Percolation model

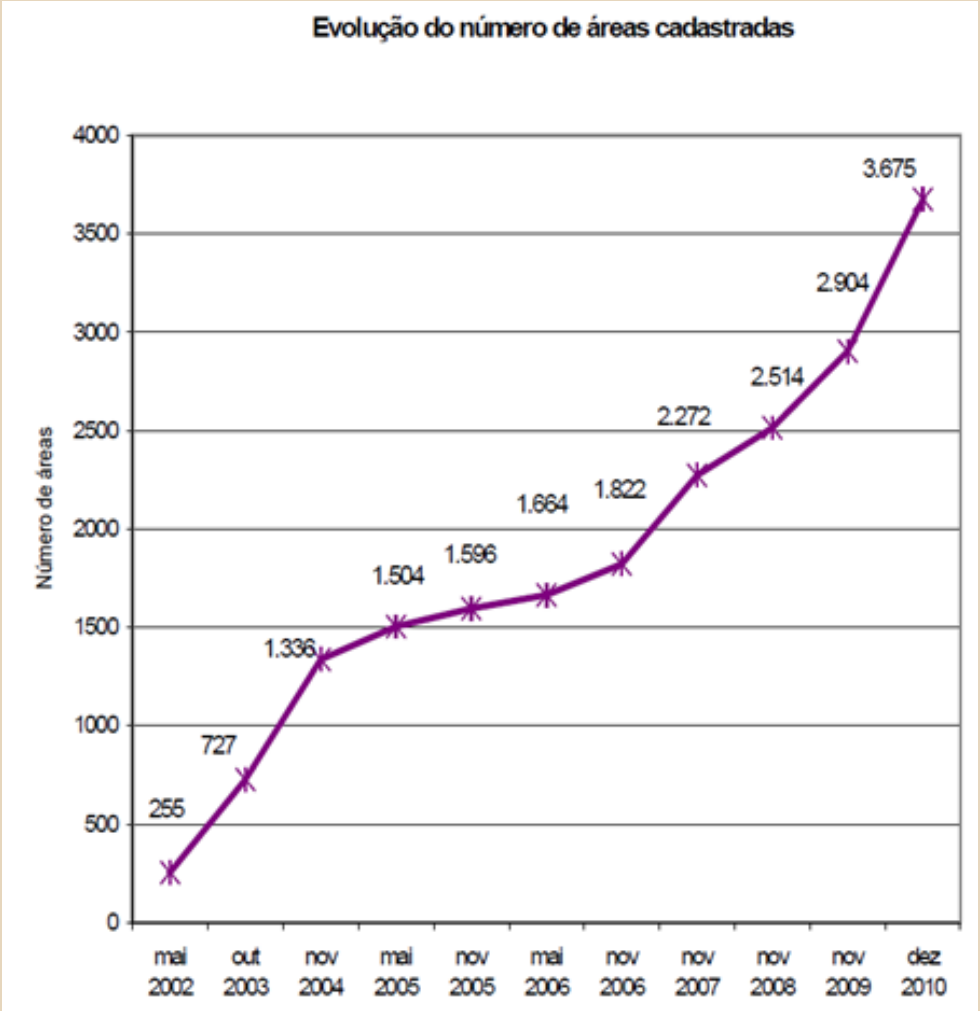
Environmental modeling project

SoSe 2014
Daniel Machado
Ji Yusi

Summary

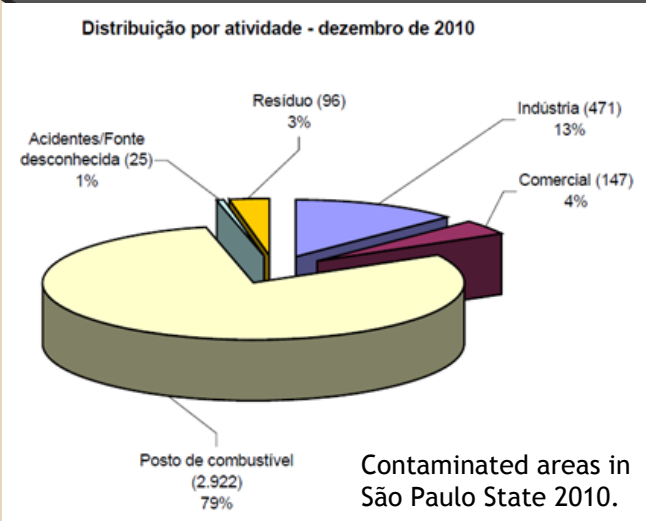
- Relevance & Context;
- Characteristics & Concepts;
- Physical models;
- Computanional model in TerraME
- References;

Contaminated areas in São Paulo State 2010.



Examples of Source

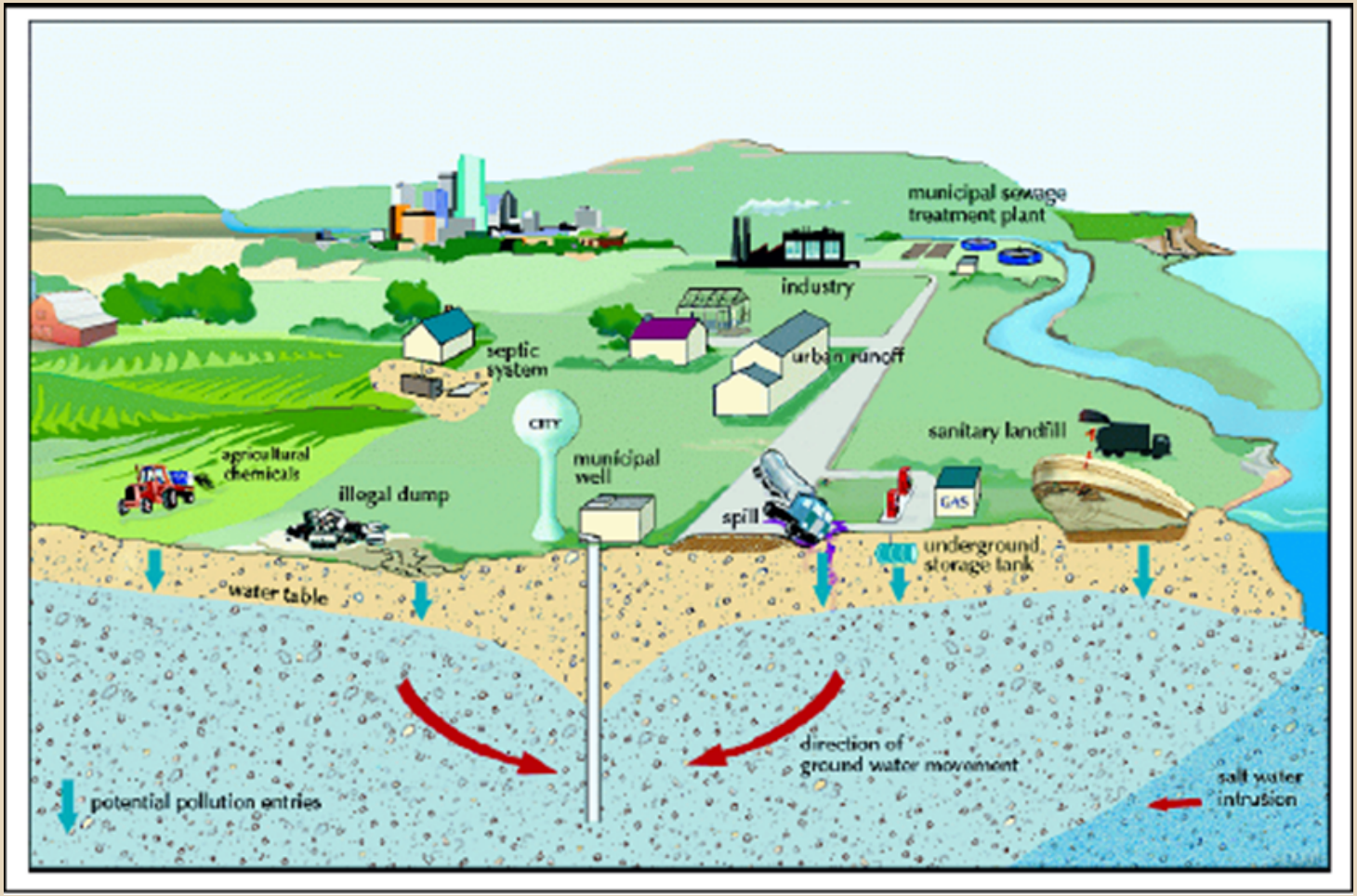
- Domestic:
  - sewage;
  - garbage;
- Hospital:
- Cemeteries:
- Industrial:
  - leakage
  - waste
  - accidents during transport
- Agricultural
  - irrigation
  - application of pesticides or fertilizers
  - overpumping
- Saline intrusion;
- Contamination with substances from adjacent areas;



Contaminated areas in São Paulo State 2010.

Why we model Oil spill?

- Forecasting contaminants plumes movements;
- Estimate contaminated areas;
- Estimate transport parameters for predictions;
- remediation techniques assist in the selection of possible alternatives;
- Delineation of protected areas of the contribution of area wells.


municipal sewage treatment plant
industry
septic system
urban runoff
CITY
municipal well
sanitary landfill
agricultural chemicals
illegal dump
spill
GAS
underground storage tank
water table
direction of ground water movement
potential pollution entries
salt water intrusion

Contaminants types:

- **Organic:**
  - **Aromatic hydrocarbons;**
    - *fuels, solvents, resins etc.*
  - **Oxygenated hydrocarbons;**
    - *solvents, plastics, adhesives, insecticides etc.*
  - **Hydrocarbons having specific elements (N, P, S, Cl, Br, I, F, etc.)**
    - *herbicides, insecticides, explosives, paints etc.*
  - **Other hydrocarbons**
    - *detergents, fuels, pharmaceuticals etc.*
- **Inorganic:**
  - **Metals and cations;**
    - *Alloys, solders, equipment, etc. tile*
  - **Non-metals and anions;**
  - fertilizers, preservatives, synthetic fibers etc.
- **Radionuclides**
  - *Radiography, measures instruments etc.*
- **Microbiological:**
  - **Bacteria;**
  - **Virus;**
  - **Fungi;**

Contaminants types:

- **Organic:**
  - Aromatic hydrocarbons;
    - *fuels, solvents, resins etc.*
  - Oxygenated hydrocarbons;
    - *solvents, plastics, adhesives, insecticides etc.*
  - Hydrocarbons having specific elements (N, P, S, Cl, Br, I, F, etc.)
    - *herbicides, insecticides, explosives, paints etc.*
  - Other hydrocarbons
    - *detergents, fuels, pharmaceuticals etc.*
- **Inorganic:**
  - Metals and cations;
    - *Alloys, solders, equipment, etc. tile*
  - Non-metals and anions;
  - fertilizers, preservatives, synthetic fibers etc.
- **Radionuclides**
  - *Radiography, measures instruments etc.*
- **Microbiological:**
  - Bacteria;
  - Virus;
  - Fungi;

Contamination source:

- **Scope:**
  - **Spot:** concentrated source in a small area

e.g.: Well, leaking tanks.

  - **Linear:** the source extends along a line

e.g.: River, channel, stream.

  - **Diffuse:** the source extends even at low concentrations, on large surfaces

e.g.: Irrigation areas, airborne transportation.

- **Duration:**
  - Continuous;
  - temporary;
  - Intermittent;

Contamination source:

- **Scope:**
  - **Spot:** concentrated source in a small area

e.g.: Well, leaking tanks

  - **Linear:** the source extends along a line

e.g.: River, channel, stream.

  - **Diffuse:** the source extends even at low concentrations, on large surfaces

e.g.: Irrigation areas, airborne transportation.

- **Duration:**
  - Continuous;
  - temporary;
  - Intermittent;

NAPLs: non-aqueous phase liquids:

LNAPLs: light non-aqueous phase liquids.

ex.: combustíveis derivados do petróleo (gasolina, diesel)

DNAPLs: Dense non-aqueous phase liquids.

ex.: solventes clorados (TCE – tricloroetileno)

NAPLs: non-aqueous phase liquids:

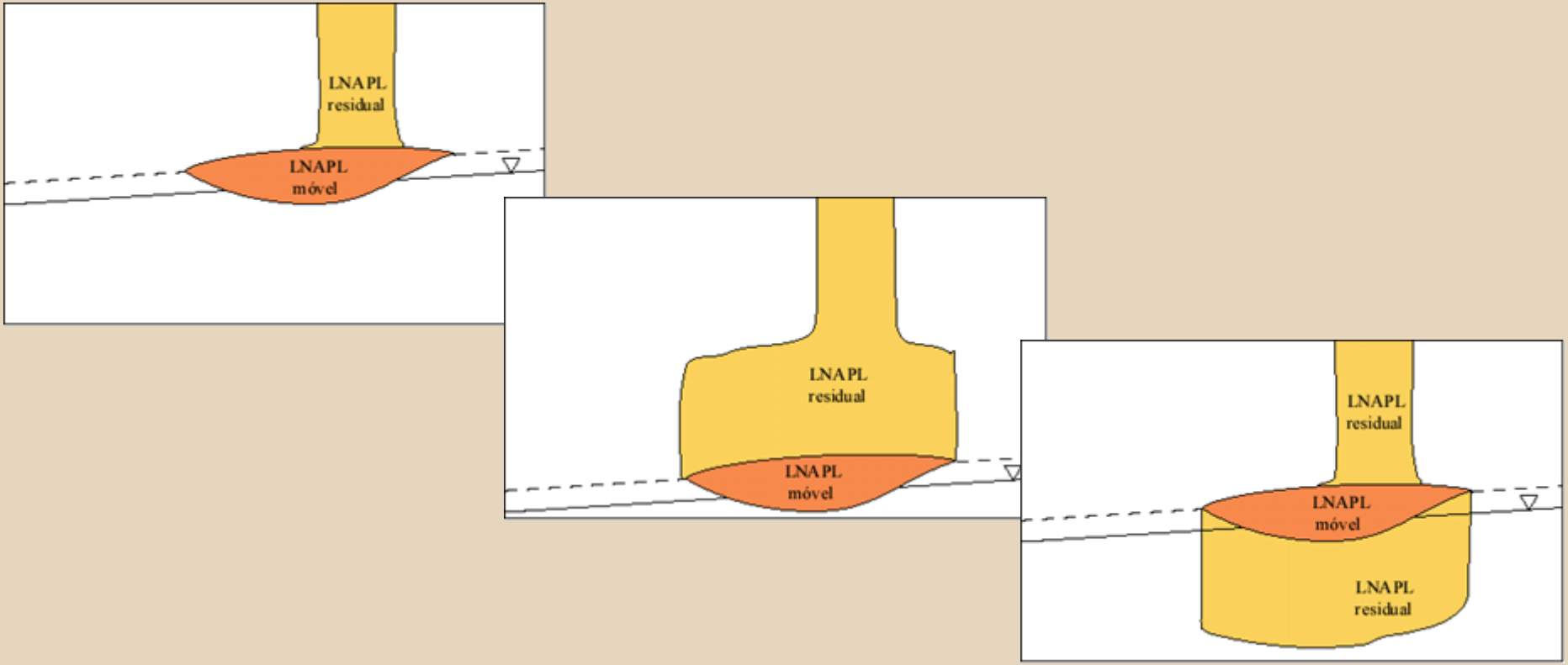
LNAPLs: light non-aqueous phase liquids.

ex.: combustíveis derivados do petróleo (gasolina, diesel)

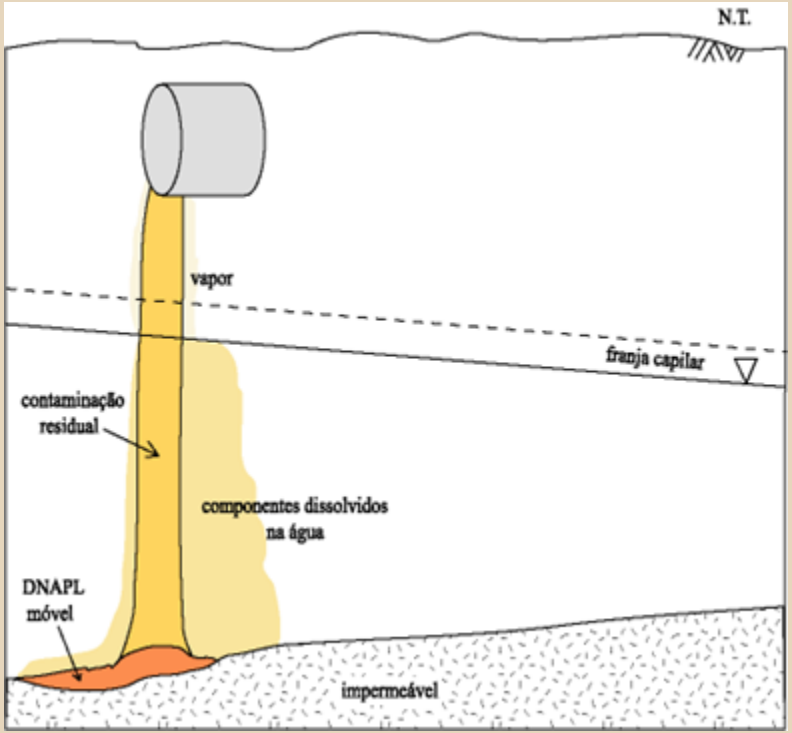
DNAPLs: Dense non-aqueous phase liquids.

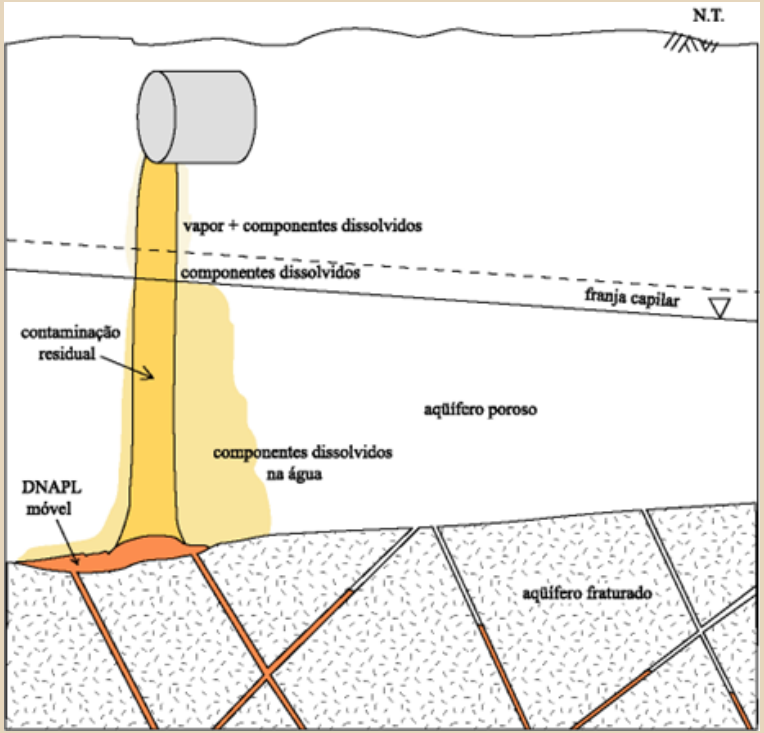
ex.: solventes clorados (TCE – tricloroetileno)

LNAPL


LNAPL
residual
LNAPL
móvel
LNAPL
residual
LNAPL
móvel
LNAPL
residual
LNAPL
móvel
LNAPL
residual

DNAPL


N.T.
vapor
franja capilar
contaminação residual
componentes dissolvidos na água
DNAPL móvel
impermeável

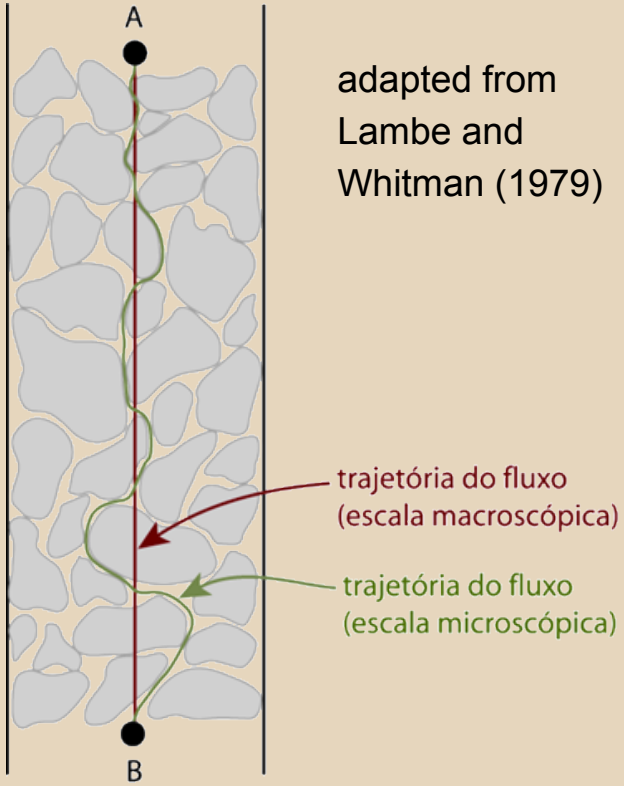

N.T.
vapor + componentes dissolvidos
componentes dissolvidos
franja capilar
contaminação residual
aqüífero poroso
componentes dissolvidos na água
DNAPL móvel
aqüífero fraturado

The model

- **Deterministic model;**
  - *due to the large number of data required for stochastic models and also because of the ease of use of the results as they require interpretation or subjective judgments.*

Non-aqueous phase liquids

- Gravity flow
- Capillarity
- Transport droplets by groundwater



adapted from Lambe and Whitman (1979)

Physical Models

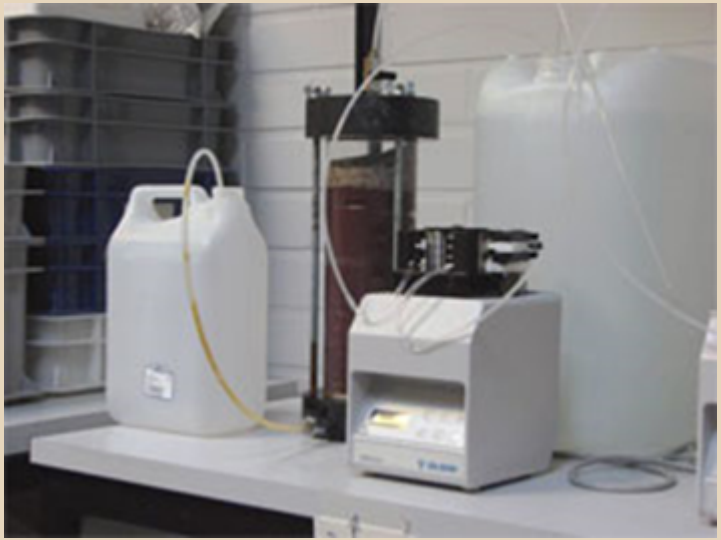
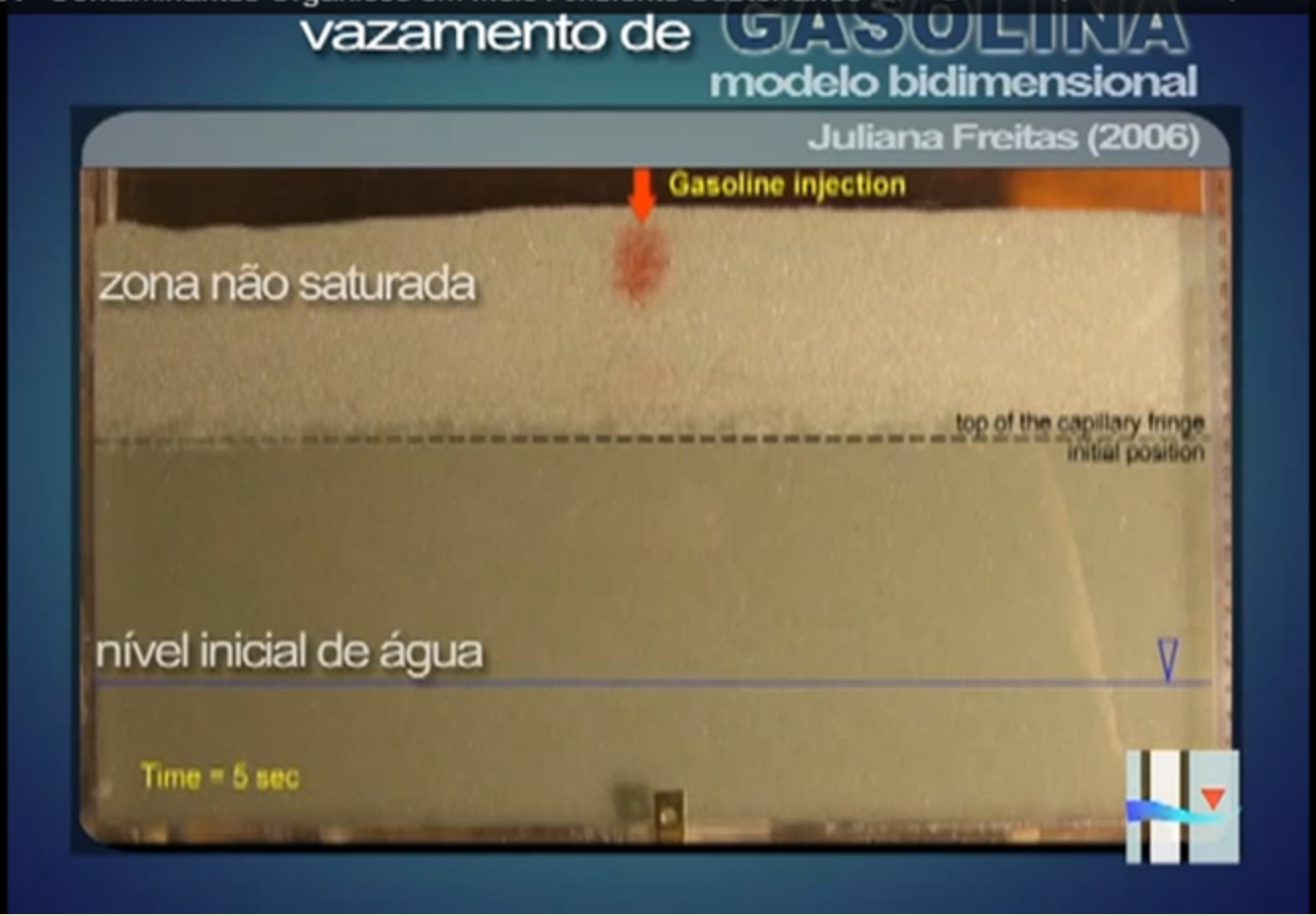


Figure XI.a.
Spill of PER. Kinematic viscosity = 0.54 mm²/s. Time = ~1 h.

Figure XI.b.
Spill of PER. Later stage of spill depicted in Figure XI.a. Kinematic viscosity = 0.54 mm²/s.

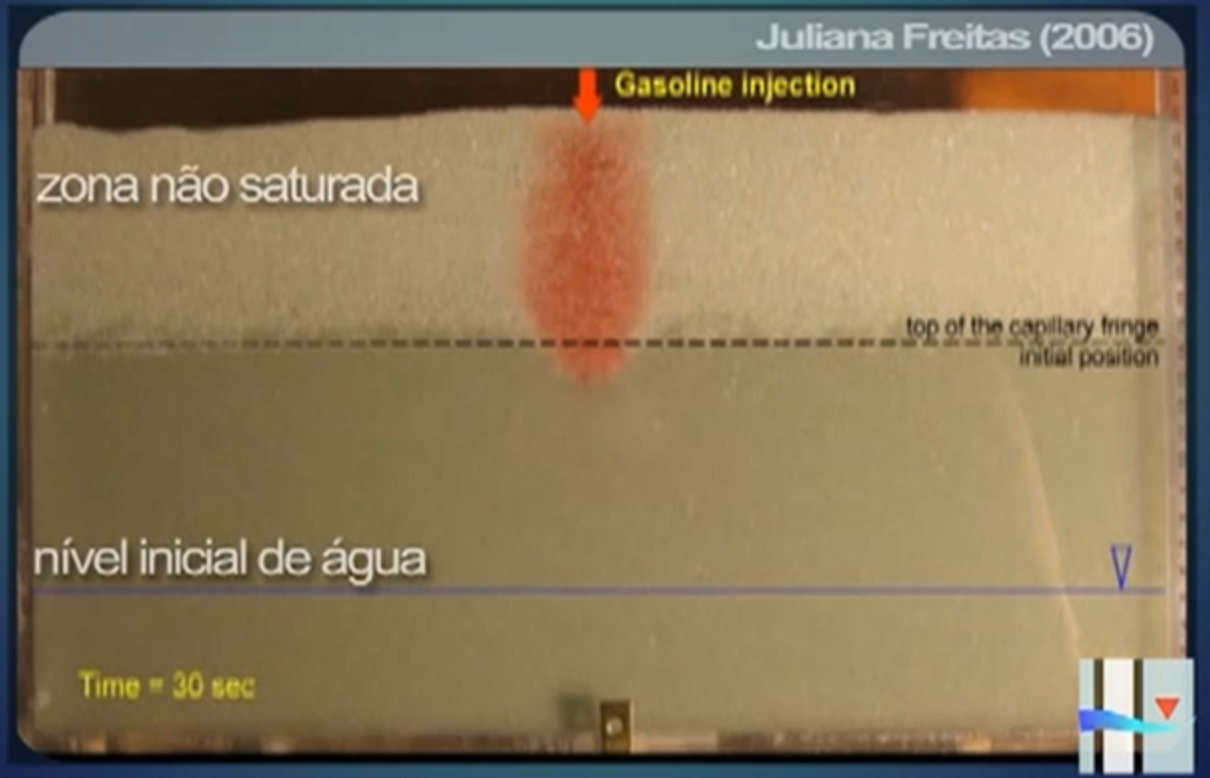
XI.a.

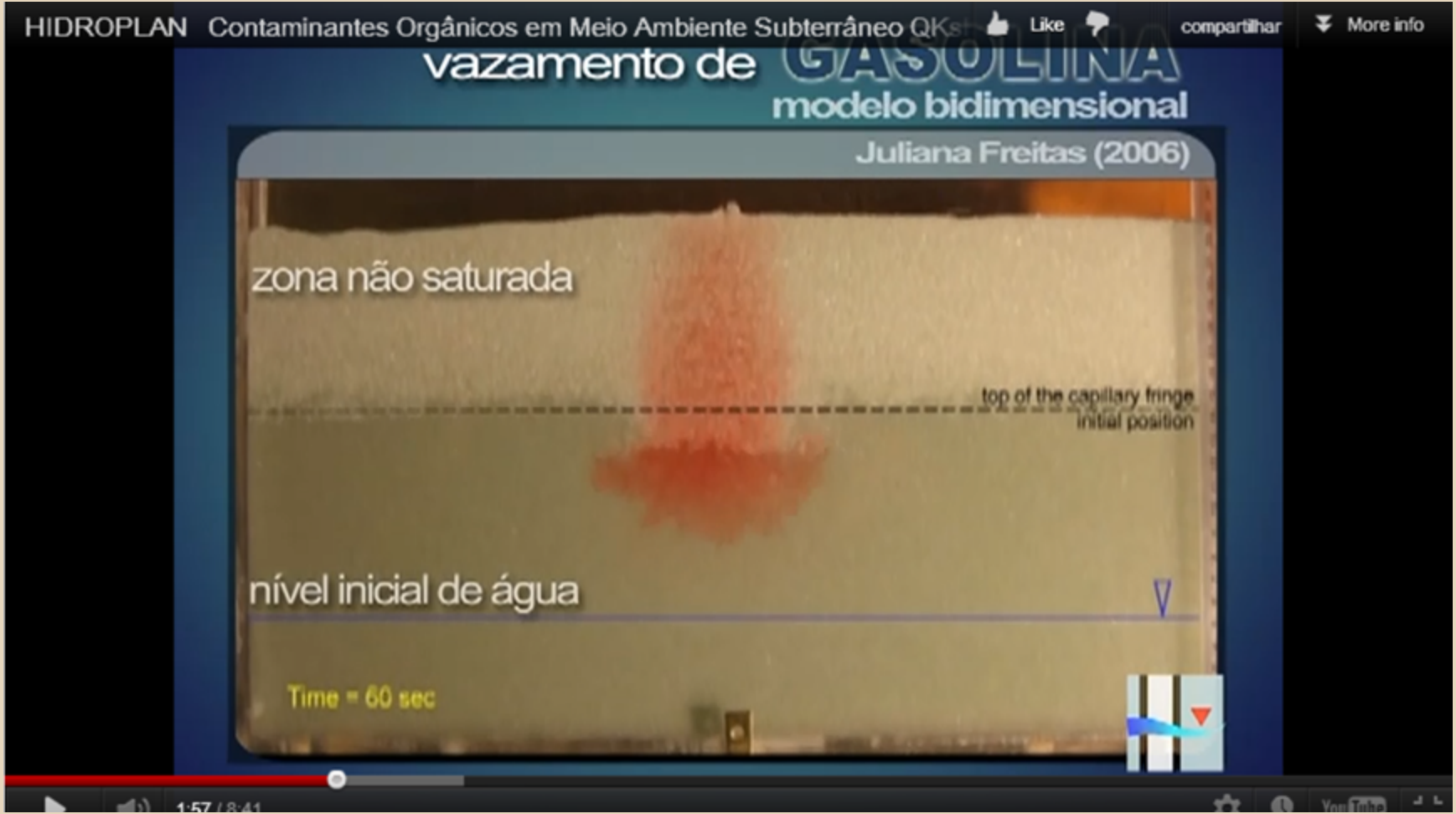
XI.b.

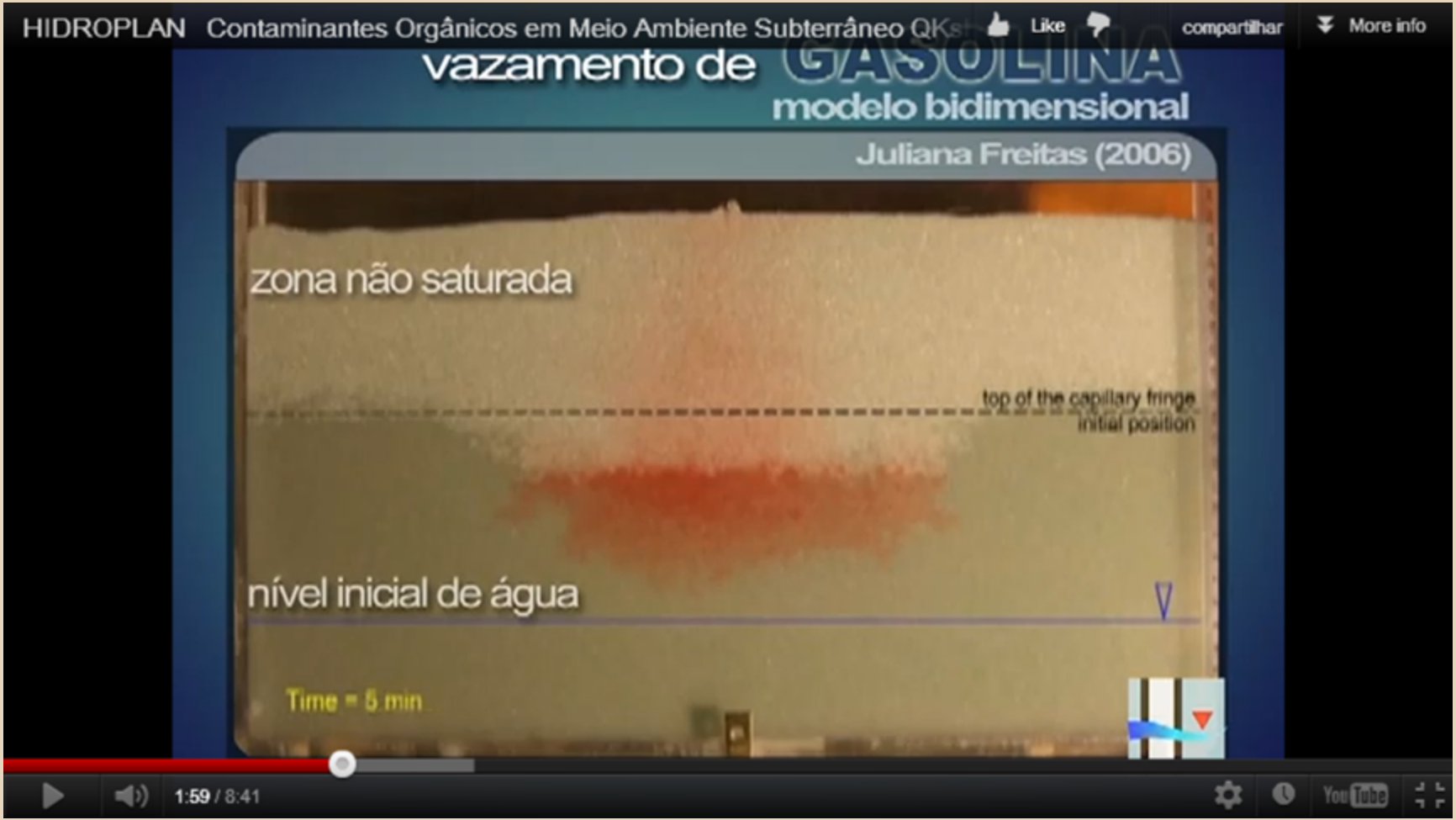

vazamento de GASOLINA
modelo bidimensional
Juliana Freitas (2006)
Gasoline injection
zona não saturada
top of the capillary fringe
initial position
nível inicial de água
Time = 5 sec

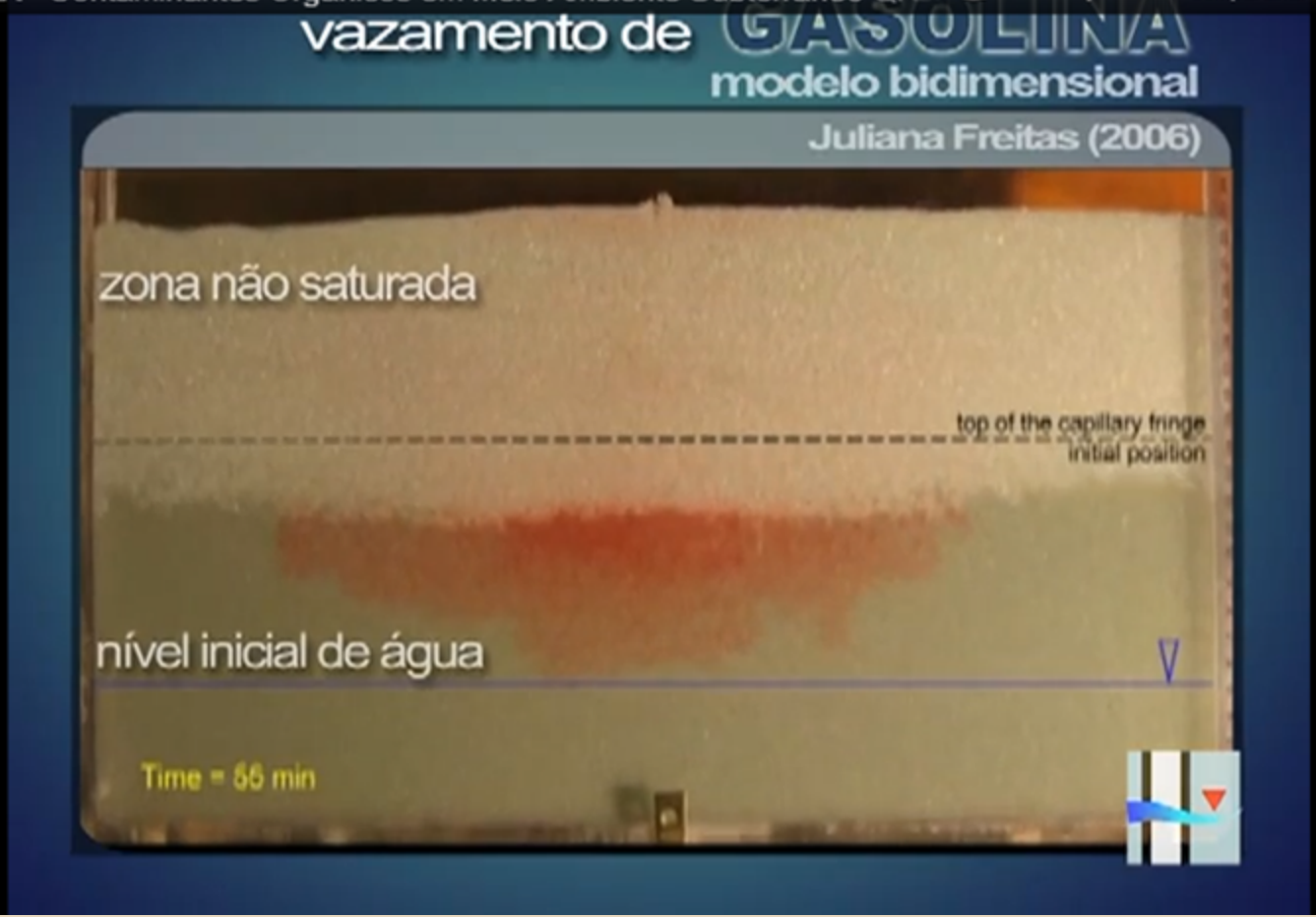
vazamento de GASOLINA

modelo bidimensional



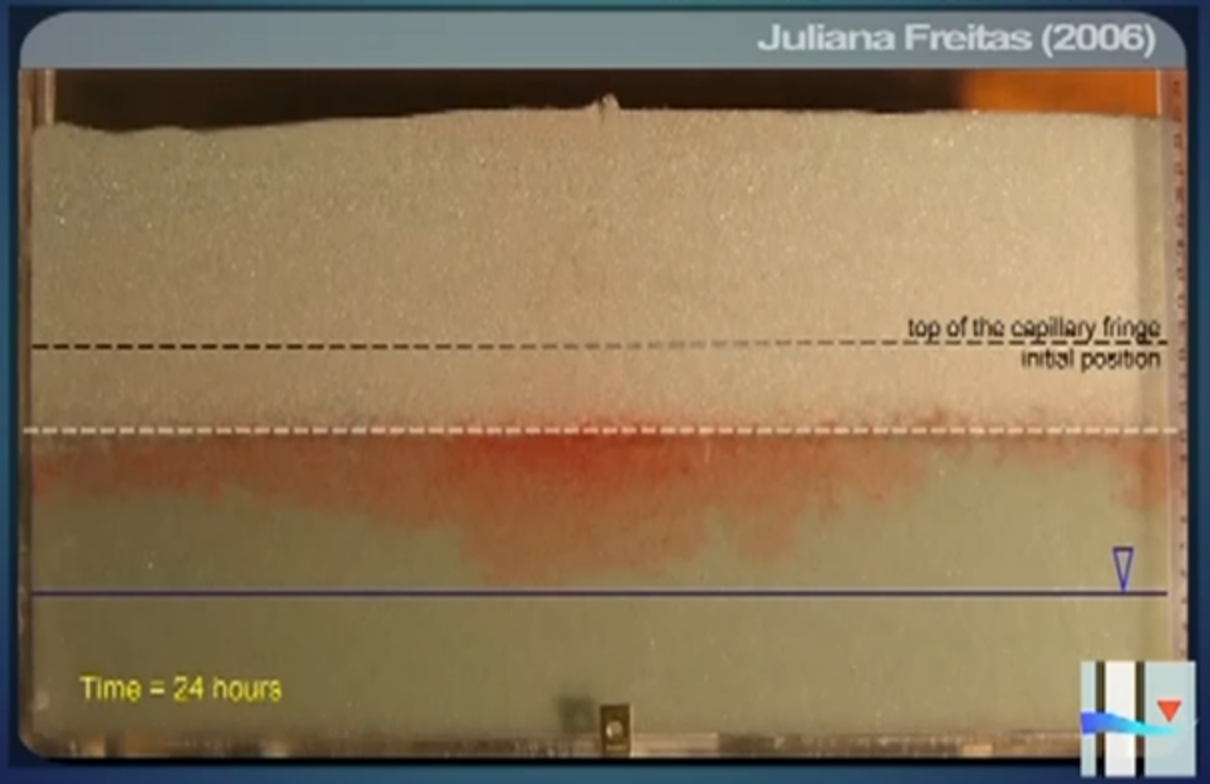

HIDROPLAN Contaminantes Orgânicos em Meio Ambiente Subterrâneo QKs
Like
compartilhar
More info
vazamento de GASOLINA
modelo bidimensional
Juliana Freitas (2006)
zona não saturada
top of the capillary fringe
initial position
nível inicial de água
Time = 60 sec
1:57 / 8:41

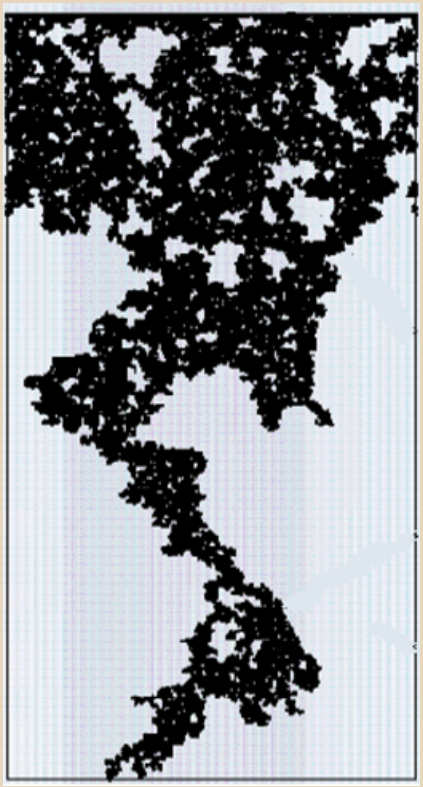

HIDROPLAN Contaminantes Orgânicos em Meio Ambiente Subterrâneo QKs
Like
compartilhar
More info
vazamento de GASOLINA
modelo bidimensional
Juliana Freitas (2006)
zona não saturada
top of the capillary fringe
initial position
nível inicial de água
Time = 5 min
1:59 / 8:41



vazamento de GASOLINA

modelo bidimensional





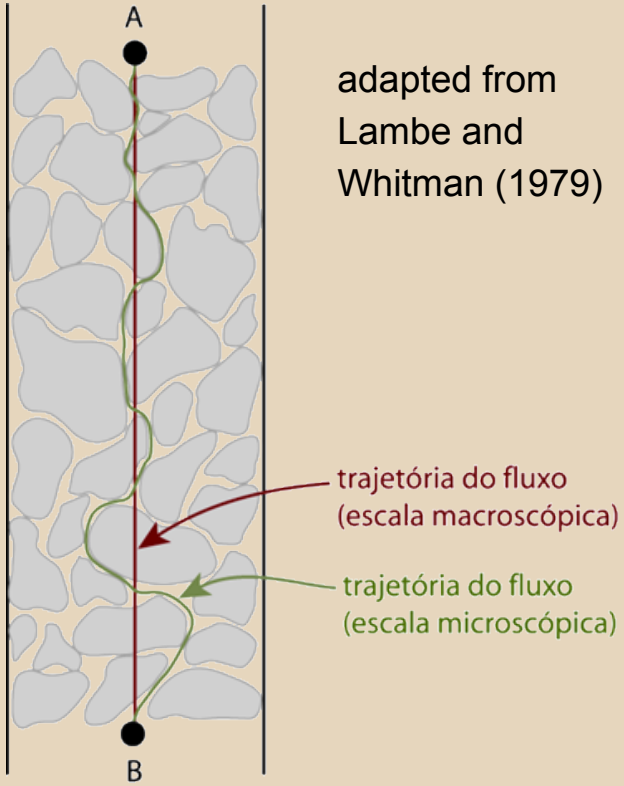
Displacement of one phase by another: "fingering" (interdigitation):

depends on the ratio between the dynamic viscosities of the phase being drained and phase that is infiltrated.

Menezes Filho et al., 2005

Non-aqueous phase liquids

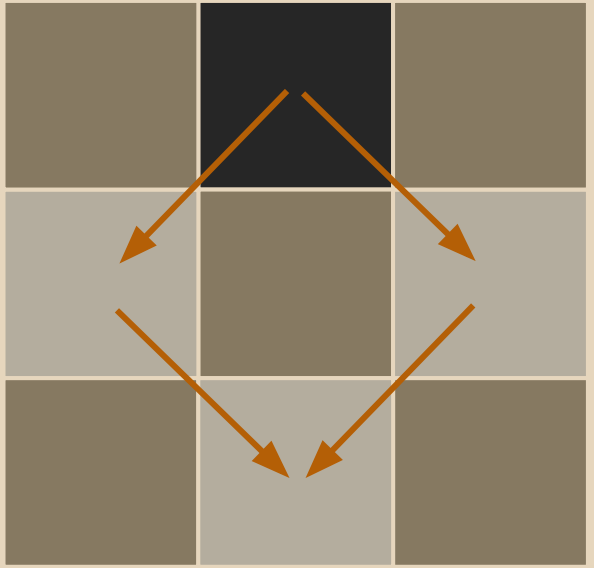
- Gravity flow
- Capillarity
- Transport droplets by groundwater



adapted from Lambe and Whitman (1979)

NAPLS

- Gravity flow
- Capillarity
- Transport droplets by groundwater



NAPLS

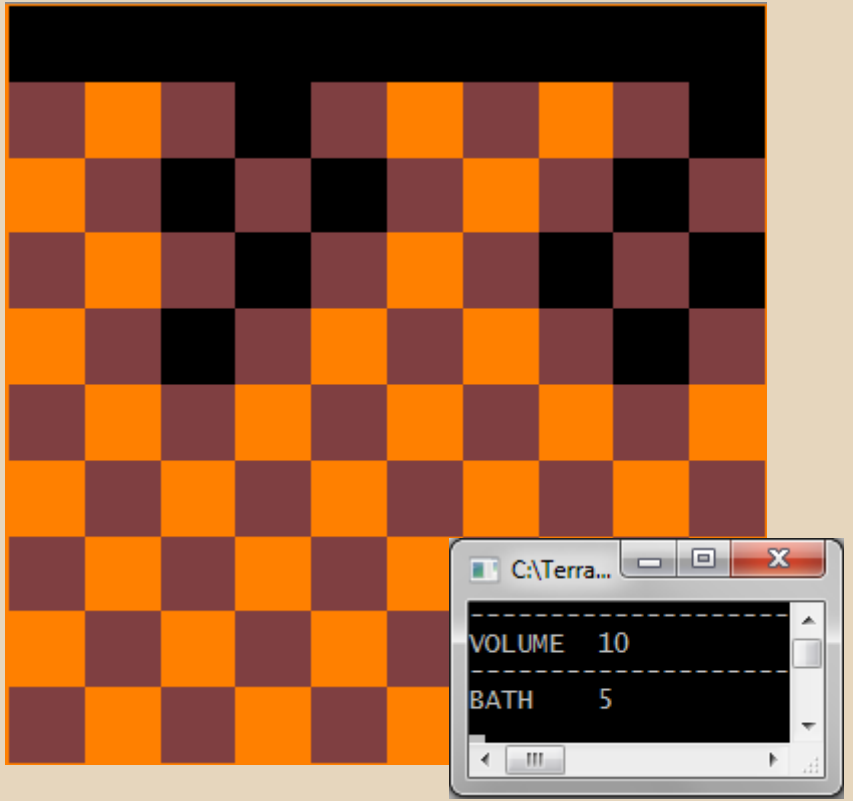
- Gravity flow
- Capillarity
- Transport droplets by groundwater

```
update = function(cs)
    still_oil = 0
   forEachCell(cs, function(cell)
      if cell.past.cover == HOLLOW then
         forEachNeighbor(cell, function(cell, neighbor)



         if neighbor.past.cover == SPILL then
               if cell.prob == false or neighbor.y == cell.y + 1 then
               cell.cover = HOLLOW
               else
               cell.cover = SPILL
               end
            end
         end)
      elseif cell.past.cover == SPILL then
         cell.cover = SPILL2
```

NAPLS

```
(((cell.x % 2)+ (cell.y % 2)) % 2 ) == 0 then
    cell.cover = HOLLOW
    counterf =counterf + 1 -- not used. no rea
else
    cell.cover = SAND
```

- Gravity flow
- Capillarity
- Transport droplets by groundwater



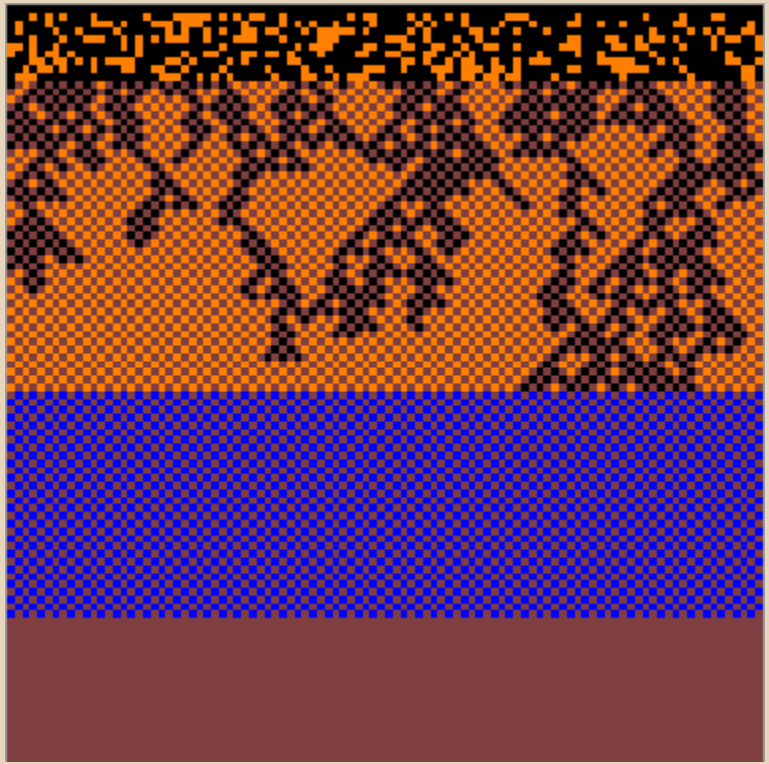
NAPLS

- Gravity flow
- Capillarity
- Transport droplet by groundwater

```
forEachCell(world, function(cell)
   if ( cell.y > 10 ) then
      cell.cover = HOLLOW
      end
   if ( cell.y < 10 ) or -- ############################## control the Bedrock level
   ((( cell.x % 2)+  ( cell.y % 2))  % 2 ) == 0 then
         cell.cover = HOLLOW
         counterf =counterf + 1 -- not used. no reason to count the hollow space;
      else
         cell.cover = SAND
         countere = countere + 1 --not used. no reason to count sand grains;
      end
      if ( cell.y ~= 0 ) then
   else
      cell.cover = SPILL
      count_spill = count_spill + 1
   end
   if ( cell.y > 50 ) and -- ############################## control the Bedrock level
   ((( cell.x % 2)+  ( cell.y % 2))  % 2 ) == 0 then
   cell.cover = SATURATED
   end
   if ( cell.y > 80 ) then -- ############################## control the Bedrock level
   cell.cover = SAND
   end
end)
```

NAPLS

- Gravity flow
- Capillarity
- Transport droplets by groundwater



THE MODEL!

QUESTIONS?

References

- Fetter, C. W. 1993 – **Contaminant Hydrogeology**. Macmillan Publishing Company.
- Freeze, R. A. e Cherry, J. A. 1979 – **Groundwater**. Prentice Hall.
- CETESB 2008 - http://www.cetesb.sp.gov.br/Solo/areas_contaminadas/relacao_areas.asp
- Lambe, T. W. e Whitman, R. V. 1979 – **Soil mechanics, SI version**. John Wiley and Sons.
- Corseuil, H. X. 2000 – **Avaliação de aqüíferos contaminados por compostos orgânicos tóxicos**. Notas de Aula. Curso realizado no Departamento de Geologia da UFRJ.
- ANA 2005 - **Panorama da qualidade das águas subterrâneas no Brasil**. - Menezes Filho et al., 2005