THE METAMORFOSI PROJECT: MONITORING AND CONTROLLING ZOOTECHNICAL EFFLUENTS IN LIVESTOCK FARMS

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1 INTRODUCTION

The recent events related to the application of the Nitrate Directive (CEE 91/676, in Italy definitively achieved by the DL n.152/2006) force livestock farmers to face as soon as possible the problem of conforming farm resources (shed structures and storage tanks) and effluent management techniques (type of waste treatment and distribution systems) to the necessity of respecting N-charge distribution constraints (170 and 340 kgN/ha.year, for vulnerable and non-vulnerable areas, respectively) established by the Directive itself. In Italy following a number of of legislative steps (which on a local level have resulted in obligations to plan activities through PUAs, (acronym for Plans for the Agronomic Use of Effluents) the directive was definitively acknowledged by the Consolidated Law on the Environment (Italian Legislative Decree No. 152/2006), in which Article 112 establishes that the Regions regulate the activities of agronomic use of the effluents from breeding farms based on the criteria and general technical regulations adopted by a Decree of the Ministry of Agricultural and Forestry Policies. The problem is particularly felt in the North Regions of the Po Valley, where a large number of both piggeries and dairy farms is concentrated in areas with a relevant presence of vulnerable sites (Provolo, 2005), especially Lombardy and Emilia Romagna, with a number of a different provinces that feature important zoo-technical characteristics.

The basic feature that is common to the various regional resolutions is that of integrating the preventive measures that are already in use (implemented through the PUAs) with more direct actions, aimed at favouring a definitive monitoring of the distributions activities that are actually performed by the farms. In fact, although it has been adopted with details and nuances that vary from one region to the next, the most recent regulation requires that the farm adopt: 1) a register for the use of the effluents, and 2) a bill of lading that is available during the distribution activities. The register, which can be managed either with a hard copy or through computerized procedures, should also be accompanied by a copy of the Regional Technical Map (CTR, 1:10000), in order to allow for easier identification of the fields involved in the spreading activities. The details of the operation must be updated in the register itself within 10 days from the time of distribution, making note:

- the date of the spreading;
- the type of effluent;
- the quantities distributed;

So, the creation of a monitoring plan, which is also aimed at the verification of the status of the application of the PUAs, becomes more or less established. In this way, the plan provides for both a monitoring phase for the farm to be managed by the administrator of the warehousing plant for the effluents, and a verification phase by the competent public administration.

In this framework, the Metamorfosi Project (acronym of *Industrial Metadistrict for developing remote monitoring and control technologies supporting zootechnical effluent spreading according to environmental low impact approaches*) was launched and funded by the Lombardy Region in order to develop hardware and software solutions suitable to provide farmers and public administrators with advanced monitor and control tools for a more sustainable effluent management (Mazzetto et al. 2009a).

2 MATERIALS AND METHODS

The project involves both University and private ICT firms the common objective of developing hardware and software solutions suitable to aid: *a*) either farmers in managing their animal wastes in a proper way, whilst ensuring sustainable investments and no complications in farm management practices, *b*) or the public control bodies (such as regions or provinces) that administrate specific areas in which a network of livestock farms operate. The whole network will be organized according to client-server logic and the farm participation to it will not be compulsory but will rather be promoted by incentive administrative measures. Overall, the entire management control chain of the zootechnical effluents requires the application of a series of computerized technologies, in an integrated way, at the following levels:

- *in the field*: monitoring devices are mounted directly on-board the equipment involved in the distributions activities, in order to automatically record their activities;
- *on the farm*: in order to archive and organize data related to the farm, with the goal of carrying out analyses and controls on spreading activities that are carried out;
- t*hroughout the territory*: in order to archive and organize the territorial data through an overall-farm control system (which should be managed by the competent public administration), with the goal of keeping the status of the territorial distribution activities and the related nitrate loads in its different areas continuously updated.

This will require information systems for both the farms and the territory that are able to interface independently or in an integrated manner with the field technologies that collect the data relating to the various events connected to the management of the effluent flows (Pierce and Elliot, 2008).

Conceptually, field and farm levels will be governed by a local Farm Information Systems (FIS), whilst territory level (TIS) implies a central server station integrating all the FISs participating to the Metamorfosi network (Mazzetto et al., 2009a). FIS hardware components will provide devices for field-data recoding (operative monitoring for the automatic updating of the farm log-books) and for enabling the automatic control of site-specific spreading according to prescription maps. TIS component will provide software interfaces (for both farmers and local administrators) for checking at every moment the status of the nitrogen spread in the areas of the territory under control. The idea is to propose new forms of automatic and widespread monitoring of the distribution activities in order to allow:

- *public administrators* to verify the actual ways in which the effluents are used through instruments that could guarantee – as much as possible - the objective compliance of the spreading activities with respect to the environmental protection plans that have been established by local governments;
- *farmer-breeders* to better manage the use of production elements in a context of quality certification for both production and environmental purposes;
- *contractors* to be able to certify the quality of their own services – with respect to both the farmer an the public administrator – with the possibility of supplying a complete documentation regarding the methods of execution for the operations performed.

In short, the whole operative monitoring system consists of: *a*) field data-logger devices (**FD**), to be mounted directly both on slurry tanks (equipped with ultra-sound sensors to provide continuous effluent volume measures) and on spreading tools (equipped with GPS-receiver to record the trajectories performed) *b*) a set of computing and inferring procedures, to produce information from the raw data achieved, and *c*) a user's interface to enable the access and the use of information in control activities related to management decision-making processes. Logged data are continuously and automatically retrieved, via a wireless GPRS-transmission, to a central server on which the main databases (**DB**) are installed. Main DBs include anagraphical farm resources (*Res-DB* = plants, machines, farm structures and lands, data-loggers), thematic maps of the land under control (*Map-DB* = parcel land register, soil and vulnerability maps), field recorded events (*Tank-DB* = uploading and downloading activities) and operations (*Spreading-DB*).

The FISs and the TISs both provide for the generation of efficient documentation in both hard copy and digital formats, mainly in terms of summary reports, registration extracts or documents in predefined formats and thematic maps. In fact, one of the basic elements of the research involved the methods used to connect the three areas (field-FIS-TIS; Figure 1). In summary, the downloading of the raw data (the elements in red in Figure 1) was performed directly by the TIS with the use of wireless connection and CAN devices in the field (also in real time, usually through GPRS, Mazzetto et al., 2009b). The role of the FIS is reduced to a simple terminal that is used for consulting the system: its use remains strictly confined to the management of the effluents according to the assessment methods defined by the TIS, which performs the functions of data processing, inference and queries, allowing for consultations by the users (the elements in green). Any expansion of the computerized procedures must be independently managed by the farm (elements in blue), and in any event without interfering with FIS-TIS communications. This is a very flexible architecture that is also suitable for distribution to third parties.

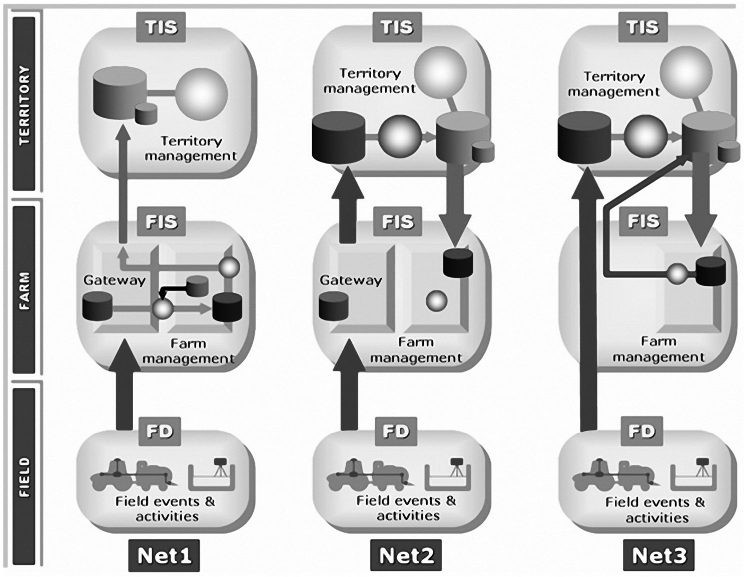

FIGURE 1 **Three possible distributed architectures were considered within the Project. Net3 is the one finally adopted.**

3 RESULTS AND DISCUSSION

The basic set-up of the research foresees that each farm must automatically provide the registration of all the implements (**IMs**) that are used for the effluent distribution activities. For this reason, each **IM** must be equipped with a **FD**; in other words an appropriate registration unit that allows for the automatic “computerized” drafting of the register of field activities. Moreover, a similar registration system provides for the continuous reporting of the volumes of effluents in the storage tanks that are annexed to the breeding farms. This in order to constantly update the total availability of effluents (and of N) within the monitored areas.

All of the raw data registered by the FD is previously processed by an inference engine which interprets the data in order to automatically identify all o the main events associated with the effluent management (loading or unloading of the storage facilities, transport and field distribution activities. The inferred data is then added to various tables in the database (*spreading-DB*).

Once a day, the presence of new measured-data to be treated is checked and the following computations are then performed: *measured-data A)⇒ raw-data B)⇒ inferred-data C)⇒ use of information by the farmer*. **A-**procedures convert and filter data logged by sensors into intelligible (raw) data, i.e. aggregate figures cleaned up as much as possible by every form of noise. **B-**procedures, on other hands, perform inferences to provide: final ave. hourly effluent volumes on tanks, identification of effluent uploading and downloading events, detail reports on effluent transport and spreading. Such events can be after confirmed, or not, by the user. Finally, **C-**procedures enable the farmer to access the inferred data both in table and graphical forms (volume vs. time diagrams, at daily, weekly or monthly scale; Gantt diagrams of events). A set of queries is even provided to permit a large series of surveys and to investigate the links between Tank-DB and Spreading-DB events.

Every spreading operation is defined as the combination of mechanized activities carried out during a typical workday (*Date*), that have the objective of withdrawing a given quantity of effluent from a storage point (*S*) through the use of a specific *IM* and its distribution across the area of a field (*A*), that does not necessarily belong to the farm that owns the IM. An operation’s uniqueness would therefore be the results of the knowledge of the following combination of parameters: < **1.** Data, **2.** IM, **3.** S, **4.** A > (Figure 2).

Through examinations of the aforementioned register, summary reports can be obtained for use by both the breeder and the controlling agency. In essence, once the reference timeframe (e. g.: from 1.1 to 31.12 of each year) has been established, the computerized system (FIS or TIS) must be able update the budget quantities of Nitrate allowed for each investigated superficial lot (field or cadastral parcel). From time to time, a numeric and graphic indicator reveals (based on a set limits) either the residual quantities that may still be distributed or the excess amounts that have already been reached.

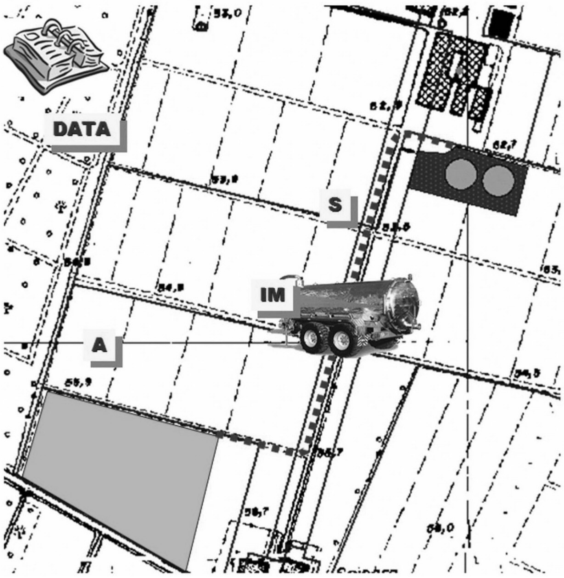

FIGURE 2 **The four parameters that identify a single spreading operation**

4 CONCLUSIONS

Approximately two years from the beginning of the project, the activities carried out have mainly been associated with: a) the installation of monitoring components at two pilot farms; b) the identification and creation of inference engines that are able to generate the aforementioned registers for the activities (spreading and events associated with the management of the storage facilities) from the reported raw data; c) the definition of the query methods to be used with the various databases by the users; d) the identification of appropriate, low-cost components that allow for distribution of the effluent with site-specific approaches.

The preliminary results are extremely promising and reassuring. Nonetheless, the farms that will not adhere to the monitoring network remain excluded from the control. The project mainly focuses on the necessity of providing more reliable information regarding the N-flows throughout the various the various territorial areas rather than creating “Big Brother” forms of control that are forced upon the breeders. This is with the full awareness that only an efficient collaboration between the breeders and the territorial administrations will provide the best possible results with regard the sustainable management of N-resources. And this will also require a quest for forms of incentives that will be able to increase the base of voluntary adherence to the network.

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