Technical sheet

Policy
Europe: *Council Directive 91/676/EEC of 12 December 1991 protection of waters against pollution caused by nitrates from agricultural sources; Directive 2000/60/EC of 23 October 2000 framework for Community action in the field of water policy; Directive 2006/118/EC of 12 December 2006 on the protection of groundwater against pollution and deterioration, EU Soil Strategy for 2030 COM(2021) 699 final*
Italy: *Legislative Decree 3 aprile 2006, n. 152*
Campania Region: *Regional Law 22 November 2010, n. 14 "Protection of waters against pollution caused by nitrates of agricultural origin"; Regional Council Resolution "Regional technical discipline for the agronomic use of farmed effluents".*

First draft

TOOL GROUNDWATER VULNERABILITY ASSESSMENT
Pesticide fate tool– *Territorial Scale: Local, Regional*

WHY

Through the European Union, high concentrations of nitrates and pesticides represent one of the main risky sources of the pollution for the groundwater resources and have potential long-term impacts on the environment and human health. Consequently, it is important to develop tools which enable us to map the most vulnerable zones with respect to specific land uses.

FOR WHOM

This tool is aimed at helping Public Authorities (Administrative Regions) and Agriculture cooperatives and consortia who need instruments to better relate agricultural activities to groundwater preservation, analysing the natural filtering capacity of the soils under different land use conditions in order to protect the precious groundwater resource.

HOW – if you want to *select your Region Of Interest (ROI)*[i]

The tool works all over the Telesina Valley (IT), Campania Region (IT), the Marchfeld Region (AT), the Zala County (HU) and RMEL area allows the free selection of any region of interest (ROI) following a very simple procedure:

Operational procedure

- Click on the "Draw (Polygon)" button on the top bar, draw the desired area (ROI) and assign it a name[ii].
- Use the "Save" button to store the ROI in the memory of the system. It is then possible to select it whenever necessary.

TOOL PESTICIDE FATE

HOW – if you want to use the "Pesticide fate"

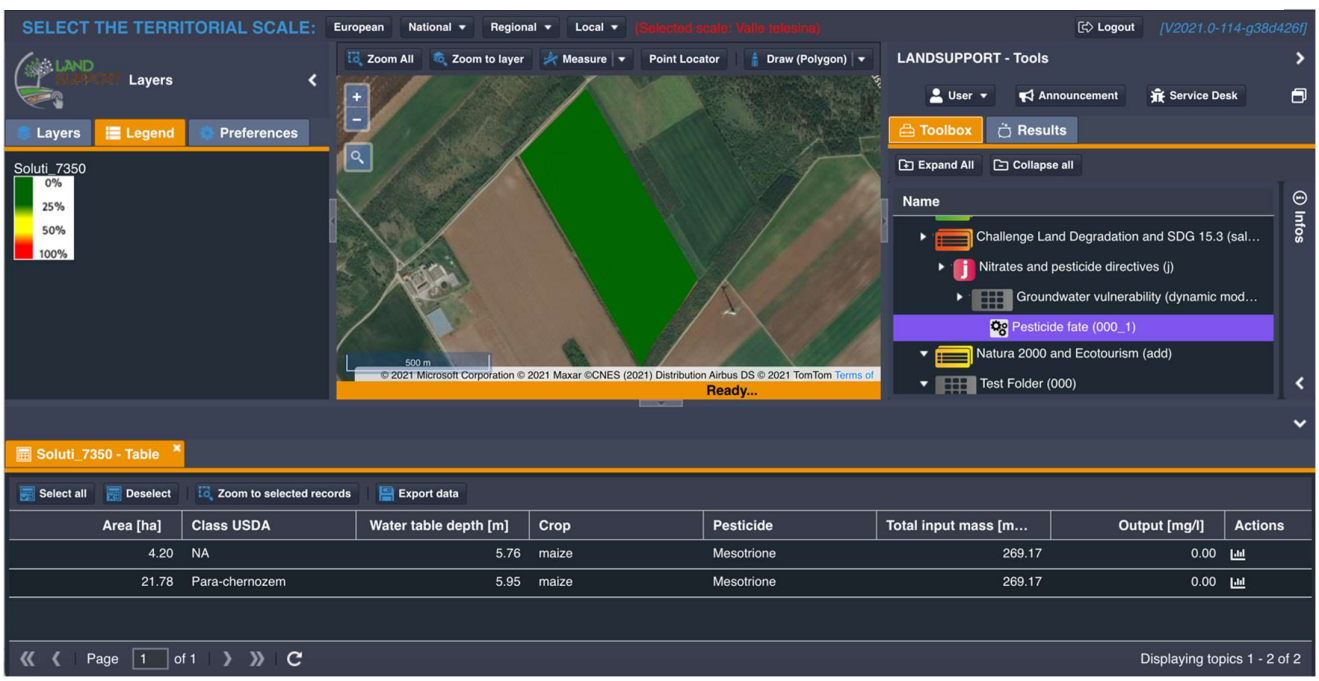
Operational procedure

The "Pesticide fate" tool for the groundwater specific vulnerability assessment, can be selected from the toolbox on the right of the Graphic User Interface. By clicking on the" Nitrates and Pesticide directives" button, then of "Groundwater vulnerability (dynamic modelling)" icon and then on the "Pesticide fate" button, it is possible to select i) the ROI previously drawn and saved, ii) a start and an end year of simulation, iii) a specific crop, defined according the local land uses and iv) a crop-related pesticide [iii].

By clicking on the "Results" section, the model produces a summary table connecting the different soils in the ROI with their filtering capacity, which is calculated as the percentage of pollutant mass that reaches the groundwater depth at the end of the simulation period. To get more information, clicking on the map, usually called "Soluti_RUNID", the end-user will have access to the full table with all the info regarding the soils, the groundwater table depth, the selected crop and pesticides, the total input mass [kg/ha], the output concentration mass [µg/l] at the end of the simulation period. Eventually, by clicking on the "Action" button in the last column of the full table, a graph shows, for each soil polygon within the ROI, the time evolution of the arrival concentration (%) at the groundwater depth.

What for

The information obtained provides support for mapping groundwater vulnerable zones, thus providing a basis for agricultural restrictions or incentives, for a better information in terms of different soil types response related to different land uses and pesticides.



LIMITATIONS

The pesticide fate tool works on a modelling chain based on the main soil type of the area of interest. The soil type is obtained from the soil map for each of the regions (or subregions). The filtering capacity of the soil can only be evaluated for time periods longer than one year, when we can assume that the stationarity of the processes is reached. Only the most important chemical processes are modelled (decay and retardation). The pesticide database is only partially complete, due to the unavailability of some chemical parameters. Pesticide metabolites are not available. The tool requires further validations versus real measurements.

FUTURE DEVELOPMENT

New outputs are going to be added, such as the graphs with the time variation of the output concentrations and the maps with iso-concentrations. We seek to let the user upload his own soil data and land use in order to get customised information about the area of interest.

Background

Model: the Extended Transfer Function Model (TFM-ext)

The pesticide fate tool is based on the newly developed extended Transfer Function Model (Bancheri et al., 2021). TFM-ext is able to simulate the spatio-temporal distribution of non-point-source pollutants, along the unsaturated zone, at different spatial scales. It computes the times that the generic solute particles take to travel across the soil from the surface of application to the groundwater table depth. Travel times are considered as random variables, which can be described through pdfs: their convolution with the concentrations in input at the surface of the soils allows to compute the breakthrough curves at a given depth. In this case the model was specifically expanded to consider the transport of reactive solutes, such as pesticides.

Input datasets

- Spatialized meteorological forcing (annual precipitation, annual reference evapotranspiration);
- Spatialized soil database (horizons, hydraulic parameters, textures and more);
- Spatialized water table depth;
- Type of crop and related common-management;
- Pesticides input concentration (dose, BBCH of application, degradation params).

The model was validated against concentration experiments carried out on four large soil columns (Bancheri et al., 2021). Besides, the outputs obtained by applying the TFM-ext model, considering a non-reactive solute and 46 soil profiles, sampled in the Valle Telesina, in Southern Italy, completely characterised from the hydrological point of view, were compared with those obtained from the Richard-based model Hydrus 1D.
Results of the comparison can be expressed computing the indices of goodness of agreement and the related upper and lower confidence intervals, using a bootstrap procedure:

Index	value	LL	UL
Root Mean Square Error index	70.15	56.44	81.86
Relative Root Mean Square Error index	0.25	0.21	0.28
Bias index	-44.05	-59.78	-24.75
rbias index	-0.16	-0.21	-0.10
fac2	1.00	1.00	1.00
FB index	-0.17	-0.24	-0.11
mgb index	0.86	0.80	0.92
d_agreement index	0.85	0.78	0.91
Pearson correlation index	0.84	0.75	0.90
determination coefficient R2	0.70	0.55	0.82
ef	0.50	0.21	0.70
ef1	0.34	0.19	0.47
IPQ	0.68	0.57	0.75
slope simulated vs observed	1.06	0.84	1.35

It is immediately clear that there was a really good agreement between the two models, with a correlation coefficient of 0.84, a percent bias of −15.8 %, a high mgb index of 0.86 and the regression line almost parallel to the bisector (coefficient of 1.06).

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[i] Special care is required when user draws/select the Region of Interest. In fact LANDSUPPORT is a multi-scale decision support system. Each of the 15 available tools is designed for a specific application and for a specific scale. Furthermore, the databases using specific standards required for that specific scale. The users of LANDSUPPORT web platform must therefore be well aware of the limitation embedded in the different maps that they require for their specific application. The users must be expert on their specific problem and must understand if the input data offered by the platform are suitable for their problem. In light of the above, the system provides very reliable results only if used appropriately.

[ii] It is also possible to draw a ROI with numerous polygons. In this case, it is possible to assign different values (eg numbers) to each of the drawn polygons.

[iii] The use of some pesticide is conditioned to the appearance of the pest. Therefore, for them, a standard management was considered, according to literature references.

REFERENCES

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