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## **Embedded ICT technology on sprayers in order to reduce water pollution; the Aware project results.**

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### **Abstract:**

Various routes exist to reduce water pollution due to pesticide spray drift: decision aid systems for spraying when necessary, a better tuning of sprayers and more precise spraying combinations involving a sprayer and its nozzles, an active matter and an adjuvant. In the European project Aware, supported by a LIFE Environment program, the interest of ICT technologies is demonstrated at the different stages of the spraying process: before, during and after spraying.

The traceability system developed in the aware project collects data about the spraying process and the environmental conditions. The recorded data are (i) on the spraying parameter side: the level in the tank, the right and left flows, the position using a GPS, and (ii) on the environmental side: the temperature, the wind speed and direction, the air moisture. These data are continuously displayed on the screen of a viewer. Before spraying the right and left flow measurements are used to help the farmers to tune his sprayer. During the spraying, it helps him into checking that no nozzle is obstructed and that the tank level is compatible to the work still to be done. After the spraying, it allows to view the maps of applied products and therefore to detect any over or under spraying. The data can also be used to build up the spraying traceability forms, which are compulsory in Europe. This system has been successfully tested during 2 years on 14 sprayers of vine growers in Montpellier region (South of France).

In parallel, these technologies are used to monitor the spraying practices and to make relationships with pollution recorded in river basins. The aim of this paper is to describe the overall results of this project which ends up in January 2009.

**Key words:** ICT, spraying, pesticide, traceability, monitoring, GPS, water quality

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## **1 Introduction**

The European Water Framework Directive sets the goal of achieving a “good status” for all of Europe's surface waters and groundwater by 2015. Both underground and ground water masses are affected by pesticide pollution. In 2004, the contamination levels are significant: 49% of ground water samples were graded “average to bad” quality, 27% of underground water would need to be processed for being made potable.

In 2001 already, Miller outlined “the need to provide more detailed traceability of product use and application». Although monitoring and traceability was already well carried out for aerial spraying (Orchard et al 1982, Needham et al 2006) and for large boom sprayers (specmeters). However, in the vineyard, pesticide tracing is not at all developed yet, due to the high cost of the monitoring devices.

Our aim was therefore to develop and test a low-cost traceability sensor device able to lonitor pesticide application. After studies in the early 2000's, we had the opportunity to validate this concept in a large project, AWARE, supported by a European fund (LIFE). This three-year project aimed at showing how the optimisation of agricultural practices and spraying equipments related to pesticide in viticulture can help the farmers to preserve the quality of water entities and to maintain a high quality production. Aware was carried out by the following consortium: research laboratories CEMAGREF (F), SUPAGRO M (F), LISAH-INRA (F), IRTA (SP); ICT companies: E.RE.CA (F) ,VOE Développement (F); local authorities and transfer institutions: CISA (I) CG 34 (F), CA 34 (F), and vinegrowers: NEFFIES cooperative (F).

The first objective of this project was to test the capacity of information and communication technologies (ICT) to help farmers to reduce the total amount of pesticides released during the crop protection process. The second objective was to study the relation between this decrease of pesticides quantities on a standard catchment basin and the actual improvement of the water quality at the basin outlet. Finally, we aim at extending the method and results to other contexts thanks to the modelling of pesticides transfer, and to assess the feasibility of knowledge transfer through implementation of the methodology and ICT system in others European contexts (Spain, Italy).

The aim of this paper is to describe the ICT equipment developed for the sprayer and the opportunities offered to the farmer by this new equipment.

## **2 Material and methods**

The Aware device aims at measuring a number of data relevant for the spraying operation and delivering them to the farmers of the Cooperative. It is made up of two parts:

- The Aware mobile device is an embedded sensor device for measuring and recording spraying data.

- The Aware Server is the processing and display unit, located at Neffies wine cooperative;

Aware mobile consists in embedded electronics on the tractor (MPU) and on the sprayers (APU). Data recorded by the Aware Mobile are the following:

- Climate data: temperature, humidity, wind direction and force
- Tank level
- right and left flows of the spraying,
- the position (GPS) and speed.

The MPU (Fig. 1) manages the GPS referencing, the climate data, the data display and man-machine interface (for manual data input), so as the Wifi interface to data transfer. The APU (Fig.2) deals with acquisition of data related to tank level and right / left flows.

The Aware Server unit is aimed at

- recording and processing the data received through the Wifi, in order to compute trajectories and to fuse data;
- generating information related to the sprayed plots and to the various processing dates.



Fig 1: The MPU unit in the tractor cabin



Fig 2: the APU box on the sprayer.

A GIS has been implemented for gathering all terrain data (topography, hydrographic network, vineyard plots...).

The sensors have been implemented on the sprayers of 15 vineyard growers, representing 80% of the vineyard plots of the Neffies river basin. These sprayers were all of different brands and models and the implementation has been realized without any major problem (Fig 3).

Both the Mobile and the Server Aware units have been developed in order to be as user-friendly as possible. The Aware project also deals with assessing the acceptance of the device by vineyard growers. In 2006, two training sessions have been organized, one in July 2006

and the other one in October 2006, after the agricultural season, in order to carry out a first return on experience from the farmers.

One campaign has been carried out in 2007 with these 15 sensing devices. At the beginning of the season all sprayers have been cleaned and tuned. Various parameters are checked and remained to the farmers during the training sessions: the nozzle orientation, the cleaning up and the maintenance of the sprayer between two spraying operations; the tuning of the right and left flows.

In parallel to the spraying data recorded by the Aware device, the farmers are invited to fill up a “spraying book”, in which all data dealing with spraying are theoretically written.

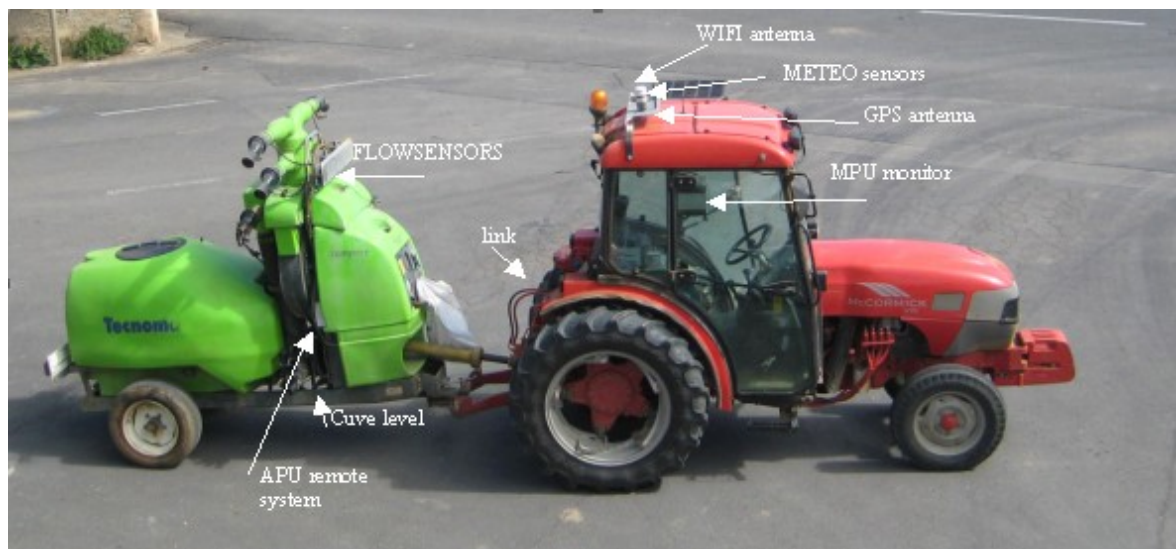


Fig 3: the implementation of the Aware device on the Cemagref tractor.

### 3. Results

#### Role of the Aware devices for sprayer tuning

The Aware sensing devices have been used at two steps by the farmer, in an on-line configuration:

- first, during the filling up: the tank level sensor is very useful to the farmer as it allows the farmer to stop the filling when necessary. This operation was much less comfortable when using the sprayer embedded level sensors;
- second, during the spraying, because the farmers can monitor the spraying and external parameters and therefore adapt its speed or detect any dysfunctionning (ex: stuck nozzle...); the displayed parameters are at present: the right and left flows (in l/min) and the weather parameters (then the farmer can stop if the wind is strengthening).

### Role of Aware devices for farmer practice improvements

After processing, data are turned into graphs and maps , which can be used by the farmers and advisors for farmer self improvement.

The following graphs (FIG.4) are being shown to the farmer. For instance Fig.4a shows a lack of balance between left and right arms. The regular flow drops show that the farmer systematically switch off the flow when arriving at the plot border. Fig.4b shows that the wind force, although unstable (varying between 2 and 10 km/h), never goes above the upper authorized speed, I.e. 19 km/h.

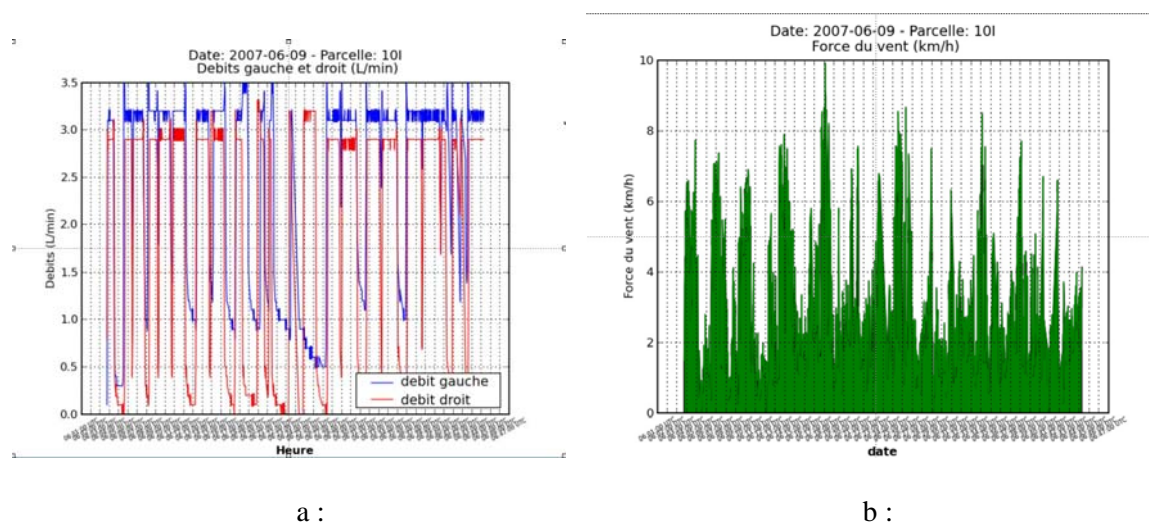


Fig 4. Graphs recorded by the Aware device : a) the right and left flows, b) the wind speed.

Maps are also very informative for farmers. On Fig.5b is shown the map of the total flow (addition of right and left flows) sprayed on a plot.

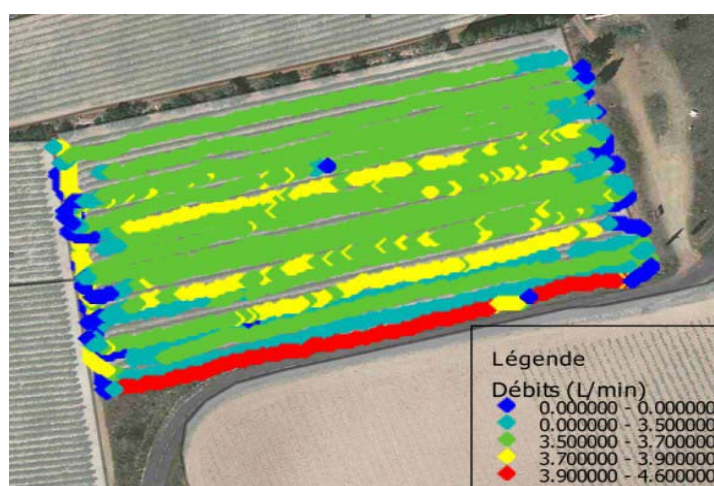


Fig. 5: Map of total sprayed flows on a plot.

This map clearly shows that:

- the farmer switches off at the border of the plot;

- but that there are some overlapping and therefore some over-dosing (in red) in the plot.

Using these types of maps, the farmer can get involved into a self-teaching scheme.

**Role of Aware devices for traceability improvement**

Data can also be organised in order to fill up a “traceability book”, similar to the one that is filled compulsorily by the farmer. Outputs as the following (Fig 6) can be automatically generated in order to help the farmer to have a guaranteed “traceability book”.



First comparisons made with the manual traceability books show several discrepancies. They are always due to farmer errors (due to a delay in filling up the book, to writing errors...). Therefore, Aware offers a secure way for elaborating the “traceability book”.

	Tracabilité automatique	Tracabilité papier	Comparaison
Date du traitement:	2007-06-09	2007-06-09	OK
Parcelle traitée	101 (surface déclarée=0.99Ha, interrang=2.25m,intercep=1.2m)		
Produits utilisés			
Produit 1:	None : None	vivum flash (2000321) à 1.0 kg/ha	
Produit 2:	None : None	cascade (8900291) à 0.4 l/ha	
Produit 3:	None : None	collis (2060085) à 0.4 l/ha	
Produit 4:	None : None	0:à	
Produit 5:	None : None	0:à	
Produit 6:	None : None	0:à	
Caractéristiques du traitement			
Vitesse de fonctionnement	4.7 km/h	4.8 km/h,	-2.08 %
Débit gauche de fonctionnement	3.14 L/min	différence gauche-droite: 0.24	
Débit droit de fonctionnement	2.9 L/min		
Débit total de fonctionnement	6.04 L/min	5.4	11.85 %
Passe tous les :	1.7 rangs	2 rangs	-15.0 %
Volume de bouillie pulvérisé	165.76 L	-	
Surface traitée	1.09 / 1.15 Ha	-	
Volume de bouillie par hectare	152.0 L/ha	150.0 l/ha,	1.33 %
Conditions météorologiques			
Force du vent moyen	3.1 km/h (1.0)	1: tres legere brise	dif=0.0
Force du vent maximum	9.9 km/h (2.2)	-	
Température moyenne	18.4 °C	-	
Température maximum	19.8 °C	-	
Humidité moyenne	63.0 %	-	
Humidité minimum	60.0 %	-	

Fig. 6. An example of sheet of the « traceability book » automatically generated by the Aware devices.

## Conclusion

The Aware sensing device has been tested during one year on 15 different sprayers of the Neffies cooperative, on the Neffies river basin. This two-year experiment has shown that:

- these systems could be implemented with no major problems on vary different vineyard sprayers;
- during spraying (including filling up), the devices were used for sprayer tuning and for spraying monitoring by the farmers;
- the device outputs could be used for generating traceability books with a higher fidelity than the one of manual traceability;



- the maps and graphs generated from the sensor could be used by the advisors for training farmers;
- the acceptability of these devices was very good because of the reduced number of entries.

More, this experiment enabled us to build up a data basis made up of pesticide spraying monitoring data. These data, in addition to rain fall data are fed into a hydrological model, MHYDAS (Tiemeyer et al, 2007). This model describes the hydrological functioning of the river basin. The outputs are simulations of the river flow and the concentration of pesticides molecules in the river. They are to be compared with the river flows and pesticide concentrations which have been measured in situ during these 2 years. These computations are now carried on and results are to be shown in January.

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