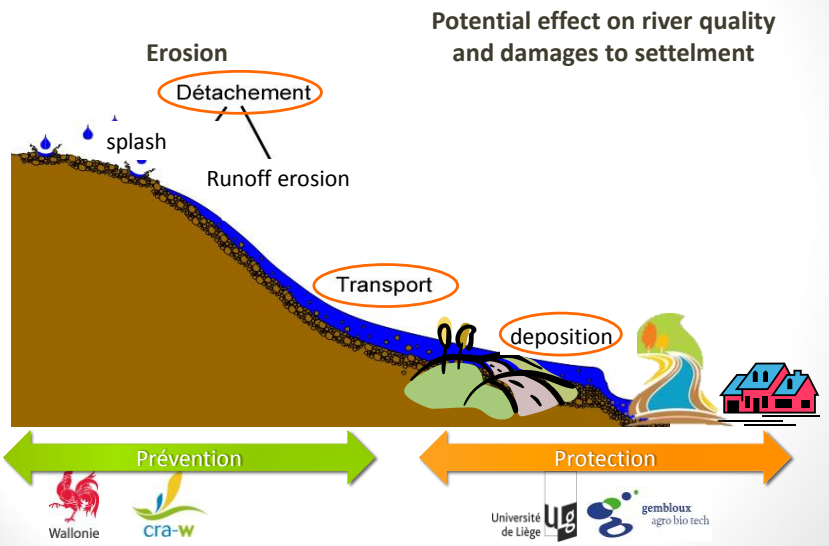
Surface water diffuse pollution by PPP: focus on runoff & erosion

B. Bah, L. Vandendael, R. Oger, A. Degré

Wallonie cra-w Université de Liège gembloux agro bio tech

Runoff and erosion risks



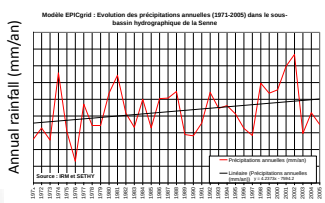
Wallonie cra-w Université de Liège gembloux agro bio tech

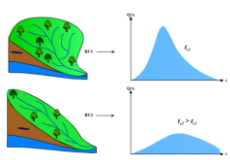
Some illustrations of the problems

Wallonie cra-w Université de Liège gembloux agro bio tech

3

The causes : rain, soil, slope, slope lenght, landuse (soil cover and watershed organisation)

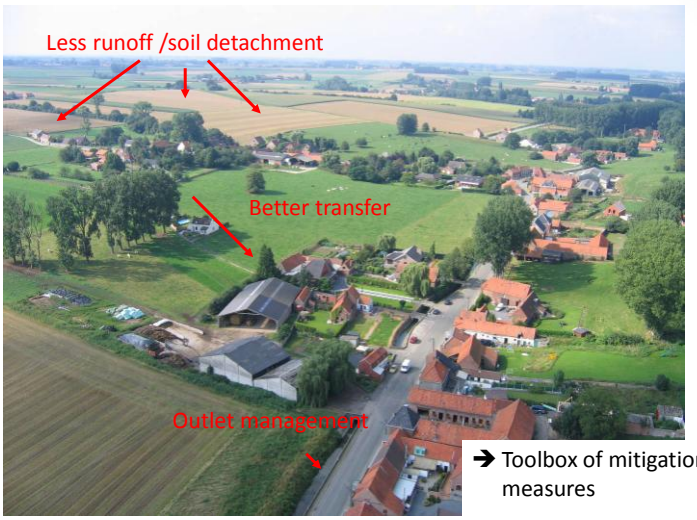




Wallonie cra-w Université de Liège gembloux agro bio tech

4

The solutions : in-field AND watershed management

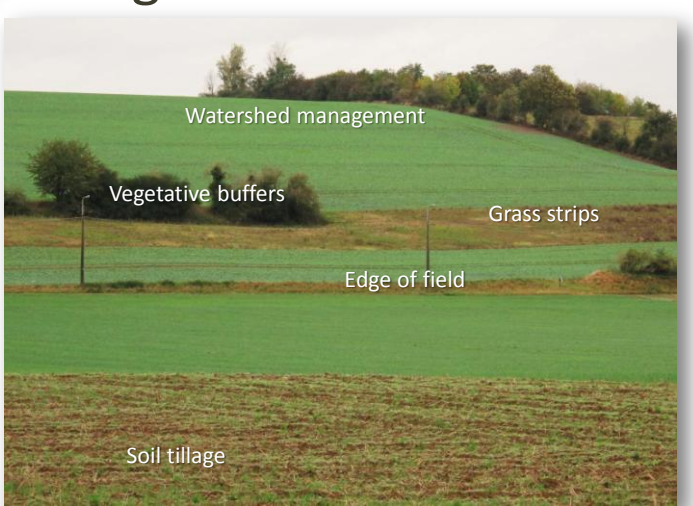


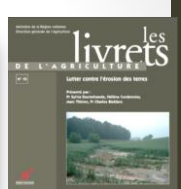
➔ Toolbox of mitigation measures

Wallonie cra-w Université de Liège gembloux agro bio tech

5

Mitigation measures





TOPPS PROWADIS

Wallonie cra-w Université de Liège gembloux agro bio tech

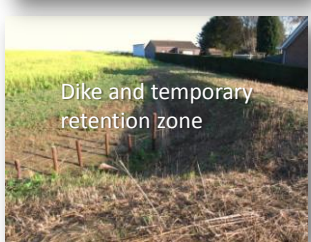
6

Mitigation measures (2)

Wallonie cra-w Université de Liège gembloux agro bio tech

7

Mid- and downhill protection



Wallonie cra-w Université de Liège gembloux agro bio tech

8

Which measure ??
Where??
When??

The « ERRUISSOL » Project

- **A focus on the very beginning of runoff and erosion phenomenon for <u>risk mapping</u>**
- ERosion
  - Diffuse erosion risk mapping
    - Slope, Rain erosivity, Soil erodibility mapping
    - Actual land use mapping
- *« RUISsellement »* ➔ Runoff
  - Runoff production mapping
  - Runoff concentration mapping
- *« SOL »* ➔ Soil
  - Soil map, one of the basic data

Diffuse erosion risk map

Calculated for each 10 x10m pixel

Soil losses [t/ha.an]
Fixed at a reference level admitted : 10 t/ha.an

Crop factor
Fixed for 3 land uses :
- Row crop
- Other crops
- Grassland

Practices to limit erosion
Fixed to 1

$$A = R.K.C.LS.P$$

Rain erosivity
On the basis of 30 years of daily observation and previous research aiming at R factor adaptation to the Walloon context

Slope and slope length
Slope mapping on the basis of DTM. Mapping of slope length, all other parameters known

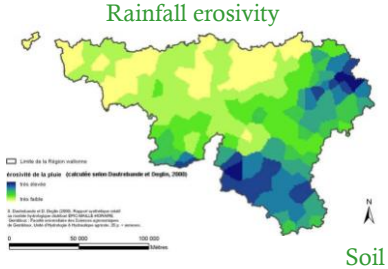
Soil erodibility
Systematic use of Wishmeier abacus and statistical analysis

Wallonie cra-w Université de Liège gembloux agro bio tech

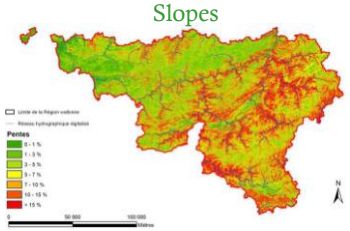
11

Diffuse erosion risk map

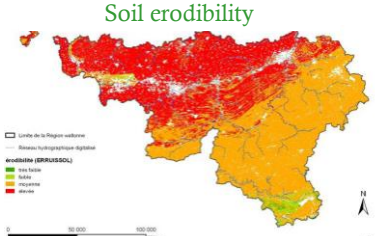
Rainfall erosivity



Slopes



Soil erodibility



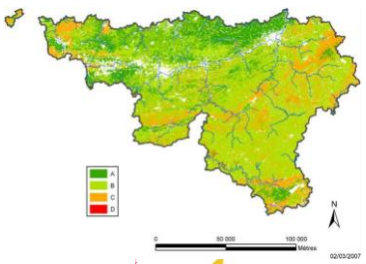
Wallonie cra-w Université de Liège gembloux agro bio tech

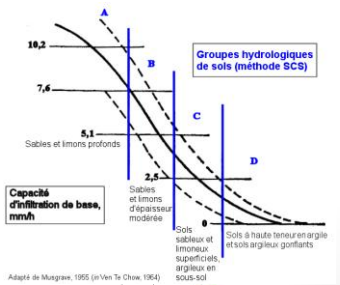
12

Runoff production risk map

Calculated for each 10 x 10 m pixel

- Which part of rain will infiltrate?
- Thus, which part will stream??
  - Soil Hydraulic groups mapping (on the basis of limit infiltration rate)
  - Land use map and slope map
    - ➔ estimation of CN (SCS abstraction method USDA)



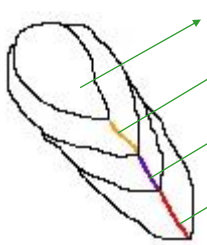


Wallonie cra-w Université de Liège gembloux agro bio tech

13

Runoff concentration risk map

- Risk definition (given for each pixel by its catchment area)



< 1 ha : insignificant risk

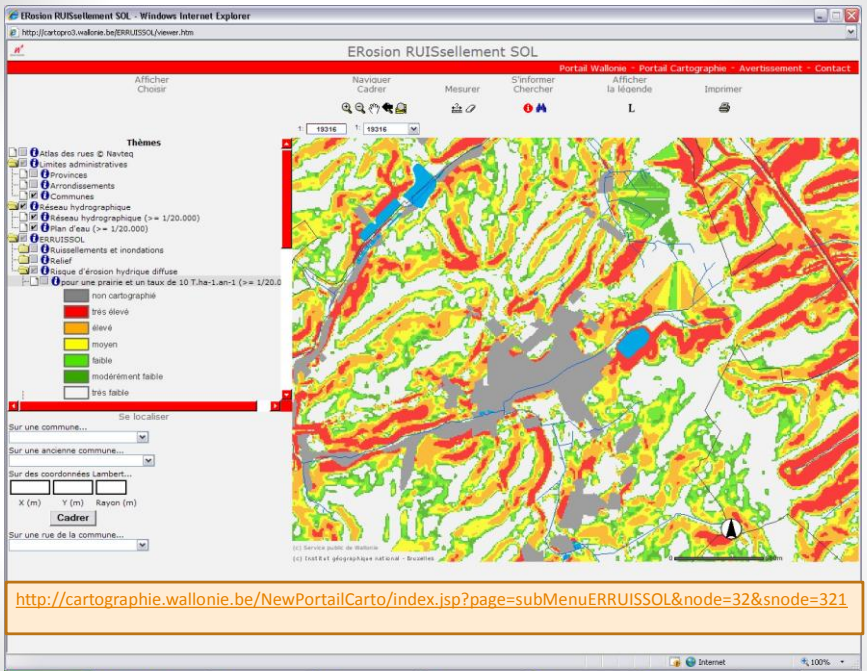
1< area < 9 ha : low risk

9 < area < 18 ha : intermediate risk

> 18 ha : high risk

Wallonie cra-w Université de Liège gembloux agro bio tech

14

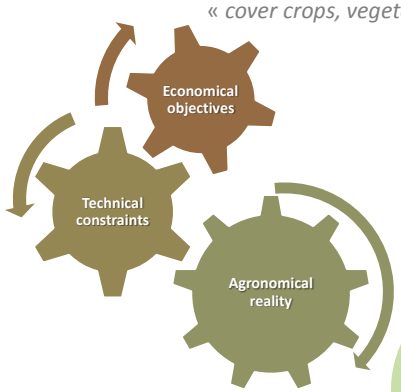


http://cartographie.wallonie.be/NewPortailCarto/index.jsp?page=subMenuERRUISSOL&node=32&snode=321

15

In the field, let's act!

« cover crops, vegetated strips, waterways, retention zones,… »



~~Recipy~~
Method

Avoid soil detachment and movment

To slow down and diffuse water

Drive and stock water to improve its quality and protect outlets

Wallonie

cra-w

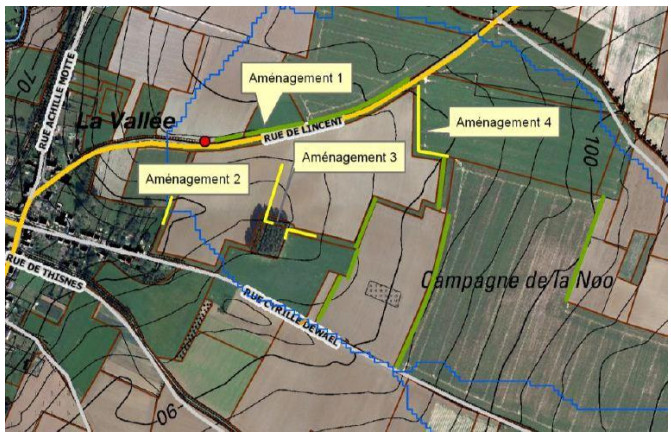
Université de Liège

gembloux agro bio tech

16

Objective : to find a combination of necessary and sufficient measures to limit erosion and excess runoff

- the right measures at the right places
- at field and watershed levels



Exemple : proposal for in field and watershed management to be discussed with the municipality and the farmers

Wallonie cra-w Université de Liège gembloux agro bio tech

17

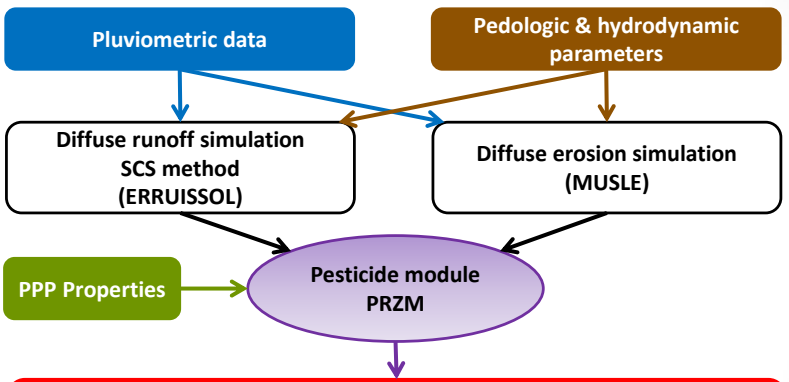
TOPPS-PROWADIS Stakeholder workshop 04/04/2012

PESTICIDES TRANSFERTS BY DIFFUSE RUNOFF & EROSION

Wallonie cra-w Université de Liège gembloux agro bio tech

18

Surface water transfert model



PRZM : Pesticide runoff loss

Carsel & al (2003) – PPP runoff loss estimation:

$$J_{r,i} = DRI_i . C_{w,i} . Q . 10$$

- $J_{r,i}$: pesticide runoff loss from compartment *i* [mg m^{-2}]
- DRI_i : fraction dissolved-phase chemical present in compartment *i* available for runoff [-]
- $C_{w\,i}$: concentration of dissolved pesticide in the water phase [mg dm^{-3}]
- *Q* : amont of surface runoff [cm] ← **ERRUISSOL**
- 10 : unit correction factor (dm^3 to m^3 & cm to m)

PRZM : Pesticide runoff loss

Carsel & al (2003) – PPP runoff loss estimation: $J_{r,i} = DRI_i.C_{w,i}.Q.10$

Concentration of dissolved PPP in the topsoil water phase (Cw_i)

- **Retention phenomena (Freundlich adsorption & desorption isotherm)**

$$Cs = K_f.Cw^n \quad \Rightarrow \quad K_d = \frac{Cs}{Cw} \qquad K_d = K_{oc}.OC$$

- Cs : concentration of adsorbed PPP in the solid phase [mg kg^{-1}]
- Cw : concentration of dissolved PPP in the water phase [mg dm^{-3}]
- Kf / Kd : Freundlich coef./soil-water adsorption coef. [dm^3 kg^{-1}]
- n : Freundlich exponent – affinity index of the PPP to the soil [-]

Wallonie cra-w Université de Liège gembloux agro bio tech

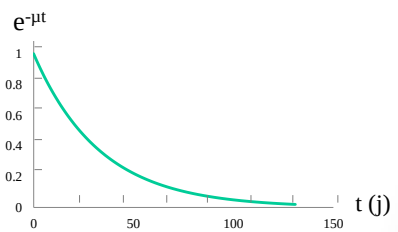
PRZM : Pesticide runoff loss

Carsel & al (2003) – PPP runoff loss estimation: $J_{r,i} = DRI_i.C_{w,i}.Q.10$

Concentration of dissolved PPP in the topsoil water phase (Cw_i)

- **Degradation phenomena (temporal first-order kinetics)**

$$\frac{\partial C}{\partial t} = -\mu.C = -\frac{\ln 2}{DT50}C$$



$$C_{tot}(t) = C_{tot}(0) \cdot \exp(-\mu \cdot t) = C_{tot}(0) \cdot \exp(-\frac{\ln 2}{DT50} \cdot t)$$

Wallonie cra-w Université de Liège gembloux agro bio tech

PRZM : Pesticide runoff loss

Carsel & al (2003) – PPP runoff loss estimation: $J_{r,i} = DRI_i.C_{w,i}.Q.10$

Concentration of dissolved PPP in the topsoil water phase (Cw_i)

- **Degradation phenomena (integration of the temporal first-order kinetics)**

$$C_{tot}(t) = C_{tot}(0)\cdot\exp(-\mu\cdot t) = C_{tot}(0)\cdot\exp(-\frac{\ln 2}{DT50}\cdot t)$$

$$C_{tot}(t) = \int C_{tot}(0).\exp(-\frac{\ln 2}{DT50}.t)dt = -\frac{DT50}{\ln 2}.C_{tot}(0).\exp(-\frac{\ln 2}{DT50}.t)$$

$$t : [0-365\ j] \quad C_{tot-mean} = -\frac{1}{365}.\frac{DT50}{\ln 2}.C_{tot}(0).\left(\exp(-\frac{\ln 2}{DT50}.365)-1\right)$$

- $C_{tot\text{-}mean}$: Average predicted total concentration in the soil layer before the rainfall event

PRZM : Pesticide runoff loss

Carsel & al (2003) – PPP runoff loss estimation: $J_{r,i} = DRI_i.C_{w,i}.Q.10$

Concentration of dissolved PPP in the topsoil water phase (Cw_i)

$$C_{tot,i} = Cw_i.\theta + Cs_i.\rho \quad \Rightarrow \quad C_{tot,i} = Cw_i.\theta + Cw_i.K_d.\rho$$

- $C_{tot,i}$: total concentration of PPP in the soil layer *i* [mg dm^{-3}]
- θ : volumetric soil moisture at field capacity [dm^3 dm^{-3}]
- ρ : bulk density [kg dm^{-3}]

$$Cw_i = \frac{C_{tot,i}}{\theta + K_d.\rho}$$

$$Cs = Kd.Cw$$

$$K_d = K_{oc}.OC$$

PRZM : Diffuse erosion

Carsel & al (2003) – PPP erosion loss estimation:

$$J_e = \frac{X_e . r_{om} . C_{s,i}}{10.A}$$

- J_e : Pesticide erosion loss [mg m^{-2}]
- X_e : Event soil loss [t] ← **MUSLE**
- A : Field size [ha]
- C_{si} : Concentration of adsorbed PPP in the solid phase in the top soil layer i [mg kg^{-1}]
- r_{om} : Enrichment ratio for organic matter of sediments eroded from the topsoil surface [-]
- 10 : Unit correction factor (t to kg & ha to m^2)

Wallonie cra-w Université de Liège gembloux agro bio tech

PRZM : Diffuse erosion

X_e : Event soil loss (MUSLE ; Williams, 1975):

$$X_e = 11{,}8.(Q.q_p)^{0,56}.K.LS.C.P$$

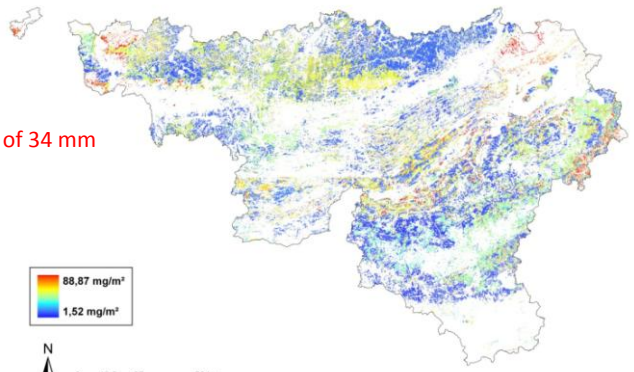
- Xe : Event soil loss [t]
- Q : Volume of event runoff
- q_p : peak storm runoff rate
- K : Soil erodibility
- C : Soil cover factor / crop management factor
- LS : Length-slope factor
- P : Conservation practice factor

Wallonie cra-w Université de Liège gembloux agro bio tech

Total Pesticide loss by diffuse runoff & erosion

Example for Isoproturon (DT50 : 23 d ; Koc : 36 dm³ kg^{-1})

Rainfall of 34 mm



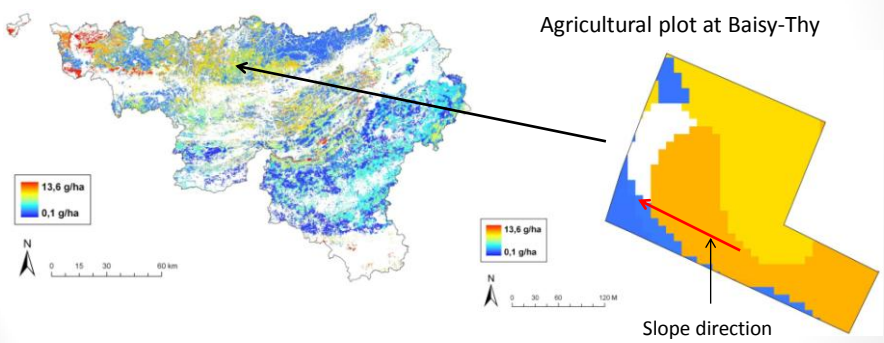
Wallonie cra-w Université de Liège gembloux agro bio tech

Total Pesticide loss by diffuse runoff & erosion

Example for Mancozeb (DT50 : 5 d ; Koc : 174 dm³ kg^{-1})

Rainfall of 34 mm

Agricultural plot at Baisy-Thy



Wallonie cra-w Université de Liège gembloux agro bio tech

Laurent Vandendael
Walloon Agricultural Research Center
Agriculture and Natural Environment
Soil Fertility & Water Protection

PESTEAUX project

l.vandendael@cra.wallonie.be
http://www.cra.wallonie.be

Aurore Degré
Ulg Gembloux Agro-Bio Tech
Soil – Water Systems

ERRUISSOL project
GISER project (www.giser.be)

aurore.degre@ulg.ac.be
http://www.gembloux.ulg.ac.be/ha
publications : http://orbi.ulg.ac.be