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Design, development and performance evaluation of small scale grey water treatment plant

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■ **ABSTRACT :** The design, development of grey water system was done by using locally available filtration and adsorbent media and its performance was evaluated. The media size and depth decided by experiment were sand (0.42 mm), grit (6-8 mm), gravel (15-25 mm), brick pieces (25-30 mm) and charcoal (12-16 mm) (Zainudin and Abundi, 2011) having layer thickness of 450 mm, 450 mm, 150 mm, 300 mm and 30 mm, respectively. The hydraulic retention time (HRT) of designed filter was 1.33 hours at hydraulic loading rate of (HLR) of 3.77 m day^{-1}. The filtration area of one square meter would have capacity of 3770 $lit.day^{-1}$. At steady state head of 1.5 m, the overall performance of the combined system was 82.70 per cent BOD removal, 85.10 per cent COD removal, 78.78 per cent oil and grease removal, 69.23 per cent residual sodium carbonate removal (RSC), 21.33 per cent reduction in sodium adsorption ratio (SAR) and 31.19 per cent TDS removal, respectively, were noted. The pH of the entire system remained stable (7.32 ± 0.5) throughout the experiment. The calcium, bicarbonate, potassium, nitrogen, magnesium, sodium, were also reduced after filtration by 20, 44.82, 48.76, 5.55, 33.33, 31.42 per cent, respectively. Generally, the final effluent was found to be suitable for a range of uses such as toilet flushing, irrigation and fire protection.

■ **KEY WORDS :** Grey water, Grey water filter, Hydraulic retention time, Filtration area

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As pressures on freshwater resources growing around the world 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 sources of supply are grey water reuse, desalination and rainwater harvesting. The shortage and quality deterioration of water, have led to an increased interest in reuse of treated grey water in many parts of the world. Nations are endowed with resources for survival, growth, and development. Water, one of nature's most important gift to mankind is a finite and an invaluable resource. India is facing a water crisis and by 2025 it is estimated that India's population will be suffering from severe water scarcity (Amarsinghe *et al.*, 2007). Of the three mentioned above, greywater reuse is less favoured and acceptable because of aesthetics and health considerations. The possible reuse options for the treated water are urinal and toilet flushing, irrigation of lawns (college campuses, athletic ields, cemeteries, parks and golf courses, domestic gardens), washing of vehicles and windows, ire protection, boiler feed water, concrete production, develop and preserve wetlands, infiltrate into the ground (for recharge of aquifers), agriculture and

viticulture reuse.

There is a great challenge ahead to produce more food for increasing population using less water, as agriculture sector has to release fresh water to meet the enhanced requirement of other sectors such as domestic and industrial.Contrarily, increasing urbanization is resulting in increased domestic (grey and black) waste water generation, which is mainly disposed of as untreated. Partially treated and untreated waste water is discharged into rivers or over the lands causing various environmental problems as well as groundwater problems in developed and developing countries. The pollution of aquifers and surface water, breaking of epidemic diseases are the results of unhygienic disposal (Blanca, 2006). On the other hand, waste water would be beneficial in case if it is scientifically used for irrigation, as it can act as an important source of water and nutrient.

Grey water makes up about 60-70 per cent of domestic waste water volume in developed countries (Friedler, 2004). The factors that influence the use of waste water for irrigation are the degree of filtration of waste water treatment, the crop type and its use. Generation of waste water in huge amounts is putting a lot of pressure on irrigation engineers for its safe disposal or reuse in agriculture. Hence, study was conducted either for safe disposal or judicious use of huge amount of grey water after proper purification.

METHODOLOGY

Grey water treatment setup:

The experiment was set up in grey water of Jayaprabha Girl's Hostel of Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli. In all, 350 girls accommodation generating 25000 lit grey water every day. The treatment process comprises of sedimentation unit, filtration and adsorption unit, screen filter and storage unit. The sedimentation unit is a 200-litre bucket which receives raw grey water from the source. In this unit the particles are allowed to settle under gravity without the addition of coagulants as this would disturb the biological process in the filter. This sedimentation unit also serves as a sampling point to test for the level of contamination of the grey water. The filtration and adsorption unit is vertical flow slow sand filter model constructed using two PVC pipe candles of internal diameter 83 mm ϕ of height 120 cm. Both ends of candles were closed with 90 mm ϕ end cap. The inflow of raw grey water from sedimentation unit was controlled by the manual control valve of size 16 mm ϕ. Supply, interconnecting and delivery line used for model were of 16 mm ϕ. The air vent of 16 mm ϕ and drain valve of 16 mm ϕ were installed at the top and bottom cap of each candles. The candles are filled with gravel acting as drain and support with size range of 15–25 mm to a layer thickness of 150 mm from the bottom of the unit followed by brick pieces with size range 25-30 mm, layer thickness 300 mm and charcoal with size 12-16 mm, layer thickness 300 mm, respectively. The grit media with size range 6-8 mm and layer thickness of 450 mm was filled. A sand filter media with d_{10}=0.42 and uniformity co-efficient, Cu=2.2 was laid on top with layer thickness of 450 mm (Fig. 1). The screen filter of capacity of 7 $m^3 hr^{-1}$ was installed after second candle. The steady state head was adjusted at 1.5 m.

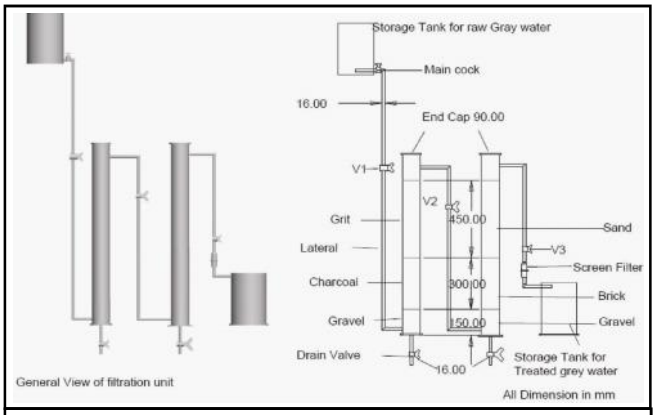

Fig. A : Designed grey water treatment plant

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Performance of designed grey water filter:

The performance of the designed filter was determined from physical and chemical properties of untreated and treated water. The results obtained were given Table 2.

The results show reduction in the undesirable colour, odour and turbidity of untreated water. The turbidity reduces from 80 NTU to 30 NTU due to filtration through designed filter (Miguntana *et al.*, 2014). There is considerable reduction in colour and offensive odour of

grey water.

The pH of grey water lowered from 7.32 to 7.27 after filtration increasing its utility. The electrical conductivity was also reduced from 2.1 to 1.55 ds/m showing reduction in salt content. Total dissolved salts also lowered than untreated water. The sodium adsorption ratio, residual sodium carbonate also reduced upto 0.92 me/l and 0.4 me/l which protects soil and crop from sodium hazard. Oil and grease (saponification value) reduced from 13.2 to 2.8 showing precise filtration of designed filter. Chemical oxygen demand (COD) and biological oxygen demand (BOD), mg/lit lowered upto

Table 1 : Designed parameters of filtration media for small scale waste water treatment plant

Sr. No.	Design parameter	Results obtained
1.	Discharge (Q)	24 lit/day
2.	Flow velocity (v)	3.8 m/day
3.	Surface area of filter bed (A)	6.35×10^{-3} m^2
4.	Hydraulic loading rate (HLR)	3.77 m/day
5.	Volume of filter unit (v)	$0.011m^3$
6.	Hydraulic retention time (HRT)	1.3 hour
7.	Average interstitial velocity (V_a)	9.7m/day
8.	Equivalent vertical hydraulic conductivity (k_z)	8.18 m/day
9.	Types of flow through filtration media on the basis of Reynolds number (N_R)	
	Gravel	
	Grit	
	Sand	All are laminar flow
	Brick pieces	
	Charcoal	

Table 2 : Physical properties of grey water

Sr. No.	Properties	Untreated	Treated
1.	Temperature	27^oC	28^oC
2.	Colour	Cloudy	Clear
3.	Turbidity	80 NTU	30 NTU
4.	Odour	Non offensive	Reduced

Table 3 : Chemical properties of grey water and treated water

Sr. No.	Properties	Untreated	Treated	Per cent reduction
1.	pH	7.32	7.27	0.6
2.	Electrical conductivity (EC), ds/m	2.1	1.5	26.19
3.	Total Dissolve Solids, mg/lit	134	92.2	31.19
4.	Calcium, me/l	1	0.8	20
5.	Carbonate, me/l	Nil		-
6.	Bicarbonate, me/lit	2.9	1.6	44.82
7.	Potassium, me/l	8.1	4.15	48.76
8.	Nitrogen, mg/l	5.04	4.76	5.55
9.	Magnesium, me/l	0.6	0.4	33.33
10.	Sodium, me/lit	1.05	0.72	31.42
11.	Sodium adsorption ratio, me/l	1.17	0.92	21.33
12.	Residual sodium carbonate, me/lit	1.3	0.4	69.23
13.	Oil and grease	13.2	2.8	78.78
14.	Chemical oxygen demand (COD), mg/lit	376	56	85.10
15.	Biological oxygen demand (BOD), mg/lit	185	32	82.70

56 and 32 mg/lit. indicates reduction in the organic matter content in treated water (Mohamed *et al.*, 2014.)

Conclusion :

The results presented in this study establish the potential applicability of the developed methodology. The grey water samples collected from Jayaprabha girl's hostel which contained some chemical constituents were above the permissible limit than irrigation water. Hence this water cannot be used directly for irrigation purpose and treatment of such water is necessary. But treated water shows drastic reduction in COD, BOD, SAR, RSC, Oil and grease and turbidity over untreated water.

Porosity found for sand 39 per cent, grit it was 37 per cent, gravel 32 per cent, brick pieces 31 per cent and for charcoal it was 38 per cent. Voids ratio values were 0.63 for sand, 0.59 for grit, 0.44 for gravel, 0.46 for brick pieces and 0.63 for charcoal. Dry and wet bulk density for sand was 0.86 $g.cc^{-1}$ and 1.16 $g.cc^{-1}$, for grit it was 0.95 and 1.33 $g.cc^{-1}$, for gravel 1.12 $g.cc^{-1}$ and 1.27 $g.cc^{-1}$, for brick pieces 0.54 $g.cc^{-1}$ and 0.89 $g.cc^{-1}$, respectively. Hydraulic conductivity determined by using constant head method and for sand medium it was 4.5 $m.day^{-1}$, for grit 53.5 $m.day^{-1}$, 4.5 $m.day^{-1}$, for gravel 85.11 $m.day^{-1}$, for Brocken brick 123 $m.day^{-1}$ and for charcoal it was 19 $m.day^{-1}$. Hydraulic retention time for combinations of media was 1.3 hrs for 1.8 m media depth. Interstitial velocity (Va) considering sand medium having effective size 0.42 mm was concluded 9.57 $m.day^{-1}$ Filtration area of 1 m^2 can have 3.6 $m^3.day^{-1}$ filtration capacity. The total depth of media in designed filter was 1.8 m. The benefits found are low energy demand, less operating and maintenance cost, lower load on fresh water, highly effective purification and ground water recharge. Hence this is an environmental friendly, cost effective and resourceful plant.

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REFERENCES

Amerasinghe, D., Bhardwaj, R.M., Scott, C., Jella, K. and Marshall, F. (2013). Urban waste water and agriculture reuse challenges in India36: IWMI Research Report 147,pp.1-2

Amarsinghe.,U.A., Shah, T.,Turral, H. and Anand., B.K. (2007). India's water future to 2025-2050.business as usual scenario and deviations. Research report 123, IWMI,52pp.

Blanca, Jimenez (2006). Irrigation in developing countries using wastewater, *Internat. Rev. Environ. Strategies*, **6** (2) : 229 - 250.

Friedler, E. (2004). Quality of individual domestic grey water streams and its implications for on-site treatment and reuse possibilities. *Environ. Technol.,* **25** : 997-1008.

Miguntana, N.S., Jayalath, C.P.G., Kariyawasam, C., Prerera, H.A.K.C., Sriwarnasinghe, S.M. and Wijerathna, W.M.R.I. (2014). Use of bricks as an alternative filter media for pebble matrix filters (PMF).SAITM research symposium on engineerin advancement, pp.116-118.

Mohamed, R.M.S.R., Chan, C.M., Senin, H. and Kasim, A.H.M. (2014). Feasibility of direct filtration over peat filter media for bathroom grey water treatment. *J.Mater.Environ. Sci.,* **5**(6) : 2021-2029.

Zainudin, Naji and Abundi (2011). The effect of sand filter characteristics on removal efficiency of organic matter from grey water. *Al-Qadisiya J. Engg. Sci.,* **4** (2) : 143-149.