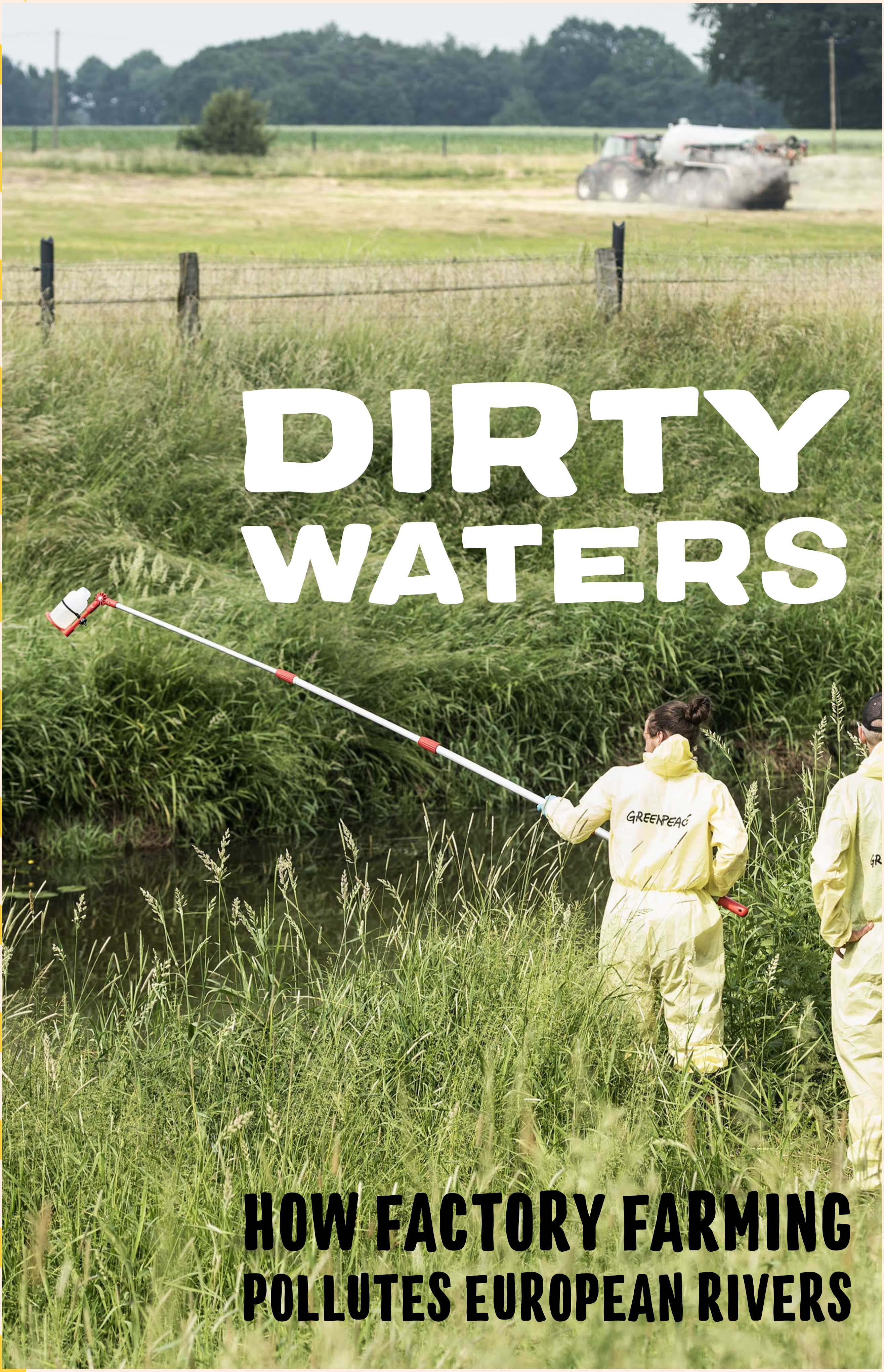
DIRTY WATERS



HOW FACTORY FARMING POLLUTES EUROPEAN RIVERS

IMPRINT

Published
November 2018
by Greenpeace e.V., Hongkongstraße 10, 20457 Hamburg, Germany,
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Introduction

About 47 million tonnes of meat are produced in the European Union each year. That is about 1.8 kg of meat per week for every inhabitant of the European Union.[1] Also, more than 150 million tonnes of cow milk are produced annually in the EU – roughly six litres per capita per week.[2]

Livestock production – including feed crop cultivation and pasture land – takes up 75 percent of all agricultural land globally.[3] Even though production of animal products in the European Union relies heavily on feed imports, it still uses more than half of all agricultural land in Europe.[4]

Industrial livestock production, so-called “factory farming”, places a heavy burden on the environment. Huge amounts of feed, water and medicines are required to maintain this system. Massive areas of land are dedicated to growing feed crops like maize or barley. Large quantities of pesticides, synthetic fertilisers and manure are applied to these fields. Animal manure from industrial agriculture often contains residues of metals and veterinary drugs like antibiotics. Artificial fertilisers and manure both contain nutrients like nitrates, which are essential for life, but which in excess can harm the ecology of waterways.

Through factory farming, veterinary drugs, pesticides, metals and excessive nutrients leak into the environment and wash into our rivers, leading to cocktails of substances that can harm our delicate ecosystems.[5]

Industrial livestock production in the EU is supported by public subsidies via the European Union’s common agricultural policy (CAP). The policy is currently undergoing a reform, providing the opportunity for European decision makers to shift financial support away from harmful factory farming, and instead foster a transition towards ecological food production[6], raising fewer animals and growing more fruits and vegetables in ecological ways.

In June and July 2018, Greenpeace conducted testing in ten EU countries indicating that Europe’s industrial livestock production pollutes our rivers.[7] Testing took place in 29 rivers and canals in regions with intensive animal farming. The samples were analysed for veterinary drugs, pesticides, nutrients and metals. All in all, Greenpeace found more than 20 different veterinary drugs – among them 12 antibiotics – and more than 100 different pesticides. Nitrate concentrations were below the EU limit of 50 mg per litre, above which countries must take action to protect rivers, lakes and aquatic life.[8] This is likely related to the fact that samples were taken in a period where nitrate concentrations are expected to be at relatively low levels within the annual cycle. Nevertheless, half of the samples contained nitrates at levels that could be harmful to the most sensitive invertebrates, fish and amphibians.[9] Metal concentrations were within the range previously reported for European streams.[10] Only four samples contained metal concentrations that stand out and might be linked to agriculture – mainly concerning cadmium. The test results for metals can be found in Annex 1 and 2.

Factory farms are a major concern for both the environment and human health. We also know that substantial amounts of European Union subsidies, through the common agricultural policy, flow into some of the testing regions. Unfortunately, there is not nearly enough transparency nor consistency in the data on EU farm subsidies to know exactly the amount of public money supporting every factory farm area we tested, either directly, or indirectly via subsidies for feed production.

1 Carcass weight equivalents, FAO 2016; http://www.fao.org/fileadmin/templates/est/COMM_MARKETS_MONITORING/Meat/Documents/FO_Meat_June_2016.pdf
EU population 2015, Eurostat; http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=demo_gind&lang=en

2 Collection of cow’s milk 2015, Eurostat, https://ec.europa.eu/eurostat/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tag00037&language=en

3 Foley, J. A., et al. 2011. Solutions for a cultivated planet. Nature, 478: 337–342

4 European Environmental Agency 2017: 72 percent of all land needed to produce the food consumed in Europe, no matter where it is situated globally, is used for feed production. It is further estimated that 20 percent of all land (feed and food) are not in the EU. Consequently, at least 52% of all agricultural land in the EU is used to grow feed; https://www.eea.europa.eu/publications/food-in-a-green-light

5 Almost one in four (24.5 percent) vulnerable or endangered species in the EU are threatened by agricultural products or run-offs, including the use of pesticides and fertilizers, like nitrates and phosphates. IUCN 2015: database-search on 9th of October 2015; http://www.iucnredlist.org/search/link/56178c5cdbe482f8

6 Ecological Farming: The seven principles of a food system that has people at its heart. Greenpeace 2015
https://storage.googleapis.com/planet4-international-stateless/2016/12/b254450f-food-and-farming-vision.pdf

7 Austria, Belgium, Denmark, France, Germany, Italy, Poland, Spain, The Netherlands and UK

8 EEC (1991) Council Directive of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources. Official Journal of the European Union, L375 (31/12/91), 1-8

9 These samples were above the suggested limit for chronic exposure proposed by Camargo et al. Camargo, J. A., Alonso, A., & Salamanca, A. (2005). Nitrate toxicity to aquatic animals: A review with new data for freshwater invertebrates. Chemosphere, 58(9), 1255–1267. https://doi.org/10.1016/j.chemosphere.2004.10.044

10 Flem, B.; Reimann, C.; Fabian, K.; Birke, M.; Filzmoser, P.; Banks, D. Graphical statistics to explore the natural and anthropogenic processes influencing the inorganic quality of drinking water, ground water and surface water. Applied Geochemistry, 2018, 88(B), 133-148

Agricultural pollutants and their risks

Man-made micropollutants: Pharmaceuticals and pesticides

Large numbers of synthetic chemicals are constantly being produced and released into the environment – and many of these originate from agricultural activities.[11] The most obvious examples are residues of pesticides used on fields. But residues of veterinary drugs also enter the environment through the application of manure from industrial livestock, or human sewage sludge as natural fertilisers. Both pesticides and veterinary drugs are typically highly biologically active[12] and can, therefore, cause negative impacts at very small concentrations. The impact of such micropollutants on the ecosystem is difficult to assess, as mixtures of those substances often have to be considered. These could create potentially dangerous cocktails, as biological impacts from exposure to mixtures could be significantly greater than for single compounds.
Risk assessments for such complex mixtures at trace concentrations are currently a subject of research. We do know, however, that many rivers worldwide and in Europe are ecologically impaired or put at risk by such micropollutants.

VETERINARY PHARMACEUTICALS

The use of veterinary pharmaceuticals like antibiotics has dramatically increased in recent decades. Even though there recently have been some indications that the sales of antibiotics have reached a plateau or decreased in many European countries, usage within Europe remains high.[13, 14]
Pharmaceuticals, comprising antimicrobials such as antibiotics, together with other drugs, represent an emerging class of pollutants which are attracting increasing regulatory scrutiny. More than 2,000 different veterinary drugs are available on the market today. Many antibiotics are poorly absorbed by animals and therefore a high proportion – between 30 and 90 percent – can be excreted unchanged.[15]

Veterinary drugs and drugs used in human medicine are introduced into the environment when contaminated manure or human sewage sludge is spread onto fields. Given the widespread use of antibiotics in industrial livestock production and in human medicine, their consequent release into the environment by this route is a cause for concern. Antimicrobial resistance is considered by the World Health Organisation (WHO) to be one of the three biggest threats to public health, but our knowledge of the relationship between antibiotic residues and the development of resistance is still incomplete. In 2016, however, the United Nations recognised that overuse and misuse of antimicrobials, both in human and veterinary treatments, was the primary cause of rising antimicrobial resistance.[16] In 2017, the WHO also launched new guidelines on use of medically important antimicrobials in livestock production, recommending that farmers and the food industry stop using antibiotics routinely to promote growth and as precautions for healthy animals.[17]

A new EU regulation on veterinary medicinal products will soon enter into force, waiting only for the formal adoption by the European Council of national governments.[18] This law is an important first step towards addressing the heavy use of antibiotics in factory farming. The legal requirement for a veterinarian to examine animals before prescribing antimicrobials to treat whole herds, and the ban of such herd treatments as a preventative measure (except in exceptional cases), are particularly welcome. However, the law foresees several exceptions which allow the livestock sector to continue applying antimicrobials generously, including using them preventively for whole herds, with all the related risks to human health and the effectiveness of our antibiotics.

11 Campbell, B. M., et al. 2017. Agriculture production as a major driver of the earth system exceeding planetary boundaries. Ecology and Society, 22: 8
12 Biologically active substances can affect organisms - e.g. pharmaceuticals, EDCs (endocrine disrupting chemicals) or pesticides
13 Charuaud L, Jarde E, Jaffrezic A, Thomas M-Florence, Le Bot B, Veterinary pharmaceutical residues from natural water to tap water: Sales, occurrence and fate, Journal of Hazardous Materials (2018), https://doi.org/10.1016/j.jhazmat.2018.08.075
14 European Medicines Agency (EMA). Sales of veterinary antimicrobial agents in 30 European countries in 2016. 2018;
15 Sarmah, A. K.; Meyer, M. T.; Boxall, A. B. A. A Global Perspective on the Use, Sales, Exposure Pathways, Occurrence, Fate and Effects of Veterinary Antibiotics (VAs) in the Environment. Chemosphere 2006, 65 (5), 725–759.
16 United Nations 2016. High-Level Meeting on Antimicrobial Resistance. https://www.un.org/pga/71/2016/09/21/press-release-hl-meeting-on-antimicro
17 WHO 2017 http://www.who.int/foodsafety/areas_work/antimicrobial-resistance/cia_guidelines/en/
18 European Parliament News 25-10-2018. http://www.europarl.europa.eu/news/en/press-room/20181018IPR16526/meps-back-plans-to-halt-spread-of-drug-resistance-from-animals-to-humans

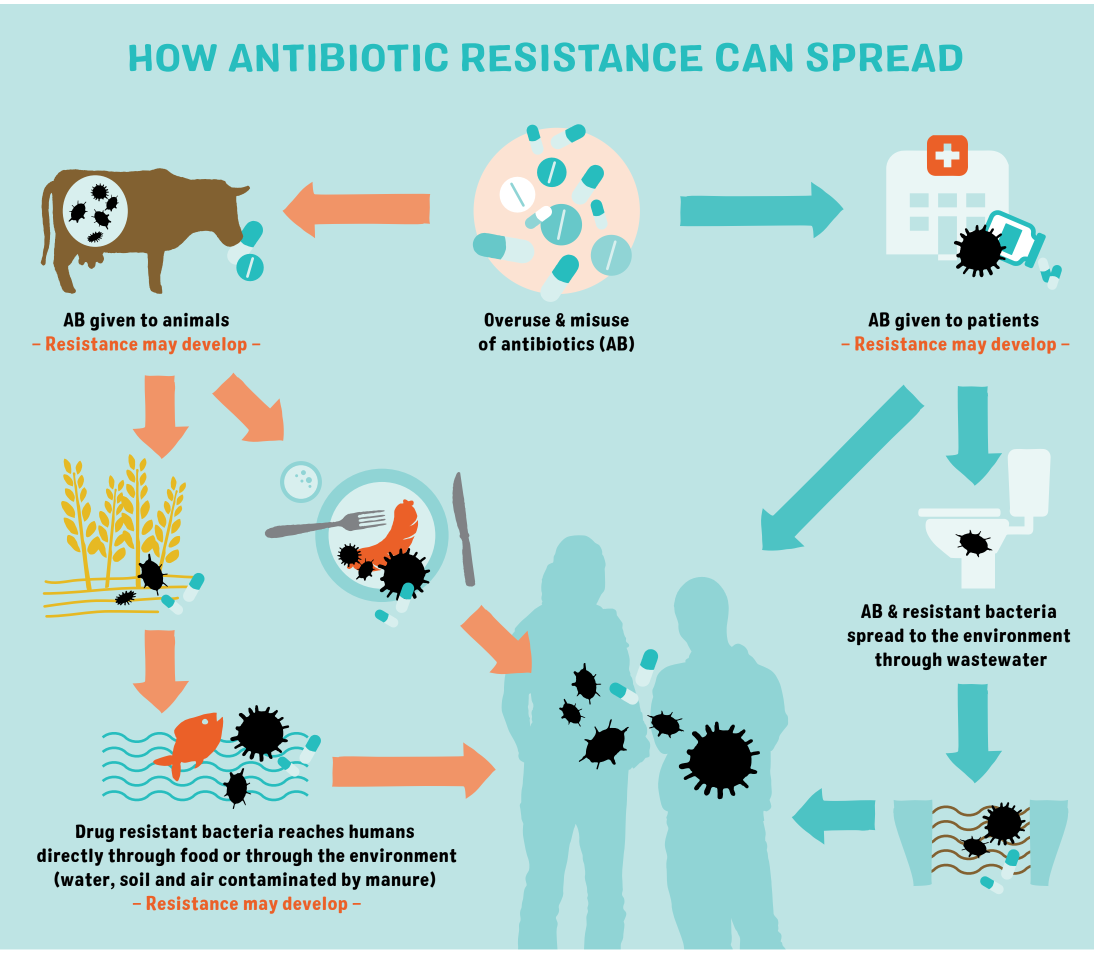
What are antimicrobials, what are antibiotics?
Antimicrobials are a group of pharmaceuticals used against micro-organisms. Antibiotics are the antimicrobials used to fight bacteria.

How many antibiotics are given to livestock?
The European Medicines Agency (EMA) estimated that about two thirds of all antibiotics in the EU are given to animals.[19] In Europe, antibiotic usage is particularly high in intensive farming of pigs and poultry. There is some overlap between the pharmaceuticals used to treat humans and animals, although some substances are restricted to veterinary or to human use only.

What is antimicrobial resistance (AMR)?
Some micro-organisms can evolve to withstand an antibiotic – they become resistant to it. Bacteria can transfer their drug-resistance to other bacteria.

Why is AMR a threat?
Diseases due to resistant bacteria can't be treated with the antibiotics to which they are resistant. In case of multiple resistance (when bacteria are resistant to several antibiotics) there may be no effective treatment.

Why does it occur?
Overuse and misuse of antibiotics, both in human and veterinary treatments, give bacteria more chances to become resistant to them.



19 European Medicines Agency (EMA). Joint Interagency Antimicrobial Consumption and Resistance Analysis Report. 2015: EU (26): 3399,8 humans to 7982 tonnes for animals (expressed in tonnes of active substance sold in the EU). https://www.ema.europa.eu/documents/presentation/presentation-joint-interagency-antimicrobial-consumption-resistance-analysis-jiacra-report-jordi_en.pdf

PESTICIDES

490 pesticides were approved for current use in 2018 in the EU, ranging through herbicides, fungicides and insecticides.[20] Industrially produced crops – both for human and animal consumption – are treated with a variety of pesticides on a routine preventative basis, rather than being used as a last resort in cases of heavy pest infestations. But many of those substances are harmful for the environment and human health: the Greenpeace Blacklist identified 209 out of 510 authorised active ingredients as potentially dangerous.[21] This assessment was based on parameters ranging from human health dangers, such as acute toxicity and carcinogenicity, to environmental toxicity to birds, fishes or pollinators like bees, and their environmental fate (bioaccumulation[22] and persistence[23]).
The excessive use of pesticides in industrial agriculture has significantly affected the quality of surface water.[24] Pesticide residues are among the major dangers for European bodies of water, especially for stream ecosystems in agricultural catchment areas.[25, 26]

Natural pollutants: Nutrients

Nutrients naturally occur in the environment. They cycle between places where they are not easily available to organisms, called long-term sinks (e.g. rocks and sediments), and places in the environment where they become available to plants and animals (e.g. water or humus), and can be taken up by living organisms. These cycles can be altered by human activities such as the production and use of artificial fertilisers. Even though nutrients are essential for life, changing their amounts present in the environment can have significant negative impacts on ecosystems.

Both animal manure and artificial fertilisers contain the nutrients nitrogen and phosphorus in a form that's easily taken up by organisms – phosphates for phosphorus and nitrate, nitrite and ammonia for nitrogen. Both nitrogen and phosphorous are indispensable nutrients for most forms of life. They are used in agriculture to promote plant growth, but excess nitrogen and phosphorous have a major impact on global ecosystems. In the case of nitrogen and phosphorus, industrial agricultural practices have greatly contributed to pushing the natural cycles of these substances far beyond what our planet can sustain.[27] In the European Union, 73 percent of the nitrogen and phosphorus water pollution caused by agriculture can be attributed to livestock production.[28]

A well-known example of ecosystem-wide impacts due to excess nutrients are the aquatic "dead zones" caused through excess nitrogen and phosphorus in water. Dead zones are created through eutrophication, an excess of nutrients, which can lead to rapid growth of algae, followed by oxygen depletion when the algae decompose. These dead zones of low or no oxygen cannot support anything but organisms tolerant of very low oxygen levels.

20 Pesticides database of the European Commission, 2018. http://ec.europa.eu/food/plant/pesticides/eu-pesticides-database/public/?Event=activesubstance.selection & language=EN.

21 The EU Pesticide Blacklist 2016, Greenpeace 2016 https://www.greenpeace.org/slovakia/PageFiles/736013/EU%20Pesticide%20Blacklist%202016.pdf

22 A substance that can accumulate in certain organisms because it is absorbed faster than it is metabolised or excreted.

23 A substance that can endure in the environment for a long time because it isn't readily degradable.

24 Carazo-Rojas, E.; Pérez-Rojas, G.; Pérez-Villanueva, M.; Chinchilla-Soto, C.; Chin-Pampillo, J. S.; Aguilar-Mora, P.; Alpízar-Marín, M.; Masís-Mora, M.; Rodríguez-Rodríguez, C. E.; Vryzas, Z. Pesticide Monitoring and Ecotoxicological Risk Assessment in Surface Water Bodies and Sediments of a Tropical Agro-Ecosystem. Environ. Pollut. 2018, 241, 800–809.

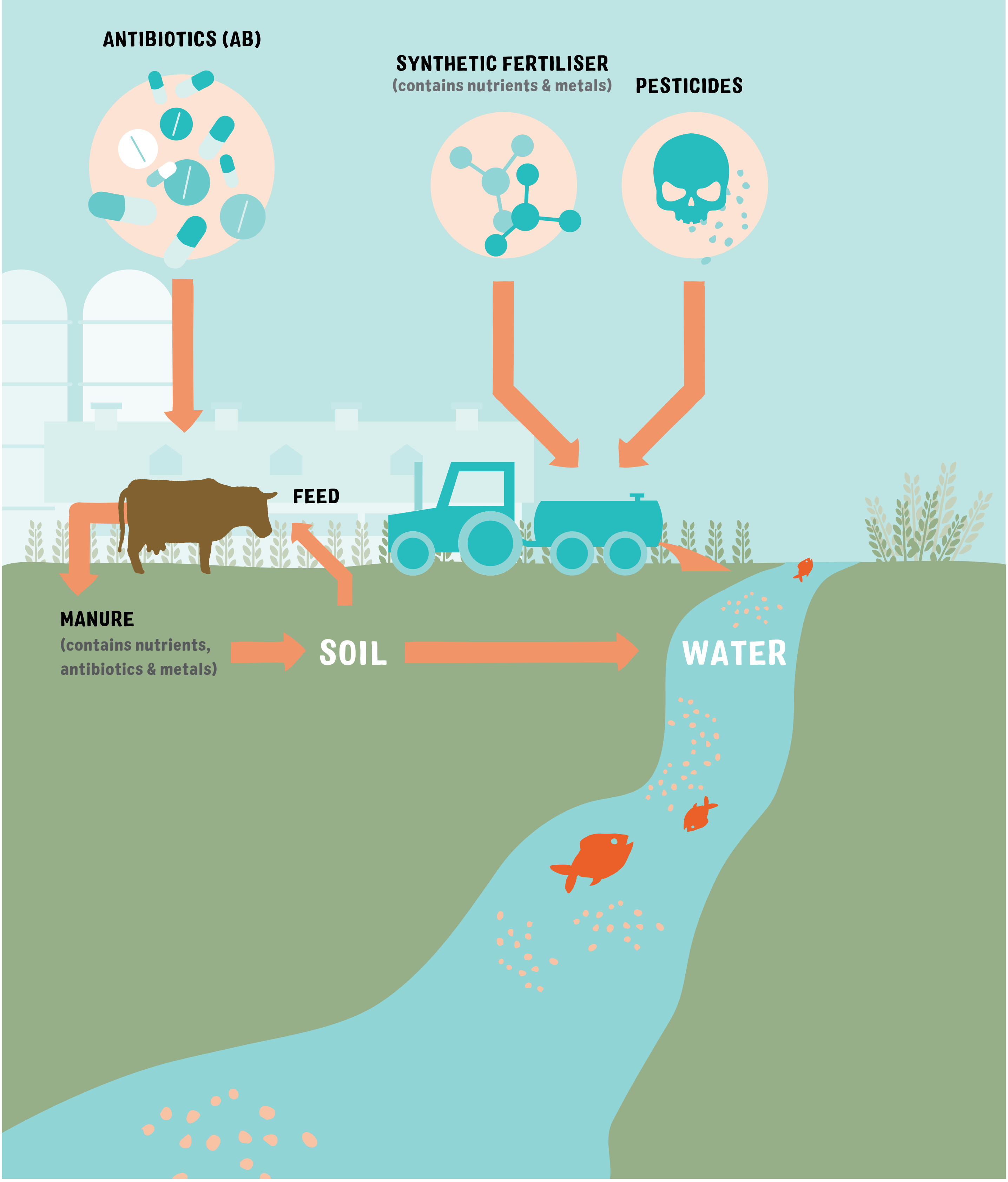
25 Malaj, E.; von der Ohe, P. C.; Grote, M.; Kühne, R.; Mondy, C. P.; Usseglio-Polatera, P.; Brack, W.; Schäfer, R. B. Organic Chemicals Jeopardize the Health of Freshwater Ecosystems on the Continental Scale. Proc. Natl. Acad. Sci. 2014, 111 (26), 9549 LP-9554. | Hernández, F.; Ibáñez, M.; Portolés, T.; Cervera, M. I.; Sancho, J. V.; López, F. J. Advancing towards Universal Screening for Organic Pollutants in Waters. J. Hazard. Mater. 2015, 282, 86–95 | Meffe, R.; de Bustamante, I. Emerging Organic Contaminants in Surface Water and Groundwater: A First Overview of the Situation in Italy. Sci. Total Environ. 2014, 481, 280–295.

26 Liess, M.; Ohe, P. C. Von Der. Analyzing Effects of Pesticides on Invertebrate Communities in Streams. Environ. Toxicol. Chem. 2009, 24 (4), 954–965 | Schäfer, R. B.; Caquet, T.; Siimes, K.; Mueller, R.; Lagadic, L.; Liess, M. Effects of Pesticides on Community Structure and Ecosystem Functions in Agricultural Streams of Three Biogeographical Regions in Europe. Sci. Total Environ. 2007, 382 (2–3), 272–285 | Liess, M.; Schäfer, R. B.; Schriever, C. A. The Footprint of Pesticide Stress in Communities—Species Traits Reveal Community Effects of Toxicants. Sci. Total Environ. 2008, 406 (3), 484–490.

27 Steffen, W., et al. 2015. Planetary boundaries: Guiding human development on a changing planet. Science, 348: 1259855

28 Adrian Leip et al 2015 Environ. Res. Lett. 10 115004. http://iopscience.iop.org/article/10.1088/1748-9326/10/11/115004/pdf

HOW ANTIBIOTICS, PESTICIDES AND NUTRIENTS END UP IN OUR RIVERS



Greenpeace water testing: results

In June and July 2018, Greenpeace tested rivers and canals in intensive livestock farming regions in ten European Union countries: Austria, Belgium, Denmark, France, Germany, Italy, Poland, Spain, the Netherlands and the United Kingdom. The samples were subsequently analysed in the facilities of the Greenpeace Research Laboratories in Exeter, UK. Altogether, 29 different waterways were examined for veterinary drugs, pesticides, nutrients and metals.[29]

Overall results

In 23 out of 29 samples Greenpeace found veterinary drugs. Overall, 21 different drugs were detected. 17 of them were antimicrobials, of those, 12 were antibiotics.
All 29 samples contained pesticides. Overall, 104 different pesticides were found. Nitrate concentrations in all samples were below the limit of 50 mg per litre, set by the EU, above which governments must act to protect waterways and aquatic life.[30] This might be related to the fact that samples were taken in a period where nitrate concentrations might be expected to be at relatively low levels within the annual cycle. Nevertheless, 15 of the samples were found to contain nitrate levels that could be harmful to the most sensitive invertebrates, fish and amphibians.[31] (For detailed results on antibiotics, pesticides and nutrients see Annex 2).
Metal concentrations were within the range previously reported for European streams.[32]
(See metal test results in Annex 1 and 2)

VETERINARY PHARMACEUTICALS

Veterinary drugs were found in roughly four out of five samples (79 percent) and antibiotics in more than two thirds (69 percent). 21 different veterinary drugs were detected, the majority were antimicrobials, most being antibiotics (12 substances). The antibiotic dicloxacillin was present in two thirds of all analysed samples. The antibiotic sulfamethoxypyridazine and the pharmaceutical sulfaquinoxaline were found in 14 of the 29 samples (48 percent) – both are reserved for veterinary use only. Up to 11 different veterinary drugs were found in a single sample – and up to 7 different antibiotics (River Roggia Savarona, Italy).

PESTICIDES

Pesticides were found in all samples. In total, 104 different pesticides (28 of them banned in the EU) were detected.[33] The highest number of pesticides found in one sample was 70, and this sample also contained the highest combined pesticide concentration of 94.02 µg/L (Wulfdambeek Canal, Belgium). Ten samples from seven countries contained single pesticide levels above regulatory acceptable concentrations set by the German Environment Agency, indicating concentrations of immediate ecotoxicological concern that may be harmful to aquatic organisms.[34] The compounds most frequently found above the regulatory acceptable concentrations were imidacloprid (17 percent) and clothianidin (10 percent).
Recently, both substances have been partially banned within the EU based on the threat they pose to bees and other pollinators.[35] When considering mixtures found in the samples (by summing up the risk quotients), 13 out of 29 samples yielded risk quotients indicating cause for concern as those mixtures may be harmful for aquatic ecosystems.[36]

29 All samples were screened for 101 different veterinary drugs, 275 pesticides, 20 metals and nitrate. For reasons of logistics and availability, nitrite and phosphate were measured in only 20 samples. Pesticides and veterinary drugs were analysed according to the following method: J. Casado, D. Santillo, P. Johnston, Multi-residue analysis of pesticides in surface water by liquid chromatography quadrupole-Orbitrap high resolution tandem mass spectrometry, Analytica Chimica Acta (2018), doi: 10.1016/j.aca.2018.04.026.

30 EEC (1991) Council Directive of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources. Official Journal of the European Union, L375 (31.12.91), 1-8

31 These samples were above the suggested limit for chronic exposure proposed by Camargo et al. Camargo, J. A., Alonso, A., & Salamanca, A. (2005). Nitrate toxicity to aquatic animals: A review with new data for freshwater invertebrates. Chemosphere, 58(9), 1255–1267. https://doi.org/10.1016/j.chemosphere.2004.10.044

32 Flem, B.; Reimann, C.; Fabian, K.; Birke, M.; Filzmoser, P.; Banks, D. Graphical statistics to explore the natural and anthropogenic processes influencing the inorganic quality of drinking water, ground water and surface water. Applied Geochemistry, 2018, 88(B), 133-148

33 Pesticides may be found in waterways even if they were used in agriculture some time (possibly years) ago. They can persist in soil or groundwater and can slowly be leached over time. Accordingly, finding banned pesticides may not be due to illegal use, but simply a function of their environmental persistence.

34 There is a lack of consensus which environmental quality standards should be applied to assess the risks for most active substances. There are several scientific sources developing RACs, the UBA being one of them. The UBA covered 59 out of the 104 pesticides detected. Regulatory acceptable concentration for selected crop protection agents. Federal Environment Agency of Germany https://webetox.uba.de/webETOX/public/basics/literatur.do?id=24559.

35 Ban on open air application of imidacloprid, clothianidin and thiamethoxam in the European Union since 30 May 2018. Neonicotionoids. European Commission https://ec.europa.eu/food/plant/pesticides/approval_active_substances/approval_renewal/neonicotinoids_en

36 By summing up the risk quotients for all pesticides with known regulatory acceptable concentrations in the sample.

DK 1 Vasby DENMARK
DK 2 Lille Skensved DENMARK
DK 3 Ambæk DENMARK
Denmark
NL 1 Groote Wetering NETHERLANDS
NL 2 Lage Raam NETHERLANDS
NL 3 Snepheiderbeek NETHERLANDS
Netherlands
PL 1 Drwęca POLAND
PL 2 Wkra POLAND
PL 3 Mława POLAND
Poland
DE 3 Soeste GERMANY
DE 2 Essener Canal GERMANY
DE 1 Ems GERMANY
Germany
UK 2 Tale UNITED KINGDOM
UK 1 Otter UNITED KINGDOM
United Kingdom
BE 1 Moubeek BELGIUM
BE 3 De Wamp BELGIUM
BE 2 Wulfdambeek BELGIUM
Belgium
FR 3 Le Gouessant FRANCE
FR 2 Ruisseau du Vernic FRANCE
FR 1 Ruisseau de la Madoire FRANCE
France
AT 3 Sipbach AUSTRIA
AT 2 Stiefing AUSTRIA
AT 1 Schwarzaubach AUSTRIA
Austria
IT 3 Canal 2 ITALY
IT 2 Roggia Savarona ITALY
IT 1 Canal 1 ITALY
Italy
Spain
ES 1 Aragón SPAIN
ES 2 Flumen SPAIN
ES 3 Segre SPAIN
TYPE
River
Canal

NUTRIENTS

Nitrate, nitrite and phosphate were also measured. Nitrate was measured in all samples, nitrite and phosphate in a subset of 20 locations.[37] Measured concentrations of nitrate broadly fall within the range for average nitrate concentrations already reported for a number of major European rivers.[38] All concentrations were below the EU limit of 50 mg per litre, beyond which governments must take action to protect rivers, lakes and aquatic life, though in several cases only slightly below.[39] Samples were collected in June and July, when dissolved nitrate concentrations are expected to be at relatively low levels in the annual cycle because of depletion as a result of the growth of algae and other plants. Additionally, in some countries summer was exceptionally dry this year, which may also impact on nutrient concentration in rivers. The observation that nitrate concentrations in surface water samples at that time of the year are even approaching the EU 50 mg limit at some locations is a cause for some concern, especially as the 50 mg limit cannot be assumed to protect sensitive aquatic species, as it is a somewhat pragmatic value, based largely on what may be achievable through better management of agricultural practices. Scientists have suggested that concentrations must stay below 9 mg per litre to protect the most sensitive freshwater invertebrates, fish and amphibians.[40] About half of the samples collected were found to contain nitrate levels above that proposed 9 mg per litre 'safe' limit for chronic exposure.

Nitrite concentrations at the time of sampling exceeded the level for granting 'good ecological status' (0.3 mg nitrite per litre) under the EU's water protection laws in four samples, were detected in eight and below limits of quantification in another eight locations.[41] Phosphate concentrations were too low to measure in the majority of samples (17 of 20), with measurable concentrations in three samples from Belgium and Denmark.

Veterinary drugs in canals

The test results indicate that the number of veterinary drugs found in canal samples is, in general, lower than in rivers. This may be because the canal systems sampled were in some way more conducive to degradation of the relatively chemically unstable veterinary drugs. All three sampling locations in Belgium and the Netherlands, as well as two in Italy (IT1, IT3) and one in Denmark (Ambæk stream, DK3), were canals.

37 For reasons of logistics and availability of test kits, nitrite and phosphate were measured in 20 out of 29 samples.
38 Bouraoui, F., & Grizzetti, B. (2011). Long term change of nutrient concentrations of rivers discharging in European seas. Science of the Total Environment, 409(23), 4899–4916. https://doi.org/10.1016/j.scitotenv.2011.08.015
39 EEC (1991) Council Directive of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources. Official Journal of the European Union, L375 (31.12.91), 1-8
40 Camargo, J. A., Alonso, A., & Salamanca, A. (2005). Nitrate toxicity to aquatic animals: A review with new data for freshwater invertebrates. Chemosphere, 58(9), 1255–1267. https://doi.org/10.1016/j.chemosphere.2004.10.044
41 EC (2000). Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy (Water Framework Directive). Official Journal of the European Parliament, L327(22.12.2000), 1–82. https://doi.org/10.1039/ap9842100196

Country results

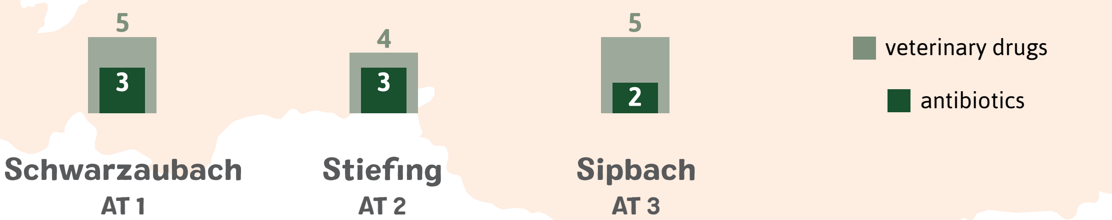
Austria

Pork is by far the largest meat production sector in Austria. Greenpeace took three water samples from small rivers in districts with a high density of pigs, located in the federal states Upper Austria and Styria. In 2017, more tonnes of pork meat were produced in Austria than all other kinds of meat combined (beef, poultry, sheep, goats, horses and any others).[42]

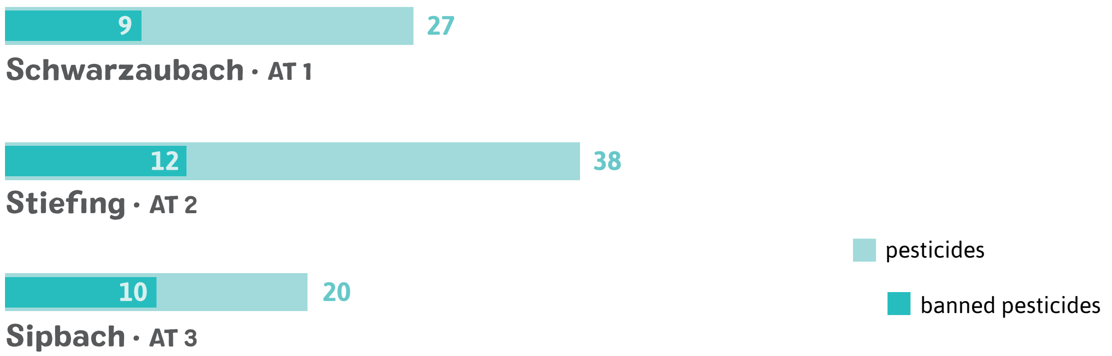
All three water samples were found to contain veterinary drugs. Nine drugs were detected altogether, with four or five different drugs present in every sample. Each sample contained at least two antibiotics. Sulfaquinoxaline, a pharmaceutical used for animal treatment only, was found in all three samples.

Between 20 and 38 pesticides per sample were found in Austria. The sample from River Stiefing contained one pesticide in very high concentrations.[43] Overall, 43 different pesticides were detected. 12 of these are no longer allowed to be used in the EU, but can persist in soil or groundwater and can slowly be leached or washed out into rivers over time.
All three samples contained nitrate concentrations above the level considered to be safe for the most sensitive aquatic invertebrates, fish and amphibians.[44] The concentration measured in the sample from River Sipbach reached 77 percent of the EU limit.[45] Furthermore, the nitrite concentrations in the sample from River Schwarzaubach reached 86 percent of the EU nitrite indicator for to be designated 'good ecological status'.[46]

Number of veterinary drugs



Number of pesticides



42 470,601 tonnes of pork compared to 435,644 tonnes of other meat combined; Statistik Austria Versorgungsbilanz Fleisch: http://www.statistik.at/web_de/statistiken/wirtschaft/land_und_forstwirtschaft/preise_bilanzen/versorgungsbilanzen/index.html

43 1,29 µg/L terbuthylazine (a herbicide)

44 Camargo, J. A., Alonso, A., & Salamanca, A. (2005). Nitrate toxicity to aquatic animals: A review with new data for freshwater invertebrates. Chemosphere, 58(9), 1255–1267. https://doi.org/10.1016/j.chemosphere.2004.10.044

45 EEC (1991) Council Directive of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources. Official Journal of the European Union, L375 (31.12.91), 1-8

46 EC (2000). Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy (Water Framework Directive). Official Journal of the European Parliament, L327(22.12.2000), 1–82. https://doi.org/10.1039/ap9842100196

Belgium

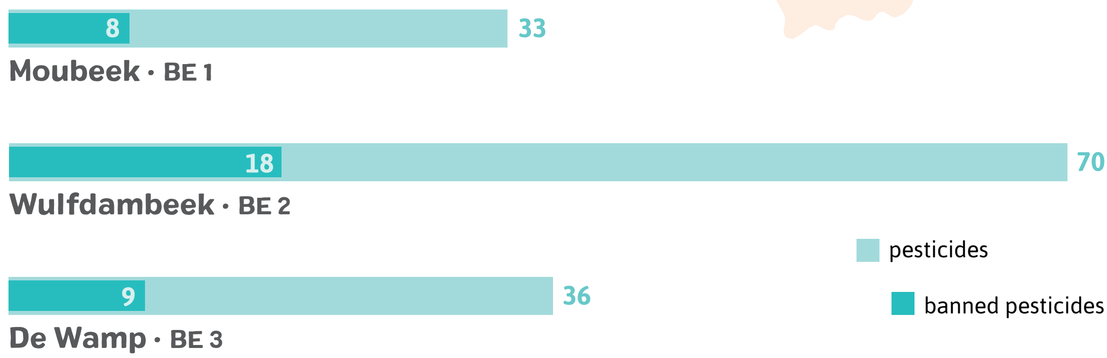
Greenpeace took three water samples in Flanders, which produces 84 percent of Belgium's chickens. Belgium is also one of the largest pig meat producers in Europe, and much is reared for export. Belgium had 6.1 million pigs in 2017, with 94 percent of them in Flanders, where the most intensive pig farming takes place. More than half of Belgium's pig farms are in the province of West Flanders, where two of the water samples were taken. West Flanders is also an intensive production area for chickens: of 40 million chickens reared in Belgium (2017), more than 12 million were reared in that province. Ten million chickens were produced in the province of Antwerp, where the third sample was taken.

Aspirin was found in two samples. The anti-inflammatory drug is used for treating both humans and pigs, chickens and other animals. It was detected in the waters of two canals, without sewage treatment plants upstream, but with a number of pig farms in the surrounding area (see also Box on veterinary drugs in canals, p. 12). The three samples also contained 33, 36 and 70 different pesticides respectively. Overall, 75 different pesticides were detected, including 20 that are no longer allowed in the EU. Five of the 70 pesticides found in the water of the Wulfdambeek Canal were found in very high concentrations.[47]

Nitrate concentrations were found to be low in all three samples, but the two highest phosphate concentrations determined in the samples overall were found in Belgium.[48] In one sample more than 5 mg phosphate per litre was detected.

Number of veterinary drugs

Number of pesticides



47 59.85 µg/L dimethenamid, 10.01 µg/L MCPA, 9.70 µg/L 2,4-D, 4.71 µg/L ethofumesate and 2.52 µg/L prosulfocarb (five herbicides)

48 Despite these results, it should be noted that ongoing nitrate and phosphate monitoring by the Flanders Environment Agency (VMM) shows systematic exceeding of legal maximum thresholds, with no recent signs of improvement. During the last four winters (2013-2017), 21 percent of the checks-points for surface water exceeded the nitrate threshold. During the 2017 winter, maximum phosphate levels were exceeded in 67percent of the checkpoints. Vlaamse Land Maatschappij (2018). Mestrapport 2017. https://www.vlm.be/nl/SiteCollectionDocuments/Publicaties/mestbank/Mestrapport_2017.pdf

Denmark

All three sampling spots, Lille Skensved, Vasby and Ambæk streams, are in close proximity to EU-subsidised industrial farms. Denmark is the EU's most intensively farmed country, with 62 percent of the total land area under cultivation. 80 percent of the farmland is used for producing feed for animals. In two of the three sampling spots, Lille Skensved and Vasby streams, Danish scientists had already identified pesticides in tests run in 2012.[49] The third Danish sampling spot, Ambæk stream, is adjacent to a major industrial pig farm.

The number of veterinary drugs found in the water samples differed: the two samples from Lille Skensved and Vasby streams contained five and eight drugs respectively, while none were detected in the sample taken from the canal Ambæk (see Box on veterinary drugs in canals, p. 12). Five of the ten different substances found were antibiotics.

Between 10 and 18 pesticides were identified in each sample. Overall, 27 different pesticides were detected, including eight that are no longer allowed to be used in the EU. According to official data, three of these now banned pesticides have not been available for purchase in Denmark since 2010 or earlier.[50]

The samples in Denmark were taken after six weeks of drought.[51] Nitrate concentrations were low in all three samples, but the nitrite levels measured in Lille Skensved stream exceeded the EU nitrite indicator for 'good ecological status',[52] and Vasby stream was one of three samples with measurable phosphate concentrations.

Number of veterinary drugs

Number of pesticides

49 Rasmussen, J. J., Wiberg-Larsen, P., Baattrup-Pedersen, A., Cedergreen, N., McKnight, U.S., Kreuger, J., Jacobsen, D., Kristensen, E.A., Friberg, N.. The legacy of pesticide pollution: An overlooked factor in current risk assessments of freshwater systems. Water Research 84 https://doi.org/10.1016/j.watres.2015.07.021

50 Danish Environmental Protection Agency, Bekæmpelsesmiddel-statistik 2016 https://www2.mst.dk/Udgiv/publikationer/2017/11/978-87-93614-41-3.pd

51 In May 2018 Denmark got in average 18 millimeter of rain. It was the driest May since 2008 and the 9'th driest May ever registered. In June 2018 Denmark got in average 24 millimeter rain, which is 56% under normal. It was the driest June since 1996. Danish Meteorological Institute, https://www.dmi.dk/vejr/arkiver/maanedsaesonaar/vejret-i-danmark-maj-2018/ https://www.dmi.dk/vejr/arkiver/maanedsaesonaar/vejret-i-danmark-juni-2018/

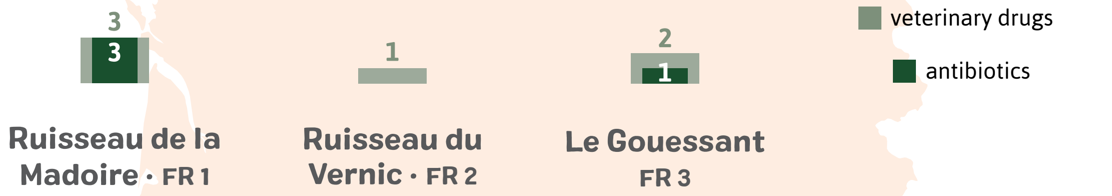
52 EC (2000). Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy (Water Framework Directive). Official Journal of the European Parliament, L327(22.12.2000), 1–82. https://doi.org/10.1039/ap9842100196

France

Greenpeace took samples from three locations in France chosen for the presence of the largest number of agricultural animals, as reported in 2010. Taken together the three municipalities have more than 32,000 live-stock units.[53] Two of the municipalities where samples were taken, near the River Vernic and River Gouessant, also have a very high animal density (5.9 and 6.7 animals per hectare of agricultural land respectively). The third area, around River Madoire, has a density of 2.4 animals per hectare.

All French river samples contained between one and three different veterinary drugs. Three of the four different substances found were antibiotics. Two of the four pharmaceuticals – furaltadone and sulfadime-thoxin – are for veterinary use only.
15 to 25 pesticides per sample were found in France. Overall, 29 different pesticides were detected, including six that are no longer allowed in the EU. Imidacloprid, a neonicotinoid insecticide recently banned in France due to the danger it poses to bees, was found in all samples.[54]
All three samples contained nitrate concentrations above the level scientifically suggested as necessary to ensure the protection of the most sensitive aquatic invertebrates, fish and amphibians.[55] The concentrations measured were particularly high in samples from the locations known to have the highest animal densities (River Vernic and River Gouessant), the nitrate concentration in the sample from River Vernic reached 82 percent of the EU-designated limit.[56]

Number of veterinary drugs



Number of pesticides

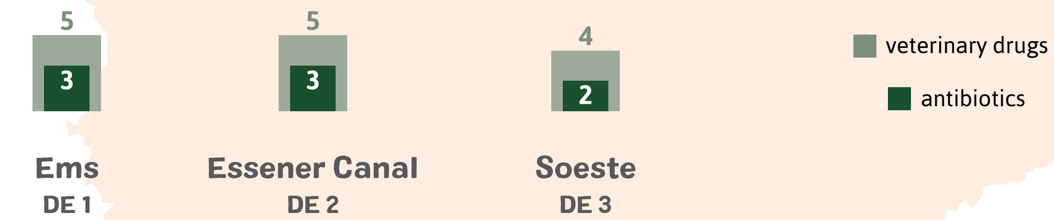
53 Livestock units are used to better compare different animals. For instance 1 Livestock Unit can be 1 dairy cow, 2 sows or 37 piglets.
54 France has a ban on all neonicotinoids since September 2018, while the European Union as a whole has a partial ban (on open air application) of imidacloprid, clothianidin and thiamethoxam since May 2018
55 Camargo, J. A., Alonso, A., & Salamanca, A. (2005). Nitrate toxicity to aquatic animals: A review with new data for freshwater invertebrates. Chemosphere, 58(9), 1255–1267. https://doi.org/10.1016/j.chemosphere.2004.10.044
56 EEC (1991) Council Directive of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources. Official Journal of the European Union, L375 (31.12.91), 1-8

Germany

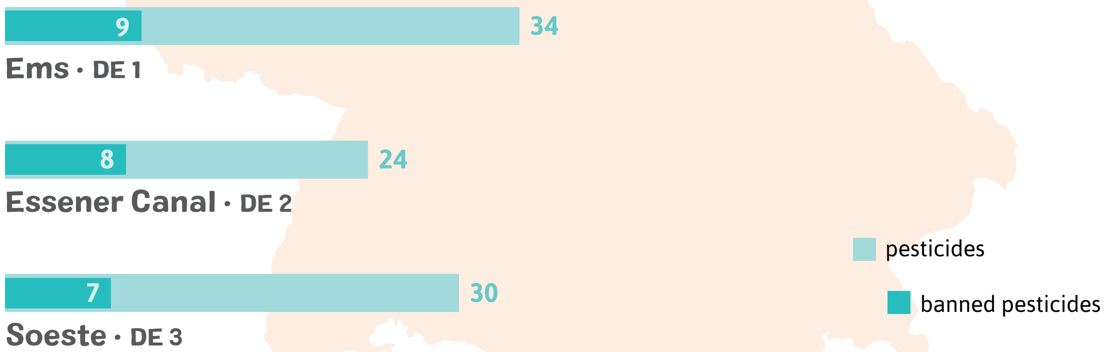
All German samples were taken in lower Saxony, in a region which is called the 'pig-belt', because of its high density of pigs. The first sampling spot was in River Ems, in which area are up to 600 pigs per 100 hectares. The second sample was taken from the Essener canal in a region with around 900 pigs per 100 hectares. The third sample was taken from River Soeste with more than 900 pigs per 100 hectares.[57]

Five veterinary drugs were detected – four of them in all three samples. Three of the five different substances found are antibiotics.
Between 24 and 34 pesticides per sample were found. Overall, 44 different pesticides were detected, including nine that are no longer allowed in the EU.
Two samples contained nitrate concentrations above the level suggested as necessary to ensure the protection of the most sensitive aquatic invertebrates, fish and amphibians,[58] the concentration measured in the sample from River Soeste reached 79 percent of the EU limit value.[59] This sample also contained nitrite concentrations more than 20 times higher than the EU nitrite indicator for 'good ecological status' (0.3 mg nitrite per litre).[60]

Number of veterinary drugs



Number of pesticides



57 Atlas der Agrarstatistik. https://www.atlas-agrarstatistik.nrw.de/
58 Camargo, J. A., Alonso, A., & Salamanca, A. (2005). Nitrate toxicity to aquatic animals: A review with new data for freshwater invertebrates. Chemosphere, 58(9), 1255–1267. https://doi.org/10.1016/j.chemosphere.2004.10.044
59 EEC (1991) Council Directive of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources. Official Journal of the European Union, L375 (31.12.91), 1-8.
60 EC (2000). Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy (Water Framework Directive). Official Journal of the European Parliament, L327(22.12.2000), 1–82. https://doi.org/10.1039/ap9842100196

Italy

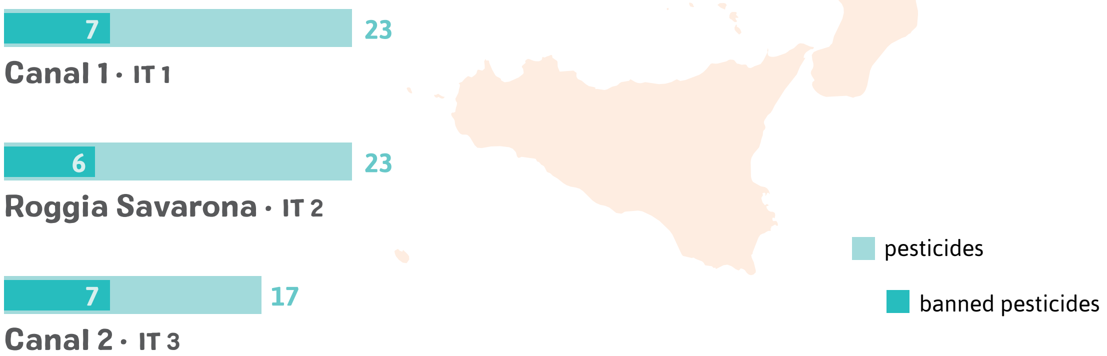
In Italy intensive livestock farms are mainly concentrated in the River Po valley (Pianura Padana). In particular, the Lombardia region hosts more than half of the national pig live animals stock.[61] Greenpeace took three samples in this region, in the three provinces with a very high presence of pigs – Cremona, Mantova, Brescia.

12 veterinary drugs were detected in the samples from Italy. The two canal samples contained three and six different drugs respectively, the river sample the maximum number of eleven different drugs in one sample (see also Box on veterinary drugs in canals, p. 12). Eight of the substances found were antibiotics. Three substances – all three of them antibiotics – were detected in each of the three samples.

17 to 23 pesticides per sample were found in each Italian sample. Overall, 30 different pesticides were detected, including nine that are no longer allowed in the EU.
All three samples contained nitrate concentrations above the level scientifically suggested as necessary to ensure the protection of the most sensitive aquatic invertebrates, fish and amphibians,[62] the concentration measured in the sample from River Roggia Savarona reached 66 percent of the EU limit.[63] In two samples the EU nitrite indicator for 'good ecological status' was also exceeded.[64]

Number of veterinary drugs

Number of pesticides



61 From 8,375,523 pigs in Italy, 4,391,075 are from Lombardia; Istat 2016. https://www.istat.it/en/archive/200600

62 Camargo, J. A., Alonso, A., & Salamanca, A. (2005). Nitrate toxicity to aquatic animals: A review with new data for freshwater invertebrates. Chemosphere, 58(9), 1255–1267. https://doi.org/10.1016/j.chemosphere.2004.10.044

63 EEC (1991) Council Directive of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources. Official Journal of the European Union, L375 (31.12.91), 1-8

64 EC (2000). Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy (Water Framework Directive). Official Journal of the European Parliament, L327(22.12.2000), 1–82. https://doi.org/10.1039/ap9842100196

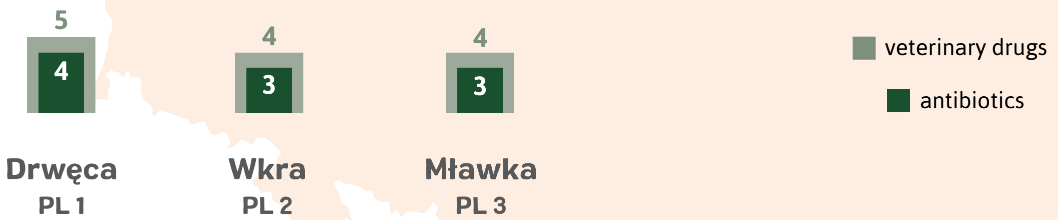
Poland

Greenpeace took three water samples in Poland: the first Polish sampling spot was located below the river catchments of Iława poviat, an area with a lot of pig production. The other two samples were taken in Masovia region, where about a quarter of the Polish poultry production, which in total exceeds a billion chickens slaughtered per year, and ten percent of the Polish pig population is located. Farms in neighbouring Żuromin poviat, where the second sample was taken, are populated with more than 600,000 pigs,[65] over 50,000 cattle, and more than 20 million fowl.[66] Mława poviat, where the third sample was taken, is dominated by poultry farms, with livestock population estimated above 50 million chickens,[67] over 45,000 pigs and 60,000 cattle.[68] These areas have become zones of conflict between local communities and investors.

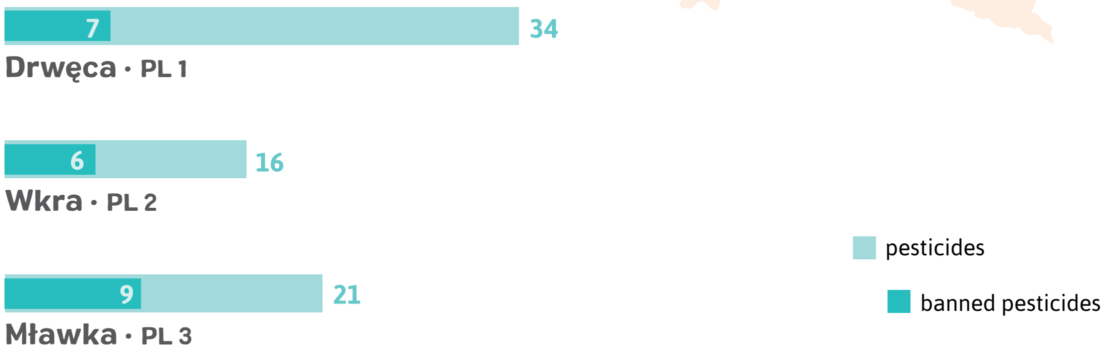
Five veterinary drugs were detected – four of them in all three samples. Four of the five substances found are antibiotics.
The number of pesticides found in the Polish river samples ranged from 16 to 34 different active substances. Overall, 41 different pesticides were detected, including 12 that are no longer allowed in the EU.

Only nitrate was analysed in Poland, not nitrite and phosphate. With concentrations from 5.98 to 7.97 mg of nitrate per litre, all three samples were below the level scientifically suggested as necessary to ensure the protection of the most sensitive aquatic invertebrates, fish and amphibians.[69]

Number of veterinary drugs



Number of pesticides



65 Figures for pigs and cattle: Agency for the Restructuring and Modernization of Agriculture, 2016
66 Figures for poultry: Veterinary Office in Żuromin, 2016
67 Figures for chicken: District Office of Mlawa, 2016
68 Figures for pigs and cattle: Census of Agriculture, 2010
69 Camargo, J. A., Alonso, A., & Salamanca, A. (2005). Nitrate toxicity to aquatic animals: A review with new data for freshwater invertebrates. Chemosphere, 58(9), 1255–1267. https://doi.org/10.1016/j.chemosphere.2004.10.044

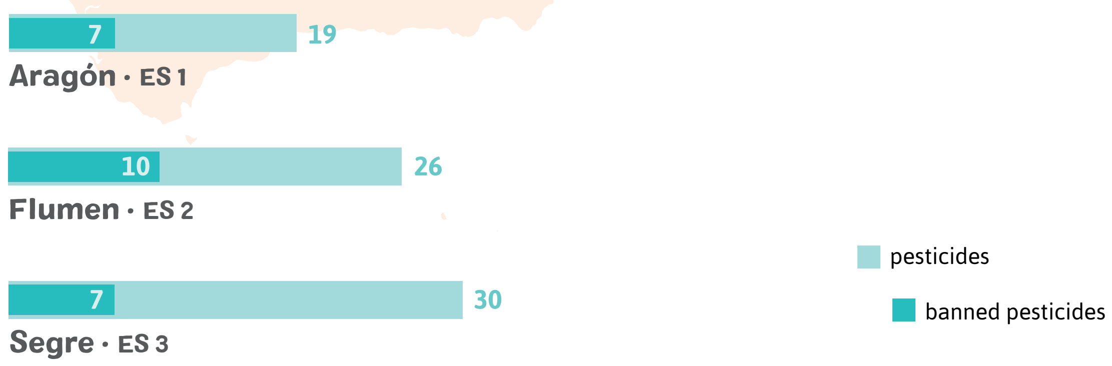
Spain

Spain is the fourth largest intensive producer of pig meat in the world. Production is mainly concentrated in two regions, Aragón and Catalonia. Additionally, intensive chicken production is increasing and there are also plans to establish the biggest dairy farm in Europe, with almost 24,000 cows. Greenpeace took samples to give a snapshot of the impact of the three sectors (pork, poultry and dairy production). In Catalonia (River Segre) for pig farms, Aragon (River Flumen) for chicken farms and Navarra (River Aragón) for dairy farms. River Aragón, however, is further from livestock farms than the other two rivers.

Overall, 10 different drugs were detected in Spanish river samples. Two samples (River Flumen and River Segre) each contained seven different drugs. Four of those substances were detected in both samples. Six of the substances found are antibiotics.
Between 19 and 30 pesticides per sample were found in the samples from Spain. Overall, 43 different pesticides were detected, including 10 that are no longer allowed in the EU.
Nitrate concentrations in the sample from River Flumen exceeded the level scientifically suggested as necessary to ensure the protection of the most sensitive aquatic invertebrates, fish and amphibians.[70] Furthermore, nitrite concentrations in the sample from River Segre reached 78 percent of the EU nitrite indicator for 'good ecological status'.[71]

Number of veterinary drugs

Number of pesticides



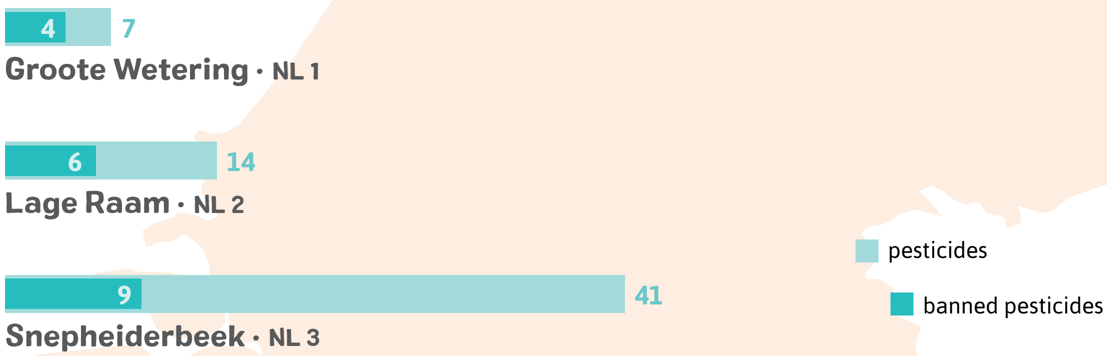
70 Camargo, J. A., Alonso, A., & Salamanca, A. (2005). Nitrate toxicity to aquatic animals: A review with new data for freshwater invertebrates. Chemosphere, 58(9), 1255–1267. https://doi.org/10.1016/j.chemosphere.2004.10.044
71 EC (2000). Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy (Water Framework Directive). Official Journal of the European Parliament, L327(22.12.2000), 1–82. https://doi.org/10.1039/ap9842100196

The Netherlands

Two of the sample locations in the Netherlands are in the south of the country, in the regions Noord Brabant and Limburg. This region is known for a high density of pigs, poultry and dairy cows and other livestock. The sampling location at the canal 'Lage Raam' is close to a big biogas installation and pig stable, the 'Snepheiderbeek' is a small river flowing through a landscape with different types of intensified livestock and other agricultural activities. The third location is in the region of Gelderland in the middle of the country, known for its production of veal meat. The small river 'Grote Wetering' flows through meadows with industrial livestock farms around.

No veterinary drugs were found in the samples from the Netherlands, even though the selected region Noord-Brabant has intensive pig and dairy farming. All three samples were taken from canals (see Box on veterinary drugs in canals, p. 12). The number of pesticides ranged from seven up to 41 different active substances in one sample. Overall, 45 different pesticides were detected, including 11 that are no longer allowed in the EU.
Nitrate was the only nutrient analysed in the Netherlands. Nitrate concentrations in the sample from Canal Snepheiderbeek (region of Limburg) exceeded the level scientifically suggested as necessary to ensure the protection of the most sensitive aquatic invertebrates, fish and amphibians,[72] and reached it in the sample from Canal Lage Raam (region of Noord-Brabant).

Number of pesticides



72 Camargo, J. A., Alonso, A., & Salamanca, A. (2005). Nitrate toxicity to aquatic animals: A review with new data for freshwater invertebrates. Chemosphere, 58(9), 1255–1267. https://doi.org/10.1016/j.chemosphere.2004.10.044

United Kingdom

In the UK, two samples were taken from rivers in intensively farmed regions in the Southwest of England. River Otter and River Tale were selected as sampling sites because the catchments are rural with a mixture of small cattle, sheep and dairy farms and some pig rearing. In the case of both rivers, livestock rearing and arable cultivation as a component of agricultural and rural land management overall are considered as probable reasons for failures to achieve a classification status of "good" under the EU's water protection laws. The overall classification for the River Tale in 2016 was "moderate"[73] and for the Lower River Otter "poor".[74] Seven veterinary drugs in total were found in the river samples, six in River Otter and two in River Tale. Sulfaquinoxaline was detected in both rivers. Four of the seven substances found were antibiotics. The UK-river-samples contained 19 and 24 pesticides respectively. Overall 29 different pesticides were detected, including nine that are no longer allowed in the EU.

For reasons of logistics and availability of test kits, only nitrate was analysed in the UK, not nitrite or phosphate. Nitrate exceeded levels scientifically suggested as safe to ensure the protection of the most sensitive aquatic invertebrates, fish and amphibians[75] in both samples. The nitrate concentration in the sample from River Tale reached 67 percent of the EU limit value.[76]

Number of veterinary drugs

Number of pesticides

73 Environmental Agency CDE, river classification for River Tale; http://environment.data.gov.uk/catchment-planning/OperationalCatchment/3405
74 Environmental Agency CDE, river classification for Lower River Otter; http://environment.data.gov.uk/catchment-planning/WaterBody/GB108045009170
75 Camargo, J. A., Alonso, A., & Salamanca, A. (2005). Nitrate toxicity to aquatic animals: A review with new data for freshwater invertebrates. Chemosphere, 58(9), 1255–1267. https://doi.org/10.1016/j.chemosphere.2004.10.044
76 EEC (1991) Council Directive of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources. Official Journal of the European Union, L375 (31.12.91), 1-8

Conclusions and recommendations

The way we produce our food will help determine the future of our planet. Currently, our environment is under pressure from industrial agriculture, especially from industrial farming of animals for meat and dairy. This report provides a snapshot of the pervasive contamination of European waterways, particularly in areas with intensive livestock production. It shows that our rivers contain a cocktail of agrochemicals and pharmaceuticals. The possible consequences are serious: higher risks of development of bacteria resistant to antibiotics; the threat to different species posed by pesticides and other pollutants; or the growth of algae blooms caused by excess nutrients. Above all, we still have little knowledge on how to assess the cumulative impacts that these potentially dangerous cocktails formed by various pollutants present in our ecosystems.

Via the common agricultural policy (CAP), the European Union has contributed to shaping the way food is produced in Europe for half a century. As confirmed by the results of this testing, such policy has so far failed to effectively protect us and the environment from the pollution caused by industrial farming. For decades, public subsidies have been provided without sufficiently taking into account environmental impacts and have therefore contributed to the expansion of an ever more industrialised meat and dairy production. For instance, the number of heavy polluting pig and poultry farms rose by 31 percent in the last decade, to more than 6,500 farms.[77]

Currently, a new common agricultural policy is being developed by the European Union. European health, environmental, and agricultural decision-makers must collectively take this opportunity to end financial support for factory farming, in order to protect our environment and people's health. Instead, public money should support farmers who adopt ecological methods to produce healthy, diverse and sustainable crops for our meals, or those who raise livestock in an ecological way while producing only as much meat and dairy as the planet can sustain.

In light of the systemic problems caused by factory farming that our testing results expose, we recommend European and national decision-makers to:

- **prevent public money from supporting industrial livestock production (factory farming).**
  More concretely, CAP money should not support farms that:
  - Have more than one and a half 'livestock units' per hectare of land (1 livestock unit being for instance 1 dairy cow, 2 sows or 37 piglets)
  - Get less than 50 percent of their feed from their farm and/or heavily rely on animal feed imports
  - Rely on the use of antibiotics as a preventative, or treat entire herds when just one or a few animals get sick

- **promote less and better meat and dairy production.**
  EU farm payments should support farms that fulfill one or more of these criteria:
  - Put in place measures to transition towards fewer numbers of animals, thereby reducing emissions of pollutants such as methane and ammonia
  - Raise animals in ecologically managed extensive systems
  - Minimise – and where possible eliminate – antibiotic use, and abandon antibiotics which are also used to treat humans, to lower the risk of creating resistant bacteria

- **increase support for ecological production of fruit and vegetables.**
  Despite globally producing 14 percent of greenhouse gas emissions, the livestock sector receives substantial EU financial support, both directly and via payments towards the cultivation of feed crops. Instead, the EU should preferentially pay for ecological production of fruit, vegetables and legumes for direct human consumption.

77 European Pollutant Release and Transfer Register. https://prtr.eea.europa.eu/#/home

- **tighten the environmental conditions that farmers must abide by to receive EU farm subsidies:** The European Commission has rightly proposed to strengthen the environmental conditions that farmers have to abide by before they qualify for subsidies. However, effective 'conditionality' must cover compliance with all EU environmental protection laws, including laws protecting our water from pollution, limiting harmful emissions, managing the use of pesticides and protecting wildlife and their habitats. Only then can 'enhanced conditionality' be effective in reducing the environmental damage caused by farming.

- **ensure the disclosure of how much EU farm subsidies go to industrial meat and dairy production,** either directly to factory farms or indirectly through subsidies for feed production, in order to provide complete transparency.

For more information

on the Greenpeace vision of a new meat and dairy system and on the impacts of industrial meat and dairy production see our report "Less is more" or our website: lessismore.greenpeace.org.

Annex 1: Metals

Greenpeace also tested for metals as they can be brought into the environment through fertilisers and feed additives. Due to the natural occurrence of metals in rivers only some samples contained concentrations that stand out, mainly concerning cadmium in four samples.

The presence of metals in rivers is not necessarily a problem in itself – on the contrary, many metals play an essential role for living organisms and are needed as trace elements. But the margin between too little, the amount needed and toxic levels can be very small. Many human activities influence the amount of metals available to organisms. These include activities from mining and metallurgical industries through to the use of metals as feed additives. Higher amounts of available metals can result in too much metal being absorbed by organisms.

Agriculture has an impact on metal concentrations through, for example, metal contamination of artificial fertilisers produced from mineral raw materials – such as phosphate fertilisers produced from phosphate rock that can contain metal impurities such as cadmium.[78] Manure from industrial agriculture – often also used as a fertiliser together with sewage sludge – can be an important source of metals to soils, as metals like zinc and copper are used as feed additives.[79]

RESULTS

The dissolved concentrations of all metals and semimetals in all samples were within the range of concentrations previously reported for European stream water samples, which can vary significantly.[80] For four of the metals (cadmium, lead, mercury and nickel) there are environmental quality standards set for inland waters in the EU.[81] Four samples stand out: two samples from Germany (Essener Canal and River Soeste) and one sample from the Netherlands (Canal Lage Raam) had high levels of cadmium. One sample from Germany (River Ems) exceeded the maximum allowable environmental quality standards concentration for mercury. The sources of the contamination are not known. However, synthetic phosphate fertilisers could have contributed to the elevated cadmium levels as well as the presence of other metals. One possible source for the mercury reported in one sample could be old discharge from an industrial site.

78 Huton, M.; and C. De Meeus. Analysis and conclusions from Member States' Assessment of the risk to health and the environment from cadmium in fertilizers, European Commission - Enterprise DG, 2001, Brussels, Belgium

79 Cai, L., et al. 2015. Multivariate and geostatistical analyses of the spatial distribution and source of arsenic and heavy metals in the agricultural soils in Shunde, Southeast China. Journal of Geochemical Exploration, 148: 189–195 | Zhu, Y.-G., et al. 2013. Diverse and abundant antibiotic resistance genes in Chinese swine farms. Proceedings of the National Academy of Sciences, 110: 3435–3440

80 Flem, B.; Reimann, C.; Fabian, K.; Birke, M.; Filzmoser, P.; Banks, D. Graphical statistics to explore the natural and anthropogenic processes influencing the inorganic quality of drinking water, ground water and surface water. Applied Geochemistry, 2018, 88(B), 133-148

81 EU (2008) Directive 2008/105/EC of the European Parliament and of the Council of 16 December 2008 on environmental quality standards in the field of water policy, amending and subsequently repealing Council Directives 82/176/EEC, 83/513/EEC, 84/156/EEC, 84/491/EEC, 86/280/EEC and amending Directive 2000/60/EC of the European Parliament and of the Council

Annex 2: Results in detail

TABLE 1 SAMPLING SITES

Sample code	Type	Name	Town (Region)	Country	Latitude	Longitude	Date	Time (local)
AT1	River	Schwarzaubach	Hainsdorf im Schwarzautal (Steiermark)	Austria	46° 49′ 15.4″ N	15° 38′ 42.5″ E	6/6/2018	8:30
AT2	River	Stiefing	St. Georgen an der Stiefing (Steiermark)	Austria	46° 52′ 47.5″ N	15° 34′ 6″ E	6/6/2018	10:45
AT3	River	Sipbach	Sattledt (Oberösterreich)	Austria	48° 04′ 27.2″ N	14° 05′ 25.6″ E	10/7/2018	10:15
BE1	Canal	Moubeek	Zedelgem (West-Vlaanderen)	Belgium	51° 6′ 0.9″ N	3° 6′ 15.6″ E	19/6/2018	9:00
BE2	Canal	Wulfdambeek	Ledegem (West-Vlaanderen)	Belgium	50° 52′ 17.4″ N	3° 9′ 47.8″ E	19/6/2018	11:30
BE3	Canal	De Wamp	Kasterlee (Antwerpen)	Belgium	51° 14′ 51.0″ N	5° 0′ 27.9″ E	19/6/2018	15:40
DE1	River	Ems	Geeste (Weser-Ems)	Germany	52° 35′ 40.8″ N	7° 15′ 03.7″ E	4/7/2018	12:21
DE2	Canal	Essener Canal	Osteressen (Weser-Ems)	Germany	52° 41′ 50.4 “N	7° 58′ 11.2″ E	4/7/2018	14:15
DE3	River	Soeste	Molbergen (Weser-Ems)	Germany	52° 52′ 5.5″ N	7° 56′ 54.5″ E	4/7/2018	15:15
DK1	River	Vasby	Vadsby (Hovedstaden)	Denmark	55° 40′ 51.1″ N	12° 13′ 10.7″ E	27/6/2018	5:35
DK2	River	Lille Skensved	Lille Skensved (Sjælland)	Denmark	55° 30′ 49.6″ N	12° 08′ 39.1″ E	27/6/2018	6:00
DK3	Canal	Ambæk	Ambæk (Sjælland)	Denmark	55° 06′ 49.4″ N	12° 06′ 48.4″ E	27/6/2018	7:30
FR1	River	Ruisseau de la Madoire	Bressuire (Poitou-Charantes)	France	46° 54′ 22.7″ N	0° 25′ 43.7″ W	13/6/2018	6:11
FR2	River	Ruisseau du Vernic	Pleyben (Bretagne)	France	48° 13′ 53.5″ N	3° 58′ 20.5″ W	13/6/2018	7:47
FR3	River	Le Gouessant	Lamballe (Bretagne)	France	48° 27′ 42.5″ N	2° 29′ 17.9″ W	13/6/2018	10:38
IT1	Canal		Mariana Mantovana (Lombardia)	Italy	45° 11′ 13.9″ N	10° 29′ 16.5″ E	13/6/2018	11:27
IT2	River	Roggia Savarona	Quinzano D’Oglio (Lombardia)	Italy	45° 19′ 54.2″ N	9° 59′ 59.8″ E	13/6/2018	13:05
IT3	Canal		Cumignano sul Naviglio (Lombardia)	Italy	45° 21′ 33.7″ N	9° 50′ 31.6″ E	13/6/2018	14:47
NL1	Canal	Groote Wetering	Terwolde (Gelderland)	Netherlands	52° 16′ 24.8″ N	6° 3′ 31.5″ E	20/6/2018	14:06
NL2	Canal	Lage Raam	Wanroij (Noord-Brabant)	Netherlands	51° 40′ 29.8″ N	5° 49′ 42.7″ E	20/6/2018	15:54
NL3	Canal	Snepheiderbeek	Egchel (Limburg)	Netherlands	51° 17′ 51.2″ N	5° 57′ 39.2″ E	20/6/2018	17:12
PL1	River	Drwęca	Nowe Miasto Lubawskie (Warminsko-Mazurskie)	Poland	53° 29′ 28.8″ N	19° 36′ 30.7″ E	26/6/2018	10:00
PL2	River	Wkra	Żuromin (Mazowieckie)	Poland	53° 3′ 4.1″ N	19° 51′ 40.0″ E	26/6/2018	11:38
PL3	River	Mławka	Radzanów (Mazowieckie)	Poland	52°57′ 14.4″ N	20° 04′ 43.4″ E	26/6/2018	12:33
ES1	River	Aragón	Villafranca (Navarra)	Spain	42° 17′ 20.0″ N	1° 45′ 43.3″ W	4/7/2018	8:45
ES2	River	Flumen	Grañén (Aragón)	Spain	41° 56′ 10.3″ N	0° 22′ 44.0″ W	4/7/2018	12:10
ES3	River	Segre	Torres de Segre (Cataluña)	Spain	41° 32′ 5.4″ N	0° 30′ 35.5″ E	4/7/2018	14:01
UK1	River	Otter	Ottery St Mary (Devon)	UK	50° 45′ 29.9″ N	3° 17′ 0.6″ W	3/7/2018	12:00
UK2	River	Tale	Payhembury (Devon)	UK	50° 48′ 9.2″ N	3° 18′ 30.4″ W	2/7/2018	12:00

TABLE 2 VETERINARY DRUGS

X = detected

Veterinary drug	Use	AT 1	AT 2	AT 3	BE 1	BE 2	BE 3	DE 1	DE 2	DE 3	DK 1	DK 2	DK 3	FR 1	FR 2	FR 3	IT 1	IT 2	IT 3	NL 1	NL 2	NL 3	PL 1	PL 2	PL 3	ES 1	ES 2	ES 3	UK 1	UK 2	Detection frequency in % of all samples
Acetylsalicylic acid	Anti-inflammatory drug				X	X																									7
Cloxacillin	Antibiotic			X				X	X		X							X	X				X	X	X		X	X	X		41
Dicloxacillin	Antibiotic	X	X	X				X	X	X	X	X		X		X	X	X	X				X	X	X		X	X	X		66
Enoxacin	Antibiotic																	X													3
Flubendazole	Antimicrobial										X																				3
Flumethasone	Anti-inflammatory drug																	X										X			7
Furaltadone	Antimicrobial	X													X	X		X									X				17
Ketoprofen	Anti-inflammatory drug			X								X						X													10
Mebendazole	Antimicrobial										X																		X		7
Metronidazole	Antibiotic																	X													3
Nitrofurantoin	Antibiotic											X																			3
Oleandomycin	Antibiotic																											X			3
Paracetamol	Anti-inflammatory drug																	X	X												7
Penicillin G	Antibiotic	X												X			X	X	X				X				X			X	28
Sulfadimethoxine	Antibiotic		X											X			X	X	X												17
Sulfadoxine	Antibiotic																	X													3
Sulfamethizole	Antibiotic																											X			3
Sulfamethoxazol	Antibiotic										X																				3
Sulfamethoxy-pyridazine	Antibiotic	X	X					X	X	X	X	X							X				X	X	X		X	X	X		48
Sulfaquinoxaline	Antimicrobial	X	X	X				X	X	X	X	X											X	X	X		X		X	X	48
Tinidazole	Antimicrobial			X				X	X	X	X																X	X	X		28
Number of veterinary drugs detected		5	4	5	1	1	0	5	5	4	8	5	0	3	1	2	3	11	6	0	0	0	5	4	4	0	7	7	6	2	
Number of antibiotics detected		3	3	2	0	0	0	3	3	2	4	3	0	3	0	1	3	7	5	0	0	0	4	3	3	0	4	5	3	1	

TABLE 3 PESTICIDE CONCENTRATIONS

< LOQ = detected below the limit of quantification
Detected = detected not quantifiable

concentrations in ng/L

Pesticide	Use	allowed in the EU	LOQ (ng L-1)	Concentration ± Error (ng L-1)												
				AT1	AT2	AT3	BE1	BE2	BE3	DE1	DE2	DE3	DK1	DK2	DK3	FR1
2,4-D	Herbicide	yes	100					9702.2 ± 79.7								
Acetamiprid	Insecticide	yes	5		< LOQ			< LOQ				< LOQ				
Ametryn	Herbicide	no	1	< LOQ	< LOQ			< LOQ								
Atrazine	Herbicide	no	1	4.2 ± 0.2	3.1 ± 0	13.4 ± 0.2		7.4 ± 0								
Azoxystrobin	Fungicide	yes	0,5	< LOQ	< LOQ		2.5 ± 0.1	12.1 ± 0.3	0.6 ± 0	0.8 ± 0.1	0.6 ± 0.1	6.1 ± 0.2	1.6 ± 0.1		< LOQ	2 ± 0.1
Bendiocarb	Insecticide	no	5													
Bensulfuron-methyl	Herbicide	yes	2,5													
Bentazone	Herbicide	yes	2,5			9.9 ± 0.4	86.1 ± 1.3	625.7 ± 4.4	57.5 ± 0.9	3.3 ± 0.1	2.6 ± 0.4			< LOQ		3.2 ± 0.1
Boscalid	Fungicide	yes	2,5	< LOQ	3.2 ± 0.2			159.4 ± 3.4	< LOQ	26.4 ± 1.2	4.8 ± 0.7	8.2 ± 0.1	10.3 ± 0.9	< LOQ	< LOQ	< LOQ
Bromoxynil	Herbicide	yes	2,5													
Bromuconazole	Fungicide	yes	10													
Carbendazim	Fungicide	no	0,5	1 ± 0	0.8 ± 0	< LOQ	13.2 ± 0.4	24.5 ± 0.3	3.8 ± 0	61.3 ± 2	2.8 ± 0.2	4.1 ± 0.3	8.5 ± 0.5	0.9 ± 0	0.7 ± 0.1	
Carbofuran	Insecticide	no	1													
Chlorantraniliprole	Insecticide	yes	10		< LOQ											
Chloridazon	Herbicide	yes	2,5			< LOQ	< LOQ	94.1 ± 1.5	3.2 ± 0.1						< LOQ	
Chlorpyrifos-Ethyl	Insecticide	yes	1					2.4 ± 0.7								
Chlortoluron	Herbicide	yes	2,5		< LOQ			22.5 ± 0.6	< LOQ	< LOQ						3.6 ± 0.1
Clethodim	Herbicide	yes	-					Detected								
Clomazone	Herbicide	yes	1	3.8 ± 0.1	17.2 ± 0.3		< LOQ	58.2 ± 0.3	< LOQ							
Clothianidin	Insecticide	partially	5	12 ± 0.2	10.7 ± 0.4	< LOQ				20.9 ± 0.7						
Cyromazine	Insecticide	yes	-	Detected			Detected	Detected	Detected			Detected				
Desmedipham	Herbicide	yes	50					< LOQ								
Desmetryn	Herbicide	no	0,5					< LOQ								
Difenoconazole	Fungicide	yes	5					6.7 ± 1								
Diflubenzuron	Insecticide	yes	5													
Dimethenamid	Herbicide	no	1	44.8 ± 1.2	463.1 ± 15	< LOQ	14.3 ± 2.5	59848.8 ± 8134.4	10.7 ± 0.4	3.4 ± 0.1	1.1 ± 0.1	< LOQ				57 ± 0.5
Dimethoate	Insecticide	yes	1					995.1 ± 12.2								
Dimethomorph	Fungicide	yes	10	< LOQ	< LOQ					< LOQ		< LOQ				
Dimoxystrobin	Fungicide	yes	1													
Dinotefuran	Insecticide	no	10				< LOQ		< LOQ							
Diuron	Herbicide	yes	2,5	< LOQ	< LOQ		57.5 ± 0.7	9.5 ± 0.3	3.6 ± 0.1	5.3 ± 0.2	4 ± 0.1	9 ± 0.1	3.9 ± 0.3			< LOQ
DNOC	Herbicide, Fungicide, Insecticide	no	50													
Epoxiconazole	Fungicide	yes	2,5	< LOQ	< LOQ			299.6 ± 2.8		59.2 ± 9.8	< LOQ	< LOQ	< LOQ			< LOQ
Ethiofencarb	Insecticide	no	-		Detected			Detected								
Ethiofencarb sulfone	Insecticide	yes	5				6.5 ± 0.6									
Ethofumesate	Herbicide	yes	5					4707.7 ± 409.3		100.3 ± 3.1						
Fenhexamid	Fungicide	yes	5					< LOQ								
Fenuron	Herbicide	no	1													
Florasulam	Herbicide	yes	5					117.7 ± 1.6								
Flufenacet	Herbicide	yes	1	255.2 ± 6.5	207.1 ± 2.7		1.8 ± 0.1	926 ± 4.6	33.1 ± 0.3	2.9 ± 0.5	2.1 ± 0.4	5.9 ± 0.3				
Fluopicolide	Fungicide	yes	2,5				< LOQ	6.6 ± 0.7	< LOQ			4.2 ± 0.4				
Fluopyram	Fungicide	yes	1	< LOQ	3.3 ± 0.1	< LOQ	1.6 ± 0	250.2 ± 1	< LOQ	3.1 ± 0.2	1.2 ± 0	< LOQ	2.1 ± 0.2	< LOQ	< LOQ	14.8 ± 0.3
Fluoxastrobin	Fungicide	yes	2,5					6.4 ± 0.2		< LOQ						
Flusilazole	Fungicide	no	2,5					< LOQ								
Fosthiazate	Insecticide	yes	2,5													
Griseofulvin	Fungicide	no	1	< LOQ	< LOQ	< LOQ									5.1 ± 0.5	
Haloxyfop	Herbicide	no	25					52.8 ± 1.3								
Hexazinone	Herbicide	no	0,5					< LOQ						3.1 ± 0.1		
Imazalil	Fungicide	yes	1				< LOQ	< LOQ	< LOQ			< LOQ		< LOQ		
Imidacloprid	Insecticide	partially	2,5	< LOQ	< LOQ	< LOQ	3.4 ± 0.3	4.3 ± 0.4	6 ± 0.4	34.5 ± 1.2	2.6 ± 0.1	8.5 ± 0.7	25.7 ± 0.8			5.1 ± 0.3
Iprovalicarb	Fungicide	yes	1	< LOQ												
Isoproturon	Herbicide	no	2,5		< LOQ	< LOQ		88.1 ± 0.7	11.9 ± 0.1	< LOQ	3.8 ± 0.3	< LOQ		< LOQ		
Isoxaben	Herbicide	yes	5	5.4 ± 0.2	13.9 ± 0.4			30.4 ± 0.3								< LOQ
Lenacil	Herbicide	yes	25					73.1 ± 0.7	< LOQ	< LOQ						
Mandipropamid	Fungicide	yes	1				< LOQ	1.8 ± 0.3	26.5 ± 0.8							
MCPA	Herbicide	yes	100				< LOQ	10006.3 ± 456.3	< LOQ		< LOQ	< LOQ	< LOQ			

TABLE 3 PESTICIDE CONCENTRATIONS

Pesticide	Use	allowed in the EU	LOQ (ng L-1)	Concentration ± Error (ng L-1)												
				AT1	AT2	AT3	BE1	BE2	BE3	DE1	DE2	DE3	DK1	DK2	DK3	FR1
Mepiquat	Herbicide	yes	-					Detected								
Metamitron	Herbicide	yes	2,5					635 ± 4.8	< LOQ							
Metazachlor	Herbicide	yes	2,5					< LOQ		< LOQ						
Metconazole	Fungicide	yes	2,5		< LOQ			97.6 ± 1.7								
Methabenzthiazuron	Herbicide	no	0,5				< LOQ	5.8 ± 0.2	< LOQ	< LOQ	< LOQ	< LOQ				
Methiocarb	Insecticide	yes	2,5													
Methiocarb-sulfoxide	Insecticide	yes	1													
Metobromuron	Herbicide	yes	2,5				11.5 ± 0.7	252.3 ± 1.2	73 ± 0.6		< LOQ					
Metolachlor	Herbicide	no	0,5	437.1 ± 5	974.9 ± 25.2	4.8 ± 0.9	66.9 ± 0.4	96.4 ± 1.5	23.7 ± 0.3	14.8 ± 1.2	10.8 ± 1	2.5 ± 0.1				3.3 ± 0.1
Metrafenone	Fungicide	yes	2,5													
Metsulfuron-methyl	Herbicide	yes	5			< LOQ				< LOQ						
Monolinuron	Herbicide	no	2,5					10 ± 0.4	< LOQ							
Napropamide	Herbicide	yes	1				2.5 ± 0									
Nicosulfuron	Herbicide	yes	5	70.6 ± 2.8	237.9 ± 4.8	< LOQ		45.7 ± 2.3	< LOQ							12 ± 0.7
Omethoate	Insecticide	no	5					16.4 ± 0.5								
Oxadixyl	Fungicide	no	5				6.7 ± 0.3	< LOQ								
Paclobutrazol	Herbicide, Fungicide	yes	1													
Penconazole	Fungicide	yes	2,5													
Pencycuron	Fungicide	yes	0,5				0.8 ± 0.1	11.3 ± 0.3	3.4 ± 0.1	0.9 ± 0.1		5.8 ± 0.3				
Phenmedipham	Herbicide	yes	100					< LOQ								
Picoxystrobin	Fungicide	no	5													
Piperonyl-butoxide	Safener	yes	1				47 ± 0.7	488.3 ± 2	1.5 ± 0.2			< LOQ		1.7 ± 0.2		
Pirimicarb	Insecticide	yes	1		4.9 ± 0		1.8 ± 0.1	2.3 ± 0.1								
Prometon	Herbicide	no	1		< LOQ	< LOQ		< LOQ		< LOQ			< LOQ			
Prometryn	Herbicide	no	2,5	< LOQ	< LOQ	< LOQ	< LOQ		< LOQ	4.2 ± 0.1	< LOQ	4 ± 0.1	2.5 ± 0.1			
Propamocarb	Fungicide	yes	5				< LOQ	29.1 ± 0.6								
Propiconazole	Fungicide	yes	2,5		< LOQ		5.4 ± 0.9	6.8 ± 0.2	2.9 ± 0.3	3.8 ± 0.3	5.5 ± 0.2	3.2 ± 0.4	10.8 ± 0.5	< LOQ		355.4 ± 3.4
Propyzamide	Herbicide	yes	2,5					720.3 ± 4.7					< LOQ		< LOQ	
Prosulfocarb	Herbicide	yes	0,1					2523.1 ± 323.2		0.2 ± 0	0.3 ± 0	0.2 ± 0	0.9 ± 0	0.2 ± 0	0.5 ± 0	
Pymetrozine	Insecticide	yes	25		< LOQ			< LOQ				< LOQ				
Pyraclostrobin	Fungicide	yes	1		< LOQ											
Pyrimethanil	Fungicide	yes	1													
Pyroxsulam	Herbicide	yes	2,5											< LOQ		
Rimsulfuron	Herbicide	yes	5		5.5 ± 0.4											
Spiroxamine	Fungicide	yes	2,5					7.8 ± 0.4		< LOQ						
Tebuconazole	Herbicide, Fungicide	yes	5	5.1 ± 0.3	6 ± 0.2	< LOQ	< LOQ	513 ± 2.7	< LOQ	16.5 ± 0.5	< LOQ	< LOQ	11.7 ± 0.8	< LOQ	< LOQ	30.4 ± 0.7
Tebufenpyrad	Acaricide	yes	2,5				< LOQ									
Terbumeton	Herbicide	no	0,5	< LOQ	< LOQ	< LOQ		0.8 ± 0		< LOQ	< LOQ		< LOQ			
Terbuthylazine	Herbicide	yes	1	722.6 ± 9	1286 ± 33.7	24.8 ± 0.5	5.3 ± 0.3	275.4 ± 3.8	10.1 ± 0.6	49.8 ± 1.5	22.6 ± 0.6	7 ± 0.1	2.5 ± 0.2	< LOQ	1.3 ± 0.1	4.6 ± 0.1
Terbutryn	Herbicide	no	2,5	< LOQ	< LOQ	< LOQ	< LOQ	3 ± 0.1	< LOQ	4.2 ± 0.1	< LOQ	4 ± 0.1	2.5 ± 0.1			
Tetraconazole	Fungicide	yes	2,5					5.9 ± 0.1								
Thiabendazole	Fungicide	yes	0,5	< LOQ	< LOQ	< LOQ		130.3 ± 0.3	2.7 ± 0.1	< LOQ	< LOQ	1.4 ± 0	< LOQ			
Thiacloprid	Insecticide	yes	0,5	0.7 ± 0	< LOQ				21.5 ± 0.3	< LOQ	< LOQ	< LOQ				
Thiamethoxam	Insecticide	partially	2,5		< LOQ			< LOQ	< LOQ			10.1 ± 0.4		< LOQ		
Thiophanate-methyl	Fungicide	yes	-				Detected	Detected								
Triadimefon	Fungicide	no	2,5													
Triadimenol	Fungicide	yes	10							22.1 ± 1.9						
Tricyclazole	Fungicide	no	0,5													
Number of pesticides detected	**104**			**27**	**38**	**20**	**33**	**70**	**36**	**34**	**24**	**30**	**18**	**14**	**10**	**15**
Total concentration (ng L-1)				**1562,5**	**3237,5**	**52,8**	**334,9**	**94023,6**	**295,6**	**437,9**	**65**	**84**	**83,1**	**5,9**	**7,5**	**491,4**

TABLE 3 PESTICIDE CONCENTRATIONS

< LOQ = detected below the limit of quantification
Detected = detected not quantifiable

concentrations in ng/L

Pesticide	Concentration ± Error (ng L-1)															
	FR2	FR3	IT1	IT2	IT3	NL1	NL2	NL3	PL1	PL2	PL3	ES1	ES2	ES3	UK1	UK2
2,4-D														< LOQ		
Acetamiprid											< LOQ			< LOQ		
Ametryn																
Atrazine	6.5 ± 0.1	3.5 ± 0.1	3.5 ± 0.1	4.9 ± 0.1	2.2 ± 0			2 ± 0.1		< LOQ		1.3 ± 0.1	< LOQ	< LOQ	2.3 ± 0.1	1.1 ± 0.1
Azoxystrobin	< LOQ	8.7 ± 0.5	5.6 ± 0.2	< LOQ				2.2 ± 0.2	6.7 ± 0.1	2.2 ± 0.1	< LOQ	< LOQ	0.7 ± 0.1		< LOQ	< LOQ
Bendiocarb																5.6 ± 0.3
Bensulfuron-methyl												< LOQ				
Bentazone		6.6 ± 0	401.8 ± 9.8			16.1 ± 0.6	132.1 ± 4	15.3 ± 0.5	3.2 ± 0.1		< LOQ	234.4 ± 3.1	105.1 ± 2.8			
Boscalid	< LOQ	< LOQ			< LOQ			4 ± 0.2	< LOQ			< LOQ		13.6 ± 1.4		
Bromoxynil		< LOQ											3.3 ± 0.2			
Bromuconazole													< LOQ			
Carbendazim	< LOQ		4 ± 0.1	2.2 ± 0.2	0.9 ± 0.1	0.7 ± 0.1	1.3 ± 0.2	2.8 ± 0.2	192 ± 1.9	2.4 ± 0.2	2.5 ± 0.3	0.5 ± 0.1	4.5 ± 0.2	2.6 ± 0.1	0.8 ± 0	< LOQ
Carbofuran							4 ± 0.1									
Chlorantraniliprole				< LOQ									< LOQ	< LOQ		
Chloridazon	< LOQ		< LOQ				< LOQ	11.7 ± 0.1	< LOQ		< LOQ					< LOQ
Chlorpyrifos-Ethyl																
Chlortoluron		< LOQ						< LOQ	6 ± 0.3	< LOQ	< LOQ					
Clethodim																
Clomazone			2.9 ± 0.2	4.9 ± 0.1				2.5 ± 0	< LOQ			< LOQ				
Clothianidin		< LOQ	< LOQ	< LOQ										< LOQ		< LOQ
Cyromazine		Detected					Detected									Detected
Desmedipham																
Desmetryn																
Difenoconazole														< LOQ		
Diflubenzuron				< LOQ												
Dimethenamid	< LOQ	26.7 ± 0.5	< LOQ			2.2 ± 0.1	1.5 ± 0.1	55.6 ± 0.8		2.7 ± 0.3		3.6 ± 0.2	1.3 ± 0.1	4.8 ± 0.1		1.3 ± 0
Dimethoate									1.9 ± 0.1					< LOQ		
Dimethomorph			< LOQ	< LOQ	< LOQ							< LOQ				
Dimoxystrobin		< LOQ						< LOQ			< LOQ					
Dinotefuran																
Diuron	< LOQ	< LOQ	< LOQ	< LOQ	< LOQ	< LOQ	< LOQ	4 ± 0.1								
DNOC			< LOQ	< LOQ	< LOQ											
Epoxiconazole	< LOQ	3.6 ± 0.2	< LOQ					2.9 ± 0.3	4.5 ± 0.7				3.1 ± 0.1		< LOQ	< LOQ
Ethiofencarb																
Ethiofencarb sulfone																
Ethofumesate								22.5 ± 3.5	6.6 ± 0.3							7.1 ± 0.2
Fenhexamid																
Fenuron					1 ± 0.1	< LOQ	1.5 ± 0.1									
Florasulam																
Flufenacet			6.5 ± 0.2	27.9 ± 0.5	1.8 ± 0.2			5.9 ± 0.2								
Fluopicolide								< LOQ								
Fluopyram	< LOQ	5.7 ± 0.2					< LOQ	2.4 ± 0.1	< LOQ	< LOQ	< LOQ	2.2 ± 0.1	< LOQ	15.5 ± 0.1	< LOQ	
Fluoxastrobin																
Flusilazole																
Fosthiazate							< LOQ									
Griseofulvin					< LOQ			< LOQ	3.1 ± 0.2	< LOQ	< LOQ	1.8 ± 0	9.9 ± 0.1	2.6 ± 0.1	< LOQ	< LOQ
Haloxyfop																
Hexazinone	0.9 ± 0									< LOQ	0.9 ± 0		< LOQ			
Imazalil														3.2 ± 0.2		
Imidacloprid	< LOQ	6.3 ± 0.5	5.1 ± 0.2	5.8 ± 0.3	< LOQ			< LOQ	< LOQ	7.5 ± 0.2	5.9 ± 0.2	< LOQ	9.4 ± 0.3	47.1 ± 1.5	13.9 ± 0.1	7.2 ± 0.4
Iprovalicarb																
Isoproturon		< LOQ						< LOQ			< LOQ	< LOQ	< LOQ	< LOQ		
Isoxaben		< LOQ						< LOQ								
Lenacil								< LOQ	< LOQ							
Mandipropamid								< LOQ								
MCPA									< LOQ			< LOQ		< LOQ	< LOQ	< LOQ

TABLE 3 PESTICIDE CONCENTRATIONS

Pesticide	Concentration ± Error (ng L-1)															
	FR2	FR3	IT1	IT2	IT3	NL1	NL2	NL3	PL1	PL2	PL3	ES1	ES2	ES3	UK1	UK2
Mepiquat																
Metamitron	< LOQ								< LOQ							7.2 ± 0.2
Metazachlor		< LOQ						< LOQ	< LOQ	< LOQ					< LOQ	
Metconazole		< LOQ														
Methabenzthiazuron								< LOQ								
Methiocarb			< LOQ	4.1 ± 0.1												
Methiocarb-sulfoxide				1.8 ± 0.1												
Metobromuron								14.3 ± 0.3								
Metolachlor	12.6 ± 0.6	393.9 ± 3.4	194.6 ± 3.1	729.5 ± 11.9	16.5 ± 0.4	1.1 ± 0.1	6.9 ± 0.1	80.9 ± 0.7	19 ± 1.5	1.3 ± 0.2	0.8 ± 0.1	5.8 ± 0.4	18.5 ± 1.6	90.4 ± 9.3	2 ± 0.2	28.5 ± 2.1
Metrafenone																
Metsulfuron-methyl																
Monolinuron																
Napropamide																
Nicosulfuron	< LOQ	77.6 ± 0.8	20.7 ± 1.2	25.3 ± 0.6	< LOQ			8.7 ± 0.1	18.2 ± 0.4	< LOQ	< LOQ		10.2 ± 0.9	16 ± 0.8	47.3 ± 1.7	11.9 ± 0.8
Omethoate																
Oxadixyl																
Paclobutrazol														5.3 ± 0		
Penconazole				< LOQ												
Pencycuron								0.8 ± 0.1								23.3 ± 0.3
Phenmedipham																
Picoxystrobin																
Piperonyl-butoxide			5.8 ± 0.3	33.2 ± 1.2	2.6 ± 0.2			1.5 ± 0.1					1.9 ± 0.1	3.2 ± 0.3		1.2 ± 0.1
Pirimicarb														< LOQ		
Prometon											< LOQ					
Prometryn			< LOQ	2.9 ± 0.1				< LOQ	< LOQ		< LOQ		< LOQ		< LOQ	
Propamocarb								18.5 ± 0.5	< LOQ							< LOQ
Propiconazole		< LOQ						7.4 ± 0	13.8 ± 0.8				< LOQ		< LOQ	< LOQ
Propyzamide								< LOQ								
Prosulfocarb								13 ± 0.7	2.1 ± 0.1	1.1 ± 0.1			0.3 ± 0			
Pymetrozine																
Pyraclostrobin												< LOQ		< LOQ		
Pyrimethanil														< LOQ		
Pyroxsulam																
Rimsulfuron																
Spiroxamine								< LOQ	< LOQ							
Tebuconazole	< LOQ	27.9 ± 0.2	< LOQ	< LOQ	< LOQ			5 ± 0.2	28 ± 0.9	< LOQ	< LOQ	5.8 ± 0.3	10.8 ± 0.2	44.8 ± 1.3	< LOQ	5.6 ± 0.2
Tebufenpyrad																
Terbumeton									< LOQ		< LOQ				< LOQ	
Terbuthylazine	4.5 ± 0.5	59.5 ± 1.8	107.2 ± 1.6	299.8 ± 9	16 ± 0.2	12.8 ± 0.6	14.6 ± 0.2	43.3 ± 1.1	13.8 ± 0.2	3.5 ± 0.3	3.3 ± 0.2	2.6 ± 0.4	10.3 ± 0.3	40.6 ± 0.9	5.4 ± 0.4	3.5 ± 0.2
Terbutryn			< LOQ	2.9 ± 0.1	< LOQ		< LOQ	< LOQ	< LOQ		< LOQ		< LOQ	< LOQ	< LOQ	
Tetraconazole		< LOQ							4 ± 0.2	< LOQ				< LOQ		
Thiabendazole								11.3 ± 0.1	< LOQ		< LOQ		< LOQ	9.1 ± 0.2	< LOQ	< LOQ
Thiacloprid		2.9 ± 0.2						< LOQ	< LOQ				1.3 ± 0	3.7 ± 0.2	< LOQ	< LOQ
Thiamethoxam			2.5 ± 0.3	9.4 ± 0.4	2.5 ± 0		< LOQ	< LOQ	< LOQ					< LOQ		
Thiophanate-methyl									Detected							
Triadimefon									131.5 ± 4.2							
Triadimenol																
Tricyclazole												< LOQ	3.4 ± 0.1			
Number of pesticides detected	**16**	**25**	**23**	**23**	**17**	**7**	**14**	**41**	**34**	**16**	**21**	**19**	**26**	**30**	**19**	**24**
Total concentration (ng L-1)	**24,5**	**622,9**	**760,2**	**1154,7**	**43,5**	**32,9**	**162**	**338,5**	**454,3**	**20,8**	**13,4**	**258,1**	**193,9**	**302,4**	**71,8**	**103,4**

TABLE 4 PESTICIDES CONCENTRATIONS

CHECKED AGAINST THE REGULATORY ACCEPTABLE CONCENTRATIONS

There is a lack of consensus which environmental quality standards should be applied to assess the risks for most active substances. There are several scientific sources developing regulatory acceptable concentraions (RACs), the German Environmental Agency (UBA) being one of them. The UBA has set regulatory acceptable concentrations for a number of pesticides, including 59 of the 104 pesticides detected.

RQ = risk quotient

Pesticide	UBA's RAC (ng L-1)	AT1	AT2	AT3	BE1	BE2	BE3	DE4	DE5	DE6	DK1	DK2	DK3	FR1	FR2	FR3	IT1	IT2	IT3	NL1	NL2	NL3	PL1	PL2	PL3	ES1	ES2	ES3	UK4	UK5	Exceed-ance frequency in % of the samples found
2.4-D	1100	0	0	0	0	8.820	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3%
Acetamiprid	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
Azoxystrobin	550	0	0	0	0.005	0.022	0.001	0.001	0.001	0.011	0.003	0	0	0.004	0	0.016	0.010	0	0	0	0	0.004	0.012	0.004	0	0	0.001	0	0	0	0%
Bentazone	535000	0	0	0.000	0.000	0.001	0.000	0.000	0.000	0	0	0	0	0.000	0	0.000	0.001	0	0	0.000	0.000	0.000	0.000	0	0	0.000	0.000	0	0	0	0%
Boscalid	12500	0	0.000	0	0	0.013	0	0.002	0.000	0.001	0.001	0	0	0	0	0	0	0	0	0	0	0.000	0	0	0	0	0	0.001	0	0	0%
Bromoxynil	3300	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.001	0	0	0	0%
Carbendazim	150	0.007	0.006	0	0.088	0.164	0.025	0.409	0.019	0.027	0.057	0.006	0.004	0	0	0	0.027	0.015	0.006	0.005	0.009	0.019	1.280	0.016	0.016	0.004	0.030	0.017	0.005	0	3%
Chlorantraniliprole	355	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
Chloridazon	56000	0	0	0	0	0.002	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000	0	0	0	0	0	0	0	0	0%
Chlorpyrifos-Ethyl	0.45	0	0	0	0	5.240	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3%
Chlortoluron	2300	0	0	0	0	0.010	0	0	0	0	0	0	0	0.002	0	0	0	0	0	0	0	0	0.003	0	0	0	0	0	0	0	0%
Clomazone	5660	0.001	0.003	0	0	0.010	0	0	0	0	0	0	0	0	0	0	0.001	0.001	0	0	0	0.000	0	0	0	0	0	0	0	0	0%
Clothianidin	7	1.719	1.526	0	0	0	0	2.979	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10%
Difenoconazole	360	0	0	0	0	0.019	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
Dimethoate	4000	0	0	0	0	0.249	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000	0	0	0	0	0	0	0	0%
Dimethomorph	5600	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
Dimoxystrobin	31.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
Diuron	790	0	0	0	0.073	0.012	0.005	0.007	0.005	0.011	0.005	0	0	0	0	0	0	0	0	0	0	0.005	0	0	0	0	0	0	0	0	0%
Epoxiconazole	537.5	0	0	0	0	0.557	0	0.110	0	0	0	0	0	0	0	0.007	0	0	0	0	0	0.005	0.008	0	0	0	0.006	0	0	0	0%
Ethofumesate	24000	0	0	0	0	0.196	0	0.004	0	0	0	0	0	0	0	0	0	0	0	0	0	0.001	0.000	0	0	0	0	0	0	0.000	0%
Fenhexamid	10100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
Florasulam	118	0	0	0	0	0.998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
Flufenacet	2400	0.106	0.086	0	0.001	0.386	0.014	0.001	0.001	0.002	0	0	0	0	0	0	0.003	0.012	0.001	0	0	0.002	0	0	0	0	0	0	0	0	0%
Fluopicolide	1300	0	0	0	0	0.005	0	0	0	0.003	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
Fluopyram	5120	0	0.001	0	0.000	0.049	0	0.001	0.000	0	0.000	0	0	0.003	0	0.001	0	0	0	0	0	0.000	0	0	0	0.000	0	0.003	0	0	0%
Imidacloprid	9	0	0	0	0.380	0.479	0.661	3.832	0.290	0.941	2.860	0	0	0.563	0	0.698	0.566	0.646	0	0	0	0	0	0.836	0.657	0	1.043	5.236	1.541	0.797	17%
Iprovalicarb	189000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
Isoproturon	1300	0	0	0	0	0.068	0.009	0	0.003	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
Lenacil	650	0	0	0	0	0.112	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
Mandipropamid	7600	0	0	0	0	0.000	0.003	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
MCPA	6410	0	0	0	0	1.561	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3%
Metamitron	38000	0	0	0	0	0.017	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000	0%
Metazachlor	880	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
Methiocarb	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.409	0	0	0	0	0	0	0	0	0	0	0	0	0%
Metobromuron	2000	0	0	0	0.006	0.126	0.036	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.007	0	0	0	0	0	0	0	0	0%
Metrafenone	22500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
Metsulfuronmethyl	36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
Napropamide	6700	0	0	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
Nicosulfuron	85	0.831	2.799	0	0	0.537	0	0	0	0	0	0	0	0.142	0	0.914	0.244	0.297	0	0	0	0.102	0.214	0	0	0	0.120	0.188	0.557	0.140	3%
Paclobutrazol	820	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.006	0	0	0%
Penconazole	3200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
Phenmedipham	1400	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
Picoxystrobin	600	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
Pirimicarb	90	0	0.055	0	0.020	0.026	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
Propamocarb	630000	0	0	0	0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000	0	0	0	0	0	0	0	0	0%
Propiconazole	2000	0	0	0	0.003	0.003	0.001	0.002	0.003	0.002	0.005	0	0	0.178	0	0	0	0	0	0	0	0.004	0.007	0	0	0	0	0	0	0	0%
Propyzamide	34000	0	0	0	0	0.021	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
Prosulfocarb	3800	0	0	0	0	0.664	0	0.000	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0	0	0	0	0.003	0.001	0.000	0	0	0.000	0	0	0	0%
Pymetrozine	2500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
Pyraclostrobin	317	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
Pyrimethanil	8000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
Pyroxsulam	160	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
Rimsulfuron	460	0	0.012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
Spiroxamine	130	0	0	0	0	0.060	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
Tebuconazole	578	0.009	0.010	0	0	0.888	0	0.029	0	0	0.020	0	0	0.053	0	0.048	0	0	0	0	0	0.009	0.048	0	0	0.010	0.019	0.078	0	0.010	0%
Terbuthylazine	1200	0.602	1.072	0.021	0.004	0.230	0.008	0.042	0.019	0.006	0.002	0	0.001	0.004	0.004	0.050	0.089	0.250	0.013	0.011	0.012	0.036	0.011	0.003	0.003	0.002	0.009	0.034	0.005	0.003	3%
Thiacloprid	4	0.173	0	0	0	0	5.363	0	0	0	0	0	0	0	0	0.720	0	0	0	0	0	0	0	0	0	0	0.324	0.918	0	0	3%
Thiamethoxam	43	0	0	0	0	0	0	0	0	0.234	0	0	0	0	0	0	0.059	0.219	0.058	0	0	0	0	0	0	0	0	0	0	0	0%
Triadimenol	3400	0	0	0	0	0	0	0.007	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
Number of individual RQs > 1		**1**	**3**	**0**	**0**	**3**	**1**	**2**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**1**	**1**	**1**	**0**	
Total sample RQ		**3.447**	**5.569**	**0.021**	**0.581**	**21.544**	**6.129**	**7.425**	**0.341**	**1.239**	**2.954**	**0.006**	**0.006**	**0.947**	**0.004**	**2.452**	**0.999**	**1.849**	**0.078**	**0.016**	**0.021**	**0.199**	**1.585**	**0.859**	**0.677**	**0.017**	**1.553**	**6.481**	**2.108**	**0.949**	

TABLE 5 **NUTRIENTS**

Nutrient concentrations in mg/L for nitrate nitrogen (NO_3^--N), nitrate (NO_3^-), nitrite nitrogen (NO_2^--N) and phosphate phosphorous (PO_4^{3-}-P). The conversion factor to calculate nitrate concentrations from nitrate nitrogen concentrations (only counting the nitrogen and not the oxigen in nitrate) is 4.4268.
The conversion factor to calculate nitrite concentrations from nitrite nitrogen concentrations is 3.284.

under range = below the detection limit of the kit used
<xy = below the detection limit of the kit used
>xy = above the detection limit of the kit used
- = not measured

	Nitrate		Nitrite	Phosphate
Sample	**NO_3^--N (mg/L)**	**NO_3^- (mg/l)**	**NO_2^- N (mg/L)**	**PO_4^{3-}-P (mg/L)**
AT1	3.58	15.85	0.077	under range
AT2	3.57	15.80	0.059	under range
AT3	8.65	38.29	-	-
BE1	1.26	5.58	<0.6	1.685
BE2	<0.23	under range	<0.6	>5
BE3	0.54	2.39	<0.6	<0.5
DE1	3	13.28	0.017	under range
DE2	1.6	7.08	0.033	under range
DE3	8.9	39.40	2.438	under range
DK1	1.5	6.64	0.03	0.65
DK2	0.49	2.17	0.158	under range
DK3	<0.23	under range	under range	under range
FR1	2.3	10.18	<0.4	<1.5
FR2	9.25	40.95	<0.4	<1.5
FR3	6.76	29.93	<0.4	<1.5
IT1	4.3	19.04	0.122	under range
IT2	7.45	32.98	0.197	under range
IT3	2.28	10.09	0.022	under range
NL1	0.23	1.02	-	-
NL2	2	8.85	-	-
NL3	2.89	12.79	-	-
PL1	1.7	7.53	-	-
PL2	1.35	5.98	-	-
PL3	1.8	7.97	-	-
ES1	1.91	8.46	under range	under range
ES2	2.83	12.53	0.061	under range
ES3	1.81	8.01	0.07	under range
UK1	3.9	17.26	-	-
UK2	7.6	33.64	-	-

TABLE 6 METAL CONCENTRATIONS

Concentrations of metals and metalloids in µg/L in filtered water samples for samples from
Austria (AT), Belgium (BE), Denmark (DK), France (FR), Germany (DE), Italy (IT), the Netherlands (NL), Poland (PL), Spain (ES) and the United Kingdom (UK).

	AT1	AT2	AT3	BE1	BE2	BE3	DE1	DE2	DE3	DK1	DK2	DK3	FR1	FR2	FR3
Aluminium	14.0	9.6	5.6	10.8	7.7	11.1	10.4	8.6	17.0	17.0	8.2	4.8	404	47.6	272
Antimony	0.20	0.17	0.06	0.24	1.15	0.33	0.39	0.31	0.15	0.37	0.16	0.18	0.34	0.05	0.12
Arsenic	1.86	1.42	0.26	2.35	4.94	0.91	0.90	0.63	0.84	1.55	1.14	1.80	12.1	0.37	3.24
Barium	24.9	24.3	30.9	12.7	31.0	26.4	67.2	54.9	26.2	39.5	36.1	110	29.9	12.5	38.8
Beryllium	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	0.07	<0.03	0.08
Cadmium	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	0.35	0.15	<0.01	0.02	0.03	0.02	0.02	0.04
Chromium	0.10	0.07	0.54	0.33	0.15	0.14	0.16	0.12	0.14	0.13	0.07	0.30	0.70	0.23	1.00
Cobalt	0.21	0.13	<0.05	2.51	0.74	0.83	0.47	0.47	1.47	0.88	0.15	0.17	0.48	0.10	0.72
Copper	3.42	3.11	0.63	1.74	1.40	1.90	2.50	5.38	2.03	1.47	2.29	1.16	2.45	0.95	2.75
Iron	29	26	8	209	146	1910	149	349	1370	88	72	164	642	131	819
Lead	0.10	<0.02	<0.02	0.14	0.28	0.15	0.08	1.67	0.10	0.14	0.11	0.25	0.88	0.10	0.49
Manganese	8.58	14.0	4.54	360	697	63.9	245	303	272	93.4	59.2	440	21.8	4.81	48.1
Mercury	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.22	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Nickel	1.09	0.86	<0.05	6.06	3.11	2.94	2.45	2.39	3.99	4.42	4.68	0.86	1.47	1.19	5.73
Selenium	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Strontium	226	210	372	564	684	178	1000	639	213	1200	1560	1520	142	101	137
Thallium	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Uranium	1.07	0.94	0.54	0.14	0.68	0.12	0.30	0.25	0.06	3.25	3.53	3.15	0.57	0.02	0.14
Vanadium	0.78	0.60	0.58	2.02	2.22	0.53	0.46	0.35	1.09	1.12	0.31	0.62	2.23	0.24	1.48
Zinc	<0.2	<0.2	1.0	3.7	1.4	2.1	6.5	4.3	6.9	2.3	4.0	5.2	5.5	4.8	2.0

	IT1	IT2	IT3	NL1	NL2	NL3	PL1	PL2	PL3	ES1	ES2	ES3	UK2	UK1
Aluminium	18.9	80.8	14.2	4.3	43.9	29.2	15.8	7.5	14.6	39.1	37.3	13.2	44.3	12.7
Antimony	0.24	0.16	0.10	0.11	0.22	0.34	0.11	0.09	0.11	0.09	0.19	0.15	0.18	0.23
Arsenic	1.89	1.51	0.94	0.93	0.72	0.57	1.07	2.11	1.87	0.41	1.81	1.39	2.28	4.43
Barium	79.4	50.1	37.4	72.6	58.0	27.4	19.5	14.7	16.7	33.1	42.2	24.0	53.3	53.6
Beryllium	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Cadmium	0.01	<0.01	<0.01	<0.01	0.09	0.02	0.05	0.01	0.01	<0.01	<0.01	0.07	0.02	0.01
Chromium	0.20	0.20	0.14	0.15	0.29	0.17	0.11	0.08	0.25	0.10	0.08	0.07	0.20	0.17
Cobalt	0.12	0.15	<0.05	0.09	0.26	0.91	0.09	0.07	0.13	<0.05	0.11	0.05	0.12	0.20
Copper	1.11	2.45	0.87	0.99	1.88	1.67	2.27	0.69	1.10	0.72	0.81	1.92	1.60	1.55
Iron	23	75	13	80	218	200	125	133	159	33	40	17	114	59
Lead	0.05	0.18	<0.02	0.08	0.79	0.16	1.08	0.19	0.24	<0.02	<0.02	0.22	0.12	0.12
Manganese	9.27	16.0	2.13	2.07	21.9	40.4	90.3	40.0	25.0	1.04	2.63	4.52	5.60	6.14
Mercury	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Nickel	0.41	0.52	0.63	0.67	4.24	3.67	0.37	0.74	1.02	0.18	0.30	0.60	1.85	1.39
Selenium	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Strontium	295	667	615	248	335	230	219	169	192	868	2220	1050	131	357
Thallium	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Uranium	2.44	1.24	0.66	0.08	0.58	0.38	0.61	0.82	0.49	0.49	2.69	3.23	0.55	0.79
Vanadium	2.40	1.53	0.56	0.21	0.19	1.47	0.39	0.48	0.55	0.58	1.02	0.56	0.75	1.48
Zinc	0.8	1.9	0.8	0.8	1.6	2.1	1.3	0.4	1.0	<0.2	0.5	1.2	2.1	2.5

TABLE 7 METAL RANGES

The first two columns show the median and range of concentrations of metals and metalloids in µg/L for all filtered water samples, together with (a) medians and ranges for European stream waters from second order drainage basins[82] and (b) EU environmental quality standards (EQS) for inland waters (EU 2008).[83]
* Cd value is for class 1 waters (< 40 mg $CaCO_3$ L-1) which is applicable to analysed samples

	median	range	median for European streams (a)	Range for European streams (a)	EU EQS inland surface waters (annual average) (b)	EU EQS inland surface waters (maximum allowable concentration) (b)
Aluminium	14.2	4.3 - 404	17.7	0.70-3370	-	-
Antimony	0.18	0.05 - 1.15	0.07	0.005-2.91	-	-
Arsenic	1.42	0.26 - 12.1	0.63	<0.001-27.3	-	-
Barium	33.1	12.5 - 110	24.9	0.20-436	-	-
Beryllium	<0.03	<0.03 - 0.08	0.009	<0.005-2.72	-	-
Cadmium	0.01	<0.01 - 0.35	0.010	<0.002-1.25	≤ 0.08*	≤ 0.45*
Chromium	0.15	0.07 – 1.00	0.38	<0.01-43.0	-	-
Cobalt	0.15	<0.05 - 2.51	0.16	0.01-15.7	-	-
Copper	1.67	0.63 - 5.38	0.88	0.08-14.6	-	-
Iron	125	8 - 1910	67.0	<1-4820	-	-
Lead	0.14	<0.02 - 1.67	0.092	<0.005-10.6	7.2	not applicable
Manganese	21.9	1.04 - 697	15.9	<0.1-3010	-	-
Mercury	<0.05	<0.05 - 0.22	-	-	0.05	0.07
Nickel	1.19	0.18 - 6.06	1.91	0.03-24.6	20	not applicable
Selenium	<0.2	<0.2 - <0.2	0.340	<0.01-15.0	-	-
Strontium	335	101 - 2220	109	1.00-13600	-	-
Thallium	<0.05	<0.05 - <0.05	0.005	<0.002-0.220	-	-
Uranium	0.58	0.02 - 3.53	0.320	<0.002-21.4	-	-
Vanadium	0.60	0.19 - 2.4	0.46	<0.05-19.5	-	-
Zinc	1.9	<0.2 - 6.9	2.65	0.09-310	-	-

82 Flem, B.; Reimann, C.; Fabian, K.; Birke, M.; Filzmoser, P.; Banks, D. Graphical statistics to explore the natural and anthropogenic processes influencing the inorganic quality of drinking water, ground water and surface water. Applied Geochemistry, 2018, 88(B), 133-148

83 EU (2008) Directive 2008/105/EC of the European Parliament and of the Council of 16 December 2008 on environmental quality standards in the field of water policy, amending and subsequently repealing Council Directives 82/176/EEC, 83/513/EEC, 84/156/EEC, 84/491/EEC, 86/280/EEC and amending Directive 2000/60/EC of the European Parliament and of the Council

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