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"Greywater use in tower gardens in peri-urban households in Kitgum,Uganda"

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Background

- Fresh water is becoming a rare resource (mainly among others, pollution and waste management)
- > 40% of world's population will live in countries facing water scarcity in the next 50 years (especially in parts of Asia and Africa)
- Rapid urbanization - synonymous with development of densely populated peri-urban settlements (slums) in most cities of developing countries. High health risks (polluted surface waters, contaminated ground water)
- The populations in slums have enhanced the demand for fresh water supply.
- Urgent need for alternative water resources and optimisation of water use efficiency through reuse options

Background (*Cont d*)

- Greywater (~50-80% residential wastewater) - cost effective alternative source of water
- In Kitgum's peri-urban areas-greywater is disposed of untreated onto the ground and into storm water drains (public and environmental health hazard)
- The majority of peri-urban locals in Kitgum, do not reuse greywater and yet experience water supply shortages (power outages) and are with limited boreholes.
- Appropriate reuse of greywater not only reduces agricultural use of drinking water and costs, but also increases food security and improves public health
- Main barrier for wider and faster dissemination of suitable greywater management systems at household level - lack of knowledge and experience, sparse scientific knowledge of greywater characteristics

Study objectives

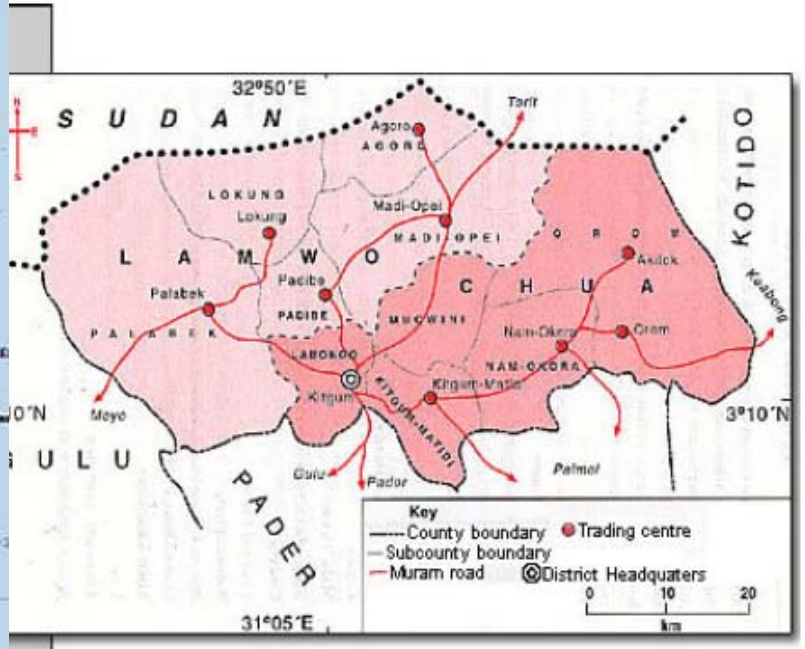
- To determine the characteristics of the greywater
- Demonstrate a low cost direct greywater reuse option in agriculture at a household level in a selected peri-urban settlement.
- Ascertain communities' perspectives of this technology

A tower garden is a simple innovative system which uses greywater for growing vegetables on a small footprint (<1 m^2) and can be easily self constructed with few local materials. Additionally, it is easy to operate and maintain.

Study area

er and commercial centre of
in Northern Uganda, 452km from

tion of 62,000 inhabitants spread



Map of Uganda showing the location of Kitgum District

(Source www.kitgum.go.ug)

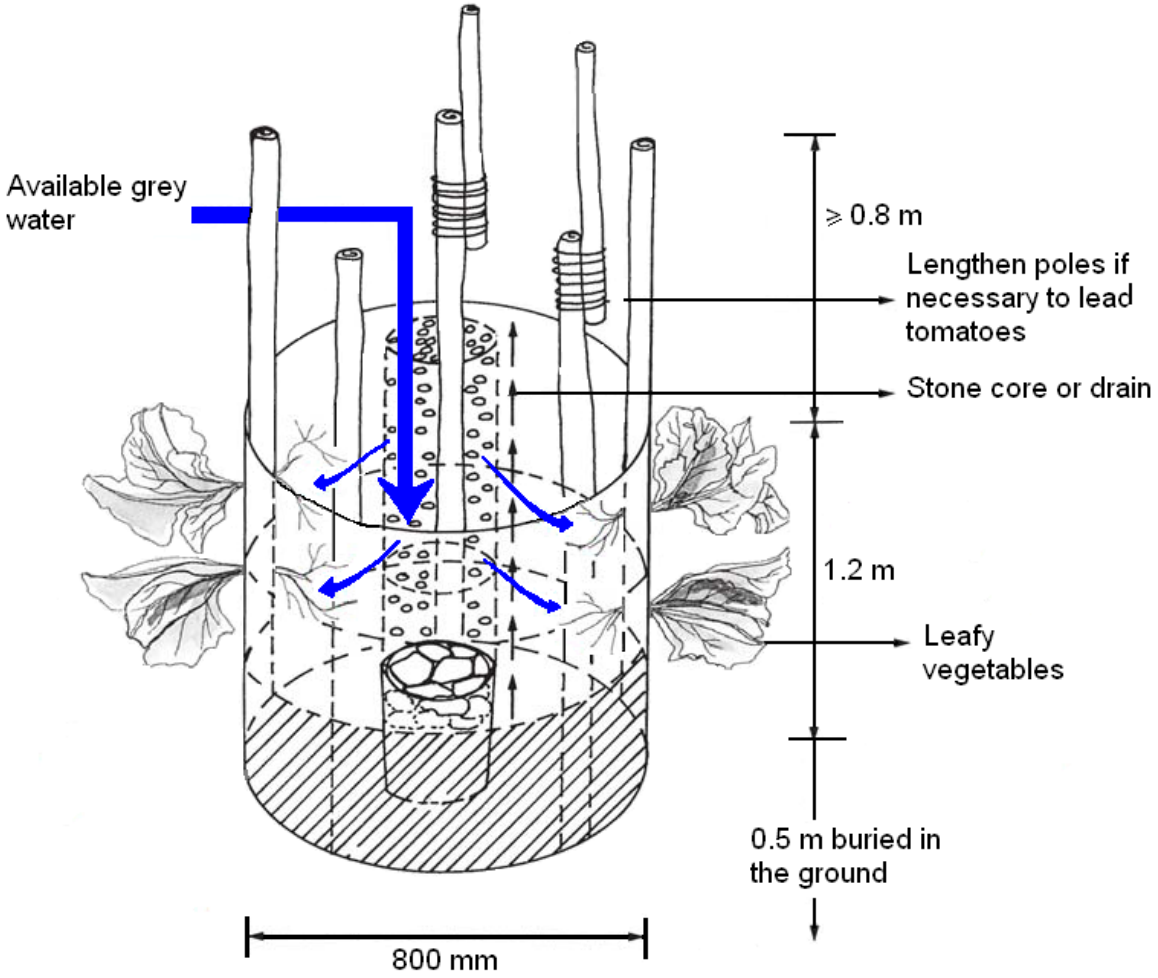
Materials and Methods

- Baseline situation regarding greywater reuse practices (if any) – a review of available reports, interviews with Households (38no.) within KTC area.
- Selection and sensitisation of study households (6no.) in Pondwongo village – Study households selected with the guidance of town council authorities, community leaders and local residents.
- Setting up of tower gardens (3no at each household, 1 control at one household)

Sensitisation of the households by the research team

- Soil sample collection and analysis to ascertain impact of greywater; initially and thereafter once a month for 3 months- pH, organic matter content, nitrogen, phosphorus and potassium
- Grey water collection and analysis from Kitchen, Laundry and Bathroom (6 households) every 2-3 weeks over a period of 6 months - Physico chemical (pH, DO, EC, Temp., TDS, Turbidity, COD, BOD_5, NH_3-N, Ortho-P. Total-P, SAR) and bacteriological (E.Coli).
- Plant measurements to ascertain impact of greywater application (undertaken at 2 households including one with the control) and informal interviews with the locals to ascertain their perception

Setting up of the tower gardens



- Planted with tomatoes and onions
- Greywater from bathing and washing of clothes was applied on a daily basis ~ 3 litres.
- Over the weekend, about 10 litres of ground water were applied to wash away the soap.
- Control tower garden received ~3 litres of groundwater daily.

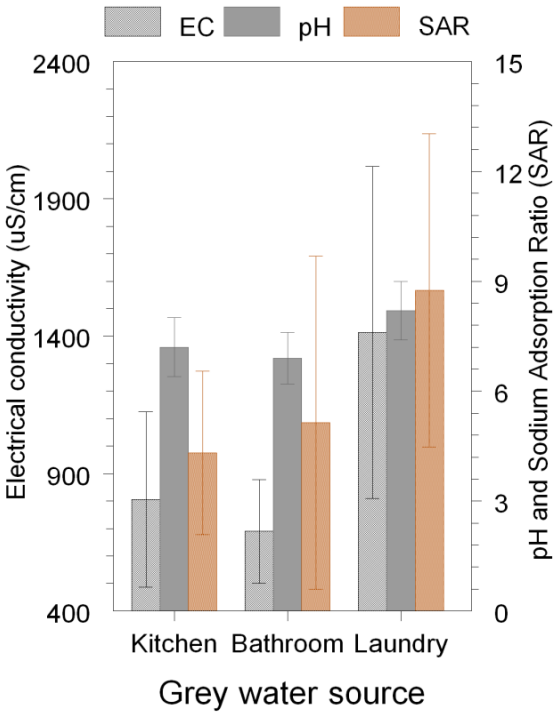
Results and Discussion

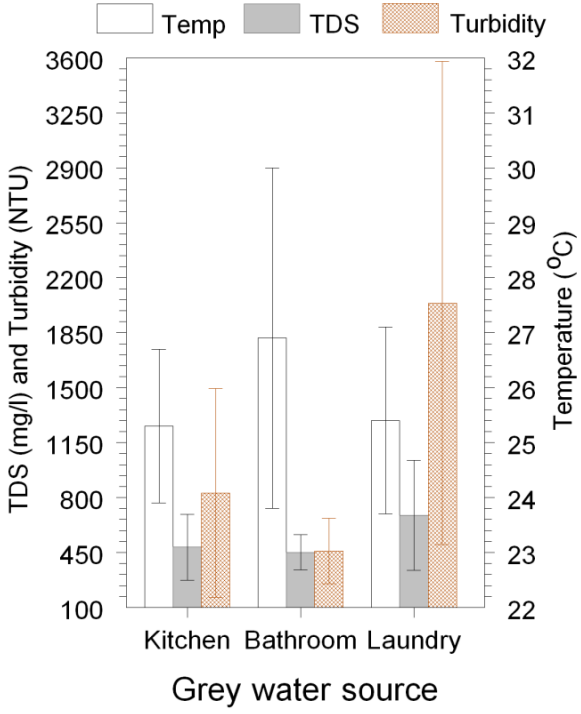
Water consumption, amount of greywater produced and reuse

- Most households (63%) use between 60-80 litres of water daily for washing, bathing, cooking and drinking. The daily per capita water consumption is in range of 10 -13 litres (< national policy recommendation 20-25 litres; < WHO standard quantity 50 litres for consumption and basic hygiene)
- Kitgum Town Council (KTC) is unsewered - Approx. 48-64 litres of wastewater is generated daily per household.
- Common sources of greywater in KTC were found to be kitchen, bathroom and laundry.
- Majority of the households (68%) were disposing of their greywater either in open spaces and or open channels, 21% in soak pits where possible and the rest (11%) disposed of it in gardens.
- Locals were not aware of any greywater disposal best practices but expressed willingness to reuse greywater if taught how.

Greywater characteristics

- Greywater was moderately alkaline with pH values in line with the range observed elsewhere (i.e., 8 -10 Erikson et al., 2002)
- The average SAR and EC values of the greywater when considered together indicate that the long term application of greywater may be detrimental (3-6 and 250-1300µS/cm: slight to moderate) to the hydraulic conductivity and physical properties of the soils.
- Mean EC and TDS values were <700µS/cm) and < 450 mg/l resp for bathroom greywater suggesting no impact on crop water availability
- The greywater exhibited high turbidity (> 100 NTU) with laundry water having the highest values.

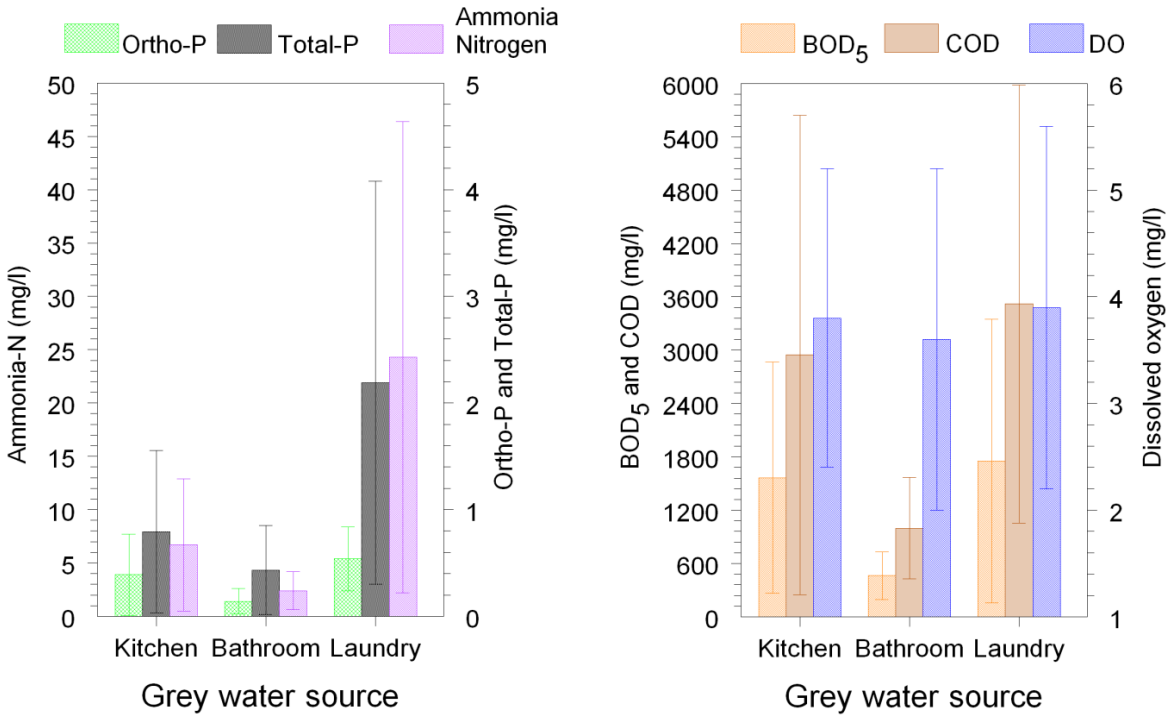




Characteristics of greywater from the different sources in Kitgum Town Council (Bars represent mean values±1SE, n= 35 per source)

Greywater characteristics

- Phosphorus concentrations in the Kitchen and laundry water (> 3mg/l)-phosphorus containing detergents are used.
- The mean ammonia nitrogen levels of the greywater are within the range (<0.1-15 mg/l) reported for other studies in the developed countries.
- The greywater exhibited higher COD values for the different sources (**K** 120-14680mg/l; **B** 170-2322mg/l; **L** 410-8500 mg/l) and higher BOD_5 values (**K** 76-4866mg/l; **B** 111-1221mg/l; **L** 273-5673mg/l) than reported values in the developed countries.
- The greywater had mean BOD_5/COD ratios (**K** 0.7, **B** 0.5, **L** 0.7) slightly close to 0.5 implying that the waters may not be easily treatable by biological means.



Characteristics of greywater from the different sources in Kitgum Town Council (Bars represent mean values±1SE, n= 35 per source)

Greywater characteristics

- All the greywater from the different sources had E.Coli, an indication of faecal contamination
- That Kitchen water has E.Coli may be due to contaminated uncooked food and raw meat, use of contaminated waters, washing of utensils with dirty and contaminated fingers
- Need for safe reuse practices-with respect to the tower gardens, the handling of the greywater, proper application to the tower garden and not allowing ponding, washing of hands after application

Bacteriological quality (E.Coli) of the greywater source types (n=8 per source; cfu/100ml)

Greywater source	Average Log_{10} Ecoli	Range Log_{10} Ecoli
Kitchen	8.42	<1-9.32
Bathroom	7.50	<1-8.24
Laundry	8.53	<1- 9.40

Soil characteristics

Soil chemical characteristics (initially and after greywater application) at the study households (Average values ±SD; Initial: n=7; after application: n =14)

Parameter	Initial	After application
pH	9.06 ±0.85	8.79 ±0.66
Nitrogen (%)	0.086 ±0.021	0.085 ±0.015
Phosphorus (mg/kg dry soil)	21.89 ±7.80	19.79 ±20.82
Potassium (meq/100g dry soil)	2.52 ±0.90	2.22±0.83
Organic matter (%)	1.61 ±0.53	1.55 ±0. 42

- Largely alkaline soils with high phosphorus (> 15mg/kg of dry soil) with low nitrogen, potassium and organic matter content.
- Greywater application to the tower gardens is seen to result in a decrease of the phosphorus content of the soil mixture.
- Though the greywater contains ammonia-N, the nitrogen content in the soils after greywater application does not change much-plant uptake and to a less degree ammonia volatilisation and loss to the atmosphere as nitrogen (pH > 7).

Plant growth measurements & observations

- Plants receiving grey water (household B) performed better compared to the control (Table).

- The planted vegetables thrived with greywater application (Figure). However, most were attacked by pesticides necessitating pest control.

Plant Measurements

	Control	A	B
Tomatoes			
Length of 1st Stem (cm)	3	3	3.4
Length of 1st leaf (cm)	43.3	27.2	37.5
Length of leaflet (cm)	10.4	8	11.7
No of flowers	16	7	18
No of seeds	1	5	5
Length of inter-node (cm)	14.5	17.2	18
No of branches	4	4	7
Onions			
No of leaves	9	10	8
Length of leaf (cm)	8.7	15	19

Growth of tomatoes (on top) and onions (in the sides (b) flowering of tomatoe plants

Community perceptions of the tower gardens

- Informal interviews with the locals revealed that they have knowledge of the tower garden and would want to have one at their homes
- A walk through the area indicated that 15 additional households set up their own tower gardens after seeing the benefits of the study units
- Where the vegetables were harvested from the tower gardens, the area was converted into small gardens irrigated with greywater (Figure).
- Little water was produced particularly from laundry (do not wash daily, water scarcity)
- The shade cloth used not only was destroyed by roaming animals but also worn out within 2months (Figure)

Area around the tower gardens used as a small garden and planted with pumpkins

Shade cloth-sack bag wearing out

Conclusions and Recommendations

- The common greywater sources in Kitgum town council are kitchen, bathroom and laundry.
- Greywater disposal in the area is poor with the majority of the households (68%) pouring greywater onto the ground, 21% dispose of it into drain channels and soak pits while very few (11%) pour it into their garden.
- The relatively low BOD_5/COD ratio (slightly >0.5) the greywater is not easily treatable by biological means.
- The effect of greywater application on the soil characteristics was slight with respect to potassium, organic matter and nitrogen content. However, there was a slight decrease in phosphorus content
- Tomato and onion plants grown in the tower gardens thrived with the greywater. However they were attacked by pests.

Conclusions and Recommendations (cont´d)

- Given the greywater characteristics presented in the study, this wastewater stream should be properly managed to prevent contamination of the environment and disease prevalence.
- To enhance interest and demand so as to scale up this greywater reuse option necessitates increased sensitization and social marketing within the community on greywater reuse and associated benefits
- Promote use of biological measures for pest control and investigate use of other materials to prolong the life of the tower garden.
- There is need to ascertain the hydraulic load and life of a tower garden so as to guide the number or size of gardens needed for a particular quantity of generated greywater for optimum performance
- Further monitoring of this reuse option is needed so as to ascertain the vegetable yield per volume of soil for each tower garden, impact of greywater application on crop growth and content and, people's livelihoods

Acknowledgements

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Thank you for listening!