STOREYES: A SOFTWARE APPLICATION PACKAGE FOR MONITORING FLUXES OF LIVESTOCK EFFLUENTS AT FARM LEVEL

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1 INTRODUCTION

StorEyes is a software program developed in the framework of the Metamorfosi Project *(*Mazzetto et al., 2009) which handles the control of nitrogen flows in a specific territory, starting with the monitoring of the management of the zoo-technical effluents at the farm level. The overall project deals with the automatic monitoring at the individual farms (McKinion et al., 2004: Pierce and Elliott, 2008; Wang et al., 2006), including both the storage tanks for zoo-technical effluents and the spreading activities for the same. In this way, extending the system to a congruous number of farms within a single area, it is possible: 1) to control the potential entry of nitrogen from zoo-technical effluents in that territory through the monitoring of the storage tanks, 2) associate the withdrawals with the areas for the final destination of the effluents through the monitoring of the machines used for the spreading activities.

This paper shall address the research that has taken place in relation to the monitoring of the storage facilities for effluents. The possibility of constantly monitoring the volume of effluents present at each, individual farm allows for a very realistic estimate of the nitrogen flows which enter and leave the territory, and which are related to the volumes of incoming and outgoing effluents at the individual farm storage points. Obviously, this is much simpler if it involves liquid or semi-liquid effluents (slurry waste), which are exactly the types of effluents that have been considered for use with the monitoring system described herein. In detail, a complete slurry waste tank monitoring system consists of: a) a data-logger device to be mounted directly on the tank that also includes an ultra-sound sensor to provide slurry waste level figures through distance-measurements (Mazzetto et al. 2007). In an other version, the measurement of the slurry waste level is carried out by a pressure sensor, b) a set of computing and inferring procedures used to produce information from the raw data collected and c) a user interface to facilitate access and the use of information in the control activities that are related to the management and decision-making processes. Logged data are continuously and automatically retrieved (a single measurement per minute) via a wireless GPRS-transmission and transmitted to a central server on which StorEyes is installed, along with the databases (DB) relating to the basic farm resources (Res-DB = plants, machines, farm structures and land, data-loggers) and recorded activities (Tank-DB and Operation-DB).

Once a day, it checks the presence of new measured-data to be treated and then performs the following computations (Figure 1): 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 are cleaned up as much as possible removing all forms of noise and definitively expressed in terms of effluent volumes; to do this StorEyes recalls information on tank features from Res-DB. B-procedures, on the other hand, also perform inferences to provide final average hourly volumes of slurry waste contained in the tanks and to identify effluent uploading and downloading events. Such events can later be confirmed, or not, by the user. Finally, C-procedures enable the farmer to access the inferred data both in table and graphic forms (volume vs. time diagrams, at daily, weekly or monthly scales; Gantt diagrams of events).

The results of the inference procedures that must be maintained are stored in the Inf-DB. A set of queries is also provided in order to allow for a large series of surveys and to investigate the links between Tank-DR and Operation-DB events. The possible settings for the use of the information derived from the monitoring of the storage facilities for the zoo-technical effluents can be found both on the farm and throughout the territory. At this time, the principal analyses and assessments that can be performed with StorEyes are targeted at farm use.

2 MATERIALS AND METHODS

The StorEyes functions attempt to satisfy the project's general objectives with regard to the monitoring of the storage tanks. In the current version, the farm user has the following usage scenarios available: a) data collection in relation to the farm, b) data collection in relation to the environment, c) collection of information registered by sensors, d) data inferences, e) consultation and modification of the registration of loading and unloading events, f) graphic visualization and printouts of effluent volumes during a given time period, g) synthesised visualization of the daily situation of unloads and loads (Gantt diagram) on a monthly basis, h) visualization and printout of reports with the list of loading and unloading events in a given timeframe, along with the calculation of incoming and outgoing flows and the nitrogen balance. With regard to the architecture of the data (Figure 1) it is considered opportune to maintain separate DBs according to their logical function: the data relating to the information from the farms, those relating to the territory (rainfall), data registered by the dataloggers which are used for monitoring the storage tanks, and finally, the portion of the data collected from inferences that must remain persistent. Specifically, all of the data processing and analysis by the user (procedures F in Figure 1) are carried out in runtime, visualized and/or printed out, but it is not necessary to keep traces in the DBs. On the contrary, the procedure that are automatically performed by StorEyes (procedures A through E) result in the creation of data that is then memorized in the DB that will provide the basis from which to perform successive data processing.

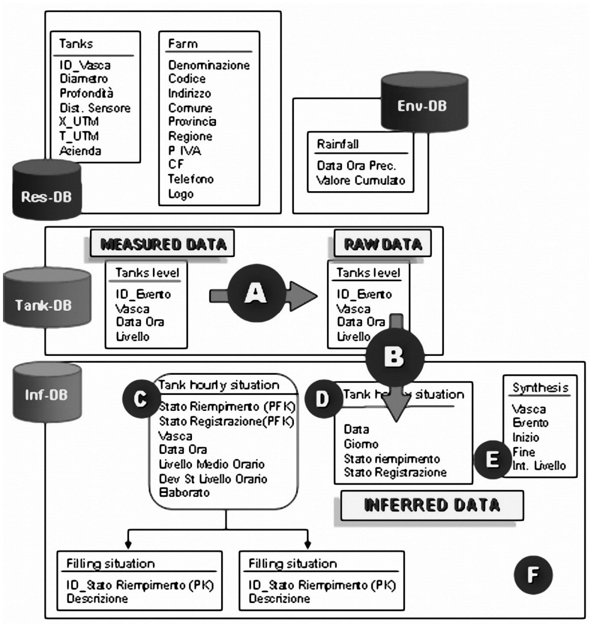

FIGURE 2 **Architecture of the data in StorEyes software**

The different calculation procedures are automatically performed on a daily basis beginning with the data that are measured by the dataloggers and which include (see Figure 2): A) the conversion of the values of the tensions registered by the dataloggers as effluent volumes; B) the elimination of the outlayers and noise, the average calculation of the volume present at 5 minute intervals; C) the calculation of the hourly average with the associated standard deviation, assignment of a filling status with respect to the previous value and a judgment regarding the reliability of the data; D) reconstruction of the missing data for holes in the registration and the presumed load and unload events; E) recognition of the effluent load and unload events and their quantification; F) assignment of the daily status of each individual storage facility with the reporting of events and a judgment regarding the reliability of the data.The F procedures relating to the balance are interactively recalled by the user. It is important to note that the calculation procedures are completely general and applicable to different farm contexts, but they use some parameters that are strictly associated with the management of the zoo-technical effluents of the individual breeding farms. These parameters have been calibrated according to the specific characteristics of the pilot farms involved in the Metamorfosi Project. For example, a particular aspect relates to the type of effluent load or unload event, which may occur either continuously or discontinuously. The farms considered present the following situations: the first has continuous loading and discontinuous unloading while the second features discontinuous loading and continuous unloading.

3 RESULTS AND DISCUSSION

The current version of StorEyes operates in stand-alone mode and all of its user interfaces (GUIs) have been designed to satisfy the requirements of "farm users" (along with the functions of the processing unit F in Figure 1). These GUIs foresee the use of query windows, specific components that have been developed ad hoc (Gantt diagrams), graphs and reports. The calculation procedures that are associated with the GUIs are based on: both the definition of parametric queries that extract sub-combinations of data from the tables deriving from the inferred data, and from the association of the calculation procedure queries for the generation of non-persistent information destined for visualization and/or printout. The software's principal functions are included in the categories offered by the tools menu: a) *home page*: is the initial page that appears when the software is started-up and it informs the user of the current status of the storage tanks; h) *load data*: allows the user to import the measured data and transform it into raw data regarding effluent volumes (application .A in Figure 1); c) process data: in which the user can choose the combination of raw data to which the inference engine shall be applied; once the choice is confirmed, the program launches a sequence of calculations that are provided for by the procedures B, C, D and E in Figure 1A: d) monthly reports: allow for the graphic visualization of all of the management events relating to the storage facilities (Figure 2); e) event analysis: offers the detailed information contained in the load and unload event registers for the time periods chosen by the user; f) data visualization: offers the possibility of visualizing the diagrams relating to the volumes of effluents in the individual tanks, as well as the possibility of associating the precipitation data; g) settings: in order to select the calculation parameters.

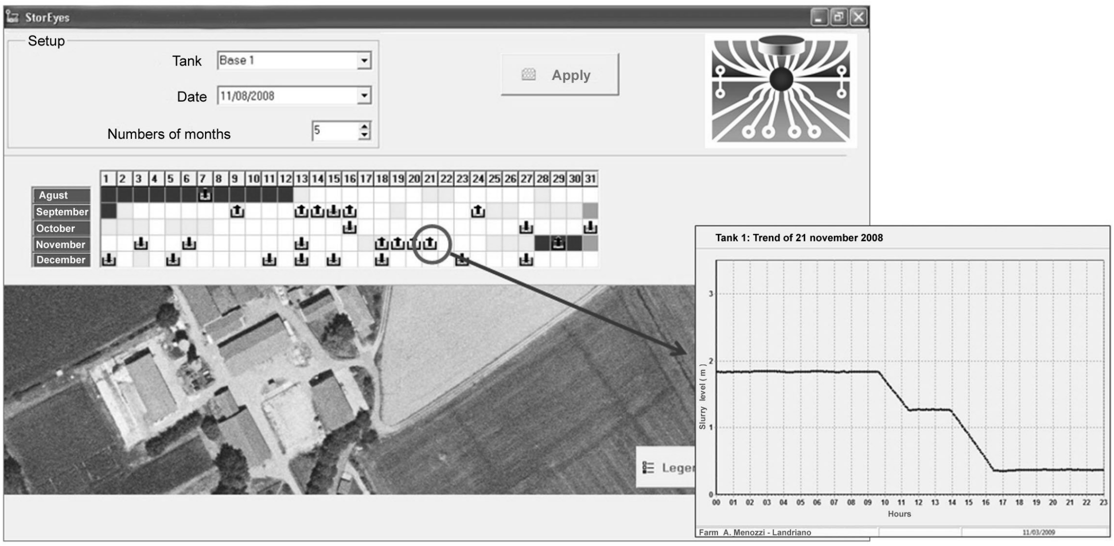

FIGURE 2 **The StorEyes software. It is possible to visualize the slurry level in the tank and evaluate loading and unloading events**

After approximately two year of farm monitoring (1/01/08-31/10/09) it is possible to verify the high correspondence between what was automatically recorded by the system and what was observed and manually recorded by the farm manager, concerning any single distribution event (Table 1). The comparison between the two archives allowed to observe, as regard the automatic monitoring, the loss of only 4 slurry distributions. This was due to the interruption of the connection service from the mobile phone company, which led to the failure of data transfer via GPRS.

By contrast, the automated system allowed the identification of 5 slurry distributions, carried on in November 2008, and 3 in year 2009 and not recorded, out of forgetfulness, by the farm manager. Analyzing only the data recorded on both manual and automatic notebooks it was possible to compare expected and actually distributed slurry quantities. Results are conflicting: 10 events out of 15 (recorded in both archives) appear realistic (assuming a tolerance of +/- 15%) and 5 events show a high discrepancy (over 20%), due to mistakes in the manual registration (admission of the farm manager).

TABLE 1 **Comparing distribution events recorded in Manual Field Notebook and StoreEyes**

Data	**Manual Field Notebook** **A.** Estimated slurry vol. (m3)	**StoreEyes** **B.** Measured slurry vol. (m3)	**Difference** **(A-B)/A** (%)
23/04/08	200	203	-1.5
30/04/08	170	117	31.2
14/05/08	280	220,9	21.1
26/05/08	180	60,5	Relev. data losses
27/05/08	60	66	-10.0
28/05/08	160	180	-12.5
24/09/08	80	74,8	6.5
01/10/08	138	156,1	-13.1
06/10/08	220	223	-1.4
07/10/08	175	164	6.3
08/10/08	95	101,1	-6.4
10/10/08	105	96,2	8.4
27/03/09	340	349.85	-2.9
04/05/09	160	205.08	-28.2
18/05/09	565	433.66	23.2
19/05/09	145	112.59	22.4

4 CONCLUSIONS

In conclusion, StorEyes software seems to be a valid tool for the management of livestock manure, capable of measuring the flows in and out from the storage tanks. The user-friendly graphical interface makes it appropriate for farmers, while the database architecture, by contrast, allows the development of software according to a client-server logic. In this way a tool for the environmental monitoring can be created which could be managed by the public administration. Finally, combined with technologies for the operational monitoring, the system is able to identify fields where the distribution was carried out. So it is possible to create an information system in order to achieve an objective and comprehensive monitoring of the activities of livestock manure spreading.

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