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Grey Water Treatment Advancements (Naturally-Physically-Chemically-Biologically) - A Review

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Abstract — *Water is growingly becoming a sparse resource. About 35% reduction of water usage in residential units can be attained with simple technology if grey-water is recycled and reused in toilet flushing and irrigation and construction purposes. Also, it has been a vital technology in developing countries to treat and reuse industrial waste water saving money on all levels; water-heavy-consumption-industry can reduce its consumption by 80% through recycling processes provide benefit after reasonable return of investment period. Large and medium-scale water users need to take measure to conserve it for an active demonstration of their concern about the global pollution and environmental problems. This paper presents the treatment methods for greywater. Technologies used for greywater treatment are classified into natural, physical, chemical and biological systems or a combination of all these. Usage of physical processes solely as the main treatment method is insufficient for greywater treatment, chemical greywater treatment processes are captivating for single household low-strength greywater treatment systems, as the irregularity in the flow of the greywater did not affect their treatment performance. In Natural ways, constructed wetland can be regarded as the most environmental friendly and cost-effective technology for greywater treatment and reuses. Finally, greywater treatment methods mostly vary based on site conditions and the characteristics.*

Keywords- *Greywater, recycle, reuse, advancements, treatments.*

I. INTRODUCTION

Freshwater supply of the world has been in the high risking factor from a past decade and it will face very severe threat in another decade. As the pressure of perseverance of freshwater resources has met a high peak, sufficient enough new sources of supply became increasingly expensive and scarce. Efforts are made to discover contemporary methods in order to increase the efficiency of water & freshwater usage and to expand the practicality of the unorthodox methods which were considered to be unusable. One among those prospective sources of supply is **Grey water**. Grey water reuse is a promising source, which can be utilized on a regular basis and treated for non-potable purposes (1). Progressively, greywater use is seen as a vital component of local, national and international efforts to adapt to climatic changes, extend potable water supply, enhance agricultural income and minimize pollutants in the environment (2).

1.1 Definition

Grey water is a part of Sewage or black water and is a constituent of wastewater from Bathrooms, Sinks, Bathtubs, Showers and Washing Machines (3)(4)(5). Through its name, it suggests us that it is an intermediate product between fresh water and black water but is not so safe to get in contact with. Grey water constitutes of about 55-75% of Domestic waste water generated (6).

1.2 Benefits of Grey water

1.2.1 Minimal fresh water use

Through a vast usage of already used water there will be a very minimal need of the fresh water and many purposes what we need in our day-to-day lives doesn't require usage of fresh water, so as to reduce the strain on treatment plants.

1.2.2 Water table recharge

With the supply of water in excess to the plants than its requirement helps in increasing the recharge of the groundwater level which helps development of water cycle.

1.2.3 Excessive plant growth

Through adequate amount of water supplied to the plants in which fair number of nutrients are present, helps in the increase of plant growth and life.

1.2.4 Improvement of soil through Nutrient Reclamation

Through wastewater disposal into the rivers, it causes the loss of high amounts of nutrients and even lead to soil erosion. Through greywater treatment loss of nutrients can be prevented and fertility of the soil is maintained.

1.2.5 Minimize chemical and energy use

Through the processes such as constructed wetlands and greywater treatments there will be a huge advantage economically and environmentally. From reduction in pumping cost to usage of less chemicals helps in varied ways to the nature.

1.3 Grey water Categories and Characteristics

Majorly the classification is of two types namely:

1) Low Strength Greywater
2) High Strength Greywater

Low Strength Greywater includes bathtubs, showers and traces of urine (4), whereas High Strength Greywater includes Laundry outlets, oils, paints and Kitchen outlets (7).

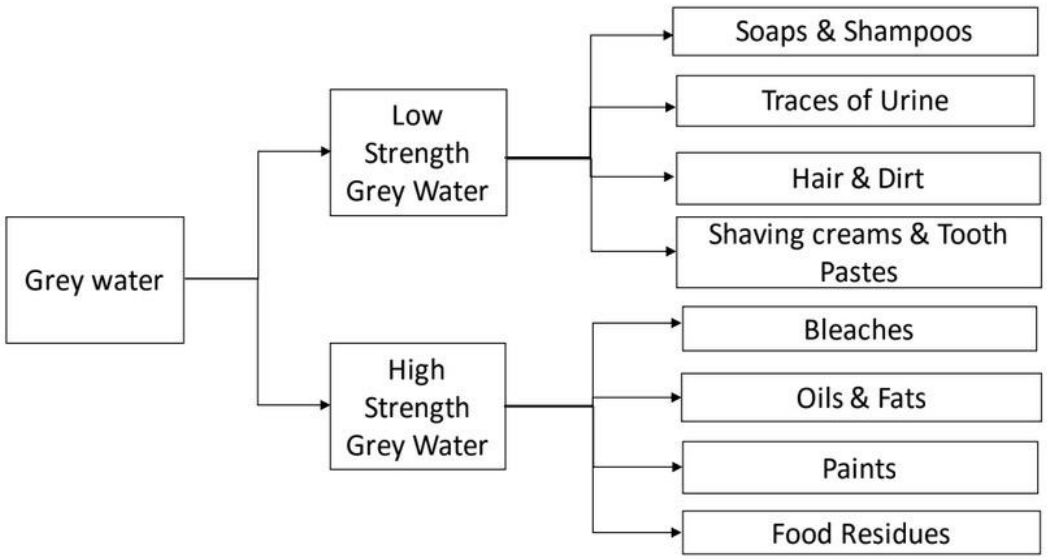

Fig 1: Categories of Greywater

It is very essential to characterize Greywater in order with its physical and chemical parameters before reuse (2). Physical Parameters include temperature, colour, turbidity, Electrical Conductivity, Dissolved solids and Suspended solids whereas Chemical Parameters include pH, COD, BOD, nutrients like Nitrogen and Phosphorus, residual chlorine, ORP, Alkalinity and Acidity. Some Characteristics like nitrogen will be in eminent quantities by presence of urine in Greywater (8).

II. VARIOUS TREATMENTS OF GREYWATER

2.1 Natural Grey Water Treatment Systems

Some of the methods that fall under this natural category are Sand filters, anaerobic filter, vertical and horizontal constructed wetlands.

(9) Natural systems are extensions for the existing naturally available filter media extensively used in the low and middle-income countries due to cost efficiency of the system. Natural system can be used for the treatment of the high strength greywater but requires a disinfection stage to make it free from pathogens.

(10) A slanted soil system was used to treat kitchen greywater using a peculiar soil named kanuma and the slanted nature is to enhance the gravity flows. Presence of earthworms and slugs helped in removal of food particles, preventing clogging. Adsorption helped in removing the Phosphorous whereas suspended solids and organic matter were naturally removed by the general phenomenon of soil. Depletion of nitrogen is assisted by the existence of aerobic and anaerobic zones.

(11) Requirement of large area (0.5 - 3 m^2/person) makes it a tougher ask for its suitability in urban and semi urban areas. makes it a tougher ask for its suitability in urban and semi urban areas. (12) Conductivity was on a rise and observation was made on non-removal of sodium, Magnesium and Calcium in all the constructed wetland technologies. (13) Quality of the treated effluent increasing with increase of recirculation in the system.

2.2 Physical Grey Water Treatment Systems

Some of the methods that fall under this Physical category are filtration and sedimentation. Generally, this method is used as a pre-treatment or post-treatment process. It is either a requirement before chemical or biological method or a continuation for the disinfection process.

(14) Outlined the reduction of BOD and COD values of 274 mg/l and 451 mg/l in the influent to 53 mg/l and 117 mg/l of the effluent respectively using a medium strength UF membrane grey water treatment system. (15) Reported Usage of Sand filter, disinfection and filtration for extreme removal of BOD and turbidity with only usage of physical process.

(10) Using a slanted soil filter consisting of soil, alumina and hydrated silica removed partially phosphorus and completely the traces of nitrogen from kitchen greywater. Nitrogen was removed almost completely due to the de-nitrification reactions from the treatment system. This treatment cannot be considered as the single treatment process but a combination of filtration along with bio-degradation.

(16) Performance and suitability of nutrient oriented decentralized greywater treatment system using a submerged spiral wound module was evaluated. (17) 93% organic removal rate was able to be achieved through direct Nano-filtration membrane, for a low strength grey water.

(18) Grey water samples were collected from bathroom sinks in a university once in a week and were treated by using slow sand filter. 89% and 71.85% efficiency were obtained for BOD and COD respectively. 72.8% and 67% efficiency were obtained for suspended solids and turbidity. Various parameters were evaluated for in varied conditions for various months and it was found that the treated effluent have the required quality to be used for agricultural purposes.

2.3 Chemical Grey Water Treatment Systems

Some of the methods that fall under this Chemical category are coagulation, ion exchange, photo-catalytic oxidation and granular activated carbon. Comparatively very few chemical processes have been reported.

(19) 90% removal of organics by an advanced oxidation process based on photo-catalytic oxidation with titanium dioxide and UV. (20) Treatment of low strength laundry grey water using coagulation, sand filter and granular activated carbon was reported. Reduction of COD, BOD and suspended solids of the influent from 280 mg/l, 195 mg/l and 35 mg/l were reduced to 20 mg/l, 10 mg/l and <5 mg/l of the effluent respectively.

(21) Flocculation process of grey water treatment was evaluated using coagulation with aluminum salt. Anionic surfactant concentration and COD were reduced to 90% and 70% respectively. Study also stated that the process of flocculation was alone not able to reduce organic substances to the permitted reuse standards.

(22) Experiments were conducted on a series of units consisting Filtration, Flocculation, Sedimentation and Disinfection. The main purpose was to provide a low-cost treatment to the University Kitchen and students through a combination of Physical, Physio-Chemical and Biological processes. pH values of greywater from the Kitchen are higher than that of the laundry.

(23) Ferrate (VI) was used for the treatment of greywater and oxidation process was carried out through standard jar test. Samples from 28 apartments and 17 houses were collected using storage tanks. Screens of 6mm and 3mm were used and temperature was maintained at 20^{o}c for a period of 48hrs. Ferrate (VI) was made by electrochemical method. There was a considerable reduction in COD and BOD but showed no result for the regulation of Total Suspended Solids.

(24) Study conducted on unsorted slanted soil medium for the greywater revealed the removal of Suspended solids and COD by 80% and 75%. Considerable amount of organic reduction can be achieved if the filtration is conducted along with chlorination.

2.4 Biological Grey Water Treatment Systems

Some of the methods that fall under this Biological category are Sequencing batch reactors, anaerobic sludge blankets, Rotating biological contractors and membrane bio reactors. Typically, Biological treatment requires pre-physical treatment like sedimentation or/and screening.

(25) Rotating Bio Contactor was analyzed which included pre-physical treatment through sedimentation tank and post-chemical treatment through UV disinfection process. The final quality of the effluent was well within the prescribed standards. (26) Analyzed a submerged plate and frame Membrane Bio Reactor to treat the grey water including kitchen effluent. 85% reduction in the COD and 50% reduction in phosphorus from the influent was found and removal efficiency of nitrogen was not constant and was ranging from 20% to 80%.
(27) Low strength grey water treatment was studied for a sports club using submerged Membrane Bio Reactor. Ammonia, COD and BOD in the effluent were reduced from 11.8mg/l, 109mg/l, 59mg/l to 3.3mg/l, 15mg/l, 5mg/l in the effluent respectively. Effluent was also colourless and Odour-free

(28) Artificial wetlands and commercial bio filters were analyzed. It was carried out in block like apartment consisting of 50 inhabitants. Artificial wetlands were found to be suitable for the new constructions where payback period is around 20 years but the commercial bio filters were found unfeasible, given an estimation period of over 52 years.

(29) Evaluation was done based on three processes namely Activated Sludge process and Moving & Packed bed bio film reactors. On a comparison with this Packed bed bio film reactor shown good results showing a removal efficiency of 92% BOD, 87% COD, 82% Total Suspended Solids. On a whole in this study packed bed bio film reactor proves to be more efficient and producing lower bio solids.

(30) Water flow meters were installed at the inlets of all the grey water treatment systems. Moving bed film reactor and settling tank lab scale equipment was installed. Evaluation was done based on monitoring of Physiochemical and microbiological water quality parameters during the operation. Removal efficiencies of 59% and 70% were obtained for BOD and COD respectively. Removal efficiency of phosphorous was low but the overall treatment effluent quality was ensured to be with in the standards.

III. TREATMENT TECHNOLOGIES IN A DETAILED COMPARISON

S.no	Method of Treatment	Level of Treatment	Application
1	Direct reuse	No treatment	Water recharge through plain land irrigation.
2	Basic physical	Basic treatment techniques such as screening, skimming debris off the surface and segmentation in the storage tanks.	Garden irrigation, pavement cleaning.
3	Natural	Naturally available soil, locally available materials, nylon ropes	Garden irrigation, agriculture and pavement cleaning.
4	Physical, chemical and biological	Filtration, coagulation, disinfection, aeration and membrane bioreactors are typically used in these systems	Garden irrigation, toilet flushing, pavement cleaning, agriculture, construction works, car washing

IV. CONCLUSION

It is very critical to conclude and suggest the best treatment method suitable for the greywater reuse because it majorly depends on the site conditions as well as characteristics. Majority of the people have started to implement greywater treatment techniques around the world to counter the water scarcity, making it more complex to suggest the best method. Laws on standards of treated grey water vary from country to country and there is no law enacted for the standards of grey water yet in India. All the greywater treatment systems have their own advantages as well as disadvantages and off all Natural and Biological treatment methods can be preferred as the best treatment methods. Grey water can also be treated with the combination of any two of the four-available methods to increase the efficiency as well as to reduce the cost.

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