Grey water generation and quality measurement at a specific site in Dhaka city

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ABSTRACT: With increasing pressures on water resources, the concept of beneficial use of treated wastewater has rapidly become an imperative for water agencies around the world. Water reclamation, recycling and reuse are now recognized as key components of water and wastewater management. As long as the problem is about the scarcity of water and no new sources can be developed in Bangladesh without the traditional underground water, surface water and some other sources of potable water, the only choice remain is to reuse the household water, which in environmental science is named as 'Grey water'. Any wash water that has been used in the home, except water from toilets, is called Grey water. The introduction of Grey water recycling will surely give a lasting impetus to economy and society alike. This study has been a little effort to introduce Grey water recycling in Bangladesh. Our one objective has been estimation of water use in household chores and find out the amount of grey water generation. For this purpose we have performed the following jobs- selection of convenient locations for our study (Agargaon and Tejgaon in Dhaka, Bangladesh); determination of water use for each household on both working day and holiday and estimation of grey water generated by subtracting the amount of black water from the total amount of water use. This study has shown that the amount of greywater generated (almost 60-70 % of total use) is greater than that of blackwater in both cases. Per capita water consumption is 245 lpcd on average. WASA billing shows much higher water consumption than that found by estimations.Water use in % for different purposes are- 37% for toilet flushing, 16% for bathing , 14% for laundry & 12.5% for kitchen use on average. Besides like other countries we regularly waste the highest amount of fresh water for toilet flushing which can be saved by reuse of treated greywater. Our another objective has been charecterization of the greywater.For this purpose we have tested three types of samples (cloth wash-without detergent, wash water, rinse water; basin water and bathing water) for five water quality parameters-pH, color, turbidity, COD and BOD_5. The quality of greywater varies from sample to sample. The pH varies from 6.43 to 7.35; color varies from 29 to 490 (Pt-Co); turbidity varies from 27.6 to 370 (NTU); COD varies from 172 to 1307 (mg/l); BOD_5 varies from 16 to 750 (mg/l) in our tested samples. After the study of our test results and comparison with available standards for water reuse we have found that only rinse water, basin water & bathing water almost lie in the maximum permitted range of BOD_5, so they can be used for agricultural sector without any treatment. And the rest of the sample need further treatment for toilet flushing or domestic water recycling or even for agricultural use. So from our study some scopes of further works in this study regarding the present work can be data collection from different points of the city, more qualitative parameter testing particularly Fecal Coliform (FC) test, advanced technology for the recycling process, standard value recommendation by the government, more survey for knowing the actual level of public acceptance etc.

1 INTRODUCTION

1.1 *General Background*

With increasing pressures on water resources, the concept of beneficial use of treated wastewater has rapidly become an imperative for water agencies around the world. Water reclamation, recycling and reuse are now recognized as key components of water and wastewater management. As long as the problem is about the scarcity of water and no new sources can be developed in Bangladesh without the traditional underground wa-

ter, surface water and some other sources of potable water, the only choice remain is to reuse the household water, which in environmental science is named as 'Grey water'. Any wash water that has been used in the home, except water from toilets, is called Grey water. The introduction of Grey water recycling will surely give a lasting impetus to economy and society alike. This study has been a little effort to introduce Grey water recycling in Bangladesh.It will obviously change the current water crisis scenario of densely populated Dhaka city.

1.2 *Objectives of the study*

The objectives of the study are Estimation of water use in household chores and find out the amount of grey water produced and Characterization of the grey water.

1.3 *Methodology*

In order to estimate the water use in household chores and find out the amount of grey water produced at first we fixed the locations where we could get suitable environment to complete our task. Considering many things we selected two spots at Agargaon & Tejgaon area for our study. The determination of water use is done for two categories of days-working day & holiday. In case of Agargaon area it was quite easy for us to do the tusk as we live here. Here we determined the amount of water used for cloth wash, bathing, utensils & cooking, floor wash, hand wash, ablution, drinking purpose, bathroom wash and toilet flushing(overall covering the total household use). In order to determine the amount of black water generated a day, the amount of water being used in the toilet flushing is calculated. Then the amount of greywater is calculated by subtracting the amount of black water from total water use. In case of Tejgaon area it was not possible to go to that house several times and estimate the water use too accurately. So we did a questionnaire survey among the household members. For qualitative analysis of greywater we collected sample from Agargaon only. Here three types of samples are collected-(i) cloth wash (without detergent, wash water, rinse water), (ii) basin water & (iii) bathing water. Then we tested our samples in BUET environmental laboratory. We tested five water quality parameters- (i) pH (ii) color (iii) turbidity (iv) COD (v) BOD_5 .

1.4 *Greywater generation and quality*

1.4.1 Water use in other countries

For the purpose of successful implementation of greywater recycling different countries of the world have already started the quantification of greywater generation and also the characterization of greywater. The available criteria of indoor household water use for the Republic of Korea, China, Sweden, UK and USA (Zhang & Brown, 2005; Bradely, 2004; Eriksson et al., 1999) is presented in Table 1.

Table 1: Indoor Household Water Use

Use	Korea (% of total use)	China (% of total use)	Sweden (% of total use)	UK (% of total use)	USA (% of total use)
Bathing	23	20	33	26	30
Toilet	45	21	22	34	21
Laundry	11	20	17	12	24
Kitchen	20	39	28	28	25

In most countries, guidelines and standards for water reuse in buildings either do not exist or are being revised or expanded. The available criteria for water reuse for toilet flushing (EPA, 1992) is presented in Table 2. No separate criteria for water reuse for laundry have been reported in the literature. However, criteria for domestic water recycling are available (Surendran & Wheatley, 1998). These values are also included in Table 2.

Table 2: Standards and criteria/ guidelines for water reuse for toilet flushing and domestic water recycling

Parameter	Toilet flushing		Domestic water recycling					
	US	Japan	WHO	USEPA	USA NSF	Australia	UK	Germany
pH	6-9	5.8-8.6		6-9				6-9
BOD_5 (mg/l)	≤10			10		20		20
Turbidity (NTU)	≤2			5		2		1-2
TC (no./100ml)			1000(m) 200(g)	<10		<1	ND	100
FC (no./100ml)	ND	≤10 (E.Coli)		<10	<240	<4		10
Residual Cl_2(mg/l)	1	Retain d*						
Odor	odorless	NU						
Appearance		NU						

ND = not detectable; NU = not unpleasant
(m) = mandatory; (g) = guideline
* at last holding tank in distribution line

The following are the requirements of greywater parameters that must be met in the agricultural sector:

Table 3: Parameters to Use Greywater on the Agricultural Sector

Parameters	Maximum Permitted Values
pH	6.5 – 8.5
Conductivity (Ds/cm)	2000
BOD (mg/L)	120
COD (mg/L)	200
Total Suspended Solid (mg/L)	120
Fecal coliform (MPN/100 mL)	1000

Source: M. Platzer, V. Caceres, dan N. Fong, 2004

2 QUANTIFICATION OF GREYWATER GENERATION

2.1*General*

The main aim of this thesis work is to find out the generation rate of the greywater. Two different areas in the city have been surveyed for the data. These areas are Agargaon and Tejgaon.

2.2 *Chosen Fields of water use*

Cloth wash, Bathing, Utensils & Cooking, Floor wash, Hand wash, Ablution, Drinking purpose, Bathroom wash, Gardening, Car washing and Toilet flushing.

2.3 *Analysis of the Data*

2.3.1Water Consumption at Agargaon Area

Address: 3A, Al-Amana House,105/2/1, West Agargaon, Dhaka-1207

Date: 05/06/2010 and 03/06/2010

Table 4: No. of members: 2

	male	female
Adult	-	2
Working Member	-	1

Table 5: Water use on Working Day and Holiday

Field of using	Quantity (lpcd) on Working day	Quantity (lpcd) on Holiday
Cloth wash	27	27
Bathing	30	30
Utensils & Cooking	24	24
Floor wash	15	15
Hand wash	8	11
Ablution	8.75	12.5
Drinking purpose	2	2
Bathroom wash(done per week)(No. of Bathroom:3)	6	6
Gardening	-	-
Car washing	-	-
Toilet flushing(10.5L commode)	68.25	84
Total	189	211.5

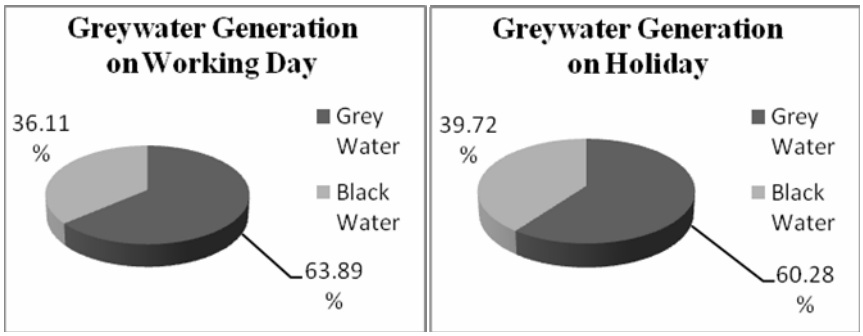

Figure 1: Greywater generation on both working day & holiday

On both days-working day and holiday, almost 60-70% of total water use is greywater.

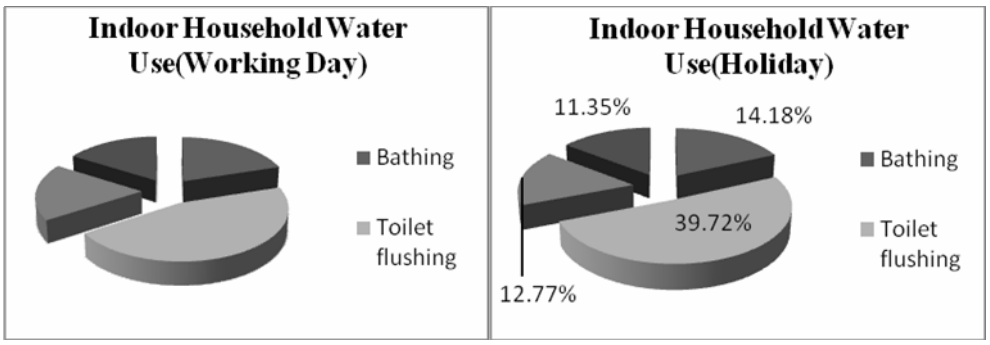

Figure 2: Indoor Household Water Use on Both Working day & Holiday

Table 6: Indoor Household Water Use in other countries

Use	Korea (% of total use)	China (% of total use)	Sweden (% of total use)	UK (% of total use)	USA (% of total use)
Bathing	23	20	33	26	30
Toilet	45	21	22	34	21
Laundry	11	20	17	12	24
Kitchen	20	39	28	28	25

2.3.2Water Consumption at Tejgaon Area:

Address: 233 D.M.C.,Old 158 West Nakhalpara, Tejgaon, Dhaka.

Table 7: No. Of members: 8

	male	female
Adult	3	4
Children	-	1
Working Member	2	2

Table 8: Water use on Working Day and Holiday

Field of using	Quantity (lpcd) on Working day	Quantity (lpcd) on Holiday
Cloth wash	33	33
Bathing	36	40
Utensils & Cooking	30	30
Floor wash	20	20
Hand wash	8.5	11.5
Ablution	12.5	13
Drinking purpose	2	2
Bathroom wash(done per week)(No. of Bathroom:3)	7.5	7.5
Gardening	-	-
Car washing	-	-
Toilet flushing(10.5L commode)	77	93
Total	226.5	250

From Table 5 and Table 8 , we could easily find out the following things:

Amount of water used in toilet flushing is less on working day than holiday. It happens because of the absence of four members for a fixed office hours. The little variation in case of hand wash & ablution occurs due to the same reason; Amount of water used for cloth wash, utensils & cooking, floor wash and bathroom wash remains almost the same for working day & holiday. This is because these things are done regularly by the same person (housemaid); Amount of water in bathing is greater on holiday than the regular working day. This is because on holiday members get extra time to take a long shower.

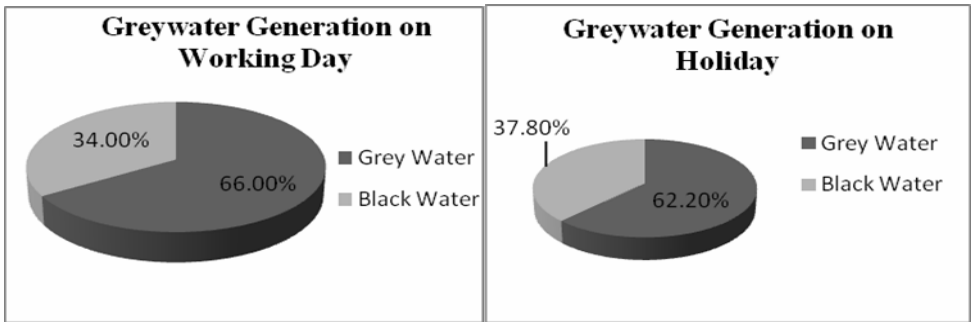

Figure 3: Greywater generation on both working day & holiday

On both days-working day and holiday, almost 60-70% of total water use is greywater.

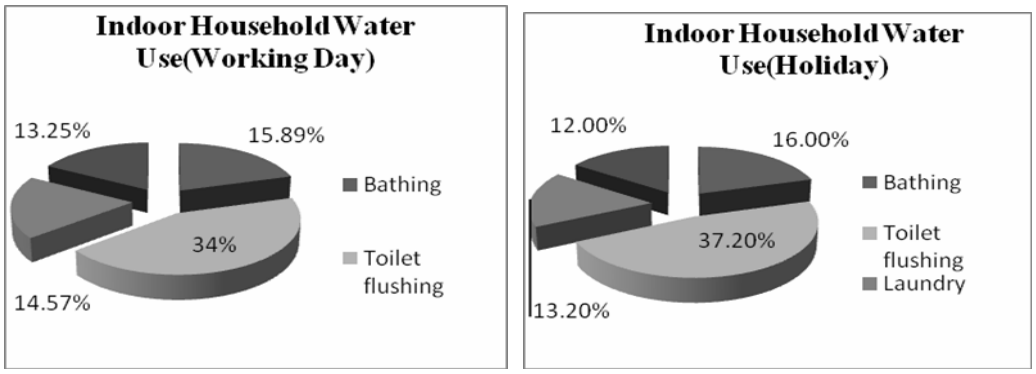

Figure 4: Indoor Household Water Use on Both Working day & Holiday

2.3.3 Comparison with other countries

From Table 6, it is clear that like other countries in ours a significant amount of supplied water to households is used for toilet flushing;Amount of water used for bathing (as % of total use) is close to that of China; Amount of water used for toilet flushing (% of total use) is close to that of UK;Amount of water used for laundry (% of total use) is close to that of Korea & UK; Amount of water used for kitchen use (as % of total use) is close to that of Korea.

2.3.4 Reason of the variation between studied & WASA water consumption

Comparing the water consumption of our study & WASA, we see that WASA provides more water consumption than the actual. This is because WASA meter reading is not accurate and due to the formation of iron layer on provided meter it may give grater reading than actual. Besides, there may be another reason of this variation; our study might not cover all the areas of water consumption accurately.

3 QUALITY OF GREYWATER

3.1 General

Samples of Greywater taken from one particular position as being discussed in the previous chapter according to their user behavior. For the chemical testing, samples are taken from Agargaon only. All the samples are taken after it has been turned into the Greywater. The sample being used here are of 1.Cloth Wash : Without detergent, Wash water, Rinse water; 2. Basin water and 3. Bathing water

3.2 Discussion on Test Results

Table 9: Test results on (19/6/2010)

Serial No.	Water Quality Parameter	Unit	Cloth Wash (without detergent)	Cloth wash (wash water)	Cloth wash(rinse water)	Basin water	Bathing water
1.	pH	-	6.97	6.8	6.87	6.86	6.9
2.	Color	Pt-Co	151	416	72	105	72
3.	Turbidity	NTU	39.9	313	27.6	75.5	131
4.	COD	mg/l	388	1263	236	325	561
5.	BOD_5 @20°C	mg/l	50	512	55	16	64

Table 10: Test Results on (3/7/2010)

Serial No.	Water Quality Parameter	Unit	Cloth Wash (without detergent)	Cloth wash (wash water)	Cloth wash(rinse water)	Basin water	Bathing water
1.	pH	-	7.04	6.43	6.76	7.35	7.07
2.	Color	Pt-Co	325	313	133	47	29
3.	Turbidity	NTU	120	370	43.1	65.8	123
4.	COD	mg/l	1307	1232	172	201	317
5.	BOD_5 @20°C	mg/l	650	750	68	110	144

3.3 *Variation of pH*

pH is a measure of the acidity or basicity of a solution. Pure water has a pH around 7; the exact values depend on the temperature. When an acid is dissolved in water the pH will be less than 7 and when a base, or alkali is dissolved in water the pH will be greater than 7. The pH values of cloth wash samples indicate that most of the water is acidic, but the water from basin and bathing is slightly basic.This is because the cloth wash samples contain more amount of soap, detergent,washing powder etc.(which are quite acidic) than other samples. All the values are taken at 25°C.[Refer to Table-2;According to US, Japan,USEPA,Germany pH should be 6-9, so our samples fall within this range, can be reused for toilet flushing & domestic water recycling.]

Table 11: Test Results on (31/7/2010)

Serial No.	Water Quality Parameter	Unit	Cloth Wash (without detergent)	Cloth wash (wash water)	Cloth wash(rinse water)	Basin water	Bathing water
1.	pH	-	6.86	6.78	6.8	7.31	7.2
2.	Color	Pt-Co	490	372	143	478	56
3.	Turbidity	NTU	28.2	345	38.2	46.3	145
4.	COD	mg/l	846	1260	217	343	393
5.	BOD_5 @20°C	mg/l	400	475	85	120	220

3.4 *Variation of Color*

Color is another parameter. Pure water should not contain any color. All the water samples contain color because of various impurities. From the graph we find that color of rinse water is always less than that of wash water. This is because initially when cloths are kept wet with detergent the maximun color of that cloth are come out. And then when the cloths are being washed several times with fresh water, the color becomes lighter than before.Besides the color of cloth wash(without detergent) may become higher in case of those cloths whose color easily come out. And the color of other samples vary from day to day depending on the quantity of impurities.

3.5 *Variation of Turbidity*

The increase in turbidity in Greywater is quite natural because this water contains a lot of solid particles and colloids that comes after its use for washing purposes. From the graph we find that the turbidity of rinse water is always less than that of wash water.[Refer to Table-2;According to US, USEPA, Australia, Germany turbidity should be 1-5 NTU, so our samples are out of this range;further treatment is needed for their reuse for both toilet flushing & domestic water recycling]

3.6 Variation in COD and BOD_5

Comparing the values of COD & BOD we can see that the COD value is always higher than the BOD value. Because during the determination of COD, organic matter is converted to carbondioxide and water regardless of the biological assimilability of the substance.The COD & BOD values of cloth wash (wash water) is always greater than those of cloth wash (without detergent). Only one time the COD of cloth wash(without detergent) is slightly greater than that of cloth wash(wash water), may be due to the presence of too much external dust.[Refer to Table-2; BOD of our all samples are above the range, so further treatment is needed for reuse for toilet flushing & domestic water recycling.Refer to Table 3; BOD value of our rinse water, basin water & bathing water almost lie in the maximum permitted range, so they can be used for agricultural sector without any treatment]

4 CONCLUSIONS

This study has shown that the amount of greywater generated in two households of different parts of the city. From our analysis it is seen that the amount of greywater generated (almost 60-70 % of total use) is greater than that of blackwater in all cases.Besides we regularly waste the highest amount of fresh water for toilet flushing which can be saved by reuse of treated greywater.The study also includes the charecterization of greywater for one household. From our analysis we can find that further treatment is needed for reuse of most of our sample of greywater for toilet flushing or domestic water recycling or even for agricultural use.From the study the following conclusions can be made:

Per capita water consumption is 245 lpcd on average. WASA billing shows much higher water consumption than that found by estimations;Water use in % for different purposes are- 37% for toilet flushing, 16% for bathing, 14% for laundry & 12.5% for kitchen use on average;The quality of greywater varies from sample to sample. pH varies from 6.43 to 7.35, color varies from 29 to 490 (Pt-Co), turbidity varies from 27.6 to 370 (NTU), COD varies from 172 to 1307 (mg/l), BOD_5 varies from 16 to 750 (mg/l) in our tested samples;Only rinse water, basin water & bathing water almost lie in the maximum permitted range of BOD_5, so they can be used for agricultural sector without any treatment. And the rest of the sample need further treatment for toilet flushing or domestic water recycling or even for agricultural use.

5 RECOMMENDATIONS

Some scopes of further works in this study regarding the present work are:

The test results of our samples particularly turbidity, COD, BOD_5 have been too high that don't match with the available greywater characteristics. This happened either there might be question on laboratory equipment reliability or accuracy of testing procedure or the status of sample. So more care should be taken on these issues for future work; Data collection from different points of the city zone;More qualitative parameter testing particularly Fecal Coliform (FC) test;Advanced technology for the recycling process; Standard value recommendation by the government; More survey to know the actual level of public acceptance.

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