"Utilization of ashes in landfill construction"
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Air permeability, diffusion coefficient, and tortuosity of incineration ash

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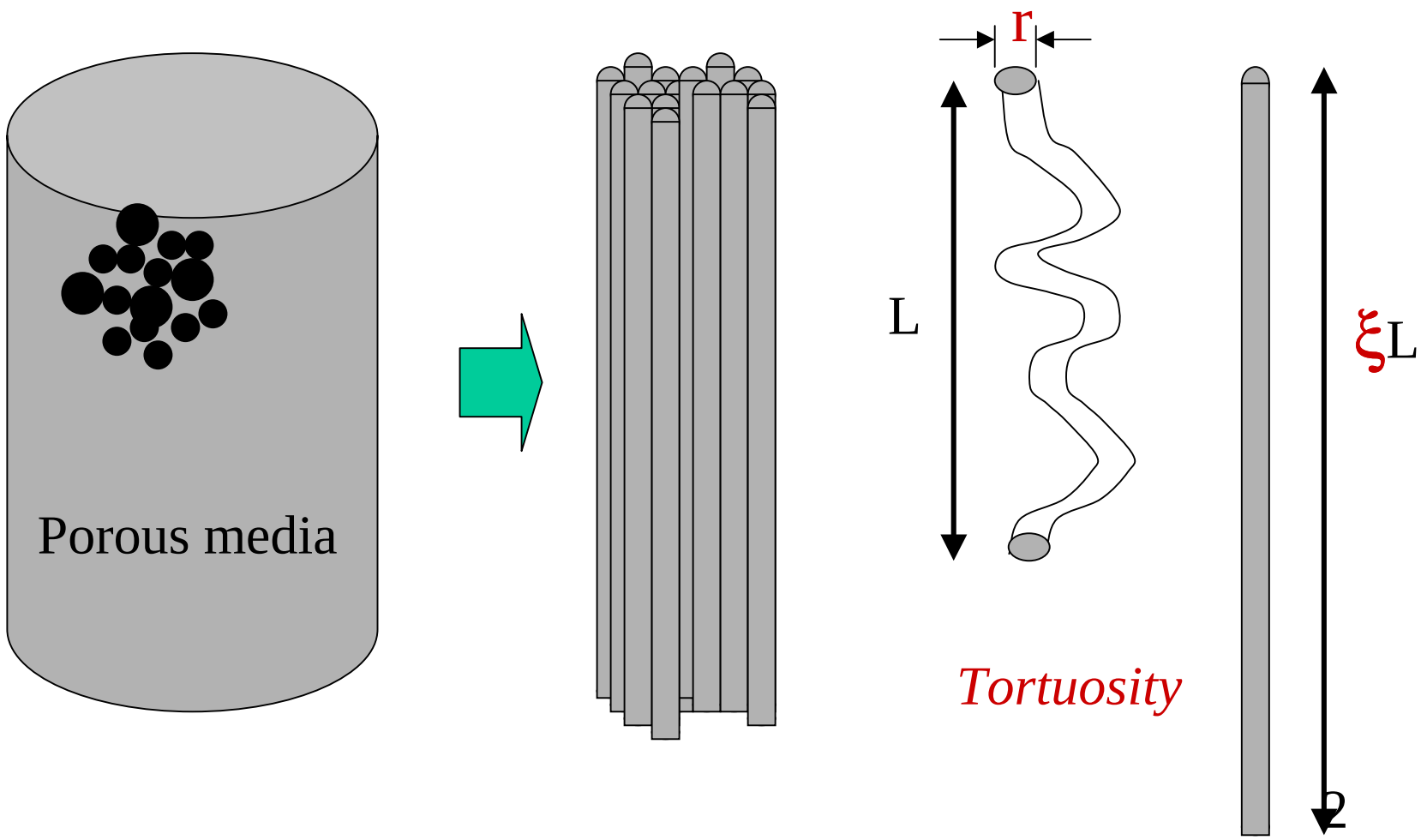
Capillary tube model



Permeability

$$v = \left(\frac{r^2}{8\mu_g} \frac{\varepsilon}{\xi} \right) \frac{P_0 - P_L}{L} = K_g \frac{P_0 - P_L}{L}$$

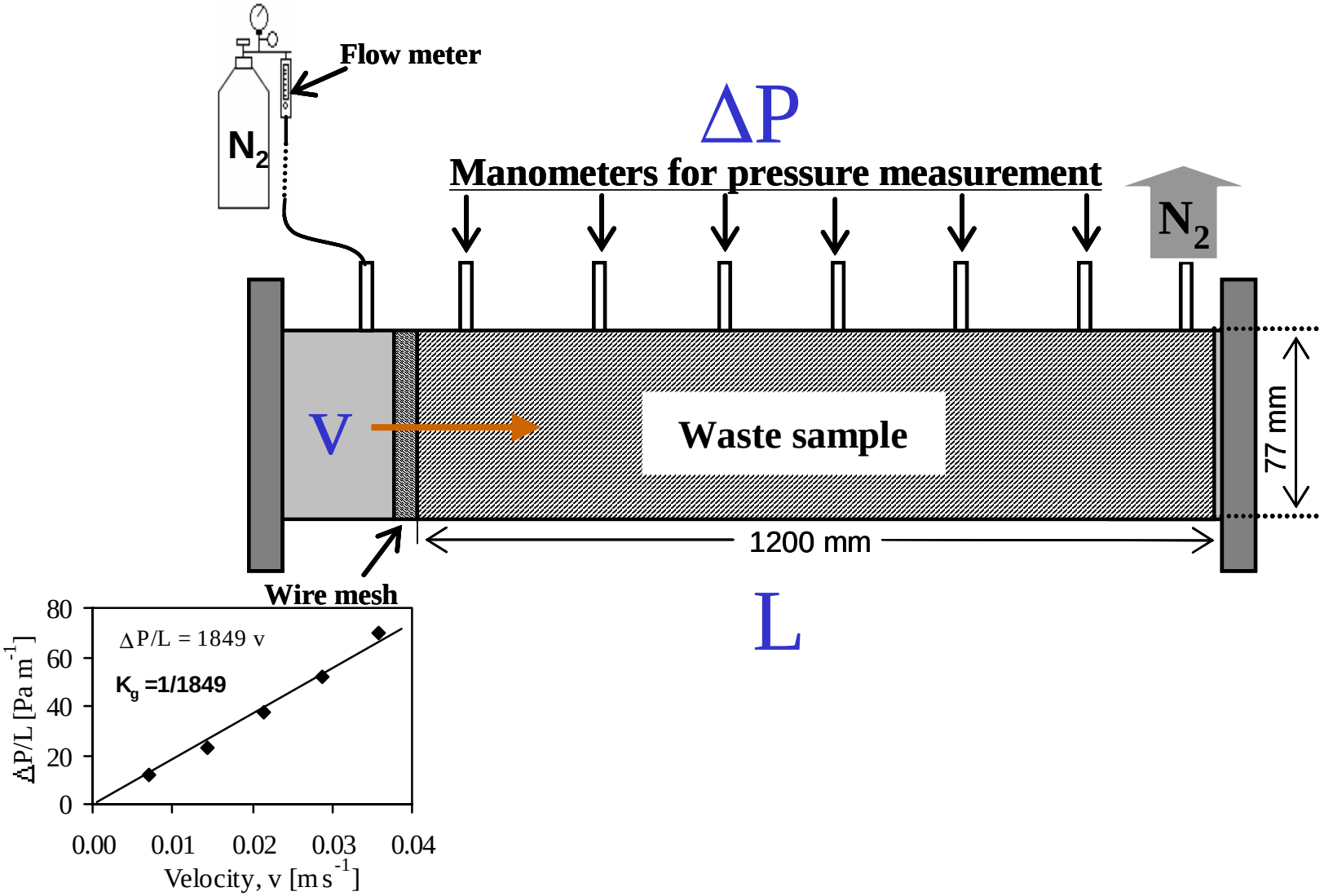
v: Darcy's velocity of the gas [m s^{-1}]

ε: gas porosity [-]

K_g: Gas permeability [$m^2 Pa^{-1} s^{-1}$]

The relation between r and ξ is obtained once Kg is determined.

Permeability measurement (Kg)



Binary gas diffusion

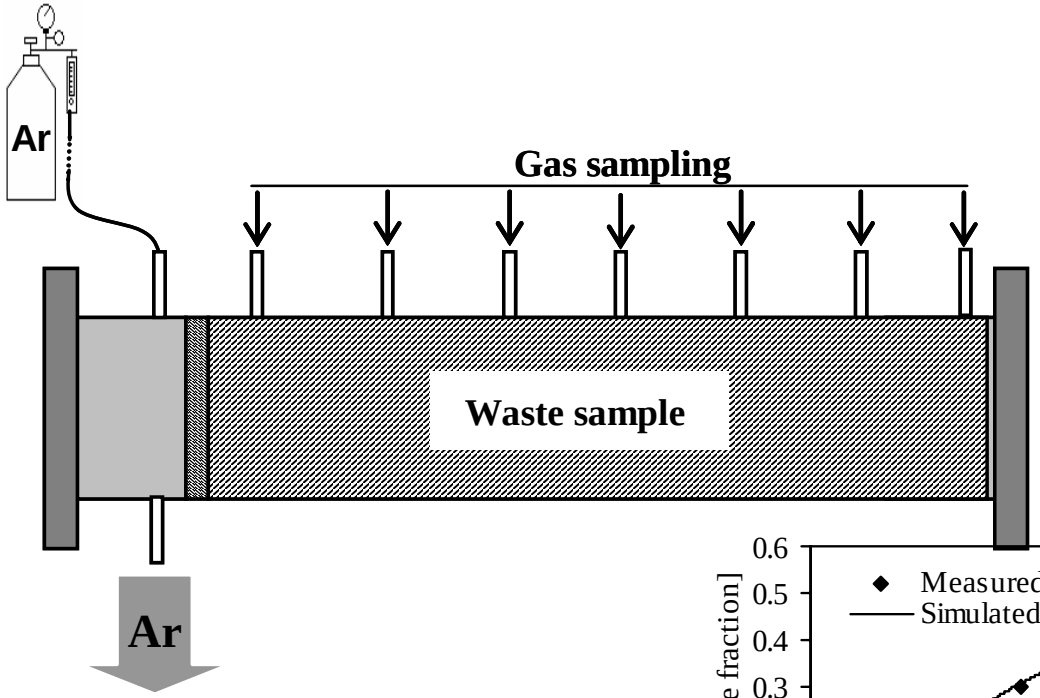
$$-\frac{P}{RT}\frac{\partial x_1}{\partial z}=\left(\frac{N_1^D x_2 - N_2^D x_1}{D_{12}^0}\right)\frac{\xi}{\varepsilon}$$

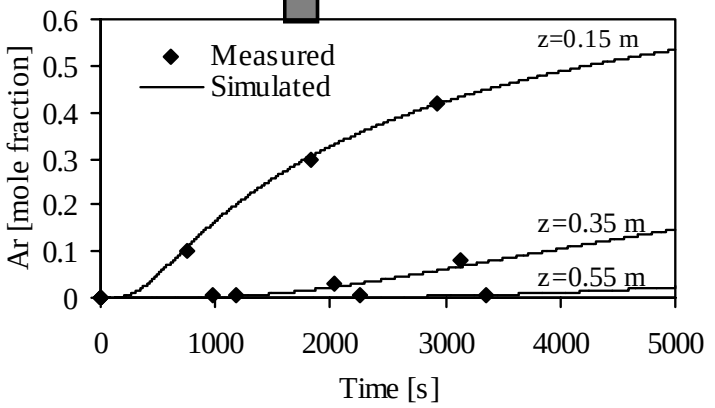
x_i: mole fraction of gas component "i"
D_0: diffusion coefficient between two gas

Based on mass balance

$$\frac{\partial x_1}{\partial t}=\frac{D_{12}^0}{\xi}\frac{\partial^2 x_1}{\partial z^2}=D_e\frac{\partial^2 x_1}{\partial z^2}$$

Diffusion test to determine ξ





$$K_g = \frac{r^2}{8\mu_g}\frac{\varepsilon}{\xi}$$

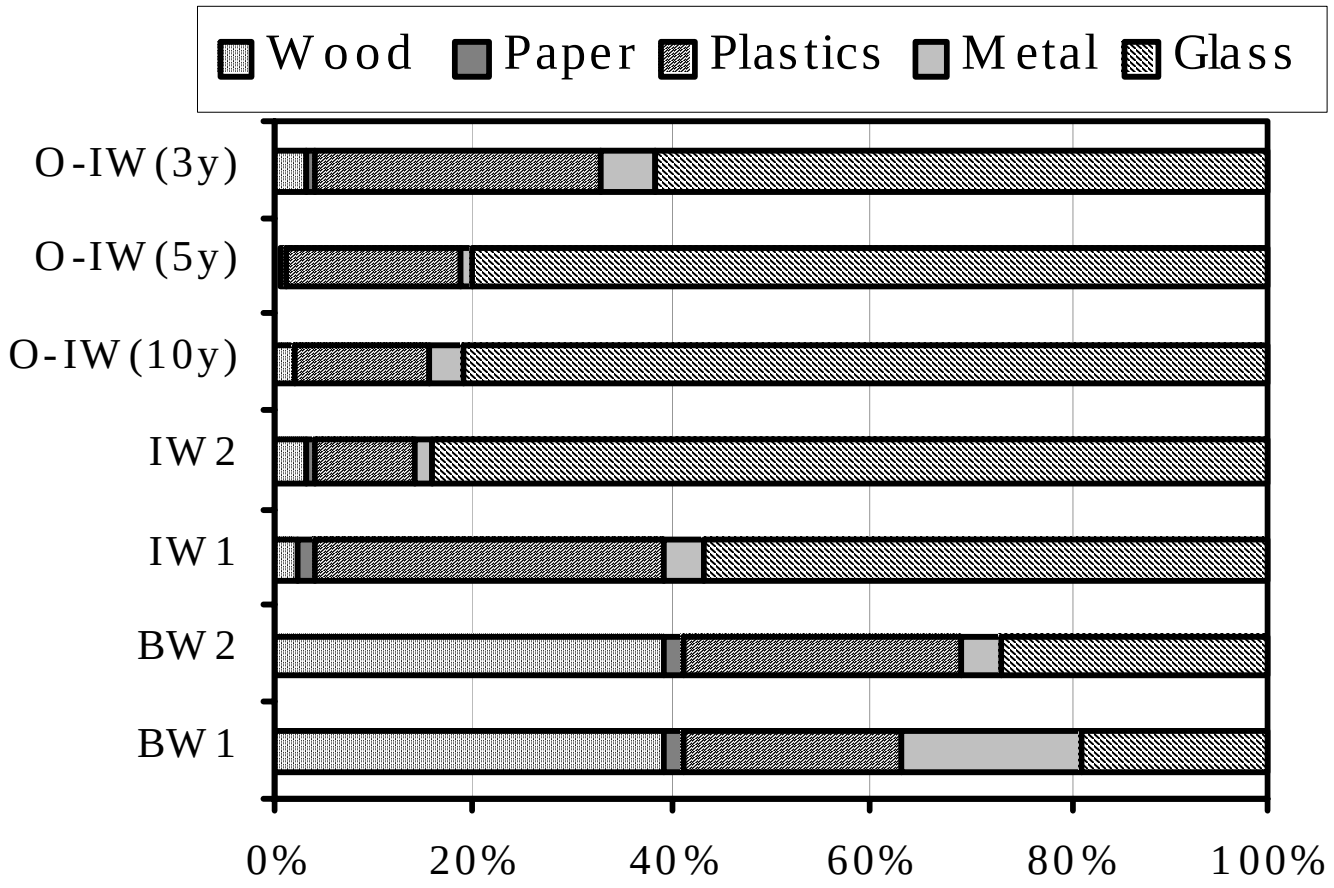
then

ξ is obtained by curve-fit

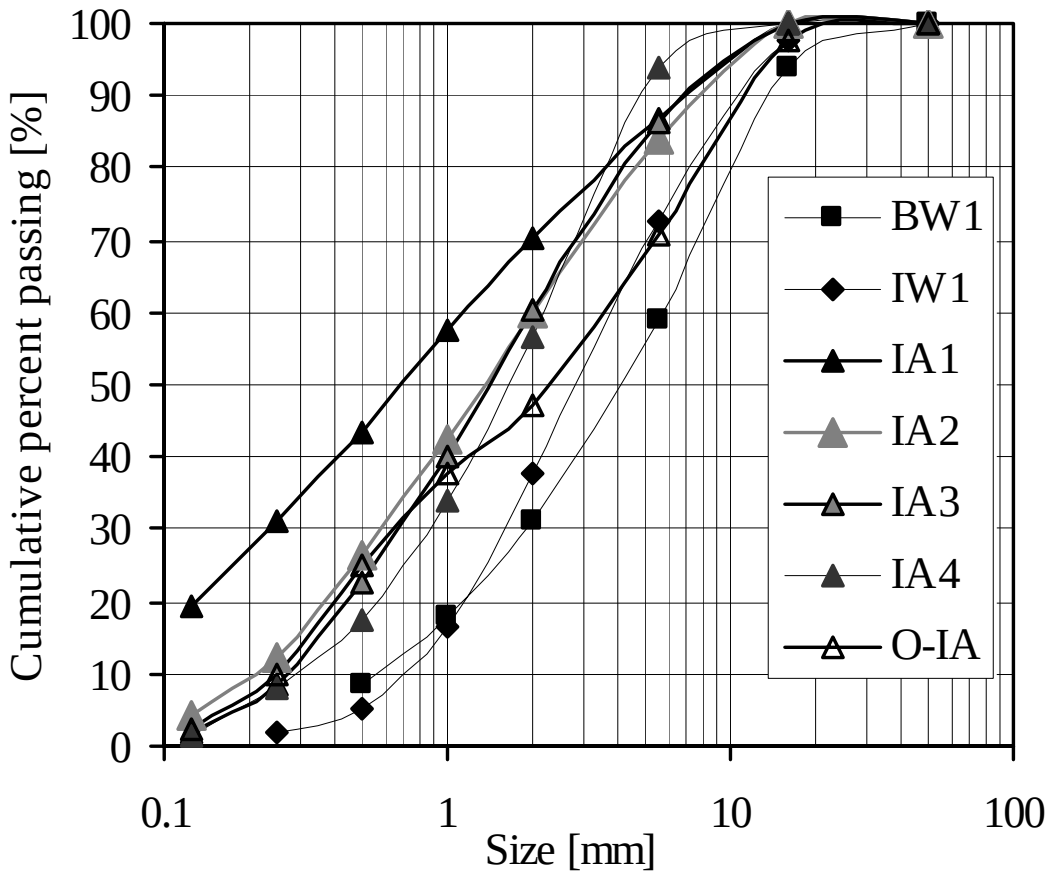
Tested material

BW	Under-sieve fraction of shredded bulky waste. Metal is recovered.
IW	Under-sieve fraction of shredded incombustible wate.
IA	Incineration ash (bottom ash)
Old IA	Incineration ash dug out from landfill
S	Sand of particle size between 2-2.8 mm

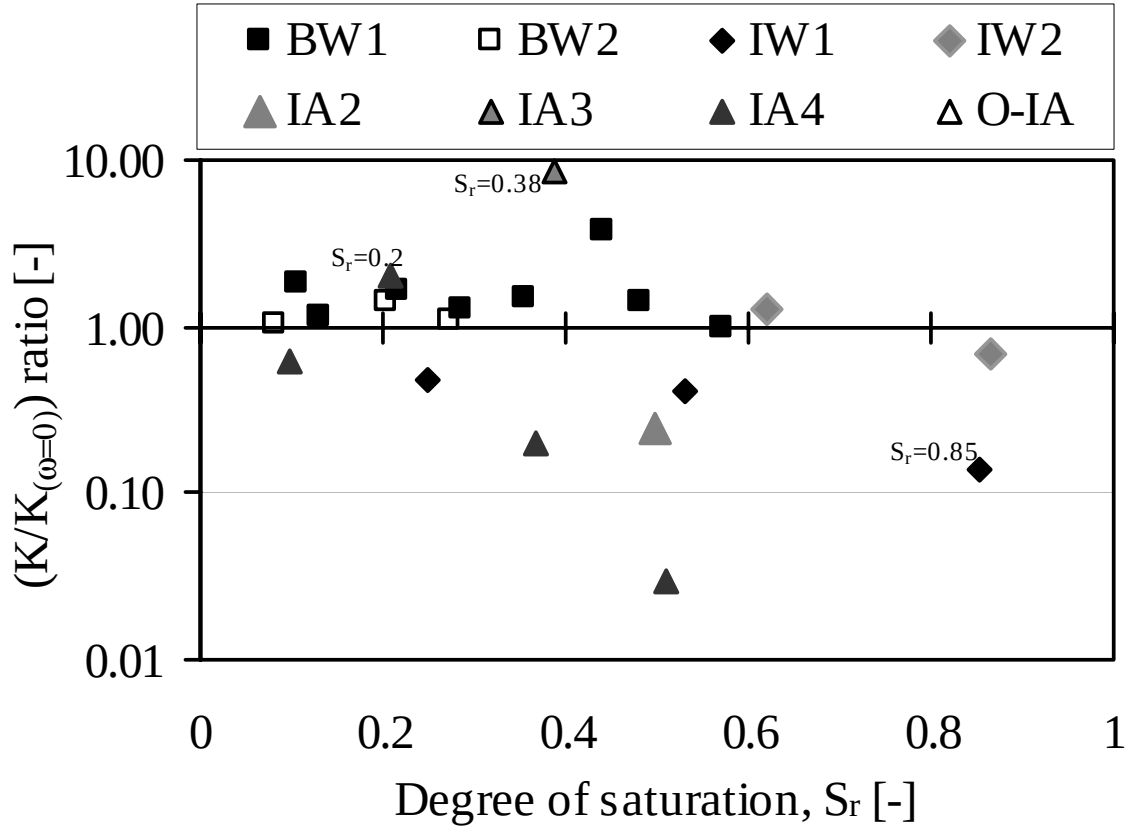
Composition of waste



Particle size distribution



Influence of water saturation on permeability



Intrinsic permeability

$K=\mu_g K_g$

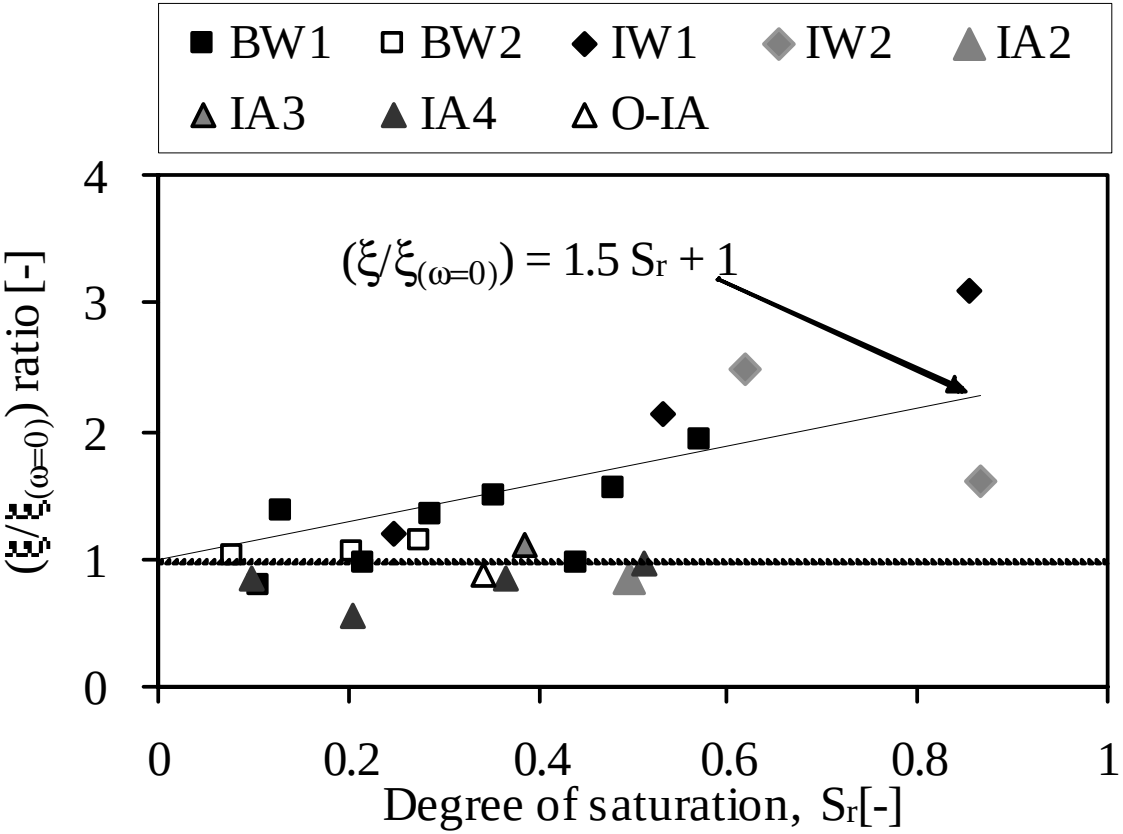
Degree of saturation

Sr=moisture /total porosity

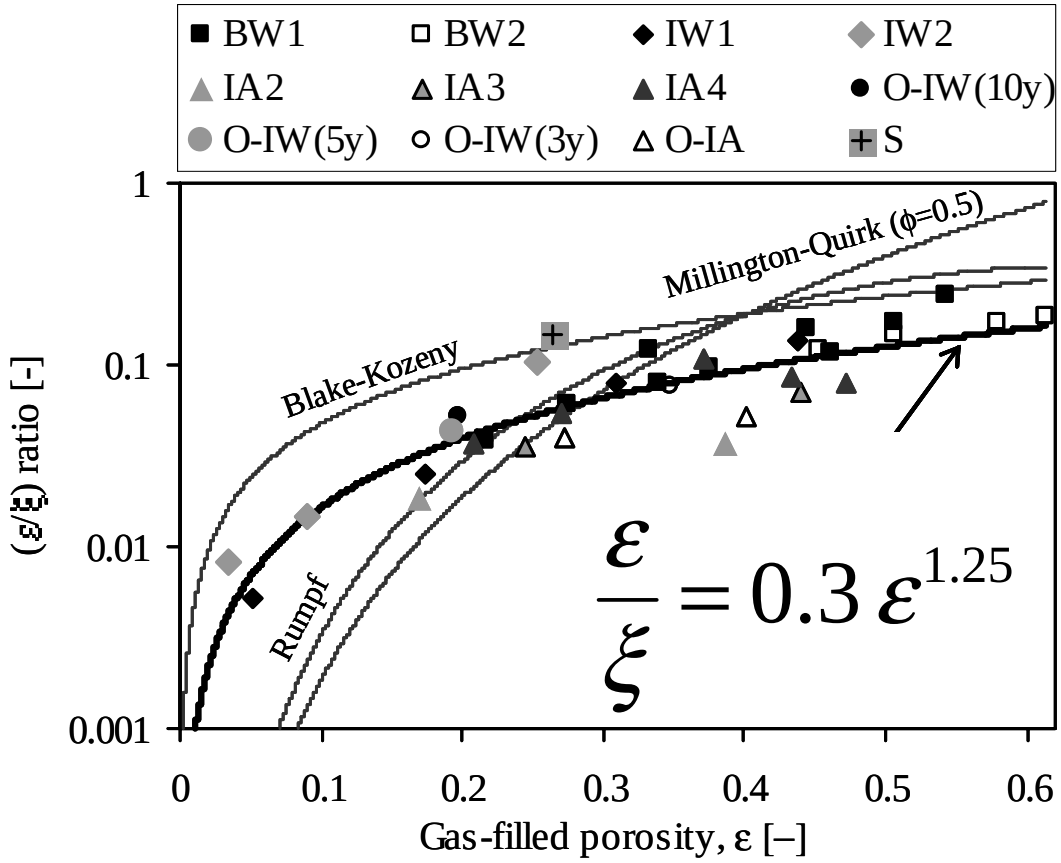
Determined parameters (dry)

	ε [–]	K [m^2]	ξ [-]	r [mm]
Bulky waste (shredded)	0.51	4.6×10^{-10}	2.9	0.14
	0.61	6.7×10^{-9}	3.3	0.52
Incombustible waste (shredded)	0.44	4.9×10^{-10}	3.2	0.17
	0.25	2.1×10^{-10}	2.5	0.13
MSWI ash	0.50	4.6×10^{-12}	n.a.	
	0.39	2.1×10^{-10}	10.7	0.21
	0.44	5.7×10^{-11}	6.2	0.079
	0.47	7.3×10^{-11}	6.0	0.086
Old MSWI ash	0.40	1.8×10^{-11}	7.7	0.051
Sand	0.26	2.9×10^{-9}	1.8	0.39

Influence of water saturation on tortuosity



Estimation of ε/ξ as function of ε



$$D_e = \frac{\varepsilon}{\xi} D_g^0$$

D_e : *effective diffusion coef.*

D_g^0 : *diffusion coef. in the air*