Environmental drug load can be reduced

As the use of pharmaceuticals increases, increasing amounts of drug residues end up in sewage treatment plants. They can be harmful for fish, for example, and they can end up in soil through the utilization of wastewater sludge. More efficient removal of drug residues would bring about an estimated need for an increase of about five percent in the wastewater fees paid by consumers.

Drug emissions come from households, hospitals, and the pharmaceutical industry. Emissions can be reduced by introducing more advanced treatment methods at wastewater treatment plants or at the emission sources.

The environmental effects occurring during the whole life cycle of pharmaceutical products should be given more consideration when prescribing pharmaceuticals and in public procurements. This would be supported by developing a classification system for pharmaceuticals that would take environmental impact into consideration.

The return of unused drugs by consumers to pharmacies needs to be made more efficient through consistent raising of awareness. Wastage of drugs could be reduced by lowering the price of small initiation packs.

Drugs also end up in agricultural soils through the manure of animals undergoing treatment. The sale of veterinary medicines can already be restricted on the basis of environmental risk. Compliance with restrictions on use should also be monitored.

Daily pharmaceutical emissions in the dozens of kilos

With the ageing of the population, the use of medicines is on the increase[1] and pharmaceutical emissions are increasing accordingly. Drug emissions to wastewater treatment plants come from households, hospitals and other care facilities, and the pharmaceutical industry. At a wastewater treatment plant the medicines sometimes undergo transformations to become entirely different substances. Ultimately the substances can end up in wastewater sludge or a waterbody.

The drug load that reaches an individual wastewater treatment plant can reach dozens of kilos a day. The amount that enters the waterways through treatment plants ranges from a few hundred grams to a few kilos.

The percentage of pharmaceutical load from care facilities ending up at wastewater treatment plants ranges from a few percent to a few dozen percent[2]. However, there is considerable variation depending on the pharmaceutical substance involved. For example, cytostatic agents used in cancer treatment and contrast agents used in diagnostics come mainly from care facilities.

Industry can be a significant source of pharmaceutical emissions[3] at the local level. However, evaluating the emissions of industrial plants is difficult because the reports that they make on pharmaceutical emissions are not open to the public.

Harm to fish and organisms in the soil

Traces of antibiotics ending up in the environment promote the spread of antibiotic resistance. On the global level this is one of the most serious threats to health[4].

Some pharmaceutical substances have been found to be harmful to fish when they seep into waterways. For instance, oestrogens have been found to cause hermaphroditism[5]. Hermaphroditic individuals have both male and female features.

Anti-anxiety medications can make fish more daring and active than others of the same species[6].

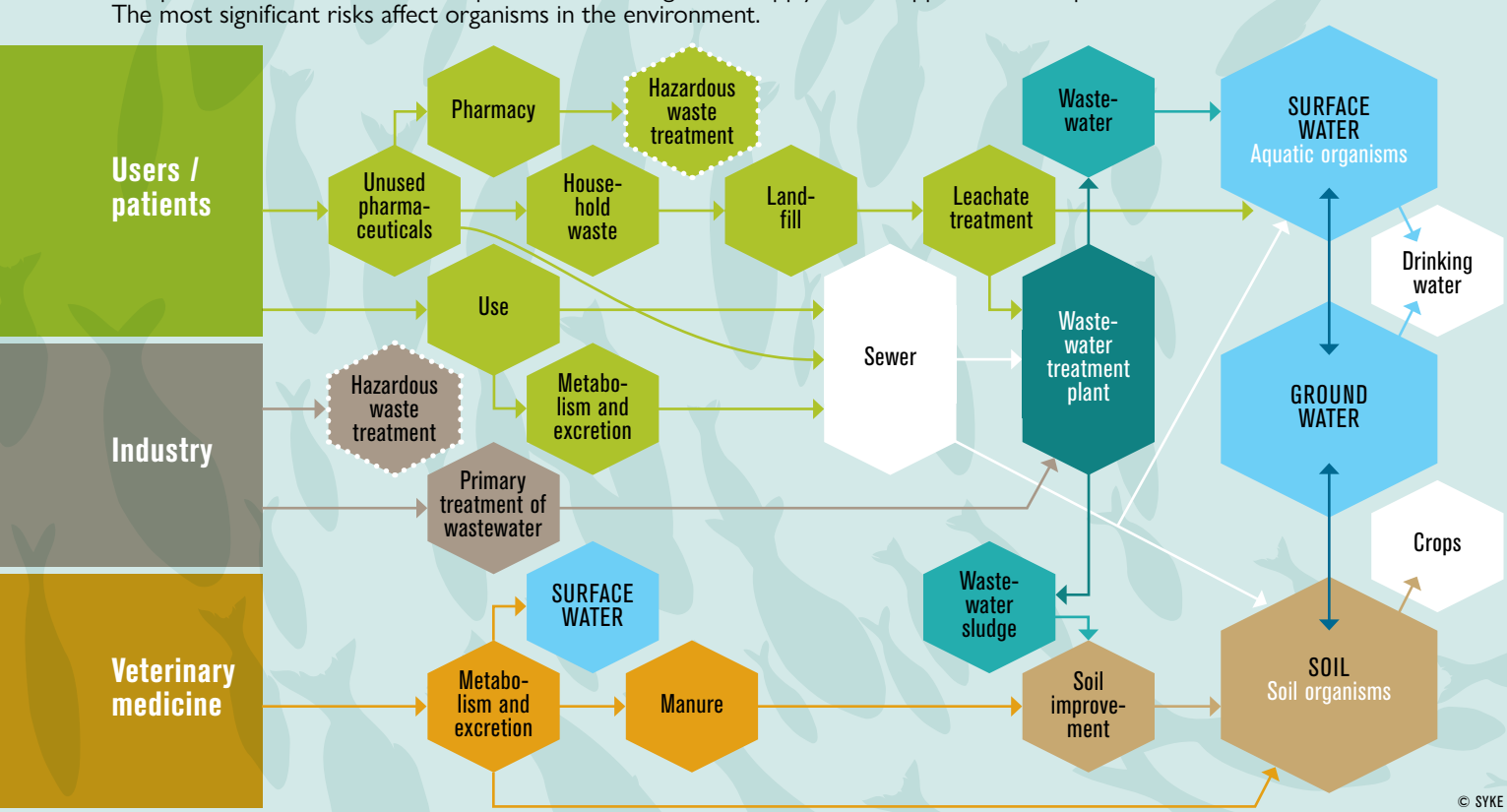
Pharmaceutical substances end up in the soil through wastewater sludge. Sludge is used as a soil improver and a fertilizer. Pharmaceutical residues also end up in fields through the manure of medicated animals.

Certain pharmaceutical substances are persistent in the soil. They are harmful to organisms in the soil and can accumulate in them[7]. In pasture areas antiparasitic drugs given to animals reduce the activity of organisms that advance the decomposition of manure. Manure decomposition can even be impeded[8], making the manure difficult to get rid of.

Treating cattle with antibiotics and other antimicrobial drugs increases methane emissions from the manure[9]. Methane is a powerful greenhouse gas. Research is needed into the drug content of manure, the environmental hazards caused by drug residues, and into ways to reduce them.

PHARMACEUTICAL SUBSTANCES TAKE SEVERAL DIFFERENT ROUTES TO REACH WATERS AND SOIL

Pharmaceutical substances can end up in drinking water and can even reach crops. However, surveys conducted in Finland suggest that pharmaceutical residues in crops and the drinking water supply do not appear to cause problems for the food chain. The most significant risks affect organisms in the environment.



Greater efficiency is possible in removing drug residue

Initial treatment of wastewaters from care facilities and pharmaceutical production plants for the removal of pharmaceutical substances could be a cost-effective option. This would also reduce seepage of pharmaceutical substances into the environment in connection with sewer leaks, pumping station overflows, or bypass of wastewater'.

Traditional wastewater treatment processes hardly remove any pharmaceutical substances. However, methods that enable the removal of pharmaceutical substances already do exist. These include the degradation of the substances through oxidation, adsorption into activated carbon, and filtering through membrane technology.

Different methods can be combined to improve the efficiency of purification according to which pharmaceutical substances need to be reduced[10]. For example, a combination of membrane filtration and oxidation has been shown to be an efficient way to remove pharmaceutical substances[11].

The removal of pharmaceutical residue adds to the costs of wastewater treatment. According to preliminary estimates by the Finnish Environment Institute, a combination of membrane filtration and oxidation through electric pulse for the removal of pharmaceutical residue would raise the cost of treatment by about fifteen cents per cubic metre. This could make it necessary to raise water rates paid by consumers by about five percent from the current level.

Use needs to be directed at less harmful substances

The environmental impact of drugs can be reduced by steering use toward less harmful and more sustainably produced pharmaceuticals. An environmental classification system of pharmaceutical products is already in use in Sweden and Norway. Such a system would also be needed in Finland. It is important to base the classification on reliable and transparent information[12]. The classification would make it possible to focus public procurement of pharmaceuticals on more environmentally friendly products.

Rational pharmaceutical treatment can diminish the amount of pharmaceutical waste produced. Unnecessary and duplicated use of medications should be reduced. Patients getting new prescriptions could initially be given a small package of the medication, as this would minimize amount of pharmaceutical waste if it becomes necessary to switch one medicine for another. The pricing and reimbursement system for medicines does not currently provide incentives for the use of small package sizes.

Decisions on granting environmental permits for the Finnish pharmaceutical industry rarely include a requirement to monitor pharmaceutical emissions[13].

Drug emissions from the pharmaceutical industry are usually estimated to be low, but they can be significant at the local level. Setting strict standards for the domestic pharmaceutical industry does not affect production in other parts of the world. Managing the environmental aspects of the pharmaceutical industry requires action by the EU.

SOURCES: SALIMÄKI ET AL.[14]

PHARMACEUTICAL SUBSTANCES FROM WASTEWATER TREATMENT PLANTS END UP IN WATERBODIES

	Paracetamol Analgesic, one of Finland's most common pharmaceutical substances	**Furosemide** Diuretic, used in the treatment of high blood pressure, among other things	**Diclofenac** Anti-inflammatory medicine, used in analgesic gels, for example.	**Tetracycline** Antibiotic, also used in veterinary medicine
Amount used	200 000 kg/year	2 900 kg/year	2 500 kg/year	1 100 kg/year
In wastewater to WWTP [A]	10 000 kg/year	2 300 kg/year	1 500 kg/year	660 kg/year
From WWTP [A] to waterbodies	**100** kg/year	**2 300** kg/year	**1 400** kg/year	**99** kg/year
Removal in the activated sludge process [B, C]	99%	0%	10–20% [D]	85% [E]
In influent wastewater [C]	100 µg/l	2 µg/l	1,5 µg/l	1,5 µg/l
In effluent wastewater [C]	Not detected	2 µg/l	1 µg/l	0,1 µg/l
In the environment [C]	Water: **0,02** µg/l	Water: **0,1** µg/l	Water: **0,07** µg/l	Soil: **110** µg/kg Avg.

SOURCES: SYKE & FIMEA[15]

Annual estimates of use of pharmaceutical substances are based on sales figures for 2015-2017. Annual pharmaceutical loads have been estimated computationally. | A) Wastewater treatment plant | B) The activated sludge process is the treatment method that is usually used at wastewater treatment plants in Finland | C) Indicative results from Finnish surveys | D) Elimination of diclofenac fluctuates considerably | E) Most of the elimination of tetracycline involves the substance binding on the sludge. The load that reaches the treatment plant does not disappear. It continues its journey in the sludge processing chain.

Now is the time to act

Although environmental concentrations of pharmaceutical substances are generally low, organisms have already been found to have suffered harm from the substances. Some pharmaceutical substances and their transformation products are very persistent in the environment and they accumulate in organisms. They can be harmful for fish, for example, and they can end up in the soil through wastewater sludge. Therefore, measures need to be taken without delay.

- The pharmaceutical industry, health care institutions, and wastewater treatment plants should monitor their pharmaceutical emissions and limit values should be set on those emissions.
- Environmental permits for the pharmaceutical industry should oblige the plants to produce a risk assessment for possible pharmaceutical emissions occurring at each individual plant and to report on the results and the methods used.
- The environmental impact of pharmaceutical emissions should be included in the price of the medicines. It also needs to be ascertained how they could be taken into consideration in the system of reimbursement for medicines.
- The content of pharmaceutical substances in manure used as a soil improver, and the related environmental risks needs to be studied.

The EU published a strategy

In March 2019 the EU issued a strategy on the environmental effects of pharmaceutical products. The strategy covers the entire life cycle of medicines. A statement issued by the Commission proposes measures that could reduce harmful effects of medicine. These include, for example, the improvement of the evaluation of the environmental risks of medicines, the reduction of drug waste, and greater efficiency in wastewater treatment. Member states are already considering how to implement the strategy at the national level.

www.ec.europa.eu/environment/water/water-dangersub/index.htm

References:

[1]OECD (2017). Pharmaceutical consumption. Health at a Glance 2017: OECD Indicators. OECD Publishing, Paris. DOI: https://dx.doi.org/10.1787/health_glance-2017-70-en

[2]Lienert J., Koller M., Konrad J., McArdell C.S., Schuwirth N. (2011). Multiple-criteria decision analysis reveals high stakeholder preference to remove pharmaceuticals from hospital wastewater. Environ Sci Technol. 2011; 45(9):3848–5.https://pubs.acs.org/doi/abs/10.1021/es1031294

[3]Scott T., Phillips P.J., Kolpin D.W., Colella K.M., Furlong E.T., Foreman W.T., Gray J.L.(2018). Science of the Total Environment Pharmaceutical manufacturing facility discharges can substantially increase the pharmaceutical load to U . S . wastewaters. Sci Total Environ 2018; 636: 69–79. https://doi.org/10.1016/j.scitotenv.2018.04.160

[4]WHO (2019). Ten threats to global health in 2019. https://www.who.int/emergencies/ten-threats-to-global-health-in-2019

[5]Jobling S., Williams R., Johnson A., Taylor A., Gross-Sorokin M., Nolan M., Tyler C.R., van Aerle R., Santos E., Brighty G. (2006). Predicted Exposures to Steroid Estrogens in U.K. Rivers Correlate with Widespread Sexual Disruption in Wild Fish Populations. Environmental Health Perspectives. 2006; 114 (1), 32–39. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1874167/

[6]Brodin T., Nordling J., Lagesson A., Klaminder J., Hellström G., Christensen B., Fick, J. (2017). Environmental relevant levels of a benzodiazepine (oxazepam) alters important behavioral traits in a common planktivorous fish, (Rutilus rutilus). Journal of Toxicological and Environmental Health. 2017; 80 (16–18), 963–970. https://www.ncbi.nlm.nih.gov/pubmed/28829722

[7]Munne P., Äystö L. (2015). Eräiden lääkeaineiden ja triklosaanin esiintyminen puhdistamolietteissä sekä käyttäytyminen suomalaisilla maatalousmailla (In Finnish). Ympäristö ja Terveys 4/2015: 34–39

[8]Floate KD. (2006) Endectocide use in cattle and fecal residues: environmental effects in Canada. Can J Vet Res. 2006; Jan; 70(1), 1–10. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1325088/

[9]Hammer T.J., Fiere, N., Hardwick,B., Simojoki A., Slade E., Taponen J., Viljanen H. & Rosli, H. (2016) Treating cattle with antibiotics affects greenhouse gas emissions, and microbiota in dung and dung beetles. Proc R Soc B. 2016; 283: 1831. https://royalsocietypublishing.org/doi/full/10.1098/rspb.2016.0150

[10]Verlicchi P., Aukidy M.A., Zambello E. (2015). What have we learned from worldwide experiences on the management and treatment of hospital effluent? – An overview and a discussion on perspectives. Science of the Total Environment 515; 2015; 467-491 https://www.sciencedirect.com/science/article/pii/S0048969715001564

[11]Ajo P., Preis S., Vornamo T., Mänttäri M., Kallioinen M., Louhi-Kultanena M. (2018). Hospital Wastewater Treatment with Pilot-Scale Pulsed Corona Discharge for Removal of Pharmaceutical Residues. Journal of Environmental Chemical Engineering. 2018; Vol 6, Issue 2. https://www.sciencedirect.com/science/article/pii/S2213343718300794

[12]Vieno N., Karlsson S., Äystö L., Mehtonen J., Sikanen T., Kärkkäinen R., Yli-Kauhaluoma J., Nystén T. (2019). Alternatives for introducing an environmental classification system of pharmaceuticals in Finland (In Finnish with English abstract). Suomen ympäristökeskuksen raportteja 19/2019

[13]Äystö L., Mehtonen J., Vieno N., Ahkola H., Leppänen M., Sikanen T., Yli-Kauhaluoma J., Nystén T. (2019), Pharmaceuticals in environmental permits issued to Finnish pharmaceutical industry (In Finnish with English abstract). Suomen ympäristökeskuksen raportteja 20/2019

[14]Salimäki J., Kujala V. (2016). Voiko lääkejätteen määrää vähentää? (In Finnish)Sic! 3/2016. Lääketietoa Fimeasta. http://sic.fimea.fi/arkisto/2016/3_2016/luonto-ja-laake/voiko-laakejatteen-maaraa-vahentaa-

[15]Fimea (2017). Suomen lääketilasto (In Finnish). Fimea, KELA. https://www.fimea.fi/documents/160140/1188389/Suomen+l%C3%A4%C3%A4ketilasto+2017/8363a352-a008-9686-1a63-22aedbb52bde

Further information: UNESCO & HELCOM (2017). Pharmaceuticals in the aquatic environment of the Baltic Sea region – A status report. Baltic Sea Environment Proceedings No. 149. http://www.helcom.fi/Lists/Publications/BSEP149.p
www.syke.fi/projects/epic | www.cwpharma.fi | www.sudden.fi

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