13th IWA
Specialized Conference on
Small Water and Wastewater
Systems

5th IWA
Specialized Conference on
Resources-Oriented Sanitation

the international water association

Greywater characteristics and loadings – treatment to promote reuse

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Athens, Greece
September 15, 2016

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European Union
European Social Fund

OPERATIONAL PROGRAMME
EDUCATION AND LIFELONG LEARNING
investing in knowledge society
MINISTRY OF EDUCATION & RELIGIOUS AFFAIRS
MANAGING AUTHORITY

NSRF 2007-2013
programme for development
EUROPEAN SOCIAL FUND

Co-financed by Greece and the European Union

HYDROPOLIS

Acknowledgment

This research has been co-financed by the European Union (European Social Fund – ESF) and Greek national funds through the Operational Program "Education and Lifelong Learning" of the National Strategic Reference Framework (NSRF). Research Funding Program: THALES. Investing in knowledge society through the European Social Fund – Hydropolis: Urban development and water infrastructure – Towards innovative decentralized urban water management.

Scope of research

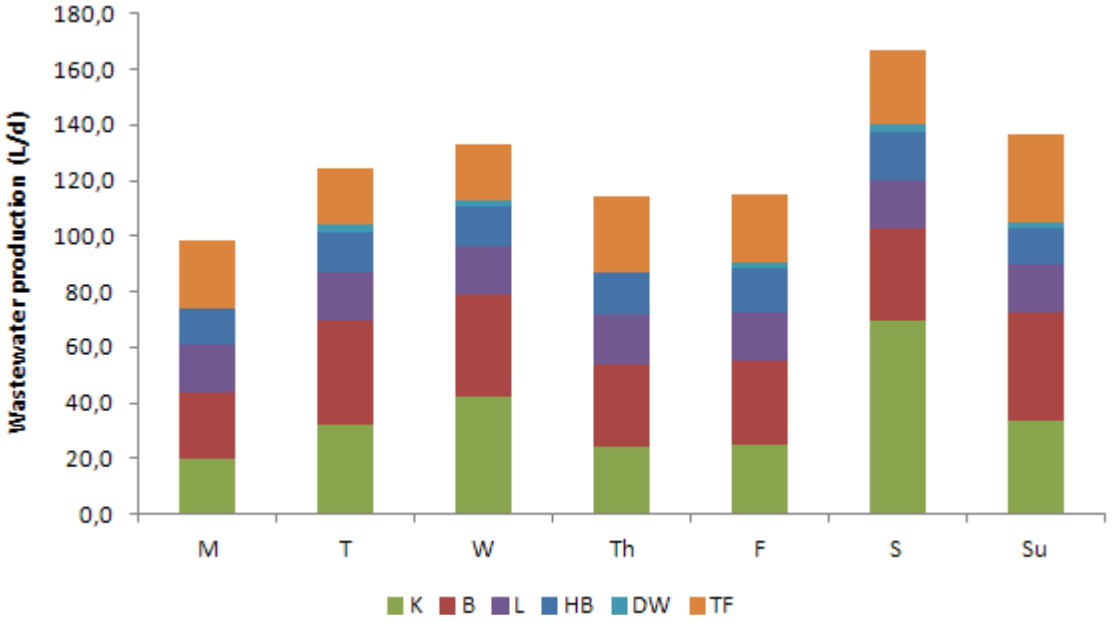
- Characterization of the different greywater sources in Greek households

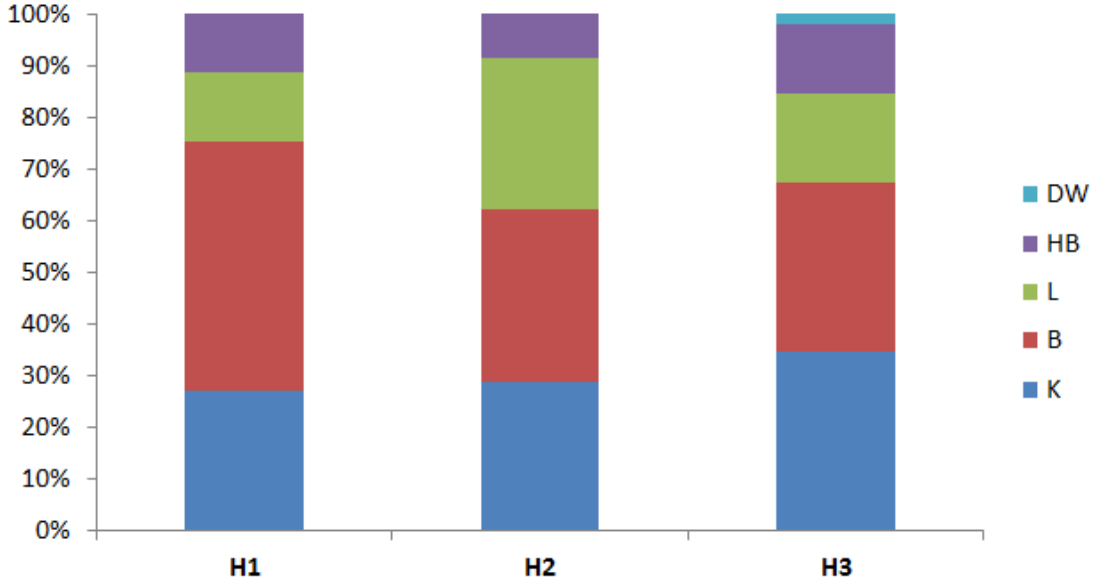
- Evaluation of the effectiveness of several physicochemical greywater treatment systems

Greywater characterization

- Three residencies in area of Athens (H1, H2, H3) were monitored for two weeks
  - the average daily water consumption was recorded as the sum of greywater produced in all sources
- Several samples were collected from different greywater sources and being analyzed (60 samples)
- pH, conductivity, total solids (TS), total and volatile suspended solids (TSS, VSS), total and soluble COD, BOD_5, TP, TN, linear alkylbenzene sulfonates (LAS), heavy metals (Pb, Ni, Cu, Zn, Cr, Cd), emerging contaminants (nonylphenol, nonylphenol monoethoxylate , nonylphenol diethoxylate, bisphenol-A, triclosan).

Quantitative greywater characterization





Wastewater production presents a great variability throughout a week due to the daily habits of the residents

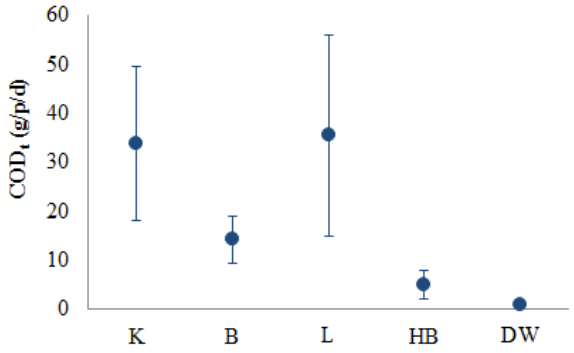
Average greywater production: **98.1±29.5 L/PE/d**
Average wastewater production: **135±31.6 L/PE/d**

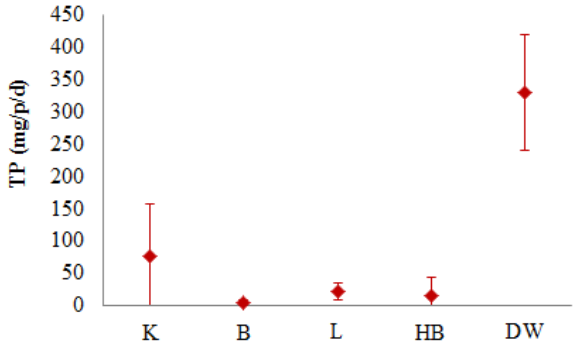
The major portion of greywater is produced in bathrooms (bath tub, shower, hand basin): **≈ 50%**

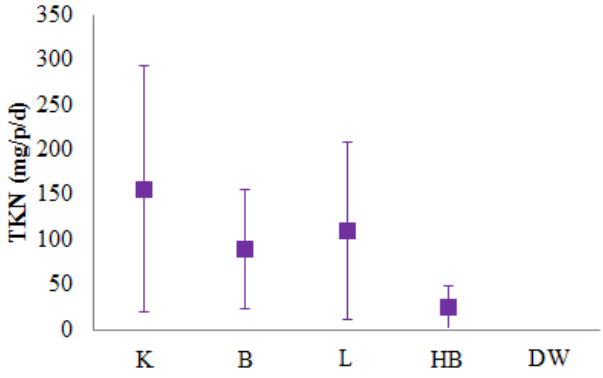
Qualitative greywater characterization

Main quality characteristics of greywater sources

Greywater source	pH	TS (mg/L)	TSS (mg/L)	CODt (mg/L)	CODs (mg/L)	BOD5 (mg/L)	TP (mg/L)	LAS (mg/L)	NH4-N (mg/L)	TN (mg/L)
Kitchen	6,90±0,42	883±426	319±209	1119±476	518±225	831±358	2,7±3,1	87±76	0,20±0,26	6,5±5,0
Bathtub	7,49±0,17	325±55,3	73,5±38,3	390±125	193±113	263±83,9	0,10±0,14	78±34	0,53±0,28	2,7±2,2
Laundry	8,19±0,76	1085±608	169±96,1	2072±1401	1165±920	1363±950	1,2±0,81	436±288	1,4±1,1	6,2±5,3
Hand basin	7,64±0,25	373±96,0	90,5±68,3	427±192	272±203	305±129	1,3±2,0	42±26	0,33±0,50	2,5±1,9
Dishwasher	10±0,2	2535±1053	11±1,3	411±59	307±2,9	184,6±24,8	187,1±51,4	7±5,6	0,11±0,07	< 1



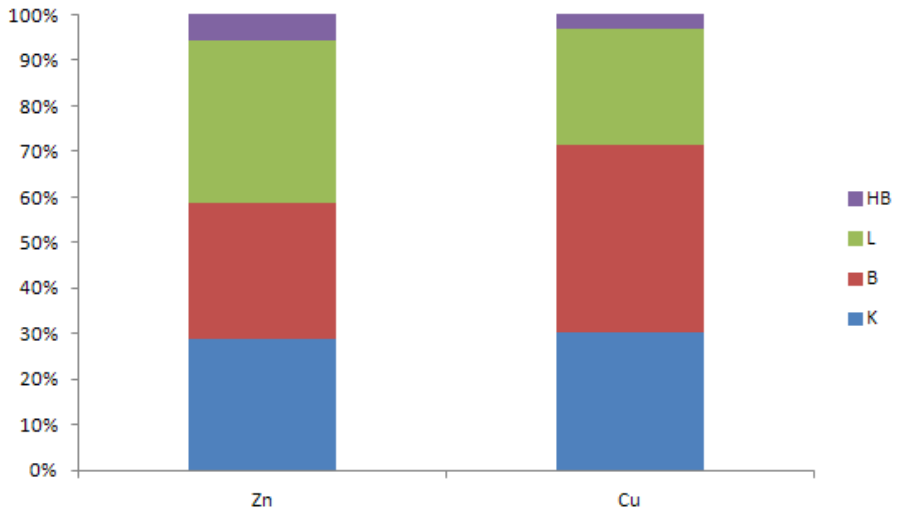




Contribution of different sources to the total greywater mass

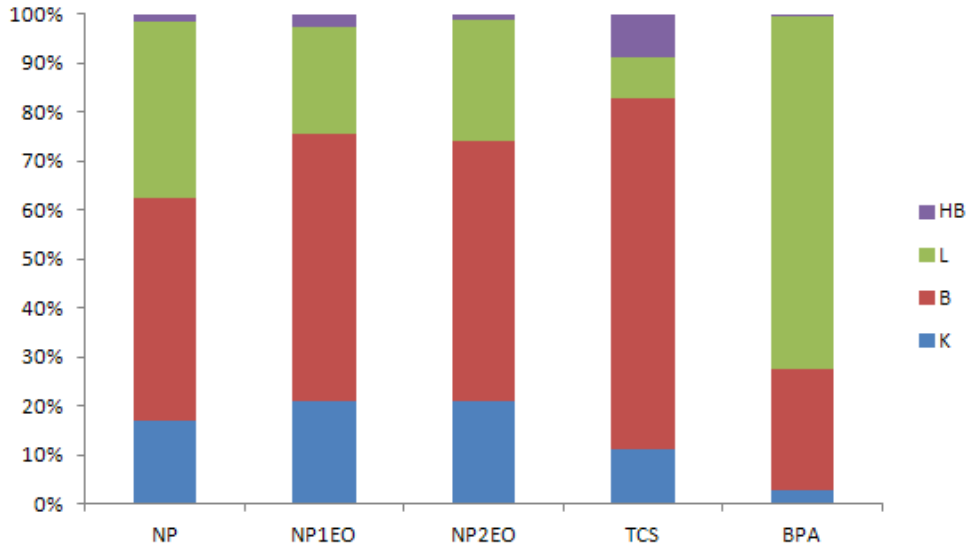
Qualitative greywater characterization heavy metals

Greywater source	Cd (µg/L)	Pb (µg/L)	Cr (µg/L)	Ni (µg/L)	Zn (mg/L)	Cu (µg/L)
Bath/shower	<0,15	<2,5	<2,5	<5,0	0,078±0,069	35±47
Hand basin	<0,15	<2,5	<2,5	<5,0	<0,050	7,3±9,4
Kitchen	<0,15	<2,5	<2,5	<5,0	0,091±0,071	27±27
Laundry	<0,15	3,9±3,3	7,3±7,1	<5,0	0,20±0,16	43±29
Dish washer	<0,15	3,65±0,9	<2,5	<5,0	0,076±0,015	16,23±1,0



Qualitative greywater characterization emerging pollutants

Greywater source	NP (µg/L)	NP1EO (µg/L)	NP2EO (µg/L)	TCS (µg/L)	BPA (µg/L)
Kitchen	15,2±18,5	1,46±2,03	1,30±2,84	0,0885±0,0970	0,0974±0,124
Bath/shower	32,8±12,7	3,22±2,68	2,39±1,49	0,436±0,385	0,701±0,510
Laundry	61,8±91,5	2,76±3,44	2,89±4,46	0,0991±0,0869	0,439±0,467
Hand basin	3,66±1,71	0,465±0,403	0,206±0,150	0,208±0,232	0,0268±0,0261

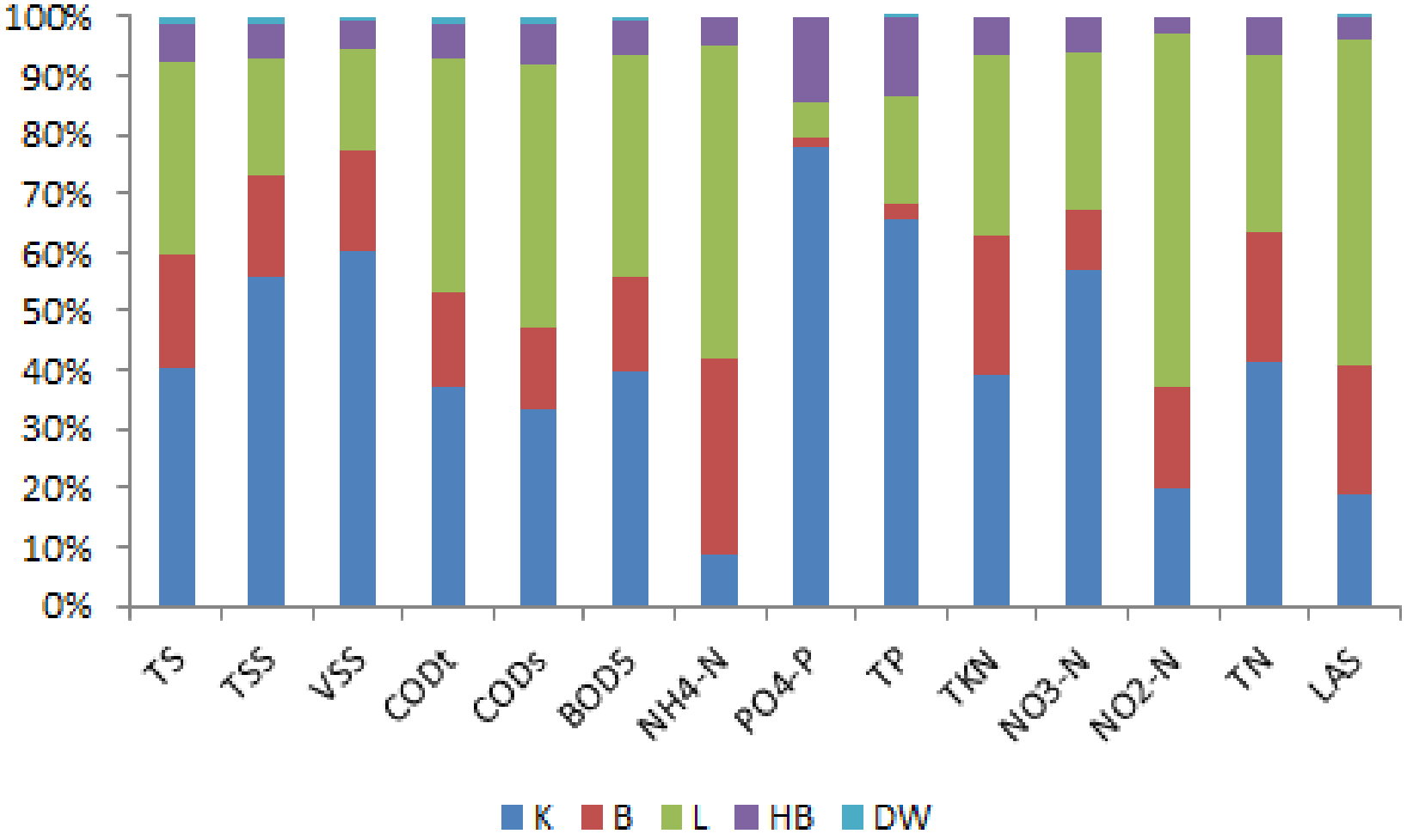


Qualitative greywater characterization

Greywater type	CODt (mg/L)	CODs (mg/L)	BOD_5 (mg/L)	TP (mg/L)	LAS (mg/L)	TN (mg/L)
GW-A[1]	398±112	210±113	272±73,1	0,37±0,61	70±25	2,6±1,9
GW-B[2]	873±346	481±297	582±242	0,61±0,52	173±84	3,6±2,1
GW-C[3]	861±286	476±259	571±233	5.43±1.5	169±48	3,6±2,7
GW-D[4]	939±260	489±232	649±213	4.6±0,89	144±38	4,4±2,7

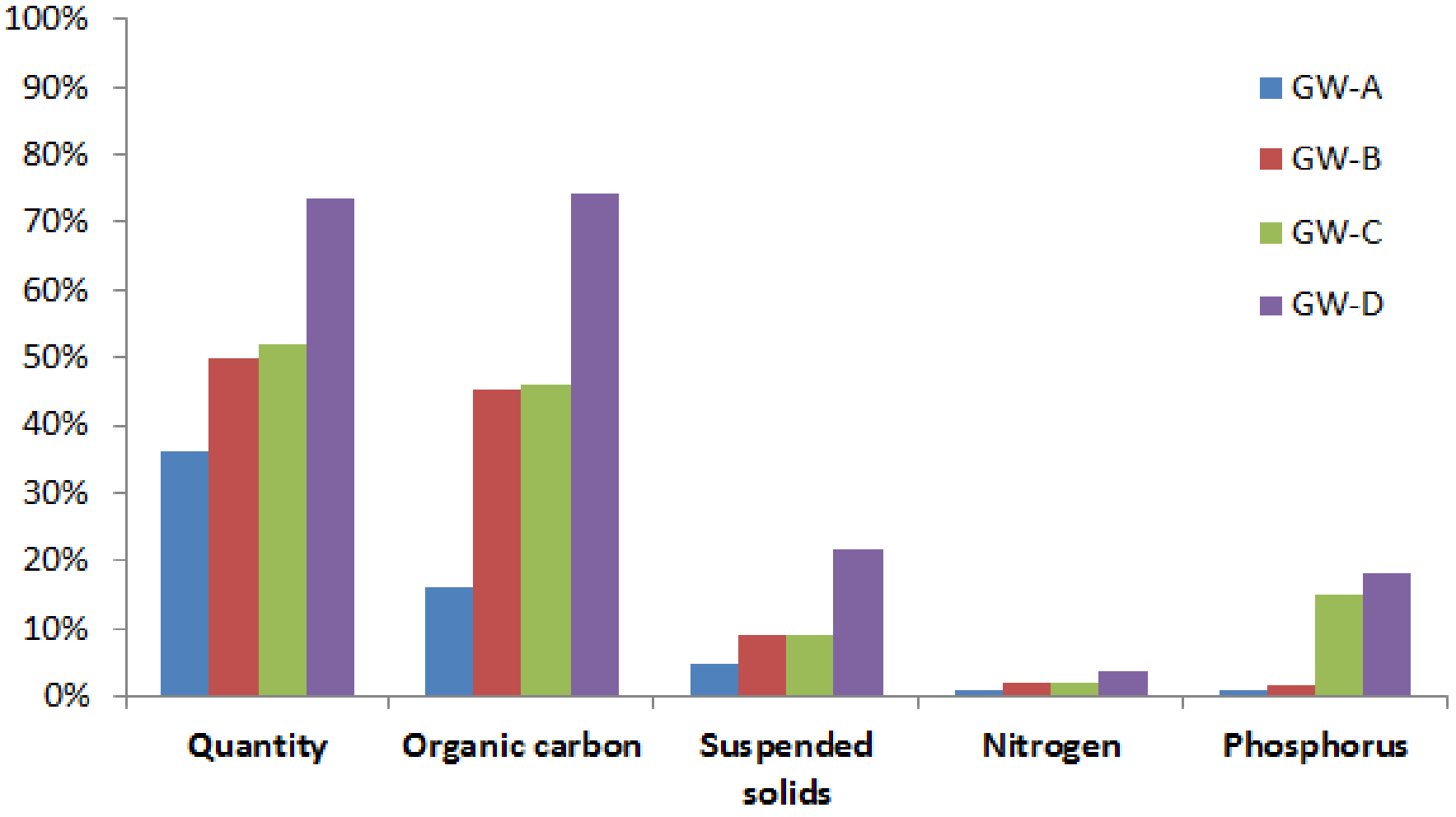
[1] refers to a mix of greywater originating from bath wastewater (bath and handbasin),
[2] bath, laundry, handbasin,
[3] bath, laundry, handbasin, dishwaher,
[4] bath, laundry, handbasin, dishwaher, kitchen

Qualitative greywater characterization



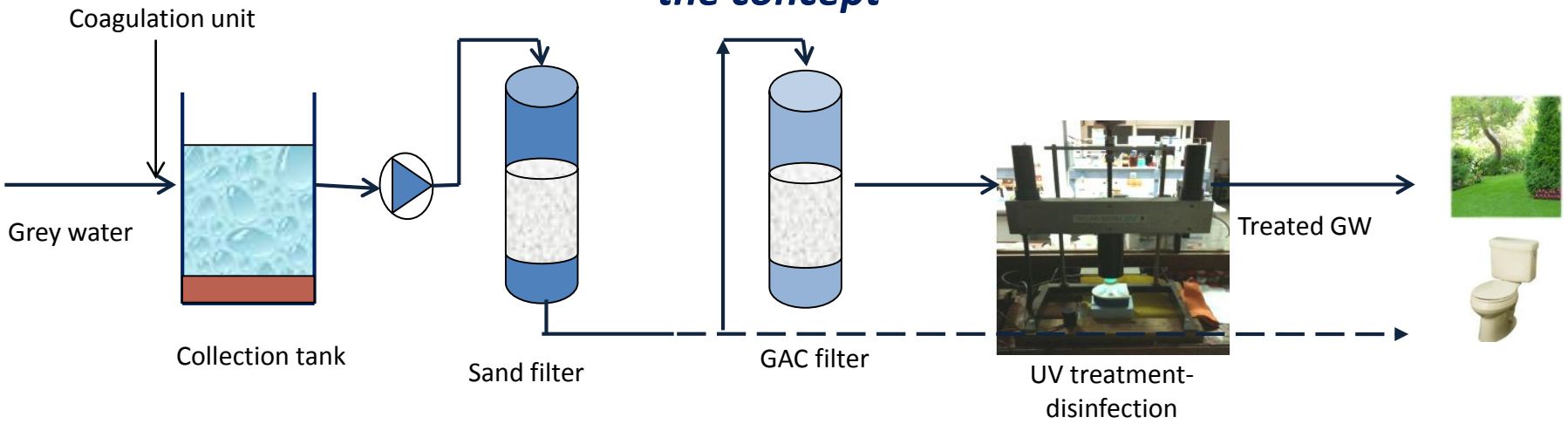
Contribution of several sources to the total greywater mass

Comparing with total wastewater

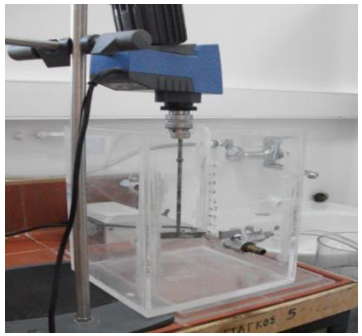
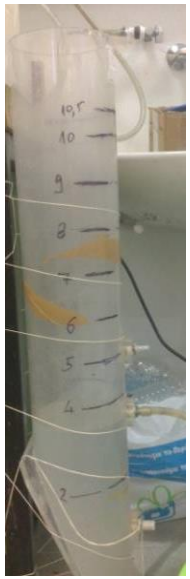


Greywater treatment

the concept



in the lab…

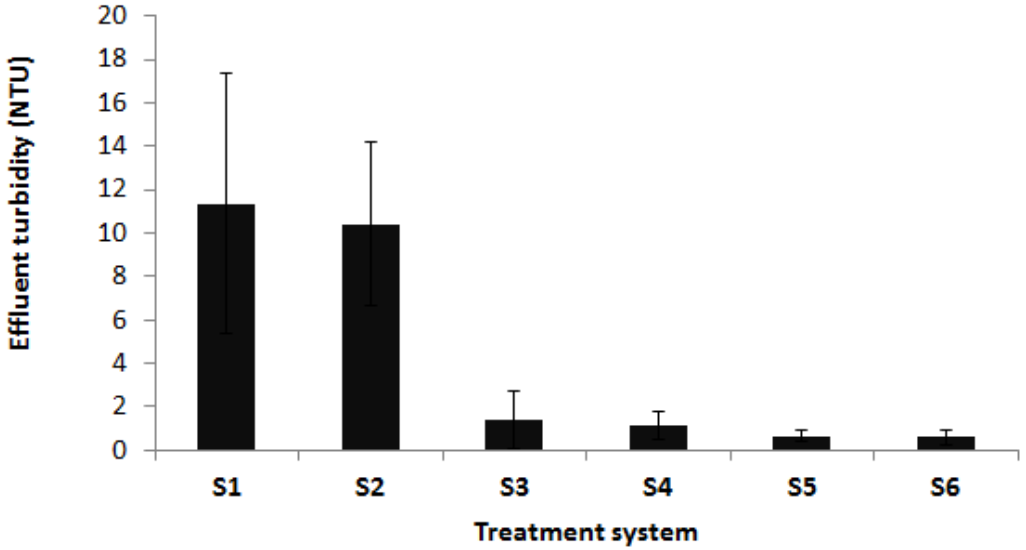



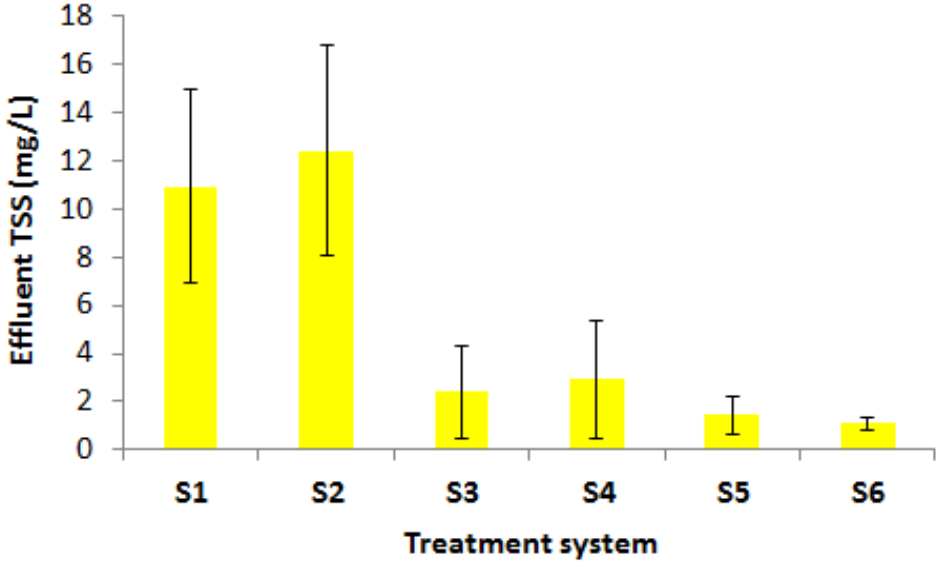


Greywater experimental treatment systems

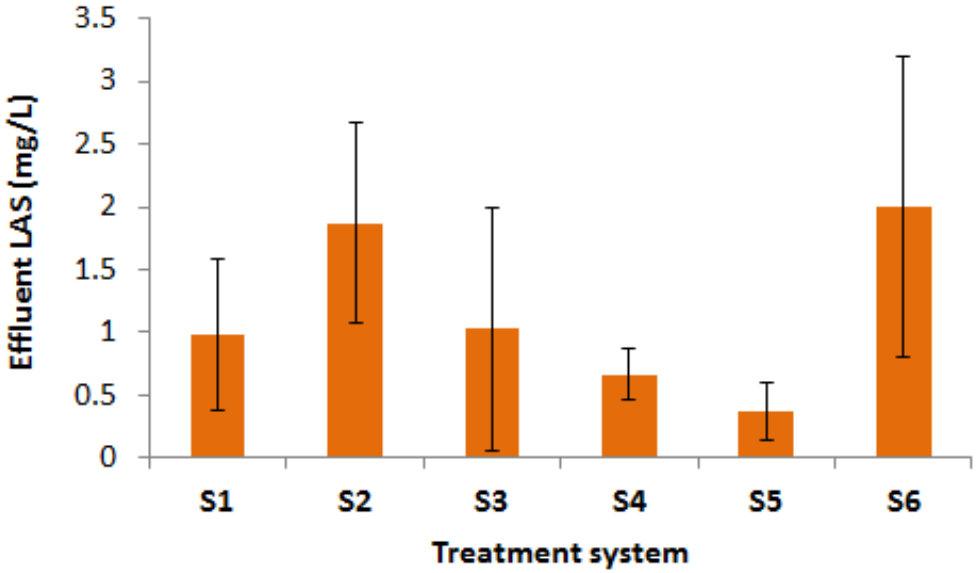
Treatment System	Greywater source				Treatment stages			
	Kitchen	Laundry	Bath/shower	Handbasin	Coagulation	Sedimentation	Sand filter	GAC filter
System 1			77%	23%		×	×	×
System 2		29%	55%	16%		×	×	×
System 3		29%	55%	16%	×	×	×	×
System 4	13%	48%	25%	14%	×	×	×	×
System 5	31%	38%	20%	11%	×	×	×	×
System 6	13%	48%	25%	14%	×		×	×

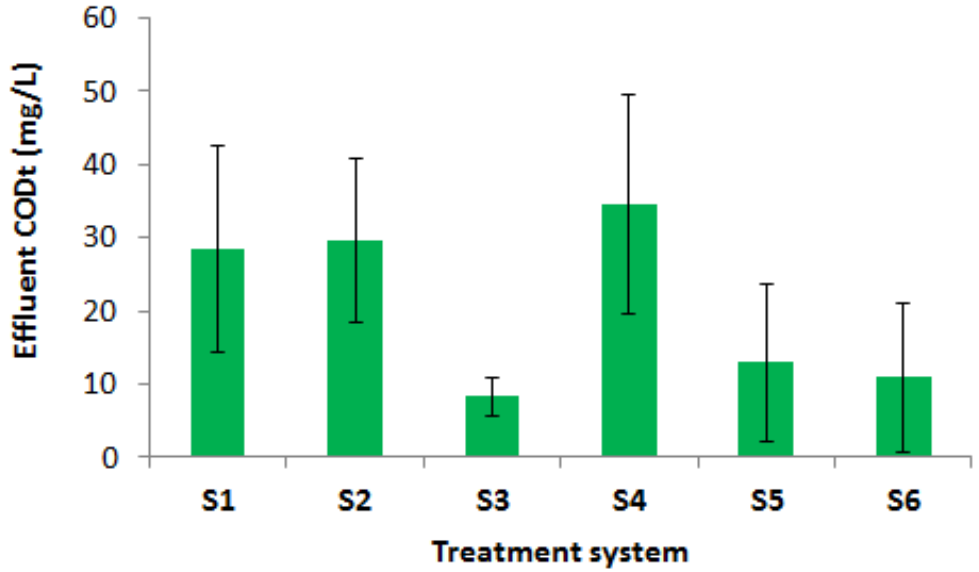
Greywater treatment systems – results



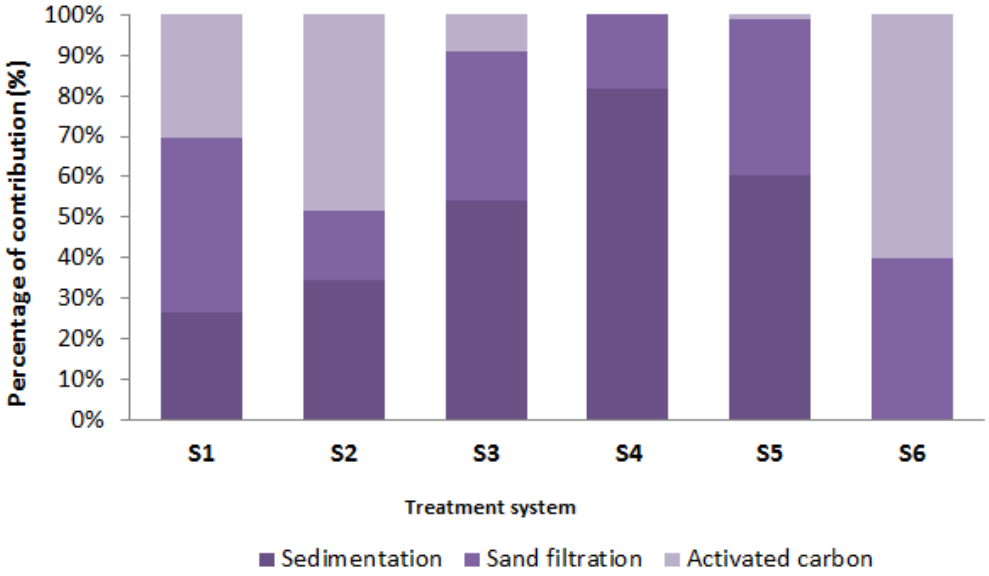


Greywater treatment systems – results



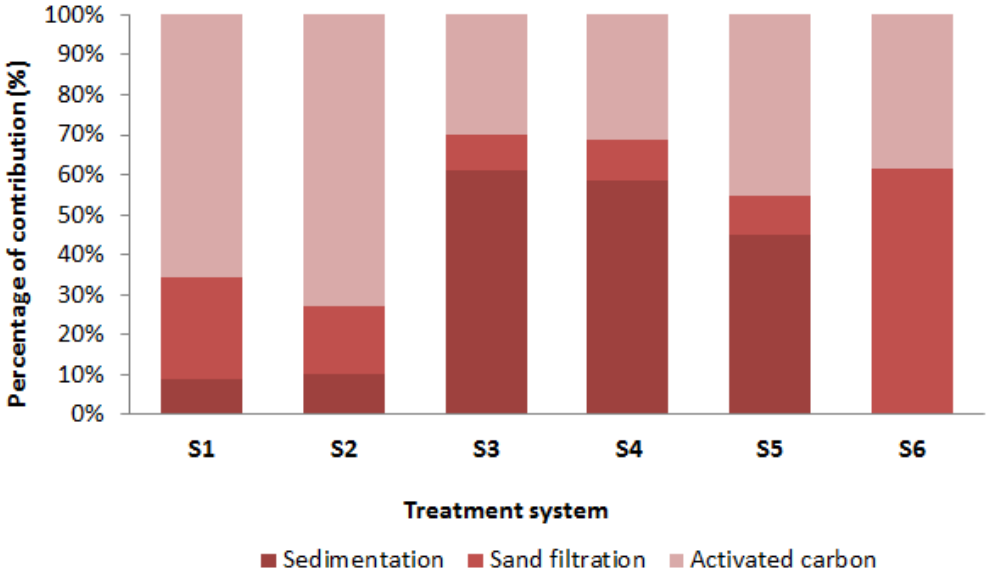


Greywater treatment systems – removal mechanisms



TSS

CODt



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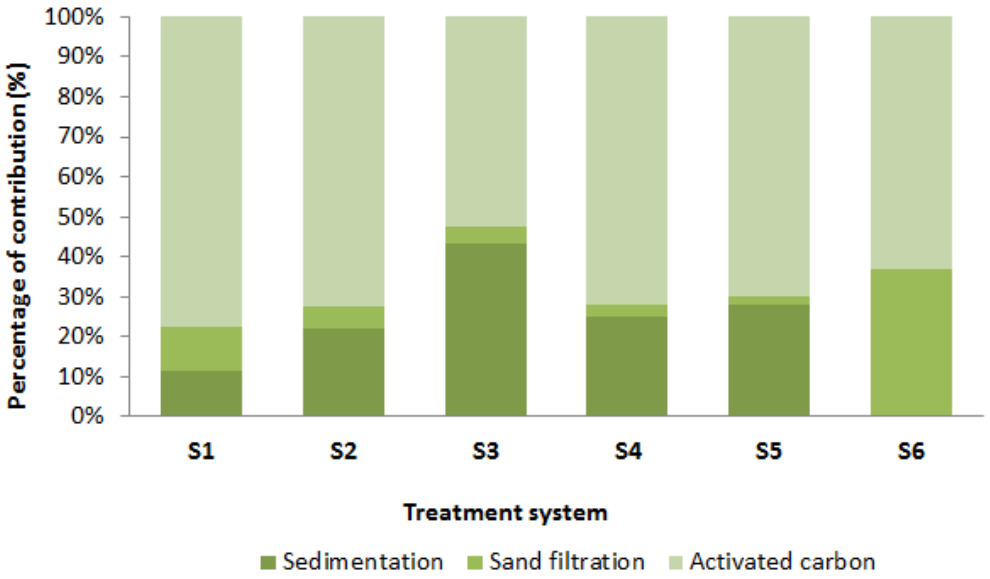
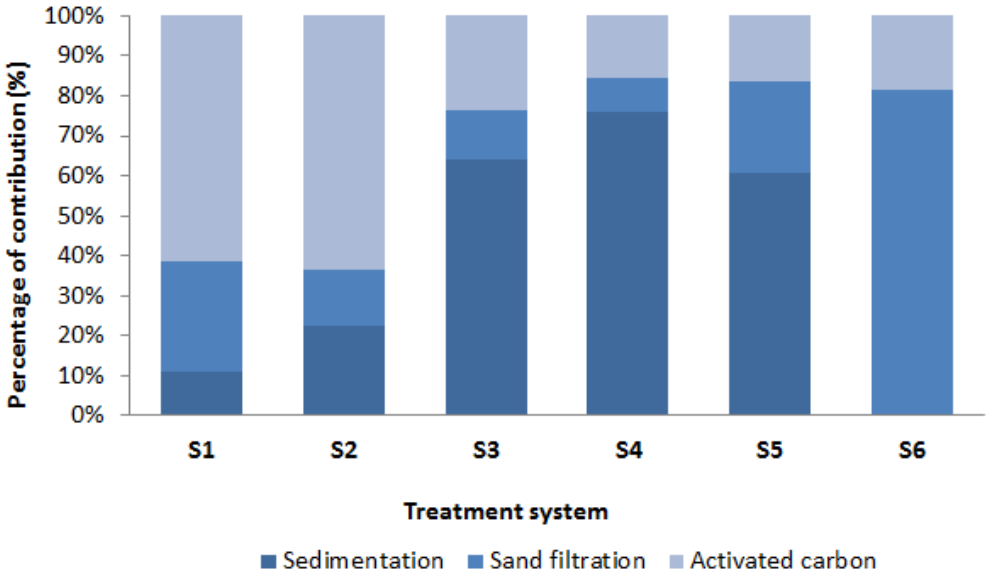


CODs

LAS



Conclusions

❖ The average daily wastewater production in Greece was estimated to 135 L per inhabitant and the 73% of this corresponds to greywater which is similar to values than have been reported by other researchers

❖ Greywater characteristics are highly variable depending on the living standards, the products used, the income and the habits of the residents

Conclusions

❖ Among the different sources, laundry and kitchen sink are the main contributors to the total greywater load of organic carbon and suspended solids, whereas bathtub and hand basin are the less polluted sources of greywater

❖The application of a treatment system consisting of coagulation, sedimentation, sand filtration, GAC filtration and disinfection can provide a high quality effluent for onsite reuse purposes.

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