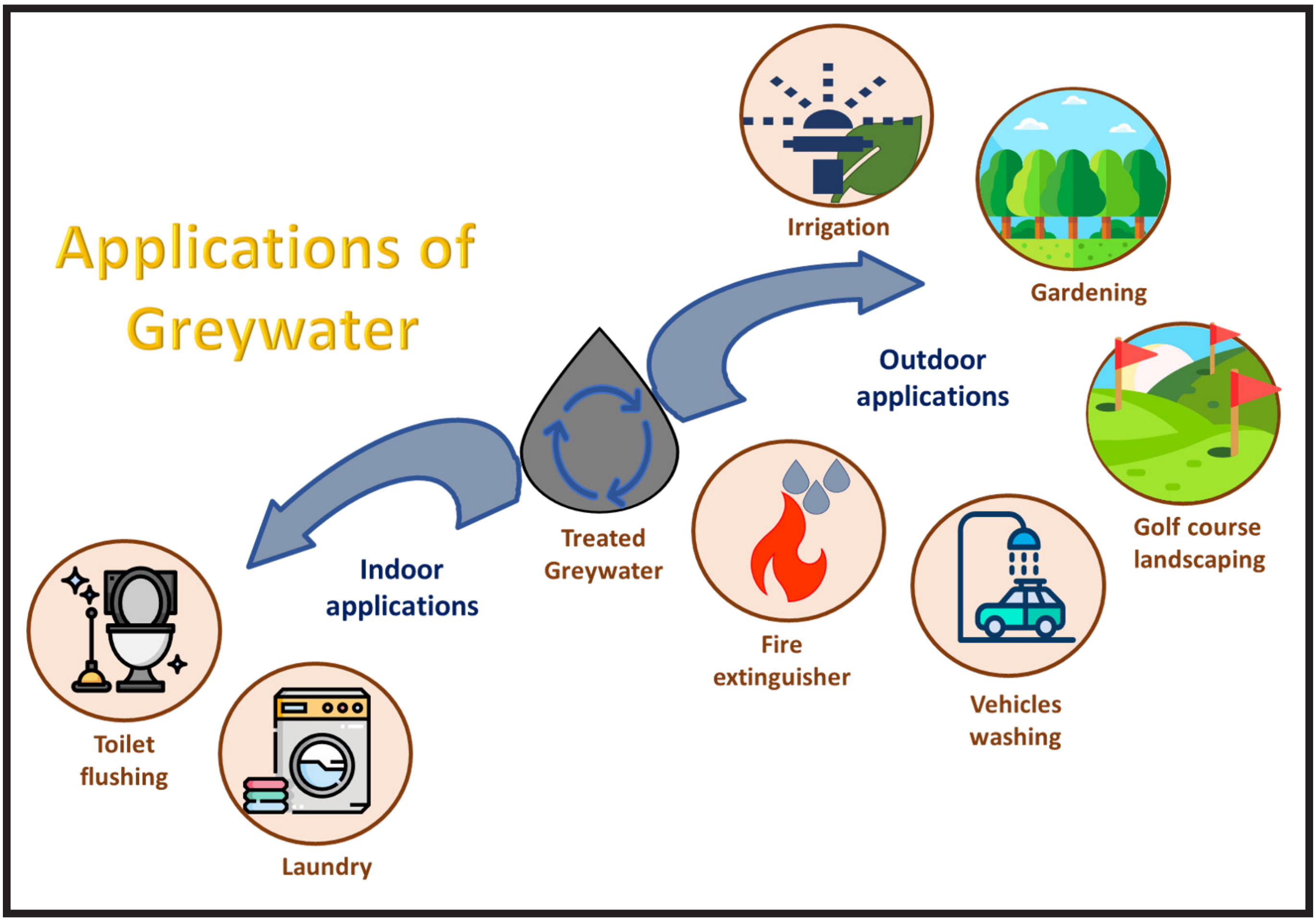
c) **Biodegradation of oil and grease:**

The microbes producing lipolytic enzymes such as lipases and esterases[9] – *Pseudomonas Acinetobacter, Rhodococcus, Thiobacillus, Nocardia, Bacillus subtilis, Flavobacterium, Seratia Corynebacterium, Arthrobacter, Clostridium, Alcanivorax.*

However, several explorations employing the microbes for biodegradation of greywater are still at the nascent stage and requires the optimization of the treatment procedure on a commercial scale.

Applications of greywater

The treated greywater can be extensively utilized in urban, agriculture, industrial and environmental sectors. The reuse of greywater is not recommended in the area where there are high probable chances of direct human contact with the greywater. Greywater is widely suited for gardening and landscape irrigation. Several studies suggest the safe utilization of greywater in irrigating the crops except for vegetables that are eaten raw. Generally, the standards adopted for the reuse of water for irrigation protects human health irrespective of their level of stringency. Therefore, policymakers should be cautious of not making the recycling of greywater costlier with the stringent regulation, as that may be unrelated to human health and obstruct the greywater reuses applications. Greywater applications are broadly categorized as outdoor and indoor application as depicted under:



Socio-economic and environmental benefits of greywater recycling

Owing to the aforesaid reasons, the recycled greywater efficiently meets most of the daily household water demands. Greywater recycling not only relieve the water stress but also forms a major alternative to sustain a balance between water supply and demand in globally. The overall benefits of greywater reuse are as following[10]:

- Lowering the freshwater demands.
- Allowing the establishment of much smaller waste water treatment plant, making the treatment more economically viable.
- Mitigating the damaging impact on the aquatic ecosystem by a significant reduction in the volume of wastewater discharged.
- Decreasing the chemicals utilization during the treatment of waste water, thereby favoring the environment.
- Alleviating the strain on sewage treatment plant resulting into increased lifespan of the plant.
- Reducing the river and groundwater pollution.
- Enhancing the quality of top soil.
- Relatively simple technology with low to medium capital investment.
- Lower energy, maintenance, and operational costs.
- Energy saving owing to non-mandate transport of water.
- Enhancing the sanitation and hygiene standards of people and community.
- Improving the water security.
- Reduction in carbon-footprint.
- Inculcating the sense of responsibility to protect the planet and reduce the generation of waste water into communities.
- Supporting the home gardening practices and thereby, improving the lifestyle of people.

Challenges concerning greywater recycling

Greywater reuse illustrates a series of advantages; however, the recycling of greywater is also associated with several downsides and challenges. Mentioned under are some of the potential concern (though not limited to) associated with greywater recycling[10]**:**

- The probable chances of human contact with the greywater due to an unintentional interconnection of the potable or recycled water system.
- Reduction in the maximum operating efficiency of wastewater treatment plant owing to decreased input of wastewater.

- Relatively a long payback period for the individual systems installed by the home-owners.
- Unavailability of extensive data regarding the occurrence of several pathogens in greywater and risk assessment.

Most of these challenges can be taken care of through public education and awareness and determining suitable water quality criteria for various applications. The cost associated with greywater system installation and its use is expected to decrease with greywater recycling becoming more common. The estimated increase in wastewater service charges in the future allows an increased adoption of greywater recycling systems.

Future research prospects of greywater management

Enough research is done for the implementation of the greywater recycling system at a small scale i.e. in an individual house, with the minimum possible human exposure risks. However, a limited exploration is conducted for the implementation of the large-scale greywater recycling system. The focal point of future research should intend to define the quality parameters of greywater and investigate the potential human health risk. Several implications of water conservation on the communities should be analyzed. Research related to policies and regulations should emphasize the stimulation and adoption of the greywater recycling system. Various compact, modular, easy to use and ready to install greywater treatment products should be endorsed and developed. The microbial degradation of greywater requires intensive research involving microbial enzymes and biochemical pathways. Accumulating and assessing data regarding cost, energy, and water savings, as well as the environmental and community benefits of greywater reuse; plays a noteworthy role in providing evidence and forming the base of policymaking. Development and advancement of greywater recycling infrastructure and strategies to enhance greywater reuse can potentially help the communities to be more sensitive towards water conservation.

Conclusion

Greywater recycling must be taken as a promising step for the conservation of water and to deal with the ever-increasing water scarcity in India and worldwide. Several treatment stages along with the biodegradation of the greywater generate a satisfactorily treated greywater for non-potable applications. The greywater recycling system along with being eco-friendly also offers various socio-economic returns. The utilization of greywater recycling system on the commercial scale needs to be backed up by the government and other non – profit organization in form of funds, awareness, and training. Greywater recycling is the most convenient, simple, and cost-effective technique to address the water scarcity issue in the most affected regions. Proper planning and management of greywater recycling system can significantly contribute to improve and battle the water shortages scenarios globally.

References

1. Bureau of Reclamation. (2020, 11 4). Retrieved from Central California Area Office: https://www.usbr.gov/mp/arwec/water-facts-ww-water-sup.html
2. Is the world running out of fresh water? (2017, April 13). Retrieved from BBC: https://www.bbc.com/future/article/20170412-is-the-world-running-out-of-fresh-water
3. Manna , 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).
4. Ajit, K. (2016, May). A Review on Grey Water Treatment and Reuse. International Research Journal of Engineering and Technology (IRJET), 3(5).
5. Devotta, S. (2007). Grey Water Reuse In Rural Schools Guidance Manual. National Environmental Engineering Research InstituteNehru Marg, Nagpur . United Nations Children's Fund UNICEF, Madhya Pradesh, India.
6. Imhof, B., & Mühlemann, J. (February 2005). Greywater Treatment On Household Level In Developing Countries – A State Of The Art Review. SANDEC - Water and Sanitation in developing countries.
7. Kshetri, P., & Ningthoujam, D. S. (2016). Keratinolytic activities of alkaliphilic Bacillus sp. MBRL 575 from a novel habitat, limestone deposit site in Manipur, India. Spinger Open.
8. P. S., A. (August 2010). Biodegradation Of Anionic Surfactant Sodium Dodecyl Sulphate (Sds) And analysis Of Its Metabolic Products. Shodhganga : a reservoir of Indian theses @ INFLIBNET.
9. Alkhatib, M. F., Alam, M., & F.M. Shabana, H. (2015). Solation Of Bacterial Strain For Biodegradation Of Fats, Oil And Grease. Malaysian Journal of Analytical Sciences, 19(1).
10. Clark, B. Y. (2018, October). The Benefits, Challenges, and Impediments of Greywater Use in EPA Region 5. SSRN Electronic Journal.