International Journal of Engineering, Science and Mathematics
Vol.7Issue 4,April 2018,
ISSN: 2320-0294 Impact Factor: 6.765
Journal Homepage: http://www.ijesm.co.in, Email: ijesmj@gmail.com Double-Blind Peer Reviewed Refereed Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gage as well as in Cabell's Directories of Publishing Opportunities, U.S.A

GREYWATER REUSE TOWARDS AUGMENTATION OF FRESHWATER DEMAND IN HIGH RISE BUILDINGS

Singh Vandana*
Kaur Amarjeet**
Gupta N. C.***

Abstract

Water crisis is a universal phenomenon now, though its severity varies from place to place. This has led to the substitution of the freshwater by alternate sources. Considering the ease of treatment and round the year supply of Greywater, it is one of the most promising alternatives. Therefore, in this paper an attempt has been made to present a case study for reuse of treated Greywater to encourage planners and researchers for optimal utilization of available resources. Paper suggests that though the probability of microbial contaminants in Greywater is low, however its presence must not only be investigated but should also the risk associated with it in reuse should be eliminated in planning reuse. In addition to this, paper gives a series of steps to popularize the reuse of Greywater in India. The authors understand the public sentiments associated with GW and thus advices to improve social acceptance of treated Greywater through awareness.

Keywords:

Greywater,
Greywater Characteristics,
Treatment,
Reuse Standard,
Public Awareness

Author correspondence:

Singh Vandana,
USEM, GGGSIPU, Delhi, India

*Research Scholar, USEM, Guru Gobind Singh Indraprastha University, Delhi, India
**Director, CDMS, Guru Gobind Singh Indraprastha University, Delhi, India
***Dean, USEM, Guru Gobind Singh Indraprastha University, Delhi, India

1. Introduction

Fresh water resources are shrinking across the globe due to various reasons including increasing population, rapid urbanization etc. India is one of the most water stressed countries in the world [1]. In Indian cities, surface water resource and ground water resource are being over exploited [2]. This has led to shortage of freshwater and therefore calls augmentation/substitution of freshwater supply.

According to WHO greywater can be one of the best resource to augment the freshwater resource through recycle and reuse. Greywater (GW) is 70% of total consumed water and has lower level of pollutants and pathogen content [3]. Primary, secondary and tertiary levels treatment technologies reported for greywater treatment vary based on the site conditions and greywater characteristics and reuse applications.

Even though it is reported that treated GW reuse might represent 40 to 47% reduction of total water consumption in domestic water demand [4], large scale implementation of greywater reuse systems in India is not in existence. The major reasons for this includes site specific economics of reusing greywater as a resource and public acceptance.Therefore, in this paper it is attempted to investigate the possibility of reusing GW in a multistoried institutional complex.

2. Benefits of reusing Greywater

Large consistent source with a low organic content makes greywater most suitable for recycling. It is because of this that its treatment is relatively easy and cheap [5]. The major pros and cons of recycling and reusing greywater have been summarized in Table 1.

Table 1: Advantage and Disadvantages of Recycling and Reusing Greywater [6]

Pros of recycling/reusing greywater	**Cons of recycling/reusing greywater**
• Reduction of overall fresh water demand • Reduction of Organic and hydraulic loadings on the municipal wastewater treatment system • Reduction in water bills • Reduction in pumping cost of collective conveyance and treatment system • Replenishment of ground water which contributes to a healthy water cycle • Protection of aquatic ecosystem due to decreased diversions of freshwater • Efficient wastewater management and increased reuse	• GW cannot be stored for more than 24 hrs (since nutrients break down and cause bad odour) • Biodegradable soaps and detergents can also present a problem over a period of time when greywater is used for irrigation • Health standards of the water and quality concerns • Contain fats, oils, oils, grease, hair, lint, soaps, cleaners, fabric, softeners and other chemicals that are harmful plants.

3. Methodology

3.1 Sample Collection

In this paper GW from a residential complex in an institutional campus was collected from the drain pipe by diverting partial flow through a plumbing connection. The partially diverted GW from the residential complex is stored in a 500 l tank at the first floor of the girls hostel which is a multi-storeyed building. The overflow from the tank is connected to the nearest manhole. Seven (one each day) samples were collected for one week and the average occupancy of hostel during this period was between 30-40 students. These samples were collected in between 12 am to 5 pm after collecting fresh GW for two hrs.

The average GW characteristics were then calculated using the individual GW analysis results. The average value was then subjected to removal efficiencies of various conventional treatment processes to give treated GW quality. The treated effluent characteristic is then compared with applicable reuse standard and most suitable reuse was suggested. In order to keep the entire process simple, light strength GW has been considered in this study and the oil and grease laden GW from kitchen was not made a part of this study.

3.2 Analysis

Samples of GW were collected from the collection tank and analysed in accordance with the respective Indian Standards. Determined parameters include pH, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), Nitrate, Sulphate, Chloride, Phosphate and Faecal Coliform (FC).

4. Results and Discussion

4.1 Characteristics of raw greywater generated

The characteristic of raw GW from the girls' hostel is presented in Table 2. From the table it is seen that the GW generated shows wide variation in characteristics indicating need of longer hour of storage for homogenisation. The higher value for pH, chlorides, phosphate and Sulphates is due to the type of detergent and/or soap used for bathing, handwashing and laundry activities. The value of nutrients in GW is typically on the lower side due to the absence of wastewater from toilet flushing.

The measure of BOD and COD of any wastewater indicates its strength. Here, the value of BOD and COD are comparatively lower due to the fact that it is light GW which has combined waste streams from laundry, shower and wash basin.

The presence of FC is generally not expected in GW unless there are small children [7]. However, there presence cannot be rejected as the GW collected is from shower, hand wash and laundry.

Table 2: The characteristics of GW

Parameter	Results	Test Method
pH	7.66- 7.76	IS:3025:1983(P-11)
BOD (mg/l)	8.65-46	IS:3025:1993(P-44)
COD (mg/l)	48-168	IS:3025:2006(P-58)
TSS (mg/l)	4-17	IS:3025:1984(P-17)
Nitrate (mg/l)	2.44- 13.38	IS:3025:1988(P-34)
Sulphate (mg/l)	47.23- 123	IS:3025:1986(P-24)
Chloride mg/l)	238.13-300.84	IS:3025:1988(P-32)
Phosphate (mg/l)	1.35-5.96	IS:3025:1988(P-31)
FC (MPN/100ml)	7-33	IS: 1622:1981

4.2 Treatment of raw GW generated

In this paper we have considered the removal efficiencies of the conventional treatment methods and using these efficiencies the strength of treated wastewater is projected in Table 3.

4.3 Reuse Standards

The reuse standard of treated wastewater is laid as statutory guideline by urban local body/state/country. Developed countries like USA, Japan, Australia and Singapore have well developed comprehensive guidelines for GW reuse. In India there are no guidelines specific to GW reuse however; Central Pollution Control Board (CPCB) lays down standard for disposal of treated wastewater in (i) inland surface water body and (ii) discharge into land for irrigation. Therefore, USA EPA guideline for treated water reuse can be suitably adopted for reusing treated GW. These guidelines are available for various reuse of treated wastewater but only the preferred reuse guideline is presented in the Table 4.

Table 3: Projected GW strength considering removal efficiencies of conventional treatment techniques [8]

Parameter	**Avg. Raw GW characteristic**	**Avg. % removal for treatment**			**Project water quality after treatment**		
		Primary treatment	**Activated sludge**	**Trickling filter**	**Primary treatment**	**Activated sludge**	**Trickling filter**
BOD	27	42	89	69	16	3	8
COD	108	38	72	58	67	30	45
TSS	11	53	81	63	5	2	4

Table 4: Preferred reuse standard for treated GW [9]

Standard	Parameter
US EPA- Urban Reuse	pH=6-9 BOD≤10mg/l Turbidity≤2NTU FC=No detectable Chlorine (Cl2)=1 mg/l residual (minimum)
US EPA- Construction works	BOD≤30mg/l TSS≤30mg/l FC<200/100 ml Chlorine (Cl2)=1 mg/l residual (minimum)
CPCB – Discharge into inland surface waters	SS<100mg/l pH=5.5 to 9.0O&G<10mg/l Ammonical Nitrogen (as N)<50mg/l BOD<30mg/l COD<250mg/l AS<0.2mg/l
CPCB – Discharge into land for irrigation	SS<200mg/l pH=5.5 to 9.0 O&G<10mg/l Ammonical Nitrogen (as N)<50mg/l BOD<30mg/l AS<0.2mg/l

4.4 Suggested Reuse of GW

Considering the characteristics of treated GW projected using typical removal efficiencies of conventional treatment methods for wastewater and standards from CPCB and US EPA the possible reuse of treated GW from the multistoried hostel building is presented in the Table 5.

Table 5: Reuse of Treated GW

Standard for reusing treated GW	Treatment scheme suggested	Reuse
Reuse - USA EPA, 2004	Primary treatment + Filtration (optional) +disinfection	Construction – soil compaction, dust control, washing aggregate, making concrete
	Activated sludge / Trickling filter followed by disinfection	Urban Reuse- landscaping, toilet flushing, fire- fighting etc.
Reuse - CPCB, 1986 (revision)	Primary treatment/ Activated sludge / Trickling filter	Discharge into inland surface water body
		Discharge into land for irrigation

The alternate approach to the above activity could be to decide treatment of greywater required based on the Potential Reuse. Disinfection of treated GW has been considered critical prior to reuse by researchers [10] and therefore has been suggested in this study.

4.5 Steps to popularize GW reuse in India

The major steps to promote GW reuse in India are as following:

Step 1: Need assessment based on demographic and urbanisation trends, available water resource, existing water supply, etc. The outcome of this need assessment may lead to identification of target groups for reuse and mapping of the total available GW resource.

Step 2: Identification of obstacles in GW reuse and development of mechanism to address these issues.

Step 3: Establishing Legal and Institutional Framework for GW reuse. The outcome for this may lead to policy adaptation, modification in existing rules/laws, reuse guidelines/standards, promote demand led water management and incentives for GW reuse etc.

Step 4: Public Awareness. Public acceptance of GW reuse may be a problem due to the 'dirty water' feeling amongst people. This cannot be overcome without public awareness.

6. Conclusion and Recommendation

This case study provides the guiding steps required in planning GW reuse towards resource conservation. It shows that how the characteristics of GW generated may be conveniently used in resource planning by planers. However, the treatability of GW for specific reuse may require further investigation based on source of generation, climatic condition, soil characteristics etc.

Depleting sources of freshwater can be suitably substituted using GW. Therefore, it is prudent to treat GW as an economic good and consider its large scale reuse. However, GW reuse not only depends on the level of treatment or quality of treated effluent but also on the aspects such as the financial investment, maintenance requirements, reuse infrastructure and on-site application feasibility.

References

[1] Srinivasan, Veena. "Doing science that matters to address India's water crisis." *Resonance* 22, no. 3, pp. 303-313, 2017.

[2] Maria, Augustin. "Urban water crisis in Delhi. Stakeholders responses and potential scenarios of evolution." *IDD-RI Idee Pour le Debat* 6, 2008.

[3] Nirmala, M.D., Muthukumar, K., Ravikumar, G. "Review of greywater treatment methods. International Conference on Current Research in Engineering Science and Technology." *ICCREST*, pp. 76-94, 2016

[4] Santasmasas, Carme, Miquel Rovira, Frederic Clarens, and César Valderrama. "Grey water reclamation by decentralized MBR prototype." *Resources, conservation and recycling* 72, pp. 102-107, 2013.

[5] Lin, Ching-Yung, Min Wu, Jeffrey A. Bloom, Ingemar J. Cox, Matt L. Miller, and Yui Man Lui. "Rotation-, scale-, and translation-resilient public watermarking for images." In *Security and watermarking of multimedia contents II*, vol. 3971, pp. 90-99. International Society for Optics and Photonics, 2000.

[6] Murthy, P., Sadashiva Murthy, B.M. and Kavya, S.. "Greywater Treatment & Reuse: A Technological Review." *Gjra-global journal for research analysis. ISSN*, (2277-8160), pp.408-410, 2016.

[7] Little, Jess. "AIES Constructed Wetland Greywater Treatment Systems: Water Quality Monitoring and System Report." *Arava Institute for Environmental Studies* (2014).

[8] Manual, E. P. A. *Guidelines for water reuse*. EPA/625/R-92/004, 1992.

[9] Ghaitidak, Dilip M., and Kunwar D. Yadav. "Characteristics and treatment of greywater—A review." *Environmental Science and Pollution Research* 20, no. 5, pp. 2795-2809, 2013

[10] Winward, Gideon Paul. "Disinfection of grey water." (2007).