A Review on Grey Water Treatment and Reuse

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Abstract - *Increasing water demand due to the exponential growth in population has led to the idea of using waste water as a source of water. Immense technological advancements have been made in the field of waste water engineering which helps in separating various types of solids from waste water. Identification of the reuse potential of different types of waste water thus facilitates in treating them at source and using them for various beneficial purposes. Grey water, a mixture of waste water from kitchen, laundry and bathroom is such a source which due to its less organic and coliform content compared to mixed sewage may be treated and reused for purposes like landscape irrigation, agriculture, toilet flushing and ground water recharge. The current paper looks at the reuse possibilities of grey water by studying the characteristics and available treatment options of grey water.*

Key Words*:** ***Waste water, Grey water, Reuse, Organic, Coliform, Treatment

1. INTRODUCTION

Decentralized waste water treatment or treating waste water at source is gaining importance as the country is facing water shortage for meeting various water uses. Grey water includes any household water that is free from fecal matter. Hence water from kitchen sinks, bathroom, wash basins and washing machines can collectively be called as grey water. On the contrary water from toilets containing urine and fecal matter is known as black water. Grey water constitutes about 55-75 % of total household waste water (Shaikh et al., 2015[1]). In this context grey water has good reuse potential as it is free from fecal coliforms and hence can be collected and treated separately in individual households. The degree of treatment decides its use for various non potables uses such as irrigation, toilet flushing or ground water recharge.

The Ministry of Environment and Forests norms for environment clearance to construction projects is 100% treatment of grey water by collecting grey and black water in separate pipelines and reusing it for irrigation or flushing. But there are no recommendations for separating household grey water in India. The knowledge of the state of the art technologies adopted in grey waste water management in households in other countries can help in utilizing the reuse potential of it.

Sometimes kitchen water and laundry water are not included in grey water due to the presence of oil and greases in kitchen water and surfactants in laundry water which may decrease the efficiency of the various physical and biological treatment techniques.

2. GREY WATER CHARACTERISTICS

The water requirement per capita for an average Indian household where sewerage system is present accounts to 135lpcd (CPHEO Manual,1993 [2]) of which nearly 70L - 90Lwill be generated as grey waste water.

The characteristics of grey waste water vary highly among households depending upon the food habits and standard of living. Kitchen waste water will be rich in TSS, oil, grease and BOD but the bathing water and laundry water will show more COD, Phosphorous (mainly inorganic in the form of phosphates) and xenobiotic compounds. The common laundry detergents used in India contains about 40% Sodium Tri Poly Phosphate (Consumer Voice, 2015[3]) which increases the phosphate and sodium ion concentration totally affecting the water reuse potential of laundry water. On the contrary the nutrient content in grey water will be comparatively lesser as the urine and toilet flushing water are discharged to the black water stream.

The waste water characteristics of grey water in published literature were found to vary highly from individual household to community centers and also from one geographical location to another. The pH was found to lie in the range 6.3-8.1 (Li et al., 2009[4]). The laundry water will be of more alkaline nature but on mixing with comparatively high volume of bathing water and kitchen water the pH comes to above range. Suspended solids will be contributed by food particles, hair and dust matter. BOD has been reported to lie in the range 47mg/L - 466 mg/L as per Li et al., 2009[4] and Simon Jabornig, 2013[5]. High BOD is contributed by kitchen waste water due to the presence of food particles where as higher COD for laundry water as well as kitchen water due to the use of chemical cleansing agents, detergents and soaps. BOD/COD ratio has been found to be in the range 0.6 which shows it favors biological treatment techniques.

The pathogenic bacterial load in grey water will be less, but occasionally enteric pathogenic bacteria like Salmonella and Campylobacter will be present in kitchen waste water during food handling (WHO Grey water reuse guidelines[6]) and the total coliform lies in the order of 10^6 - 10^8 CFU/100mL (Li et al.,2009 [4] and Simon Jabornig 2013[5]).

3. GREY WATER TREATMENT TECHNIQUES

Degree of treatment can be decided based on the treatment quality to be achieved. Reuse of domestic waste water for potable use requires a higher degree of treatment including the tertiary treatment. But water quality for various non potable uses like landscape irrigation, agriculture, toilet flushing and ground water recharge can be achieved more easily by using the conventional and cost effective treatment techniques like coagulation, filtration and biological treatment systems. For effluent reuse treated water quality must satisfy the characteristics listed in Table 1 (US EPA, 2012[7]).

Table -1: US EPA reuse water standards for various purposes

	pH	BOD (mg/L)	Turbidity (NTU)	TSS (mg/L)	Fecal Coliforms (CFU/100mL)	Residual Chlorine (mg/L)
Landscape Irrigation	6- 9	10	2	-	0	1
Agriculture	6-9	30	-	30	200	1
Toilet Flushing	6-9	10	2	-	0	1
Ground Water Recharge	6.5-8.5	-	2	-	0	1

1.1 Preliminary treatment

Removal of a fraction of suspended particles as well as oil and grease will help the efficient functioning of the main treatment scheme. Fine screens (size < 6mm) can be used to remove the suspended particles like dust, hair and food particles escaping kitchen sink strainer. Oil and grease are less soluble in water which reduces their microbial degradation (Metcalf & Eddy [8]) thereby affecting the treatment units and hence oil trappers must be provided after screens to remove them.

1.2 Physico Chemical treatment

Achieving non potable water usage standards for grey water demands considerable removal of turbidity and SS which can be achieved by physicochemical techniques like filtration and coagulation. These are conventional and cost effective techniques used in community water supply schemes. As the organic loading in grey water is less, properly designed sand filtration unit or coagulation unit can attain required BOD removal standards also. But to achieve total coliform and residual chlorine standards, a chlorination unit is also required.

Lab scale Drawer Contacted Sand Filter designed by Assayed et al., 2005[9] showed 90-95 % organic removal efficiency for synthetic grey water and an Ecoli removal of 99% attributed to the straining of bacteria by the biofilm growth on the upper 10 cm of sand media. A similar study conducted by Ushijima et al., 2015 [10] on unsorted soil media in slanted soil treatment system showed an average SS removal of 80% and COD removal of 75%. The E Coli removal rates achieved were of 4-5 log reductions. Considerable SS and organic matter removal could be achieved in these cases and hence if filtration is properly coupled with chlorination, water reuse standards by USEPA could be met.

1.3 Biological treatment

Studies have reported biological treatment techniques like Membrane Bio Reactor, Rotating Biological Contactor and Sequential Batch Reactor to be effective for comparatively low organically loaded grey waste water.

Baban et al., 2010 [11] studied on the treatment of grey waste water using RBC and reported 85% COD removal. The BOD, TSS and turbidity of effluent were satisfying the effluent reuse standards but total coliform count of 10^4 required further removal. RBC technique also demands an additional filtration unit to remove the detached biofilm particles. MBR proved to be very efficient in degrading COD and detergents apart from high removal of BOD and TSS as noticed by Liberman et al., 2015 [12]. This technique has the additional advantage that further filtration or sedimentation is not needed for removal of biomass. Total coliform removal was 100% showing that the treated water from MBR can directly be used for irrigation and toilet flushing. Gabarro et al., 2012 [13] studied removal characteristics of grey water from a sports center where the organic load was comparatively less, by using SBR. The study reported organic removal satisfying standards but additional unit was needed for filtering the microbial mass and for disinfection.

1.4 Effect of Refractory Organics

Refractory organics include the organic compounds that are less biodegradable and thereby resisting the conventional treatment techniques (Metcalf and Eddy [8]). These are present in grey waste water in the form of surfactants (detergents) and phenol compounds (cleansing agents). Sawadogo et al., 2014 [14] noticed that higher concentration of detergents in grey water inhibits plant growth as well worsen the problem of soil salinity which demands the need of considering the concentration of anionic surfactants also in deciding the reuse possibility of grey water. Li et al., 2009 [4] reported that anionic detergent concentration for reuse water must not exceed 1mg/L. They were found to be present in grey water in the range 1.51-14.88 mg/L (Khalid et al., 2012 [15]) and very less studies are available on their removal.

But Khalid et al., 2012 [15] reported that when electro coagulation preceded the biological treatment technique, 96% anionic surfactant removal was achieved. The study also reported 100% coliform removal, 100% TSS removal, 89% COD removal and enhancement of phosphate removal efficiency by 30%. Recent study on laundry water treatment by Migual et al., 2016 [16] reported 90% anionic surfactant removal by coagulation using Aluminum salt.

4. CONCLUSIONS

As grey water characteristics vary considerably with households, characterization need be done for individual households for arriving at the treatment options. Proper guidelines for reuse of grey water depending upon the socio economic conditions of a country will help in deciding degree of treatment required for various beneficial purposes. The available reuse standards are limited for the parameters TSS, Turbidity, BOD, Residual Chlorine and Coliforms. The removal of phosphates and anionic surfactants are not considered in many of the studies as standards for them do not exist. Various biological techniques coupled with disinfection units are capable of achieving reuse water standards and MBR could give 100% removal of total coliform and considerable reduction in BOD, COD and TSS without any disinfection or filtration unit. Plain filtration was also effective in achieving discharge standards if followed by disinfection. Removal of phosphates and surfactant can be achieved if coagulation is selected as a pretreatment option.

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