MANURE PRODUCTION AND MANAGEMENT ON COMMERCIAL FARMS

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1 INTRODUCTION

The intensification in recent decades by agriculture, maximizing productivity from a minimal surface area through the use of artificial inputs, has reduced the reliance on manure as fertilizers, with a subsequent increase of pollution risk and agricultural cost.

Environmental sustainability of livestock production can be defined by a set of principles of good management (for example a Code of Good Agricultural Practice) and application of a number of related techniques to reduce emissions to air, water and soil resulting from activities necessary for the rearing of animals. However, even if guidelines and computing systems to support the hypothetical evaluation of the effects of different management systems are available, there is not enough knowledge to fully understand the true effects of interventions that may be implemented to reduce the environmental impact of farms.

In reality, after the Rio Conference of 1992 new tools of industrial policy oriented to sustainable development were introduced by the European Community, individual member States, local and regional governments and voluntary organizations; these were aimed at integrating production needs and those of environmental conservation. Environmental Management Systems (EMS) were one such tool designed to "develop, implement, achieve, review and maintain the environmental policy" (ISO 14001). Their objectives are the protection of the environment through continual improvement of environmental performance of a company. An EMS does not include a prescriptive set of practices that must be implemented universally, but does provide a set of procedures for the pro-active participation of companies in ongoing improvement of environmental performance.

The application of integrated environmental management systems, planned for intensive livestock by law (Directive 96/61/CE), requires continuous monitoring of farm activity. Monitoring is a fundamental principle embodied in all continuous improvement schemes such as EMS, as only through monitoring one can verify that measures taken have the intended effect. Monitoring promotes the collection of information on production processes that can not only help the improvement of existing management, but also identify possible future measures that will enable continuous improvement towards environmental sustainability.

Many farms are facing the introduction of Best Available Technologies under Directive 96/61/CE in order to reduce environmental emissions (e.g., to decrease the nitrogen load on the land). To accomplish these objectives, farmers should use an adequate monitoring methodology to assess the amount of manure produced, its nutrient content and management.

Up to now, there are not available monitoring methodologies, protocols and instruments that apply specifically to Italian livestock farms. In fact, although there are many experiences related to certain components of possible monitoring systems, and many countries have implemented schemes that require monitoring actions of various farm operations, there are no specific experiences on integrated systems for environmental monitoring of intensive livestock farms that have been implemented and tested on commercial farms.

Such a system must include equipment for monitoring the management of effluent and, where possible, emissions that come from farms, taking into account the cost of equipment acquisition and management. The implementation of these systems can also enable scientific knowledge to be gained on the effect of different manure management techniques in working conditions. The results obtained through monitoring could also be used to provide significant support to the development of models for estimating production and emissions; these models are currently based mainly on experiments carried out in other contexts of production.

To assess the possibility of introducing environmental management systems in Italian livestock farms, research was conducted to: i) define a simplified methodology to record, manually or automatically, the main parameters of manure management; ii) develop a software tool to process recorded data into useful information for the farmer; and iii) validate the methodology and the software on commercial farms.

2 MATERIALS AND METHODS

Environmental monitoring of livestock production systems is based on “supply chain” management of effluents at “control” points from production to use in the field, and applies the principle of mass balance used in other studies. The methodology adopted in this research concentrated control (and monitoring) in specific parts of the livestock production system, in order to assess an appropriate method for evaluating the whole-path management.

In particular, the approach required careful monitoring of all items that enter the production system (inputs), and everything that leaves the farm (outputs). Inputs include feed, drinking and washing water, and animals acquired from external sources. Naturally occurring inputs such as rain are also included in the analysis. Outputs include animals sold or that die on-farm, milk products and effluents. The difference between inputs and outputs is either stored in the system or lost to the environment. Where the rainfall / runoff process does not transport pollutants off the farm, environmental losses mainly concern air emissions of nitrogenous compounds and water vapor. Both can be determined by difference if the others factors are kept under control.

In this research the following “control points” of the livestock production system were monitored, using the noted metrics:

Consistency of livestock (animals per category, weight);

- Supply of feed (quantity and composition of the ration for each category of animals);
- Milk (volume collected, for dairy systems) and meat production (weight gain);
- Water consumption (volume);
- Waste production (volume);
- Characteristics of waste products (e.g., total N, total P and solids concentrations);
- Time, quantity and location of manure (effluent) applications;
- Climatic conditions (rainfall, temperature).

Using this information it was possible to apply a balance between inputs and outputs, with the aim of controlling the volume of effluent produced and the concentration of nutrients (nitrogen and phosphorus) therein.

Three different production systems (dairy cows, fattening pigs, farrow-to-finishing pigs) were monitored for 16 months to assess manure production and subsequent management, using both manual recordkeeping and automated sensors. The amount of manure in storage was recorded using ultrasonic sensors, while the spatial application of manure was monitored by GPS tracking devices. Manual measurements and manure sampling provided reference values on the farms against which to compare automated measurements. Software to support data collection and processing was written.

A simplified model for animal manure production and composition was devised both for pigs and dairy farms using information derived from literature (Aarnik et al., 1992; ASABE, 2005, Berthiume et al., 2005, ERM/AB-DLO, 1999, Nennich et al., 2005, Wilkerson et al., 1997). The model was calibrated in the initial phase in order to adjust the slurry production obtained by the model with the measured values from the tanks. After this initial calibration, the model was used without further adjustment. Predictions obtained from the model were compared to actual measurements as a means to highlight specific points in a production system where improvements could be made to achieve environmental sustainability.

3 RESULTS AND DISCUSSION

Figure 1 shows comparisons between measured manure production and that predicted using the software for the three monitored farms. The Root Mean Square Errors for manure production were are 1.0%, 7.6%, and 2.9% respectively for farms 1, 2 and 3. Although the model required an initial calibration, its slurry production predictions are judged to be accurate enough for use as part of a monitoring system.

Although nutrient concentration in slurry tanks was verified by periodic sampling, the size of the storage tanks and the difficulty encountered in retrieving representative samples without adequate mixing prevented good validation of the model. Another difficulty in validating the model was encountered for the slurry spreading part of the production systems. In fact, farms typically use very simple machinery (slurry tankers) to apply manure, and often do not mix the slurry store before withdrawing slurry at the beginning of (or during) the spreading operation. Thus, the amount of nutrients that leaves the tank during spreading is not known. The model assumes that the average nutrient concentration of the storage tank is transferred in each tanker load; a considerable error can be introduced when this does not occur in reality. Large variations in manure characteristics from farm to farm are typical (Derikx, 1999; Dou et al., 2001, Martínez-Suller et al., 2008). Thus, a more suitable validation of the model for nutrient production might be obtained using an on-line slurry analyzer mounted on the slurry tanker. Nevertheless, predicted values for N and P concentration seem to be realistic and give an indication of the variation of the nutrient concentration of the slurry in the tanks.

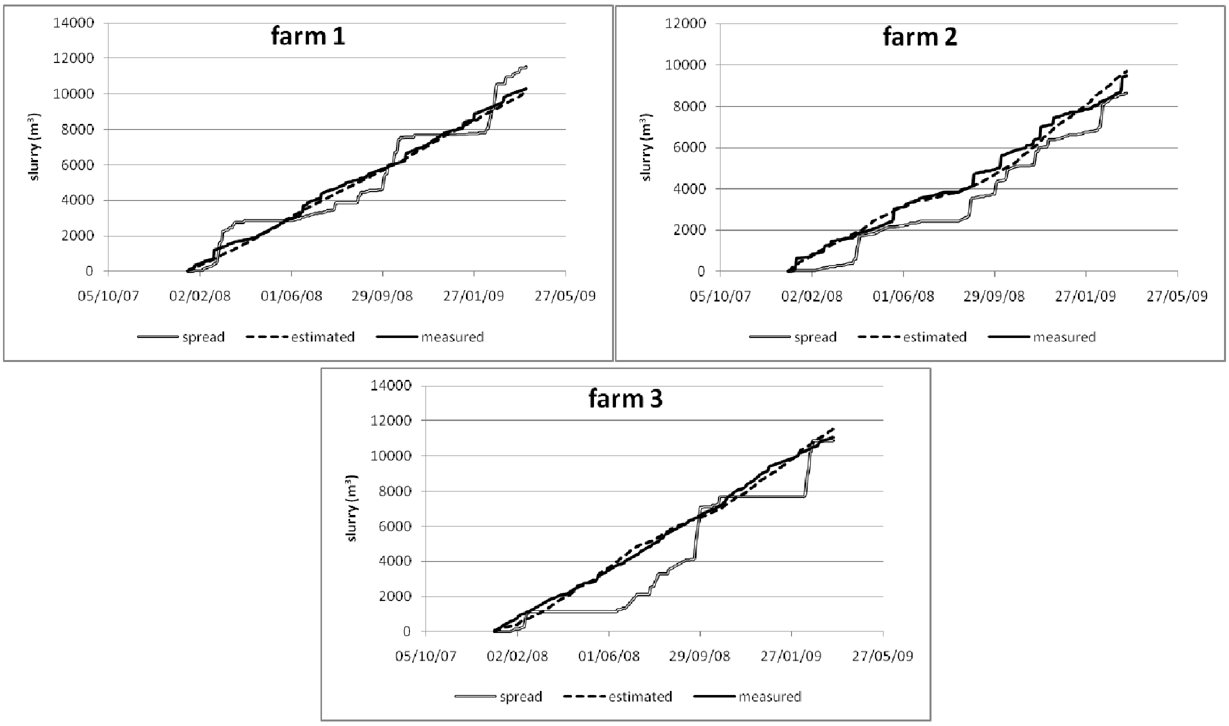

FIGURE 1 **Manure cumulated values for the three monitored farms**

Moreover, the devised monitoring system appears to be useful in evaluating the actual manure production values of the farm and thus providing more appropriate values on which to assess the farm requirements under legislation. For the monitored farms, a comparison of the slurry and nitrogen production obtained using the model and using the standard values (specified in legislation) is reported in Figure 2. The three farming systems in the study produced 40% more manure (for dairy cows) and 10% and 30% less manure (for fattening and farrow-to-finishing pigs, respectively) than would have been estimated using the standard values proposed by regulations. All the three farms reported a production of 5-10% more nitrogen than would be estimated using standard values. Nevertheless, the indirect evaluation of manure quantities obtained by calculations based on the recorded data gave results very close to the measured data (differences< 10%).

Farm managers already collect most of the data required for such a monitoring system (number of animals, feed quantity and quality, etc.); other data can be easily collected manually or automatically.

4 CONCLUSIONS

The results of the research demonstrated that the devised methodology and software tool are effective in monitoring on-farm activity related to manure production and management. The model seems to be a valuable part of an overall monitoring system that can improve farm and environmental management. From the results obtained it can be concluded that the devised monitoring system can be used effectively in commercial farms to assess the actual manure production and thereby improve manure and nutrient management, and the continual improvement towards environmental sustainability.

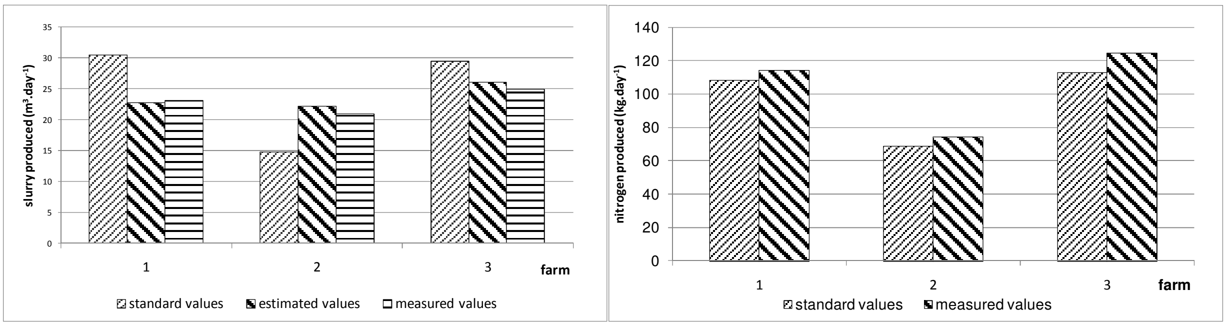

FIGURE 2 **Comparison of measured manure production (left) and amount of nitrogen produced (right) against estimates using the monitoring system and standard values from legislation, for the three monitored farming systems.**

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