Modelling the impact of the cadmium content in mineral P fertilisers on changes in soil cadmium

Background:

As part of the revision of regulation EU2003/2003 (related to the quality of fertilisers, (EU, 2003)), the allowed cadmium (Cd) content in mineral P fertilisers is being discussed. The main goal of this revision is to facilitate trade of fertilisers within the EU by setting uniform quality standards for all EU member states, both for the nutritional content as well as for potentially harmful substances like heavy metals including but not limited to Cd. Setting standards for contaminants leads to a regulation of the load of contaminants to agricultural soils. Since Cd in mineral P fertilisers is a substantial source of the total load of Cd to land, setting limits to the Cd content in mineral P fertilisers will affect the long term development of the Cd content in soil. Proposed levels of Cd in mineral P fertilisers with a P content of more than 5% as discussed in view of the revision of EU2003/2003 are 20, 40 and 60 mg Cd kg^{-1} P_2O_5. At present, various policy options on the level of Cd in fertilisers are being discussed which vary between either a fixed level or a combination of the levels mentioned starting with 60 mg Cd kg^{-1} P_2O_5 which is then to be reduced within a yet to be specified number of years after implementation.

Question and Timeline

The key issue in the discussion is the quantification, via model studies, of the extent to which proposed levels of Cd in mineral P fertilisers (20, 40 or 60 mg Cd kg^{-1} P_2O_5) induce long term (100 years) changes of Cd in soil; both at a regional, Member State (MS) and EU-25 level.

Scientific experts from Wageningen Environmental Research (Romkens et al.) and from KU Leuven (Smolders) have performed studies about this subject independent from each other.

In 2016 PhosAgro commissioned a study to Wageningen Environmental Research to quantify these changes using an available model (INTEGRATOR), developed prior to the study, that is able to calculate spatially explicit, dynamic changes in the nutrient and metal content in soil across the EU (De Vries et al., 2011).

The results from this study were finalized in the fall of 2017 and a first concept report with results was prepared and sent to PhosAgro in November 2017. Prior to this (in June 2017), a concept paper summarizing the main findings of this study were made publically available by PhosAgro via the Safer Phosphate website (Römkens et al., 2017).

This paper and a video, in which the same results were discussed, was put on the Safer Phosphates website with the consent of the project members at Wageningen Environmental Research even though the paper as such contains preliminary results. This paper was not yet submitted to a journal, at that time nor in the period thereafter, for peer review. The main finding of this preliminary paper was that – on average- accumulation of Cd in arable land at EU-level continues regardless the Cd level in mineral P fertilisers decided upon (i.e. 20, 40 or 60 mg Cd kg^{-1} P_2O_5).

At the same time, a study by Smolders (2017) showed that within the same proposed range (20 – 60 mg Cd kg^{-1} P_2O_5) Cd is, on average, lost from soil at EU level. In other words, accumulation did not occur in either of the three scenarios but instead a net –average- decline in the Cd content in soil was predicted.

Both studies also demonstrated a rather large range of predicted levels of Cd in soil when considering Cd in soil at a regional level. This predicted range for the scenarios included was approximately equal for both models used and for all assumed levels of Cd in mineral P fertiliser.

Neither the study by Smolders (2017) nor the study by Römkens et al. (2017), which was disclosed in its preliminary form by PhosAgro, however included an uncertainty analysis. As a result, the statistical significance of the changes in soil Cd for each of the two studies, nor the statistical significance of the differences *between* the public available results from the two studies were quantified.

The discrepancies between both models appeared to be such that the lead scientists involved in the studies (i.e. E. Smolders from KU Leuven and P. Römkens from Wageningen Environmental Research) decided to set up a project, independent from the commissioned work, to look into the scientific reasons for these differences. During a meeting that took place the 8th of February 2018, both models were evaluated. The main cause for the differences in the outcome of the models used by either Leuven and Wageningen appeared to be the choice of the leaching model, i.e. the model part that calculates the amount of Cd that is lost from soil via water flow.

This finding initiated a discussion as to how to improve, based on the existing scientific concepts, the model to predict leaching. It was concluded that by *i.* combining parts of the source data used to derive the two separate models; and *ii.* to harmonize the process formulations that were used to describe the soil chemical equilibrium, a single model could be derived that was agreed upon by both science groups at Leuven and Wageningen.

This model was further developed and tested during March and April 2018. It was also agreed that this new model was to be incorporated in the original model used by Wageningen Environmental Research (De Vries et al., 2011) since this approach is able to actually represent the spatial variability in not only soil type and Cd content in the soil but also land use, crop type, climate, atmospheric deposition and regionally variable use of fertilisers, both inorganic and organic.

In addition to the prediction of changes in the soil Cd content at a regional, national and EU scale in response to the Cd content in mineral P fertilisers, an uncertainty analysis was included. This was done for the same scenarios regarding the Cd content in mineral P fertilisers, i.e. Business as Usual (BaU, using present day quality based on country specific current data with Cd levels in mineral P fertilisers ranging from 0 to 58 mg Cd kg^{-1} P_2O_5, data from Smolders, 2017) and the generic scenarios based on an average Cd level in mineral P fertilisers for all countries of 20, 40 or 60 mg Cd kg^{-1} P_2O_5, respectively.

The aim of the model revision was twofold: *i.* to improve the quantification of the degree of changes in soil Cd; and *ii*. to assess to what degree these changes, compared to current levels in soil, are significant in view of the model uncertainty.

During April 2018, the revised Cd leaching model was implemented in the spatially explicit model (De Vries et al., 2011) and used to calculate average long term (100 yr) changes of Cd in soil at Member State and EU level for the same scenarios as was done in the studies from 2017. In addition, an uncertainty analysis was performed to determine the significance of the changes in soil Cd for each of the scenarios (Cd20, Cd40, Cd60 scenario).

Based on these results, a paper for peer review is being prepared to be submitted. In addition a short summary has been prepared on request of the European Commission.

Disclaimer

The results contained in this summary are preliminary in that they have been reviewed by scientists from KU Leuven and Wageningen Environmental Research but they have not been submitted for peer review yet; this will be done after finalization of the manuscript (June 2018).

References included in the text

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