

Characterizing Soil Quality and Assessing Emerging Pollutants in Clusters of Crohn's Disease Incidence in France

Presented by Lara Maria Wakim

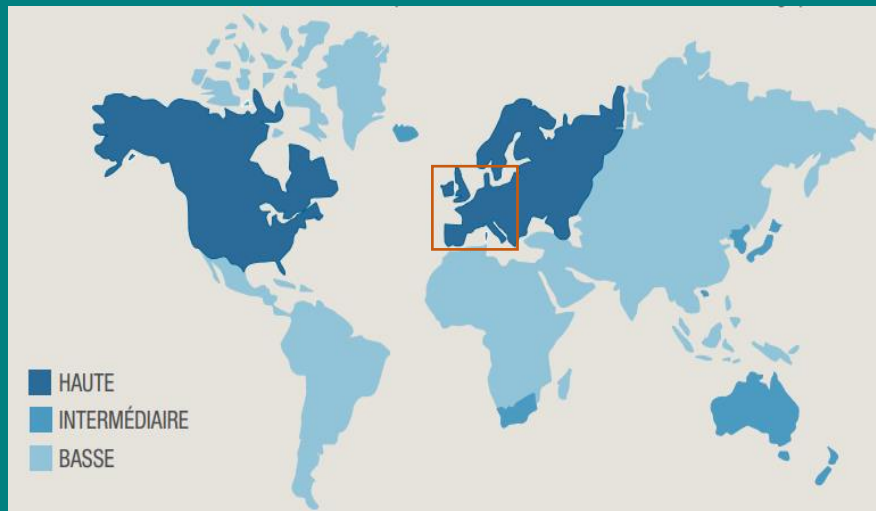
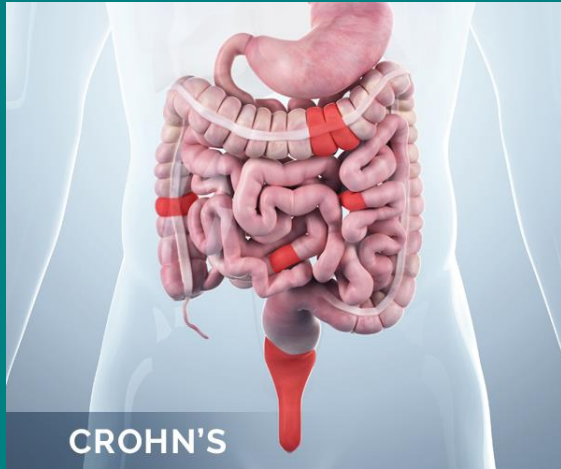
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intersol'2024

Congrès-Exposition International sur les Sols, les Sédiments et l'Eau
International Conference-Exhibition on Soils, Sediments and Water



Crohn's disease



Chronic intestinal disease affecting the various segments of the digestive tract, from the mouth to the anus. It is one of the chronic inflammatory bowel diseases (IBD).



10 million cases of IBD worldwide. Incidence has been rising in Eastern Europe over the past 30 years.



150,000 cases in France in 2014.
23% increase in incidence over 12 years (1988-1999) in northern France.

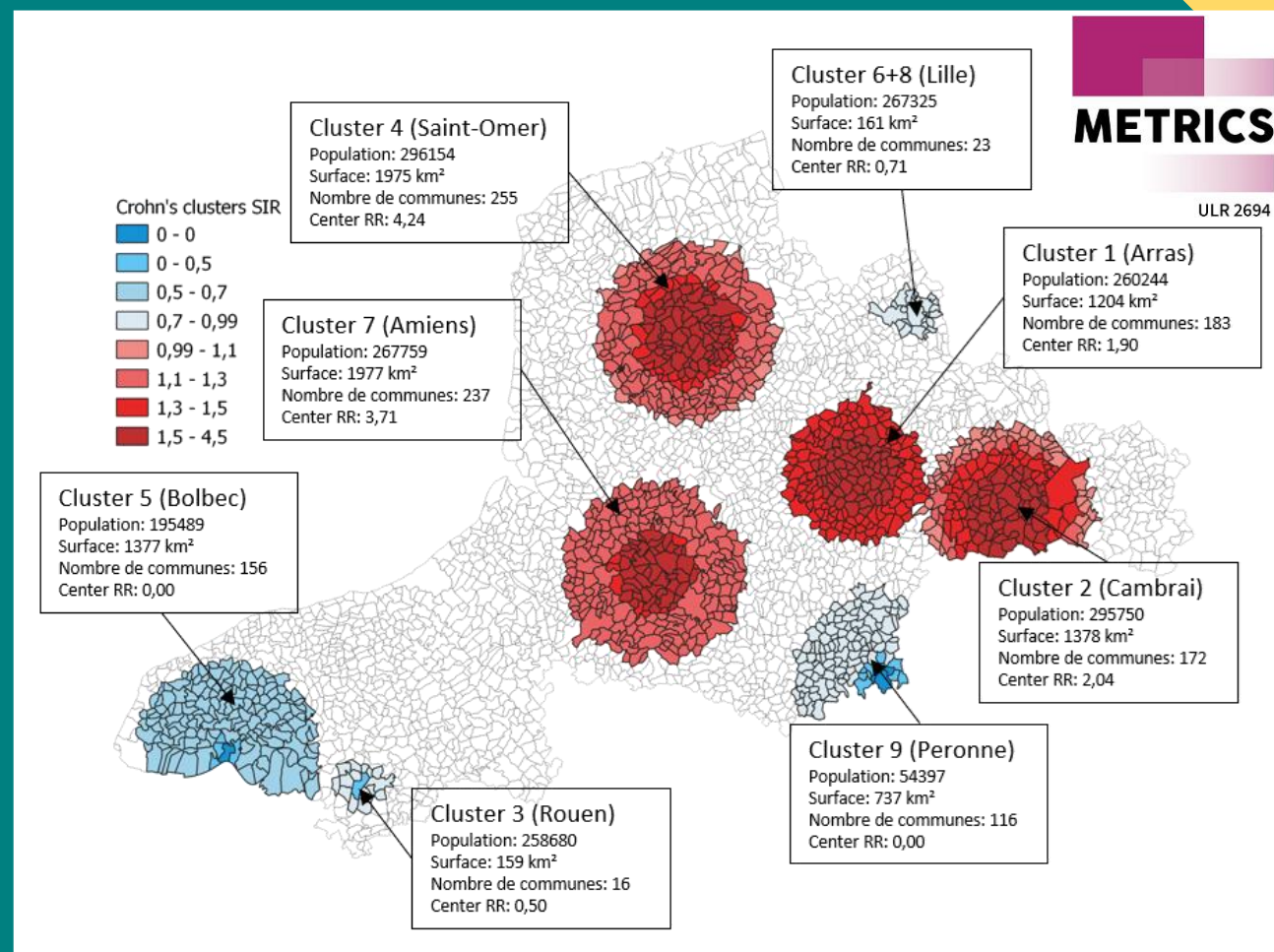
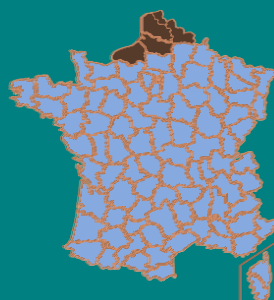
Disease incidence in the study area

EPIMAD

Only registry in France and the biggest worldwide

Registry created in 1988 to cover IBD patients in the 4 departments of north-western France: **Nord (59)**, **Pas-de-Calais (62)**, **Somme (80)** and **Seine-Maritime (76)**.

The register covers 6 million people (9.1% of the French population) and **19,266** cases were registered up to 2014.



Gender- and age-adjusted isotonic spatial clusters (1990-2014) identified by the METRICS team
(*Evaluation des technologies de sante et des pratiques medicales - URL 2694*)

Etiology of the disease



Unknown etiology: the disease is partly genetic, and many indications are linked to environmental factors.

A review article on environmental factors linked to Crohn's disease highlights the lack of studies on soil pollution, and makes recommendations such as "follow the leads currently identified - in particular metals and endocrine disruptors; **explore soil contamination...** " (Tenailleau *et al.*, 2020).

Exposure to soil particles

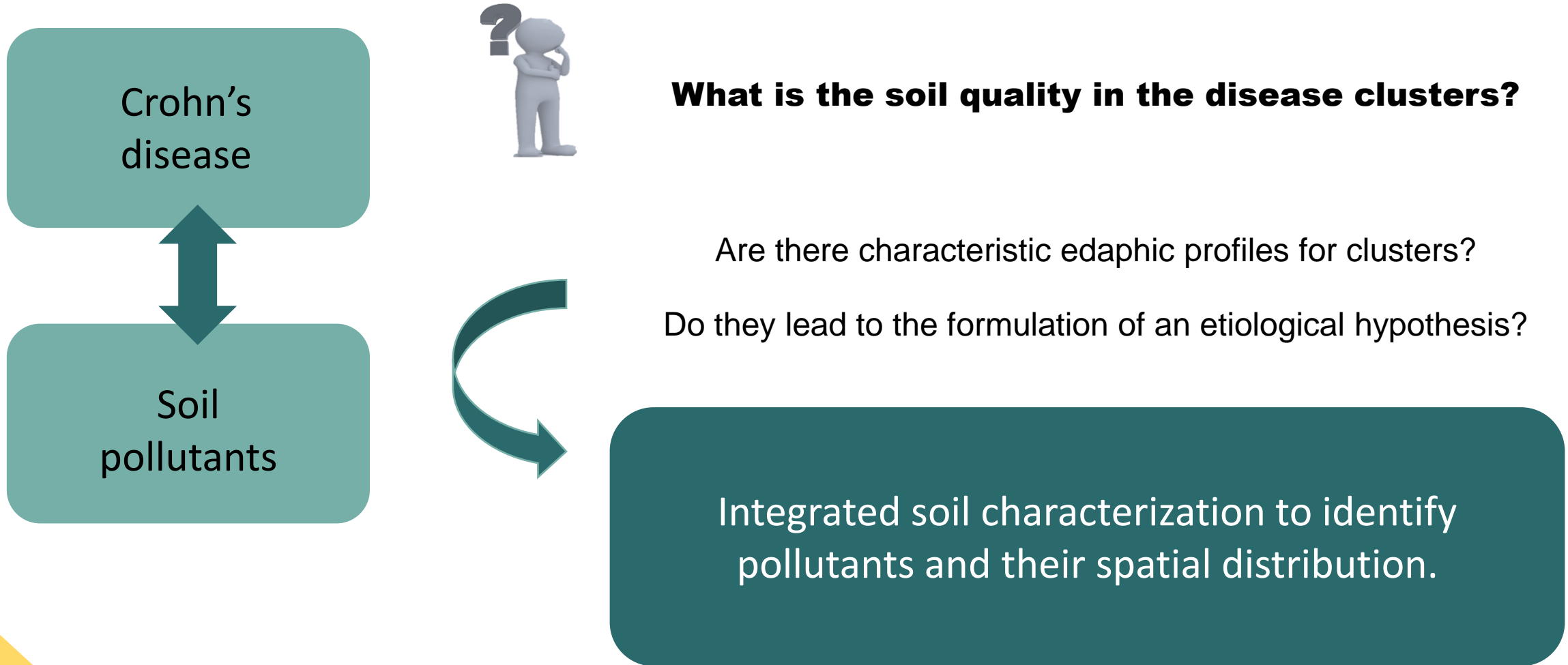
Ingestion of soil particles

Contact with soil

Inhalation of soil particles



Objectif of the study



293 POLLUTANTS
16 FAMILIES

Analyzed pollutants in soil

Hydrocarbon index

C10-C40	C10-C12	C12-16
C16-C21	C21-C40	

Heavy metals and metalloids

Arsenic	Copper	Zinc
Cadmium	Nickel	Mercury
Chromium	Lead	

Benzene and aromatics (BTEX)

Benzene	n butylbenzene	Ethyl tertibutyl ether (ETBE)
Toluene	Sec butylbenzene	Isobutyl benzene
Ethylbenzene	Isopropyl benzene (cumene)	2-ethylmethylbenzene (2-ethyltoluene)
Xylene ortho	n propyl benzene	3-ethylmethylbenzene (3-ethyltoluene)
Xylenes (m+p)	1,2,4-trimethylbenzene (pseudocumene)	4-ethylmethylbenzene (4-ethyltoluene)
Xylenes (o m p)	1,3,5-trimethylbenzene (mesitylene)	
Styrene	MTBE	

Amides and chloroacetamide

2,6-dichlorobenzamide	Isoxaben	Propyzamide
Acetochlore	Metazachlore	Tebutam
Alachlore	Metolachlor	Dimethenamide
Amitraze	Napropamide	Mefenacet
Benalaxyl	Ofurace	Propachlore
Furalaxyl	Oxadixyl	Pretilachlore
Dimetachlore		

Organohalogen solvents

Chlorure de vinyle	Tetrachloroethylene	1,1,1,2-tetrachloroethane
Chloroprene	Carbone Tetrachloride	Trichlorofluoromethane
1,1,1-trichloroethane	Trans 1,2-dichloroethylene	1,1-dichoro, 1-propene
1,1,2-trichloroethane	Trichloroethylene	Hexachlorobutadiene
1,1-dichloroethane	1,1,2-trichlorotrifluoroethane (freon 113)	1,2-dichloroethylene (cis + trans)
1,1-Dichloroethylene	Hexachloroethane	1,3-dichlororopylene (cis + trans)
1,2-dichloroethane	1,2-dibromoethane	Bromomethane
Bromochloromethane	1,2-dichloropropane	Chloromethane
Bromoforme	1,3-dichloropropane	Chloroethane
Chloroforme	Cis 1,3-dichloropropylene	Dichlorodifluoromethane
Cis 1,2-dichloroethylene	Trans 1,3-dichloropropylene	2,2-dichloropropane
Dibromochloromethane	2,3-dichloropropylene	1,2,3-trichloropropane
Dichlorobromomethane	1,1,2,2-tetrachloroethane	Dichlorodibromomethane
Dichloromethane	3-chloropropene	

Carbamates

Chinomethionate	Dimetilan	Thiobencarbe (benthiocarbe)
Chlorprofam	Molinate	

Pesticides

Kresoxim methyl	Cloquintocet mexyl	Nuarimol
Anthraquinone	Cyprodinil	Oxadiazon
Mepronil	Diflufenican (Diflufenicanil)	Oxyfluorfene
Bromopropylate	Ethofumesate	Piperonil butoxyde
Bupirimate	Fenpropidine	Pyridabene
Propanil	Fenpropimorphe	Pyrifenox
Buprofezine	Flurochloridone	Quinoxifene
Pyrimethanil	Flurprimidol	Terbacile
Chloroneb	Lenacile	Tolyfluanide
Chlorothalonil	Naptalame	Dimethomorphe
Chlorthal	Norflurazon	Spiroxamine
Clomazone	Norflurazon desmethyl	Boscalid

Polycyclic aromatic hydrocarbons (PAHs)

Fluoranthene	Acenaphtene	2-methyl naphtalene
Benzo (b) fluoranthene	Chrysene	2-methyl fluoranthene
Benzo (k) fluoranthene	Dibenzo (a,h) anthracene	Benzo (a) anthracene
Benzo (&) pyrene	Fluorene	Acenaphtylene
Benzo (ghi) perylene	Naphtaene	1-methyl naphtalene
Indeno (1,2,3 cd) pyrene	Pyrene	
Anthracene	Phenanthrene	

Anilines

Benfluraline	Pendimethaline	Trifluraline
	Butraline	

Pyrethrinoïds

Acrinathrine	Cyfluthrine	Tefluthrine
Alletrine	Cypermethrine	Fenpropathrin
Alphamethrine	Esfenvalerate	Tralomethrine
Bifenthrine	Lambda cyhalothrine	Deltamethrine
Bioresmethrine	Permethrine	

Benzonitriles

Dichlobenil	Fenarimol	Bromoxynil-octanoate
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Polychlorinated biphenyls (PCBs)

PCB 28	PCB 153	PCB 126
PCB 35	PCB 170	PCB 180
PCB 44	PCB 180	PCB 31
PCB 52	PCB 194	PCB 54
PCB 101	PCB 209	PCB 66
PCB 105	PCB 77	PCB 128
PCB 118	PCB 156	PCB 149
PCB 138	PCB 169	

Organochlorine pesticides

Mirex	Chlordane (cis+trans)	HCB (hexachlorobenzene)
Methoxychlor	Chlordane cis (alpha)	HCH alpha
Quintozene	Chlordane beta (trans)	HCH beta
2,4' DDD	Dicofol	HCH delta
2,4' DDE	Dieldrine	HCH epsilon
2,4' DDT	Endosulfan alpha	Heptachlore
4,4' DDD	Endosulfan beta	Heptachlore epoxyde endo trans
4,4' DDE	Endosulfan sulfate	Heptachlore epoxyde exo cis
4,4' DDT	Endosulfan total (alpha + beta)	Isodrin
Aldrine	Endrine	Lindane (HCH gamma)

Organophosphate pesticides

Azinphos ethyl	Ethion	Parathion methyl
Azinphos methyl	Ethoprophos	Phorate
Bromophos ethyl	Fenchlorphos	Phosalone
Bromophos methyl	Fenitrothion	Pririmiphos ethyl
Cadusafos	Fenthion	Pirimiphos methyl
Carbophenothion	Fonofos	Profenofos
Chlorfenvinphos	Formothion	Propetamphos
Chlormephos	Heptenophos	Pyrazophos
Chlorpyrifos ethyl	Iodofenphos	Quinalphos
Chlorpyrifos methyl	Isazofos	Sulfotep
Demeton S methyl	Isofenphos	Terbufos
Diazinon	Malathion	Tetrachlorvinphos
Dichlofenthion	Methidathion	Teradifon
Dichlorvos	Mevinphos	Thiometon
Dimethoate	Naled	Triazophos
Disulfoton	Parathion ethyl	

Dicarboxymides

Aclonifen	Dichlofluanide	Procymidone
Captafol	Folpel (Folpet)	Vinchlozoline
Captane	Iprodione	

Targeted research



Factor	Affecting CD (etiology or symptoms)	Connects to the environment	Existing in soils	Study originality	Considered in this study
Smoking	Assigned to the high occurrence of MC (Abdallah <i>et al.</i> , 2023)	Heavy metals	Soil contaminants	Major pollutant	Conventional
		Pesticides	Soil contaminants	Major pollutant	Conventional
Antibiotics	High antibiotic intake in childhood causes high risk (Ungaro <i>et al.</i> , 2014)	Found in manure and wastewater	New soil threat	Emerging pollutant	YES

Environmental factors	Associated with the disease	Found in the soil	Targeted compounds
Antibiotics	High consumption of antibiotics during childhood (Carbonnel <i>et al.</i> , 2009)		Sulfadiazine Roxithromycine Penicillin G
Hormones	Contribution of oral contraceptives and hormonal additives to the risk of disease onset (Ananthakrishnan <i>et al.</i> , 2013)	Present in soils of animal and human origin, in wastewater, sludge spreading, manure in agricultural soils.	17 β -estradiol 17 α -estradiol Estrone Estriol 17 α -ethinylestradiol Testosterone Progesterone
Human contaminants	Non-steroidal anti-inflammatory drugs and paracetamol can exacerbate disease symptoms (Forrest <i>et al.</i> , 2004)		Paracetamol Carbamazepine Bisphenol A

Experimental protocol

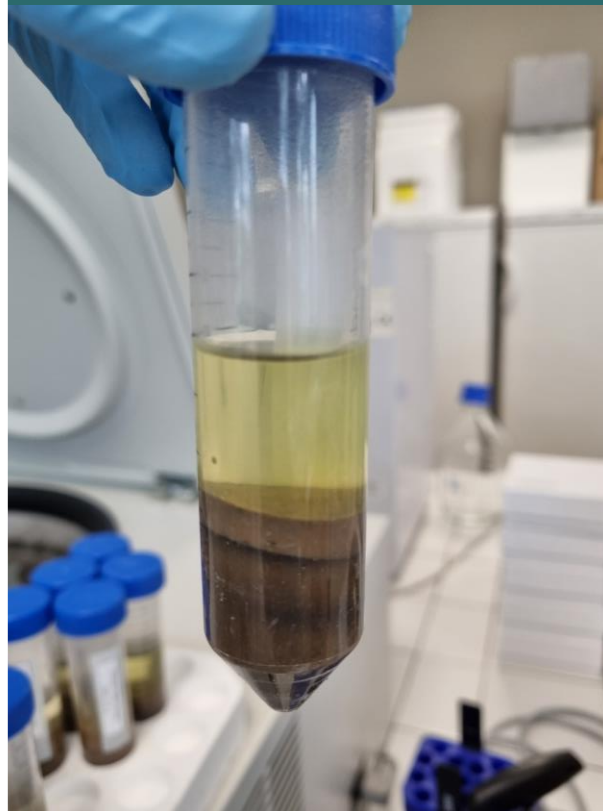
Soil preparation



Double extraction

QuEChERS

Quick, easy, cheap, effective,
rugged, and safe



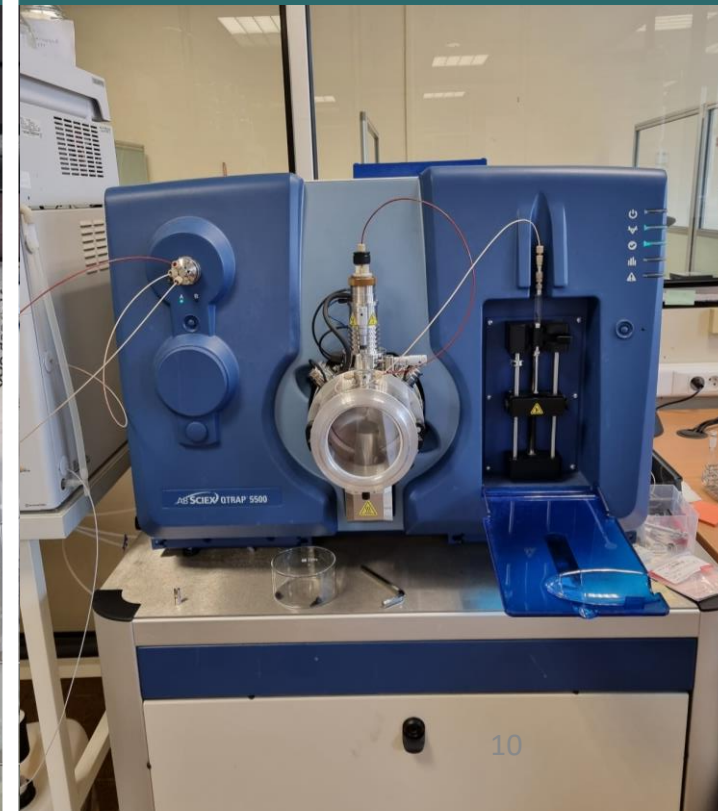
SPE

Solid Phase Extraction

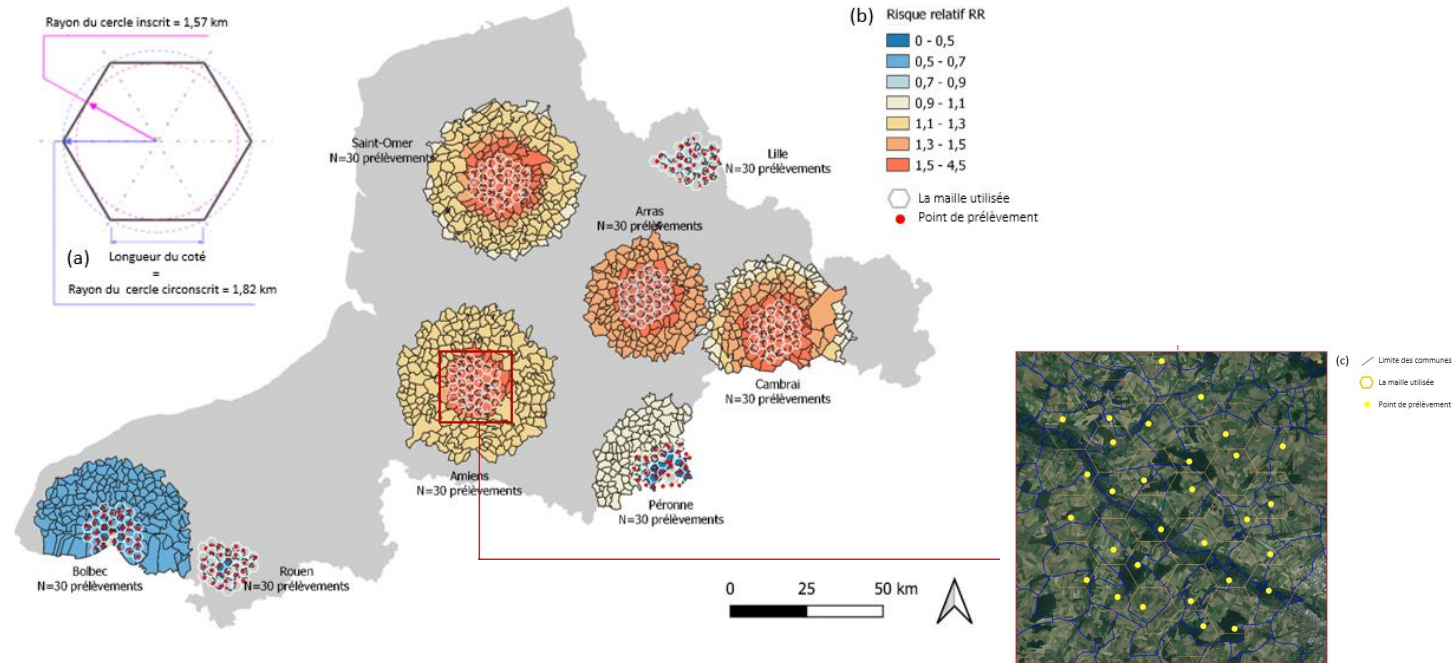
(Salvia, 2015)



Liquid chromatography-mass spectrometry analysis (LC-MS/MS)



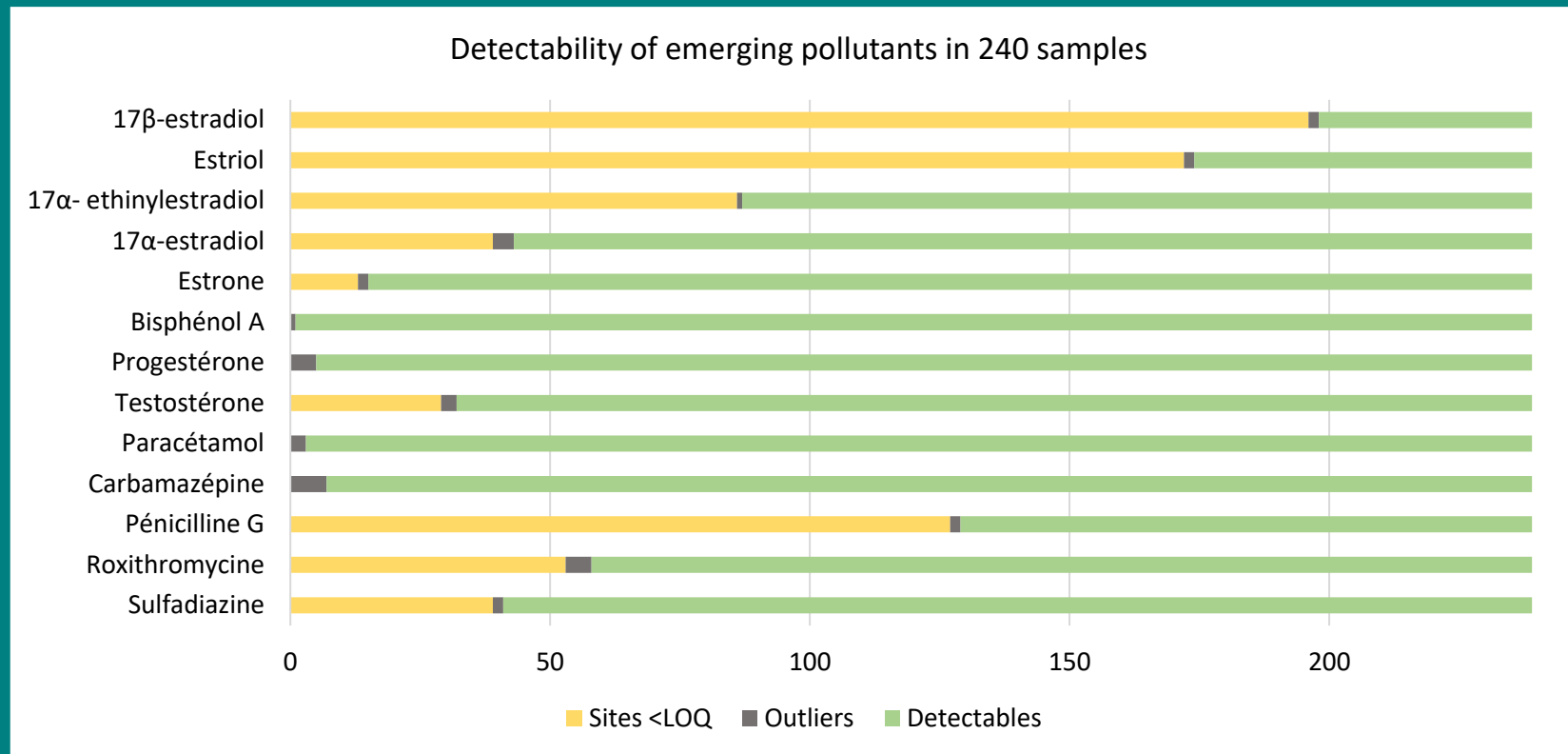
Sampling campaigns



	EP	CROPS
Number of sites	240	266
Distance between sites	3.15 km	3.15 km
Pollutants analyzed	13 EP	296 conventional
Land cover	All	All



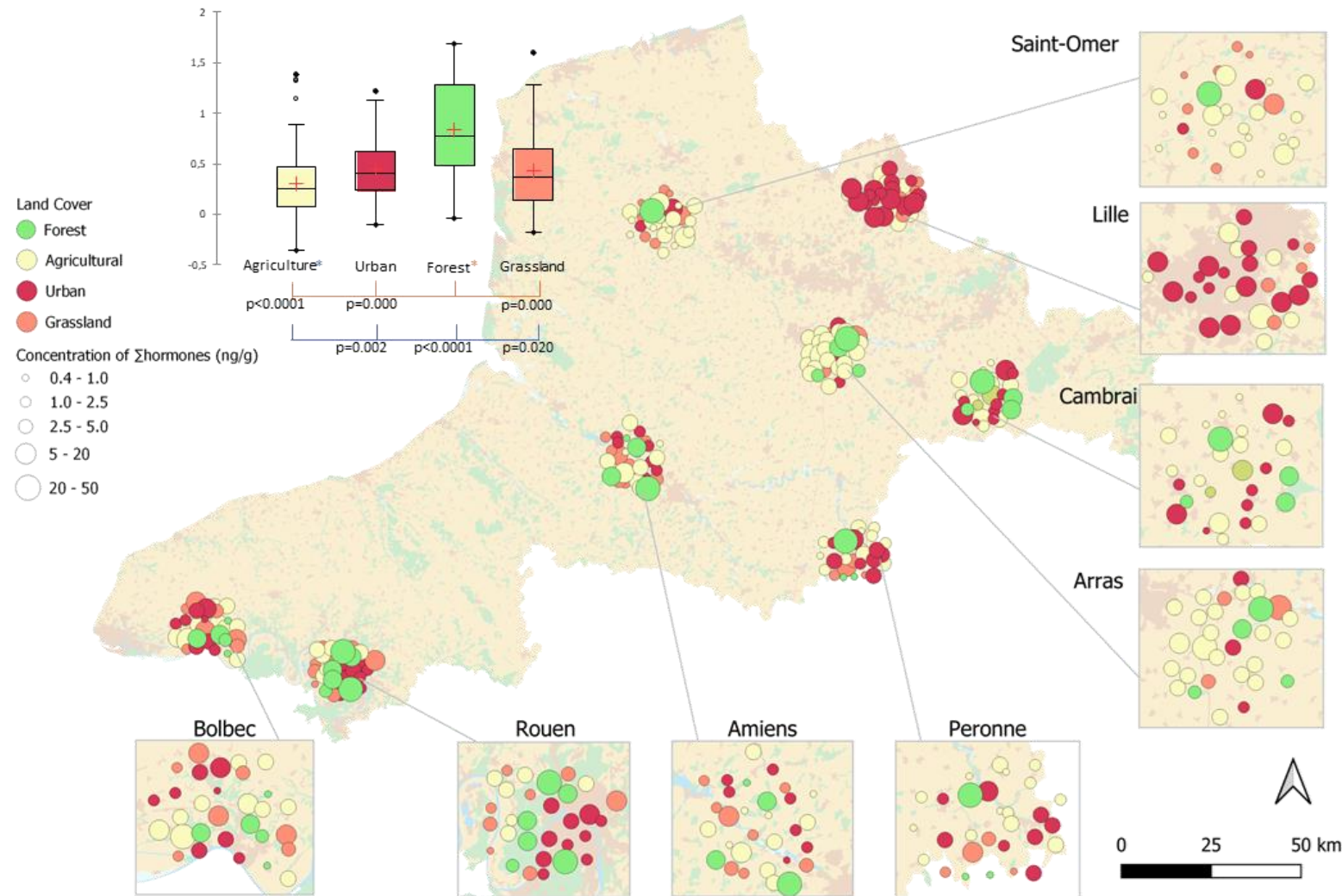
Detectability of emerging pollutants in soil



Concentration of emerging pollutants in soil

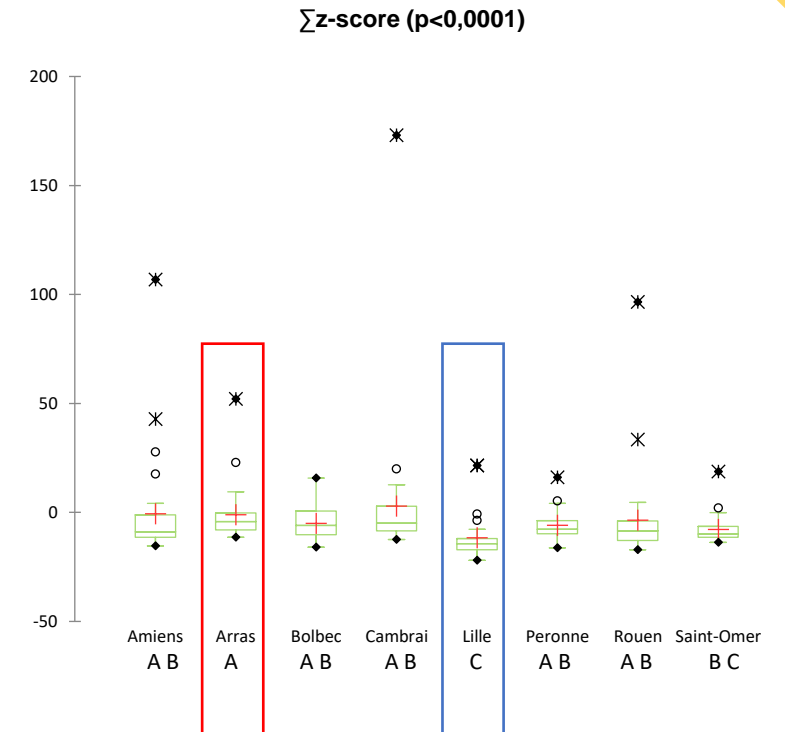
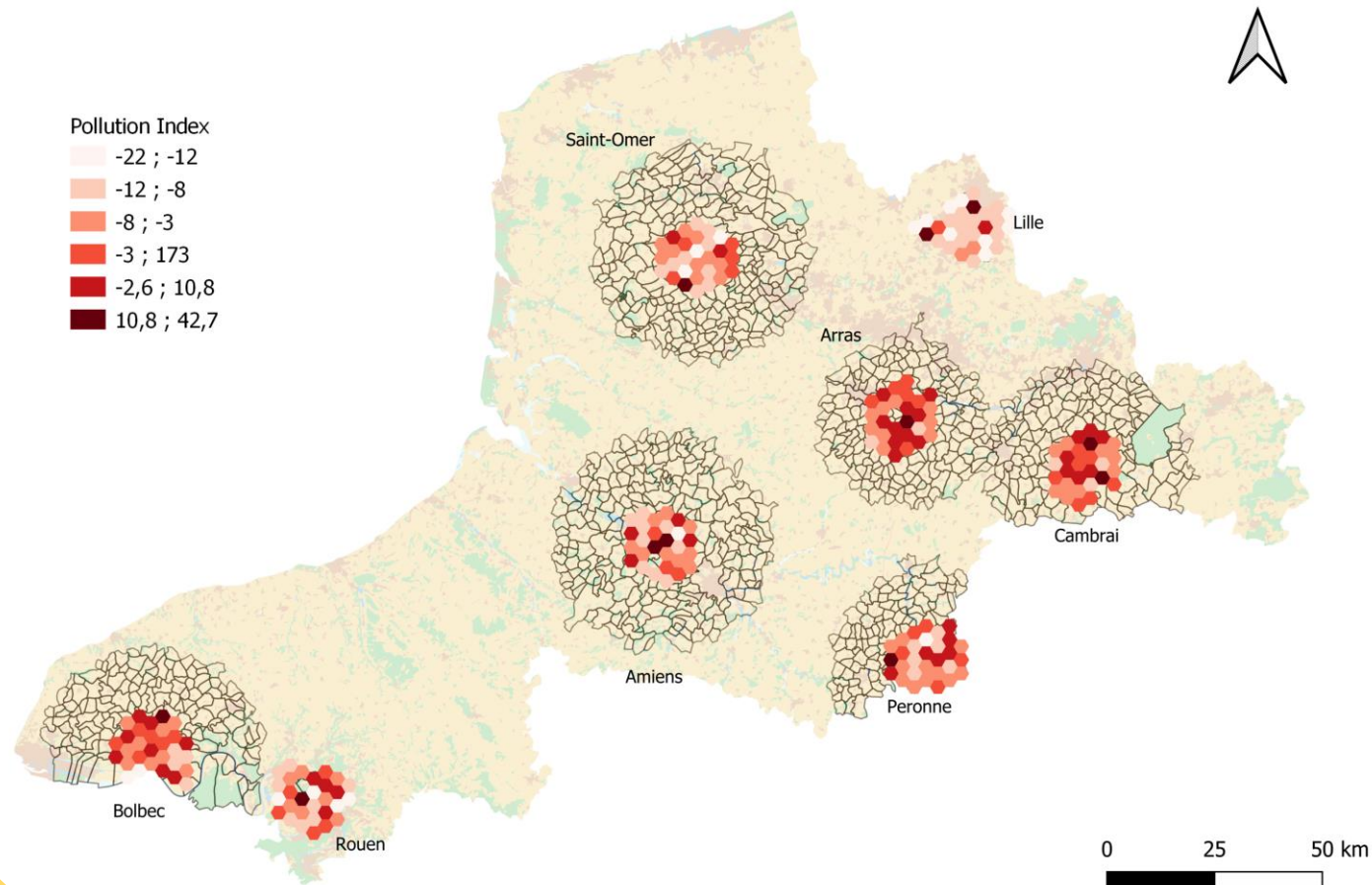
	Study area		Literature		Reference
	Range	Mean \pm SD	Range	Mean \pm SD	
Sulfadiazine	<LOQ - 0,47	0,13 \pm 0,11	<LOQ - 0,12	—	(Salvia et al. 2012)
Roxithromycine	<LOQ - 3,14	0,67 \pm 0,64	—	—	—
Penicillin G	<LOQ - 0,66	0,20 \pm 0,11	—	—	—
Carbamazepine	0,01 - 4,22	0,74 \pm 0,63	<LOQ - 7,00	—	(Aznar et al., 2014)
Paracetamol	0,17 - 46,30	2,47 \pm 5,30	<LOQ - 0,5	—	(Aznar et al., 2014)
Testosterone	<LOQ - 1,02	0,11 \pm 0,14	<LOQ - 0,99	0,09 \pm 0,17	(Yang et al., 2021)
Progesterone	0,14 - 6,58	1,53 \pm 1,20	<LOQ - 12,50	0,74 \pm 1,25	(Yang et al., 2021)
Bisphenol A	0,66 - 357,96	18,20 \pm 35,03	<LOQ - 166,00	—	(Xu et al., 2021)
Estrone	<LOQ - 0,54	0,04 \pm 0,06	<LOQ - 9,89	0,53 \pm 0,91	(Yang et al., 2021)
17 α -estradiol	<LOQ - 3,28	0,27 \pm 0,43	—	8,00 \pm 0,90	(Dutta et al., 2012)
17 α - ethinylestradiol	<LOQ - 47,16	2,43 \pm 5,71	<LOQ - 2,33	0,06 \pm 0,17	(Yang et al., 2021)
Estriol	<LOQ - 1,20	0,25 \pm 0,16	<LOQ - 6,26	0,35 \pm 0,96	(Yang et al., 2021)
17 β -estradiol	<LOQ - 29,39	5,71 \pm 7,32	<LOQ - 3,46	0,18 \pm 0,39	(Yang et al., 2021)

Hormones in different land cover

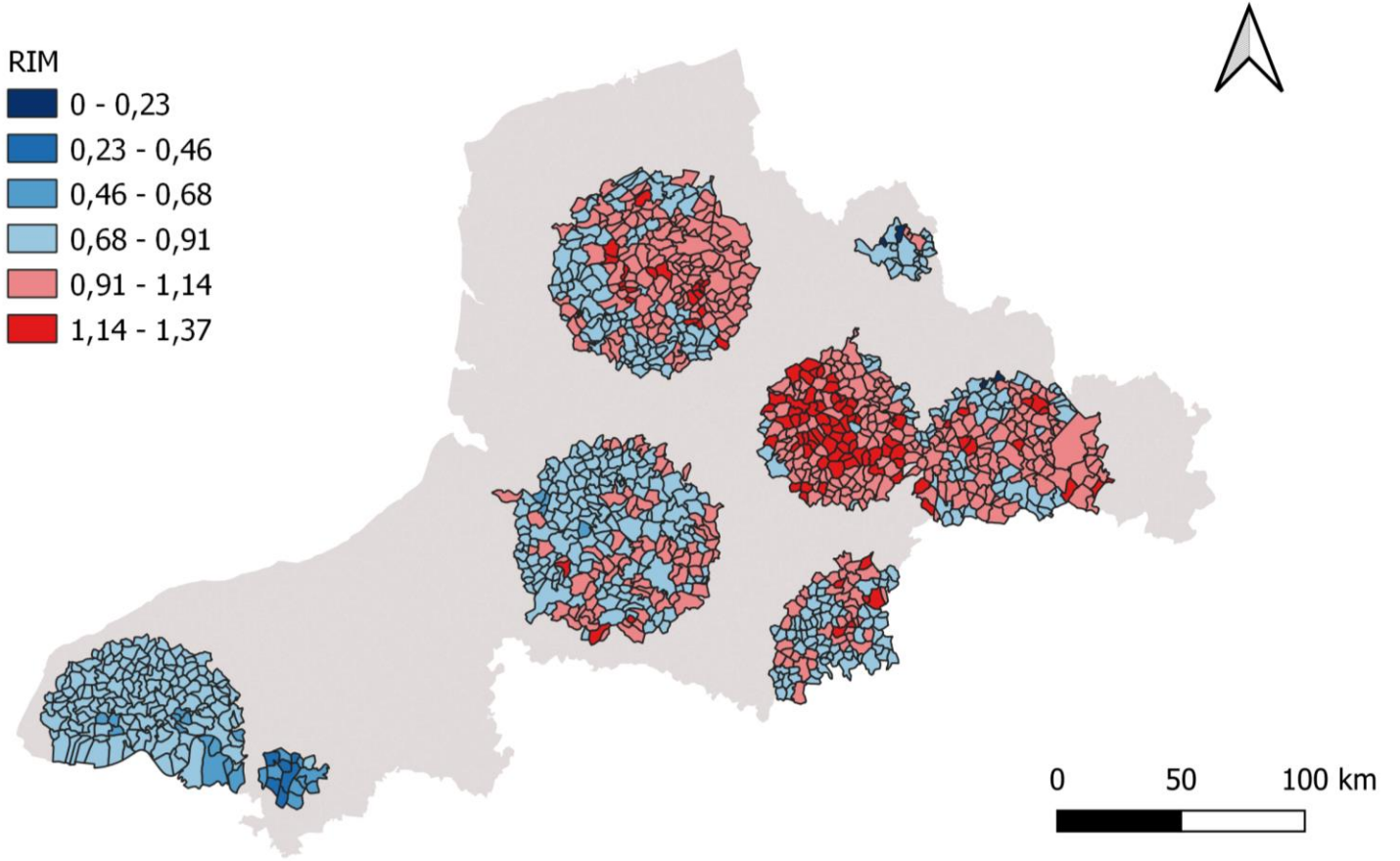
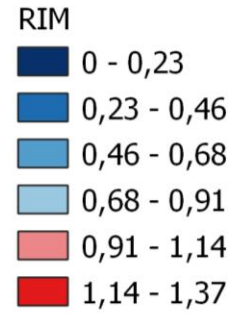
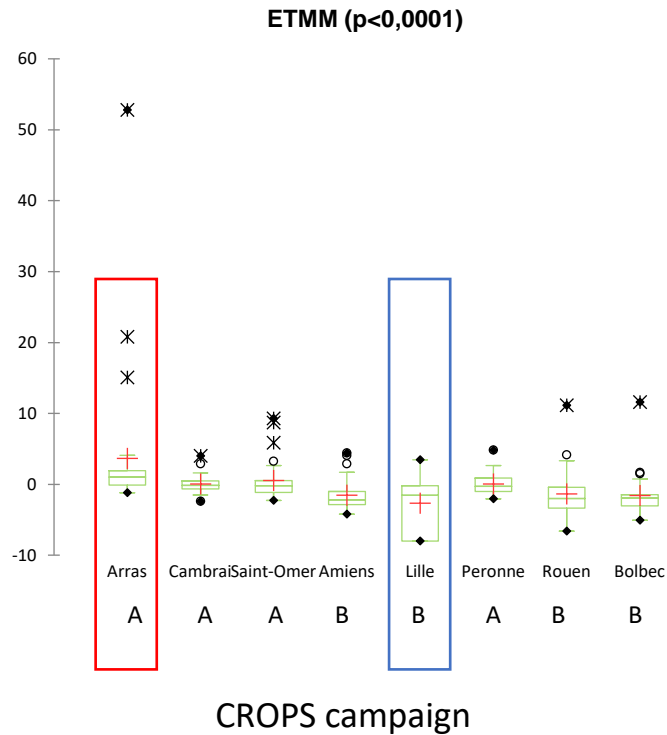


Spatial distribution of pollutants

$$\text{Pollution index} = \sum \text{z-score}$$



Trace elements and metalloids in clusters



Composite index (RIM) based on the data
from RMQS in clusters

Discussion

From an environmental perspective

- Analysis of more than 300 pollutants in soil of different land covers
- The detection of emerging pollutants in soil is the first large scale study in Europe that detects these pollutants
- Optimization of an analytical protocol
- Detection of synthetic estrogens in high concentration in forest and semi-natural lands

From an environmental health perspective

- First study of correlation between soil pollution and Crohn's disease
- This study allowed the creation of profiles of pollution for each cluster with a large heterogeneity between clusters
- Heavy metals have been detected in clusters of high-incidence and have been correlated with the incidence of the disease

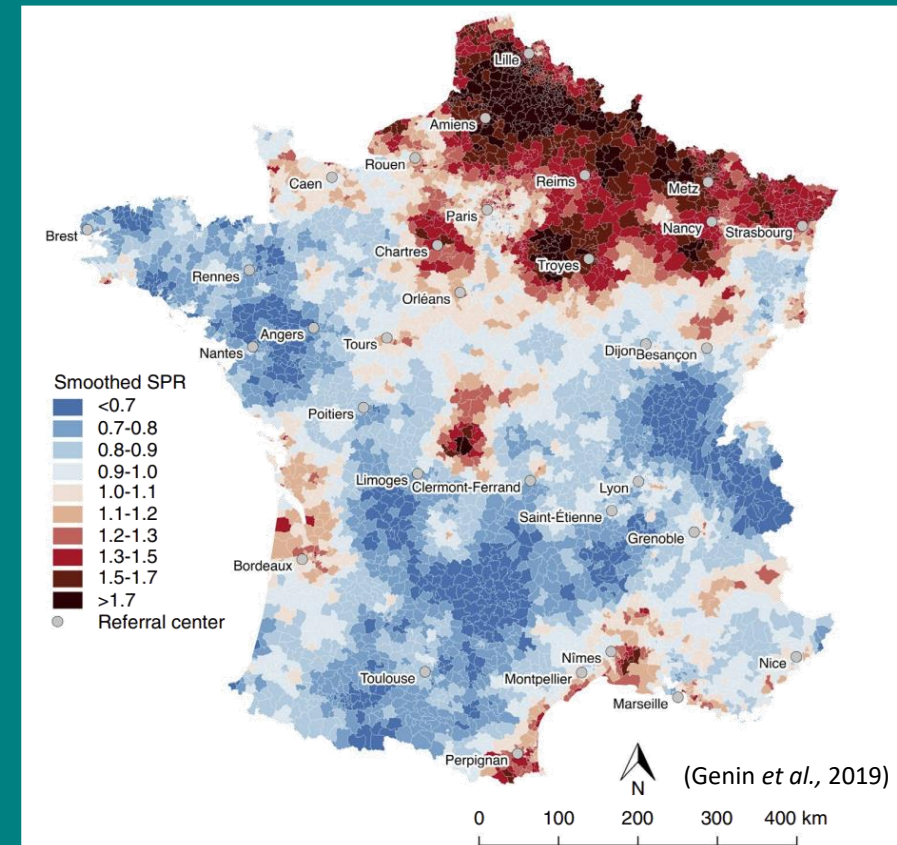
Perspective

From an environmental perspective



- Expand soil characterization and target more pollutants, such as additional pesticides and PFAS.
- Study the DNA of soil

From an environmental health perspective



Soil quality in low-prevalence zone on national scale?

Thank you for your attention

Hosting



Funding



Collaborations

