Ultimate Disposal of Solid Waste

CE 431

Methods

1. Landfilling
2. Landfarming
3. Deep-well Injection
4. Land Burial
5. Dumping in oceans and other large water bodies

Sanitary Landfill

- Sanitary Landfill is an engineered method for land disposal of solid and hazardous wastes in a manner that protects the environmental and public health. It is the only acceptable method of solid waste disposal currently all over the world

Site Selection

Factor	Remarks
Available land Area	Site should have a useful life greater than 1 yr (minimum value)
Haul distance	Will have significant impact on operating costs
Soil conditions and topography	Cover material must be available at or near the site
Surface water hydrology	Impacts drainage requirements
Geologic and hydrogeologic conditions	Probably most important factors in establishment of landfill site, especially with respect to site preparation
Climatologic conditions	Provisions must be made for wet-weather operation
Local environmental conditions	Noise, odor, dust, vector, and aesthetic factors control requirements
Ultimate use of site	Affects long-term management for site

Landfilling Methods

- Area Method
  - Wastes are spread and compacted on the surface of the ground
  - Cover material is spread and compacted over the layer of waste
  - Suitable on flat and gently sloping land and where the groundwater table is high
- Trench Method
  - Involves the excavation of a trench
  - Excavated soil serves as cover material
  - Suitable for sites having flat or gently rolling surface, a low groundwater table and a thick soil layer
- Depression Method
  - At locations where natural or artificial depressions exist.
  - The technique varies with the geometry of the site, the characteristics of the cover material, the hydrology and geology of the site and the access to the site

Advantages/Disadvantages

1. Where land is available, a sanitary landfill is the most economic method of solid waste disposal.	1. In highly populated areas, suitable land may not be available within the economical haul distances.
2. The initial investment is low compared with other disposal methods.	2. Proper sanitary landfill practices must be adhered to; otherwise it will turn into an open dump.
3. A sanitary landfill is the final or complete disposal method as compared to other method that need subsequent operations.	3. Sanitary landfills located in residential area cause nuisance and provoke public opposition.
4. A sanitary landfill can receive almost all types of solid wastes, eliminating the necessary for separate collection.	4. A completed landfill will settle and require periodic maintenance.
5. A sanitary landfill is flexible; increased quantities of solid wastes can be disposed of with little additional personnel and equipment.	5. Buildings constructed on completed sanitary landfills require special considerations for design.
6. Low-land can be reclaimed and used for many purposes.	6. Methane and other gases generated in landfills may become a hazards and nuisance and interfere with the use of

Occurrence of gases

- Landfill gas is primarily a mixture of methane and carbon dioxide produced by the decomposition of organic matter in the solid waste.
- Landfill gas is highly flammable and poses a risk of explosion if not properly managed

Stages of Decomposition

- The process of degradation of the organic fraction of solid waste within a landfill may be broadly divided into five stages

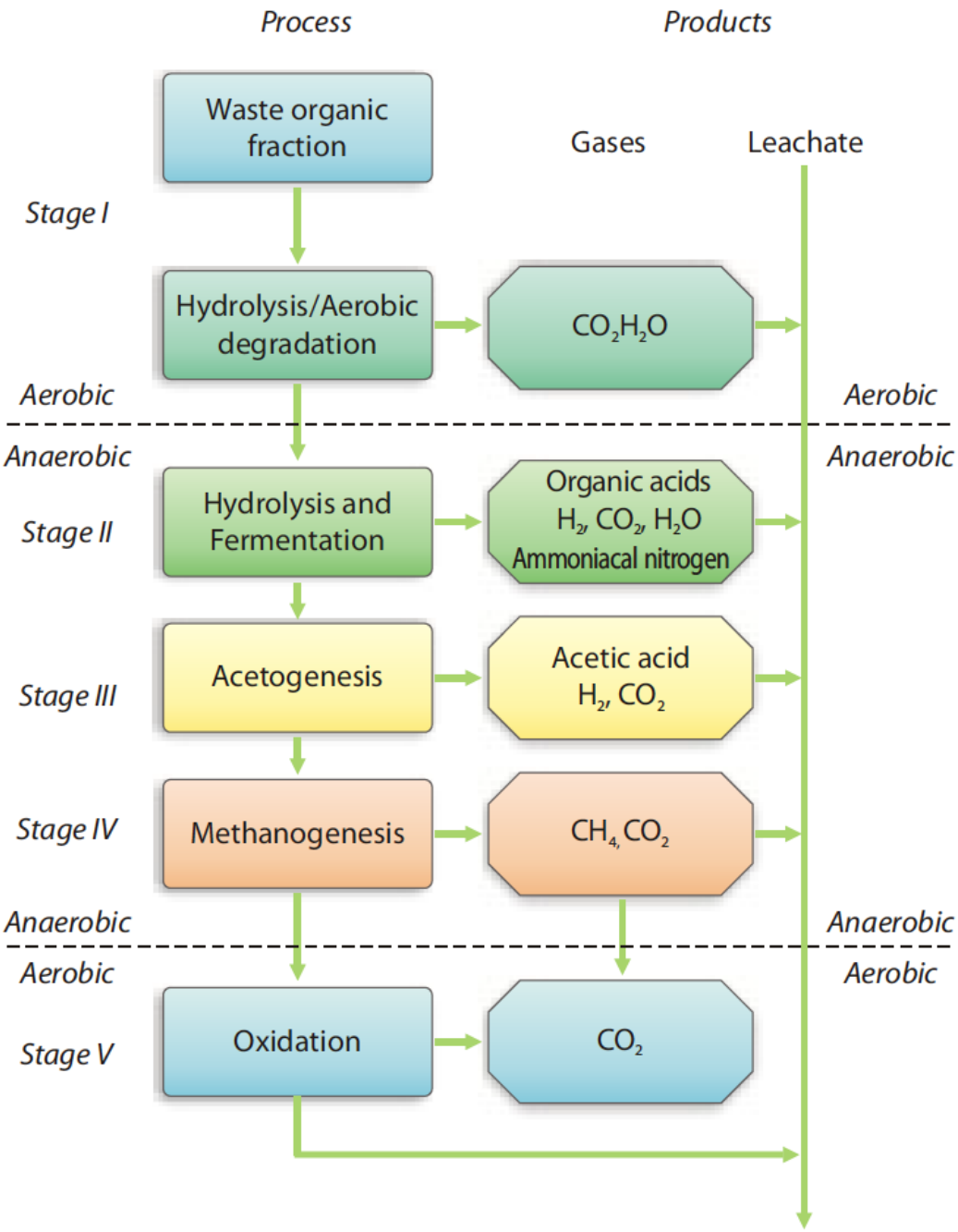
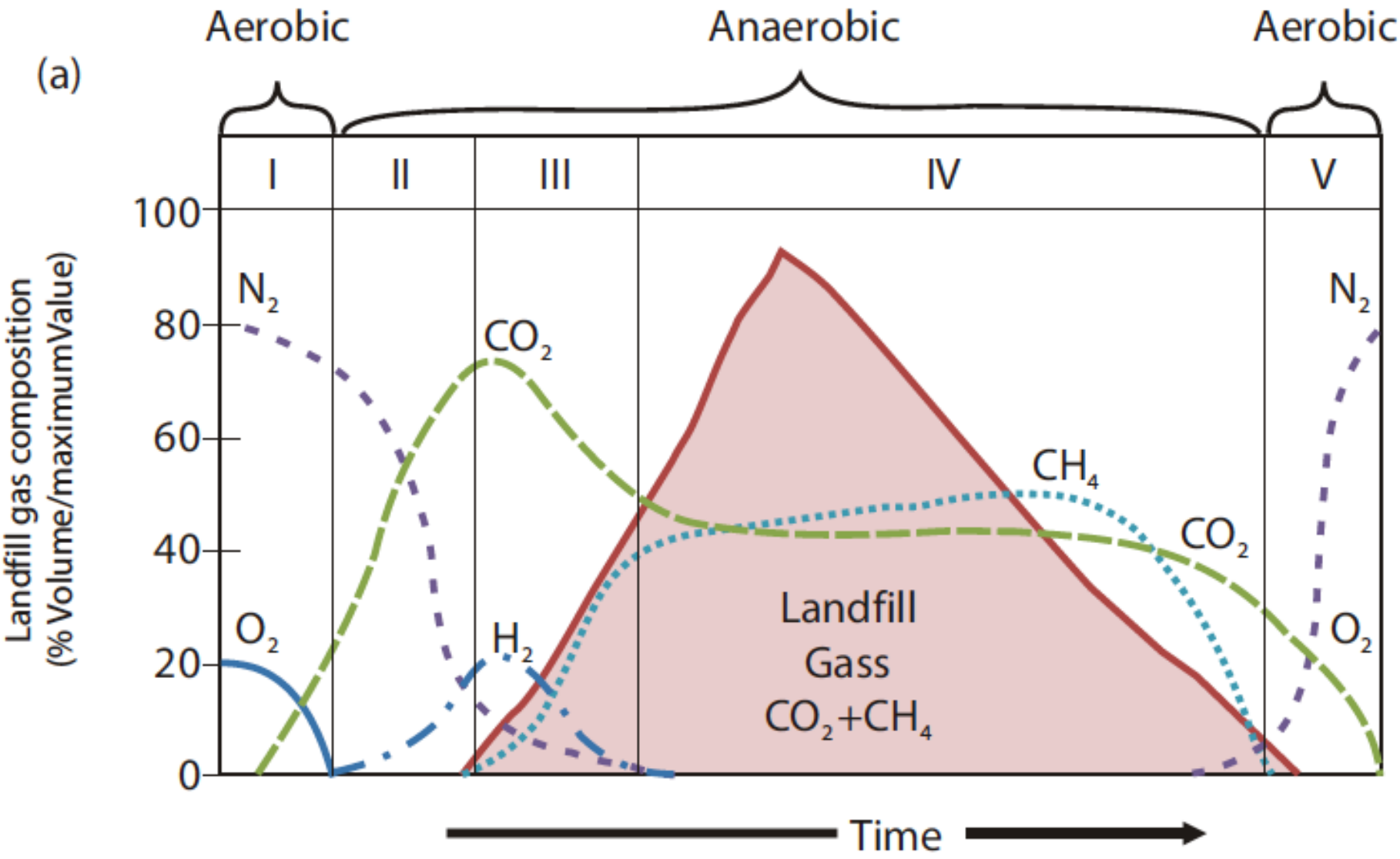
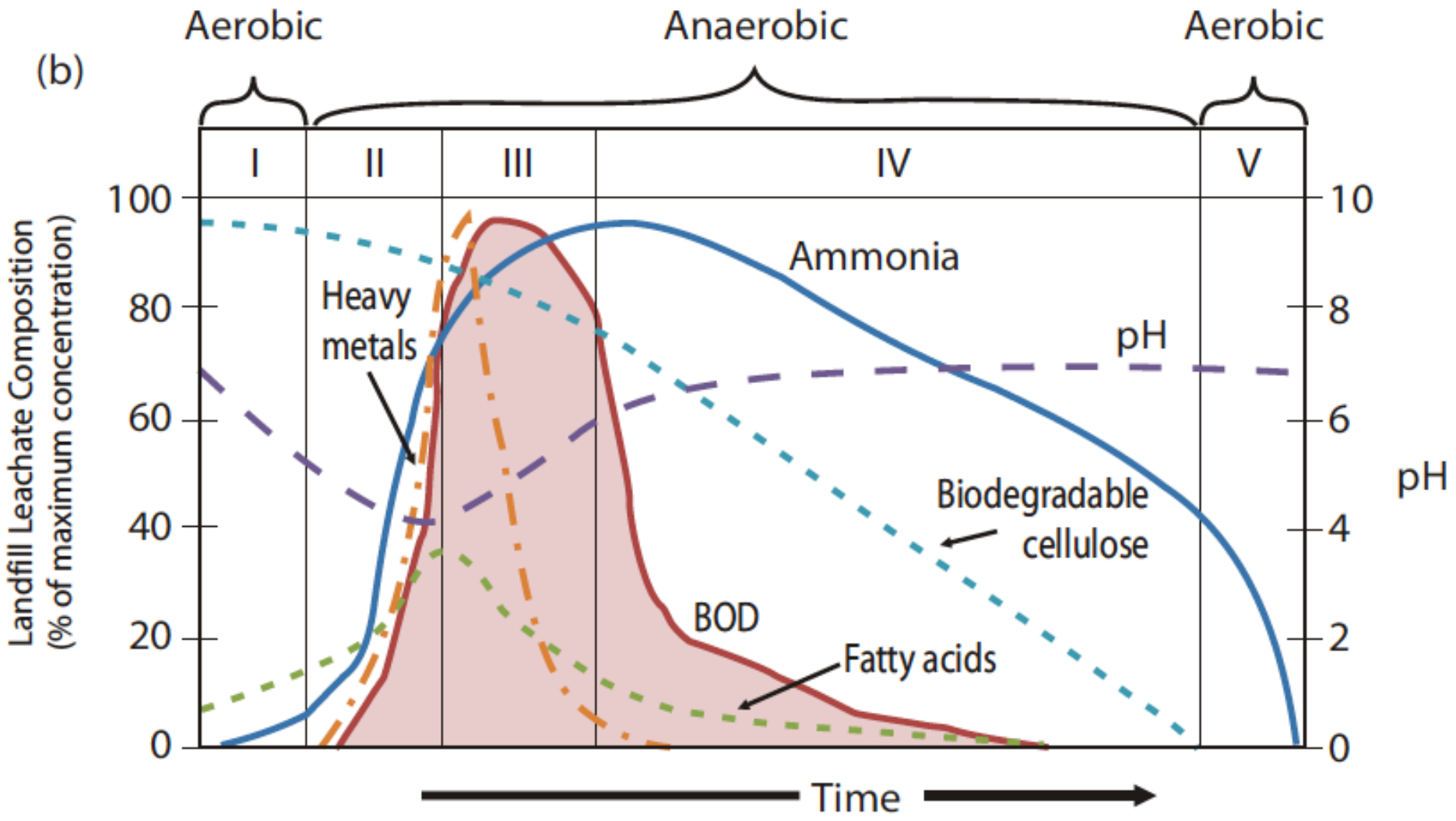


Figure 9.2: Major stages of waste degradation in landfills


(a)
Aerobic
Anaerobic
Aerobic
I
II
III
IV
V
100
80
60
40
20
0
Landfill gas composition
(% Volume/maximumValue)
N_2
CO_2
O_2
H_2
CH_4
CO_2
N_2
O_2
Landfill
Gass
CO_2+CH_4
Time


(b)
Aerobic
Anaerobic
Aerobic
I
II
III
IV
V
100
80
60
40
20
0
10
8
6
4
2
0
pH
Landfill Leachate Composition
(% of maximum concentration)
Heavy
metals
Ammonia
pH
Biodegradable
cellulose
BOD
Fatty acids
Time

Leachate in Landfills

- The natural decomposition of solid waste in combination with rainwater infiltration into the landfill site causes the production of potentially toxic leachate which flows toward the bottom of the landfill
- The wetter the climate, the greater the potential risks of groundwater and surface water contamination from landfill leachate
- Natural or synthetic materials are often used to line the bottom and side of landfills to prevent the migration of leachate into nearby groundwater and surface water

Data on the composition of leachate from landfills

Parameter	Concentration mg/L*	
	Range	Typical
BOD_5	2000-30000	10000
TOC	1500-20000	6000
COD	3000-45000	18000
TSS	200-1000	500
Organic nitrogen	10-600	200
Ammonia nitrogen	10-800	200
Nitrate	5-40	25
Total phosphorus	1-70	30
Ortho-phosphorus	1-50	20
Alkalinity as $CaCO_3$	1000-10000	3000
pH	5.3-9.6	6
Total hardness as $CaCO_3$	300-10000	3500
Calcium	200-3000	1000
Magnesium	50-1500	250
Potassium	200-2000	300
Sodium	200-2000	500
Chloride	100-3000	500
Sulfate	100-1500	300
Total iron	50-600	60

Control of gas Movement

- Passive Collection system - A low cost design consisting of buried vertical perforated pipes to collect the gas using its natural pressure and vent or flare it at the surface
- Active Collection system – More costly system utilizing a buried network of pipes and pumping to trap the gas, which is then processed and used for process heat and electricity generation

Control of leachate

- Key components of leachate management are
  - Leachate minimization
  - Leachate containment
  - Leachate collection
  - Leachate recirculation
  - Leachate treatment
  - Final disposal of leachate
  - Monitoring of leachate leakage

Summary of Leachate Treatment

Treatment option	Removal objective	Comments
Biological		Best used on "young" leachate
Activated sludge	BOD/COD	Flexible, shock resistant, proven, minimum SRT increases with increasing organic strength, >90 % BOD_5 removal possible.
Aerated lagoons	BOD/COD	Good application to small flows. >90 % BOD_5 removal possible.
Anaerobic	BOD/COD	Aerobic polishing necessary to achieve high-quality effluent
Powered activated carbon	BOD/COD	>95 % COD removal >99 % BOD removal
Physical/chemical		Useful as polishing step or for treatment of "old" leachate
Coagulation/ precipitation	Heavy metals	High removal of Fe, Zn, moderate removal of Cr, Cu, Mn, little removal of Cd, Pb, Ni
Chemical oxidation	COD	Raw leachate treatment requires high chemical doses, better used as polishing step.
Ion exchange	COD	10-70 % removal, slight metal removal
Adsorption	BOD/COD	30-70 % COD removal after biological or chemical treatment
Reverse osmosis	TDS	90-96 % TDS removal

Landfill Design considerations

- Useful lifespan and area – important parameters are depth of fill, quantity, rate of delivery, characteristics of solid wastes and operating practice
- Size of the site – Includes two elements such as gross area and useful fill area.
- Landfill cells are designed based on the quantity of wastes requiring disposal – Important elements are height, length, width of working face, slope of side walls and thickness of daily cover
- Height of a daily cell is a function of the quantity of waste, thickness of daily cover,

Environmental Factors

- Established regulations requiring inclusion of environmental controls in the design and operation of landfill in order to protect public health and environment from potential negative impacts
- Commonly adopted environmental controls include

1. Installation of a liner for leachate containment
2. A leachate collection and treatment system
3. Landfill gas management systems, and
4. Cover systems

- More specific environmental factors such as control of dusts, litter, odor, noise, vectors and

Problem 1

Problem 1: A refuse has the following components and bulk densities:

Component	Percentage by weight	Uncompacted bulk density (lb/ft^3)
Miscellaneous paper	50	3.81
Garden waste	25	4.45
Glass	25	18.45

Assume that the compaction in the landfill is 44.4 lb/ft^3. Estimate the % volume reduction achieved during compaction of the waste. Estimate the overall uncompacted bulk density, if the miscellaneous paper is removed.

Problem 2

Problem 2: Calculate the required landfill capacity for a community for the year 2010 from the following data:

Projected population = 12.00.000

Per capita generation rate = 6.4 lb/cap/d

Diversion fraction = 0.25

Compacted waste density = 44.4 lb/ ft^3

Assume a soil daily cover is used that accounts for 20% of the landfill volume.

Problem 3

The following three soils layers are lying between the base of a landfill and the underlying aquifer. How long will it take for leachate to migrate to the aquifer? Also, calculate the amount of leachate flowing down if the landfill area is 50 hectare.

	Depth (m)	Porosity (%)	Permeability (m/s)
Soil A	2.0	42	$3.0*10^{-9}$
Soil B	2.5	44	$2.0*10^{-8}$
Soil C	3.0	43	$5.8*10^{-7}$