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# Greywater Reuse: A Feasibility Study for NIT Raipur Residential Buildings

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## ABSTRACT

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). India supports over 15% of world's population but only 4% of the world's water resources. It is therefore essential for a sustainable urban future, 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. Reuse of domestic greywater and rainwater has a significant role to play in this task. Reusing greywater serves two purposes: it reduces the amount of freshwater needed to supply a household, and reduces the amount of waste water entering sewer or septic systems. This paper focuses on the reuse of greywater mainly for the purpose of flushing in toilets in the residential buildings of NIT Raipur. Our greywater treatment system will include settling tank, disinfectants and filters. The water treated from this system will be supplied to the overhead tanks supplying water to the toilet flushes and to irrigating pipes. The economical and environmental aspect of greywater reuse has been dealt in this paper. Initially this system might involve high capital investment but eventually in the long run it will generate profits and be a boon for the future generations.

**Keywords:** greywater, reuse, treatment, flushing toilets

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## 1. INTRODUCTION

Population growth, rapid urbanization, higher standards of living and climate change have led and will lead to continuous growth of urban water consumption. International Water Management Institute (2002) projected that total urban water consumption will increase from 1995 to 2025 by 62%. As pressures on freshwater resources grow and as new sources of supply become increasingly scarce, expensive, or politically controversial, efforts are underway to identify new ways of meeting water needs. Among these potential new sources of supply is "greywater." Greywater is water that has been used for washing dishes, laundering clothes, or bathing. Essentially, any water, other than toilet wastes, draining from a household is greywater. Although this used water may contain grease, food particles, hair, and any number of other impurities, it may still be suitable for reuse. In particular, the reuse of greywater can help reduce demand for more costly high-quality potable water.

## 2. ESTIMATION OF GREYWATER AT NIT RAIPUR

As per Central Ground Water Board for Raipur district the phreatic aquifer depth to water level ranges from 4-15 m below ground level(bgl) in the pre-monsoon period and 1.3-9 m bgl during post monsoon period. As NIT Raipur lies in the region which experiences water shortage during the pre-monsoon period it is an urgent need to develop a greywater reuse system which will reduce the stress on the underground water table and instill in the public an awareness of water conservation.

According to state and local authorities we each use about 135 litres of water per day for cleaning and washing, flushing, bathing, etc. The detailed partition of each has been clearly represented in the pie chart below (Figure 1). Of the total water supplied, sewage produced is around 80% (i.e. 110 lpcd) of which Greywater produced is about 65% (70 litres). This water which goes as waste can be efficiently reused for other purposes like flushing of toilets, irrigating gardens, etc.

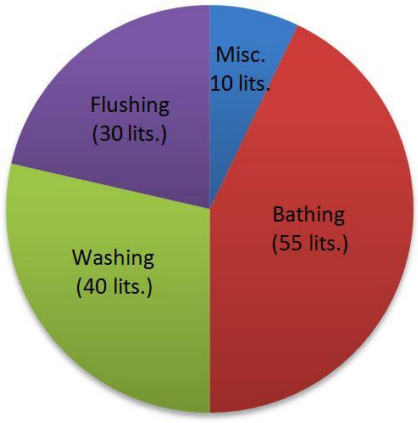


**Figure 1** Pie chart depicting water demand per capita for various purposes

Here in NIT Raipur which has 8 hostels, houses around 1600 students, generates about 176000 litres of wastewater of which 114400 litres is greywater. As per BIS 1772:1993 flushing toilet requires around 30 litres of water per capita per day, hence summing to a total of 48000 litres per day. If this greywater be used to its full capacity, can comfortably replace the use of underground freshwater for flushing toilets as well as could also suffice the demand for watering of gardens.

## 3. COMPOSITION OF GREYWATER

Composition of greywater varies largely and depends upon its source of origin. Classifying according to its source into three broad areas:

### 3.1. Greywater from Bathroom

Water used in hand washing and bathing generates around 50-60% of total greywater and is considered to be the least contaminated type of greywater. 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.



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### 3.2. Greywater from Cleaning or Washing Area

Water used in cloth washing generates around 20-25% of total greywater. Wastewater from the cloth washing varies in quality from wash water to rinse water to second rinse water. Greywater generated due to cloth washing can have faecal contamination with the associated pathogens and parasites such as bacteria.

### 3.3. Greywater from Mess/Kitchen

Kitchen greywater contributes about 15-20% of the total greywater volume. It is contaminated with food particles, oils, fats and other wastes. It readily promotes and supports the growth of micro-organisms. Kitchen greywater also contains chemical pollutants such as detergents and cleaning agents which are alkaline in nature and contain various chemicals. Therefore kitchen wastewater may not be well suited for reuse in all types of greywater systems.

## 4. GREYWATER TREATMENT SYSTEM

The basic components in greywater treatment system include the collection tank, treatment system, distribution system and storage tanks. Greywater will be collected from various sources like washbasins, kitchen, bathrooms, etc. and sent to the collector tank situated underground. Water will be treated in the treatment plant and successively stored in the storage tanks after treatment. The excess untreated grewater will be diverted from the collector tank by an overflow pipe to the sewers. The treated greywater will be stored in the storage tanks and pumped to the overhead tanks supplying water to the toilet flushing systems as shown in figure 2. There will be two greywater treatment plants required at NIT Raipur one each for boys hostel and girls hostel.

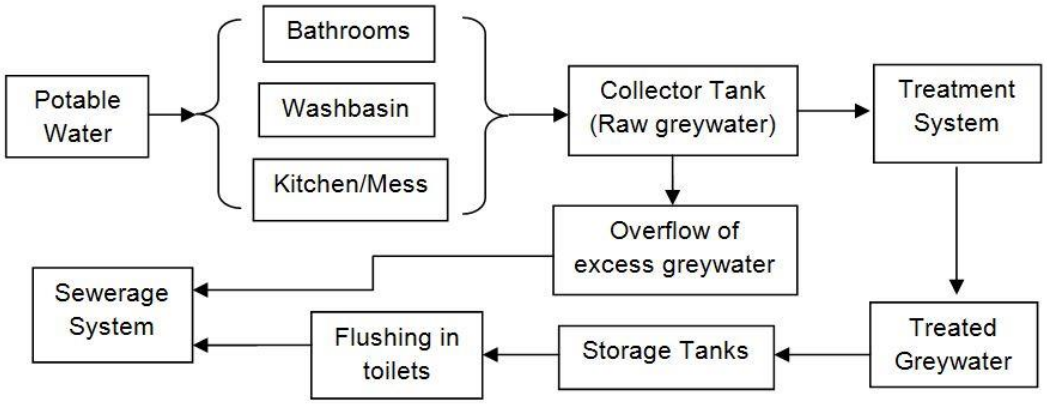


**Figure 2** Flowchart of the various components involved in the greywater treatment system

## 5. TREATMENT OF GREYWATER

Greywater reuse methods can range from low cost methods such as the manual bucketing of greywater from the outlet of bathroom, to primary treatment methods that coarsely screen oils, greases and solids from the greywater before irrigation via small trench systems, to more expensive secondary treatment systems that treat and disinfect the greywater to a high standard before using for irrigation.

### 5.1. Primary Treatment System

In primary treatment system, a sedimentation tank is used to coarsely screen out oils/greases and solids prior to reuse. This system is recognized as an economically attractive option for greywater reuse because it requires minimal maintenance, and chemicals.

### 5.2. Secondary Treatment System

In secondary treatment system, Chemical and Boilogical treatment process are used to remove most of the organic matter. This reduces health risk at end use with human contact and provides additional safety for reuse. This system is generally more expensive, due to the initial establishment costs associated with the further treatment needs and the periodic maintenance costs.



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### 5.3. Tertiary Treatment System

Tertiary treatment processes further improves the quality of greywater or polish it for reuse applications. Fixed film biological rotating drums, membrane bioreactors, biologically aerated filters, activated sludge and membrane treatment systems are all included in this category. The choice of treatment system depends on a number of factors, here in this case for NIT Raipur we have planned it as shown in figure 3.


**Figure 3** Stages in Greywater treatment plant

## 6. DETAILS OF GREYWATER TREATMENT SYSTEM

There will be two greywater treatment plants required at NIT Raipur one each for boys hostel and girls hostel. The detailed design parameters for each treatment system have been specified in Table 1.

**Table 1** Details of both Greywater treatment System

| Design Parameters | Greywater treatment plant-1 Boys Hostel | Greywater treatment plant-2 Girls Hostel |
|---|---|---|
| Number of users | 1200 | 400 |
| Greywater requirement (per day) | 36 kl/day | 12 kl/day |
| Peak hour flow rate (per minute) | 150 lits. | 50 lits. |
| Pump power (in hp) | 1.0-1.5 | 0.5-1.0 |
| Power required per day for pumping | 25 units | 8 units |
| Underground area required | 75 $m^2$ | 30 $m^2$ |

## 7. FEASIBILITY STUDY

### 7.1. Economic Analysis

The economic analysis presented below attempted to determine all plausible costs and benefits associated with Greywater Reuse (GWR) for toilet flushing.

#### 7.1.1. Costs

The costs of the GWR system were the cost of:
(i) system design, purchase and installation and
(ii) operation and maintenance costs

Taking the design life period of installations as 20 years. The various costs involved in the treatment system is mentioned in Table 2.

**Table 2** Cost details of both Greywater treatment System

| Parameters | Greywater treatment plant-1 Boys Hostel | Greywater treatment plant-2 Girls Hostel |
|---|---|---|
| Greywater requirement (per day) | 36 kl/day | 12 kl/day |
| Capital Costs | 6,00,000 | 2,00,000 |
| Operation Costs | 34,000 | 11,000 |
| Maintenance Costs | 45,000 | 16,000 |
| Cost of Fittings and plumbing | 1,00,000 | 35,000 |



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### 7.1.2. Benefits

The economic benefit of GWR for toilet flushing is the savings in municipal potable water resulting from reuse. This benefit was calculated by multiplying the prevailing water tariff by the potable water saved. According to Raipur Municipal Corporation Water tariff 2015, 9.0/kl will be charged for potable water and increment in rate by 7% per annum was employed in this study. Potable water saved can be determined by logging demand within each building over similar months before and after GWR implementation and subtracting the 'after' from the 'before' values.

At NIT Raipur, the average potable water saving of both the treatment plant combined due to Greywater reuse is 48000 l/day (48 kl/day).

Thus Savings = 48 kl/day X 9.0/kl = 432/day

= 1,57,680 per year

The net payback period when calculated comes out to be about 10 years.

### 7.2. Environmental Aspect

The environmental benefit is the savings due to the reduction in sewage to be treated due to GWR for toilet flushing multiplied by the sewage tariff. In essence, the greywater collected resulted in the reduction of sewage being conveyed to the sewage treatment works downstream. Altogether the positives of GWR can be summed up as:

- Greywater recycling decreases waste water discharge to sensitive water bodies
- It can decrease the removal of freshwater from sensitive eco-systems
- Recycled water may be used to create or enhance wetlands or riparian (streams) habitats
- Water recycling reduces and prevent pollution.
- Can ensure water demands are met
- Recycling water can save energy

## 8. CONCLUSION

This paper reports on GWR for toilet flushing at NIT Raipur's Residential building.

The paper concludes the following:

- The lower the possibility of contact with grey water, the more acceptable GWR is to potential beneficiaries. Hence, the preference by beneficiaries for GWR is for toilet flushing instead of GWR for watering gardens/irrigation.
- To ensure the efficient functioning of GWR systems, it is important that there is regular engagement with beneficiaries, and maintenance and repair activities.
- To reduce the payback period and increase the benefit–cost ratio, initial and recurrent costs must be lower than that was experienced in this paper.

The benefits of greywater recycling include: Reduced use of freshwater, Less strain on septic tanks or treatment plants, More effective purification, Reduced use of energy and chemicals, Groundwater recharge, Plant growth, Reclamation of nutrients, Increased awareness of and sensitivity to natural cycles. Saving of 48000 liters of water per day in residential buildings/hostels of NIT Raipur can be achieved by saving of drinking water by reuse of grey water for toilet flushing and gardening.

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