# Package 'Porous'

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**Type** Package

**Title** Dual porosity SOC decomposition model (draft)

**Version** 0.1.0

**Author** Lorenzo Menichetti

**Maintainer** Lorenzo Menichetti <Lorenzo.Menichetti@slu.se>

**Description** This package contains a draft version of the dual porosity SOC decomposition model developed by Meurer and Jarvis. The model is being actively developed.
Original description in: Meurer, Katharina Hildegard Elisabeth, Claire Chenu, Elsa Coucheney, Anke Marianne Herrmann, Thomas Keller, Thomas Kätterer, David Nimblad Svensson, and Nicholas Jarvis. "Modelling Dynamic Interactions between Soil Structure and the Storage and Turnover of Soil Organic Matter." Biogeosciences 17, no. 20 (October 19, 2020): 5025–42. https://doi.org/10.5194/bg-17-5025-2020.

**Imports** SoilR

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**Encoding** UTF-8

**LazyData** true

**RoxygenNote** 7.2.3

**Suggests** knitr,
rmarkdown

**VignetteBuilder** knitr

# R topics documented:

Delta_z *Variation of the thickness of soil layer*

## Description

This function calculates the variation of the thickness of soil layer as a function of organic matter

## Usage

```
Delta_z(
  f_agg = 3,
  Delta_z_min,
  My_mic,
  Mo_mic,
  My_mes,
  Mo_mes,
  phi_mac,
  gamma_o
)
```

## Arguments

| | |
|---|---|
| f_agg | an aggregation factor (m3 pore space m-3 organic matter) defined as the slope of the linear relationship assumed between the volume of aggregation pore space $V_{agg}$, and the volume of organic matter $V_{s_o}$ |
| Delta_z_min | minimal soil thickness if no organic matter was present |
| My_mic | One of the four model pools (they are all summed up in this function for calculating the total) |
| Mo_mic | One of the four model pools (they are all summed up in this function for calculating the total) |
| My_mes | One of the four model pools (they are all summed up in this function for calculating the total) |
| Mo_mes | One of the four model pools (they are all summed up in this function for calculating the total) |
| phi_mac | macroporosity |
| gamma_o | density of organic matter |

## Value

one single value

## f_text_mic_func *Proportion of micropores*

### Description

This function calculates the proportion of the textural pore space that comprises micropores. It is used in pore_frac

### Usage

```
f_text_mic_func(clay, phi_min)
```

### Arguments

| | |
|---|---|
| clay | soil clay fraction |
| phi_min | minimal porosity, user defined |

### Value

one single value

## phi_mat *Matrix porosity*

### Description

This function calculates the matrix porosity $\phi_{mac}$ based on the variation of organic matter in the soil. It is used in pore_frac to calculate mesoporosity $\phi_{mes} = \phi_{mat} - \phi_{mic}$

### Usage

```
phi_mat(
  My_mic,
  Mo_mic,
  My_mes,
  Mo_mes,
  gamma_o,
  f_agg = 3,
  Delta_z_min,
  phi_min,
  phi_mac
)
```

### Arguments

| | |
|---|---|
| `My_mic` | One of the four model pools (they are all summed up in this function for calculating the total) |
| `Mo_mic` | One of the four model pools (they are all summed up in this function for calculating the total) |
| `My_mes` | One of the four model pools (they are all summed up in this function for calculating the total) |
| `Mo_mes` | One of the four model pools (they are all summed up in this function for calculating the total) |
| `gamma_o` | density of organic matter |
| `f_agg` | an aggregation factor (m3 pore space m-3 organic matter) defined as the slope of the linear relationship assumed between the volume of aggregation pore space $V_{agg}$, and the volume of organic matter $V_{s_o}$ |
| `Delta_z_min` | minimal soil thickness if no organic matter was present |
| `phi_mac` | macroporosity |

### Value

one single value

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`phi_mic` *Microporosity*

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### Description

This function calculates the microporosity $\phi_{mic}$ based on the variation of organic matter in the soil. It is used in `pore_frac`

### Usage

```
phi_mic(
  My_mic,
  Mo_mic,
  My_mes,
  Mo_mes,
  gamma_o,
  f_agg = 3,
  clay,
  Delta_z_min,
  phi_min,
  phi_mac,
  f_text_mic
)
```

### Arguments

| | |
|---|---|
| My_mic | One of the four model pools (they are all summed up in this function for calculating the total) |
| Mo_mic | One of the four model pools (they are all summed up in this function for calculating the total) |
| My_mes | One of the four model pools (they are all summed up in this function for calculating the total) |
| Mo_mes | One of the four model pools (they are all summed up in this function for calculating the total) |
| gamma_o | density of organic matter |
| f_agg | an aggregation factor (m3 pore space m-3 organic matter) defined as the slope of the linear relationship assumed between the volume of aggregation pore space $V_{agg}$, and the volume of organic matter $V_{s_o}$ |
| clay | fraction of clay content |
| Delta_z_min | minimal soil thickness if no organic matter was present |
| phi_min | minimal porosity, user defined |
| phi_mac | macroporosity |

### Value

one single value

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## pore_frac    *The main accessory function of the model*

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### Description

This function calculates the proportion of inputs in each of the two youg pools deending on the organic matter content

### Usage

```
pore_frac(
  phi_mac,
  clay,
  Delta_z_min,
  gamma_o,
  My_mic,
  Mo_mic,
  My_mes,
  Mo_mes,
  phi_min,
  f_text_mic = NULL
)
```

### Arguments

| | |
|---|---|
| phi_mac | macroporosity |
| clay | fraction of clay content |
| Delta_z_min | minimal soil thickness if no organic matter was present |
| gamma_o | density of organic matter |
| My_mic | One of the four model pools (they are all summed up in this function for calculating the total) |
| Mo_mic | One of the four model pools (they are all summed up in this function for calculating the total) |
| My_mes | One of the four model pools (they are all summed up in this function for calculating the total) |
| Mo_mes | One of the four model pools (they are all summed up in this function for calculating the total) |

### Value

two values, the proportion of input in the mesopore and micropore Y pools

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Porous *The SOC decomposition model*

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### Description

This function implements with the SoilR model development framework the dual porosity model described in Meurer et al. (2020). The model is an evolution of a two-pool linear SOC model, with two pools (young and old material9) running in parallel for micro and mesopores. While aboveground inputs are rooted in the mesopores, root inputs are distributed between micro and mesopores depending on porosity, which is in turn influenced by organic matter. This makes the model nonlinear, although it still behaves similarly to a linear model within a reasonable calibration range. The model is described by a series of four equations:

$$\frac{dM_{Y_{(mes)}}}{dt} = I_m + \left(\frac{\phi_{mes}}{\phi_{mes}+\phi_{mic}}\right) \cdot I_r - k_Y \cdot M_{Y_{(mes)}} + T_Y$$
$$\frac{dM_{O_{(mes)}}}{dt} = \left(\epsilon \cdot k_Y \cdot M_{Y_{(mes)}}\right) - \left((1-\epsilon) \cdot k_O \cdot M_{O_{(mes)}}\right) + T_O$$
$$\frac{dM_{Y_{(mic)}}}{dt} = \left(\frac{\phi_{mic}}{\phi_{mes}+\phi_{mic}}\right) \cdot I_r - k_Y \cdot F_{prot} \cdot M_{Y_{(mes)}} - T_Y$$
$$\frac{dM_{O_{(mic)}}}{dt} = \left(\epsilon \cdot k_Y \cdot F_{prot} \cdot M_{Y_{(mes)}}\right) - \left((1-\epsilon) \cdot k_O \cdot F_{prot} \cdot M_{O_{(mes)}}\right) - T_O$$

Please refer to the original paper for more details.

The two porosity terms, $\phi_{mes} = f(M_{Y_{(mes)}}, M_{O_{(mes)}}, M_{Y_{(mic)}}, M_{O_{(mic)}})$ and $\phi_{mic} = f(M_{Y_{(mic)}}, M_{O_{(mic)}})$, are dependent on the variation of the different C pools and everything is variable over time, introducing a nonlinearity in the system and defining the biggest peculiarity of this model.
After substitutung the terms $\left(\frac{\phi_{mes}(t)}{\phi_{mes}(t)+\phi_{mic}(t)}\right) = \varphi_{mes}$ and $\left(\frac{\phi_{mic}(t)}{\phi_{mes}(t)+\phi_{mic}(t)}\right) = \varphi_{mic}$, The

model can be rewritten in matrix form as :

$I_m(t) + I_r(t) \cdot N(C,t) + A(t) \cdot P(t) \cdot C(t)$
Or, more explicitly:

$$\frac{dC}{dt} = \begin{bmatrix} I_m \\ 0 \\ 0 \\ 0 \end{bmatrix} + \begin{bmatrix} I_r \\ 0 \\ I_r \\ 0 \end{bmatrix} \cdot \begin{bmatrix} \varphi_{mes} & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & \varphi_{mic} & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} + \begin{bmatrix} -k_y & \epsilon & 0 & 0 \\ 0 & -k_o & 0 & 0 \\ T_Y & 0 & -k_y & \epsilon \\ 0 & T_O & 0 & -k_o \end{bmatrix} \cdot \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & F_{prot} & 0 \\ 0 & 0 & 0 & F_{prot} \end{bmatrix} \cdot \begin{bmatrix} M_{Y_{mes}} \\ M_{O_{mes}} \\ M_{Y_{mic}} \\ M_{O_{mic}} \end{bmatrix}$$

## Usage

```
Porous(
  ky = 0.8,
  ko = 0.00605,
  kmix = 0.9,
  e = 0.13,
  Im = 1.1,
  Ir = 0.5,
  F_prot = 0,
  phi_mac = 0.2,
  clay = 0.2,
  Delta_z_min = 20,
  gamma_o = 1.2,
  proportion = NULL,
  phi_min = 1,
  f_text_mic = NULL
)
```

## Arguments

| | |
|---|---|
| `ky` | decomposition constant of the Young pool |
| `ko` | decomposition constant of the Old pool |
| `kmix` | mixing rate |
| `e` | efficiency, which is the transfer term between the pools and corresponds to the term h in the ICBM model in Kätterer et al. (2001) |
| `Im` | Inputs from aboveground |
| `Ir` | Inputs from roots |
| `F_prot` | protection provided by the micropore space |
| `phi_mac` | macroporosity |
| `clay` | fraction of clay content |
| `Delta_z_min` | minimal soil thickness if no organic matter was present |

| | |
|---|---|
| gamma_o | density of organic matter |
| proportion | this is the linearization term. If NULL (or not specified, since default is NULL) then the model is running as nonlinear, as in the original paper. If specified (must be between 0 and 1) then the model is linearized adopting this value as fixed proportion of inputs from roots going into the mesopore space (and its reciprocal into the micropore) |
| phi_min | minimal porosity, user defined |

## Value

two values, the proportion of input in the mesopore and micropore Y pools

## References

Meurer, Katharina Hildegard Elisabeth, Claire Chenu, Elsa Coucheney, Anke Marianne Herrmann, Thomas Keller, Thomas Kätterer, David Nimblad Svensson, and Nicholas Jarvis. “Modelling Dynamic Interactions between Soil Structure and the Storage and Turnover of Soil Organic Matter.” Biogeosciences 17, no. 20 (October 19, 2020): 5025–42. https://doi.org/10.5194/bg-17-5025-2020.
Kätterer, Thomas, and Olof Andrén. “The ICBM Family of Analytically Solved Models of Soil Carbon, Nitrogen and Microbial Biomass Dynamics — Descriptions and Application Examples.” Ecological Modelling 136, no. 2–3 (January 2001): 191–207. https://doi.org/10.1016/S0304-3800(00)00420-8.

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