

# Inquinamento da farmaci e antibiotico-resistenza

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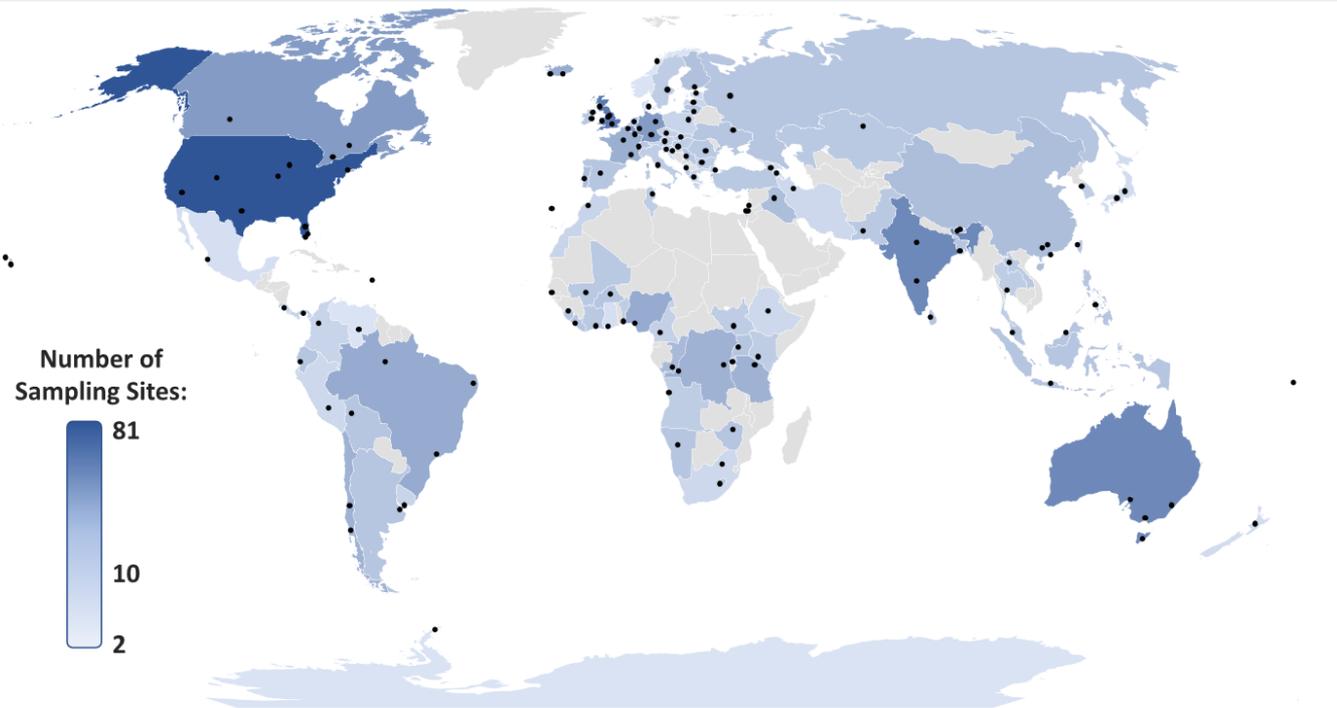


9° CONGRESSO NAZIONALE  
Inquinamento e cambiamenti climatici:  
l'impatto sulla salute in ottica di genere



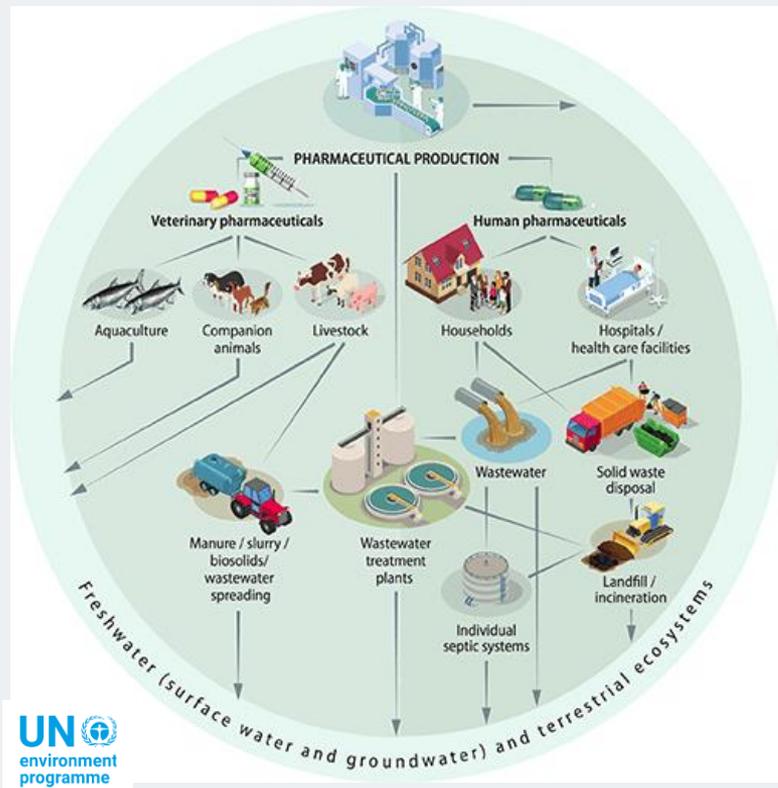
# Pharmaceutical pollution of the world's rivers

PNAS February 14, 2022 119 (8) e2113947119 <https://doi.org/10.1073/pnas.2113947119>



**Fig. 1.** Locations of studied rivers/catchments ( $n = 137$ ) for our global study (Dataset S2). Points indicate groups of sampling sites across respective river catchments and countries are shaded based upon the total number of sampling sites.

# Fonti di immissione nell'ambiente



Fonte principale



Uso Umano e Veterinario



Immissione in acque  
superficiali tramite  
acque depurate

Immissione in suoli  
tramite fanghi di  
depurazione



Riuso delle acque  
Potabilizzazione delle acque

Uso agricolo del  
suolo

- Usati in **quantità elevate**
- **Gruppi eterogenei** di sostanze
- **Immissione continua** – sostanze semi-persistenti
- Composti **biologicamente attivi**
- Presenti in **miscele complesse**
- Potenziali **rischi**: promozione antibiotico resistenza
- Fino ad oggi **regolate** solo parzialmente da Watch Lists

# Farmaci come inquinanti ambientali

RESEARCH LETTERS

## Presence of therapeutic drugs in the environment

Ettore Zuccato, Davide Calamari, Marco Natangelo, Roberto Fanelli

Therapeutic drugs can contaminate the environment because of metabolic excretion, improper disposal, or industrial waste. To assess the extent of this contamination, we listed drugs thought to be putative priority pollutants according to selected criteria, and measured them in Lombardy, Italy. Most drugs were measurable in drinking or river waters and sediments, suggesting that pharmaceutical products are widespread contaminants, with possible implications for human health and the environment.

The Lancet, 2000, 355, 1789-1790

**Primo monitoraggio** di farmaci in acque di superficie e potabili in Italia

**Bilancio di Massa** di farmaci nei fiumi principali d'Italia

## Removal of Pharmaceuticals in Sewage Treatment Plants in Italy

SARA CASTIGLIONI,<sup>†,‡</sup> RENZO BAGNATI,<sup>†</sup> ROBERTO FANELLI,<sup>‡</sup> FRANCESCO POMATI,<sup>†</sup> DAVIDE CALAMARI,<sup>†</sup> AND ETTORE ZUCCATO\*<sup>‡</sup>

Department of Biotechnology and Molecular Sciences, University of Insubria, Via J.H. Dunant 3, 21100 Varese, Italy, and Department of Environmental Health Sciences, Mario Negri Institute for Pharmacological Research, via Eritrea 62, 20157 Milan, Italy

Environmental Science and Technology, 2006, 407, 357-363

**Monitoraggio di destino e rimozione** di farmaci ed antibiotici

Source, occurrence and fate of antibiotics in the Italian aquatic environment

Ettore Zuccato\*, Sara Castiglioni, Renzo Bagnati, Manuela Melis, Roberto Fanelli

Department of Environmental Health Sciences, Mario Negri Institute for Pharmacological Research, Via La Masa 19, 20156 Milan, Italy

Journal of Hazardous Materials, 2010, 179, 1042-1048

## Strategic Survey of Therapeutic Drugs in the Rivers Po and Lambro in Northern Italy

DAVIDE CALAMARI,<sup>\*-†</sup> ETTORE ZUCCATO,<sup>‡</sup> SARA CASTIGLIONI,<sup>†,‡</sup> RENZO BAGNATI,<sup>†</sup> AND ROBERTO FANELLI<sup>‡</sup>

Department of Structural and Functional Biology, University of Insubria, Via J.H. Dunant 3, 21100 Varese, Italy, and Department of Environmental Health Sciences, Mario Negri Institute for Pharmacological Research, via Eritrea 62, 20157 Milan, Italy

Environmental Science and Technology, 2003, 37, 1241-1248

# Farmaci come inquinanti ambientali

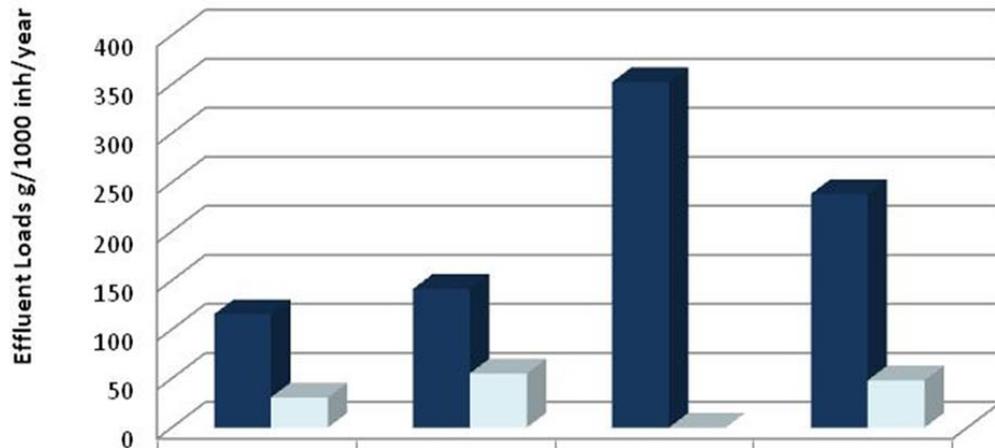
**TABLE 6. Summary of Loads and Removal Rates (RR) in STPs and Attenuation Rates and Residual Loads in Surface Water for the Most Abundant Pharmaceuticals**

pharmaceutical	load in influent (mg/day/1000 inh) <sup>a</sup>	RR in STP (%) <sup>a</sup>	residual load in effluent (mg/day/1000 inh) <sup>a</sup>	attenuation in river (%) <sup>a</sup>	residual load in surface water (mg/day/1000 inh) <sup>a</sup>	occurrence in particulate (+/-)
atenolol	494	21	281	28	257	+
ofloxacin	360	57	233	27	94	+
hydrochlorothiazide	354	44	415	64	197	+
furosemide	277	15	195	27	66	-
ciprofloxacin	259	63	97	5	224	+
ranitidine	188	72	96	17	33	+
ibuprofen	122	55	28	21	35	-
sulfamethoxazole	65	24	10	3	122	-
bezafibrate	50	30	29	34	38	+
enalapril	31	69	1.2	22	6	+
clarithromycin	21	0	55	41	66	+
carbamazepine	12	0	28	22	28	+
erythromycin	5	0	5	35	3	+
spiramycin	5	0	35	46	30	+
salbutamol	4	0	4	27	2	-
lincomycin	3	0	5	18	4	-

<sup>a</sup> Median values.

# Antibiotici come inquinanti ambientali

Amount of antibiotics discharged in the environment  
per year



	Milan	Varese	Lugano	Como
■ Effluents Loads	115.8	141.6	352.5	238.3
■ Removal in STP (%)	30.84	55.34	0.00	48.18

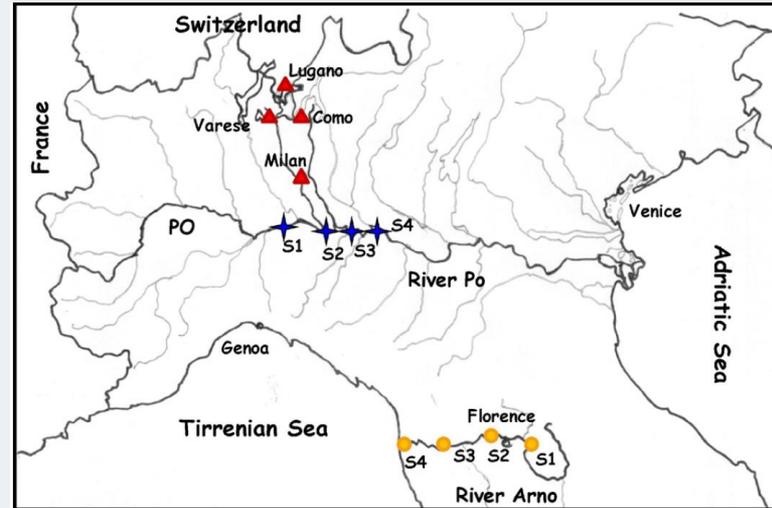
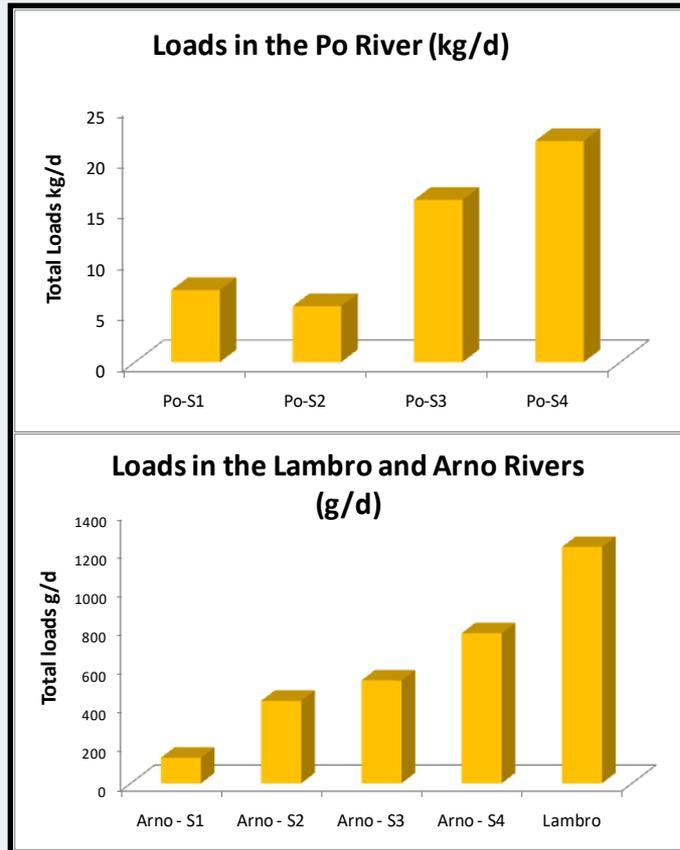
115-240 g/1000 ab/anno



6.9- 14.4 tonnellate/anno  
in Italia

Zuccato et al. J Haz Mat 2010

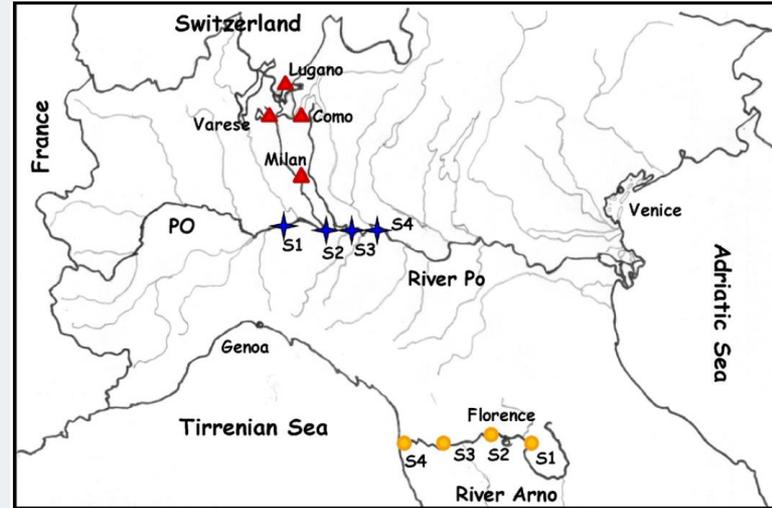
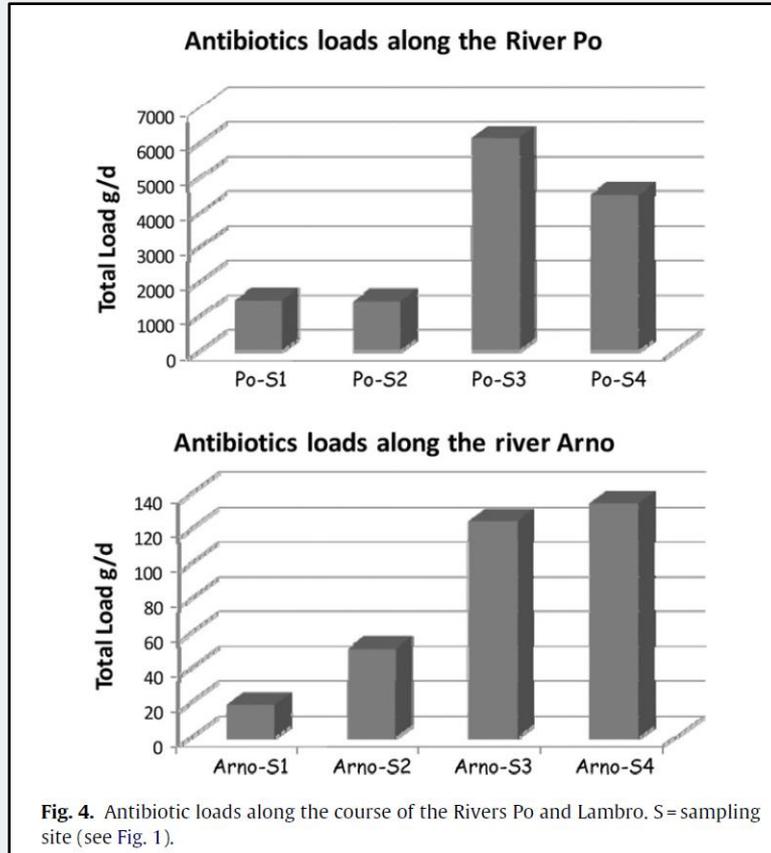
# Farmaci nelle acque di superficie



Zuccato *et al.* *J Haz Mat* 2010

**Fiume Po**  
23 kg/giorno  
8,4 ton/anno  
(principi attivi)

# Antibiotici nelle acque di superficie



Zuccato *et al.* *J Haz Mat* 2010

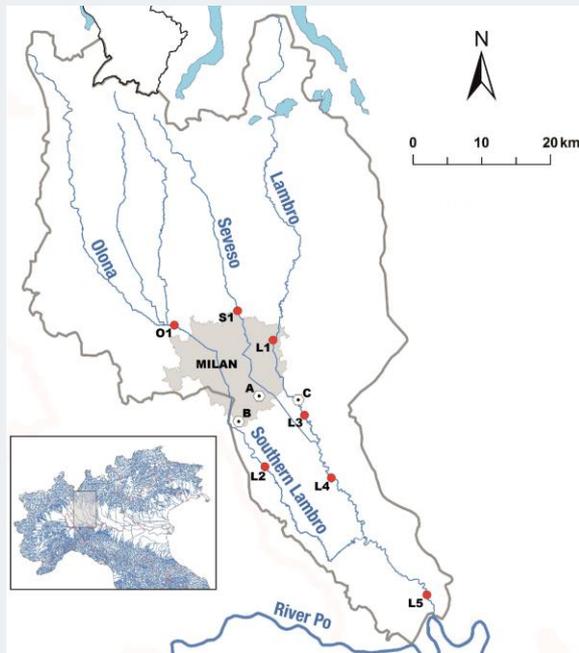
**Fiume Po**  
5 kg/giorno  
1,8 ton/anno  
(antibiotici)



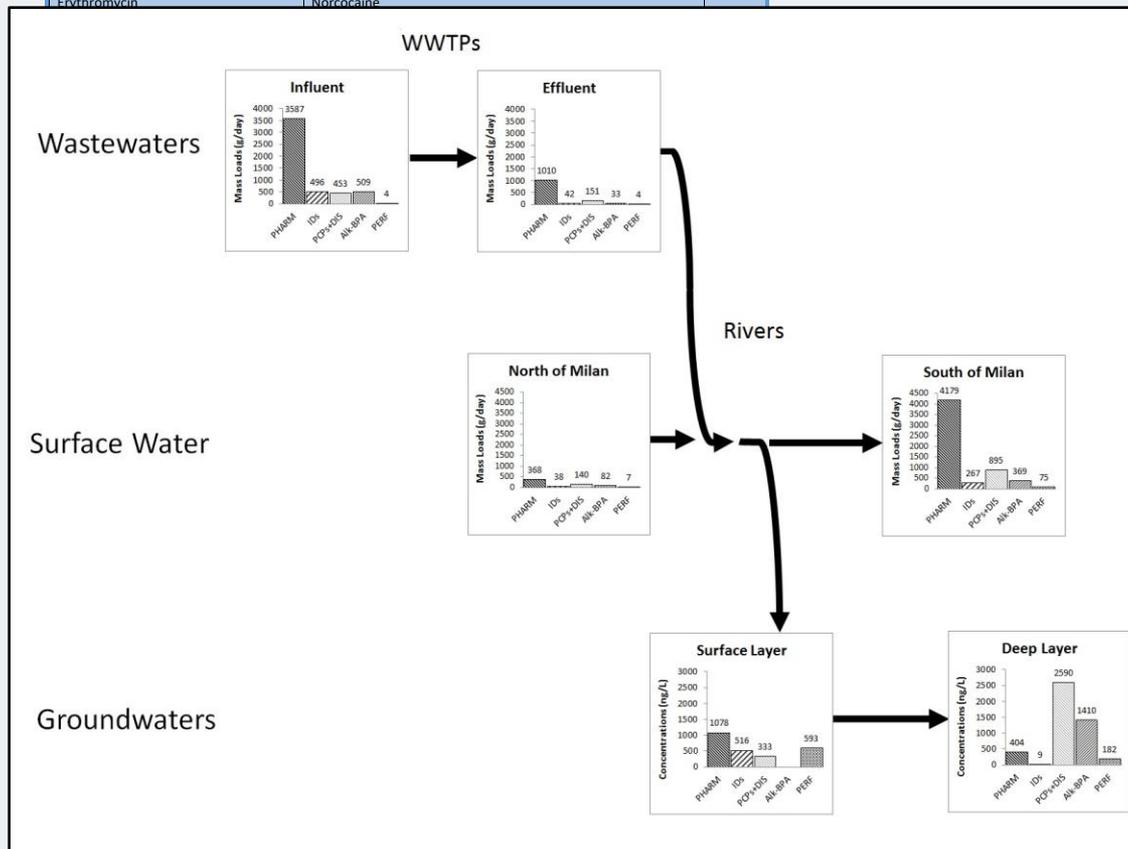
## Mass balance of emerging contaminants in the water cycle of a highly urbanized and industrialized area of Italy

Sara Castiglioni <sup>a,\*</sup>, Enrico Davoli <sup>a</sup>, Francesco Riva <sup>a</sup>, Marinella Palmiotto <sup>a</sup>, Paolo Camporini <sup>a</sup>, Angela Manenti <sup>b</sup>, Ettore Zuccato <sup>a</sup>

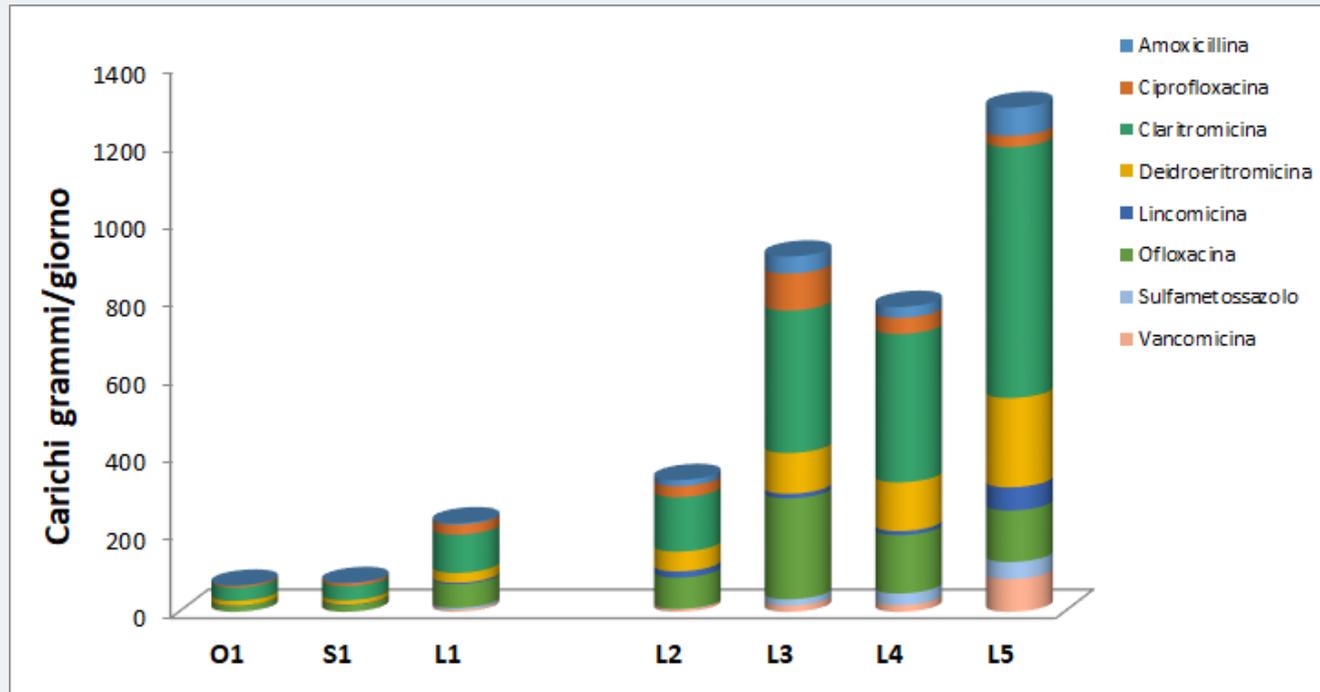
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<sup>b</sup> Metropolitana Milanese S.p.A., Area Acquedotto, Via Giuseppe Meda 44, 20141 Milan, Italy



Emerging Contaminants Investigated – MARIO NEGRI	
PHARMACEUTICALS	ILICIT DRUGS
<i>Antibiotics</i>	<i>Cocaine and metabolites</i>
Amoxicillin	Benzoylecgonine
Ciprofloxacin	Norbenzoylecgonine
Clarithromycin	Cocaine
Erythromycin	Norcocaine

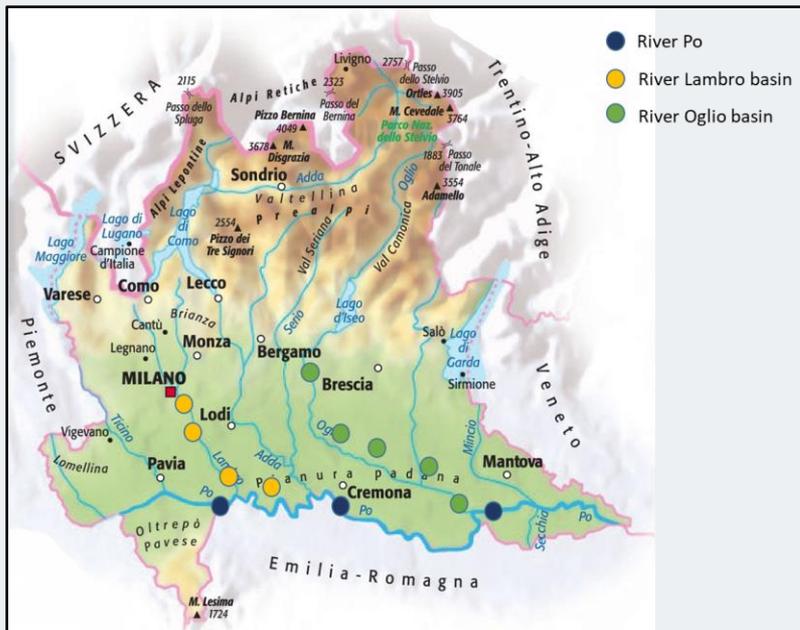


# Antibiotici nelle acque di superficie



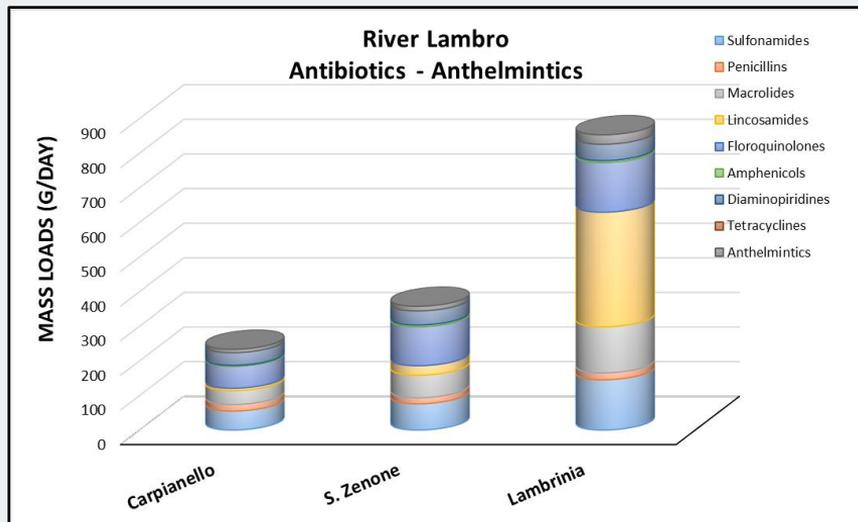
In: Gli antibiotici spiegati bene – Silvio Garattini- Edizioni LSWR, 2020

# Antibiotici nelle acque di superficie



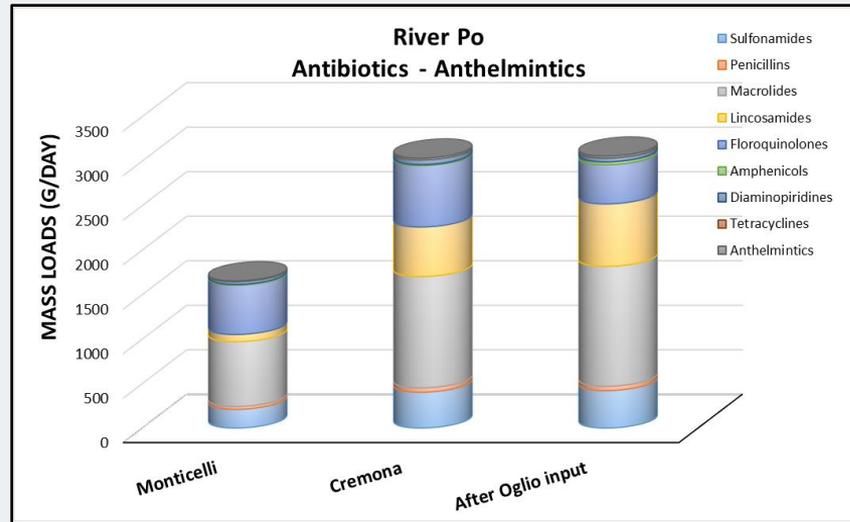
Antibiotics		Other Pharmaceuticals
<b>Sulfonamides</b>	<b>Fluoroquinolones</b>	<b>CNS drugs</b>
sulfamethoxazole	ciprofloxacin	diazepam
sulfadiazina	flumequine	demethyl-diazepam
sulfadimetossina	levofloxacin	carbamazepine
<b>Penicillins</b>	<b>Amphenicols</b>	<b>Diuretics</b>
amoxicillin	florfenicol	furosemide
ampicillin	thiamphenicol	hydrochlorothiazide
benzylpenicillin	<b>Diaminopiridine</b>	<b>Bronchodilators</b>
<b>Macrolides</b>	trimetoprim	salbutamol
spiramycin	<b>Tetraciclins</b>	<b>Anti-inflammatorys</b>
tylosin	doxycycline	ibuprofen
tilmicosin	chlortetracycline	naproxene
oleandomicin	oxytetracycline	ketoprofen
erythromycin	<b>Anthelmintics</b>	diclofenac
<b>Lincosamides</b>	ivermectine	
lincomycin	levamisol	

# Antibiotici nelle acque di superficie



Carichi g/giorno	Carpianello	S. Zenone	Lambrinia
Lincomicina	7.08	27.30	331.12

Circa 45 volte



Carichi g/giorno	Monticelli	Cremona	After Oglio input
Lincomicina	81.7	556.8	701.9

Circa 8 volte



Uso in allevamenti

# Cosa possiamo fare ??

## Depuratori



Aumento della  
rimozione, trattamenti  
quaternari

## Smaltimento/Usò



Promuovere l'informazione  
per uso e smaltimento  
appropriati (medici e pazienti)

## Interventi Legislativi

2025/439  
DECISIONE DI ESECUZIONE (UE) 2025/439 DELLA COMMISSIONE  
del 28 febbraio 2025  
che istituisce un elenco di controllo delle sostanze da sottoporre a monitoraggio a livello dell'Unione  
nel settore della politica delle acque in attuazione della direttiva 2008/105/CE del Parlamento  
europeo e del Consiglio

## Watch Lists

2024/3019  
DIRETTIVA (UE) 2024/3019 DEL PARLAMENTO EUROPEO E DEL CONSIGLIO  
del 27 novembre 2024  
concernente il trattamento delle acque reflue urbane

Direttiva Acque Reflue

# Inquinamento da farmaci e antibiotico-resistenza

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