Consolidating simplified risk assessment models for pollutant leaching to and migration across groundwater

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Representative illustrations (TFE-Laura Vicini)
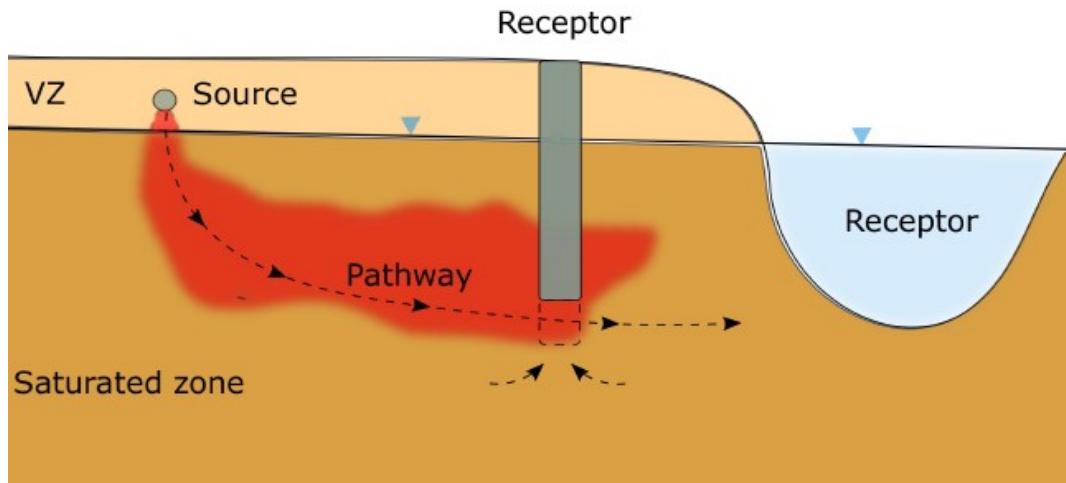
Fig. 1 Typical graphical Conceptual Model representation of RA for GW (SPR approach). Imagine made with Inkscape. The image is merely for explicative purpose. Scale is not respected.
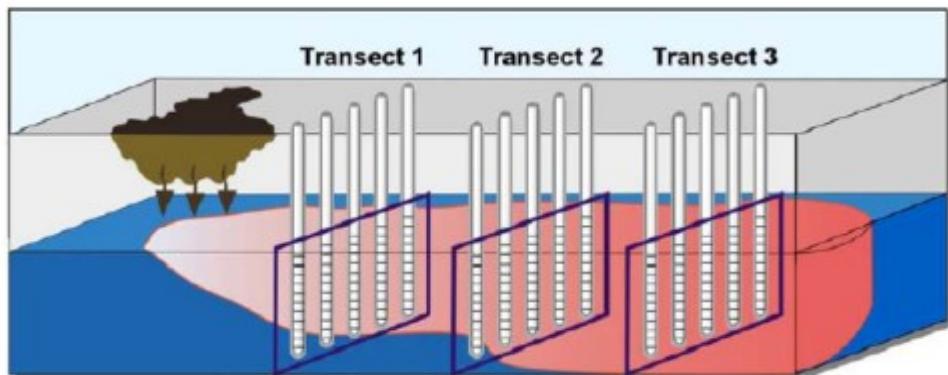
Fig. 2 Visual representation of multiple transects for measuring Mass discharge [50]
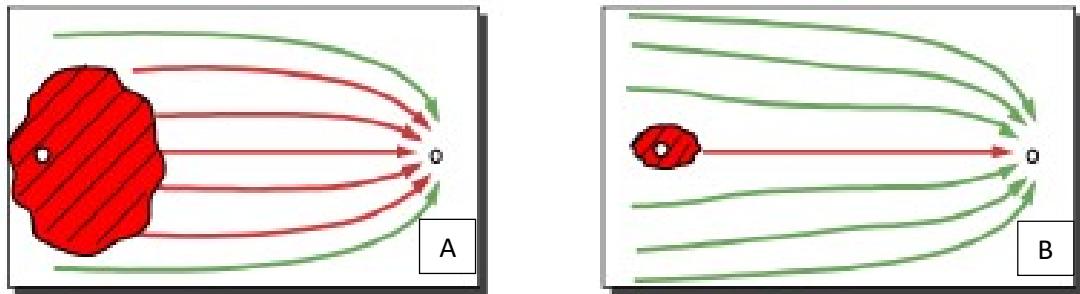
Fig. 3 Same concentration in case A and B but different risk. Case A has a large release: high max. Concentration and high mass discharge. Case B has a small release, high max. Concentration and low mass discharge [21].

Fig. 4 Effect of hydraulic conductivity on the mass flux. Concentration is not enough for risk assessing [21] originally readapted from [50]
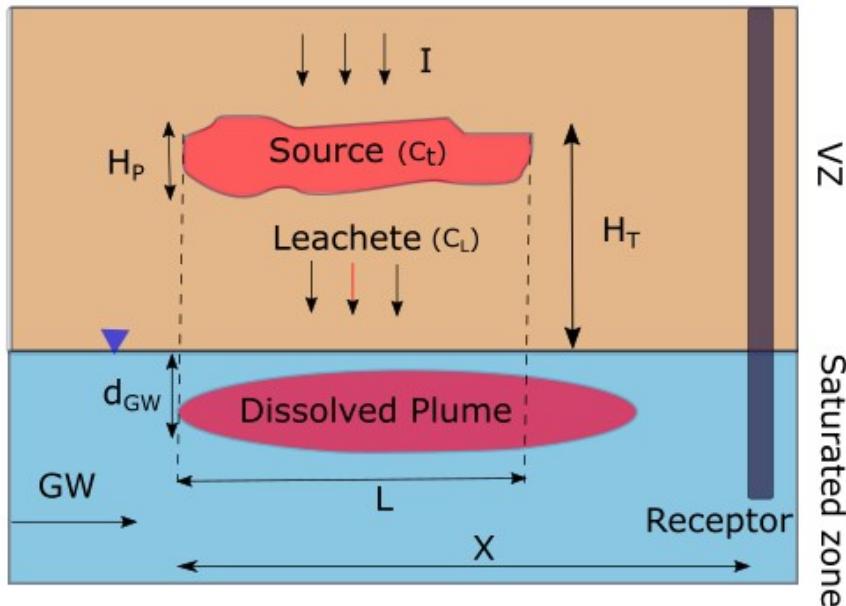
Fig. 5 Typical Conceptual Model used for estimating the movement of the pollutant from the vadose zone (VZ) towards GW and across it (inspired from Connor (1997). Some of the parameters commonly used are shown as well. Image done with Inkscape.

Where I is the infiltration rate [L/T], H_P is the thickness of the polluted VZ [L], H_T is the distance between the top of the pollution and the groundwater table [L], C_t is the total concentration measured in the soil sample [M/M], C_L is the leachate concentration [M/L^3], d_{GW} is the mixing zone thickness [L] and L is the length of the source parallel to the ground water flow [L].
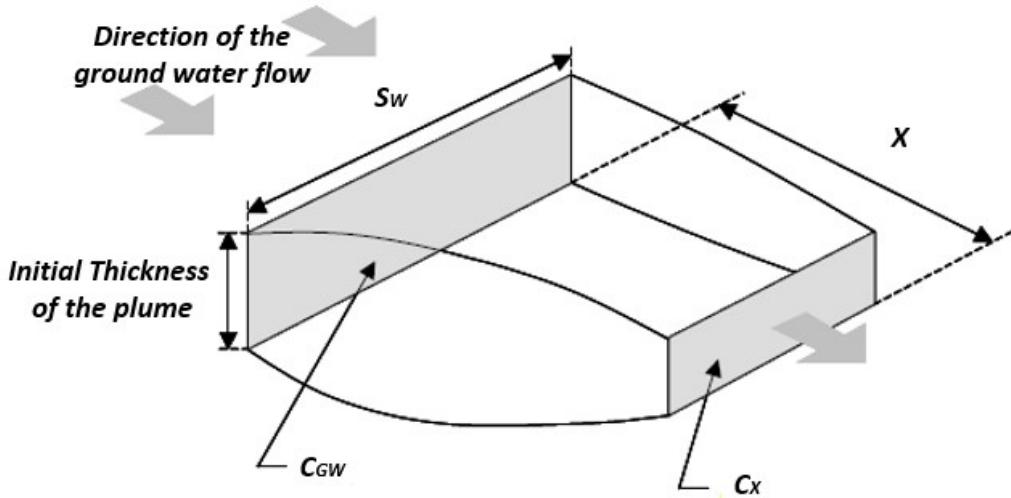
Fig. 6 Schematic representation of how tools simulate transport in the saturated zone [28] (originally from RBCA manual-Groundwater Service, 1998). Where Sw is the width of the source (length perpendicular to the GW flow) [L], C_{GW} and C_X are respectively the concentration at the source in GW and the concentration at the conformity point at a distance X [M/L³], X is the distance between the source and the receptor [L].
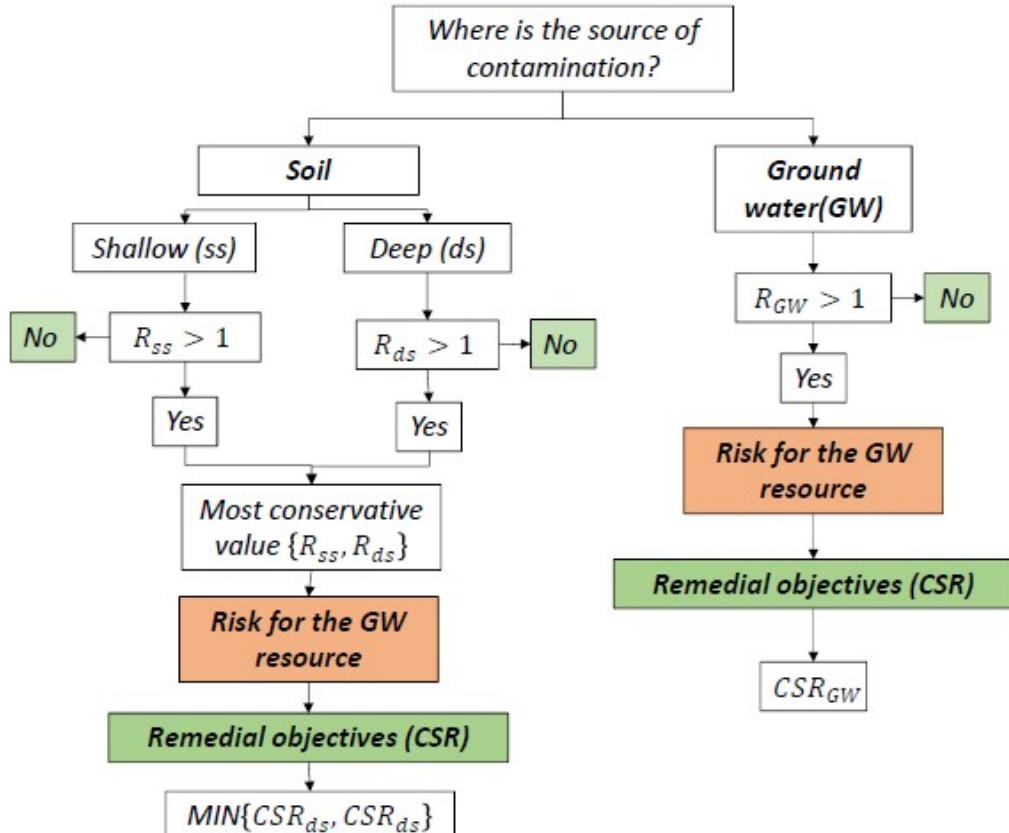
Fig. 7 Italian RA procedure for assessing groundwater pollution. Where Rss, Rds, R_{GW} are the risk factors computed respectively for the source of contamination in the shallow soil, deep soil and groundwater. CSR_{SS}, CSR_{dS} CSR_{GW} are the remedial objectives computed for shallow soil, deep soil and groundwater.

Fig. 8 English RA procedure for assessing groundwater pollution. Where RT_i is the remedial target at the i level of assessment or GW. $C_{Measured}$ is the measured concentration in soil or in groundwater.

Where is the source of contamination?

Soil

Level 1

$C_{Measured} > RT_1$ — No

Yes

Level 2

$C_{Measured} > RT_2$ — No

Yes

Level 3

$C_{Measured} > RT_3$ — No

Yes

Risk for the GW resource

Remedial Targets for soil (RT)

$RT_1 < RT_2 < RT_3$

Ground water(GW)

$C_{Measured} > RT_{GW}$ — No

Yes

Risk for the GW resource

Remedial Targets for GW (RT)

RT_{GW}

Fig. 8 English RA procedure for assessing groundwater pollution. Where RT_i is the remedial target at the i level of assessment or GW. C_{Measured} is the measured concentration in soil or in groundwater.

Where is the source of contamination?

Soil

Not exploitable Aquifer / Exploitable Aquifer

No — $C_{Measured} > VI_{ADJ}$ $C_{Measured} > VS_{ADJ}$ — No

No — $C_{Measured} > CBR_N$

$T_{Leaching} < 100\ years$ — Yes

No

"Serious Treat"

Remediate   EDR

Ground water(GW)

Not exploitable Aquifer / Exploitable Aquifer

No — $C_{Measured} > VI_{GW}$ $C_{Measured} > VS_{GW}$ — No

C_{Max}

Not exploitable Aquifer / Exploitable Aquifer

No — $C_{Max} > VI_{GW}$ $C_{Max} > VS_{GW}$ — No

"Serious Treat"

Remediate   EDR

Fig. 9 Walloon RA procedure for assessing groundwater pollution. Where C_{Measured} is the measured concentration in soil or groundwater, VS_{ADJ} and VI_{ADJ} are the adjusted threshold and Intervention value, CBR_N is the maximal concentration at the source to respect VI_{GW} at the receptor, T_{Leaching} is the computed leaching time, VS_{GW} and VI_{GW} are the threshold and intervention groundwater standards and C_{Max} is the maximal concentration at the receptor modelled with BIOSCREEN-AT tool.
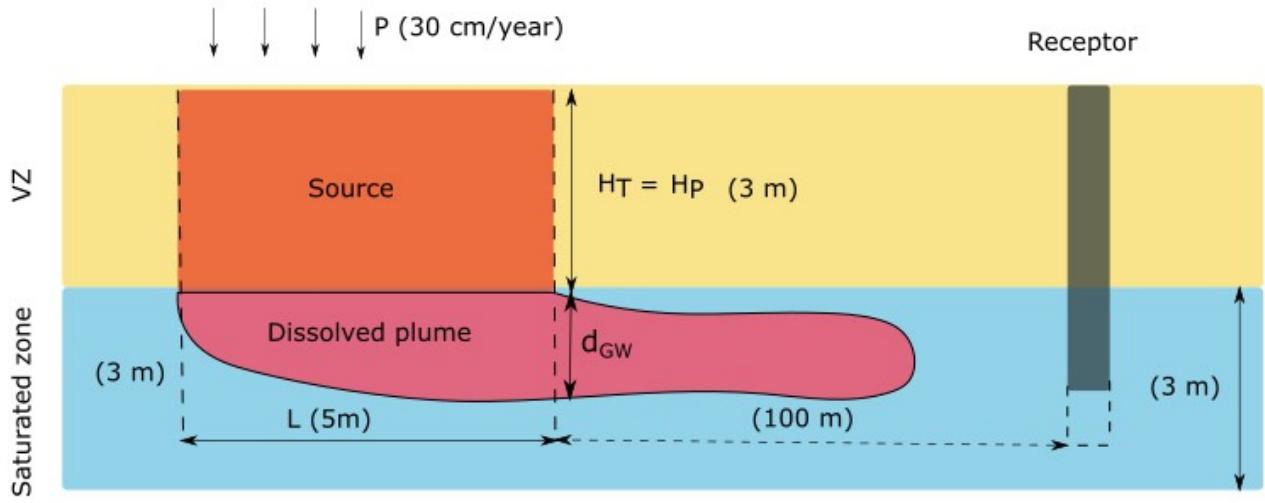
Fig. 10 Synthetic case inspired by Connor (1997). Where P is the precipitation, Hp is the thickness of the polluted soil in the unsaturated zone, H_T is the distance from the top of the source to GW table, d_{GW} is the mixing zone thickness, and L is the length of the source parallel to the GW flow.
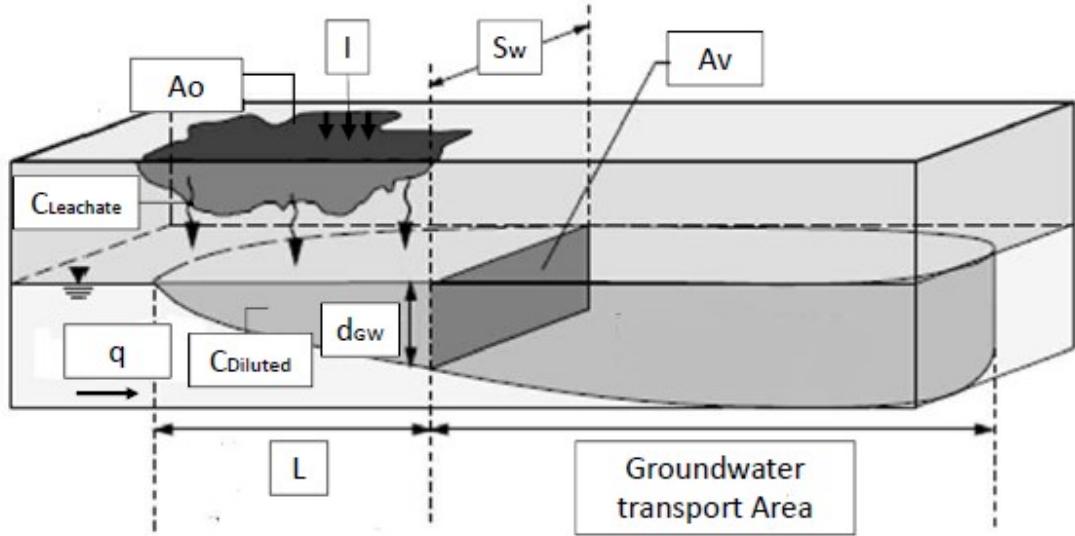
*Fig. 11 Schematic representation of the factors used for computing the Mass discharge. Original imagine from [23].*

Where I is the infiltration rate [L/T], A_O is the Horizontal polluted area [L^2], A_V is the vertical polluted area [L^2],$C_{Leachate}$ is the leachate concentration [M/L^3], $C_{Diluted}$ is the diluted concentration [M/L^3] q is the GW flow [L/T], Sw is the width of the contaminated source perpendicular to the groundwater flow, L is the length of the contaminated source parallel to groundwater [L] and d_{GW} is the initial thickness of the plume put equal to the mixing zone thickness [L].