Standard Scenarios, Critical View

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***Abstract*- The considerable data processing power available to everyday user has stimulated investigations into how mathematical modelling of predicted PPP concentrations can be used in environment protection. A small region in the north-eastern part of Slovenia was selected as a test site. According to used crops in that region, two PPPs were selected (Verita for vine and Poncho for corn). The selection of crops also influenced the selection of two representative locations (Tešanovci and Jeruzalem). Two important questions arose while running the simulations. The first one is not connected with the selection of above locations and PPPs. There is very little probability that all FOCUS scenarios belong to the same statistical population. The second question deals with a problem that is more tightly connected with environment protection. The method of calculation accepted in the FOCUS document has a serious drawback - 80% values of predicted concentrations. Daily concentrations in leachate are an order of magnitude higher! In locations of shallow and poor groundwater margin the permissible concentrations of active substances will be exceeded!**

Keywords- Environment Protection; Matematical Modelling; Model PELMO; Plant Protection Products; Standard Scenarios

I. INTRODUCTION

There are a lot of factors that cause environmental degradation. Among them PPPs (Plant Protection Products) play a very important role. To predict concentrations of active substances and their metabolites in soil and leachate, the use of mathematical models predominates. The FOCUS group has selected four mathematical models and provided nine standard scenarios in its document [2].

This paper is based on an MSc thesis submitted in the year 2008. Review of publications at that time shows that no questions have been raised regarding the appropriateness of standard scenarios for regions of EU covered in the original work of the FOCUS group. There is also only one publication treating this question for regions not included in the original work of the FOCUS group [5]. In the year 2009 the FOCUS group released a new version of groundwater report [6]. Findings in that report did not negate the conclusions in discussion.

The Council Directive concerning the placing of plant protection products on the market [1] on pages 18 and 19 defines the method for calculating annual concentrations of an active substance and its metabolites in groundwater on pages 18 and 19. On page 110 there is a short discussion on which year should be used: hydrological year or calendar year. We found no comment in literature that calculation of 80 % values can be misleading.

All four proposed mathematical models show very high accordance in predicted concentrations [3]. We decided to use the PELMO model. The principal reasons for this selection were the very simple way of changing input data and good agreement with field studies [4]. Next we had to select the PPPs. Our choice was influenced by the contemporary agricultural practice in Slovenia and the dominating crops on the selected locations. We will therefore present results obtained for Verita and Poncho. Verita has two active substances: fosetil Al (CAS No. 39148-24-8) and fenamidon (CAS No. 161326-34-7), whereas Poncho only has one active substance klotianidin (CAS No. 210880-92-5).

II. SIMULATIONS

Climatic data and soil data change in Slovenia at very short distances. Selected locations Tešanovci (Te) and Jeruzalem, more precisely Kogel (Ko), are only 25 km apart. They both have in their vicinity weather stations with sufficiently long series of climatic data. There are some minor errors in those series that are rectifiable without a significant impact on the final result. Soil data for both locations are only partially quantitative. Some qualitative descriptions were converted into quantitative by comparing with locations where both are available (i.e. organic matter content). In principle, dossiers prepared for registration of PPPs should include all the data required for simulations. We still need to find some data in accessible public databases (separately for metabolites of active substances). We also generated a "worst case" location Kogel-Tešanovci (KT) by taking the worst data from both locations (climatic data from Kogel and soil data from Tešanovci, which is a highly probable situation in the observed region).

We ran simulations with standard scenarios for 26 years. We extrapolated the climatic data for 10 years from 1996 to 2005 to 26 years in the same way as used in standard scenarios for regions with too short climatic series. By selecting years for run-in in a 6 year period we avoid the problem of leap/non-leap years. The simulation results are summarized in Figure 1 and Figure 2. To facilitate discussion we also include the simulation data in tabular form (Table 1 and Table 2).

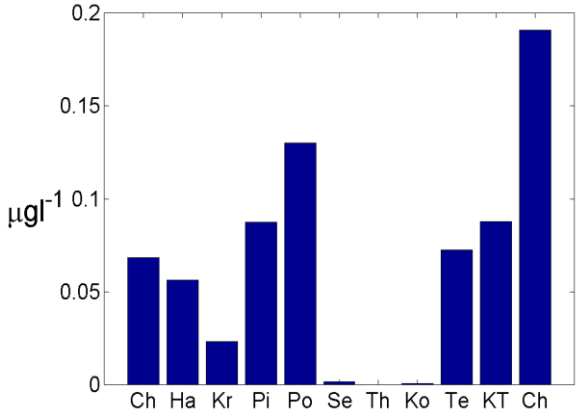

Fig. 1 Predicted concentrations of active substance Fosetil Al at 1m depth

Legend: Ch – Chateudon, Ha – Hamburg, Kr – Kremsmünster, Pi – Piacenza, Po – Porto, Se – Sevilla, Th – Thiva, Ko – Kogel, Te – Tešanovci in KT – Kogel_Tešanovci.

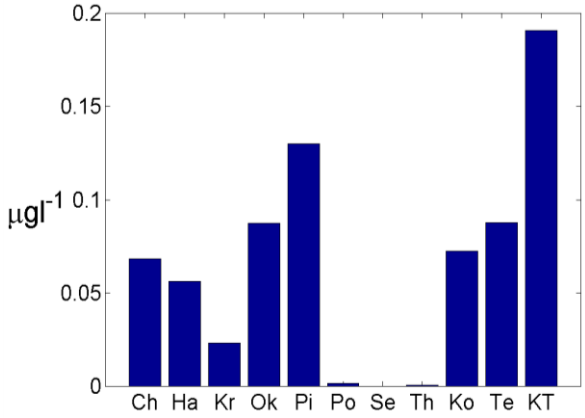

Fig. 2 Predicted concentrations of active substance Klotianidin at 1m depth

Legend: Ch – Chateudon, Ha – Hamburg, Kr – Kremsmünster, Ok – Okehampton, Pi – Piacenza, Po – Porto, Se – Sevilla, Th – Thiva, Ko – Kogel, Te – Tešanovci in KT – Kogel_Tešanovci.

We were also interested in how consecutive applications as required by Verita influence concentrations of the active substance in leachate. After analysing the output data for Kogel it was evident that the most serious year is the 20th year. We extracted the fluxes per day and calculated the daily values of predicted concentrations for the period of applications. Results are presented in Figure 3.

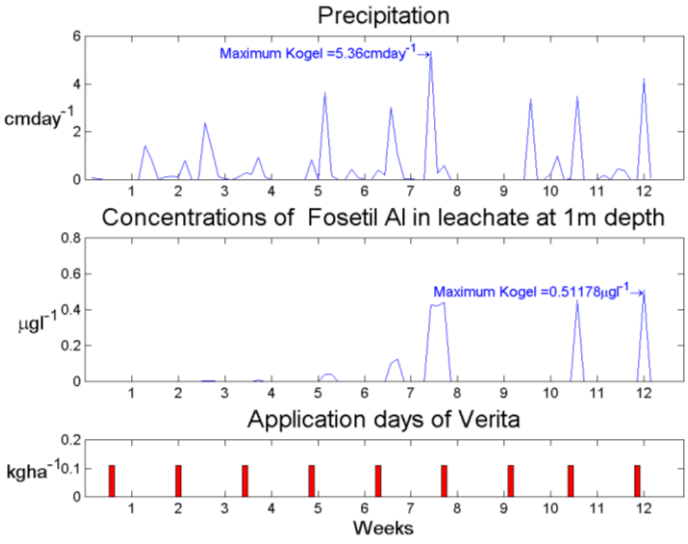

Fig. 3 Combined diagram of precipitation data, predicted concentrations of the active substance Fosetil Al and application quantities and days for 12 consecutive weeks in the most critical year

III. DISCUSSION

For fosetil Al (Table 1) there is a vast ratio of more than 30 000 between Kremsmünster and Thiva or Sevilla. Chateudon has about 1 000 times higher values than Thiva. We have three "clusters": Sevilla-Thiva, Chateudon-Porto and Hamburg-Kremsmünster-Piacenza.

TABLE 1 80 PERCENTILE VALUES OF PREDICTED CONCENTRATIONS OF FOSETIL AL IN LEACHATE AT 1M DEPTH

Standard scenario/Location	Predicted concentrations [$\mu g l^{-1}$]
Ch(teudon)	0.002487
Ha(mburg)	0.054393
Kr(emsmünster)	0.089815
Pi(acenza)	0.052271
Po(rto)	0.003984
Se(villa)	0.000004
Th(iva)	0.000002
Ko(gel)	0.037379
Te(šanovci)	0.032618
KT(Kogel-Tešanovci)	0.106183

For klotianidin (Table 2) the results are worse. Piacenza exceeds the margin 0.1 µg/l. There are two "clusters": Chateudon, Hamburg, Kremsmünster, Okehampton and Piacenza as the first and Porto, Sevilla and Thiva as the second.

TABLE 2 80 PERCENTILE VALUES OF PREDICTED CONCENTRATIONS OF KLOTIANIDIN IN LEACHATE AT 1M DEPTH

Standard scenario/Location	Predicted concentrations [$\mu g l^{-1}$]
Ch(teudon)	0.06837
Ha(mburg)	0.05636
Kr(emsmünster)	0.023225
Ok(ehampton)	0.087583
Pi(acenza)	0.129916
Po(rto)	0.001458
Se(villa)	0.00000
Th(iva)	0.000773
Ko(gel)	0.072482
Te(šanovci)	0.087874
KT(Kogel-Tešanovci)	0.190824

After elaborate examination, we could not find any uncertainty regarding the large variations in predicted values. In scope of procedure defined in [1] we have a clear solution. Scenarios with high predicted concentrations assure that the active substance is not placed in Annex I. On the other hand, scenarios with very low predicted concentrations assure that member countries can proceed with the risk assessment with more elaborated tools. However, most simple statistical tools provide results that show very little probability that all scenarios belong to one population. As an example we selected the Fosetil Al data. Due to the fact that concentrations are always above 0, predicted concentrations are not normally distributed. To come closer to normal distribution we converted the predicted concentrations to log values. We eliminated Sevilla, Thiva and our locations. Population size is very small, but we hypothesised that Sevilla and Thiva belong to the same population as other scenarios. We used the Student t distribution and obtained a probability of 0.003539 for Sevilla and 0.002671 for Thiva. These values are far too low to accept the hypothesis that both belong to the same population as other scenarios.

Predicted concentrations at 1 m depth for Klotianidin in the Piacenza scenario exceed the limit value of 0.1 µg/l, as can be seen in Figure 2. This value is in good agreement with data in the dossier (0.24 µg/l at higher application concentrations). We can raise two important questions: what is the level of predicted concentrations for less favourable conditions in Europe and can simulations with standard scenarios substitute running simulations with actual data for the selected location.

Let us answer the first question. In practice, we will never be in a position to assure that the predicted concentration on a non-negligible part of arable land in EU will not exceed a certain value (i.e. 0.1 µg/l). To reach results of treatment, its quantities cannot be diminished so that predicted concentrations would be below the limited value in all places.

Progress in collection of soil data and availability of such data for any important location has enabled running mathematical model simulations. PPP and climatological data are available, so simulations can be run to obtain predicted data. Present computing power in common workstations enables running several simulations in a very short time.

In addition, we discovered in the simulations that actual predicted daily values of concentrations differ significantly from the 80 % values (Figure 3). The ratio between them is greater than 13. If groundwater is deep there will be no problem. But if,

on the other hand, the groundwater is very shallow, local freshwater sources could be endangered.

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