Comparison of a recycled glass filter and sand filter for tertiary treatment of on-site wastewater effluent

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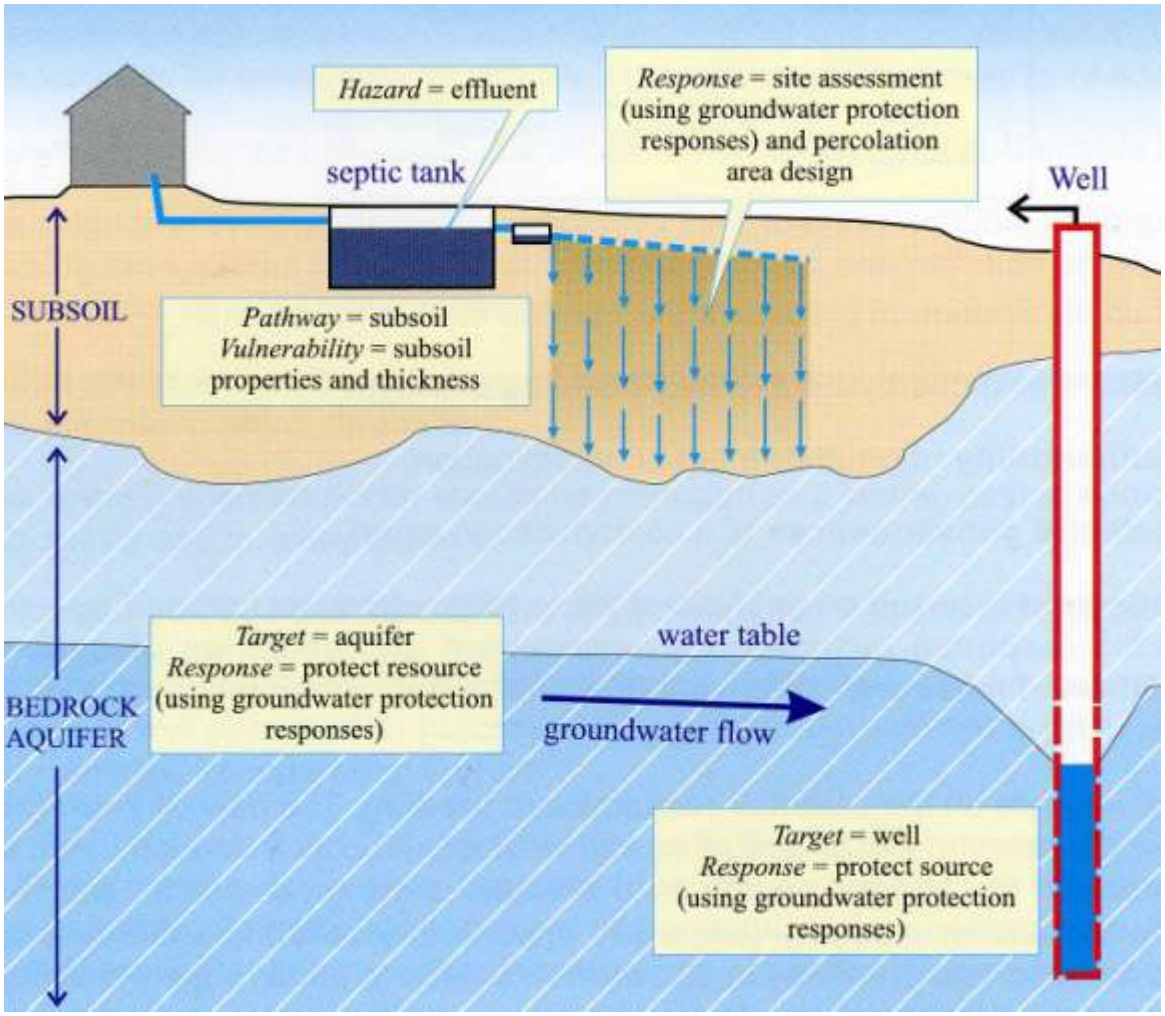

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Code of Practice Treatment systems for single houses

to conform with Groundwater Protection Response

Risk matrix - groundwater vulnerability vs value of resource

Sand filters

Secondary treatment: 30 l/m^2.d

Tertiary treatment: 60 l/m^2.d

Stratified sand filter (X-section)

100 mm **distribution gravel**
200 mm **COARSE SAND** ***(0.5 to 1.0*** mm***)*** ; D_{10} = 0.55 mm
75 mm **pea gravel** (20-30 mm)
100 mm **MEDIUM SAND** ***(0.2 to 0.63*** mm***)*** ; D_{10} = 0.35 mm
75 mm **pea gravel** (20-30 mm)
200 mm **FINE SAND** ***(0.1 to 0.5*** mm***)*** ; D_{10} = 0.30 mm
250 mm **pea gravel** (20-30 mm)
50 mm medium sand ***(0.2 to 0.6*** mm***)***

Recycled glass **from Tullagower Quarries Ltd, Kilrush - Co. Clare**

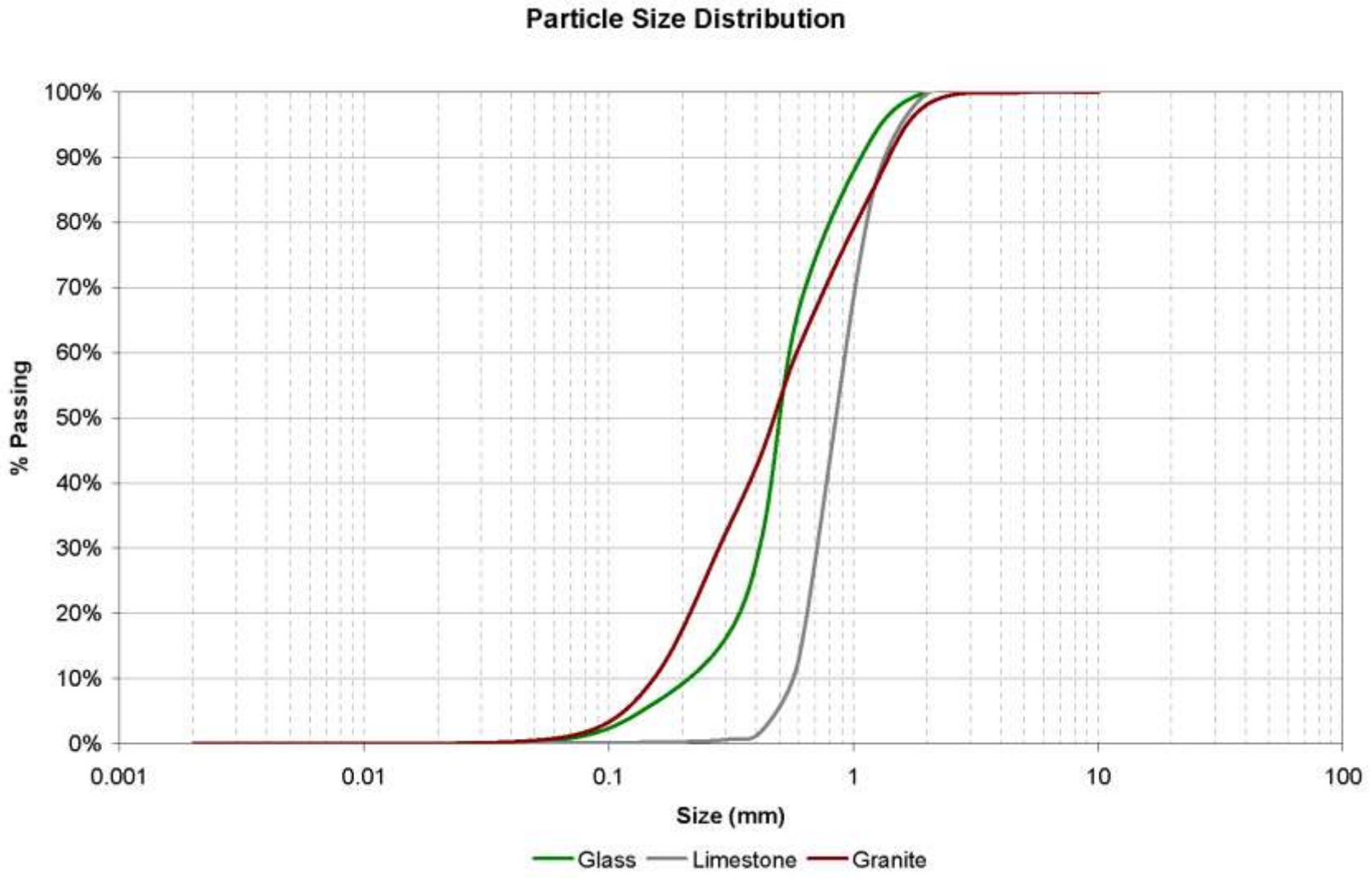
Use of recycled glass for filters addresses sustainability issues of sourcing and transporting sand

and compliments EU Waste Management Directives

- **Framework Directive on Waste (91/156/EEC)**
- **Landfill of Waste Directive (99/31/EC)**
- **Packaging & Packaging Waste Directive (94/62/EC)**

Objective – to compare recycled glass against sand as a media for tertiary treatment filter for on-site wastewater treatment

(both filters with 100 mm of limestone sand for P removal)



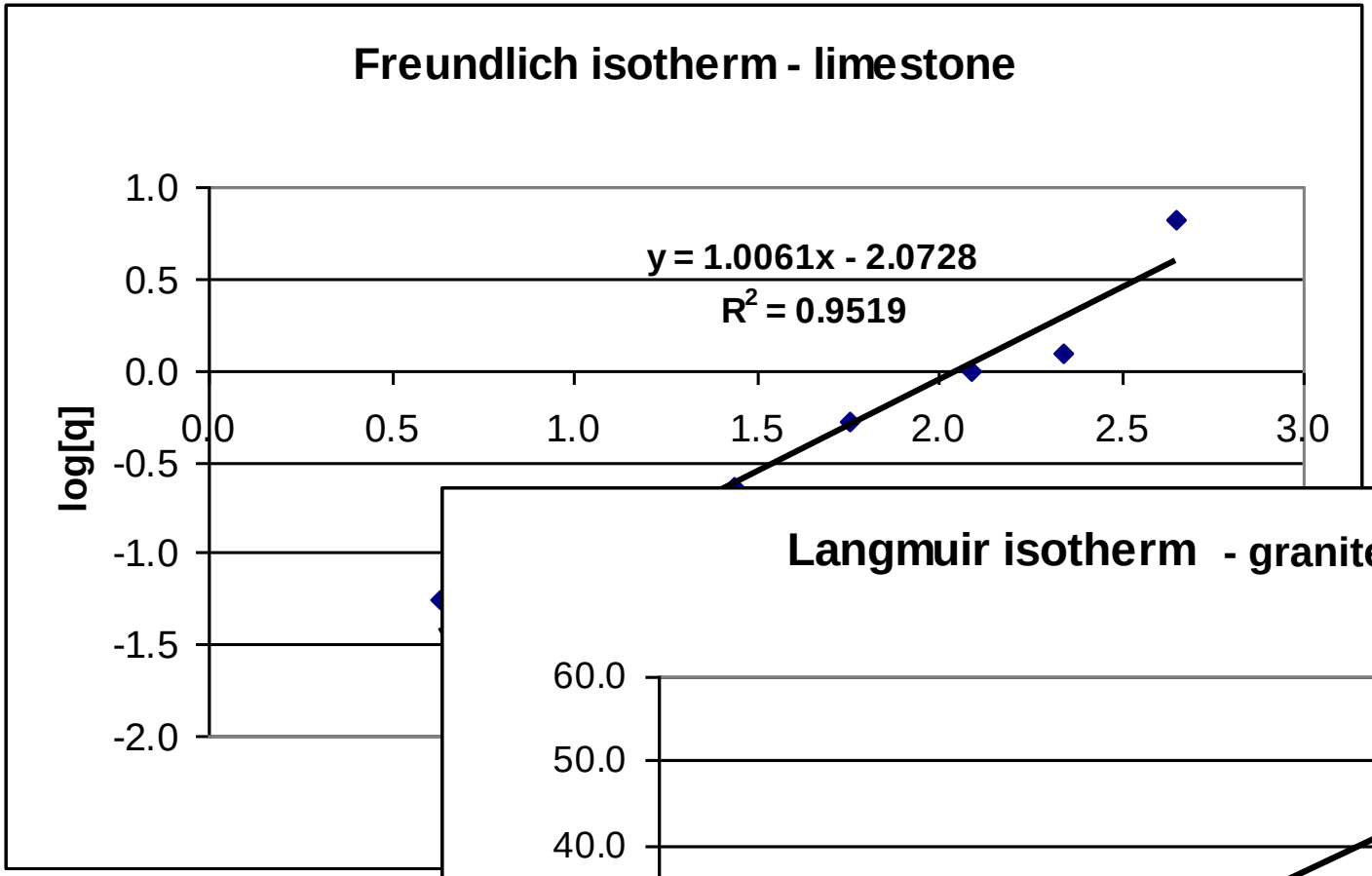
Laboratory studies

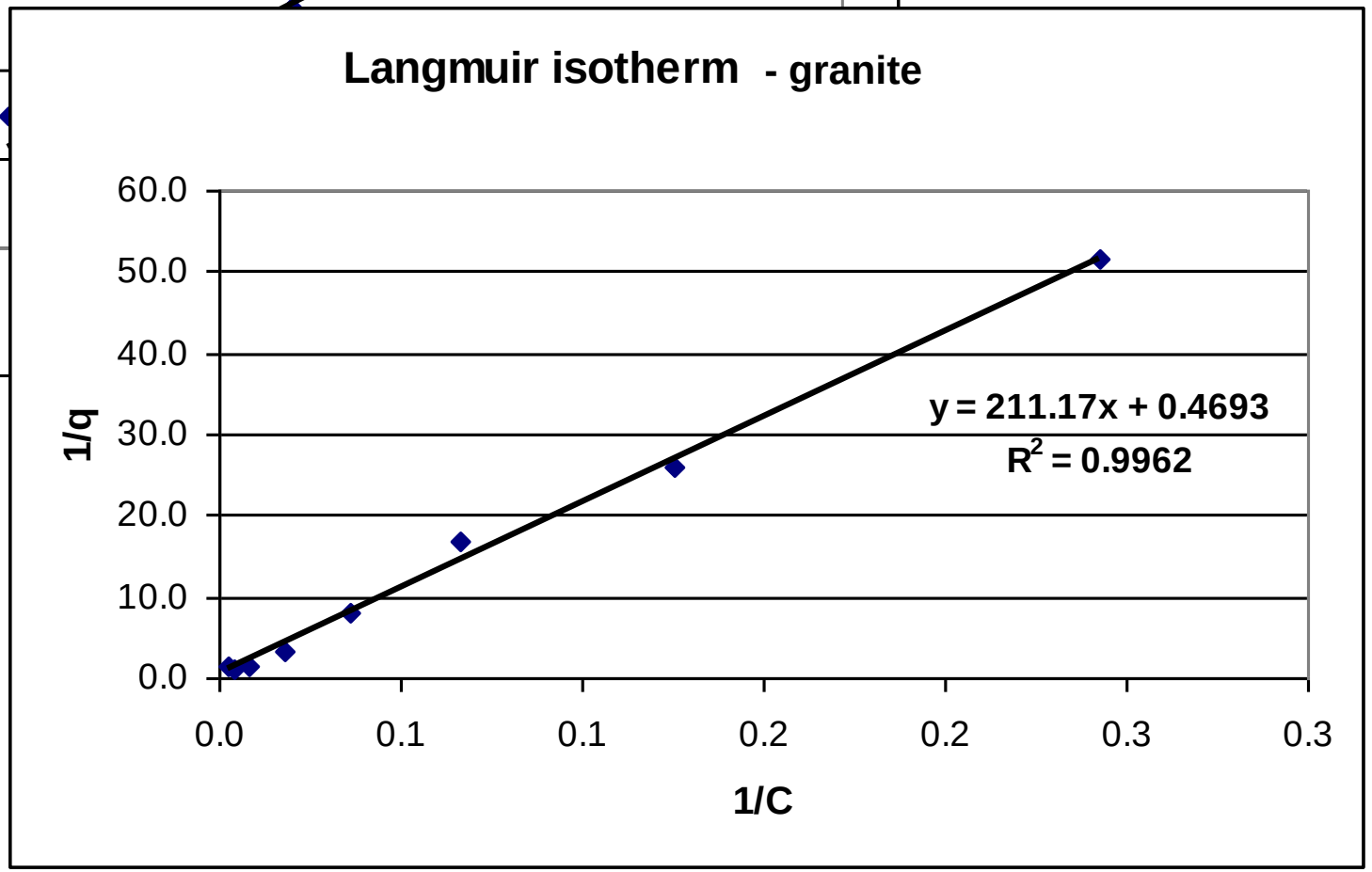
- **Phosphorous removal compared to sand**

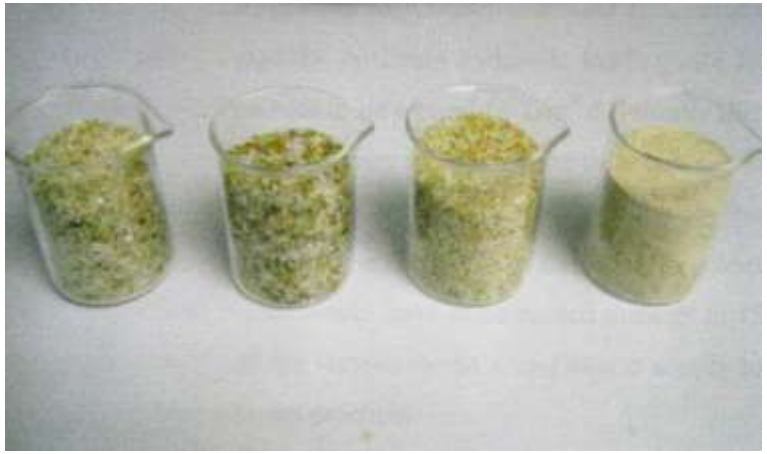
  Phosphate adsorption capacity compared by determination of Freundlich & Langmuir isotherms

- **Column tests at different loading rates**

- **Electron microscope analysis of surface of media**


Freundlich isotherm - limestone
y = 1.0061x - 2.0728
R2 = 0.9519
log[q]
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
0.0
0.5
1.0
1.5
2.0
2.5
3.0


Langmuir isotherm - granite
y = 211.17x + 0.4693
R2 = 0.9962
1/q
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0.0
0.1
0.1
0.2
0.2
0.3
0.3
1/C

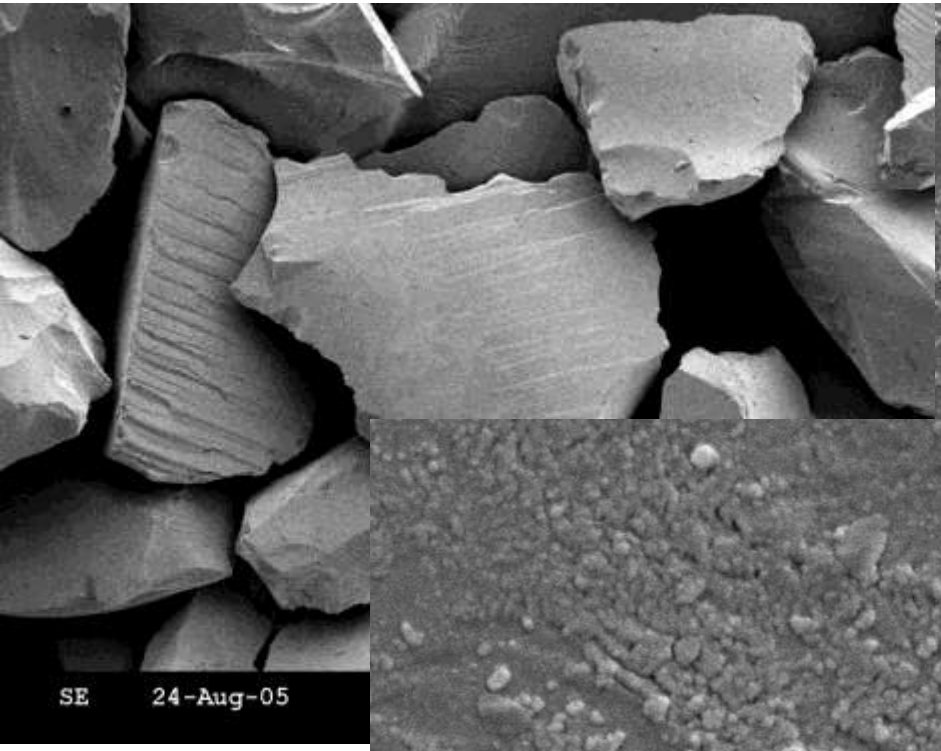


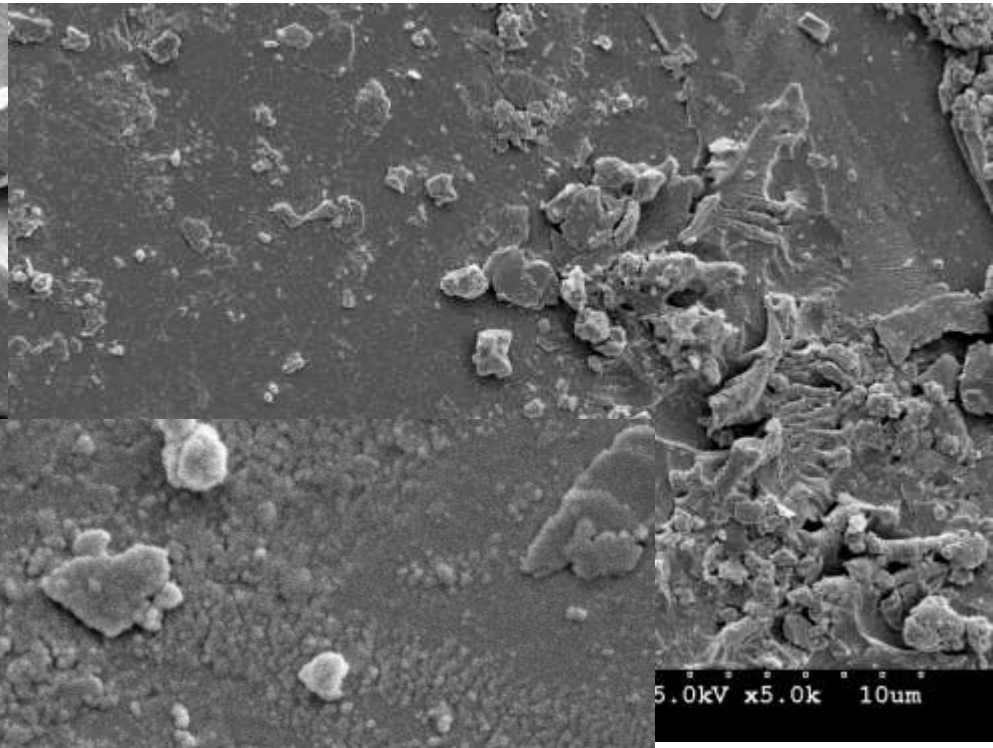
	Freundlich		*Langmuir*	
	K	**1/n**	**q_m**	**K_{ads}**
Glass (ungraded)	0.00049	1.300	0.00449	-0.0593
Glass (coarse)	0.00076	1.091	0.02837	0.0006
Glass (medium)	0.00032	1.303	-0.0324	-0.0042
Glass (fine)	0.00196	1.010	0.4040	0.0055
Silica (Drogheda)	0.00082	1.254	-0.1536	0.0328
Aughrim	0.00210	1.012	0.1221	0.0249
Chelford	0.00862	0.546	0.0762	0.1025
Granite (Carlow)	0.01271	0.510	-0.5828	-0.0103
Sligo (beach)	0.00624	0.889	2.1308	0.0022
Limestone (Larne)	0.00846	1.006	0.6761	0.0195

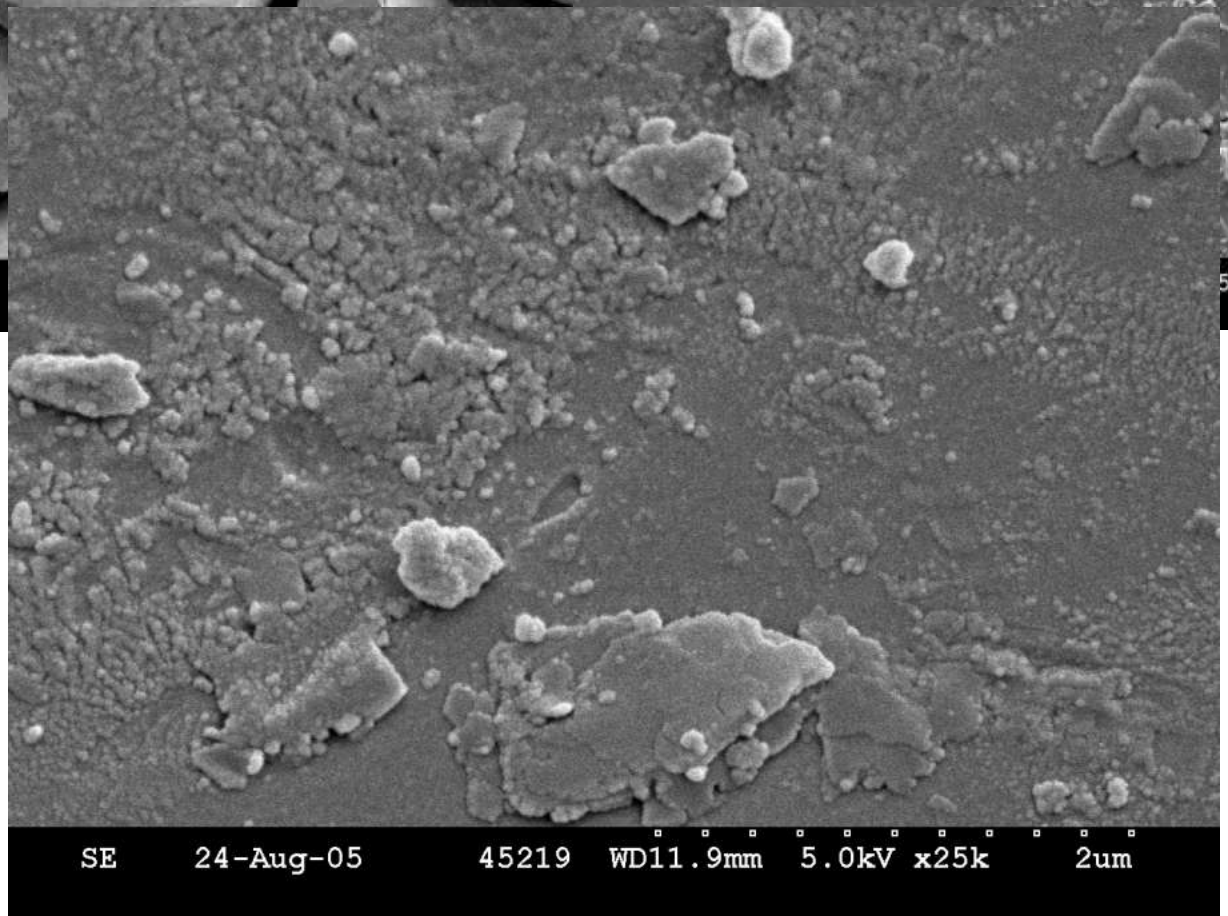
Desirable to have 1/n value slightly less than 1 and K values as high as possible

Desirable to have both high K_{ads} and high q_m for adsorption

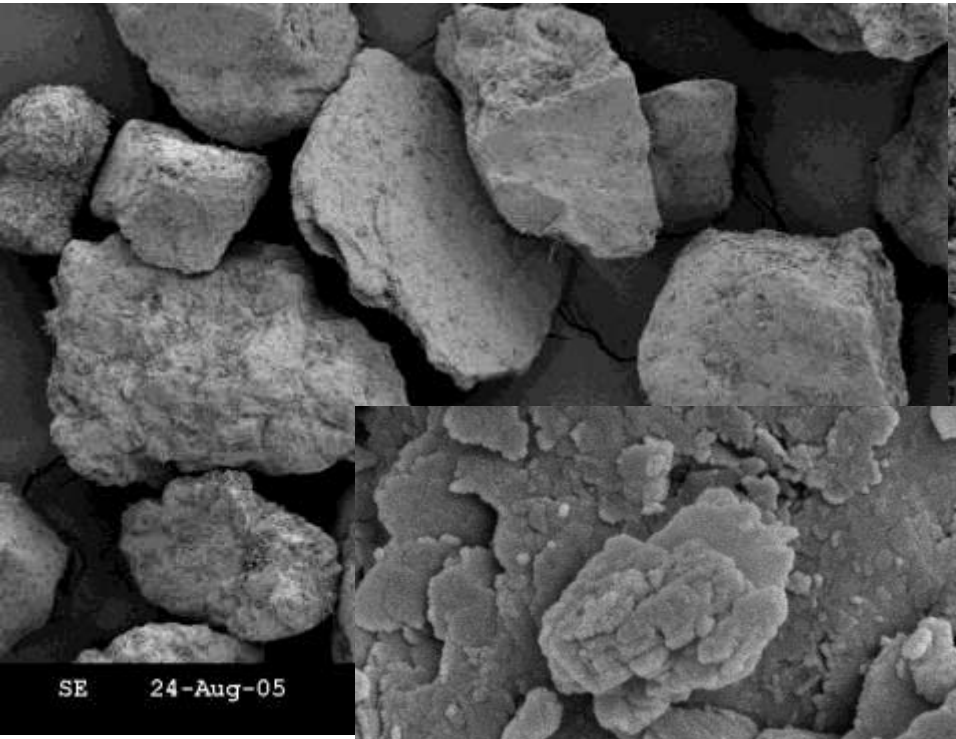
Microscopic images – glass

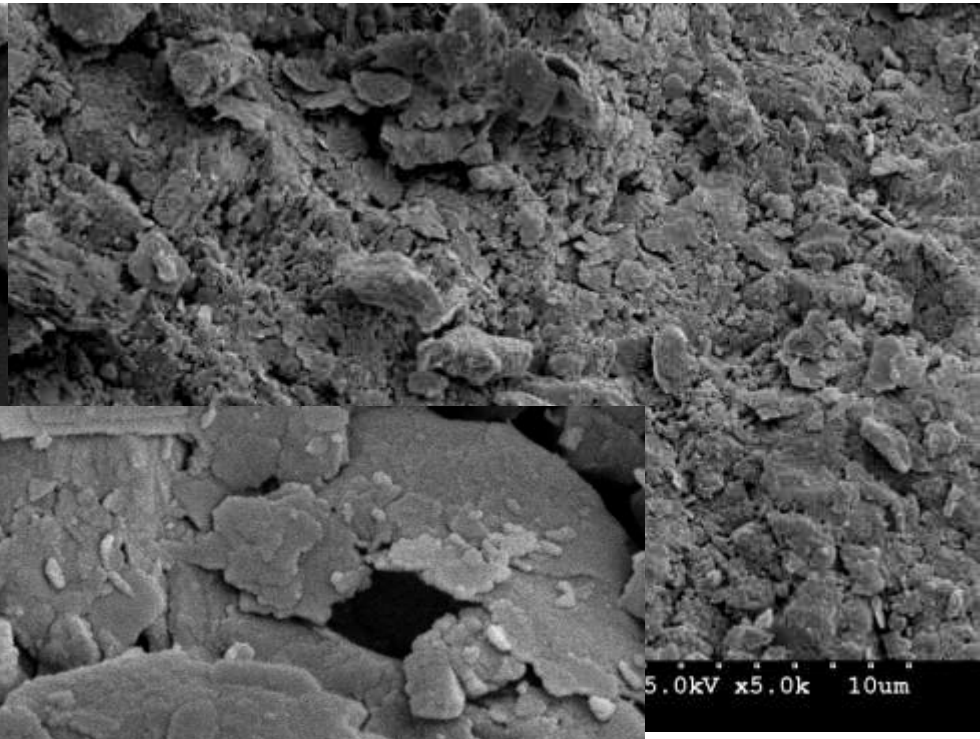


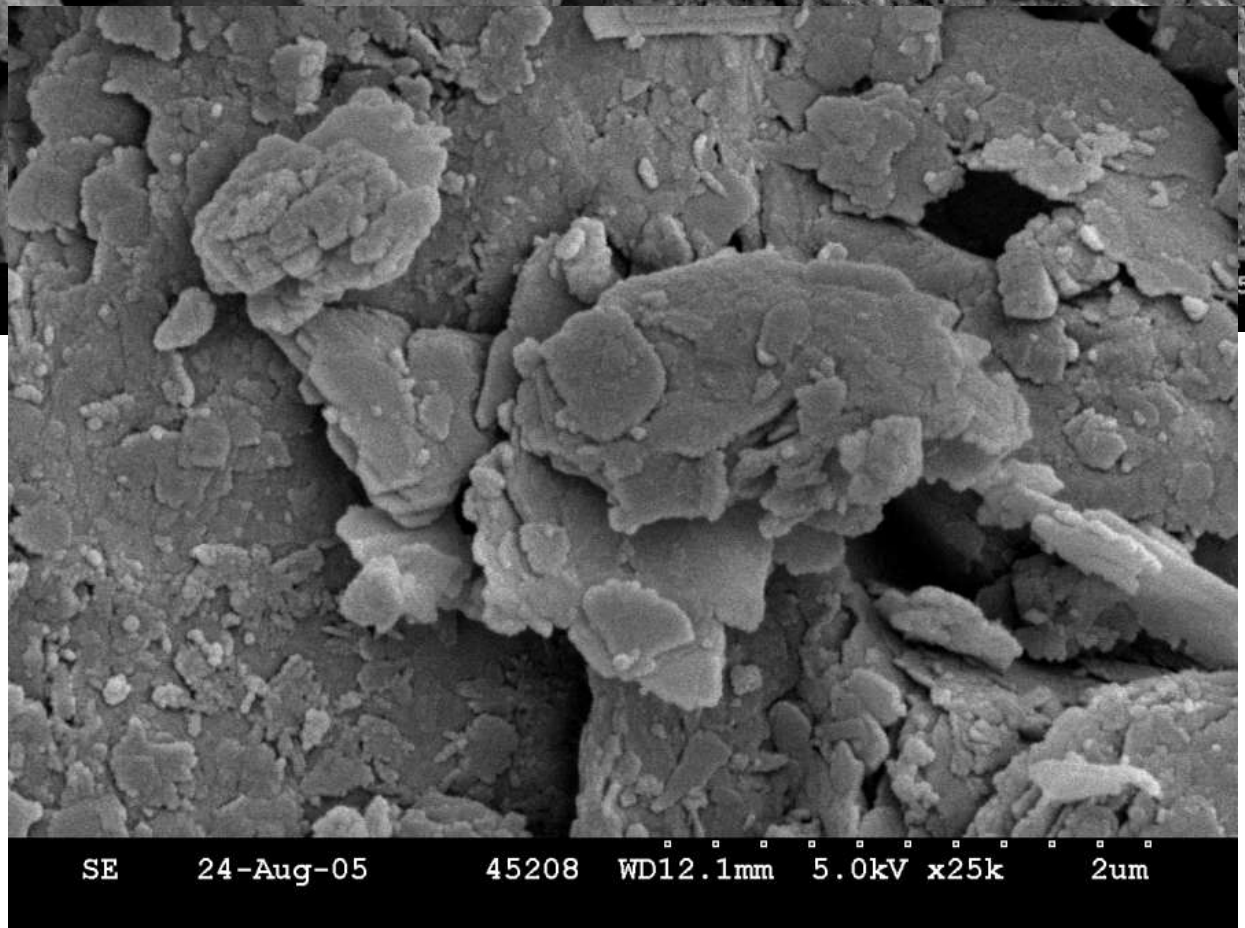




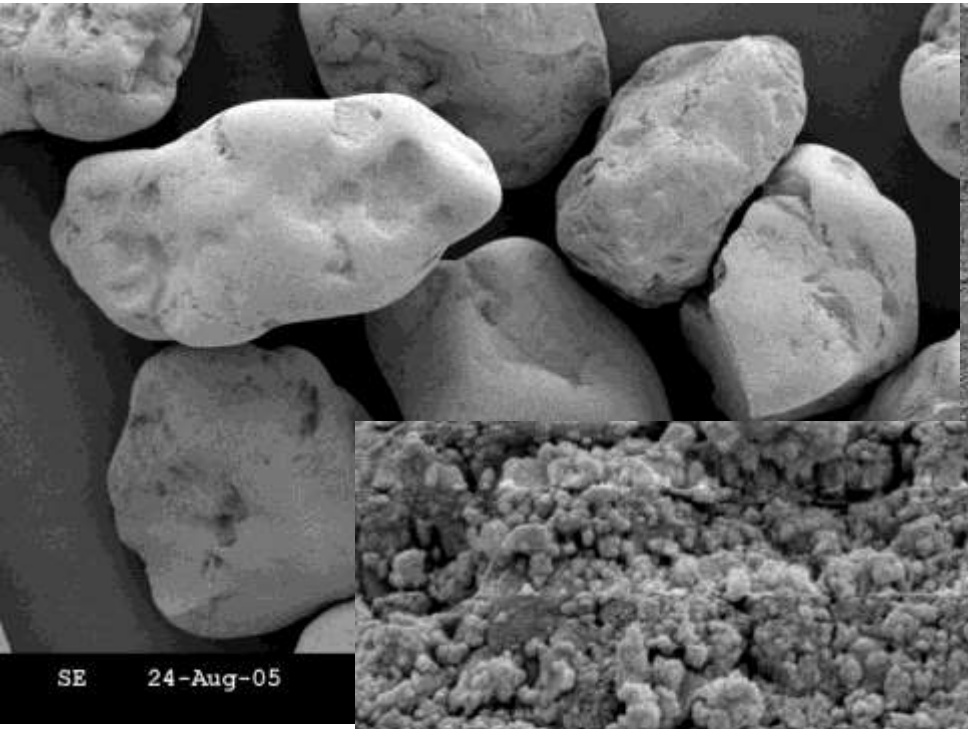
Microscopic images – granite sand

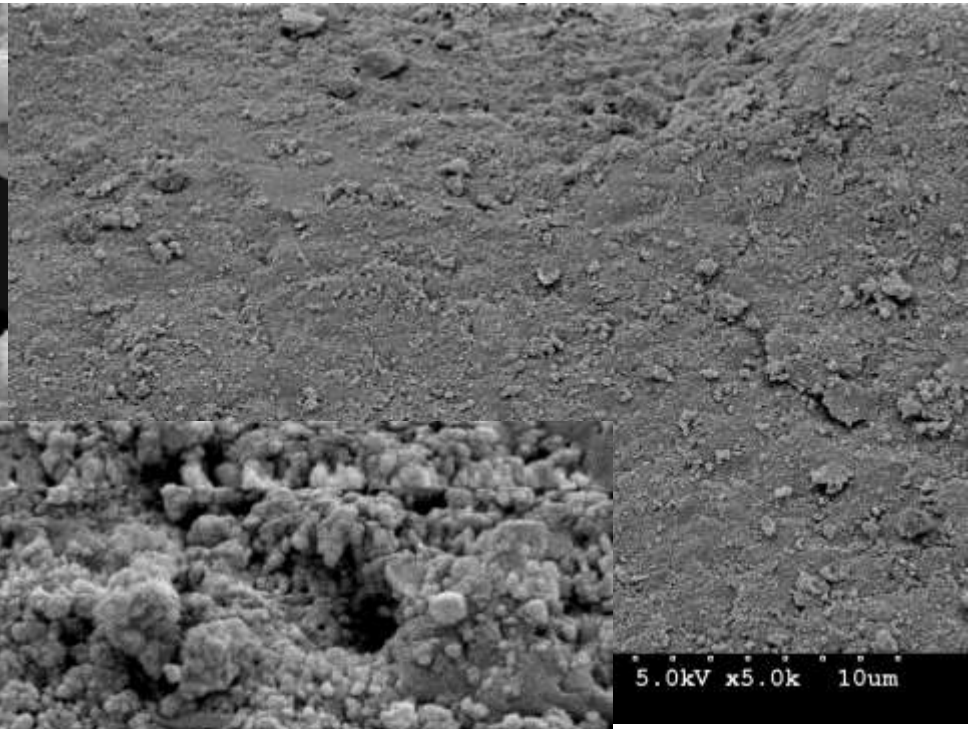


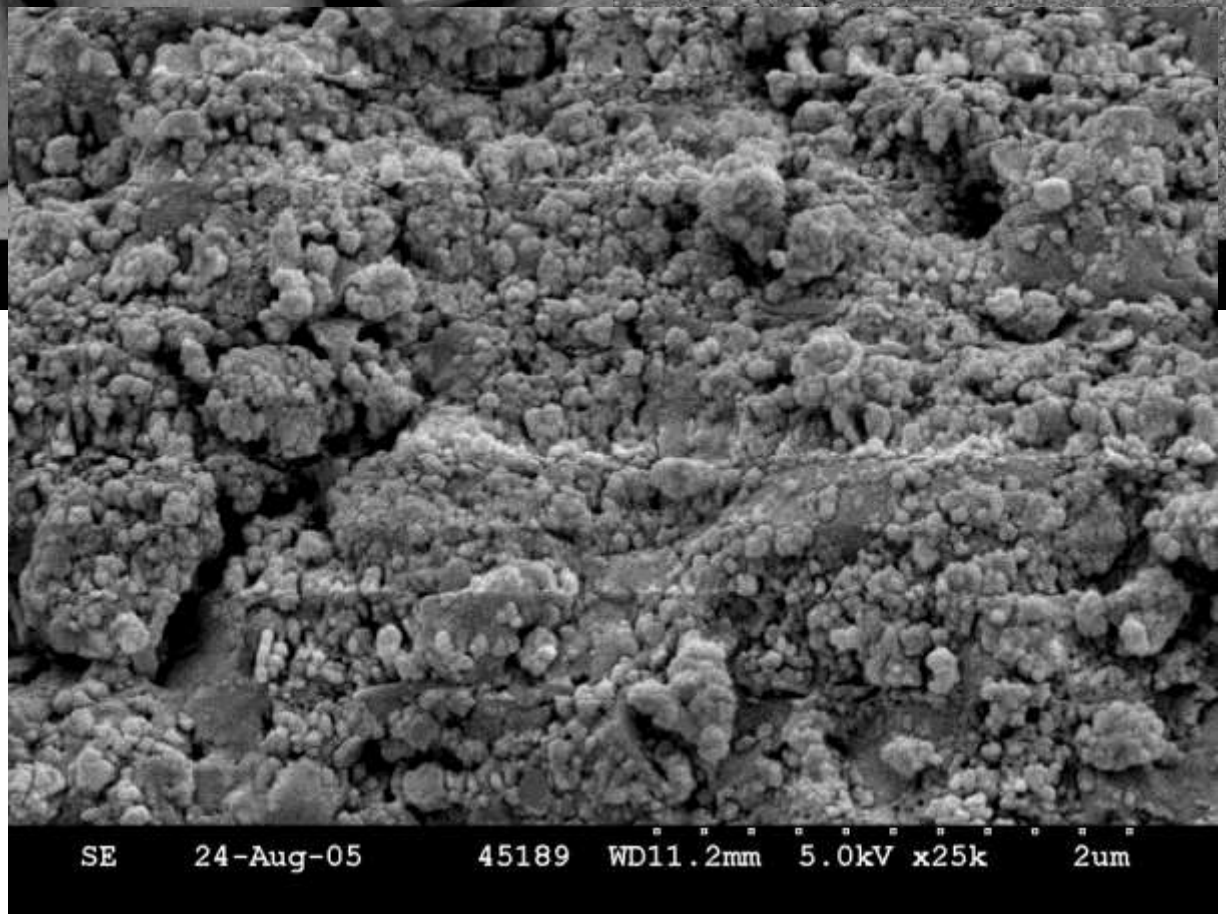


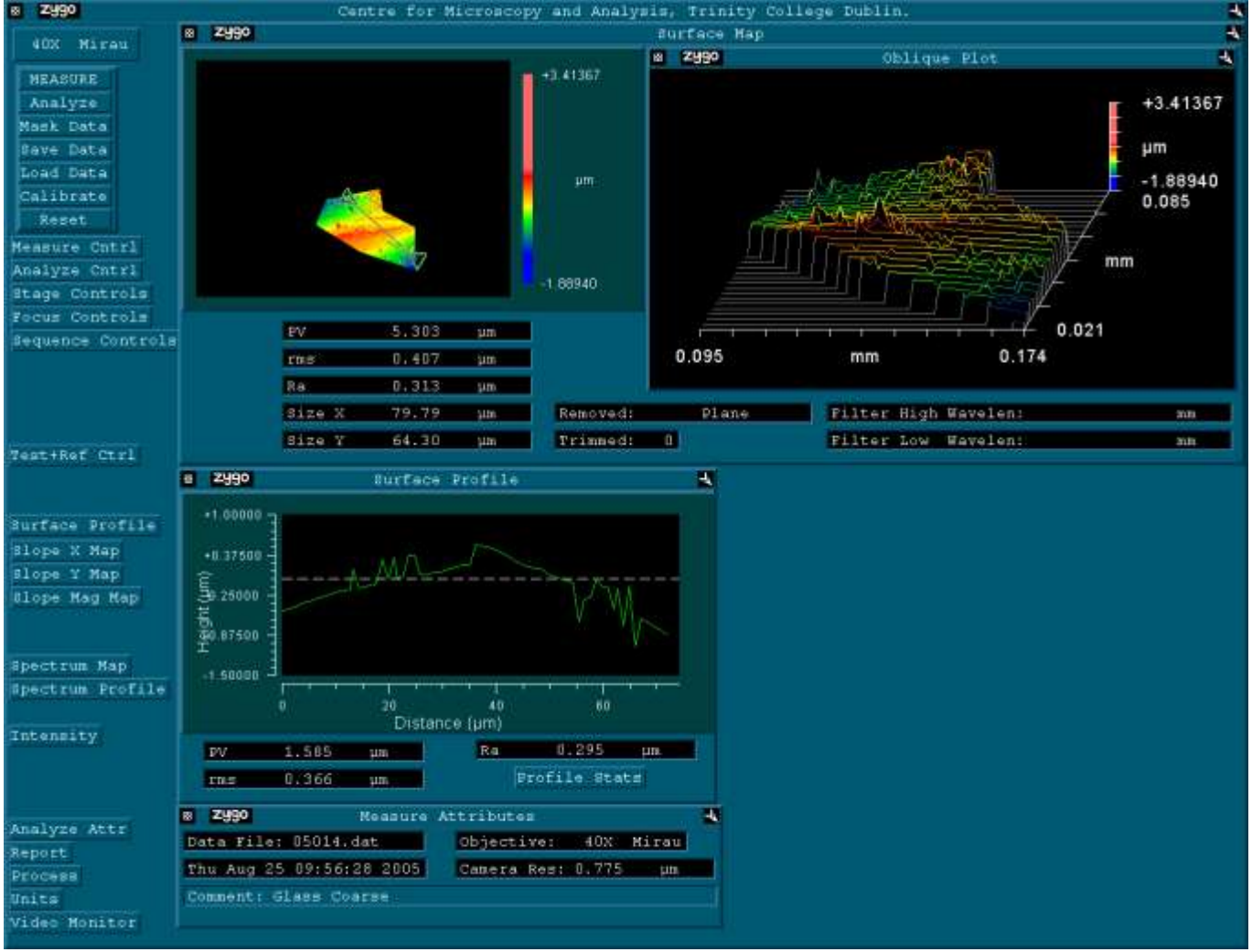


Microscopic images – limestone sand



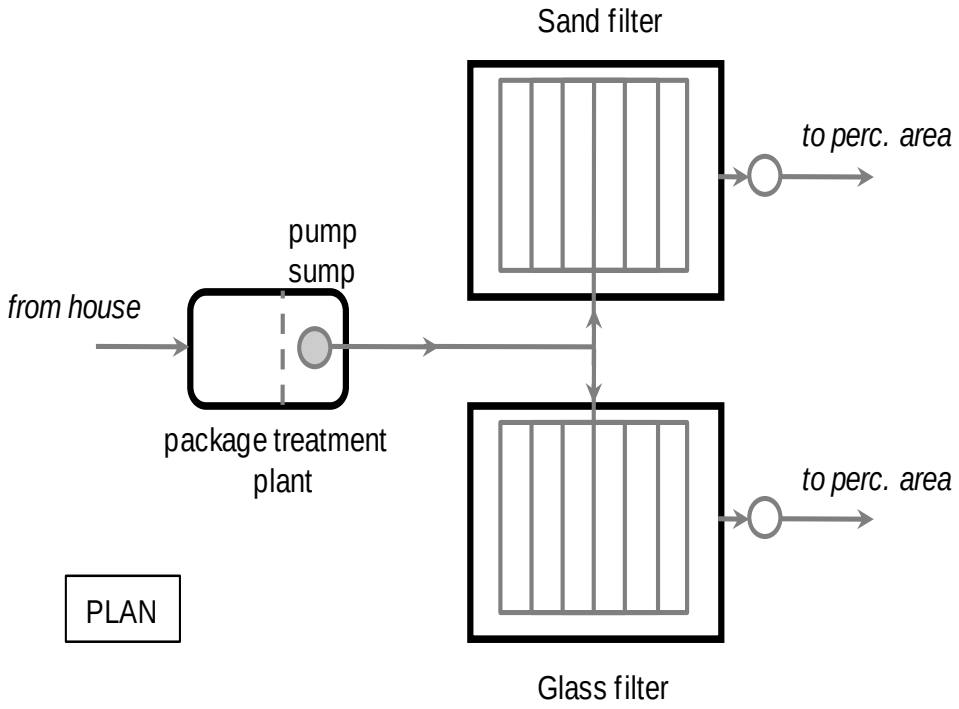


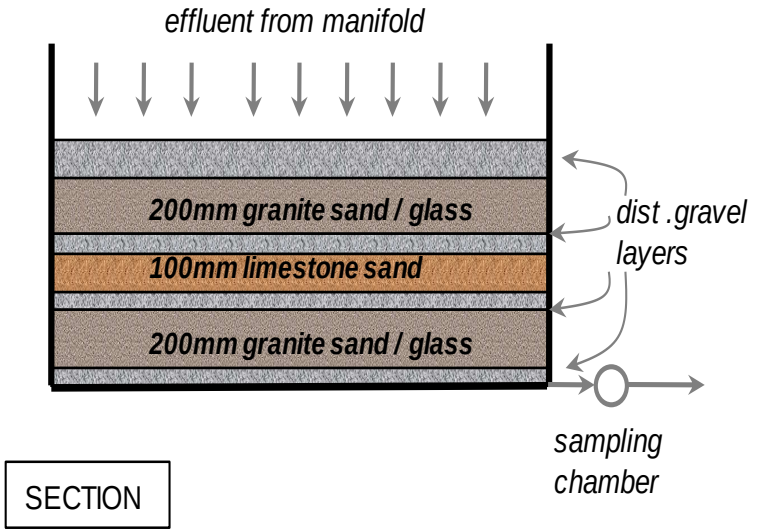




	glass	granite
Surface roughness (µm)	0.33	3.03
Surface area (m^2/g)	0.51	2.05

Site and filter construction

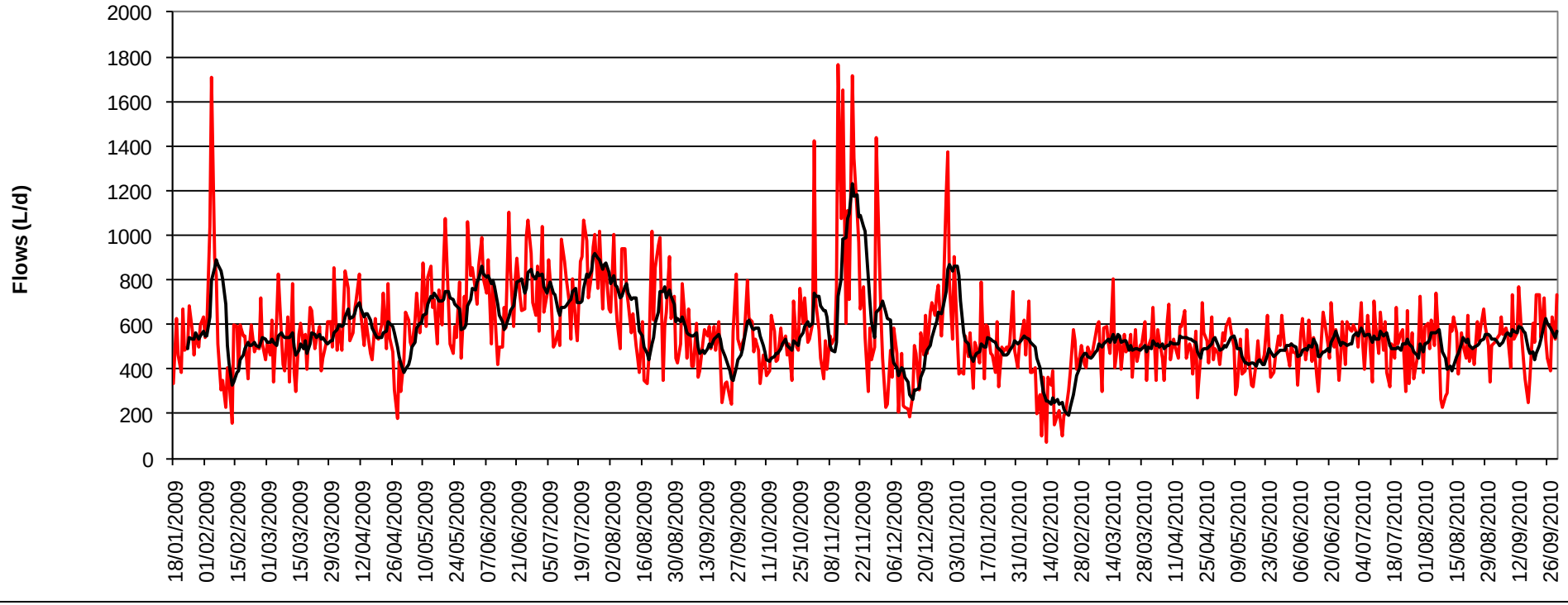




Results

Ave hyd. Loading rate = 567 L/d (38 L/m^2.d)

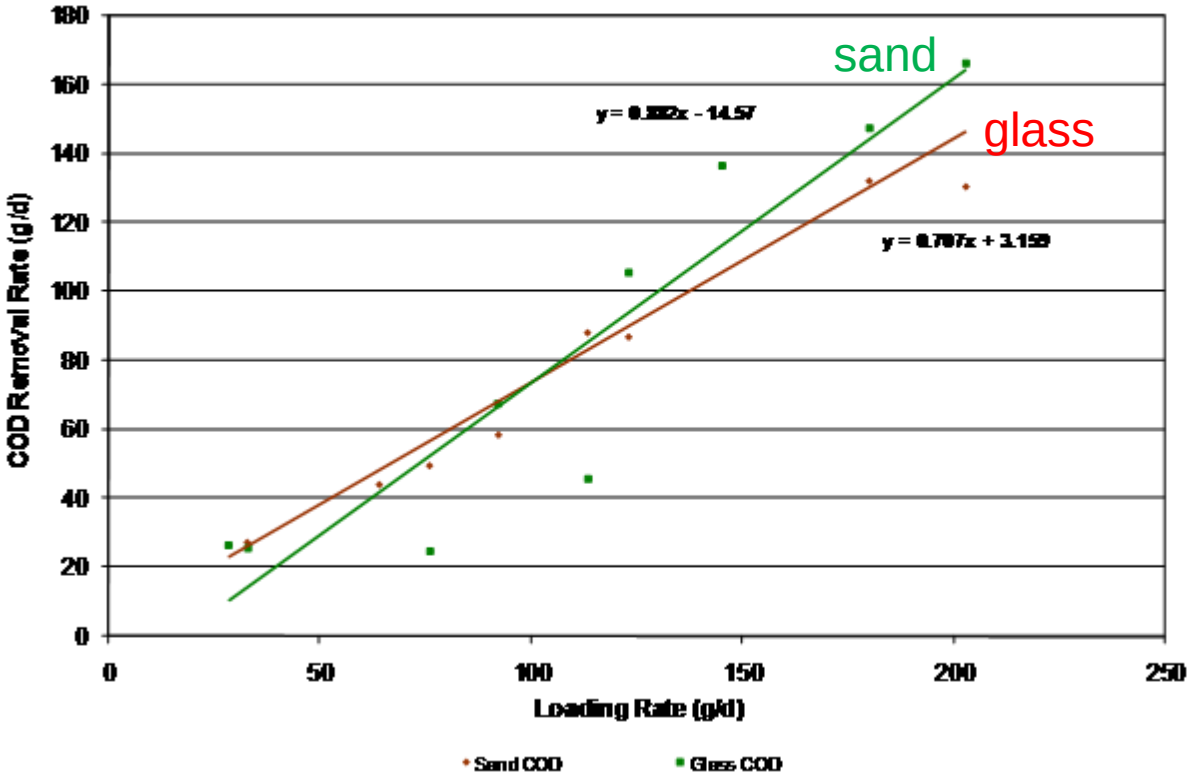
Filters dosed ave 8.9 times per day
(mean rest period between pumping cycles of 2 hours 40 mins)



Organic loads

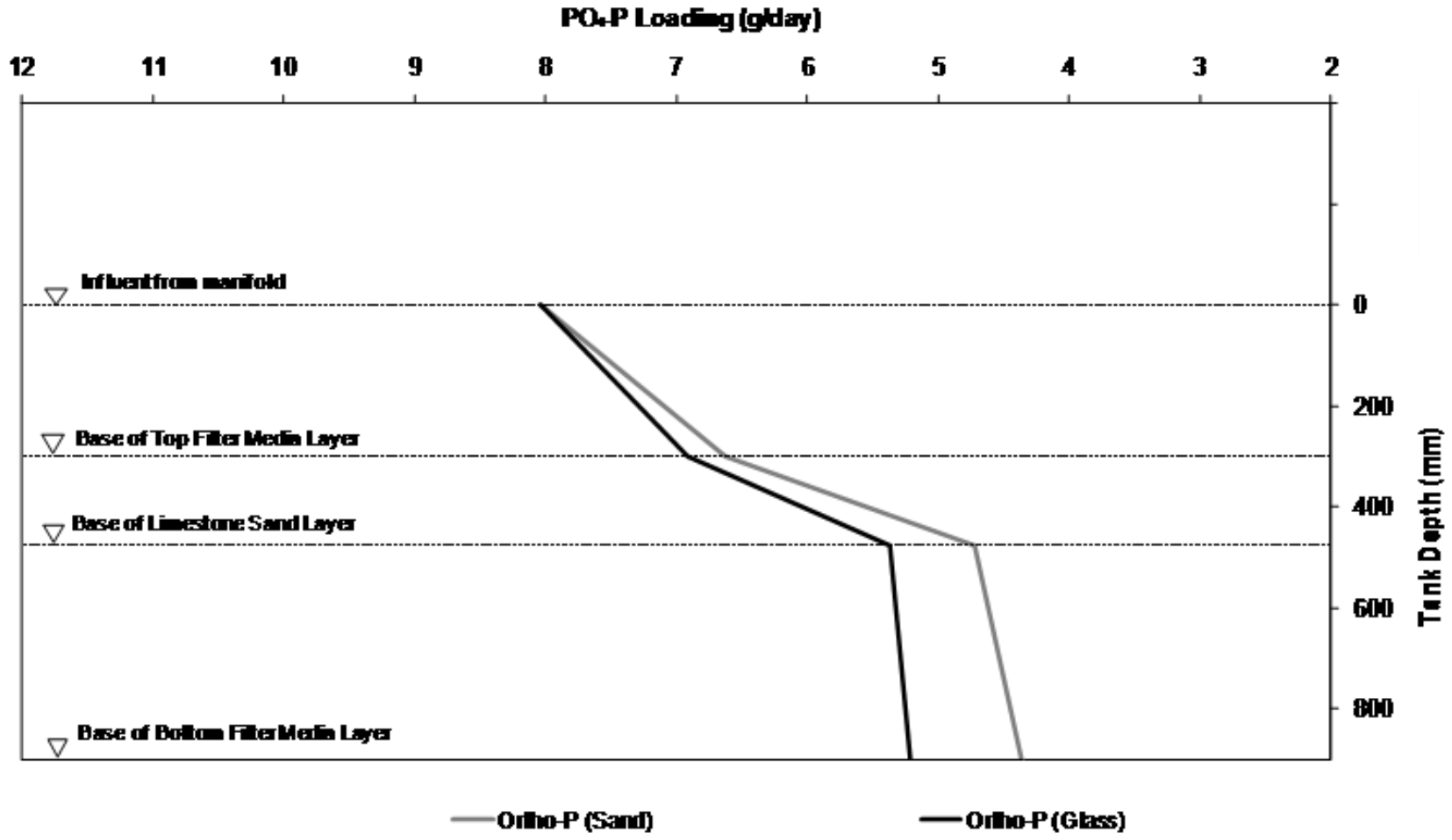
	Influent (mg/l)			Effluent –sand (mg/l)			Effluent –glass (mg/l)		
	COD	Total N	PO_4-P	COD	Total N	PO_4-P	COD	Total N	PO_4-P
Average	144	54.6	9.9	34	49.3	5.5	36	43.0	6.4
Std. dev.	58	18.3	3.4	24	21.8	5.8	30	16.7	5.3
Max	260	98.2	10.7	77	99.1	13.1	91	84.8	8.1
Min	67	28.6	5.9	9	21.7	1.2	10	16.3	1.7

COD process performance



Phosphorus removal

Ave P loading = 8.9 g/d (9.9 mg/L)



SAND

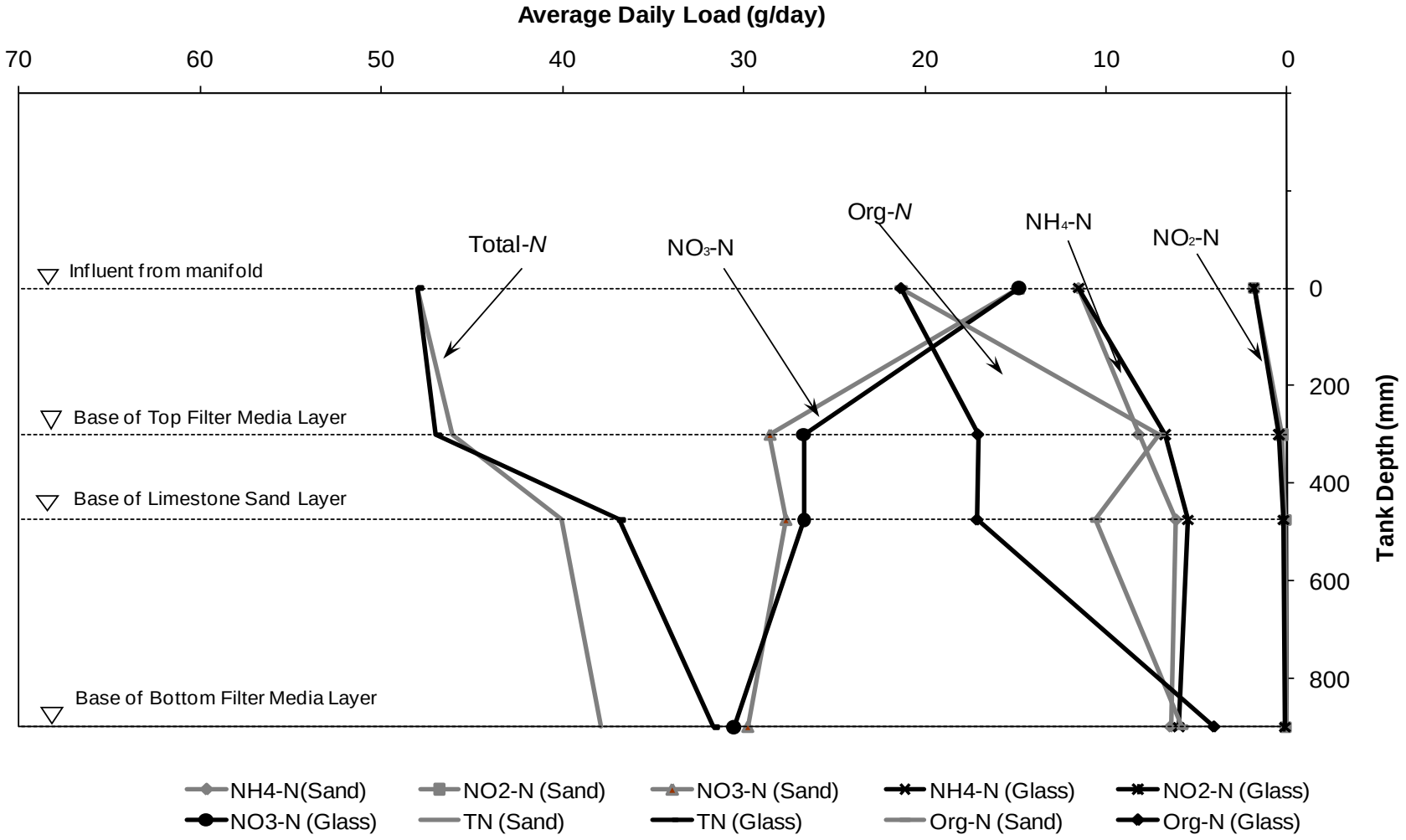
Ave P effluent load = 4.4 g/d (5.5 mg/L)

GLASS

Ave P effluent load = 5.3 g/d (6.4 mg/L)

Nitrogen removal

Ave Total-N loading =48.1 g/d (54.6 mg/L)



SAND

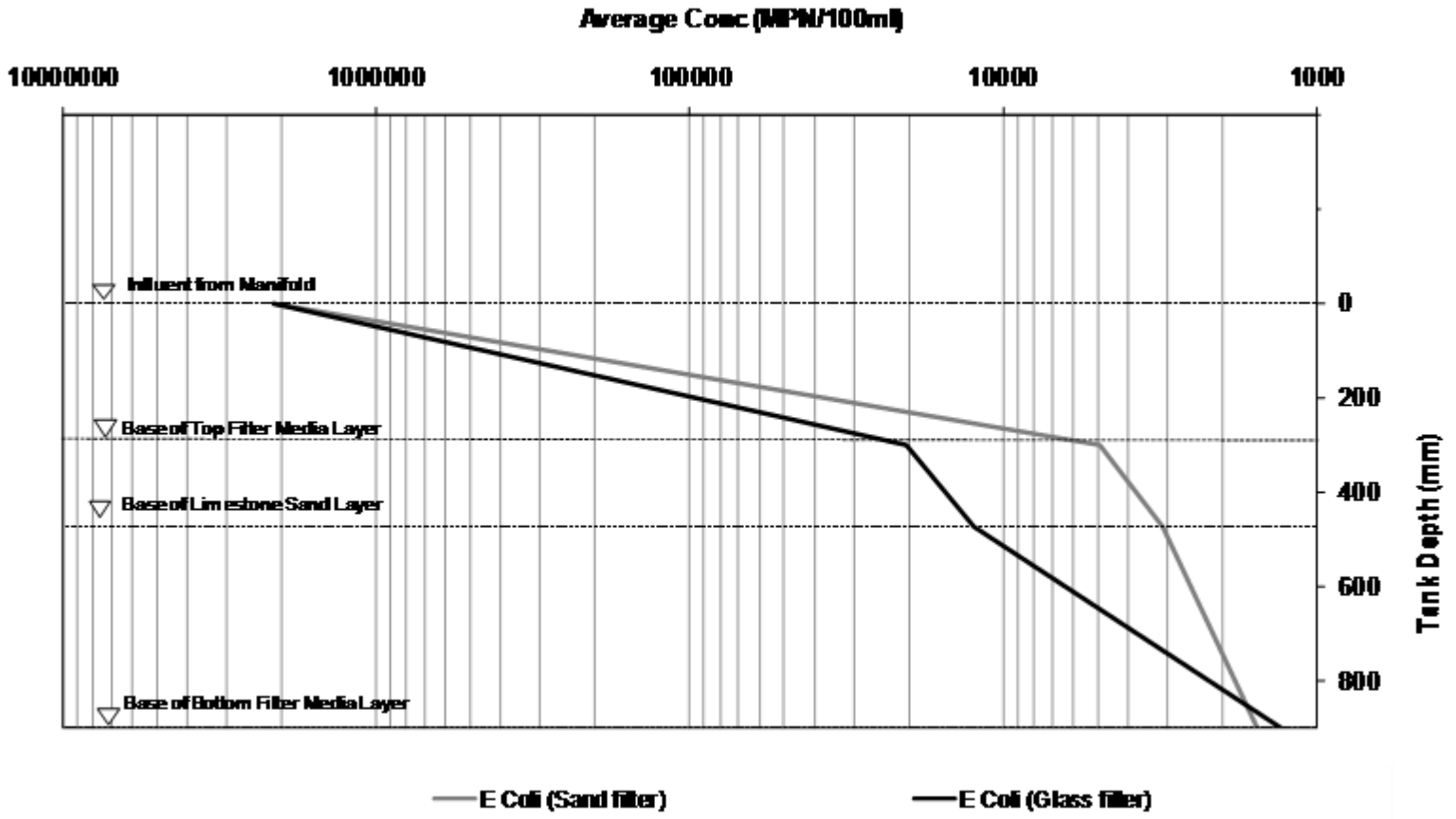
Ave N effluent load = 35.1 g/d (49.3 mg/L)

GLASS

Ave N effluent load = 29.5 g/d (43.0 mg/L)

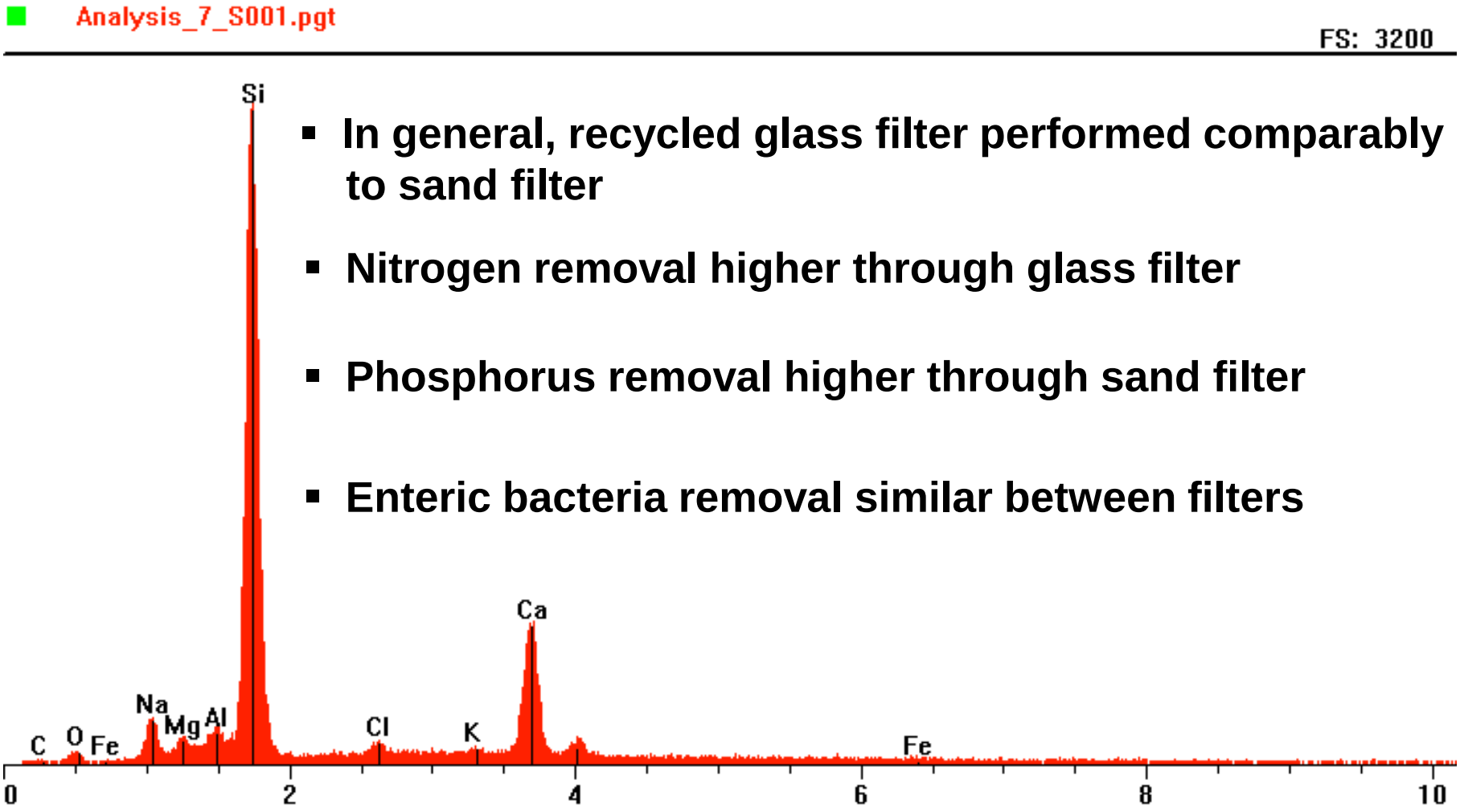
E. coli removal

Ave conc.influent = 2 x 10^6 MPN/100ml



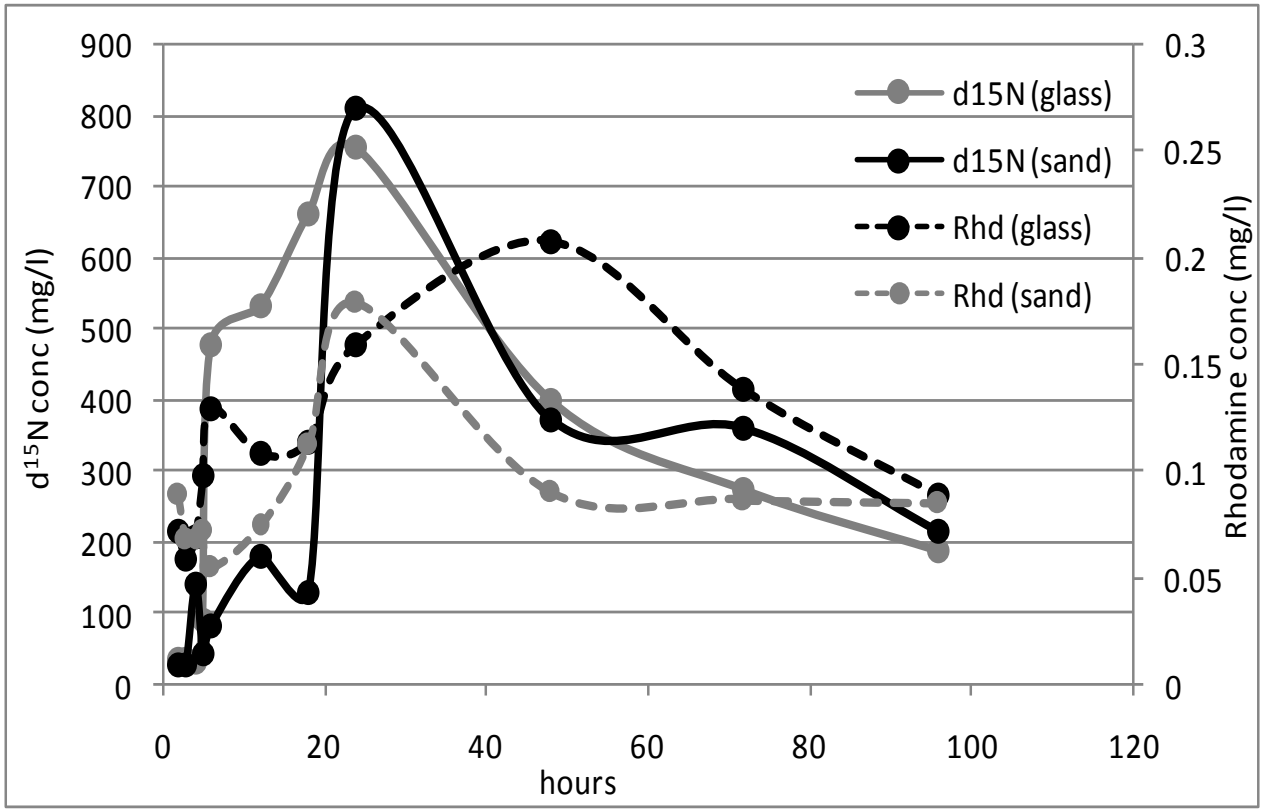
Ave conc.in effluents ~ 10^3 MPN/100ml

Conclusions



- In general, recycled glass filter performed comparably to sand filter
- Nitrogen removal higher through glass filter
- Phosphorus removal higher through sand filter
- Enteric bacteria removal similar between filters

Results from $\delta^{15}N$ and Rhodamine tracer trial (single pass filter operation)



Freundlich isotherm

$$q = KC^{1/n} \qquad \log q = \log K + \frac{1}{n}\log C$$

q = sorbed conc (mass adsorbate / mass adsorbent)
C = aqueous conc of adsorbate
K = measure of capacity of adsorbent
n = measure of how affinity for adsorbate chnages with asdoprtion density

$$slope = \frac{1}{n} \qquad y\text{-}intersect = \log K$$

Values of n>1 indicates that as adsorption density increases, affinity decreases
For n = 1, affinity for adsorbate is uniform everywhere on adsorbent

Desirable to have 1/n value slightly less than 1

and K values as high as possible

Langmuir isotherm

$$q = \frac{q_m K_{ads} C}{1 + K_{ads} C} \qquad \frac{1}{q} = \frac{1}{q_m K_{ads}}\left(\frac{1}{C}\right) + \frac{1}{q_m}$$

q = sorbed conc (mass adsorbate / mass adsorbent)
q_m = max capacity of adsorbent for adsorbate
C = conc of adsorbate in soln
K_{ads} = measure of affinity of adsorbate for adsorbent

$$slope = \frac{1}{q_m K_{ads}} \qquad y - \text{intersect} = \frac{1}{q_m}$$

Desirable to have both high K_{ads} and high q_m for adsorption