Grey Water and Rain Water as Alternative Sources of Flush Water and Irrigational Water in and around Households: A Case Study from Istanbul Atakoy District

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Abstract
Grey water and rain water are two options as alternative sources to alleviate water stress/scarcity across the world. This paper aims to investigate possible use of reclaimed grey water and harvested rain water from on-site premises as sources of flush water and irrigational water in and around households in the popular settlement district Atakoy of the water-stressed Turkish megacity Istanbul. Calculations using demographic and meteorological data along with an analysis of current municipal plans reveal that the rain water potential is 544 434 and grey water potential 2 070 662 (total)/880 032 (light grey water) m^3/year in Atakoy. This indicates that 78% of 3 347 669 m^3/year demand for flushes and irrigation of the entire green areas of privately-owned housing complexes may be covered by rain water and grey water in the area. While the entire flush water demand may be covered by light grey water only, 79% of flush water may be supplied if rain water is used. 98% of irrigational demand may be provided using both light grey water and rain water. The results show that considerable water savings may be achieved through the use of grey water/rain water which will aid sustainability.
Keywords: Grey water / rain water as alternative water sources, flush water, irrigation, sustainability.

1. Introduction

Currently the world is striving to find alternatives to overcome the water stress and water scarcity on a global scale. As of now, 700 million people, corresponding to over 9% of the world population, live in areas of water scarcity. It is estimated that 1.8 billion people will be living in areas of absolute water scarcity while two thirds of the world population will be under water stress by 2025 (UN Water, 2017). Alternative sources to alleviate the water stress/scarcity across the world have been a major item in the world agenda in recent years. Grey water and rain water provide meaningful options for this purpose. Grey water refers to all domestic wastewater except that which comes from toilets and includes mainly wastewater from different washing functions in the household. The fraction which comes from hand wash basins and showers/bathtubs are further classified as light grey water (Beler Baykal, 2015). Rain water may be collected from rooftops and paved or unpaved surfaces. Both sources are renewable and sustainable, and may be used as alternative sources of water for a variety of different purposes including toilet flushing and irrigation.
Istanbul is one of the 33 megacities of the world with a population of 15 million demanding 2 100 000 m^3 water per day (ISKI, 2018) the megacity lacks sufficient water resources and therefore depends on inter-basin water transport to supply the demand.
This paper aims to investigate the possible use of reclaimed grey water and harvested rain water collected within their premises as sources of flush water and irrigational water in and around households in the popular settlement district Atakoy of the water stressed Turkish megacity Istanbul. Atakoy has a population of 40 307, and a land area of 272 ha, 60% of which is made up of green areas. 64% of green areas within the neighborhood is possessed by privately owned housing settlements (Beler Baykal et al, 2019).

2. Method

The potential for grey water collection was estimated using population values of Atakoy (TUIK, 2018) and the assumption of a total of 120 liters of grey (Gursoy et al, 2018) and 51 liters of light grey water per capita on a daily basis. Rain water potential was calculated assuming that rain water will be collected from rooftops. It was also assumed that 90% of rain (Farreny et al, 2011) could be collected from rooftop areas which were estimated using municipal site plans, and meteorological data of 2017 (Gursoy et al, 2018). The flush water demand was estimated on the basis of 40 liters of flush water per capita per day. Using the municipal site plan, the total green area of the neighborhood was calculated as 1 640 400 m^2. 64% of this corresponding to 1 050 978 m^2 is privately owned green areas of settlements which are irrigated by land owners. The information that green areas in Istanbul are irrigated between April and October, typically using 6 liters per m^2 per day, except in July and August where 12 liters per m^2 per day, was used together with this result to calculate the irrigational water demand for those areas (Beler Baykal et al, 2019).

3. Results and Discussion

Table 1 summarizes the demand for irrigational water and flush water together with the rain water and grey water potential which is estimated to be collected in Atakoy.

It is to be noted that flush water is used regularly and at the same quantity throughout the entire year. However, irrigational water is only used during the dry season. Grey water is generated at a constant quantity throughout the entire year, while rain water may be collected only during the rainy season. As such, rain water has to be stored during the rainy season to be used in due course. This is also valid for grey water if it is to be used for irrigation implying that storage of irrigational water is an important issue to be considered. Flush water on the other hand is continuously spent in constant quantities throughout the year and may be used immediately after collection.

Table 1 reveals that 3 347 669 m^3/year water is needed to meet the demand for flushes and irrigation for the entire green areas of housing complexes in Atakoy. The rain water potential is 544 434 and predicted grey water generation is 2 070 662 (total) and 880 032 (light) m^3/year in the area.

A survey of Table 2 reveals that only by collecting light grey water, i.e. wastewater coming from hand-wash basins, showers and bathtubs, more than what is needed for flushes may be provided from this on-site alternative source, while rainwater collected from roof tops can contribute 79% for this purpose. It seems wiser to use the first option as it covers all of the flush water demand and the need for storage in case of using harvested rain water will be alleviated. Table 2 further shows that combined use of rain water and grey water will provide 98% of the irrigational water demand, which is almost the entire water needed for irrigating privately owned green areas which constitute the majority of the neighborhood green. Finally, the table indicates that 78% of the entire irrigational and flush water demand of the neighborhood may be supplied by using the two alternative sources together from the neighborhood itself. The results show that considerable water savings may be achieved through the use of grey water and rain water leading to a sustainable practice.

4. Concluding Remarks

Grey water and rain water are two renewable and dependable sources of water which will help uninterrupted water supply to communities as well as aiding sustainability of water resources. The benefits of such practice may be even more apparent in areas where the population is high and water resources are limited as in the case of the Turkish megacity Istanbul as exemplified by its Atakoy neighborhood investigated in this work.

Table 1. Water demand and alternative water resources of Atakoy in 2017

	Demand		Alternative Source		
	Irrigation (m^3/month)	Flush water (m^3/month)	Rain Water (m^3)	Grey water (m^3)	
				Total	Light
January	0	57 518	96 576	172 555	73 336
February	0	57 518	34 741	172 555	73 336
March	0	57 518	35 685	172 555	73 336
April	295 272	57 518	17 371	172 555	73 336
May	295 272	57 518	25 867	172 555	73 336
June	295 272	57 518	39 273	172 555	73 336
July	590 544	57 518	37 573	172 555	73 336
August	590 544	57 518	23 224	172 555	73 336
September	295 272	57 518	25 301	172 555	73 336
October	295 272	57 518	60 608	172 555	73 336
November	0	57 518	57 776	172 555	73 336
December	0	57 518	90 440	172 555	73 336
Total	**2 657 448**	**690 221**	**544 434**	**2 070 662**	**880 032**

Table 2. Sufficiency of alternative water resources and their combinations to provide the demand for the final uses (%)

	Rain Water (RW)	Grey Water (GW) (Total)	Light Grey Water(LGW)	RW+GW	RW+LGW
Irrigation Water(IW)	20 %	78 %	33 %	98 %	54 %
Flush Water (FW)	79 %	300 %	128 %	379 %	206 %
Total (IW+FW)	16 %	21 %	26 %	78 %	43 %

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