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

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**Faculté :** Faculté des Sciences appliquées

**Diplôme :** Master en ingénieur civil des mines et géologue, à finalité spécialisée en géologie de l'ingénieur et de l'environnement

**Année académique :** 2016-2017

**URI/URL :** <http://hdl.handle.net/2268.2/3253>

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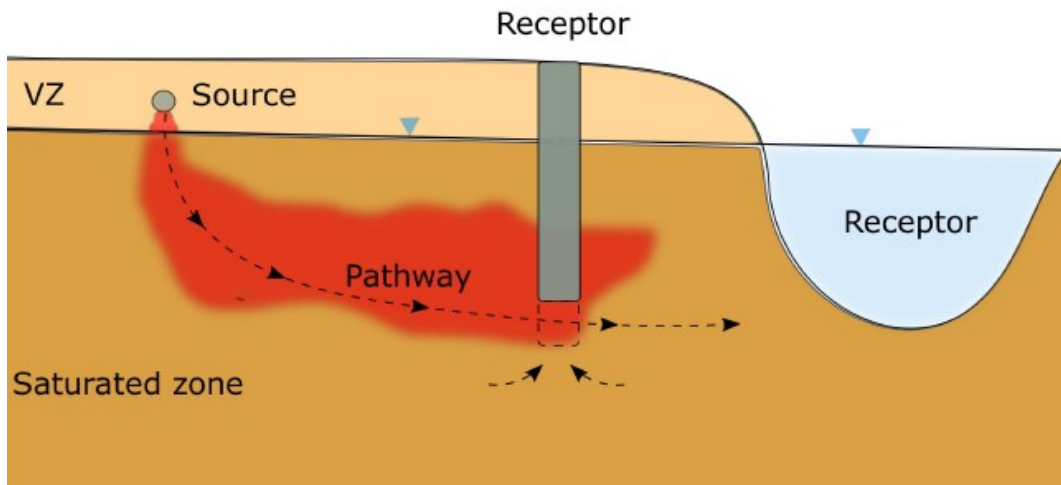
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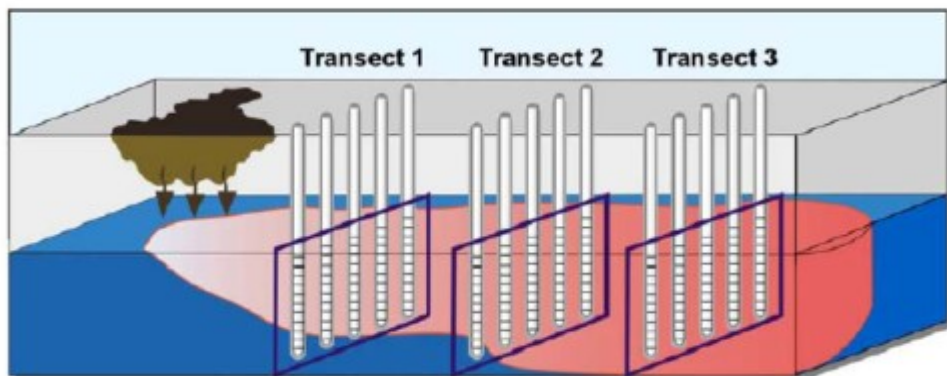
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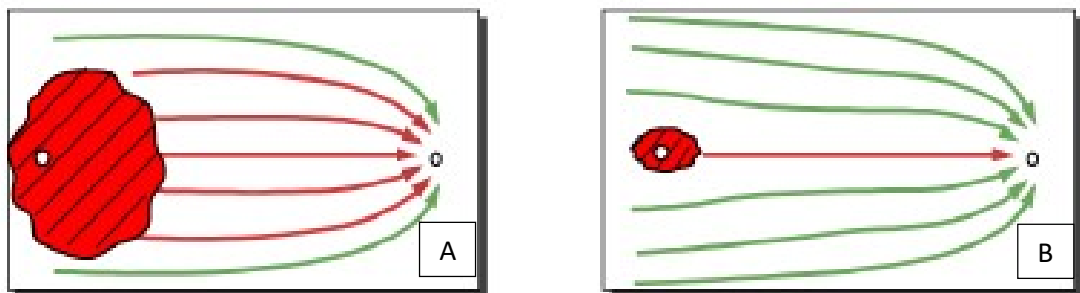
*Representative illustrations (TFE-Laura Vicini)*



*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].*

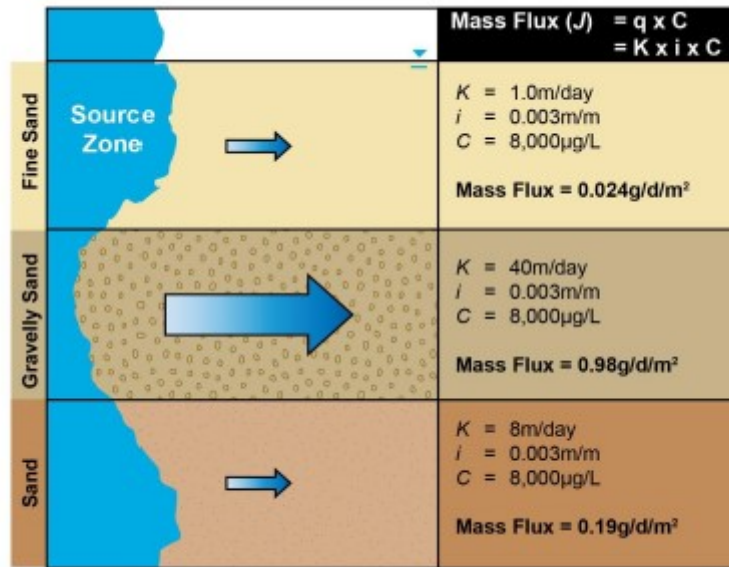


Fig. 4 Effect of hydraulic conductivity on the mass flux. Concentration is not enough for risk assessing [21] originally readapted from [50]

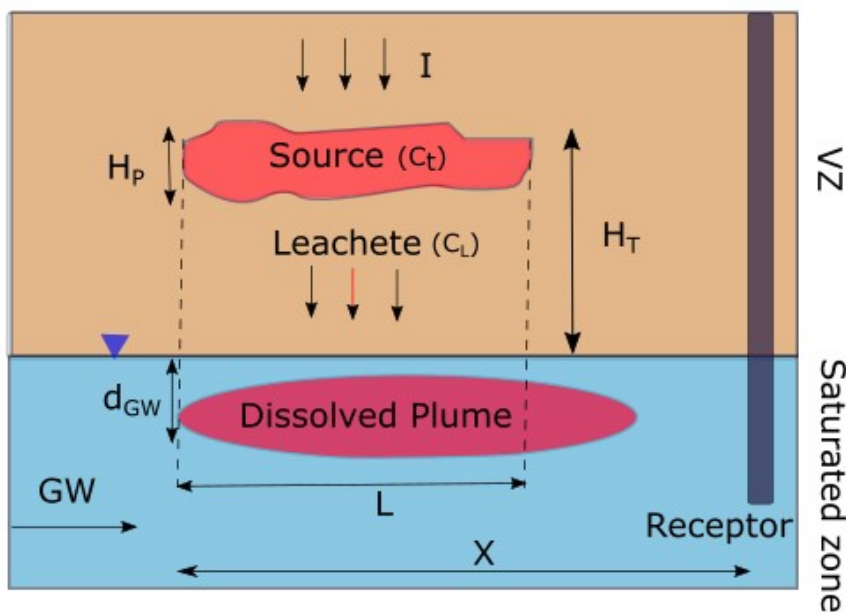


Fig. 5 Typical Conceptual Model used for estimating the movement of the pollutant from the vadose zone (VZ) towards GW and across it (inspired from Connor (1997)). Some of the parameters commonly used are shown as well. Image done with Inkscape.

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  $[L]$ .

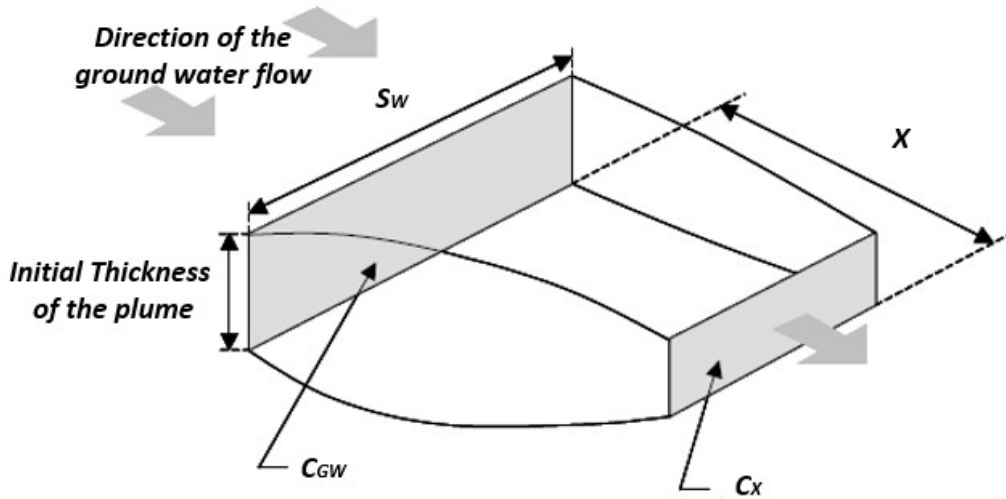


Fig. 6 Schematic representation of how tools simulate transport in the saturated zone [28] (originally from RBCA manual-Groundwater Service, 1998). Where  $S_w$  is the width of the source (length perpendicular to the GW flow) [L],  $C_{GW}$  and  $C_x$  are respectively the concentration at the source in GW and the concentration at the conformity point at a distance  $X$  [ $M/L^3$ ],  $X$  is the distance between the source and the receptor [L].

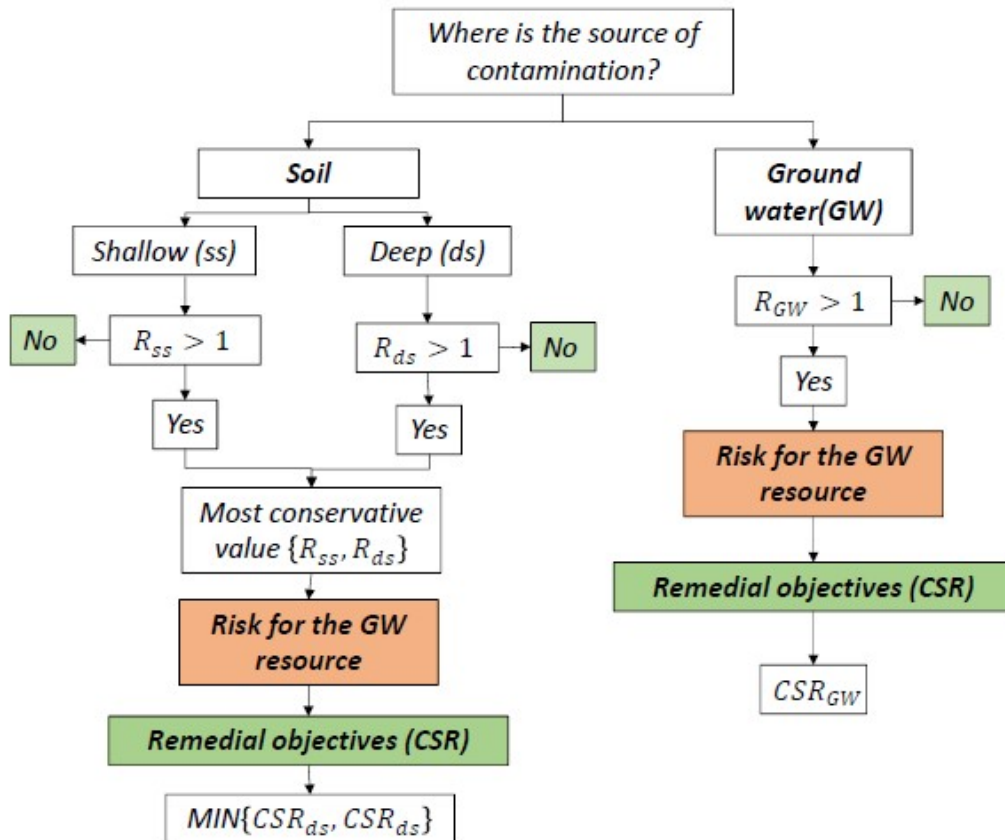


Fig. 7 Italian RA procedure for assessing groundwater pollution. Where  $R_{ss}$ ,  $R_{ds}$ ,  $R_{GW}$  are the risk factors computed respectively for the source of contamination in the shallow soil, deep soil and groundwater.  $CSR_{ss}$ ,  $CSR_{ds}$ ,  $CSR_{GW}$  are the remedial objectives computed for shallow soil, deep soil and groundwater.

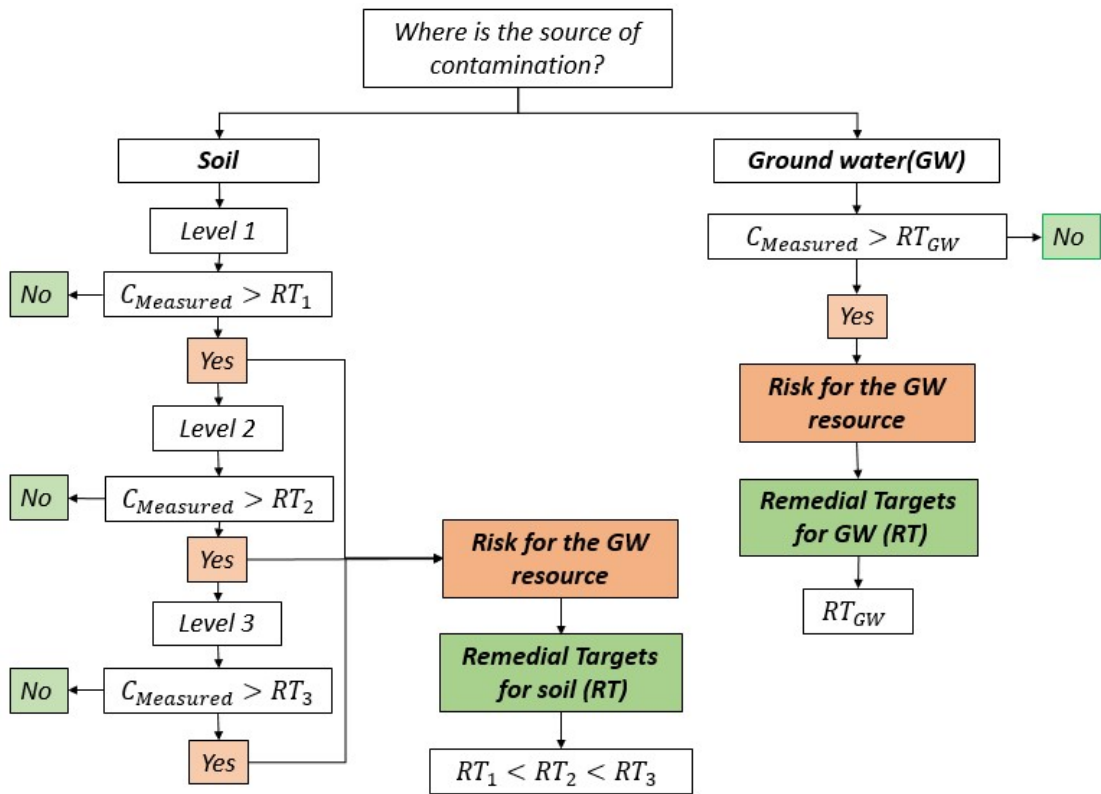


Fig. 8 English RA procedure for assessing groundwater pollution. Where  $RT_i$  is the remedial target at the  $i$  level of assessment or GW.  $C_{Measured}$  is the measured concentration in soil or in groundwater.

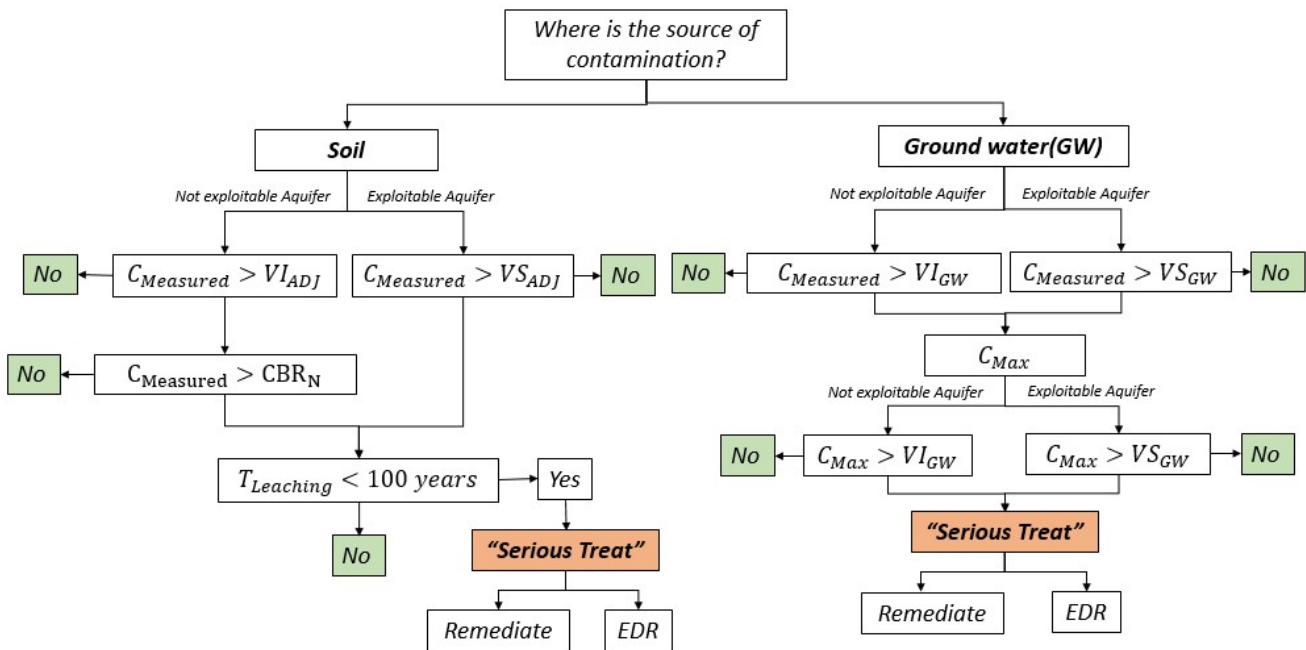


Fig. 9 Walloon RA procedure for assessing groundwater pollution. Where  $C_{Measured}$  is the measured concentration in soil or groundwater,  $VS_{ADJ}$  and  $VI_{ADJ}$  are the adjusted threshold and Intervention value,  $CBR_N$  is the maximal concentration at the source to respect  $VI_{GW}$  at 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.

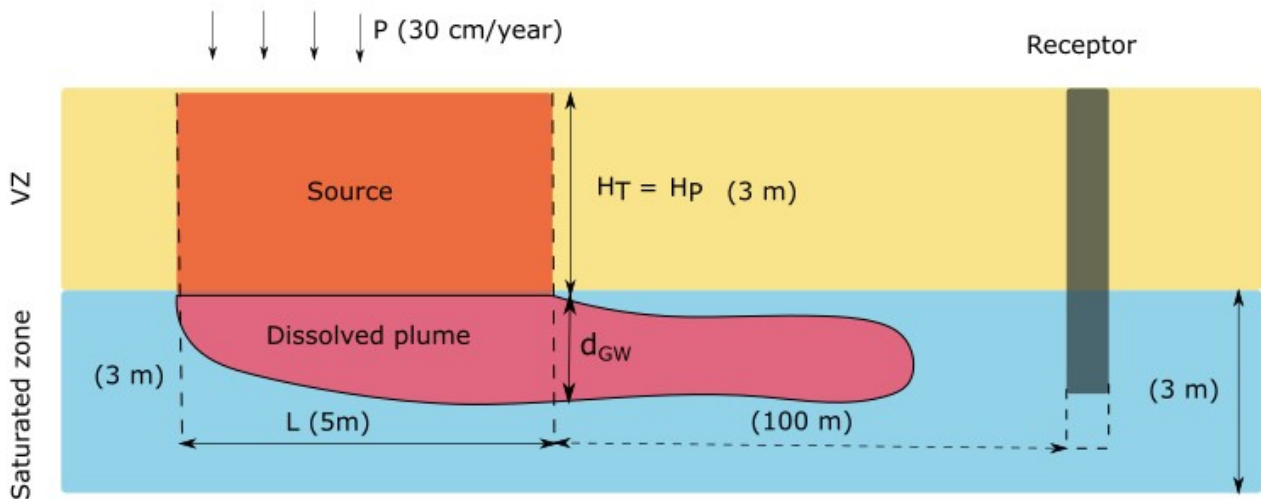


Fig. 10 Synthetic case inspired by Connor (1997). Where  $P$  is the precipitation,  $H_p$  is the thickness of the polluted soil in the unsaturated zone,  $H_T$  is the distance from the top of the source to GW table,  $d_{GW}$  is the mixing zone thickness, and  $L$  is the length of the source parallel to the GW flow.

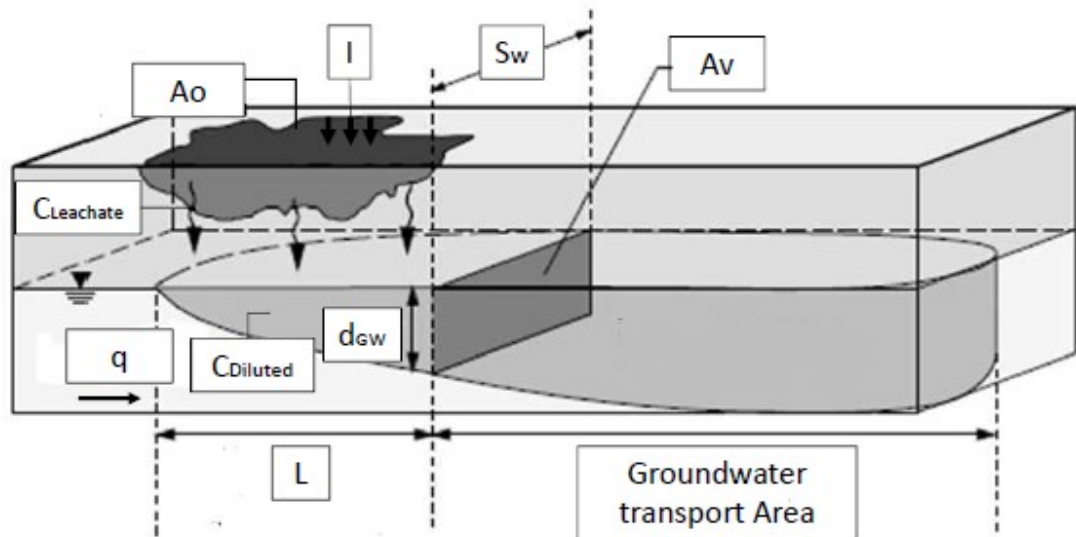


Fig. 11 Schematic representation of the factors used for computing the Mass discharge. Original image from [23].

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  $[L/T]$ ,  $S_w$  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  $[L]$ .