Investigating The Viability and Performance Of The Pilot Scale Fly Ash/Lime Filter Tower For Onsite Greywater Treatment

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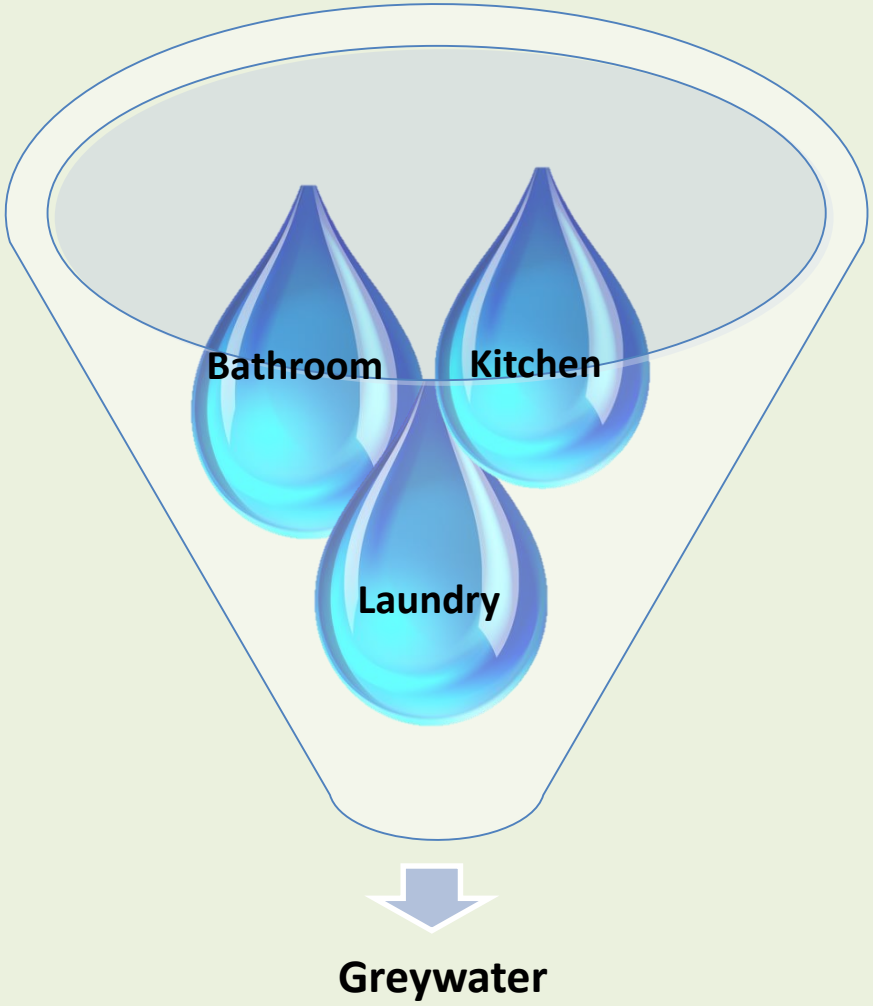
Water Scarcity

- Increase in urbanisation – Increase in water demand.
- South Africa is a water scarce country.
- Alternatives are required - e.g. Greywater, Rainwater harvesting etc.
- Innovative approaches are needed to mitigate water scarcity.

Greywater



- The use of greywater has become a common practices.
- Greywater can be used for non-potable purposes [24].
- Environmental feasibility[14].
- Economic feasibility [18].

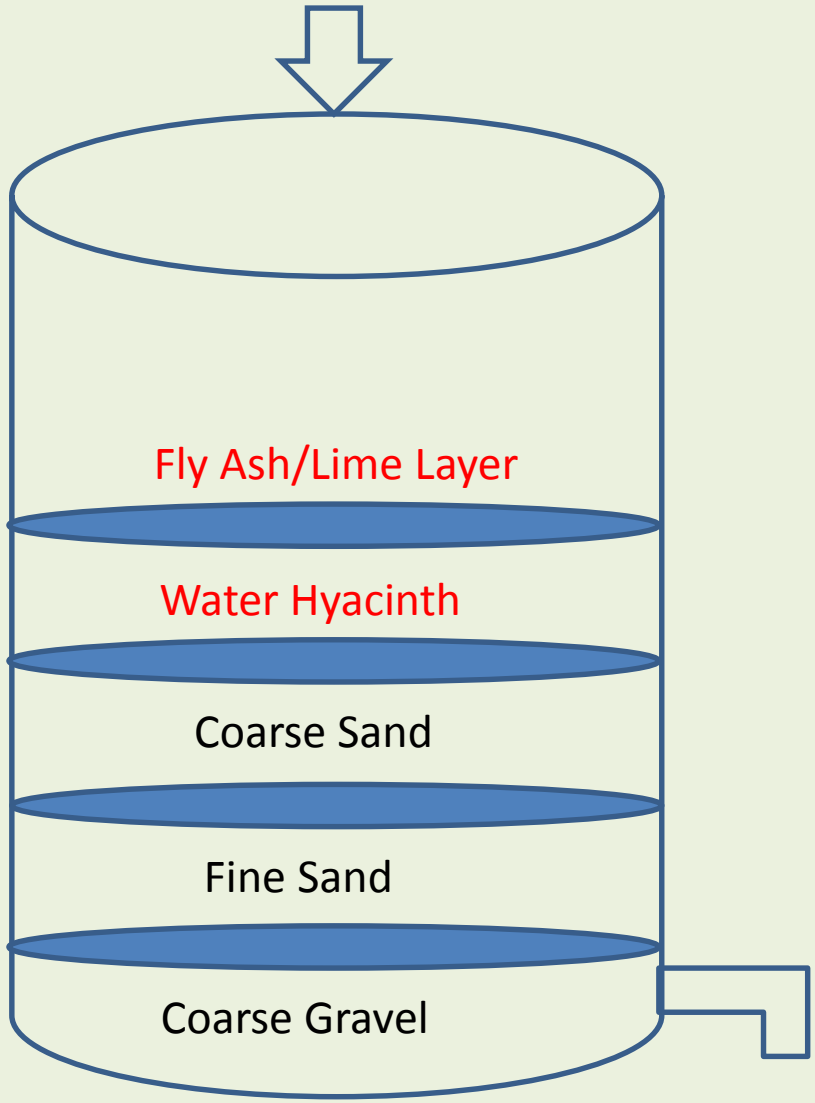
Greywater

- The US, Australia and the Middle East have accepted the use of greywater for irrigation [17,18].
- Reduces the demand for water supply [6].
- Reduce the demand for high quality potable water for non-potable uses [3,6].
- Reduce energy demands and carbon footprint of water services [6].

Greywater in South Africa

- Some areas in South Africa lack proper sanitation facilities [1].
- Greywater disposal is a major sanitation problem [1].
- Greywater is often disposed outside the houses.
- The ponded greywater creates environmental and health risks [1,4].
- Microorganisms are likely to proliferate, causing diseases in humans and animals [5].

Fly Ash/ Lime Filter Tower (FLFT)



- On-site treatment.
- Low cost material.
  - Avoid theft.
- Easy to operate.
- Coupled to a drip irrigation system.

FLFT

- Fly Ash
  - By- product of coal combustion [5].
  - Made up of different elements e.g. Al,
  - Where most of the greywater treatment occurs.

- Water Hyacinth (*Eichhornia crassipes).*
  - Invasive species [10].
  - High absorptivity [10].
  - Used for pH stability.

Image adapted from http://www.painetworks.com/previews/gj/gj0690.html

Methodology

Greywater Characterization

- Microbial constituents
  - *Faecal Coliforms*
  - *Total Bacteria*
- pH
- Turbidity
- Chemical Oxygen Demand (COD)
- Nitrates
- Phosphates
- Chlorides
- Ammonium

Environmental Impact Studies

- Faecal coliforms
- Total bacteria (Anaerobic and aerobic)
- Bulk density
- Particle size density
- Loss on ignition
- Metal analysis
- pH
- Plant analysis - Data not available

Greywater Characterization

- *Microbial analysis*

- **Faecal coliforms**
  - Influent = ~ 65 -110 CFU/100 ml
  - Effluent = ~ 20-50 CFU/100 ml

- **Total bacteria**
  - Influent = ~3.0×10^7 CFU/ml
  - Effluent = ~6.0×10^6 CFU/ml

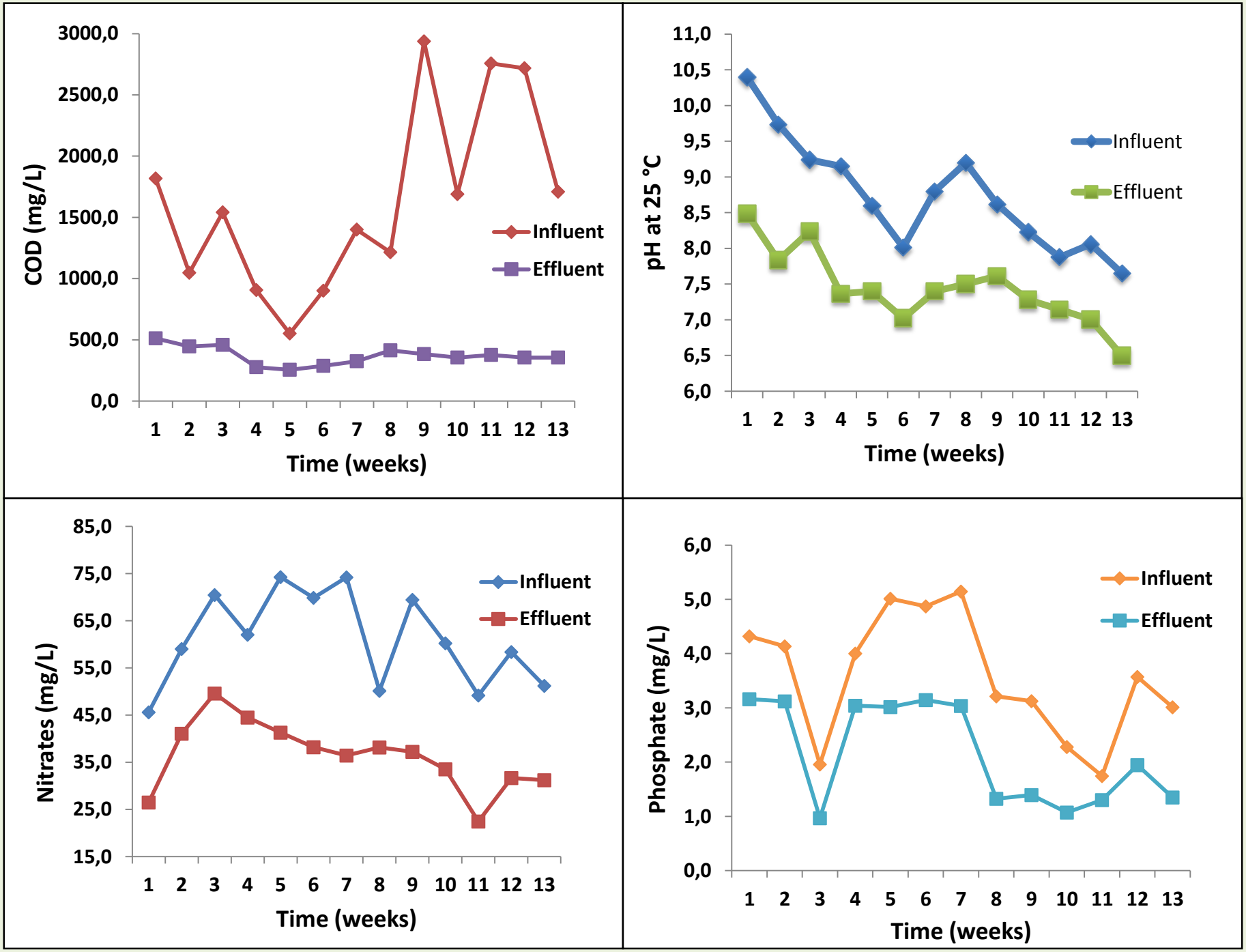
Table 1: The physico-chemical components of the greywater before and after treatment with the FLFT. (**Grahamstown East**).

Parameters	Fingo		Extension 1		Extension 9	
	Influent	Effluent	Influent	Effluent	Influent	Effluent
pH	*8.92 ± 0.5*	*6.87 ± 0.5*	*7.63 ± 0.7*	*6.91 ± 0.5*	*7.22 ± 0.6*	*7.19 ± 0.5*
Turbidity (ntu)	*748 ± 213.4*	*430 ± 411.1*	*691 ± 98.8*	*368 ± 97.3*	*1032 ± 55.5*	*598 ± 276.9*
COD (mg/l)	*2116.2 ±108.1*	*392.2 ±23.0*	*2994.5± 653.3*	*411.7 ±69.5*	*2978.3 ±129.2*	*376.5 ±96.4*
NO_3^- (mg/l)	*96.54 ± 87.9*	*45.58 ± 21.9*	*71.61 ± 50.8*	*24.43 ± 17.4*	*78.95 ± 7.4*	*44.84± 10.8*
PO_4^- (mg/l)	*1.87 ± 0.6*	*0.78 ± 0.7*	*8.08 ± 3.2*	*2.14 ± 1.8*	*3.71 ± 2.2*	*2.45 ± 1.9*
NH_4^+ (mg/l)	*3.25 ± 1.9*	*1.73 ± 1.4*	*6.93 ± 3.1*	*3.392 ± 2.6*	*2.55 ± 1.8*	*1.30 ± 1.8*
Cl^- (mg/l)	*7.80 ± 3.1*	*4.43 ± 2.0*	*15.15 ± 6.3*	*7.9 ± 3.1*	*6.0 ± 3.1*	*3.86 ± 1.9*

Table 2 : The physico-chemical components of the greywater before and after treatment with the FLFT. (**Grahamstown West**).

Parameters	Town 1		Town 2	
	Influent	Effluent	Influent	Effluent
pH	*7.23 ± 0.6*	*6.94 ± 0.5*	*9.44 ± 0.9*	*7.47 ± 0.5*
Turbidity (ntu)	*986 ± 282.6*	*26.2 ± 6.5*	*334 ± 258.2*	*29.1 ± 10.7*
COD (mg/l)	*1509.7 ±260.9*	*291.3 ±95.1*	*3046±1083.7*	*351.5±91.3*
NO_3^- (mg/l)	*35.10 ± 10.7*	*23.40 ± 8.4*	*55.43 ± 5.2*	*17.98 ±8.1*
PO_4^- (mg/l)	*1.60 ± 0.6*	*0.88 ± 0.2*	*1.47 ± 0.7*	*0.58 ± 0.4*
NH_4^+ (mg/l)	*2.95 ± 1.7*	*1.53 ± 1.6*	*4.70 ± 1.6*	*2.18 ± 1.6*
Cl^- (mg/l)	*3.31 ± 1.7*	*1.9 ± 0.8*	*5.63 ± 3.2*	*3.84 ± 2.2*

There is a significant decrease in the turbidity.


COD (mg/L)
3000,0
2500,0
2000,0
1500,0
1000,0
500,0
0,0
1 2 3 4 5 6 7 8 9 10 11 12 13
Time (weeks)
Influent
Effluent
pH at 25 °C
11,0
10,5
10,0
9,5
9,0
8,5
8,0
7,5
7,0
6,5
6,0
1 2 3 4 5 6 7 8 9 10 11 12 13
Time (weeks)
Influent
Effluent
Nitrates (mg/L)
85,0
75,0
65,0
55,0
45,0
35,0
25,0
15,0
1 2 3 4 5 6 7 8 9 10 11 12 13
Time (weeks)
Influent
Effluent
Phosphate (mg/L)
6,0
5,0
4,0
3,0
2,0
1,0
0,0
1 2 3 4 5 6 7 8 9 10 11 12 13
Time (weeks)
Influent
Effluent

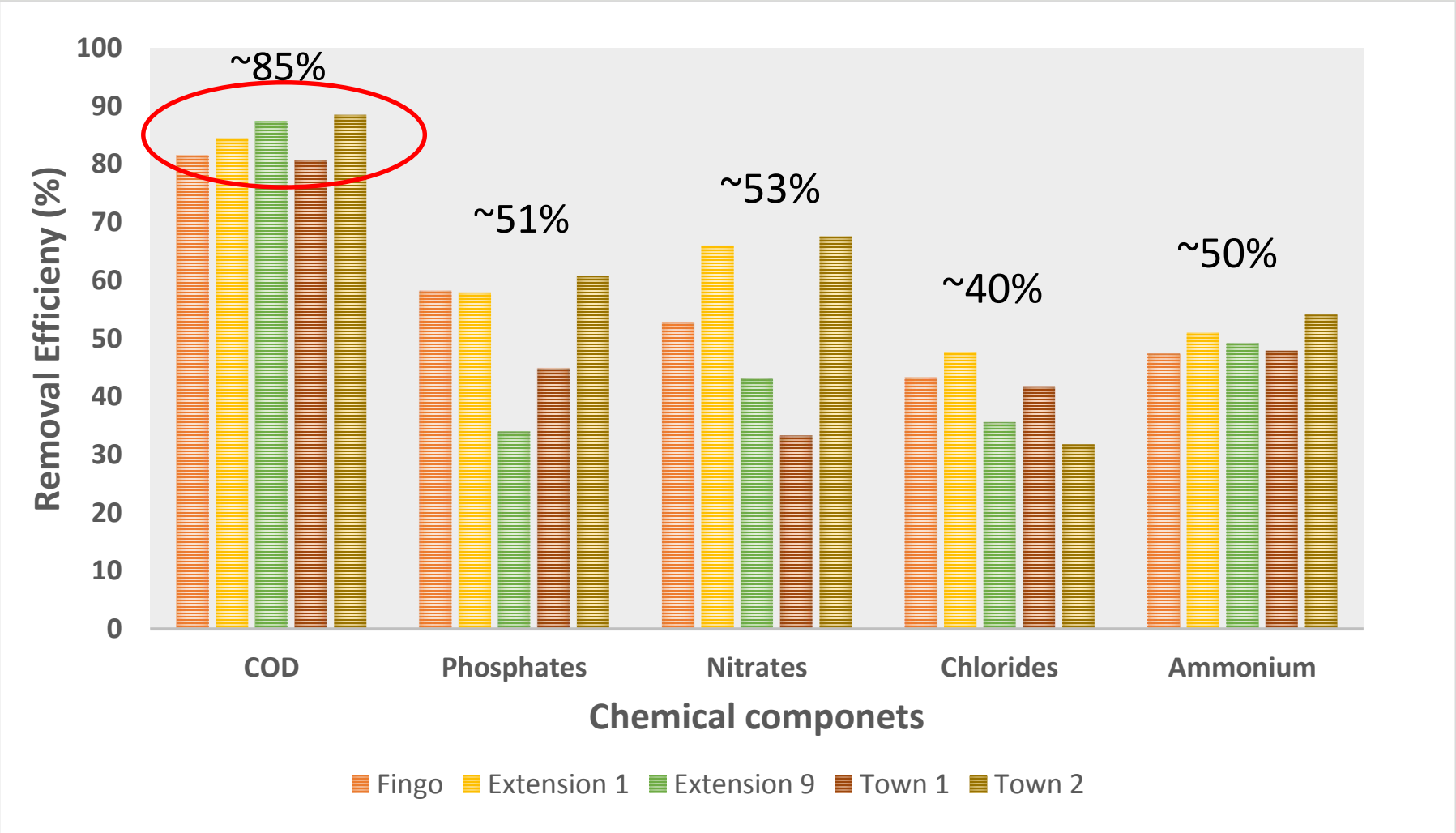


Figure 2: Percentage removal of the chemical content of the greywater after treatment with the Fly Ash/Lime Filter Tower treatment system to check the efficiency of the system with respect to the sites.

Soil Analysis

Table 1: Soil analysis of the initial samples (untreated) and treated samples (irrigated with greywater treated using the FLFT system over a period of time. (Grahamstown East)

	Fingo		Extension 1		Extension 9	
	Initial	*After*	*Initial*	*After*	*Initial*	*After*
pH	6.50±0.3	7.53±0.16	5.76±0.02	7.16±0.14	7.16±0.03	7.15±0.08
Bulk density (g/cm^3)	0.79±0.01	0.81±0.12	0.84±0.01	1.02±0.08	0.11±0.02	0.64±0.02
Particle size density(g/cm^3)	2.10±0.1	2.11±0.03	2.2±0.2	2.00±.0.02	2.35±0.2	2.05±0.01
Loss on ignition (%)	10.81±0.02	13.95±1.32	11.33±0.03	13.27±1.68	11.03±0.01	15.84±1.2

Soil Analysis

Table 2: Soil analysis of the initial samples (untreated) and treated samples (irrigated with greywater treated using the FLFT system over a period of time (Grahamstown West).

	Town 1		Town 2	
	Initial	*After*	*Initial*	*After*
pH	6.60±0.04	7.38±0.14	6.13±0.02	7.31±0.20
Bulk density (g/cm^3)	0.15±0.002	0.75±0.02	0.116±0.004	0.89±0.03
Particle size density(g/cm^3)	2.48±0.02	2.23±0.06	2.31±0.1	2.27±0.06
Loss on ignition (%)	13.05±0.04	14.52±3.79	13.89±0.02	15.33±1.19

Soil Analysis

Table 2: Metal analysis of soil after irrigation with greywater from the Fly Ash/Lime Filter Tower.

	Metal Concentration (mg/l)							
Sites	*Mn*	*Cu*	*Pb*	*Cd*	*Mg*	*K*	*Al*	*Fe*
Fingo	**8.4**	**0.63**	**3.22**	**0.0**	**75.18**	**45.34**	**142.70**	**133.90**
Ext 1	**20.60**	**0.73**	**2.10**	**0.0**	**31.38**	**25.18**	**139.52**	**182.80**
Ext 9	**32.30**	**1.12**	**2.29**	**0.0**	**41.48**	**71.00**	**149.02**	**222.24**
Town 1	**18.59**	**0.41**	**0.40**	**0.0**	**34.20**	**31.29**	**168.15**	**207.00**
Town 2	**18.69**	**0.42**	**0.0**	**0.0**	**82.99**	**23.02**	**134.20**	**174.22**

Samples were analysed using ICP/OES

Water and Plant samples

Conclusion

- The project was part of a **civic engagement** to address the community's urgent needs.
  - food security.
  - Improvement of sanitation .
- Aimed at the development of a socially responsive biotechnology and healthcare professional**.**
- Decrease in the concentration of the tested parameters: **COD, turbidity and pH.**
- Decrease in pH **: Water hyacinth** incorporated into the tower.
- The FLFT was **efficient**:
  - producing an effluent **compliant** with greywater quality guidelines in South Africa.

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Thank you