PROJECT REPORT

ON

REUSE OF GREY WATER

Submitted in partial fulfilment of the requirements

For the degree of

BACHELOR OF ENGINEERING

In

CIVIL ENGINEERING

BY

Ms. Shaikh Sana Ahmed (17DCES66)

Mr. Shaikh Razi Osi Ahmed (17DCES65)

Mr. Abdus Salam Md Suleman (16CES03)

Mr. Khan Bilal Mohammed Hanif (16CES16)

Under the guidance of

Prof. Dhaval Shah

(Assistant Professor, Civil Engineer)

Department of Civil Engineering

Anjuman-I-Islam's Kalsekar Technical Campus

Thana Naka, Khandagaon, New Mumbai 41006

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University of Mumbai

CERTIFICATE

This is to certify that **Ms. Shaikh Sana Ahmed (17DCES66), Mr. Shaikh Razi Osi Ahmed (17DCES65), Mr. Abdus Salam Md Suleman (16CES03)** and **Mr. Khan Bilal Mohammed Hanif (16CES16)** has satisfactorily completed and delivered a project seminar report on, **"Reuse of Grey Water"** in partial fulfilment for the completion of the **B.E.** in **Civil Engineering** course conducted by the Mumbai in Anjuman-I-Islam's Kalsekar Technical Campus, New Panvel, Navi Mumbai, during the academic year 2019-20.

(Prof. Dhaval Shah)

(Guide)

(Dr.R. B. Magar)
Professor and Head

(Dr. Abdul Razzak Honnutagi)
Director

Approval for B.E. Project

This B.E. Project entitled, **"Reuse of Grey Water"** by Ms. Shaikh Sana Ahmed (17DCES66), Mr. Shaikh Razi Osi Ahmed (17DCES65), Mr. Abdus Salam Md Suleman (16CES03) and Mr. Khan Bilal Mohammed Hanif (16CES16) is approved for the **Bachelor of Engineering in Civil Engineering**

Examiner

1. ____________________________
2. ____________________________

Date:-

Place:- New Panvel

Declaration

We hereby declare that this written submission entitled, **"Reuse of Grey Water"** represents my idea in my own words and where other ideas or words have been included. I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any data/fact in my submission. I understand that any violation of the above will cause for disciplinary action by the institute and can also penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

Ms. Shaikh Sana Ahmed

Mr. Shaikh Razi Osi Ahmed

Mr. Abdus Salam Md Suleman

Mr. Khan Bilal Mohammed Hanif

Place: New Panvel

Date:

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SANA AHMED SHAIKH	ABDUS SALAM MD SULEMAN
(17DCES66)	(16CES03)
SHAIKH RAZI OSI AHMED	KHAN BILAL MD HANIF
(17DCES65)	(16CES16)

ABSTRACT

Both water scarcity and the desire to increase the sustainability of domestic water resources have stimulated the search for efficient water use practices. These reasons drove our exploration of greywater—its characteristics and potential uses. Freshwater scarcity is a serious issue that affects at least one-fifth of the world's population and more will be affected due to population growth, mismanagement, increased urbanization and climate change. Innovative concepts and technologies are straight away needed to close the loop for water. Greywater reuse is one of the main alternatives for reducing potable water consumption in households, industries and commercial buildings. This article aims to review some of the principle greywater treatment technologies and their applications. This will also help to reduce the load on the sewage treatment plant

It is absolutely necessary to study the Characteristics and behavior of grey water, this will help in determining the degree and type of treatment required to be study involves the analysis of pH value, total solids, total suspended solids, hardness, alkalinity, chloride, chlorine, BOD and DO.

The samplings of the greywater will be done in different times of the day to have an average data of the measured parameters.

A greywater treatment plant will be designed with the treatment units.

Keywords: Characterization, greywater, treatment procedure.

millions of people worldwide recycle greywater to irrigate tpeheir gardens and flush their toilets.

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CHAPTER 1

INTRODUCTION

1.1 General

Water is a basic resource for life. It is used directly or indirectly in every domain: domestic consumption, urban endeavors, industry, and agriculture. In the natural environment, the diversity and health of ecosystems depend on water. However, according to a UN estimate in 2007, about one-fifth of the world's population is facing water shortage, and this number is expected to grow. Four main drivers affect the expected growth of water shortage: population growth, urbanization, increased personal consumption due to the rising standard of living, and climatic changes (UN Water, 2007). Consequently, effective and sustainable use of water resources is a global challenge that is garnering increasing attention from various international institutions. The need to save water and use water sources effectively is of particular importance in semiarid and arid regions, where water sources are scant and the precipitation volume is low. Innovative concepts and technologies are straight away needed to close the loop for water.

Greywater is gently used water from your bathroom sinks, showers, tubs, and washing machines. It is not water that has come into contact with feces, either from the toilet or from washing diapers.

In general, greywater is less polluted than the total domestic wastewater because it does not contain toilet flush wastewater or, for the most part, kitchen wastewater. Fecal contamination and the amount of solids and fats in the water are significantly decreased by removal of these flows from the greywater stream. In addition, the concentration of organic matter, particularly the biodegradable part, is lower in greywater relative to the total domestic wastewater. Despite the potential advantages over wastewater, the concentrations of pollutants in greywater are not always lower than the pollutant concentrations of the total domestic wastewater. The reason for this lies in the large variance between the relative volumes and flows of each greywater source. For example, it is easy to imagine that the characteristics of wastewater leaving a washing machine full of dirty clothing are very different from that of hand washing before a meal. Other pollutants, such as concentrations of detergents and sometimes even boron, are usually higher in greywater than in general sewage because they are not diluted in the large water volume generated by toilet flushing.

Greywater may contain traces of dirt, food, grease, hair, and certain household cleaning products. While greywater may look "dirty," it is a safe and even beneficial source of irrigation water in a yard. Keep in mind that if greywater is released into rivers, lakes, or estuaries, its nutrients become pollutants, but to plants, they are valuable fertilizer. Aside from the obvious benefits of saving water (and money on your water bill), reusing your greywater keeps it out of the sewer or septic system, thereby reducing the chance that it will pollute local water bodies. Reusing greywater for irrigation reconnects urban residents and our backyard gardens to the natural water cycle.

Greywater reuse has been considered as a reliable method of ensuring water security as compared to other methods of water capture such as rainwater harvesting which is dependent on hydrological conditions. The amount of greywater produced in a household can vary greatly ranging from as low as 15 L per person per day for poor areas to several hundred per person per day. Factors that account for such huge disparities are mostly attributed to geographical location, lifestyle, climatic conditions, type of infrastructure, culture and habits, among others. Greywater accounts for up to 75% of the wastewater volume produced by households, and this can increase to about 90% if dry toilets are used. It has also been estimated that greywater produced accounts for about 69% of domestic water consumption.

Greywater reuse is one of the main alternatives for reducing potable water consumption in households, industries and commercial buildings. This article aims to review some of the principle greywater treatment technologies and their applications.

1.2 Sources of Grey Water

Most domestic water consumption is for the purpose of cleaning or rinsing (such as bathing, washing dishes, and laundry). Each water flow resulting from rinsing that is discharged into the wastewater collection system has different characteristics. The method of consumption of each stream is different, and hence the level of pollution it produces is also different. The following sections analyze individual greywater streams and assess their contribution. The relative volumetric contribution of each individual stream to the greywater, as reported in the literature, is presented in Figure 1.1. It is worth noting that the quantities of greywater contributed by modern washing machines and even more so by modern dishwashers have fallen sharply in the last decade. This implies that in the future as existing appliances are gradually replaced by new ones, their contribution is expected to further decrease. In addition, the introduction of water-efficient fittings, such as faucet aerators, into extensive use may also decrease the volume of the water.

1.2.1 Washing Machine

Washing Machines Washing machines are the most significant contributor of pollutants to greywater (when kitchen water is excluded from the definition of greywater) (Table 1.4). Washing machines and dishwashers have approximately 4–5 cleaning stages, each of which produces greywater of different quality. Most of the contamination is released in the first two cleaning phases, and the level of pollutants then decreases sharply with each stage. The first stage in operating the washing machine contributes only 18% of the volume, but approximately 64%, 40%, 30%, and 34% of the total COD, ammonia, phosphorus, and anionic surfactants, respectively.

1.2.2 Baths and Showers

Water consumption for washing differs between people and cultures. A survey found that the average Indian water consumption for baths was 53 (±27.5) L/use and for showers 28 (±18.8) L/use. In a report, it was found that water consumption in baths was 61.4 L/use and 42.3 L/use in showers. In India, the contribution of showers to domestic greywater stands at approximately 20%. Baths and showers are the major contributors to fecal coliforms in light greywater, with an average of 4·106 cfu/100 mL.

1.2.3 Wash Basins

The water consumption of handbasins (washbasins) is widely varied depending on the nature of its use. One survey found that the average water consumption of the hand basin in Israel is 3.66 (±5.96) L/use. Another study reported that the average water consumption of the hand basin is 1.9 (±1.7) L/use. A washbasin contributes about 15% of greywater's total volume and mostly has low concentrations of pollutants.

1.2.4 Kitchen sinks/ Dishwashers

The kitchen sink produces about 26% of domestic greywater and it is reported that a single use consumes, on average, about 12 L of water. Kitchen sink water contains a high load of pollutants. Kitchen sink stream constitutes about 58% of suspended volatile solids, 42% of the general COD, 48% of the BOD5, 43% of total fats, and 40% of anionic surfactants in greywater. Despite this high concentration of pollutants, it was found that kitchen wastewater is only a secondary contributor to fecal coliforms and boron. However, washing uncooked meat in the kitchen sink can contribute to the existence of additional bacteria such as salmonella.

1.3 Grey Water Characteristic

Greywater inherently contains traces of the materials that were used within the household premises such as soaps, salts, cosmetic ingredients (e.g., face creams and makeup), food, spices, oils, and minerals. Therefore, in examining the characteristics of greywater, it is appropriate to search for common household products and other such relevant materials. The variables that characterize greywater can be divided into physical, chemical, and microbial categories. As specified earlier, greywater quality varies between sources. It can even vary within one source over time, a phenomenon that is manifested in the wide range of values for most of the water quality variables.

1.3.1 Physical Characteristics

The main physical characteristics that affect the quality of greywater and its treatment are temperature, color, odor, turbidity, suspended solids, and salinity.

Temperature: Greywater temperature is influenced by the surrounding temperature and that of the water source. In many cases, greywater will have a higher temperature than the ambient temperature since it is sourced from warm bathing, washing, laundry, and rinsing water. When greywater is collected in a storage or balancing container, temperature variability will be smaller, and the water temperature will be similar to the ambient temperature (or only slightly higher). It should be noted that in some cold climate areas, it may be feasible to harvest the heat of the greywater via heat exchangers. High temperatures, above 30°C–40°C, which is characteristic of greywater, may lead to the development of bacteria and encourage the accumulation of residues (limescale) in collecting containers and piping. However, it may also accelerate biological treatment processes and make them more efficient.

Color: Greywater is named because of its color, which in many cases is a shade of grey. The source of the color is mostly coloring substances that are added to products such as soaps and detergents. Color is usually considered an aesthetic challenge, so its removal during treatment is recommended. The color of the water can be measured in several ways. It should be noted that the method has to be adapted to the nature and source of the color (from humic substances, other color materials, metals, etc.). However, these techniques are of limited efficiency, and their relationship to the quality of the solution is limited. Usually, color does not cause significant problems in treating and reusing greywater.

Odor: The source of the odor in raw greywater is usually household chemicals, such as detergents and other cleaning agents. However, when raw greywater is stored for an extended period of time in a tank or equalization basin, the concentration of dissolved oxygen decreases within hours, and anaerobic decomposition processes begin to take place. These include the reduction of sulfate into sulfide-containing compounds, a process characterized by the release of bad smells (reminiscent of rotten eggs). The formation of odors is one reason that some treatment systems do not store the greywater, but instead, or convey it almost immediately. Quantitative odor measurements are complex and impractical when it comes to greywater recycling on a local scale.

1.3.2 Chemical Characteristics

Solids and Turbidity: The main index for describing solids in wastewater in general, and in greywater specifically, is total suspended solids (TSS). Suspended solids are defined as solids suspended in the water with a diameter larger than 1 µm (which cannot pass through a fiber glass filter). The common measurement method is moving a known volume of liquid through a filter and weighing the solids left on the filter after drying. The customary unit of measurement is milligrams per liter (mg/L). These solids are also a major source of turbidity, which is measured using a turbidity meter and expressed in nephelometric turbidity units (NTU). This measurement expresses the scattering and absorption of light as opposed to the amount of light that can pass through the water. Causes of water turbidity are suspended solids and colloid particles such as clay particles, organic materials, algae, and microorganisms. Turbidity causes aesthetic damage, can lower disinfection Greywater Characteristics 9 efficiency, and can affect the reliability of analytic tests.

pH: The appropriate pH for unlimited irrigation ranges from 6.5 to 8.5 The pH of most greywater sources is low, ranging from 7 to 8 and the pH of laundry greywater is even more basic ranging from 7.5 to 10. This is because laundry powders and liquids are made up of basic materials containing hydroxide OH^- ions, which raise pH.

Alkalinity: Alkalinity is basically the sum of alkali ions in solution or in other words a measure of ions in water that are capable of receiving a proton (H^+). The values are expressed in milli equivalents/L or mg/L of $CaCO_3$. Alkalinity expresses the buffer capacity of water, or water's ability to resist a change in pH when base or acid materials are introduced. Water with a low buffer capacity (low alkalinity) undergoes fluctuations in pH, while water with a high buffer capacity has steady pH. In biological treatment systems, it is important to maintain a strong buffer capacity. Irrigation with water of low alkalinity may be detrimental to the plants and microorganisms living in the soil and to the health of the soil itself. The main contributor to alkalinity is the water's source. For instance, laundry and dishwashing powders and liquids contain ions that belong to the carbonic and phosphoric systems, which thus contribute to the alkalinity of greywater.

Chloride contents: chlorides are generally derived from the kitchen wastes, urinary discharges, etc. The permissible chloride content for water supply is 250mg/l.

1.3.3 Biological Characteristics

The microbial quality of greywater depends on many factors such as water source, temperature, and personal hygiene habits. Bacteria, viruses, worms, and pathogenic protozoa from four main sources can infiltrate greywater: inside users' bodies (mainly fecal pathogens), external body parts (e.g., skin, nose, mouth, ears), food preparation, and dirty laundry. It has thus been shown that greywater may contain high levels of bacteria (Birks and Hills, 2007). For example, sometimes, intestinal bacteria, such as salmonella and campylobacter, may penetrate greywater as a result of processing food in the kitchen. Nevertheless, it should be stressed that the levels of pathogens in greywater are usually much lower than in blackwater. Traditionally, there is a tendency for water quality research to focus mainly on fecal contamination. As such, most water quality tests refer to fecal contamination indicators, primarily Escherichia coli. Although fecal contamination does occur in greywater, the extent is usually lower than in full household wastewater. In greywater, concentrations of pathogens from other sources may actually be higher and thus of greater concern. Even so, despite the presence of some pathogenic bacteria in greywater, many countries allow the use of greywater without treatment for relatively small flows (up to 1 m3/day, equivalent to greywater flow of a detached house) and they make no reference to microbial contamination. When using greywater for irrigation or flushing toilets, pathogenic microorganisms can pose risks to human health in different ways. For example, sometimes, they are distributed through aerosols, or an individual makes direct contact with the water. In addition, bacteria and viruses can infiltrate groundwater causing contamination. This is in contrast to protozoa and nematodes, which are relatively large and do not reach groundwater. Such risk increases in the presence of organisms that are resistant to a variety of disinfection treatments and thus can spread in greywater systems, such as Cryptosporidium and Giardia.

CHAPTER 2

LITERATURE REVIEW

- **Glenda Emmerson (1998),** suggested alternative source of water is grey water. Grey water is the water that goes down domestic bathroom and laundry drains. If this water is diverted for relatively safe applications such as garden irrigation, then a family can reduce their water usage by around 30-50 percent saving. Grey water reuse also offers environmental benefit but a caution should be exercised to avoid public health and the environment risk.
- **Peter L.M. Veneman et.al. (2002)**, investigated to grey water samples at five different commercial location in Massachusetts to quantify the variability and characteristics of grey water. The data indicated that the effect of different loading rates was statistically not significant, but that soil depth was. This seems to point to the fact that increasing the loading rates does not appear to have an adverse effect on treatment efficiency, but that decreasing soil depth does.
- **Muttukumaran, et. al., (2003)[17],** presented a study a grey water treatment at panjappur and greywater reuse at srirangam. The grey water quality has been studied by taking samples and results were compared with FAO irrigation water quality standards. The authors suggested to utilize the treated grey water for growing greens, vegetables and for agriculture.
- **Jefferson, et.al. (2004) [4],** reported Characterization of grey water that reveals a source water similar in organic strength to a low medium strength municipal sewage influent but with physical and biodegradability characteristics similar to a tertiary treated effluent.
- **Friedler, et.al. (2005)[7],** presented a study of a pilot plant treating light greywater for seven flats. The pilot plant combines biological treatment (RBC) with physicochemical treatment (sand filtration and disinfection). The pilot plant produced effluent of excellent quality, meeting the urban reuse quality regulations, and was very efficient in TSS turbidity and BOD removal : 82 %, 98% and 96%, respectively. The COD removal was somewhat lower (70-75%) indicating that the greater may contain slowly-biodegradable organics. Fecal coli forms and heterotrophic reductions were very high (100% and 99.99%, respectively) producing effluent that also met drinking water standards.
- **National Environmental Engineering Research Institute (NEERI) and UNICEF (2007) [18],** National Environmental Engineering Research Institute (NEERI) Nagpur and UNICEF Bhopal, Madhya Pradesh have developed, implemented and evaluated grey water reuse systems for small buildings (schools) in rural areas. NEERI has developed grey water treatment system as primary treatment (screening and equalization tank) followed by secondary treatment-I(gravel filter and sand filter) and secondary treatment-II(broken brick, charcoal, chlorination)for treatment of grey water at a tune of 1000-2000 l/day from hostels, schools and residential complexes . The drive for this technology was

undertaken due to decreasing availability of water, lowering of groundwater table and increase in fluoride concentration in groundwater.

- **Gideon Paul Winward, (2007) [8],** investigates pathogen removal through treatment and disinfection processes. Also the impacts of organic and particulate material in grey water on the efficiency of disinfection processes are investigated in depth.
- **Dr. Mark Pidou et.al. (2007) [6],** reported a review of existing technologies and application collating a disparate information bas and comparing strength and weaknesses of different approaches. The best overall performance is observed within the scheme combining different type of treatment to ensure effective treatment of all the fractions.
- **Sam Godfrey, et.al.(2009) [22],** presented grey water treatment and reuse system in residential schools in Madhya Pradesh, India and treated grey water used for toilet flushing and irrigating the food crops. In this study the cost-benefit analysis was undertaken for grey water reuse by considering internal and external costs and benefits. The analysis carried out indicates that the benefit exceeds the cost of the system.
- **Jonathan Glassman, et.al. (2009)[12],** suggested the design recommendation for the vertical intermittent sand filter in place of the current multi-media filter. The sand filter is easier to maintain than the existing multi-media filter because only the top layer of sand media in the filter has to be regularly replaced, compared to digging out and replacing all of the particle media in the drum.
- **Bhausaheb L. Pangarkar, et.al . (2010) [5],** investigated the economical performance of the plant for treatment of bathrooms, basins and laundries grey water showed in terms of deduction competency of water pollutants such as COD (83%), TDS (70%), TSS *83%), total hardness (50%), oil and grease (97%), anions (46%) and captions (49%).The authors suggested that this technology could be a good alternative to treat grey water in residential rural area.
- **Vasudevan Rajaram et.al. (2010) [27**], presented an integrated approach to manage the greywater treatment , concluded that every drop of greywater in rural and urban India should be recycled for reuse. So that it does not contaminate our drinking water supplies and conserve scare water resources for satisfying the thirst of the entire population.
- **Khatun et.al. (2011)[2],** reported characterization of grey water collected from different sources and different locations of Dhaka city. The author suggested an efficient, cheap and sustainable grey water treatment system for household and mosque. The treated grey water can be used for non-potable use such as irrigation, toilet flushing, car washing and aquifer recharging.
- **Saroj B. Parjane et.al (2011)[24],** presented the finest design of laboratory scale grey water treatment plant, which is a combination of natural and physical operation such as primary settling with cascaded water flow, aeration, agitation and filtration, hence called as hybrid treatment process. The economical performance of the plant were investigated for treatment of bathroom, basins and laundry grey water. The author worked out cost

benefit analysis of the system on the large scale and found more effective process in the rural region.

- **Ukpong EC. et. al. (2012)[26],** reported to design and Construct a filter for grey water reuse for irrigation of not less than one hundred household. Laboratory tests were conducted on these samples and they reveals the presence of BOD, TSS, nitrate PH, coliform etc., whose values varies where compared with that of the parameters for standard irrigation water. The author suggested that the efficiency of the slow sand filter in the reduction a all the parameters was high due to their tangible nature which enable them to succumb surface forces of the filter media.
- **Musfique Ahmed et. al. (2012)[16],** presented strategy of recycling Grey water separately from black water by using decentralized approach. The authors suggested that the recentralized system should be given priority for grey water recycling to reduce burden on centralized system and save transportation cost.
- **Amr M. Abdel-Kader (2012) [3**], reported that the treatment efficiency of the RBC system based on BOD removal was ranged between about 93.0% and 96.0%, and based on TSS removal was ranged between about 84.0% and 95.0% for all concentrations of influent grey water.
- **Ruchi Mehta, et.al. (2012) [20],** shows the calculations for estimating the required area of land treat grey water generated from 20 house community by using vertical flow reed bed(VFRB).
- **A.H.M. Faisal Anwar (2012) [1],** reveals that the reduction of capillary rise stops when the grey water concentration reaches towards the critical micelle concentration(280 mg/l)value.
- **Javed Alam et.al. (2012) [11],** suggested the concept of using grey water in various possible fields and thus,making fresh water demand with in control. The use of grey water in India is in the stage of infancy.Though,various developed countries are already utilizing this new water potential after some preliminary treatments depending upon the type of use.
- **Mohammad Hasan et.al. (2012) [15],** investigated a system involving a granular activated carbon(GAC) biofilm up flow expanded bed(UEB) reactor and slow down flow packed sand filter for treating mosque grey water. The fecal coli form, chemical oxygen demand (COD), total suspended solids (TSS), nitrate (No3) and ammonia as nitrogen were investigated under continuous flow operation using a hydraulic retention time (HRT) ranging from 1-6 hours. In this study the authors recommended to use HRT of 2 to 8 hr to remove physical, organic, chemical and microbial pollutants. This system is effective for treatment of grey water and includes low cost of operation and maintenance.
- **S. Lambe et.al. (2013)[10],** reported that with increased population growth and development, there is a need to critically look at alternative approaches to ensure water availability. These alternative resources include rain water and bulk of a water used in household will emerge as grey water and contain some minerals, organic waste materials

dissolved and suspended in it. The authors suggested to intercept this grey water at the household level, treat it so that it can be recycled for garden washing and flushing purposes.

- **Krishna Kumar O, et.al. (2013)[14],** suggested the grey water treatment by the process of bio-remediation, where dirt water from bathroom and sinks are treated using effective micro-organism solution and filtered by use of sand filter. The author concluded that by this method effective treatment of grey water form bathroom and basins can be achieved.
- **Sahar Dalahmeh et.al. (2013)[21],** developed laboratory scale pine bark activated charcoal and sand filter evaluated as regards their pollutant removal and interaction between medium properties, greywater, microbial activity and bacterial community structure. The authors suggested that the organic matter content and surface hydraulic properties of the bark filters resulted in high BODs removal rates (95%-99%). Also charcoal had large specific are which provided the capacity for high removal of BOD (83%-97%).
- **Sandeep Thakur, et.al., (2013)[23],** reported to reduce surface and ground water use in all sectors of uses and to substitute fresh water with alternative resources. The author suggested that Grey water recycling is the viable option that can be very useful in the water arid areas.
- **Kamal Rana et. al. (2014)[13],** presented some efficient, cheap and sustainable grey water treatment system for households the authors reviewed the processes to identify the best suited processes at household and community level. Septic tank, constructed wetlands and intermittent sand filter are identified as the most suitable processes for decentralized treatment due to the simple operation and maintenance facilities an well an cost effectiveness of the systems.
- **Shobha Kundu et. al. (2015)[25],** presented treatment system to treat and reuse grey water for gardening, toilet Flushing and street washing. The treatment system consists of natural process involving equalization cum sedimentation, Fitter bed consisting of sand aggregates and marbles. The author suggested that filtration increases DO concentration and other parameters decrease in grey water so as an to make it usable.

CHAPTER 3

OBJECTIVE OF STUDY

3.1Aim

The principal objective of reusing grey water is to allow the less usage of fresh water. By treating and reusing greywater for flushing, gardening, washing garages and vehicles, etc. Grey water includes household waste liquid from baths, showers, kitchen sinks, wash basins and washing machines which is mostly disposed in sewers creating a lot of load on sewage treatment plant. No danger to human health or unacceptable damage to the natural environment is expected.

The objectives of the study are:-

- Physical, chemical and biological characterization of domestic grey water samples from the kitchen, baths, etc.
- Comparison with the prescribed standards.
- Design of treatment plant.

3.2Scope of project

- Reduces fresh water requirement.
- Prevents stagnation of grey water.
- Prevents vector breeding.
- Use in flushing toilets to make toilets functional.
- Use of grey water in gardening.
- Minimal risk to users of greywater as it incorporates principles of water safety.

CHAPTER 4

METHODOLOGY

4.1 Sampling Techniques:

Waster water samples will be collected in contamination free sampling bottles of 1000ml from kitchen effluent and the bathroom waste of the building. Samples are taken at point beneath the surface where the turbulence is thoroughly mixed. This is called grab sample. The samples are collected at regular intervals during entire day. These different samples are now mixed together, and the amount utilized from each specimen is proportional to the rate of flow at the time the specimen was collected. This sample is taken for testing, as it represents more nearly, the average true strength of the greywater.

4.2 Methodology for measurement of pH value

(ELECTRONIC METHODS)

PRINCIPLE

The pH value is found by measurement of the electromotive force generated in a cell. It is made up of an indicator electrode which is reactive to hydrogen ions such as a glass electrode. When it is immersed in the test solution the contact between reference electrode (usually mercury/calomel electrode), and the test solution the electromotive force is measured. A pH meter, that is, a high impedance voltmeter is marked in terms of Varieties of electrodes have been suggested for the determination of pH. The hydrogen gas electrode is the primary standard. Glass electrode in coordination with calomel electrode is generally used with reference potential provided by saturated calomel electrode. The glass electrode system is based on the theory that a change, of 1 pH unit produces an electrical change of 59.1 mV at25°C. The membrane of the glass forms a partition between two liquids of differing hydrogen ion concentration thus a potential is produced between the two sides of the membrane which is proportional to the difference in pH between the liquids.

The apparatus used are:

1. pH meter - With glass and reference electrode (saturated calomel),
2. preferably with temperature compensation.
3. Thermometer - With least Count of 0.5°C.

PROCEDURE:

The instrument is standardized after required warm-tip period. A buffer solution of pH near to that of the sample is used. The electrode is checked against at least one additional buffer of different pH value. The temperature of the water is found and if temperature compensation is available in the instruments it is adjusted. The electrodes are rinsed and gently wiped with solution. If necessary, the electrodes are immersed into the sample beaker or sample stream and stirred at a constant rate to provide homogeneity and suspension of solids. Rate of stirring is minimized and the air transfer rate at the air-water interface of the sample is noted. The sample pH and temperature is noted.

4.3 Methodology for measurement of Alkalinity:

The sample liquid for analysis should be either free from turbidity or should be allowed to settle before analyzing it.

The apparatus used are:

1. pH Meter
2. Burette -50-ml capacity.
3. Magnetic Stirrer Assembly

The reagents used are:

1. Distilled Water - pH must be greater than 6.0. In case the pH falls below 6.0, it shall be
1. boiled for 15 minutes and cooled to room
2. temperature.
3. Sulphuric Acid - 5.6 ml of concentrated sulphuric acid is diluted with one liter with
4. distilled water
5. Standard Solution of Sulphuric Acid -0.02 N.
6. Phenolphthalein Indicator 0.5 g of phenolphthalein in 100 ml is mixed, 1: 1 (v/v)
7. alcohol water mixture is taken.
8. 6. Mixed indicator Solution - Dissolve 0.02 g methyl red and 0.01 g bromocresol green in
9. 100 ml, 35 %, ethyl or isopropyl alcohol.

PROCEDURE:

20 ml of sample is pipetted into a 100-ml beaker, 2 to 3 drops of phenolphthalein indicator is added to the sample if the pH of the sample is above 8.3. It is then titrated with standard H_2SO_4 solution till the pink color observed by indicator just disappears (equivalence of pH 8.3).The volume of standard H_2SO_4 solution used is recorded. 2 to 3 drops of mixed indicator is put to the solution in which the phenolphthalein alkalinity has been determined. The solution is titrated with standard acid to light pink color (equivalence of pH 3-7). The volume of standard acid used after phenolphthalein alkalinity is recorded.

4.4 Methodology for the determination of Turbidity:

PRINCIPLE

The intensity of light scattered by the sample under defined conditions is compared with the intensity of light scattered by a standard reference suspension under the same conditions, forms the basis of determination of turbidity. Higher the intensity of scattered lights higher the value of turbidity. Formazin polymer is generally used as turbidity standard because it is more reproducible than other types of standards used previously. The turbidity of a particular concentration of Formazin suspension is defined as 40 Jackson turbidity units. The same suspension of Formazin has a turbidity of approximately 40 units when measured on Jackson candle turbidimeter. Thus turbidity units based on the Formazin preparation closely approximate those derived from Jackson candle turbidimeter but it may not always be identical to them.

The apparatus used are:

1. Sample Tubes - The sample tubes should be of clear and colorless glass.
2. Turbidimeter

The reagents used are:

1. Turbidity-Free Water
2. Hexamethylene Tetramine Solution
3. Hydrazine Sulphate Solution
4. Turbidity Standard Suspension (Formazin)
5. Turbidity Standard Suspension II

PROCEDURE:

TURBIDIMETER CALIBRATION - The manufacturer's operating instructions is followed. The standards on turbidimeter covering the range of interest are measured. If the instrument is already calibrated in standard turbidity units, this procedure will check the accuracy of calibration.

- Turbidity less than 43 Units - The sample is shaken to disperse the solids. Air bubbles disappear gradually. Sample into turbidimeter tube is poured carefully and turbidity value is directly read from the instrument scale.
- Turbidity greater than 40 Units - If turbidity values are more than 40 units, the sample is diluted with clear distilled water to compare and bring the values within range. The readings are taken of the diluted sample. Then the turbidity is computed of the original sample from the turbidity of the diluted sample and the dilution factor.

4.5 Methodology for the determination of Acidity:

PRINCIPLE:

Acidity of water is the numerically expressible capacity to react with a strong base to a designated pH. It may be defined as equivalent concentration of hydrogen ions in mg/l. The equation in its simplest form is as follows: $H^+ + NaOH = H_2O + Na^+$

The apparatus used are:

1. pH Meter
2. Burette -50-ml capacity.
3. Magnetic Stirring Device

The Reagents used are:

1. Distilled Water
2. Potassium Acid Phthalate
3. Sodium Hydroxide Solution - 15 N.

Sodium hydroxide solution - 1 N 67 ml of 15 N NaOH solution is diluted to one liter with distilled water.

Sodium hydroxide solution - 0.02 N 20 ml of 1 N NaOH solution is diluted to one liter and is standardized using standard potassium acid phthalate

Phenolphthalein Indicator - 0.5 g phenolphthalein is dissolved in 100 ml 1: 1 (v/v) alcohol water mixture and 0.02 N NaOH solution is added drop by drop till slight pink colour is observed.

Methyl Orange Indicator - 0.5 g of methyl orange is dissolved in distilled water and made up to 100 ml in a volumetric flask.

PROCEDURE:

Indicator Method - 20 ml of a suitable amount of sample is pipetted into a 100 ml beaker. Less than 20 ml of titrant shall be required for the titration that should be the volume of sample. The pH of water is determined. If pH is less than 3.7, two drops of methyl orange indicator is added into the first sample beaker. It is titrated with standard 0.02 N NaOH solution until the colour converts to the faint orange. The volume of NaOH used is recorded. 2 to 3 drops of phenolphthalein indicator is added to the second sample beaker. It is again titrated with 0.02 N NaOH solution till the colour of solution changes to faint pink colour. The volume used is recorded.

Potentiometric Method - 20 ml of a suitable aliquot of sample is pipette into a 100 ml beaker, It is then titrated with standard NaOH solution to pH 3.7 and pH 8.3. The volume of standard NaOH used is measured. No indicator is required.

4.6 Methodology for measurement of Chloride:

PRINCIPLE:

Soluble and slightly dissociated mercuric chloride is formed when Chloride is titrated with mercuric nitrate. Diphenyl Carbazone within the pH range of 2.3 to 2.8 signals the end point by the formation of a purple complex with extra mercuric ions.

The apparatus used are:

1. Erlenmeyer flask - 250 ml capacity.
2. Microburette - 5 ml with 0.01 ml graduation intervals.

The reagents used are:

1. Standard sodium chloride solution
2. Nitric acid - O.IN
3. Sodium hydroxide - 0.1 N
4. Reagents for chloride concentrations below 700 mg/l
5. Indicator-acidifier reagent - Nitric acid concentration of this reagent decides the success of the determination and it can be varied as indicated in (a) or (b) to befit the alkalinity range of the sample. Reagent (a) contains sufficient nitric acid to counteract a total alkalinity of 150 mg as CaCO3/1 to the proper pH in a 100 ml sample.
6. 250 mg s-diphenylcarbazone, 4-0 ml. concentration nitric acid and 30 mg xylene cyanol FF in 100 ml 95 percent ethyl alcohol or isopropyl alcohol. The sample is stored in a dark bottle in a refrigerator. This reagent is not stable indefinitely. Deterioration causes a slow end point and high results.
7. Standard mercuric nitrate titrant - 23 g mercuric nitrate [Hg (NO3)2 or 2.5 & Hg (NO3).12H20] is dissolved in 100 ml distilled water containing 0.25 ml concentrated nitric acid. It is diluted to just less than 1 liter. Replicates are used containing 5.00 ml standard sodium chloride solution and 10 mg sodium bicarbonate (NaHCO3) diluted to 100 ml with distilled water. It is adjusted to 0.0141 N and a final standardization of 1.00 ml = 500 ug Cl- is made. It is stored away from light in a dark bottle.
8. Mixed indicator reagent - 0.50 g diphenylcarbazone powder and 0.05
9. Bromophenol blue powder is dissolved in 75 ml 95 percent ethyl or isopropyl alcohol and dilute to 100 ml with the same alcohol. 0.141 N standard mercuric nitrate is used as titrant.

PROCEDURE:

100 ml sample is taken such that the chloride content is less than 10 mg. 1.0 ml indicator acidifier reagents are put. pH is conformed to about 8 for highly alkaline or acid waters before adding indicator-acidifier reagent. 0.411 N Mercuric Nitrate is titrated with the solution to a definite purple end point. The solution turns from green blue to blue a few drops before the end point. The blank is determined by titrating 100 ml distilled water containing 10 mg of sodium bicarbonate.
Chloride, mg/1 = (V1-V2) x Nx35450/V3
Where,

- ✓ V1 = volume in ml of silver nitrate used by the sample,
- ✓ V2 = volume in ml of silver nitrate used in the blank titration,
- ✓ V3 = volume in ml of sample taken for titration and
- ✓ N = normality of silver nitrate solution.

4.7 Methodology for the determination of Residual Chlorine:

It is measured as the chlorine left in the water after the required contact period which will ensure complete killing of bacteria and oxidation of the organic matter usually a free chlorine residue is considered to be sufficient.

The reagents used are

1. O- Toluidine - 4 drops

PROCEDURE:

O- Toluidine is added to the sample and mixed thoroughly. After 15 to 20 minutes the colour is developed. The comparator was placed to match the colour of the sample. The volume of indicator used was noted down. Generally the concentration of residual chlorine must be 1 – 2 mg/i.

4.7 Methodology to find out the amount of Total Solids and Dissolved Solids

PRINCIPLE

Solids are to be determined in raw waters, industrial waste, domestic waste and sludge. The usual definition is that matter which remains as residue upon evaporation and drying out 103°C to 105°C. Solids are organic and inorganic and also dissolved and undissolved or suspended solids.

Total solids are classified as organic and inorganic in terms of volatile and fixed solids. The term settleable solids are applied to solids in suspension that will settle, under quiescent conditions, because of influence of gravity, Solids affect the specific conductance of raw water.

Determination of all types of solids separately is important in design consideration of variouswaste treatment methods.

EQUIPMENTS: Heating Oven, Muffle Furnace.

APPARATUS: 50 ml capacity crucibles, balance with weight box and fractional weights, measuring cylinder pipette, filter paper no.40 etc. relevant is code (IS 3025-1984).

PROCEDURE:

1. Weight the empty crucibles (w). Then take 50ml of sample in the crucibles and heat in an oven kept at 103°C for about one hour till it is completely dry. Also the crucible to cool.
2. Take weight of the crucible in a with dry residue (w1).
3. Keep the same crucible in a muffle furnace and heat it as 550°C for minutes. Take out the crucible from the furnace and allow it to cool.
4. Take weight of the crucibles with residue (w2). The loss of weight indicates fixed solids.
5. For determining dissolved solids, 50ml of sample through a filter paper (no. 40) collect the filtrate in a crucible (w) and heat it on oven at 103°C for one hour, the residue is completely dry.
6. Record weight of the crucibles with dry residue (w3).

4.8 Methodology for measurement of DO:

PRINCIPLE:

Dissolved oxygen can be measured either by titrimetric or electrometric method.

1) Titrimetric method

Titrimetric method is based on the oxidizing property of do while the electrometric titrimetric is based on the rate of diffusion of molecular oxygen across a membrane. It is, most accurate methods to determine DO. There are different methods on the nature of sample to be tested

1. Winkler method
2. Azide modification
3. Alum flocculation modification
4. Permanganate modification
5. Electrometric method

The electrode method offers several advantages over the titrimetric method including speed, elimination or minimization, field compatibility, continuous monitoring and insitu measurement. Dissolved oxygen can be measured by a special sensor kept in an electrochemical cell by the amperometric method.

The cell comprises a sensing electrode, a references electrode and a supporting electrolyte, a semi-permeable membrane, which served dual function. It separates the water sample from the electrolyte, and at the same time, permits only the dissolved oxygen to diffuse from the water sample through a permeable membrane into the supporting electrolyte.

The diffusion current created by migration of oxygen through a permeable membrane is linearly proportional to the concentration of molecular oxygen in the sample. The diffusion current by migration of oxygen through a permeable membrane is linearly to the concentration of molecular oxygen in the sample.

APPARATUS REQUIRED

Burette, Burette stand, 300 ml glass stoppered BOD bottles ,500 ml conical flask, Pipettes with elongated tips, Pipette bulb, 250 ml graduated cylinder andWash bottles

CHEMICALS REQUIRED

Manganous sulphate solution Alkaline iodide-azide solution, Sulphuric acid concentrated, Starch indicator solution, Sodium thiosulphate, Distilled or deionized water, Potassium hydroxide, Potassium iodide, Sodium azide

PROCEDURE

1. Take two 300ml glass stoppered BOD bottle and fill it with sample to be tested. Avoid any kind of bubbling and trapping of air bubbles. Remember-no-bubbles!

OR

2. Take the sample collected from the field. It should be collected from the field. It should be collected in BOD bottle filled up to the rim.
3. Add 2 ml of manganese sulphate to the BOD bottle by inserting the calibrated pipette just below the surface of the liquid. Add 2 ml of alkali iodide azide reagent in the same manner.
4. Squeeze the pipette slowly so no bubbles are introduced via pipette.If oxygen is present, a brownish orange cloud of precipitate or flock will appear.
5. Allow it to settle for sufficient time in order to react completely with oxygen. Add 2 ml of concentrated sulfuric acid via a pipette held just above the surface of the sample.

4.9 Methodology for measurement of BOD:

PRINCIPLE:

The biochemical oxygen demand (BOD) test is based mainly on the classification of biological activity of a substance. A procedure measures the dissolved oxygen consumed by micro-organisms while capable of taking and oxidizing the organic matter under aerobic conditions.

The standard test condition lets in incubating the sample in an air tight bottle, in dark at a required temperature for specific time.

The apparatus used are:

1. Incubation Bottles: The bottle has capacity of 300 ml. It has narrow neck with even mouth and has ground glass stoppers. New bottles are cleaned with 5 N hydrochloric acid or sulphuric acid and rinsed with distilled water. In normal use, bottles once used for Winkler's procedure should only be rinsed with tap water followed by distilled water. During incubation water is added to the flared mouth of the bottle time to time, to ensure proper sealing.
2. Air Incubator: Air incubation with thermostatically controlled 27°C +- 1°C. Light is avoided to prevent possibility of photosynthetic production of oxygen.

PROCEDURE:

After taking water in incubation bottles, 4 gm of NaOH is kept at the neck of the bottle. A magnetic stirrer is retained inside the bottle. The magnetic stirrer continuously revolves inside the bottle. Special caps attached with an electronic meter keep the bottle air tight. The instrument directly records BOD reading at every 24 hour. After that the bottles are preserved in the incubators for days as per need of study. The same procedure follows for BOD 3 days and BOD 5 days.

4.10 Methodology for the determination of Hardness:

PRINCIPLE

This method is contingent upon the power of ethylenediamine tetraacetic acid (C10H1408N2) or its disodium salt to form stable complexes with calcium and magnesium ions. When the dye eriochrome black T (EBT) is added to a solution containing calcium and magnesium ions at pH 10.0 a wine red complex is formed. This solution is titrated with standard solution of disodium salt of EDTA, which extracts calcium and magnesium from the dye complex and the dye is changed back to its original blue colour. Eriochrome black T is used to indicate the end-point for the titration of calcium and magnesium together.

PROCEDURE:

25.0 ml of standard calcium solution is pipetted in a porcelain basin. The volume is adjusted to 50 ml with distilled water. 1 ml buffer solution is used 1 to 2 drops of indicator is put. After continuous stirring until the reddish tinge disappears, it isn't titrated. Few drops of sample at 3 to 5 second interval are added. At the end point the colour is sky blue. For drinking, surface and saline waters - An aliquot of water sample is pipetted, in a porcelain dish or 150-ml beaker. The volume is tuned to approximately 50 ml. 1 ml hydroxylamine hydrochloride (NH4OH.HCI) is added to the solution. 2 ml of buffer solution is mixed so as to achieve pH of 10.0 to 10.1.2 ml sodium cyanide or sodium sulphide inhibitor solution is put if the end point isn't sharp. If Cu, Zn, Pb, Co and Ni are absent and if 25 the sample contains less than 0.25 mg of Fe and 0.025 mg of Mn the addition of NaCN or Na2S may be omitted. 2 ml of Eriochrome black T indicator solution is added and titrated with standard EDTA solution stirring rapidly in the beginning. It is stirred slowly towards the end when all the traces of red and purple colour disappear and solution is clear sky blue in colour. For waste waters and highly polluted waters - An aliquot of the sample is digested with 3 ml of distilled conc. HNO3 in a beaker on a hot plate. It is evaporated to near dryness while ensuring that the sample does not boil. Digestion with nitric acid is repeated till the digestate is light in colour. It is evaporated to near dryness and cooled. Little amount of 1:1 hydrochloric acid (5 ml) is added and warmed on a steam-bath to dissolve the residue.

- Note 1 - For water with very low hardness (less than 5 mg/l) micro burette is used.
- Note 2 - Sample size may be selected such that the result lies between 200 to 300 mg/l of hardness (as CaCO3).

Description:

A three-stage greywater filtration system at household level having following components may be constructed.
Inlet pipe: 63mm (2 inch) PVC pipe Inlet chamber: 30cm x 30cm x 10cm (Brick masonry Cement plaster) (A sponge piece is kept in the chamber to absorb the debris coming with the water, so that these can be checked to flow further)

Treatment chamber-1: Size: 30cm x 60cm x 30cm. filled with gravels, (40 to 60mm size), Brick masonry in 1:4 cement mortar & cement plaster 1:4 with neat cement finish.

Treatment chamber-2: Water flows from chamber-1to chamber-2 Size-40cm x 60cm x 30cm filled with fine sand Filter water Size: 40cm x 60cm x 50cm storage tank: Brick masonry in 1:4 cement mortar & cement plaster 1:4 with neat cement finish.

Base of all the chambers: Constructed with 1:2:4 RCC work with 12mm grit size and then cement finis with 5% slope (1 in 20)

Out let: Through 63mm (2 inch) PVC pipe. The operation and maintenance is not a skilled job in the system, as it requires washing of the sponge kept in the inlet chamber on regular basis and the washing and changing/refilling of gravel & fine sand time to time in the treatment chamber 1 and 2. Members of the beneficiary family are doing this and the system is functioning satisfactorily.

O&M

- Periodical cleaning of grease trap, filters and sponge
- Gravels and sand from the filtration unit need to be washed periodically
- Sedimentation tanks require de-sludging every month.

Approximate material cost – Rs 600/-

Average Pollutants Loading (grams per person per day - g/p.d)

TYPE	GREY WATER	GREY+BLACK COMBINED
BOD	34	71
SS	18	70
TOT. N	1.6	13.2
TOT. P	3.1	4.6
TOT. P*	0.5	1.9

Source of grey water and its types:

No	Source of Grey water	Quantity/day/per person
1	Bathing	20-30
2	Kitchen	5-10
3	Washing clothes	15-20
4	Animals	10-15

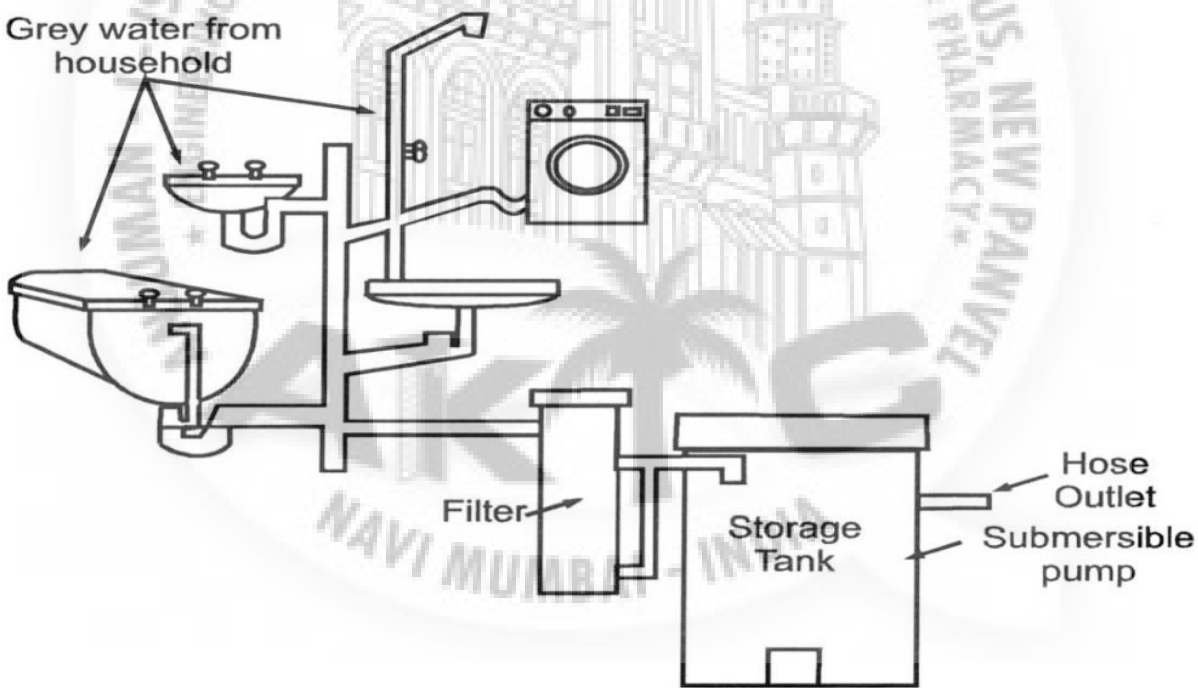
Percentage of Grey Water generated:

SR. NO	SOURCES	% GREY WATER
1	Bathing	55
2	Laundry	20
3	Washing of house	10
4	Washing of utensils	10
5	Cooking	5
TOTAL		**100**

Quantification of Grey Water:

SR. NO	METHOD	TYPES
1.	Direct method	a) Water meter b) Bucket meter
2.	Indirect method	a) Water consumption b) Types of uses

Diagrammatic representation of household grey water generation



Composition of Grey Water

SR. NO	PARAMETERS	UNIT	GREY WATER (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.	Oil and grease	Mg/l	37-78
6.	Coli form	Cu/100ml	0-500-10000
7.	Total dissolved solids	Mg/l	126-175
8.	Temperature	*C	18-38
9.	Nitrite	Mg/l	<0.1-0.8
10.	Ammonia	Mg/l	<0.1-25.4
11.	Nitrogen	Mg/l	2.1-31.5
12.	Total Phosphorous	Mg/l	0.6-27.3
13.	pH	--	6.6-8.7
14.	Conductivity	mS/cm	325-1140
15.	Sodium	Mg/l	29-230

CONCLUSION

By treating the grey water and reusing it we can save use of large amount of fresh water for flushing, gardening, irrigation and using at various other places. Also this project doesn't have any adverse effect on environment or any animal or human beings.

The method of reusing the greywater can be implied in all sectors i.e. commercial, residential, industrial, educational, parks etc.

The benefit of greywater recycling includes:

- Reduced use of freshwater,
- Less strain on septic tanks or treatment plants,
- More effective purification,
- Feasibility for sites unsuitable for a septic tank,
- Reduced use of energy and chemicals,
- Groundwater recharge,
- Plant growth,
- Reclamation of nutrients,
- Increased awareness of sensitivity to natural cycles .

Saving water per day saves upto 750 to 1000 liter water per day in residential schools (ashrams) /hostels of 50 children. Fresh water can be save by reuse of grey water.

REFRENCES

1. A H M Faisal Anwar (2012), “ Reuse of laundry grey water in irrigation and its effect on soil hydrologic parameters”, International conference on future environment and energy, IPCBEE vol 28 (@012), IACSIT Press, Singapore
2. A. Khatun & M.R. Amin, (2011), Greywater reuse: a sustainable solution for water crisis in Dhaka, Bangladesh”, 4th Annual Paper Meet and 1st Civil Engineering Congress, Dhaka, Bangladesh ISBN: 978-984-33-4363-5, pp 427-434.
3. Amr M. Abdel-Kader, “Studying the efficiency of grey water treatment by using rotating biological contractors system,” Journal of King Saud University Engineering science, May (2012), pp 1-7.
4. B. Jefferson, A. Palmer, P. Jeffrey, R. Stuetz and S. Judd, “Grey water charecterisation and its impact on the selection and operation of technologies for Urban reuse”, Journal of water science and Technology, Vol. 50, pp 157-164, (2004)
5. Bhausaheb L Pangarkar, Saroj Parjane and M.G. Sane, ”Design and Economical performance of Grey water treatment plant in Rural region,” International Journal of civil and Environmental Engineering 2:1, 2010.
6. Dr. Mark Pidou, Dr. Fayyaz Ali Memon, Prof. Tom Stepenson, Dr. Bruce Jefferson and Dr. Paul Jefferey, “ Grey water recycling: A reviw of Treatment options and applications”, Institution of Civil Engineers, proceedings in the journal engineering Sustainability, Vol. 160, pp 119-131
7.] E. Friedler, R. Kovalio and N.I. Galil, “on site grey water treatment and reuse in multi storey buildings,” Journal of water science & Technology Vol. 151, No. 1, pp 187-194. © IWA Publishing (2005)
8. Gideon Paul Winward, “Disinfection of grey water”, Ph.D. thesis of school of Applied sciences, cranfield University, 2007.
9. Glenda Emmerson, “Greywater as an alternative water source”, Research bulletin No 4/98, Queensland parliamentary library, Brisbane, July 1998.
10. J.S. Lambe, R.S. Chougule, (2013), “Greywater - Treatment and Reuse”, IOSR Journal of mechanical and civil Engineering (IOSR-JMCE), ISSN 2278-16844, pp 20-26.
11. Javed Alam and Mohammad Muzzammil (2012),” GREY WATER USE: A NEED OF HOUR, India Water Week 2012 – Water, Energy and Food Security : Call for Solutions, 10-14 April 2012, New Delhi.
12. Jonathan Glassman, Becca Kan, Diane Lee, Andrew Martinez, “Grey water systems”, Technical note of Engineers for a sustainable world, Stanford University, June 8th, 2009.
13. Kamal Rana, Mitali Shah, Amita Upadhyay, (2014), “Integrated Approach towards Grey water management”, International Journal of Engineering science and Research Technology, ISSN: 2277-9655, Vol. 3, No. 1, pp 239-242.
14. Krishna Kumar O, K. Adithya, Abhilash R. and Aravind T, (2013), “Household Grey Water Treatment-Utilization for Flushing of Toilets”, International Journal of Applied Engineering Research, ISSN 0973-4562, Vol. 8, No. 15, pp. 1801-1808.
15. Mohammed Hasan Al-Mughalles, Rakmi AbdulRahman, Fatihah Suja, Astura Mahmud,Sharifa Mastura syed Abdullah, (2012), Grey watewr treatment using GAC biofilm reactor and sand filter system”, Australian Journal of Basic and Applied Sciences, 6 (3) , pp 283-292, 2012 ISSN 1991-8178.

16. Musfique Ahmed, Meenakshi Arora, (2012), “Suitability of gray water decentralized alternative water supply option for Integrated urban water management IOSR journal of Engineering e-ISSN: 2250-3021, Vol. 2, Issue 9, pp 31-35.
17. N. Muthukumaran and Dr.N. K. Ambujam, (2003), “Wastewater Treatment and Management In Urban Areas - A Case Study of Tiruchirappalli City, Tamil Nadu, India”, Proceedings of Third International Conference on Environment and Health, Chennai, India, pp 284 - 289.
18. National Environmental Engineering Research Institute (NEERI), (2007), “ Grey water reuse in rural schools : Guidance Manual
19. Peter L M Veneman , Bonnie stewart, (2002), “ Grey water characterization and treatment efficiency”, final report for the Massachusetts department of Environmental protection, Bureau of resources protection
20. Ruchi Mehta, Prof Balazs Fekete, “Research term paper on grey water”, The city college Newyork.
21. Sahar Dalahmeh, (2013), “Bark and Charcoal Filters for Greywater Treatment”, Pollutant Removal and Recycling Opportunities, Doctoral Thesis Swedish University of Agricultural Sciences Uppsala. ISSN 1652-6880.
22. Sam Godfrey, Pawan Labhashetwar, satish wate (2009), “Grey water reuse in residential schools in madhya pradesh, India- A case study of cost- benefit analysis”, Elsevier journal Resources conservation and Recycling, 53, (2009), pp 287-293.
23. Sandeep Thakur, M. S. Chauhan, (2013), “Grey Water Recycling”, Journal of Environmental science and sustainability (JESS), Vol. 1, No. 4, pp 117-119.
24. Saroj B. Parjanne, Mukund G. Same, (2011), “Performance of Grey Water Treatment Plant by Economical way for Indian Rural Development”, International Journal of chem. Tech Research CODEN (USA): IJCRGG, ISSN: 0974-4290, Vol. 3, No. 4, pp 1808-1815.
25. Shobha Kundu, Isha Khedikar, Aruna M. Sudhame, (2015), Laboratory scale study for Reuse of Grey water”, IOSR, Journal of Mechanical And Civil Engineering (IOSR-JMCE) e ISSN: 2278-1684, P ISSN 2320-334x, Vol. 12, Iss¬¬ue 3, pp 40-47.
26. Ukpong E.C., Agunwamba, J. C. (2012), “Grey Water Reuse for Irrigation”, International Journal of Applied science and Technology, Vol. 2, No. 8. pp 97-113.
27. Vasudevan Rajarama, John R. Sheaffer, (2010), “Integrated water management for rural/urban India”, Website- www.content.asce.org/final program.