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Diffusion of Agrochemicals in the Tropical Environment and in the Food Chain Monitoring and Modelling in Biotic and Abiotic Systems (**)

1. *Introduction*

Agrochemicals are unfortunately not staying where we want them to react but diffuse to the environment, where they easily can do more harm than often foreseen. This paper attempts to give a survey to the processes of agrochemicals in the environment and discusses also the possibilities of using models in reduction of the adverse effects of fertilizers and pesticides.

2. *Fertilizers in the Environment*

Fig. 1 gives a model of nitrogen soil processes. The desired process is the uptake by plants (9) and the undesired processes are leaching to the ground- and surface water (4) and volatilization (8). The obvious question is how we can enhance process (9) and reduce processes (4) and (8).

As all components are directly or indirectly linked to each other, it is not possible to give a simple answer to this question. A good mathematical model of the conceptual diagram Fig. 1 is even not sufficient, as a total crop production model involves (see Fig. 2) the use of a much more comprehensive model. However, the concerned models have been developed and they could be used to give a certain control of the right use of fertilizers and achieve a minimum release to the environment. This does not imply that control by use of a mathematical model can be used alone. On the contrary — the control models should be used

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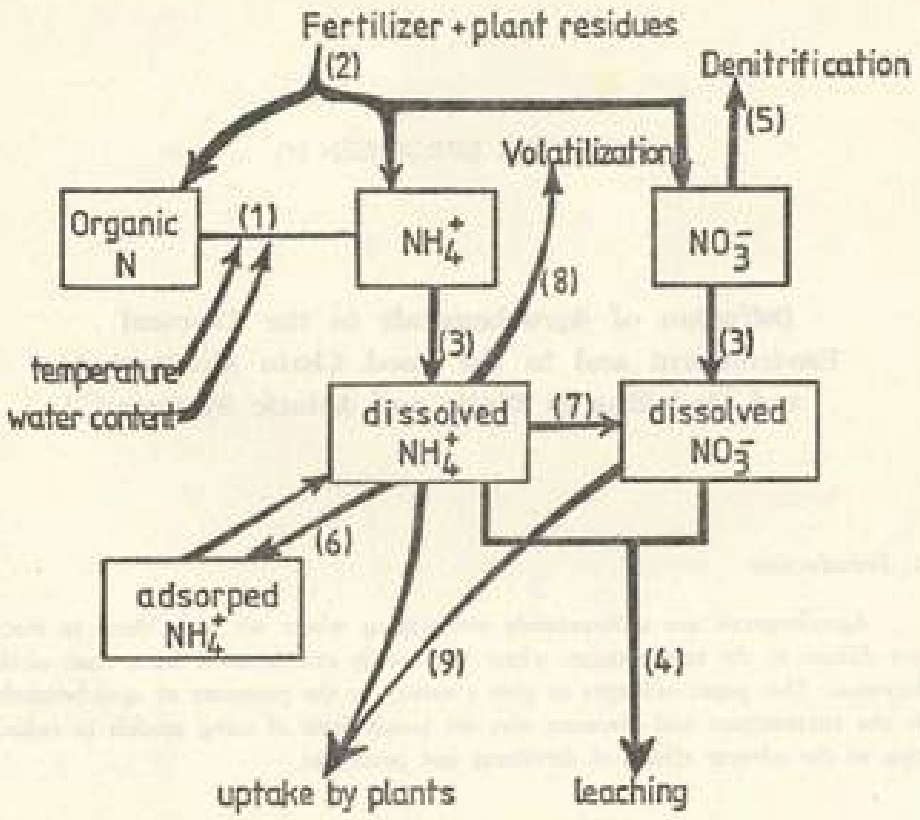

Fig. 1 - Models of nitrogen soil processes.

together with all other methods, which are discussed in this conference to assure a good result.

Furthermore, it should be mentioned that a workable model can only be developed on the basis of a good knowledge of your systems, which again require a good monitoring scheme.

Details of the models will not be presented here, but can be found elsewhere (see for instance Jørgensen, 1986):

However, some results of modelling, monitoring interpretations and process investigations should be presented.

1) Adsorption capacity of soil is highly dependent on soil composition. Leaching is much more pronounced in sandy soil than in soil where clay and/or humic substances are dominant.

2) Fertilizers should not be used on bare soil, but rather in the initial crop growth phase, as fertilizer uptake is dependent on growth.

3) Volatilization is dependent on pH, as the ratio ammonia to ammonium is increasing with pH.

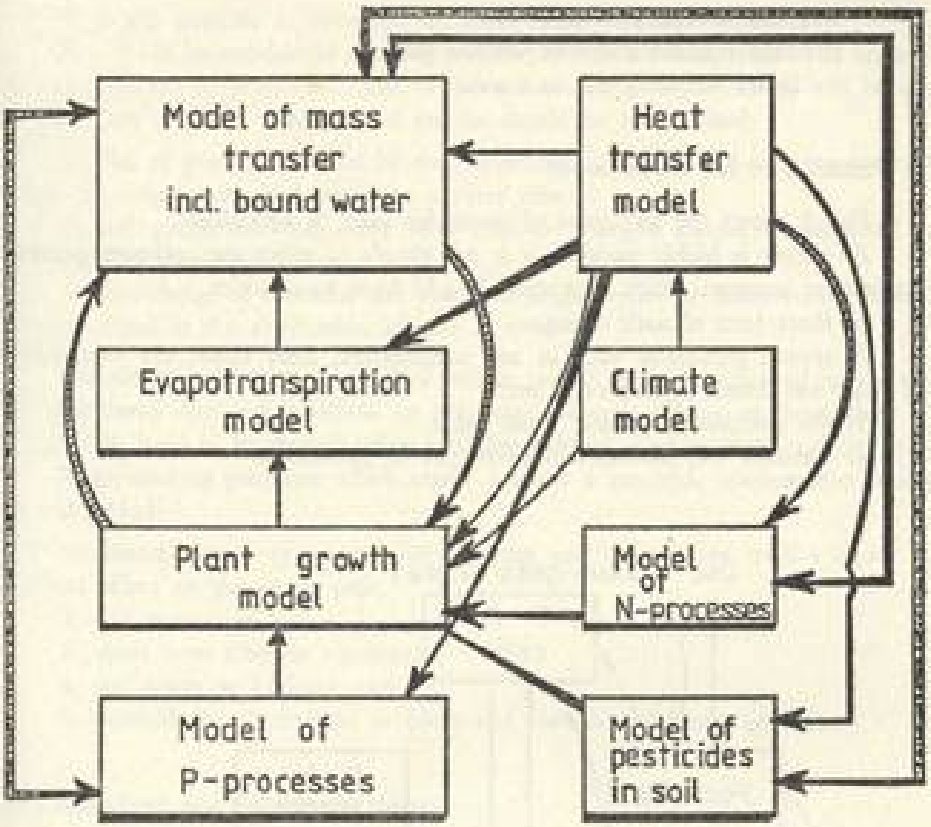

Fig. 2 - A total crop production model might require a total model, which consists of the shown 8 submodels. The relations are indicated by arrows. The arrow direction shows that output from one model is used in another model.

4) Denitrification takes place mainly in the root zone and in peatland. As this process requires anaerobic conditions, water content is an important factor.

5) Loss of fertilizer to surface water takes place at heavy rainfall.

More factors might be revealed of importance on specific sites by use of models.

A monitoring program to support a fertilizer soil model is — as all models are — site specific, although some generality is valid. From the considerations mentioned above, it is, however, obvious that a monitoring program at least should include:

soil properties,
crop growth,
pH of soil water as f (time),
soil water content,

short term conditions and
fertilizer concentrations in various soil
layers including the root zone.

3. *Pesticides in the environment*

Fig. 3 shows the pathways of pesticides used in agriculture.

As nature is highly variable, it is not simple to select the optimum pesticide application program. Such a program would have to consider

1) short term climatic changes

2) system properties such as soil composition, field slope, the composition of plant and insect communities, etc.

3) the position of ground water table

4) chemical and biochemical properties of pesticides.

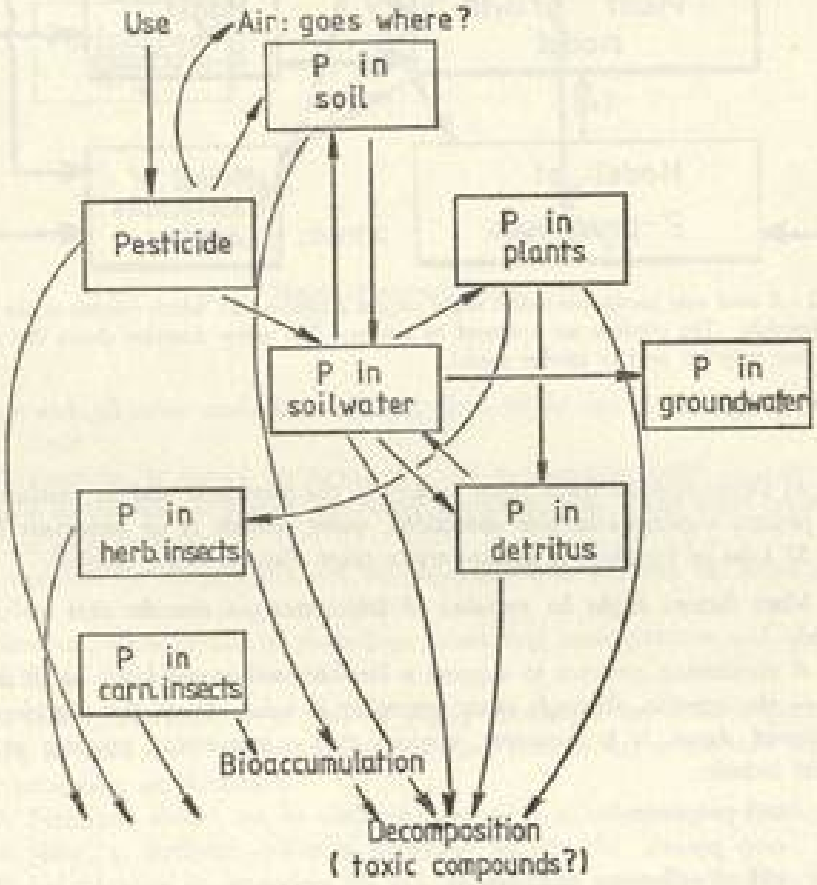

Fig. 3 - Conceptual model of pesticides (P)'s distribution in the environment.

It is not possible to overview all these factors without a model.

Fig. 3 can be considered a conceptual diagram of a model, which can be used for management of pesticides. The model and even the model results will be site specific, but anyhow, some general results should be summarized:

1) Use of pesticide should be used selectively in space and time to assure a result on target pests and minimize adverse effects.

2) Soil properties and short term climatic changes should be reflected in any pesticide application scheme.

3) Knowledge of chemical and biochemical properties of the pesticide should be considered in the application scheme as well.

The use of models for control of proper use of pesticides must of course not be considered the only method to minimize adverse effects of pesticides. It must work hand in hand with other available methods such as biological methods.

A monitoring program which could support a pesticide management model should include:

1. determinations of target pest densities and other biota with a direct or indirect effect on the target pest,
2. soil properties,
3. short term climatic conditions,
4. soil water as f (time), and
5. pesticide concentrations in biota and various soil layers as f (time).

4. *Conclusions and Recommendations*

A proper use of fertilizer and pesticides requires a significant control to assure that they are utilized where foreseen, and do not cause adverse effects.

As agriculture systems are complex systems, such a control needs the use of a model. Such control models have been used with success in the temperate zone, but it might be considered too advanced to use such models in the tropics. This is, however, a wrong statement. The saving in fertilizer and pesticides can easily pay for purchase of personal computers and model development and in addition you have a pronounced reduction of the adverse effects. Here high technology can quickly assist the developing countries with very little support.

Training courses must of course be set up to teach the local staff to develop and apply models and get acquainted with the personal computer. An ecological and economic agriculture in the tropics can only be achieved through the use of control models in addition to other initiatives.

REFERENCES

Fundamentals of Ecol. Modelling by Sven Erik Jorgensen, Elsevier (Amsterdam) 1986.