Project Report On

“USE OF DOMESTIC GRAY WATER TO REDUCE PERCAPITA DEMAND OF NATURAL WATER”

Under The Guidance

Prof. Shruti Kale

College of Engineering & Technology

DEPARTMENT OF CIVIL ENGINEERING

VIDYA PRASARINI SABHA’S COLLEGE OF
ENGINEERING AND TECHNOLOGY, LONAVALA

(An ISO 9001:2015 certified & NAAC Accredited Institute)

SAVITRIBAI PHULE PUNE
UNIVERSITY, PUNE

2021-22

Project Report On

"USE OF DOMESTIC GRAY WATER TO REDUCE PERCAPITA DEMAND OF NATURAL WATER"

Under The Guidance

Prof. Shruti Kale

College of Engineering & Technology

DEPARTMENT OF CIVIL ENGINEERING

VIDYA PRASARINI SABHA'S COLLEGE OF ENGINEERING
AND TECHNOLOGY, LONAVALA

(An ISO 9001:2015 certified & NAAC Accredited Institute)

SAVITRIBAI PHULE PUNE
UNIVERSITY, PUNE

2021-22

VIDYA PRASARINI SABHA'S COLLEGE OF ENGINEERING AND
TECHNOLOGY, LONAVALA

**(An ISO 9001:2015 certified & NAAC Accredited
Institute)SAVITRIBAI PHULE PUNE UNIVERSITY,
PUNE**

University of Pune

CERTIFICATE

This is to certify that the following students have satisfactorily carried out the first semester B.E. project work entitled "Use of Domestic Gray Water to Reduce Per capita Demand of Natural Water"

This work is being submitted for the award of degree of Bachelor of Civil Engineering. It is submitted in the partial fulfillment of the prescribed syllabus of Savitribai Phule Pune University, Pune for the academic year 2021-22 (SEM-II).

Submitted by

Shaikh Abdulraheman

Hanjgikar Aaqueeb

Jamadar Faizan

Shaikh Salman

S. Kale
PROF. SHRUTI KALE
(Guide)

(External Examiner)

Satyam.
PROF. SATYAM KALYANE
(Hod, Civil Department)

DR. S.B. JOSHI
(Principal)

DECLARATION

I declare that this written submission represents my ideas in my own words and where other's ideas or words have been included, I have adequately cited and reference the original sources. I also declare that I have adhered to all principles of academics honestly and integrity and have not misrepresented or fabricated or falsified any idea/ data/ fact/ source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

Students Name

Shaikh Abdulraheman

DATE: ---------------

ACKNOWLEGEMENT

We have great pleasure in delivering the project on the topic "Use of Domestic Gray Water to Reduce Per capita Demand of Natural Water". This project has helped to express extracurricular knowledge with incredible help from guide of our project **Prof. Shruti Kale** We would like to thanks especially to the HOD civil department **Prof. Satyam Kalyan** as well as staff members of civil department, all of them very compassionate and really went off their Way to help. We would like to thanks especially to **Prof. Shruti Kale,** Project coordinator, for his timely help and guidance toward successful completion of our project. We would like to thanks especially to **Dr. S.B Joshi,** Principal of **Vidya Prasarini Sabhas Collage of Engineering and Technology Lonavla,** for his guidance toward successful completion of our project.

Shaikh Abdulraheman

(B. E. CIVIL)

Date:

Place: Lonavla

ABSTRACT

Global freshwater consumption has increased sixfold between 1999 and 2009; this is more than twice the population growth. Freshwater use by continents is partly based on several socio-economic development factors, including population and climatic characteristics. Global efforts to manage and utilize freshwater resources in a sustainable manner have been hampered chiefly by lack of accurate information on water use for human needs in quantitative terms. The study also examined the role played by the size of urban households in determining the per capita domestic water consumption. This attribute of population was found to exert an insignificant influence on per capita domestic water consumption.

Greywater is the wastewater produced in bathtubs, hand basins, kitchen sinks, dishwashers and laundry machines. Separation of greywater and blackwater and on-site greywater treatment in order to promote its subsequent reuse for toilet flushing and/or garden irrigation is an interesting option especially in water deficient areas. The aim of this study was to characterize the different greywater sources in Greek households and to evaluate the effectiveness of a simple physicochemical treatment system consisting of sedimentation, sand filtration and granular activated carbon filtration. Based on the results average daily greywater production was equal to 98.1 L per person per day and accounts for more than 70 % of the total household wastewater production (135 L per person per day). Greywater characteristics are highly variable and depend on the living standards, the activities, the income and the habits of the residents. Among the different sources, laundry and kitchen sink are the main contributors to the total greywater load of organic carbon, suspended solids and surfactants, whereas dishwasher is the main source of phosphorus. The application of a physical treatment system consisting of sedimentation, sand filtration, GAC filtration and disinfection can provide for a final effluent with satisfactory characteristics for onsite reuse.

Keywords: *Greywater Characterization; Greywater Treatment; Reuse; Sand Filtration; GAC Filter*

INDEX

Sr. No.	Content	Pg. No.
1.	**Chapter 1**	
	Introduction	
1.1	General	1
1.1.1	Advantages Greywater	2
1.1.2	Disadvantage Greywater	4
1.2	Economic Evaluation of Greywater Reuse	8
1.3	Components of Greywater Reuse Systems	11
1.4	Objective of Study	13
		15
1.6	Project Outline	16
2.	**Chapter 2**	
	Literature Review	
2.1	Introductions	17
2.2	Literature Review	23
3.	**Chapter 3**	
	Thermotical Formations	
3.1	Composition of Grey Water	24
3.1.1	Grey Water from Bathroom	13
3.1.2	Grey water from Cloth Washing	30
3.1.3	Grey water from Kitchen	33
3.2	Advantages of Grey Water Reuse	36
4.	**Chapter 4**	
	Exeprimental Work	
4.1	Estimation of Water Requirements for Drinking and Domestic Use	40

4.2	Types of Wastewater Reuse	41
4.2.1	Reuse for Irrigation	42
4.2.2	Irrigation of Agricultural Crops	43
	A. Irrigation of Landscape and Recreational Area	46
	B. Domestic and Industrial Reuse	48
5.	**Chapter 5**	
	Result and Discussions	49
6.	**Chapter 6**	
	Conclusion, Future Scope, Reference	51

LIST OF TABLES

Sr. No.	Name Of Tables	Page No.
4.1	Residential Buildings	28
4.2	For communities with populations up to 20,000:	32
4.3	Water Requirements for Buildings Other than Residences	38

LIST OF FIGURES

Fig. No.	Name Of Figures	Page No.
1.1	Gray Water Recycling System	2
1.2	Reuse Water	9
3.1	Flowchart of the Treatment of Grey Water	20
3.2	Sedimentation Tank	22
4.1	Irrigated with Recycled Water	42

Chapter 1

INTRODUCTION

Chapter 1

INTRODUCTION

1.1 General

Increase in world population and urbanization leads to the decrease in available resources. Neither the growth or population can be stopped nor can the use of essential resources be stopped. But only the method and mentality can be changed for sustainable management of such resources, so that future generations to come can be benefited from such resources. Water is one such resource whose optimum utilization is necessary now. Depletion of water resources due to high water demand and pollution, makes governments and regulating bodies worldwide to develop new ways to conserve water resources, and reclaimed water use is one of the key methods being considered. Reclaimed water is wastewater originating from commercial, industrial or residential activities that has been treated or renovated to an acceptable standard for specific uses. Before being reused, grey water is generally treated, using a variety of treatment technologies of varying sophistication, to a quality where it can be reused for other applications such as subsurface and landscape irrigation, car washing, street cleaning or toilet flushing. There are a number of technologies available to treat the greywater for specific reuse applications. The use of wastewater recycled requires a proper sustainable & manageable approach. INDIAN URBAN SCENARIO Water is becoming a rare resource in the world. In India alone the International Water Management Institute (IWMI) predicts that by 2025, one person in three will live in conditions of absolute water scarcity (IWMI, 2003); Although India occupies only 3.29 million km2 geographical area, which forms 2.4% of the world's land area, it supports over 15% of world's population.

The population of India as of March 1, 2001 was 1,027,015,247 persons (Census, 2001). India also has a livestock population of 500 million, which is about 20% of world's total livestock. However total annual utilizable water resources of the country are 1086 Km3 which is only 4% of world's water resources. Total annual utilizable resources of surface water and ground water are 690 Km3 and 396 Km3 respectively (Ministry of Water Resources, 1999). Consequent to rapid growth in population and increasing water demand, stress on water resources in India is increasing and per capita water availability is reducing day by day. In India per capita surface water availability in the years 1991 and 2001 were 2300 m3 (6.3 m3/day) and 1980 m3 (5.7 m3/day) respectively and these are projected to reduce to 1401 and 1191 m3 by the years 2025 and 2050 respectively. Total water requirement of the country in 2050 is estimated to be 1450 Km3 which is higher than the current availability of 1086 Km3. It is therefore essential to reduce surface and ground water use in all sectors of consumption, to substitute fresh water with alternative water resources and to optimize water use efficiency through reuse options. These alternative resources include rainwater and greywater to meet the anticipated deficit. Greywater is commonly defined as wastewater generated from bathroom, laundry and kitchen. Due to rapid industrialization and development, there is an increased opportunity for greywater reuse in developing countries such as India, particularly in urban areas

The availability of freshwater across the globe is a critical factor for human development. About 71% of the earth's surface is made up of water. However, less than 3% of this is freshwater. Most of this water is inaccessible because it is either frozen as glaciers in the Polar Regions, or it may be held within deep underground aquifers. Water is one such resource whose optimum utilization is necessary now. Depletion of water resources due to high water demand and pollution, makes governments and regulating bodies worldwide to develop new ways to conserve water resources. Water is used for various domestic purpose like washing, drinking, flushing, cooking, bathing watering. Greywater is one such type of wastewater generated from domestic activities such as laundry, dishwashing, and bathing which can be recycled on-site for uses such as landscape irrigation, flushing and constructed wetlands.

The study will give more knowledge which result into benefits for future implementation with the help of Greywater. The government standard to supply 55 liters per capita per day does not take into account that a large number of rural households' own livestock and need water for their drinking and washing needs.

Moreover, in the absence of household level piped water supply and metering, it is difficult to monitor the quantity of water received by each household. This in turn, makes it challenging to estimate the per capita needs of rural households.

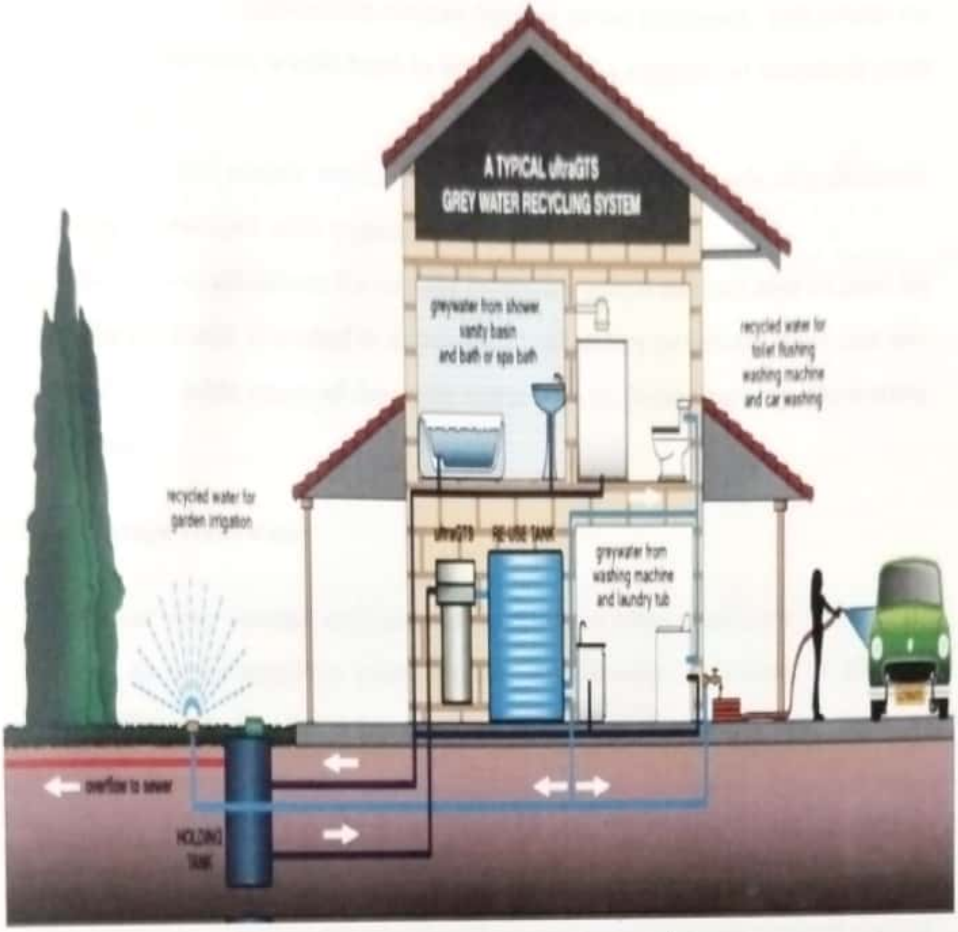

Fig. 1.1 Gray Water Recycling System

1.1.1 Advantages Greywater

1. The obvious key advantage of domestic greywater use is that it replaces or conserves potable water use, and can reduce the cost of potable water supply
2. Appropriately applied, greywater may contain nutrients (e.g., phosphorus and nitrogen from detergents), benefiting plant growth and resulting in more vigorous vegetation.
3. Offers potential cost reductions for regional sewage treatment facilities. Removing greywater from residential wastewater drainage to sewer decreases the flow through the sewer and to the treatment plant and enables the existing infrastructure to service more connections.

4. Greywater reuse applications require limited or no treatment, and where the greywater otherwise would have to be pumped to a centralized treatment plant and treated.
5. Greywater could supply most, if not all, of the irrigation needs of a domestic dwelling landscaped with vegetation in a semiarid region.
6. In addition to applications for outside irrigation, greywater can also be used for toilet flushing and, if treated to an advanced secondary or tertiary level, can also be used for a wide range of domestic water uses including bathing, showering, and laundry.

1.1.2 Disadvantage Greywater

1. Greywater may contain sodium and chloride, or other chemicals that can be harmful to some sensitive plant species. Additionally, greywater is alkaline (high pH) and shouldn't be used to irrigate acid-loving plants such as rhododendrons or azaleas.
2. Resulting diminished sewer flows from domestic greywater could potentially result in insufficient sewer flows in some circumstances to carry waste to the sewer plant (e.g., pipes with low slopes), or may result in a high strength sewage that combined with lower flow may lead to odor and corrosion problems in the centralized sewerage systems.
3. Concern regarding the public health implications of greywater reuse and the need for research to determine the risks of greywater reuse.
4. Cost of treatment and diversion/transfer pipe & pumps.

1.2 Economic Evaluation of Greywater Reuse

The two key capital cost components for greywater systems are for treatment and dual plumbing. In general, the costs for a greywater system can be classified as follows:

(1) Design costs and permit fee: The design costs depend greatly on the suitability of the site and the complexity of the system. If greywater reuse becomes a legal practice,

it would be expected that a permit would be necessary to construct an appropriate system and that there would be a fee.

(2) Installation costs: The installation costs would include materials and labor. These would be site and system specific. In some cases, the owner might prefer to do part of the work, but for some specific components of the system a licensed specialist (plumber and/or electrician) would be required.

(3) Operation and maintenance costs: The operating costs include electricity, disposable filters, and disinfectants. For systems with pumps and other ancillary equipment it may be necessary to meet the cost of repair or replacement parts.

Fig.1.2 Reuse Water

1.3 Components of Greywater Reuse Systems

1. The system should be as simple and easy to use and maintain as possible.
2. The system Also, should minimize risks to human health, either by providing for adequate treatment of the greywater, or by with humans. The
3. Sedimentation tanks to separate and remove grease, oils & settle able solids from the greywater
4. Aerobic biological treatment to remove soluble organic contaminants
5. Final clarification or filtration to remove solid particles and bacteria generated during biological treatment
6. Disinfection to remove pathogenic micro-organisms
7. Reuse water storage tank.

1.4 Objective of Study

1. Study reuse of wastewater will not only save the money but also it retains the natural resources and helps to develop a sustainable environment.
2. To compute the correlation between household size and per capita water consumption.
3. To investigate the impact of socio-economic status on per capita domestic water consumption.
4. To examine the impact of climatic variations on domestic water consumption per capita.

1.5 Problem Statement

1. Greywater is one such type of wastewater generated from domestic activities such as laundry, dishwashing, and bathing which can be recycled on-site for uses such as landscape irrigation, flushing and constructed wetlands.

2. The study will give more knowledge which result into benefits for future implementation with the help of Greywater.

1.6 Project Out Line

Chapter 1 Indicate Introductions of Project Work, problem statement and advantages.

Chapter 2 In this chapter show previous work details.

Chapter 3 Indicate that Methodology.

Chapter 4 In this chapter show experimental work details.

Chapter 5 Indicate results and discussions.

Chapter 6 Conclusions based on previous work and Reference.

Chapter 2

LITERATURE REVIEW

Chapter 2

LITERATURE REVIEW

2.1 Review

M. Dakua, M. Mahmood, S. Bhowmik, and F. Khaled (2016) Studied waste water and microorganisms for a better treatment of grey water from households. The objectives of these study were to perform quantitative analysis of grey water recycling using constructed wetland process (horizontal and vertical flow) and feasibility study of application of recycled water in daily use. It included a residential staff quarter, a residential hostel and a hospital as the subject area. The findings are, recycled grey water can be successfully used in several daily use purposes and the production of recycled water is much higher than demand. With the use of recycled water, it can be saved 17.62%,19.22% and 17.71% of total water of the three respective subject areas. Reduction of water bill to some extent and betterment of environment by improving the quality of downstream waste water and reduction in groundwater depletion by less withdrawal of water is also possible.

M. Sundaravadivel (2018) Analyse Reuse of wastewater for domestic and agricultural purposes has been occurring since historical times. However, planned reuse is gained importance only two or three decades ago, as the demands for water dramatically increased due to technological advancement, population growth, and urbanization, which put great stress on the natural water cycle. Reuse of wastewater for water-demanding activities, which, so far consumed limited freshwater resources is, in effect, imitating the natural water cycle through engineered processes. Several pioneering studies have provided the technological confidence for the safe reuse of reclaimed water for beneficial uses. While initial emphasis was mainly on reuse for agricultural and non-potable reuses, the recent trends prove that there are direct reuse opportunities to applications closer to the point of generation. All the case studies presented in this article point towards the potential wastewater has to serve as a viable alternative source of water, in future.

Siddhant Bansal (2017) In ancient times every individual or family was responsible to arrange for their water supplies. There were no collective efforts but with time urbanization came into picture and thus the collective efforts for provision of water started. But this urbanization caused a serious problem of resource exhaustion like water. Thus, it is of prime importance to manage water resources in best way so that future generation could survive. While 'water markets' are seen as a means to achieve efficient allocation of the scare resources, treated wastewater and low-quality water are now considered as potential sources of water to supplement the freshwater supplies. Wastewater reuse has been proven to ameliorate the pressure on the water environment and prevent water pollution. Greywater is one such type of wastewater generated from domestic activities such as laundry, dishwashing, and bathing which can be recycled on-site for uses such as landscape irrigation, flushing and constructed wetlands. The aim of this paper is to assess the role of greywater reuse in sustainable water management in urban regions.

Maisie Borg, Orion Edwards & Sarah Kimpel (2018) Over the past several decades concerns have been raised over the amount of water used in California. With higher rates of personal water use, average levels in aquifers across the state have begun to decline. When analyzing how to increase water efficiency and conservation, residential usage stands out as an important factor. Our project's goal is to investigate the weekly per capita indoor water use of three households in Davis, California in an effort to better understand water demands, as well as the best methods to increase water efficiency and conservation. In that project found that while low-flow devices would increase water conservation and efficiency in every household, the variations in the ways each household used water caused the benefits of low-flow devices to depend on the household in question. These variations make it difficult to extrapolate our data to the general population.

A. Andreadakis, C. Noutsopoulos, I.D. Mantziaras, N. Kouris (2012) studied characterize the different greywater sources in Greek households and to evaluate the effectiveness of a simple physicochemical treatment system consisting of sedimentation, sand filtration and granular activated carbon filtration. Based on the results average daily greywater production was equal to 98.1 L per person per day and accounts for more than 70 % of the total household wastewater production (135 L per person per day). Greywater characteristics are highly variable and depend on the living standards, the activities, the income and the habits of the residents. Among the different sources, laundry and kitchen sink are the main contributors to the total greywater load of organic carbon, suspended solids and surfactants, whereas dishwasher is the main source of phosphorus. The application of a physical treatment system consisting of sedimentation, sand filtration, GAC filtration and disinfection can provide for a final effluent with satisfactory characteristics for onsite reuse.

Y.D Chintanwar, Paras Batra, VikashKumar, RushabhGour Sumant Chorey, Nikhil Yeole, Ravikant Kumar (2018) discussed statistics about 71 % of the Earth's surface is water covered and the oceans hold about 96.5 % of the earth's water and rest is the considered as fresh water or portable water. The waste water produced can be divided into two categories black water and grey water. Black water is used to describe wastewater containing feces, urine and flush water from toilets and grey water is wastewater generated from household uses like bathing and washing clothes. Black water treatment is done on a very large scale in India, whereas it is 30% of the total waste water produced and the greywater is 70 % of the waste water produced. Grey water is a source of wastewater that can be treated for reuse much simpler than current mixed sewage or black water. Treatment of grey water will increase the amount of water that can be reused for various purpose and that will eventually help the developing contrary such as India to fight their water crises. This paper present information on grey water and its treatment that may help to manage the waste water efficiently.

Rajarshi Kar, Oindrila Gupta (2012) studied domestic wastewater produced, excluding sewage. The main difference between grey water and sewage (or black water) is the organic loading. Sewage has a much larger organic loading compared to grey water. Some people also categorize kitchen wastewater as black water because it has quite a high organic loading relative to other sources of wastewater such as bath water. In water scarce environments, waste water reuse and reclamation are often considered as viable option for increased water resources availability. For example, many Mediterranean countries are investing in waste water reclamation, and reuse due to high evaporation and evapotranspiration, low rainfall and increased demand for water for irrigation and tourism (Angelakis et al., 2001). Equally, in water scarce developing countries, grey water reuse in schools, hospitals and government institutions is proving to be an essential alternate water resource to fresh ground, surface or rain water supplies.

Daniyal Hassan, Rakhshinda Bano, Steven. J. Burian and Kamran Ansar (2017) Sustainable water resources management is challenging when a region suffers from scarcity and experiences increasing anthropogenic water demand. The Lower Indus Basin is one of the most arid regions in South Asia. Various kinds of water users (i.e., rural, urban, subsistence and commercial irrigated agriculture) are present. The growing population, climate change, and the need to meet minimum flow requirements are leading to future water resources management conflicts in an already water-stressed area. Being able to assess the ability of the catchment to satisfy potential water demands is crucial to planning and making wise decisions about water use and distribution. The Water Evaluation and Planning System (WEAP) software has been widely used to analyze complex water resources systems and to examine supply and demand management strategies. In this study, a scenario analysis approach is used in WEAP, to assess the impacts of water demands and supplies on the water resources of the Lower Indus River in Sindh in the future. For each scenario, the water resource implications were compared to a 2015 "baseline." The model analyzed water demands and reliability in these scenarios, to help comprehensive.

Dan Kennedy (2018) New Jersey typically has ample precipitation on average and the State's geology allows the storage of large quantities of groundwater as well as supports large surface water reservoirs. Generally, New Jersey has sufficient water available to meet needs into the foreseeable future provided we effectively: o Increase water efficiency through conservation and reuse; o Promote public education and outreach; o Address deteriorating infrastructure and ensure proper operation and maintenance of our water storage, treatment and distribution systems; o Pursue key water supply projects, including enhanced system interconnections and regional optimization of system networks and resources; and Fully fund current monitoring efforts/assessment studies.

Chapter 3

METHDOLOGY

3.1 Composition of Grey Water

3.1.1 Grey Water from Bathroom

Water used in hand washing and bathing generates around 50-60% of total grey water and is considered to be the least contaminated type of grey water. Common chemical contaminants include soap, shampoo, hair dye, toothpaste and cleaning products. It also has some faecal contamination (and the associated bacteria and viruses) through body washing.

3.1.2 Grey water from Cloth Washing

Water used in cloth washing generates around 25- 35% of total grey water. Wastewater from the cloth washing varies in quality from wash water to rinse water to second rinse water. Grey water generated due to cloth washing can have faecal contamination with the associated pathogens and parasites such as bacteria.

3.1.3 Grey water from Kitchen

Kitchen grey water contributes about 10% of the total grey water volume. It is contaminated with food particles, oils, fats and other wastes. It readily promotes and supports the growth of microorganisms. Kitchen grey water also contains chemical pollutants such as detergents and cleaning agents which are alkaline in nature and contain various chemicals. Therefore, kitchen waste water.

3.2 Advantages of Grey Water Reuse

Grey water is reused for a whole range of applications:

1. Urinal and toilet flushing
2. Irrigation of lawns (college campuses, athletic fields, cemeteries, parks and golf courses, domestic gardens)

3. Washing of vehicles and windows
4. Fire protection
5. Concrete production
6. Develop and preserve wetlands
7. Infiltrate into the ground
8. Agriculture and viticulture reuse

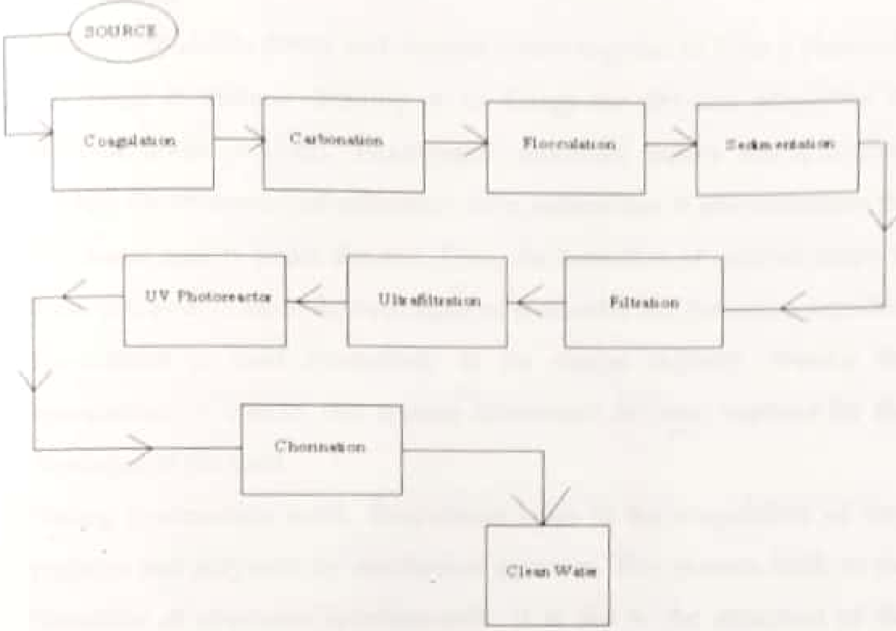

Fig.3.1 Flowchart of the Treatment of Grey Water

i) **Coagulation**

Coagulations is carried by the addition of certain chemicals which are called as coagulants. Coagulation is a process in which coagulants are added for the purpose of rapid settlement of aggregates out of finely divided dispersed matter with slow or negligible velocity. So, a larger tank may be needed to complete this process.

ii) **Carbonizations**

Carbonization is the conversion of an organic substance into carbon or a carbon-containing residue through pyrolysis or destructive distillation. Carbonization produces substances which can prove harmful and simple precautions should be taken to reduce risks. The gas produced by carbonization has a high content of carbon monoxide which is poisonous when breathed.

iii) **Flocculation**

helps in emulsion, where each droplet comes together to form a cluster. It has usage in mineral dressing or to design the physical properties of pharmaceutical products. Flocculation processes induce eutrophication through the adsorption of substances from underwater. It also maintains the freshwater quality under the soil. Thus, the formation of colloids helps in these processes. Due to the hydrolysis of molecules and the micro peptides, flocculation is used extensively in the cheese industry. During the manufacture of cheese, this process determines the time required for the formation of the curd.

During construction work, flocculation helps in the coagulation of clay particles and polymers by mechanical agitation. This process leads to the formation of structures spontaneously. It is due to the attraction of the positive and negative charges. Hence, these applications are important for civil engineering processes.

Flocculation is used in many biological and biotechnological processes. The process of microfiltration and flocculation go hand in hand. Synthetic flocculants in the bioreactor increase in size and hence help in the purification process.

Processes such as coagulation, flocculation sedimentation treat the stormwater, sewage, or industrial wastewater. Drinking water also requires such treatments.

In the brewing industry, yeast gets flocculated. It helps in the fermentation of beer. The yeast gets sedimented and floats down to the base or the top, from where it can be separated. This yeast gets reused for fermentation.

iv) Sedimentation

Sedimentation is one of the methods that municipalities use for treating water. It is a physical water treatment process. Gravity is used to remove suspended solids from water. The effectiveness depends on the size and weight of the particles. Suspended solids that have a specific gravity similar to water remain suspended while heavier particles settle. The sedimentation process in wastewater treatment usually occurs in tanks of various shapes.

Sedimentation of water is one of the most basic processes of purifying water, making it a process that is commonly used and understood throughout the world. It may be used as a preliminary step in some water treatment processes. It provides the following benefits to municipalities that employ it:

- Fewer chemicals are required for subsequent water treatment.
- It makes any subsequent process easier.
- The cost is lower than some other methods.

There is less variation in the quality of water that goes through the process.

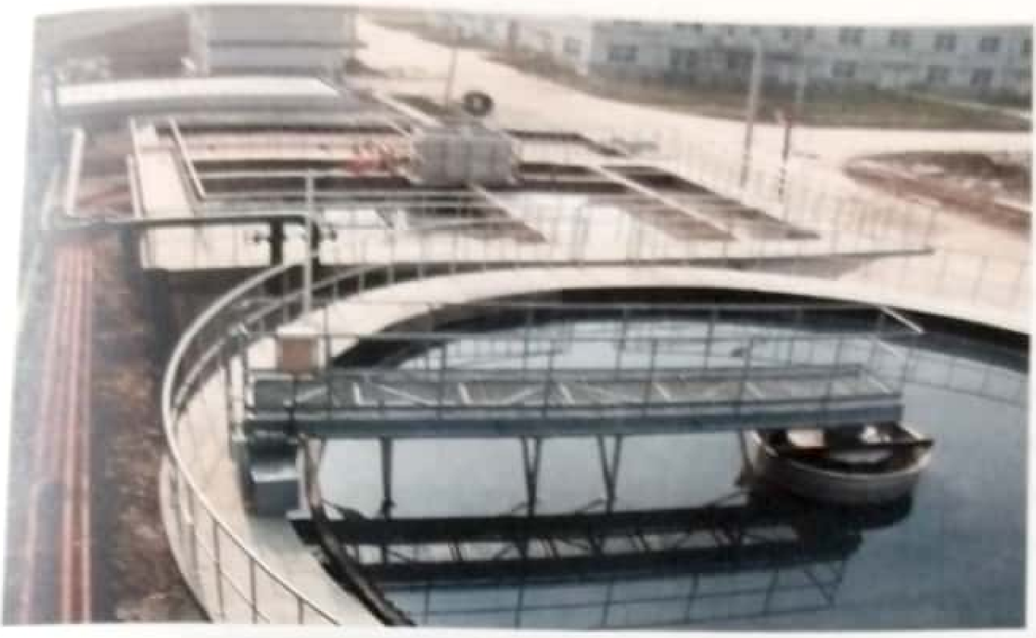

Fig. 3.2 Sedimentation Tank

v) **Ultrafiltration**

Membrane ultrafiltration: a procedure used by aqua source ® since 1984. Ultrafiltration is a physical water treatment procedure. One simple step for both clarifying and disinfecting water. A simple procedure called "low pressure" ultrafiltration permits the clarification and disinfection of water in a single step.

vi) **Filtrations**

Filtration is the process in which solid particles in a liquid or gaseous fluid are removed by the use of a filter medium that allows the fluid to pass through while retaining the solid particles.

It may mean the use of a physical barrier, chemical, and/or a biological process. The removal of particles takes place with processes including: straining, flocculation, sedimentation and surface capture.

Basic requirements are: a filter medium (thin or thick barriers); a fluid with suspended solids; a driving force to cause the fluid to flow; and the filter that holds the filter medium, contains the fluid, and permits the application of force.

vii) Chlorination's

Chlorination is the application of chlorine to the water for the purpose of disinfection. But the chlorination can also be used for taste and odor control, iron and manganese removal, and to remove some gases such as ammonia and hydrogen sulfide. Chlorination is currently the most frequently used form of disinfection in the water treatment field. However, other disinfection processes have been developed. Like several other water treatment processes, chlorination can be used as a pretreatment process (pre-chlorination) or as the final treatment of water (post -chlorination).

During pre-chlorination, chlorine is usually added to raw water after screening and before flash mixing. Post-chlorination, in contrast, is often the last stage in the treatment process. After flowing through the filter, water is chlorinated and stored in the clear water reservoir to allow a sufficient contact time for the chlorine to act. From the clear water reservoir, the water may be pumped into a service reservoir for storage and distribution to the consumers.

Chapter 4

EXPERMENTAL WORK

4.1 Estimation of Water Requirements for Drinking and Domestic Use (Source: National Building Code 2016, BIS)

Table 4.1 Residential Buildings:

Accommodations	**Population**
Bedroom dwelling unit	4
Bedroom dwelling unit	5
Bedroom dwelling unit	6
Bedroom dwelling unit and above	7

Notes:

1) The above figures consider a domestic household including support personnel, wherever applicable.
2) For plotted development, the population may be arrived at after due consideration of the expected number and type of domestic household units.
3) Dwelling unit under EWS category shall have population requirement of 4 and studio apartment shall have population requirement of 2.

As a general rule the following rates per capita per day may be considered for domestic and non- domestic needs:

Table 4.2 For communities with populations up to 20,000:

1)	Water supply through stand post :	40 LPHD (Min)
2)	Water supply through house service: connection	70 to 100 LPHD

a) For communities with: population 20,000 to 100,00 together with full flushing system — 100 to 135 LPHD

b) For communities with population: 100,000 together with full flushing system — 150 to 200 LPHD above

Note—The value of water supply given as 150 to 200 Littre per head per day may be reduced to

135 liter per head per day for houses for Medium Income Group (MIG) and Lowe Income Groups (LIG) and Economically Weaker Section of Society (EWS), depending upon prevailing conditions and availability of water.

Out of the 150 to 200 liter per head per day, 45 liter per head per day may be taken for flushing requirements and the remaining quantity for other domestic purposes.

Table 4.3 Water Requirements for Buildings Other than Residences

Sr. No.	Type of Building	Domestic liters per head/ day	Flushing Liters per head/ day	Total Consumption Liters per head/ day
1.	Factories including canteen where bath rooms are required to be provided	30	15	45

2.	Factories including canteen where no bath rooms are required to be provided	20	10	30
3.	Hospital (excluding laundry and kitchen):			
	Number of beds not exceeding 100	230	110	340
	Number of beds exceeding 100	300	150	450
	Out Patient Department (OPD)	10	5	15
4.	Nurses' homes and medical quarters	90	45	135
5.	Hostels	90	45	135
6.	Hotels (up to 3 star) excluding laundry, kitchen, staff and water bodies	120	60	180
7.	Hotels (4 star and above) excluding laundry, kitchen, staff and water bodies	260	60	320
8.	Offices (including canteen)	25	20	45
9.	Restaurants and food court including water requirement for kitchen:			
	Restaurants	55 per seat	15 per seat	70 per seat

	Food Court	25 per seat	10 per seat	35 per seat
10.	Clubhouse	25	20	45
11.	Stadiums	4	6	10
12.	Cinemas, concert halls and theatres and multiplex	5 per seat	10 per seat	15 per seat
13.	Schools/Educational institutions: Without boarding facilities	25	20	45
	With boarding facilities	90	45	135

Sl No.	Type of Building	Domestic Per Day	Flushing Per Day	Total Consumption Per Day
14.	Shopping and retail (mall) a) Staff	25	20	45
	b) Visitors	5	10	15
15.	Traffic Terminal stations a) Airports	40	30	70
	b) Railway stations (Junction) with bathing facility	40	30	70
	c) Railway stations (Junction) without bathing	30	15	45

	facility			
	d) Railway stations (Intermediate) with bathing facility	25	20	45
	e) Railway stations (Intermediate) without bathing facility	15	10	25
	f) Interstate bus terminals	25	20	45
	g) Intrastate Bus Terminals/Metro Stations	10	5	15

Notes

1. For calculating water demand for visitors, consumption of 15 liter per head per day may be taken.
2. The water demand includes requirement of patients, attendants, visitors and staff. Additional water demand for kitchen, laundry and clinical water shall be computed as per actual requirements.
3. The number of persons shall be determined by average number of passengers handled by stations, with due considerations given to the staff and vendors who are using these facilities.
4. Consideration should be given for seasonal average peak requirements.
5. The hospitals may be categorized as Category A (25 to 50 beds), Category B (51 to 100 beds), Category C (101 to 300 beds), Category D (301 to 500) and Category E (501 to 750 beds).

4.2 Types of Wastewater Reuse

Wastewater can be recycled/reused as a source of water for a multitude of water-demanding activities such as agriculture, aquifer recharge, aquaculture, firefighting, flushing of toilets, snow melting, industrial cooling, parks and golf course watering, formation of wetlands for wildlife habitats, recreational impoundments, and essentially for several other non-potable requirements. Potential reuses of wastewater depend on the hydraulic and biochemical characteristics of wastewater, which determine the methods and degree of treatment required. While agricultural irrigation reuses, in general, require lower quality levels of treatment, domestic reuse options (direct or indirect potable and non-potable) reuses need the highest treatment level. Level of treatment for other reuse options lie between these two extremes.

4.2.1 Reuse for Irrigation

Agricultural irrigation has, by far, been the largest reported reuse of wastewater. About 41 percent of recycled water in Japan, 60% in California, USA, and 15% in Tunisia are used for this purpose. In developing countries, application on land has always been the predominant means of disposing municipal wastewater as well as meeting irrigation needs. In China for example, at least 1.33 million hectares of agricultural land are irrigated with untreated or partially treated wastewaters from cities. In Mexico City, Mexico, more than 70 000 hectares of cropland outside the city are irrigated with reclaimed wastewater. Irrigation has the advantage of "closing-the-loop" combination of waste disposal and water supply. Irrigation reuse is also more advantageous, because of the possibility of decreasing the level of purification, and hence the savings in treatment costs, thanks to the role of soil and crops as biological treatment facilities. As the water supply requirements of large metropolis are growing, the option of reuse of wastewater for domestic purposes is increasingly being considered. Judging from international experience, there is potential for reuse at all system scales, from household level to the large irrigation schemes. Reuse has advantages as well as disadvantages at each level. The choice is conventionally technical and economic one, though some view it as important that the community as a whole should become more involved in the working of reuse systems.

Irrigation reuse of wastewater can be for application on:

1. agricultural crops, woodlots and pastures, or
2. landscape and recreational areas.

The choice of type of irrigation application generally depends upon the location and quantity of wastewater available for reuse.

Fig. 4.1 Irrigated with Recycled Water

4.2.2 Irrigation of Agricultural Crops

As discussed earlier, the oldest and largest reuse of wastewater is for irrigation of agricultural crops. Potential constraints in this type of application are:

i. surface and groundwater pollution, if poorly planned and managed;
ii. marketability of crops and public acceptance;
iii. effect of water quality on soil, and crops;

iv public health concerns related to pathogens.

However, many research studies have proved that in addition to providing a low-cost water source, other side benefits of using wastewater for irrigation include increase in crop yields, decreased reliance on chemical fertilizers, and increased protection against frost damage. Modern reuse for irrigation of agricultural purposes in developed countries were the result of two pioneering studies that were conducted in California during the 1970s and 1980s: The Pomona virus study and the Monterey wastewater reclamation study for agriculture.

The Pomona virus study was conducted in Los Angeles in an effort to determine the degree of treatment necessary to minimize potential transmission of waterborne diseasesvia surface water. The study concluded that complete virus removal is possible through tertiary treatment of wastewater by either direct filtration or activated carbon followed by adequate disinfection, thus proving the possibility for reclamation of "microbiologically risk free" water from wastewater. These results of this study have opened up the possibilities of wastewater reuse for various applications. Since the virus removal through treatment has been established by Pomona study, investigations of Monterey study concentrated on virus survival on crops and in soils in the field. Based on virological, bacteriological, and chemical results from sampled tissues of vegetables grown using wastewater as irrigate, the study established the safety of this type of reuse. Both studies demonstrated conclusively that even food crops that are consumed uncooked could be successfully irrigated with reclaimed municipal wastewater without adverse environmental or health effects.

In many countries in the Mediterranean region, spanning from Spain to Syria, shortage of water has been the main driving force for wastewater reuse. Wastewater from Tunis, the capital city of Tunisia, has been used to irrigate citrus fruit orchards since the 1960s. From 1989 onwards, secondary treated wastewater has been allowed for growing all types of crops, except vegetables. In countries like Morocco, Jordan, Egypt, Malta, Cyprus, and Spain, several large-scale wastewater irrigation schemes are already in operation or under planning. In Israel, the percentage of wastewater reused for irrigationpurposes is highest in the region, at 24.4%, which is expected to be increased to 36% by the year 2010.

In temperate zones of Australia, reclaimed water is being used to irrigate a variety of crops including sugarcane. A recent development is the use of reclaimed water for irrigation of tea-tree plantations, which will produce tea-tree oil as a cash crop. Eucalyptus forestry also is a major reuse option followed in Australia, which provides timber for a number of purposes including pulp wood and fire wood.

A. Irrigation of Landscape and Recreational Area

Application of reclaimed wastewater for landscape irrigation includes use in public parks, golf courses, urban green belts, freeway medians, cemeteries, and residential lawns. This type of application is one of the most common applications of wastewater reuse worldwide. Examples of such uses can be found in USA, Australia, Japan, Mexico and Saudi Arabia among others. These schemes have been operating successfully in many countries for many years without attracting adverse comments. This type of application has the potential to improve the amenity of the urban environment. However, such schemes must be carefully run to avoid problems with community health. Because the water is used in areas that are open to public, there is potential for human contact, so reuse water must be treated to a high level to avoid risk of spreading diseases. Other potential problems of application for landscape irrigation concern aesthetics such as odor, insects, and problems deriving from build-up of nutrients.

B. Domestic and Industrial Reuse

Reuse of wastewater for purposes other than irrigation may be either for:

- Industrial Reuse;
- Non-Potable Purposes;
- Indirect Potable Purposes; Or

direct potable purposes

i. Industrial Reuse

Industrial reuse of reclaimed wastewater represents major reuse next only to irrigation in both developed and developing countries. Reclaimed wastewater is ideal for many industrial purposes, which do not require water of high quality. Often industries are located near populated area where centralized treatment facilities already generate reclaimed water. Depending on the type of industry, reclaimed water can be utilized for cooling water make-up, boiler feed water, process water etc. Cooling water make-up in a majority of industrial operations represent the single largest water usage. Compared to other purposes such as boiler feed and process water, the water quality requirements for industrial cooling are not generally high. Consequently, cooling water make-up presents a single largest opportunity for reuse. In Australia, considered the "driest continent" on earth, cooling water make up would be attractive from the viewpoint of substantially lessening the demand for potable water by power stations. Operational problems encountered in cooling water recirculation systems are irrespective of the quality of make-up water used. They are scaling, corrosion, biological growth, and fouling.

A major problem associated with reuse of wastewater will be biofilm growth in the recirculation system. Presence of microorganisms (pathogens or otherwise) with nutrients such as nitrogen and phosphorus, in warm and well-aerated conditions, as found in cooling water towers, create ideal environments for biological growth.

A successful example for reuse for industrial cooling exists at Earring Power Station in New South Wales, Australia. Electrical power generation industries, by the nature of their activities, are normally located close to large urban settlements, where domestic wastewater is generated in large quantities. Since power-generating stations have a huge cooling water requirement, they provide potential reuse locations for reclaimed sewage. Earring Power Station used 4 million liters/day of potable quality water from a local water supply in the Hunter region of New South Wales. When the continued residential growth in the region necessitated an expansion of potable water infrastructure, many environmental issues were raised about the proposed water source, Lake Macquarie. It was assessed that installation of water intake and construction of pipelines to convey it. to water treatment plant would have disturbed environmentally sensitive areas around the lake. Then it was identified that such an expansion could be offset if the Power Station could replace its cooling water requirement with reclaimed water from a nearby sewage treatment plant located at Dora Creek.

Pilot scale feasibility studies carried out in Australia have concluded that it is possible to economically treat the domestic wastewater to achieve adequate quality for reuse as cooling water. Based on the conclusions of the feasibility study, a full-scale treatment plant employing cross-flow membrane microfiltration system was installed. The membrane filtration system could remove all suspended solids, fecal coliforms, and giardia cysts. It could also significantly reduce human enteric viruses such as reovirus and enterovirus. The water reclamation plant at Earring Power Station demonstrates the potential for reuse of wastewater in power generation and other industrial manufacturing facilities.

ii. Non-Potable Domestic Reuse

Adequately treated wastewater meeting strict quality criteria, can be planned for reuse for many non-potable purposes. Non-potable reuse leads to both a reduction water consumption from other sources, and a reduction in wastewater flow rate. So, non-potable reuse schemes can avoid adverse environmental consequences associated with conventional water sources and wastewater disposal systems. Non-potable domestic reuse can be planned either within single households/building, or on a larger-scale use through a reticulation system meant only for use for non-potable purpose.

Systems for individual households/buildings/facilities. In many parts of the world, it has become apparent that it may not be possible to provide a centralized sewage collection facility for all the households, due to both geographic and economic reasons. Wastewater from individual dwellings and community facilities in such unsewered locations is usually managed by on-site treatment and disposal systems. Although a variety of onsite systems have been used, the most common system consists of a septic tank for the partial treatment of wastewater, and a subsurface disposal field for final treatment and disposal.

By segregating the "gray" sullage from "black" toilet wastes, potential for reuse with minimal treatment within the household enhances manifold. There are several different schemes for reusing gray water at the household levels. In California, systems which use gray water treated to a primary level for subsurface irrigation of gardens, have been in use for many years, and studies have shown no health problems associated with the use. In non-sewered areas of Australia, water scarce conditions in some regions of Victoria have prompted interest in gray water recycling for garden irrigation. Collection and recycling systems for bathroom and laundry water have recently been tested in Victoria. A simple valve arrangement for diversion of laundry gray water for garden watering has been developed. Australian authorities are currently considering the introduction of a comprehensive guidelines for gray water recycling systems in individual households.

here the gray water is not separated from toilet wastes, improvements in the quality of treated wastewater can be brought about by many alternative systems. One of the alternatives include intermittent and recirculating granular-medium filters. The effluent from a recirculating filter has been found to be of such high quality, it can be used in a variety of applications, including drip irrigation. In Japan, the major in-house gray water reuse system is the hand basin toilets, which uses a hand basin set on the top of the cistern, so the water from hand washing forms part of the refill volume for toilet flushing. Hand basin toilets are reportedly installed in most new houses in Japan.

A large-scale non-potable reuse scheme at the Taronga Zoological Park in Sydney, Australia is operating since 1996. Before the scheme, wastewater and stormwater from the zoo premises were being discharged with less effective treatment into Sydney Harbor. Reports of foul smell and discolored water from the public were common. With the reuse scheme in place, the zoo now treats all wastewater generated, and recycles about 200 kl/day of reclaimed water to hose down animal enclosures, watering the gardens and lawns, flush public toilets and fill ornamental moats.

Large-scale non-potable reuse through a dual reticulation system. A Dual reticulation system is the wastewater reuse concept for urban areas where a centralized sewage collection system is in place, on a large scale. This system supplies treated wastewater to houses, and commercial/official/shopping complexes through a separate water supply network, to be used primarily for toilet flushing, and irrigation of lawns. Thus, households will have two water supply lines, one for potable and human-contact use purposes, and the second for non-potable, non-contact uses such as toilet flushing, use in the yards and gardens etc., hence the name "dual reticulation system."

iii. Indirect Potable Reuse

Indirect potable reuse of treated wastewater may occur unintentionally, when wastewater is disposed into a receiving body of water that is used as a source of potable water supply. It can also be through planned schemes, such as that of Cerro del la Estrella sewage treatment plant in Mexico City. Here, treated wastewater which meets the criteria for potable reuse except for total dissolved solids, is diluted by water from other sources to meet this criterion, and used for potable purposes. Another planned indirect potable reuse can be through groundwater recharge of treated wastewater.

Deliberate (artificial) recharge of groundwater aquifers with treated wastewater can be carried out to achieve one or more of the following objectives

- as storage during periods of low water demand;
- as an additional treatment method;
- as a measure to improve the depleting groundwater potential; and
- as a measure to improve the overall quality of groundwater by injecting reclaimed water of specific qualities.

Use of treated wastewater for artificial groundwater recharge is increasing as a way to treat and store effluent underground for subsequent recovery and unrestricted reuse. A recent report by the National Academy of Sciences, USA, has given a cautious green signal for potable use of water from aquifers recharged with wastewater. The report suggests that with surface infiltration systems for artificial recharge, considerable quality improvements can be obtained as the water flows through the unsaturated zone to the aquifer, and this soil-aquifer treatment (SAT) reduces pretreatment requirement.

However, it cautions that impaired quality waters used to recharge groundwater aquifers must receive a sufficiently high degree of pretreatment (prior to recharge) to minimize the extent of any degradation of groundwater quality, as well as to minimize the need for any extensive post-treatment at the point of recovery. In many arid and semi-arid countries, like Israel and Morocco, SAT is used as an extra advanced wastewater treatment process in order to produce an alternative source of water and is considered as a relatively inexpensive but efficient advanced treatment, because it removes efficiently the parasitic protozoa and helminths, as well as bacteria, mostly by filtration. It is because of this reason that water from polluted natural water (as against treated wastewater) sources also have been artificially recharged to be recovered and reused for potable purposes. In Israel, water from a lake is used for recharge for such purposes.

One of the earliest indirect reuses of treated wastewater can be traced back to a pilot study of 1930s, in the city of Los Angeles. The study reported that secondary treated wastewater treated in a long chain of tertiary treatment processes including super chlorination, ferric chloride coagulation, sedimentation, sand filtration, and activated carbon filtration, has been infiltrated into ground up to 7–5 m above groundwater table in a dry river bed 2–5 km upstream from collection galleries for the municipal water system. In Arizona, USA, many cities and towns recharge their aquifers with urban wastewater to obtain "recharge credits," which allows them to continue pumping their groundwater wells for municipal water supplies. Recharged water is recovered for use in drinking, irrigation and industrial purposes.

iv. Direct Potable Reuse

Direct potable reuse means adding treated wastewater directly into the normal drinking water distribution system. Though the idea of such a wastewater reuse may be repugnant to many, technologically, direct potable reuse of treated wastewater has been feasible for many years. A classic example of wastewater reuse for direct potable purposes in an emergency happened in 1950s in the town of Chanute, Kansas, USA. The Nesho river in eastern Kansas served as the sole water source of Chanute. Due to continuous drought for five years, surface flow of the river ceased in 1956. After considering all other alternatives, the river was dammed just below the town's sewage outfall, and the treated wastewater was used to fill the potable water intake pool. For five months, the city reused its sewage, circulating it some eight to fifteen times. Thanks to the elaborate sewage treatment as well as for raw water, the bacteriological qualities were met. An epidemiological survey showed fewer cases of stomach and intestinal illness during recycle than in the following winter when Chanute was back to use as river water. In the United States, the Denver Potable Reuse Demonstration Project has operated since 1984. A larger demonstration plant at Daspoort sewage treatment plant, however, did not reuse treated wastewater to supplement drinking water supplies for various reasons.

Case study of Windhoek water reclamation scheme for direct potable reuse. Another famous example widely quoted for direct potable reuse of reclaimed water is the reclamation scheme adopted in Windhoek, capital city of Namibia, which was initiated in 1968. The city of Windhoek, approached the limits of its conventional drinking water sources during the 1960s due to severe water shortage, as groundwater and surface water sources in the vicinity of the city had been fully harnessed. Therefore, in 1968, the city adopted a water reclamation scheme from domestic wastewater to supplement the potable water to the city. The scheme was well publicized and there has been no public opposition. The reclamation scheme was founded on the three basic premises for reclamation to succeed: diversion of industrial and other potentially toxic wastewater from the main wastewater stream, wastewater treatment to produce an effluent of adequate and consistent quality, and effluent treatment to produce acceptable potable water. In addition, it was considered that it is of utmost importance to develop a multi- barrier treatment sequence as a safeguard against pathogens.

The industrial wastewaters were diverted to be treated in separate small treatment plants, and only the industries that do not generate wastewater were allowed in areas were effluents merged with domestic sewage. The system went through a succession of modifications and improvements over the year. The wastewater is treated in two separate, consecutive treatment plants to potable standard. The first is the conventional biological treatment plant (activated sludge process) at Gammas to treat raw wastewater. This wastewater is discharged into a series of maturation ponds, from where the effluent gravitates directly to the water reclamation plant at Gore angab. The water reclamation plant consists of alum coagulation, dissolved air floatation, lime dosing, sedimentation, sand filtration, breakpoint chlorination, activated carbon filtration, and final chlorination.

Up to the present, the reclaimed water is blended in two steps. The first blending step takes place at the Gore angab treatment plant, where the reclaimed water is blended with conventionally treated surface water, which ensures a minimum 1:1 dilution of reclaimed water. The second blending step takes place in the bulk water system of Windhoek, where the blend from Gore angab is mixed with treated water from other sources. It has been estimated that in future, the surface water supply at Gore angab will not have any significant benefit, due to its quality deterioration as well as its reduced contribution to the total flow. Until 1982, the scheme had research status, and some costs of monitoring were absorbed by the South African Water Research Commission. Since then, the project is considered a normal production facility. To ensure water quality, an independent expert monitoring of system performance, a technical committee representing experts from. five independent professional bodies convened three times a year for a detailed reviewof water quality. This procedure was discontinued since 1988 and replaced by a monitoring system by three independent laboratories. The treated wastewater, before reclamation, is also continuously monitored to ensure a consistent, high quality maturation pond effluent.

The Windhoek experience with wastewater reclamation to potable drinking water standard was an unqualified success during the last twenty-five years, which is of great significance to all arid and semi-arid regions of the world, as it demonstrates that:

- with proper care and diligence, water of acceptable quality can be consistentlyproduced from domestic wastewater,

- if properly informed, consumers will fully accept this perhaps controversial option, wastewater reclamation for direct potable purpose is a practical option, not only fortechnologically advanced countries, but also for regions with relatively difficultaccess to advanced technology, management and operating skills

V. Wastewater Sludge Reuse

Wastewater sludge is the solid/semi-solid substance, concentrated form of mainly organic, and some inorganic impurities (pollutants), generated as a result of treatment ofwastewater. For any growing modern city, it is necessary to expand its sewage collection system to cater to the needs of the growing urban areas and its population. With the expansion of sewerage system comes the ever-increasing problem of how best the sludge generated in wastewater treatment facilities can be disposed. Disposal methods once used for sludge management, such as ocean disposal, are notenvironmentally appropriate. Though it is traditionally suggested that the sludge can be applied on land as soil conditioner and as fertilizer, there are many issues involved in handling and transportation, and odor nuisance, which are of concern. Experience in Europe and the USA have shown that land application/reuse of sludge options are the most promising ones that benefit the society. Sludge can be reused to reclaim parched land by application as soil conditioner, and also as a fertilizer in agriculture.

Deteriorated land areas, which cannot support the plant vegetation due to lack of nutrients, soil organic matter, low pH and low water holding capacity, can be reclaimed and improved by the application of sludge. Sewage sludge has a pH buffering capacity resulting from an alkalinity that is beneficial in the reclamation of acidic sites, like acid mine spoils, and acidic coal refuse materials. There are a number of successful land reclamation projects reported from the United States. Operational experience is available for handling systems, application systems, amount required per hectare, and response of various types of vegetation. Sludge with a solid content of 30% or more can be handled with conventional end-loading equipment, and applied with agricultural manure spreaders. Liquid sludge, typically with solid content less than 6%, are managed and handled by normal hydraulic equipment. Agricultural use of sludge matches best with priorities in waste management. Sewage sludge contains nutrients in considerable amounts, which lead to fertilization of soil and organic matters that improve the soil through humic reactions.

Netherlands, Sweden, and Spain in Europe use more than 60% of sludge for agricultural purposes. Denmark, England, and Switzerland use more than 45% for similar purposes. Their experience shows that by following regulations and strict adherence to standards, adverse environmental effects of sludge application for agricultural purpose could be reduced to a minimum, thereby giving confidence to those who rely on them.

New South Wales in Australia has taken a lead role in the adoption of sludge reuse options. Until 1990, over 60% of sludge generated in the wastewater treatment plants was disposed of into the ocean. By 1993, nearly 70% of sludge generated was being recycled, and disposal into the ocean has ceased. Low availability of organic soil conditioners and increasing interest being shown by fertilizer companies to blend organic matter with chemical fertilizers, has created demands for sewage sludge in Australia. To improve the nutrient and other beneficial qualities of sludge, alkaline adjuncts such as lime, cement kiln dust, calcium oxide or calcium carbonate are added. N-Viro soil is one such patented product in Australia, based on addition of quick lime and cement kiln dust with sludge. Composting and vermi-composting of sludge also are carried out in many parts of Australia, to convert into odorless humus material for sale at higher prices.

Sludge has also potential for reuse in manufacture of other beneficial products. Pilot scale work in Canada indicated that sludge can be used to produce a low-grade oil by heating sludge to 450□C in the absence of oxygen. The sludge oil has a calorific value of 32 MJ/kg and has been obtained at yields of 13% from anaerobically digested sludge and 46% raw sludge. Manufacturing of bricks using slag and sewage sludge has been developed in many countries. In Australia, a company uses slag ash and sludge together with shale and clay to produce a brick 15% lighter than the regular brick with a superior ratio of strength to firing time.

v. Future of Water Reuse

As of now, major emphasis of wastewater reuse has been for non-potable applications. In spite of developing sound technological approaches to producing water of any desired quality from reclaimed wastewater, it has generally been too expensive to be taken seriously as a potable supply option. There are several other key issues that include evaluation of health risks associated with trace organic and inorganic contaminants in reclaimed water, application of membrane treatment processes in production of high-quality reclaimed water, optimization of treatment trains for wastewater reclamation projects to be cost-effective, that requires additional research and demonstration for progress in reclaimed water reuse applications. There also is a psychological threshold that is keeping us at bay for reuse in portable applications, even when there are no other viable long-term options. If water reuse projects are to succeed, efforts to generate greater community awareness to judge water by its quality and not by its history, and seeking their increased participation in such schemes will also be needed.

Chapter 5

RESULTS AND DISCUSSIONS

Quantitative greywater characterization

As already mentioned, greywater production from several sources was recording at three Greek households (F1, F2 and F4). Household F1 refers to a one resident flat (a university student), household F2 refer to two residents flat (two adults) and household F4 refers to a family residence (two adults and two children). According to the results average greywater production was estimated to be 98.1±29.5 L per person per day whereas the total household wastewater production was 135±31.6 L per person per day. Similar values have been reported by other researchers as well (Friendlier et al., 2011; Antonopoulos et al., 2013), whereas there are other studies report either on lower greywater production (66 L/pe/d - Palmquist et al., 2005), or on higher greywater production (150 L/pe/d – Allen et al., 2015). Figure 1 presents the contribution of each source to the total greywater production for the three households. Based on the results it is anticipated that major sources of wastewater are toilet flushing, bathtub and kitchen sink. The major portion of greywater (to the order of 60%) is produced in bathrooms (bath tub and hand basin). Wastewater production presents a great variability throughout a week due to the daily habits of the residents (Figure 2).

Qualitative greywater characterization

Based on the sampling protocol 60 greywater samples were collected and subsequently being analyzed. The main quality characteristics for the several greywater sources are presented in Table 1, whereas Table 2 presents the daily pollution load produced per population equivalent at each greywater source. According to the results average pH in kitchen greywater is rather neutral (6.90), whereas laundry and dishwasher greywater is alkaline with an average pH value of

8.2 and 10 respectively. Kitchen sink and laundry seem to be the two more significant contributors of organic carbon (Figure 1), mainly due to the presence of drink and food residuals and dirt from vegetables (in the former case) and clothes impurities (in the latter case). Soluble COD accounts for the 48-65% of the total COD whereas biodegradability of organic carbon is rather high as COD/BOD5 ratios range between 1.3-1.5 with the exception of dishwasher wastewater which presents a rather high ratio (2.7). On the other hand, greywater produced in bathrooms (handbasins and bathtubs/showers) seems to be lighter with respect to its suspended solids, organic matter and nutrients loads.

Chapter 6

CONCLUSIONS

6.1 Conclusions

1. Reusing of grey water will definitely help to solve the problem of water demand in the world. The treatment system can be easily adopted by the developing countries. Since there is rapid development in India and there is planning of developing many smart cities, this concept of Treatment and reuse of grey water can play a major role in it.
2. The country like India and many such countries in the world are facing and if not will definitely face the problem of water crises thus our research aims to help facing the problem of water crises.

6.2 Future Scope

1. (LIG) and Economically Weaker Section of Society (EWS), depending upon prevailing conditions and availability of water. Out of the 150 to 200 liters per head per day, 45 liters per head per day may be taken for flushing requirements and the remaining quantity for other domestic purposes.
2. The computed results concerning the correlation between household size and per capita water consumption may safely be generalized to comparable urban households with piped water supplies.
3. The results on the impact of socio-economic status on per capita water consumption may safely be generalized to comparable urban households that have the same water tariffs, and the same level of service from the water utility.

4. The findings on the impact of climatic conditions on domestic water consumption may safely be generalized to comparable urban households.

Reference

1. M. Dakua, M. Mahmood, S. Bhowmik, and F. Khaled "Potential of Grey Water Recycling in Water Scarce Urban Areas in Bangladesh". International Journal of Environmental Science and Development, Vol. 7, No. 8, August 2016.
2. M. Sundaravadivel. "Recycle And Reuse of Domestic Wastewater" Wastewater Recycle, Reuse, And Reclamation - Recycle and Reuse of Domestic Wastewater - S. Vigneswaran, M. Sundaravadivel.
3. Siddhant Bansal "Study towards Waste Water Management – Grey water Reuse". International Journal of Scientific & Engineering Research Volume 8, Issue 10, October-2017 ISSN 2229-5518.
4. Maisie Borg, Orion Edwards & Sarah Kimpel (2018) "A Study of Individual Household Water Consumption". A Study of Individual Household Water Consumption Borg, Edwards, Kimpel.
5. Maisie Borg, Orion Edwards & Sarah Kimpel (2015) "A Study of Individual Household Water Consumption". Borg, Edwards, Kimpel.
6. M. Dakua, M. Mahmood, S. Bhowmik, and F. Khaled (2016) "Potential of Grey Water Recycling in Water Scarce Urban Areas in Bangladesh". International Journal of Environmental Science and Development, Vol. 7, No. 8, August 2016.

7. M. Sundaravadivel (2015) "Recycle and Reuse of Domestic Wastewater". Wastewater Recycle, Reuse, And Reclamation - Recycle and Reuse of Domestic Wastewater - S. Vigneswaran, M. Underivative.

8. Y.D Chintanwar, Paras Batra, Vikashkumar, Rushabh Gour, Sumant Chorey, Nikhil Yeole, Ravikant Kumar (2016) "Grey Water Treatment and Management: The Potential of Greywater Systems to Aid Sustainable Water Management". Journal Of Research in Engineering and Applied Sciences.

9. Rajarshi Kar, Oindrila Gupta (2012) "Grey Water Treatment and Recycling for Use in Household Applications". International Journal of Engineering Research & Technology (IJERT) Vol. 1 Issue 4, June – 2012.

10. Siddhant Bansal (2017) "Study towards Waste Water Management – Grey water Reuse". International Journal of Scientific & Engineering Research Volume 8, Issue 10, October-2017 ISSN 2229-5518.