Assessing the effects of urban waste recycling practices on pesticide leaching in a long term field study

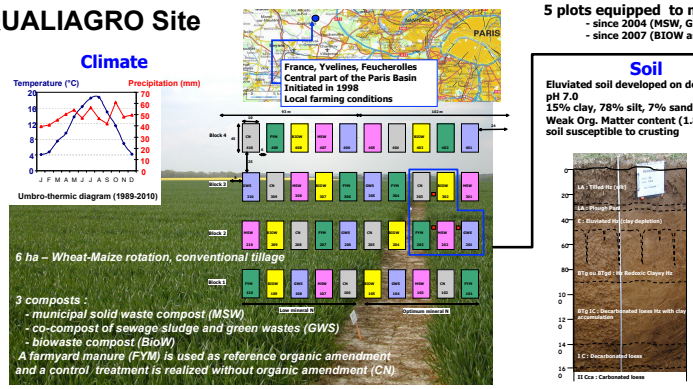
P. Benoit, N. Simon, V. Pot, M. Deschamps, A. Michaud, V. Mercier, J.N. Rampon, C. Labat, V. Etievant, N. Bernet, P. Vachier, Y. Coquet, P. Cambier, E. Barriuso, S. Houot

INRA, UMR 1091 Environnement et Grandes Cultures, INRA AgroParisTech 78850 Thiverval-Grignon

INTRODUCTION : The application of composted urban wastes to cultivated soils offers an alternative to their elimination through ultimate disposal in landfills or incineration. The immediate benefit of such a management practice is the increase of soil organic matter contents and fertility. The incorporation of organic amendment modifies soil physical properties, decreasing soil bulk density and increasing soil aggregate stability, macroporosity and soil moisture retention. Application of organic amendments is thus likely to affect water flow and leaching of solutes through soils owing to soil structural changes. In addition, the effects of repeated urban waste composts application on the mobility and bioavailability of mineral and organic pollutants remain to be further evaluated (Houot et al., 2002).

Concerning **pesticides**, the current knowledge considers that organic amendments generally increase soil organic matter content and consequently increase the soil sorption capacity for pesticides, thus may delay the leaching of pesticides through soils. However, organic amendments produce dissolved organic matter (DOM), which can alter pesticide sorption by either facilitating their leaching or increasing their sorption (Fernandes et al., 2006, Barriuso et al., 2011). Finally, organic amendments diversely affect pesticide degradation: either degradation can be retarded by the decrease of pesticide availability after its sorption (Dolaptsoglou et al., 2007) or can be enhanced by the increase of microbial activity (Vieublé-Gonod et al., 2009). Although a relatively abundant literature does already exist on these different processes, comprehensive studies conducted in environmentally relevant conditions, i.e. close to natural and complex soil ecosystems, are scarce because they are difficult to be carried out experimentally. Therefore long term field studies represent valuable tools to quantify such effects in an integrated way and to evaluate for instance the risk of leaching of pesticides associated to such organic waste recycling practices.

QUALIAGRO Site



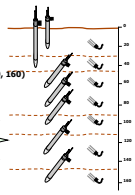
5 plots equipped to monitor soil solution fluxes
- since 2004 (MSW, GWS and CN)
- since 2007 (BIOW and FYM)

Soil

Eluviated soil developed on decarbonated loess
pH 7.0
15% clay, 78% silt, 7% sand
Weak Org. Matter content (1.8 % OM)
soil susceptible to crusting

Field Monitoring

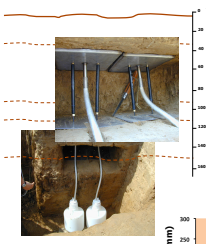
Hydrodynamics and temperature
TDR probes (20, 40, 60, 80, 100, 130, 160 cm)
Tensiometers (20, 40, 60, 80, 100, 130, 160 cm)
Temperature probes (1, 5, 10, 15, 20, 40, 60, 80, 100, 130, 160)

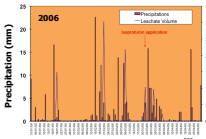


Soil solution at different depths
3 types of porous cups
ceramic (28 et 100 cm) / **inox** (28 cm)
PTFE-quartz (28 et 100 cm)

DOC, nutrients, pH, major ions
Trace Metals, **Pesticides**
Trace Organic Contaminants

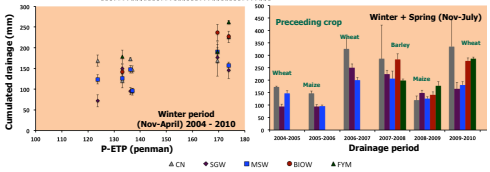
2 fiberglass wicks lysimeters per plot (45 cm)





Ponctual samples collected every week/2 weeks according to P (mm)
Two replicates per plot

Estimation of drainage (mm) at 45cm depth



Pesticides detected in leachates 2005-2010 period

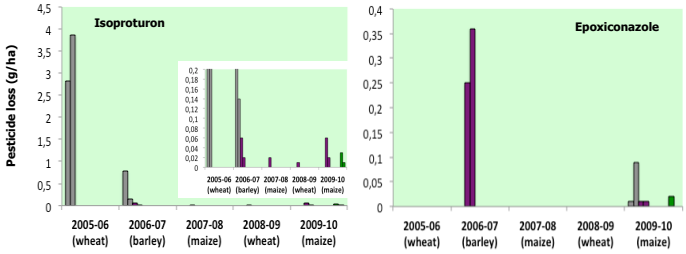
collected in wick lysimeters (45 cm depth) and ceramic cups (1 m depth)

Pesticide	Application period	Monitoring period	Frequency of detection [c]	Concentration Range µg l^{-1} [d]	
				Wick lysimeters	*Ceramic cups*
Atrazine	1998-2003[a]	2005-2006	0 %	n.q.	n.q.
Desethyl atrazine		2005-2006	**50%**	**0.03 – 0.11**	**0.02 – 0.07**
Isoproturon	1998-2010[b]	2005-2010	**20%**	**0.02 – 17**	**0.02 – 1.5**
Isopropylphenyl-methyl-urea		2005-2010	**8%**	**0.02 – 0.8**	**0.02 – 0.21**
Isopropylphenyl-urea		2005-2010	0%	n.q.	n.q.
MCPP	1998-2010[b]	2007-2010	0%	n.q.	n.q.
Ioxynil	1998-2010[b]	2007-2010	0%	n.q.	n.q.
Epoxiconazole	1998-2010[b]	2007-2010	**9%**	**0.05 – 0.97**	n.q.

[a] applied on maize once every two years until 2003 ; [b] applied on wheat once every two years; [c] calculated on the basis of total number of analyses in wick lysimeters and ceramic cups ; [d] limits of quantification 0.02 µg l-1 (atrazine, desethyl-atrazine and isoproturon) and 0.05 µg l-1 (other pesticides).

Isoproturon was more frequently detected in the SGW (30%), FMY (27%), and CN (17%) compared to the MSW (12%) and BIOW (11%) over the 2005-2010 period. Maximum concentrations of isoproturon were found in leachates collected in the CN few days after application. Contrastingly, it was detected at lower concentrations but for a longer period in the SGW treatment until the fallow period preceeding maize sowing. The same trend wad observed for the FYM plot. Fluxes of isoproturon were negligible under two compost treatments, MSW and BIOW. The maximum losses were observed in the CN plot in the 2005 winter. Among metabolites only the isopropylphenyl-methyl-urea was occasionally detected. Largely used on maize before 2003, atrazine was not detected but **desethyl-atrazine** was systematically measured in 2005, and less frequently after 2006.

Epoxiconazole was found one year after its application mostly in the CN and SGW and occasionnally in the FYM plot. On the contrary, the fungicide was not detected in the MSW and BIOW leachates. The highest peaks were analysed in the 2006-2007 after two consecutive applications when barley was planted after wheat instead of maize. In this particular case, fluxes have represented up to 0.5% of the applied dose in the SGW treatment. Otherwise, epoxiconazole fluxes represented 0.08 % in the CONT and about 0.01 % in the SGW and FYM treatments.



Long term vs short term effects on soil water dynamics and possible consequence on pesticide leaching

Compost effects on **crop productivity** and **feedbacks on soil water balances and profile recharge** :
- Relative increase in wheat and maize yields by comparison with unamended treatment CN (Houot et al., 2009)
- Combined with the influence of the preceeding crop on the drainage the following winter : maize > wheat

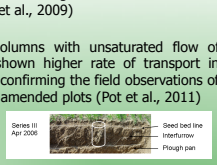
Compost effects on **soil physical** properties :
- Soil agregate stability is increased in the LA horizon (Annabi et al., 2007)

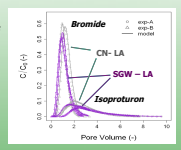
Compost effects on **soil hydrodynamic** properties :
- Soil water retention increases in the LA horizon only (Chalhoub, 2010)
- Predominant effect of tillage rather than compost on the hydraulic conductivity (Schneider et al., 2009)
- The effect of compost is localized in space (interfurrow) and time (few months after compost incorporation by tillage) (Schneider et al., 2009)

Compost effects on **soil physico-chemical** properties :
- **After 11 years** (2009) , soil organic carbon significantly increased in LA horizons (+35% in SGW and BIOW / +30% in FYM / + 23% in MSW vs CN after 11 years (2009)
- pH significantly increased in LA horizons for BIOW (pH = 7.7) and MSW (pH = 7.4) vs SGW (pH = 6.9) and CN (pH = 6.7)
- Dissolved organic carbon fluxes are impacted by compost application (SGW-BIOW >MSW>CN)

Compost effects on **microbiological** properties :
- The effect of compost is localized in space (Interfurrow in the LA horizon) with an increase of microbial and fungal biomass which is maximal after compost incorporation but can be oberved several months after compost application (Vieublé-Gonod et al., 2009)

- Drainage cumulated over one drainage season is often larger in the CN (unamended control) than in some compost treatments (SGW and MSW)
- Leaching starts usually earlier in the winter in the CN plot
- Pesticide are more retained by sorption in the compost treated plot as shown by significant increase in Kd. SGW> MSW >>CN in the LA horizon
  - Higher concentration of isoproturon in leachate after application periods in CN vs compost treatment
  - Increased delay in the leaching for more persistent compunds such as epoxiconazole in SGW
- Their is a potential effect on pesticide degradation in the surface soils as already shown for isoproturon (Vieublé-Gonod et al., 2009)
- Additionnally, undisturbed soil columns with unsaturated flow of tracers and isoproturon have shown higher rate of transport in columns sampled from LA of CN confirming the field observations of a decreased mobility in compost amended plots (Pot et al., 2011)





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