CRA-W's Committee of Intervention: Analyse of Catchments Polluted with Pesticide

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Abstract: In the Walloon Region of Belgium, a committee of intervention has been created to investigate problems of pesticide contamination of various catchments use for drinking water production. This committee involves the Agricultural Research centre - Wallonia (CRA-W, project coordinator) and some University experts. It is funded by the Société Publique de Gestion des Eaux (SPGE). The diagnosis method, base on the AQUAPLAINE method (Arvalis - France), consists of 4 steps. The first step is the preparation of diagnosis (at the office) that takes into account the paper risk of active ingredients. and their uses, the identification of the agricultural parcels, the collection of cartographic and numeric data, the description of the hydrogeological and pedological contexts and the study of the meteorological data in relation with the period of pollution. The second step consists of making a plot diagnosis (on the field) to identify the way of transfer inside the plot and collecting data. At the third step, the people who can apply PPP treatment close to the catchment are met (farmers and city services). Information are collected on treatments applied and on the state of parcels. Based on the hypothesis of pollution cause, the committee proposes solution to solve the problem. One of the catchment that has been investigated by the committee is located at Biesmerée, (Namur province, in Belgium). A temporally contamination was caused by 4 pesticides : chlortoluron, isoproturon, trifluralin and diflufenican. After investigations, it seems that the pollution was probably due to the hydrogeological context . As the river is locally perched over the aquifer, the presence of Poly-aromatic hydrocarbons (PAHs) could be due to the infiltration of surface water inside the catchment or/and to the presence of a sinkhole temporally activated during river flood period. Infiltration rate has to be assessed and river bank impermeabilization is recommended

Key word: pesticide, catchment, Committee of intervention.

INTRODUCTION

In the south part of Belgium, 80 % of the drinking water production comes from the ground water. The pollution caused by pesticide increases each year (EEW, 2007). So between 2000 and 2007, 16% of the catchments have been contaminated by pesticide, once upper than the drinking water standard of 0.1µg/l. Catchments pollution increase the cost of production, due to the remediation treatment.

To protect the catchment, protection area must be located around them. Into these areas, special legislations are taken into consideration to limit the risk of pollution by pesticide. Nevertheless, the situations are very variable and global measures seem to be inefficient. So specific measures should be considered and adapted case by case. In this context, the public body in charge of water protection (SPGE) put the Agricultural Research Center of Wallonia (CRA-W) in charge of developing a pollution of pesticide diagnosis method and proposing protection measures, site by site. A committee of intervention has been created to investigate and to propose solution to resolve the problem of pesticide pollution at the catchments used for drinking water production. This committee is composed by pedologists (FUSAGX), hydrogeologists (FUNDP), agrometerologists, geomatician (BGDA) and agricultural engineer in charge of coordination (CRA-W).

This paper presents the pilot study carried on in October 2006 and that leads this committee to develop and improve a specific methodology.

MATERIALS AND METHODS

The catchment studied is located in Biesmerée area (Mettet) in the Namur Province. The groundwater is pumped from 3 wells called: Lepoivre P2, Lepoivre P4 and Lepoivre P5 (Table1), located in an abandoned limestone quarry.

Due to the quarry floor altitude that is located below the piezometer level, constant dewatering is necessary. This creates a drawdown cone of more than 600 meters wide, extended below the river Stave (Figure 2). Due to the pumping and to the dewatering, the Stave River is perched. Seepage could occur according the alluvial deposit permeability and risks of groundwater contamination are high.

Table 1: Characteristics of the wells

Name	*Type*	*depth*	*Capacity*
Lepoivre P2	Drilled well	44m	165m³/hours
Lepoivre P4	Drilled well	37.5m	80m³/hours
Lepoivre P5	Drilled well	27m	80m³/hours
Quarry dewatering	Drilled well	?	To drawdown artificially the water level

The total volume produce by this catchment is equal to 1,700,000m³/year or 194 m³/hours. The wells are not used, permanently. Lepoivre P4 and P5 are used alternatively to support the production of Lepoivre P2. Lepoivre P4 was used when the pollution of the well appeared. The first peak of pollution was observed in "Lepoivre P4" the 9th of October 2006 with 0.275 µg/l of chlortoluron and 0.182µg/l of isoproturon. A second peak appeared the 17th of October 2006, with respectively, 1.682 µg/l, 0.4676 µg/l, 0.145 µg/l and 0.816 µg/l of chlortoluron, isoproturon (IP), diflufénican (DFF) and trifluraline (Figure 1).

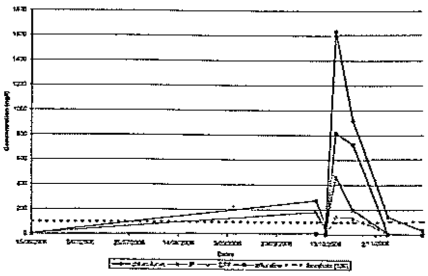

Figure 1: Concentrations of pesticides inside the well "Lepoivre P4"

The committee studied the cause of this pollution using a method based on the AQUAPLAINE diagnosis method developed by Arvalis (institut du végétal, France) consisting of 4 steps (Arvalis, 2003):

- Preparing the diagnosis using existing information.
- Plot diagnosis using data bank completed by field observations.
- Meeting and discussion with pesticide users.
- Final diagnosis and remediation proposal.

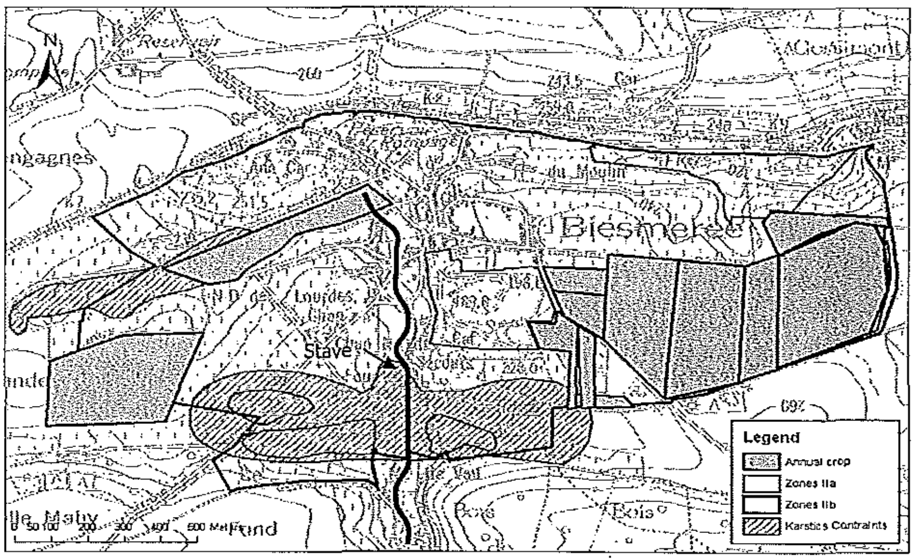

Figure 2: Site location and means observations carry on the fist step of the diagnosis

RESEARCH RESULTS

First step: Preparing the diagnosis using existing data

The first step consists of gathering the available data, to prepare a useful and efficient field visit, information regarding:

- Pesticide general information (use, application period, paper risk, analysis results,...).
- Landscape and the fields environment (agricultural parcels, coverage, key elements of the landscape, cartographic data on the site, on the geology, hydrogeology and pedology context,...)
- Meteorological data (precipitation, evapotranspiration and field capacity).

The four active ingredients (a.i.) implicated in the pollution are used specially as cereal herbicide. Their application could be carried out in pre-emergency (in spring) of in post-emergency (in autumn) depending on the type crop and the active ingredients. Isoproturon and chlortoluron presenting the same action spectrum are not usually applied together. These a.i. could be applied apart, in association with diflufenican of trifluraline to broaden the spectrum.

Based on paper risk, the chlortoluron and isoproturon present an important risk of ground water contamination according to Groundwater Ubiquity Score (GUS) (IUPAC,1995). In fact these a.i. are usually detected in Wallonia, which is not the case of diflufenican and trifluraline, according to their low GUS value.

At Biesmerée, protection areas have been defined according to the Walloon legislation. These areas consist of 3 zones:

- Catchment area or zone I: closed area owned by the water producer, its extension is 10 meter around the catchment site.
- Nearby protection area or zone IIa: inside this zone, a pollution of groundwater takes 24 hours to reach the catchment.
- Distant protection area or zone IIb: inside this zone, a pollution of groundwater takes between 1 day and 50 days to reach the catchment.

Zone IIa and IIb are located taking into account the geology, the hydrogeology and using tracer tests and groundwater modelling.

The zone IIb has an extension of 2 km in an West-East direction and about 800 m in a north-south direction. The wide extension is due to geological (karstic limestone affected by sinkholes, collapse doline,...) and the hydrogeological contexts (important drawdown due to dewatering).

At a first approach, the zone IIb has been defined as the studied zone by the committee.

Based on the study of topographical contour lines, the way of the waters runs off in each field was identified inside the parcels. Specification as annual crops or permanent meadows has been identified, supplying by the Land Parcel Identification Systems (LPIS). In total 12 agricultural parcels covered by annual crop have been spotted on which the a.i. could be applied (Figure 2). The tenants of these parcels, 5 in total, were met in step 3.

In this context, we considered that the cause events is close to the detection of pollution.

Soils are mainly developed in Paleozoic limestones, Pleistocene aeolian silt (loess), Holocene colluvial or alluvial materials, or even in Cenozoic (Oligocene or Eocene) clayey-sandy materials.

Meteorological data are used to evaluate the hydric state of the parcels, based on the Florenne weather station data, from 1988 to 2006. The daily precipitation and evapotranspiration, according to wheat crop with 1.20 meter of maximum rooting depth, are taken into account to calculate the different parameters of soil moisture affecting the Relative Soil Moisture Index (RSMI) (Buffet and al., 2005):

$$RSMI = \frac{\theta t - \theta wp}{\theta fc - \theta wp} \times 100$$

In which θt is the actual soil moisture content [cm³/cm³], θwp is soil moisture content at wilting point [cm³/cm³] and θfc is soil moisture content at field capacity [cm³/cm³].

The figure 3 represents the RSMI variations in the studied area based on the last 18 years data. At the field capacity, the RSMI is equal to 100% and the infiltration risk is important. At the wilting point, the RSMI is 0%. So, based on these data, the field capacity is reached in this area, 8 years on 10, at the date of the pollution.

The daily precipitation of 2006 showed just before the first peak of pollution, a rainy episode of 13mm the 7th of October.

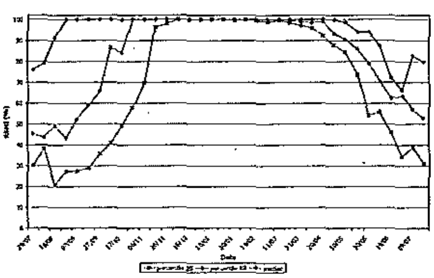

Figure 3: Evolution assessment of RSMI

Second step: Plot diagnosis using data bank completed by field observations.

The land use on the 12 parcels branded at the first step has been defined. Winter cereal were sown on 7 parcels; winter barley on 3 (Figure 4) and winter wheat on 4 parcels. The winter wheat herbicide application was carried out in post-emergency treatment, in spring. So, we focussed observations on winter barley parcels.

Into the winter barley parcels, soil profile has been investigated. There are very heterogeneous according to the augering observations. The soil water storage capacity is between 92 and 172.5 m, broad ranking due to soil profile variability (clayey or sandy). The soil profile affects the water flow inside the parcels. Actually, the risk of infiltration is very important in sandy soil profile and decreases with the part of clay, impermeable layer.

An other source of the catchments contamination by pesticide could be surface water trough the Stave River, which is a perched river or trough the active sinkhole observed in the alluvial plain. Due to the important drawdown dewatering cone, surface water infiltration could easily reach the catchments.

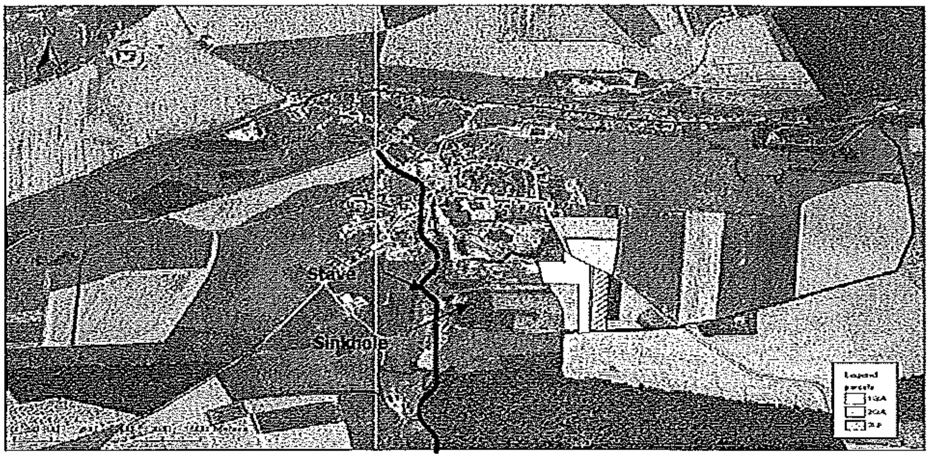

Figure 4: Parcels of winter barley

Third step: Meeting and discussion with the pesticide users

The main pesticide users in this area are the farmers and the city service in charge of road maintenance. The treatments applied by city service, containing glyphosate, flazasulfuron and dichlobénil, were not implicated in this pollution and had never been detected into the wells.

The 5 farmers identified at the first step, are met and information on pesticide treatment gathered. As we thought, no treatment was applied in pre-emergency on winter wheat, unlike the winter barley. Supposing the pollution is due to a pre-emergency application of pesticide on winter cereal, the treatments of winter barley are interesting (table 2). The farmers concerned are 2, we called them GA and LE.

The winter barley herbicide treatments were applied before the first peak of pollution, the 9th of October. One farmer (LE) applied the 4 a.i. on the same parcel, which is unusual. The herbicide treatments of winter barley were applied before the first peak of pollution. The events are well correlated into the time: herbicide application (the 22th of September), precipitation (13 mm the 7th of October), and detection of pollution (first detection, the 9th of October).

Table 2: Winter barley's herbicide treatment

Parcels	*Date*	*Application rate*	*a.i.*
1GA	22/09/06	960 g of a.i./ha	trifluraline
	22/09/06	1500 g of a.i./ha	chlortoluron
2GA	22/09/06	960 g of a.i./ha	trifluraline
	22/09/06	1500 g de sa/ha	chlortoluron
3LE	26/09/06	62, 5 of a.i./ha 500 g of a.i./ha	Diflufénican Isoproturon
	26/09/06	960 g of a.i./ha	trifluraline
	26/09/06	1000g of a.i./ha	chlortoluron

DISCUSSION AND CONCLUSIONS

Fourth step: Final diagnosis and remediation proposal

The risk of infiltration inside the parcels is support by the sandy soil profile, the presence of karstic constraints and sinkhole in the nearby protected area and the succession of the events.

Nevertheless, the rapidity of infiltration (13 days to reach the groundwater and arrive at the catchment) and the high concentration of pesticide detected don't support hypothesis of infiltration inside the agricultural parcels. In fact, according these important a.i. concentrations and the vulnerable hydrogeology context, the pollution could be due to an infiltration of surface water into the catchment.

To support the hypothesis of surface water infiltration, molecule usually present in surface water, as Poly Aromatic Hydrocarb (PAH) has been studied (table 3).

The pollution caused by pesticide is closely connected to the presence of PAH. This observation is one other element that proves the surface water infiltration into the catchment. Now, the origin of the surface water must be find: perched stream infiltration or infiltration by the sinkhole.

To get a clear answer, river gauging and tracer tests shoud be performed to answer.

In the case of the origin of this pollution is the stream infiltration, it's important to point out that the LE's farm is located closed to the stream upstream the catchment. The rinsing of the sprayer into the farmyard could be the cause of pollution.

Table 3: Detection of Poly Aromatic Hydrocarb into the Well Lepoivre P4

Dates	*Benzo (b)fluoranthène**	*Benzo (ghi)pérylène**	*Benzo (k)fluoranthène**	*Indénopyrène**	*Benzo (a)pyrène**	*Fluoranthène**	*Pesticide >0.1 µg/l*
8/02/06	0	0	0	0	0	0	None
31/03/06	0	0	0	0	0	0	None
15/06/06	11	8	3	6	6	6	Chloridazon Métolachlore
9/10/06	5	3	2	3	4	4	Isoproturon Chlortoluron
13/10/06	0	0	0	0	0	0	None
17/10/06	4	3	2	0	0	4	Isoproturon Chlortoluron Trifluraline Diflufénican
24/10/06	12	11	6	9	10	9	Isoproturon Chlortoluron Trifluraline Diflufénican
7/11/06	3	0	2	2	3	4	Chlortoluron
21/11/06	0	0	0	0	0	2	None

* PAH express as ng/l

Corrective measures will be analysed for surface water infiltration but at first the hypothesis must be proved. This point is not developed into this paper. If these hypothesis are confirmed, the river floor and banks will have to be leak proofed. In any case, surface water infiltration by sinkhole has to be stopped, as abnormal turbidity has been found in some wells during heavy rainy events.

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REFERENCES

Arvalis. 2003. Theoretical basis for diagnosing non-pont source pollution by pesticides. Footprint project. 16p.

Bourguignon p. 1959. Texte explicatif de la planchette de mettet-165e. Carte des sols de la belgique. Irsia, bruxelles, 83p.

Buffet d, oger r, delongueville v, tychon b. 2005. Workshop on climatic analysis and mapping for agriculture bologna, italy. 14-17 june 2005. Meeting report sept. 2005.

Eew. 2007. Rapport analytique sur l'état de l'environnement wallon. Ministère de la région wallonne. Dgrne.

Iupac. 1995. Offsite transport of pesticides in water : mathematical models of pesticide leaching and runoff (technical report). Pure and appl. Chem. Vol 67, 12. 2109-2148 pp.