Use of simulation models to improve individual and collective management of pig effluents in Grand-Ilet (Réunion Island)

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Introduction

Our aim is to support Grand-Ilet pig farmers to design territorial management strategies of their wastes. Actually, this community exhibits a very critical situation in terms of the environment as it concentrates on a very small agricultural land (187 ha) 25% of the pig production in Réunion, generating an amount of 17 000 m^3 per year slurry. From now, maintaining livestock farming in Grand-Ilet is strongly dependent upon the implementation of an efficient management strategy of pig slurry. First, we assessed the livestock effluent production, and the nutrient demand by crops was determined by using a GIS, considering a large zone surrounding Grand-Ilet onto which several constraints were applied to eliminate unsuitable spreading areas. This study showed that the area is too cramped to absorb all the raw slurry produced in Grand-Ilet but not to absorb solid organic matter issued from a slurry treatment plant (Médoc et al., 2004). In order to help Grand-Ilet stakeholders to define reliable management options, we are using several models devised for different tasks (Guerrin & Paillat, 2003): (i) the *Macsizut* model for evaluating and choosing slurry treatment processes, (ii) the *Approzut* model for testing various supply policies of slurry treatment plants and (iii) the *Biomas* model for simulating effluent transfers between distinct farms and evaluating the interest of collective treatment units. After describing how we are intervening in Grand-Ilet stakeholders' decision process, the presentation will end with a description of the models and first results.

Supporting agricultural stakeholders

How to support Grand-Ilet pig farmers to devise sustainable management strategies of their wastes based on the use of simulation models? First, an organisation framework with three levels (action, coordination, decision) was set up to gather the various stakeholders concerned by the issue of pig slurry treatment. These are farmers, agricultural advisers and representatives of farm cooperatives, agricultural services, city council and, when needed, any kind of experts. At the first level, four action groups were organized to discuss and elaborate tentative solutions on specific topics: implementation of the treatment plant, process choice and management, legal status of the organisation and administration, biogas unit to be coupled to waste treatment. The main results issued from the groups are presented to other participants via the coordination group. The decision committee, gathering farmers, cooperatives and private investors representatives, endorses all the final decisions. It is within the process choice and management group that simulation models are being used and discussed (Médoc et al., 2004).

Choosing a treatment process

Macsizut is a spreadsheet model devised to calculate matter balances and assess investment and running costs of pig slurry treatment plants (Farinet et al., 2003). Given the situation in Grand-Ilet and taking into account farmers' wishes, the goal of treatment should be to produce easily transferable solid products (composts, fertilizers) with sufficient nutrient content to give them a commercial value, and a liquid phase treated enough to be directly disposed of in the environment. After four contradictory discussions held with the agricultural stakeholders on the simulation results issued from Macsizut, they finally adopted a biological treatment process (centrifugation and nitrification-denitrification), which is the most reasonable cost/efficiency compromise.

Testing supply policies of the treatment plant

In Grand-Ilet, multiple small farms are distributed in a harsh environment, rather unsuited to install a slurry treatment facility. Several parameters intervene in the design of supply policies. In order to identify them as well as possible, we tried to answer the following basic questions: Where are the producers and the consumer located? How to organize the deliveries? When should a delivery be made? and How much should be delivered? The objective is to put in report a supply, that of 51 pig farms and a demand, that of the treatment plant with three constraints: 1. The farmers' slurry pits should not overflow, 2. The treatment plant's reception pit should not overflow, 3. The treatment plant's reception pit should not lack in slurry to be treated.

Three types of supply strategies were defined: 1. Planned deliveries, 2. Reactive deliveries with respect to farmers, 3. Reactive deliveries with respect to treatment plant. The Approzut model, compared to its initial version (Guerrin, 2004), was adapted, making it possible to simulate these scenarios in the context of Grand-Ilet according to the treatment process chosen with Macsizut.

Simulating effluent transfers at a territorial level

The Biomas multi-agent system allows us to simulate organic matter fluxes transferred amongst a set of farms located within a territory (Courdier et al., 2002). After a preliminary phase of checking the model against various toy-examples, we are now about to apply this model to support the farmers of Grand-Ilet manage their livestock effluents. Two scenarios were elaborated and will be tested to evaluate the collective management solution chosen by the stakeholders: 1. The current situation without spreading facilities, 2. The future situation with a slurry treatment facility chosen with Macsizut (Médoc & Guerrin, 2004).

Conclusion

The originality of this still ongoing project lies in the use of multiple simulation models devised to deal with complementary aspects of a complex problem. These models enable one to test animal waste management strategies at a territorial scale with agricultural stakeholders of different types (farmers, technical advisers, policy makers and researchers). If decision-making is obviously one of the main goals, models by themselves are not conceived to prescribe decisions. They rather are intended to be used as tools to explore, test, and iteratively devise management strategies interactively with the stakeholders.

References

Courdier, R., Guerrin, F., Andriamasinoro, F. H., Paillat, J.-M., 2002. Agent-based simulation of complex systems: application to collective management of animal wastes. Journal of Artificial Societies and Social Simulation, 5(3).

Farinet, J.-L., Hurvois, Y., Paillat, J.-M., 2003. Macsizut : un modèle d'aide au choix de techniques de traitement des effluents d'élevage. *In* Guerrin, F., J.-M. Paillat, Modélisation des flux de biomasse et des transferts de fertilité. Cas de la gestion des effluents d'élevage à l'île de la Réunion. Restitution des travaux de l'ATP 99/60. Actes du séminaire des 19-20 juin 2002, Montpellier, Cirad Colloques, Cd-Rom.

Guerrin, F., 2004. Simulation of stock control policies in a two-stage production system. Application to pig slurry management involving multiple farms. Computers and Electronics in Agriculture, 45: 27-50.

Guerrin, F., Paillat, J.-M., 2003. Modélisation des flux de biomasse et des transferts de fertilité. Cas de la gestion des effluents d'élevage à l'île de la Réunion. Restitution des travaux de l'ATP 99/60. Actes du séminaire des 19-20 juin 2002, Montpellier, Cirad Colloques, Cd-Rom.

Médoc, J.-M., Guerrin, F., Courdier, R., Paillat, J.-M., 2004. A multi-modelling approach to help agricultural stakeholders design animal wastes management strategies in the Réunion island. Actes iEMSs 2004, International Environmental Modelling and Software Society Conference on Complexity and Integrated Resources Management, Osnabrück, Germany, June 14-17.

Médoc, J.-M., Guerrin, F., 2004. Use of simulation models to improve individual and collective management of pig effluents in Grand-Ilet (Réunion Island). Intermediate report. Gis Porcherie Verte – Cirad. 15p.