Greywater recycling A review of the available treatment alternatives

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Abstract: All life on Earth depends on water. As Pakistan's economy and population grows, so does the country's water supply, which is only 3% of the world's total. Rainwater harvesting, grey and sewage reuse and desalination are all viable options for Pakistan to consider in order to alleviate the water situation. Water generated in bathrooms, lavatories and kitchens falls under the category of "grey water," which refers to waste water. Grey water, which accounts for about 70 percent of residential water use, may be treated and reused with simple technologies. Minimizes the amount of fresh water needed and reduces the amount of sewage delivered to treatment plants through the reuse of grey water. Water and waste water treatment must be linked so that water supplies are maintained and waste water can be reused for agricultural and industrial purposes.

The Christian Hospital Taxila area generated a lot of grey water, so an integrated grey water treatment facility was built. Natural physical processes were combined to create the integrated model, which includes, sedimentation, filter medium and reverse osmosis. For the sake of this investigation, the hospital area was divided into two halves. Zone-I and Zone-II, which include the hospital and residential areas. In the spring, winter, and summer seasons, 4 random samples were obtained from the kitchen and bathroom, with tap water and borewell water as sources of supply.

In the spring, winter, and summer seasons, the overall performance of the integrated plant for treatment of kitchen and bathroom grey water using tap water and borewell water was excellent, producing very high quality effluents. The effectiveness was demonstrated in terms of COD (86%), BOD (96%), Coliform (99%), TSS (87%), TDS (58%), Turbidity (98%), and Total hardness (98%) reduction competence (97 percent). In both rural and urban areas, this treatment technique can be regarded a feasible alternative to conventional treatment plants.

Keywords: Greywater, Recycling, treatment, filtration

Introduction:

Background of the Study:

Black water and grey water are the most common types of waste water. Grey water, usually referred to as sullage, is non-industrial waste water produced by household activities such as dishwashing, laundry, and bathing. Grey water accounts for 50-80% of home waste water. The number and content of chemical and biological impurities in grey water differs from that of black water (from faces or toxic chemicals)(Pangarkar et al., 2010).

The label "grey water" comes from its murky appearance and the fact that it is neither fresh nor badly contaminated. Grey water is defined as any water draining from a home that is not toilet waste. Despite the presence of grease, food particles, hair, and a variety of other pollutants, this spent water may be appropriate for reuse. Grey water reuse accomplishes two goals: it reduces the quantity of fresh water required to supply a household and it lowers the amount of waste water entering sewer or septic systems.

Grey water is domestic waste water collected from residential units, business buildings, and community institutions. It could include industrial waste water (food, laundries, etc.) as well as ground infiltration and other waste liquids. It's mostly spent water from the building's water supply that's been mixed in with the waste effluent from toilets, kitchens, and laundry(Ottoson & Stenström, 2003).

The discarded water from the kitchen, bathrooms, and laundry is referred to as domestic waste water. Because many minerals and organic matter in water serve as food for microorganisms. Reducing reliance on potable water is becoming an essential aspect of efficient water management. Many new or modified treatment technologies are being studied in an effort to address the major water supply and waste water disposal issues that the rising population and industry face. Even with the use of the water-saving strategy, a substantial volume of water is still required, and reuse of water may be required in the future. As a result, numerous possible water reuse techniques have been investigated, including distillation and membrane techniques and microbiological oxidation, filtration, and disinfection schemes for partial reuse(Dalahmeh et al., 2012).

Generation of Grey Water:

Grey water accounts for 50-80% of home waste water. Table 1 depicts the many sources of grey water generation.

TABLE I WATER REQUIREMENT & GREY WATER GENERATION

Sr. No	Description	Quantity of fresh water	Grey water generated
1	Bathing	15 – 20	15 – 20
2	flushing	10 – 15	-
3	Cloth washing	8 – 14	8 – 14
4	Washing of utensils	5 – 8	5 – 8
5	Floor washing	3 – 7	3 – 7
6	Cooking	4	-
7	Drinking	5	-
	Total	**50 – 73**	**31 – 49**

Table II shows the percentage of grey water created by home use.

TABLE II PERCENTAGE OF GREY WATER GENERATED

Sr. No	Source	Greywater %
1	Washing of house	10
2	Washing of utensils	10
3	Cooking	5
4	Laundry	20
5	Bathing	55
	Total	**100**

Quantification of Grey Water:

The first step in designing a grey water collection, treatment, and reuse system is determining grey water generation and flow rate. The following methods for quantifying grey water are proposed in table III.

TABLE III METHOD FOR QUANTIFICATION OF GREY WATER

Sr. No	Methods	Type
1	Direct Method	i. Water meter ii. Bucket method
2	indirect Method	i. Water consumption ii. Type of uses

Composition of Grey water:

Qualitative composition of grey water is given in table IV.

TABLE IV QUALITATIVE COMPOSITION OF GREY WATER

Water source	Suspended solids	Bacteria	Food particles	odor	Oil	Organic matter	Oxygen demand	Chlorine	Foam	hair	pH	Phosphate	Salinity	Soap	Sodium
Kitchen	O	O	O	O	O	O								O	
Bathing	O	O		O	O		O			O					
Cloth washing	O				O		O		O	O	O	O	O	O	O
Washing of utensils	O	O	O	O	O	O	O				O	O		O	O

Grey Water from Bathroom:

Hand washing and bathing account for about 50-60% of all grey water, and this is generally thought of as the least polluted variety. Soap, shampoo, hair dye, toothpaste, and cleaning products are among the most common sources of chemical contamination. Through the process of body washing, it has acquired a little amount of faecal contamination as well.

Grey Water from Kitchen:

Grey water from the kitchen accounts for around 10% of the overall amount. Contamination includes food particles, fats and oils, and other pollutants, all of which have been dumped there. Microorganisms thrive in this environment because it readily encourages and supports their growth. There are also alkaline cleaning products in the grey water from kitchens, including detergents and other cleaning agents.

Grey Water Quality:

Household grey water characteristics might vary depending on the number of residents, their health status and the type of tap water used, as well as the consumables used in the home (such as Soaps, Shampoos, Detergents, Mouth wash, Tooth paste, Hair style, Shaving cream and body oils). Table V shows the usual chemical composition of grey water.

TABLE V COMPOSITION OF GREY WATER

Sr. No	Parameters	Unit	Ranges
1	Suspended solids	Mg/l	45-330
2	Turbidity	NTU	22-200
3	BOD5	Mg/l	90-290
4	COD	Mg/l	280-800
5	Conductivity	mS/cm	325-1140
6	Oil	Mg/l	37-78
7	Temperature	℃	18-38
8	Ammonia	Mg/l	<0.1-25.4
9	Total Dissolved Solid	Mg/l	126-175
10	Coli form	Cu/100ml	0-500-10000
11	Total phosphorous	Mg/l	0.6-27.3
12	pH	--	6.6-8.7
13	Nitrite	Mg/l	<0.1-0.8
14	Total Kjeldahl Nitrogen	Mg/l	2.1-31.5
15	15 Sodium	Mg/l	29-230

Reuse of Grey Water:

Water scarcity is one of the most serious threats to human health and environmental integrity in many regions of the world. As the world's population increases, so does prosperity. Water needs are increasing and multiplying without the ability to meet them. Toilet flushing, garden irrigation, outdoor uses, laundry, and even showering are all examples of grey water applications. The treatment method and the quality of the treated grey water must be tailored to the reuse application. Because of the apparent benefits in terms of fresh water conservation and management, grey water has been reused and recycled in various nations.

Associated problems:

Because of the particles found in grey water, as well as its chemical and biological properties, it may be suggested that grey water has some properties that could cause damage to plant growth and, or the environment. Grey water from the kitchen sink and dish washer should not be reused since it can include high amounts of organic compounds, lipids, and caustic chemicals that are not easily broken down by soil organisms. Soaps and detergents are the components of grey water that have the greatest potential to harm plants. We chose to test for its qualities (physical, chemical, and biological) and then purify it to fulfil the standard for reuse based on these facts.

Literature review:

A summary of previous research on the quantification, characterization, and treatment of grey water, as well as its reuse for long-term development.

(Kundu et al., 2015) demonstrated a system for treating and repurposing grey water for gardening, toilet flushing, and street cleaning. The treatment system includes natural processes such as equalisation and sedimentation, as well as a Fitter bed made of of sand aggregates and marbles. Filtration, according to the author, raises DO concentration while decreasing other parameters in grey water, making it useable.

(Pachkor & Parbat, 2017) demonstrated some residential grey water treatment systems that are efficient, inexpensive, and long-lasting. The writers looked at the methods to see which ones were better for households and communities. Due to the ease of operation and maintenance, as well as the systems' high effectiveness, septic tanks, built wetlands, and intermittent sand filters have been identified as the most ideal procedures for decentralised treatment.

(By-products, 2021) reported on reducing surface and ground water use in all areas of use and substituting alternate resources for fresh water. Grey water recycling, according to the author, is a practical technique that can be highly valuable in water-scarce locations.

(Rangdale et al., 2018) Pollutant removal and interactions between medium characteristics, greywater, microbial activity, and bacterial community structure were investigated using a laboratory scale pine bark activated charcoal and sand filter. The organic matter concentration and surface hydraulic features of the bark filters, according to the authors, resulted in significant BODs removal rates (95 percent -99 percent). Also, charcoal had a big specific area, which meant it could remove a lot of BOD (83 percent -97 percent).

(El Hamouri et al., 2008) Grey water treatment via bio-remediation is recommended, in which dirty water from bathrooms and sinks is treated with an effective micro-organism solution and filtered using a sand filter. The author came to the conclusion that this procedure can effectively treat grey water from bathrooms and sinks.

(ÜSTÜN & TIRPANCI, 2015) According to the paper, with rising population expansion and development, alternative means to ensuring water availability must be rigorously examined. Rainwater and the majority of domestic water will emerge as grey water, which will contain certain minerals and organic waste items dissolved and suspended in it. The authors propose that grey water be intercepted at the household level and treated so that it can be recycled for yard cleaning and flushing.

(Al-Mughalles et al., 2012) For treating mosque grey water, researchers looked into a system that included a granular activated carbon (GAC) biofilm up flow expanded bed (UEB) reactor and a slowdown flow packed sand filter. Under continuous flow operation with a hydraulic retention time (HRT) ranging from 1-6 hours, the fecal coli form, chemical oxygen demand (COD), total suspended solids (TSS), nitrate (No3), and ammonia as nitrogen were evaluated. The authors of this study suggested using HRT for 2 to 8 hours to remove physical, organic, chemical, and microbiological contaminants. This system is efficient at treating grey water and has low operating and maintenance costs.

(Alam & Muzzammil, 2012) proposed the idea of repurposing grey water in a variety of fields, hence reducing fresh water consumption. In India, the usage of grey water is still in its infancy. However, depending on the sort of application, several developed countries are already harnessing this new water potential after some early treatments.

(Faisal Anwar, 2012) demonstrates that when the grey water concentration reaches the threshold micelle concentration (280 mg/l), the decline in capillary rise ends.

(Bruno, 2019) displays the calculations for calculating the required amount of land to treat grey water created by a 20-home neighborhood using a vertical flow reed bed (VFRB).

(Abdel-Kader, 2013) For all concentrations of influent grey water, the treatment effectiveness of the RBC system was varied between about 93.0 percent and 96.0 percent for BOD removal, and between about 84.0 percent and 95.0 percent for TSS removal.

(Ahmed, 2012) suggested a decentralized strategy for recycling grey water independently from black water. To lessen the pressure on the centralized system and save transportation costs, the authors advised that the recentralized system be given preference for grey water recycling.

(Al-Mefleh et al., 2021) reported to design and build a filter for grey water reuse for irrigation of at least 100 households These samples were sent to laboratory analyses, which revealed the presence of BOD, TSS, nitrate PH, coliform, and other parameters, the levels of which differed from those of typical irrigation water. According to the author, the slow sand filter's efficacy in reducing all parameters was high due to their palpable nature, which allows them to succumb to surface pressures of the filter media.

(Parjane & Sane, 2011) offered a good design of laboratory scale grey water treatment system, which is a hybrid treatment process that combines natural and physical operations such as primary settling with cascaded water flow, aeration, agitation, and filtration. For the treatment of bathroom, basin, and laundry grey water, the plant's economic performance was studied. The author conducted a large-scale cost-benefit analysis of the system and discovered a more efficient approach in the rural area.

(M et al., 2016) described the classification of grey water collected from several sources and sites in Dhaka. The author proposed a residential and mosque grey water treatment system that is efficient, inexpensive, and long-lasting. Grey water that has been treated can be utilized for non-potable purposes such irrigation, toilet flushing, car washing, and replenishing aquifers.

(Rajaram et al., 2010) proposed an integrated approach to water and wastewater treatment, concluding that every drop of effluent in rural and urban India should be recycled. So that it does not contaminate our drinking water supplies and conserves limited water resources for the entire population's thirst.

(Pangarkar et al., 2010) In terms of water pollutants such as COD (83 percent), TDS (70 percent), TSS *83 percent), total hardness (50 percent), oil and grease (97 percent), anions (46 percent), and captions, the plant's economic performance for the treatment of bathrooms, basins, and laundries grey water was evaluated (49 percent). According to the authors, this approach could be an excellent alternative for treating grey water in rural areas.

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