

Target Analysis of a Large Number of Steroid Hormones

Corticosteroids and Progestogens in Wastewater
Treatment Plants and Receiving Surface Waters

Alexander Weizel, M. Schlüsener, G. Dierkes, T. A. Ternes

Federal Institute of Hydrology, Koblenz Germany

Water JPI Conference

06/06/18 - 07/06/18

Helsinki

- **Aims of the research**

- Development of an analytical method (down to 0.02 ng/L)
- Determination of steroidal pollutants in WWTP effluents and surface waters

Weizel A. et al., *Environ. Sci. Technol.* **2018**, 52, 5296–5307.

Substance	Defined Daily Dose*	Class
Carbamazepine	1000 mg	Anti-epileptic
Spironolactone	75 mg	Mineralocorticoid
Dienogest	2 mg	Progestogen
Fluticasone propionate	0.2 mg	Glucocorticoid

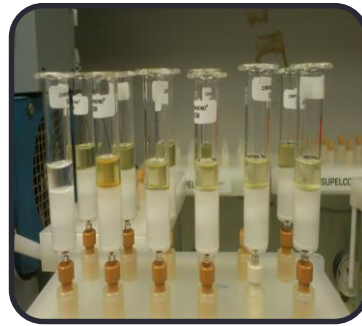
*whocc.no. ATC/DDDIndex. <https://www.whocc.no>.

- Target Compound Selection based on
 - Prescription numbers in Germany, metabolism
 - 37 Glucocorticoids
 - 18 Progestogens
 - 5 Mineralocorticoids

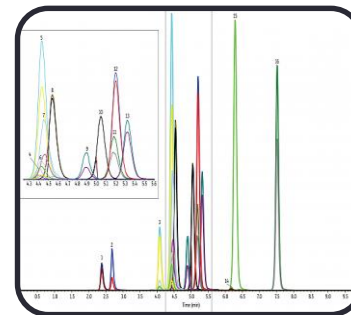
Sample Preparation



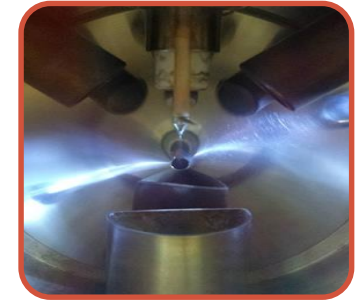
1. Solid Phase Extraction



2. Clean-Up



3. Chromatographic Separation by RP-LC



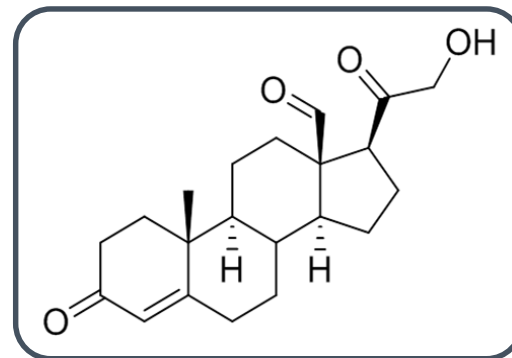
4. Quantification via ESI-Quadrupole-MS/MS

Mineralocorticoids

→ Regulation of K^+/Na^+ balance

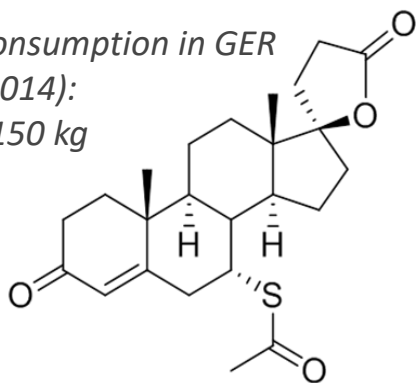
• Medical Indication

- Diuretics
- Addison's disease
- High blood pressure

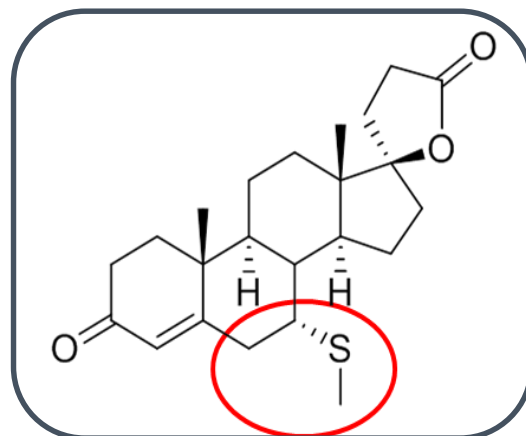


Aldosterone (natural)

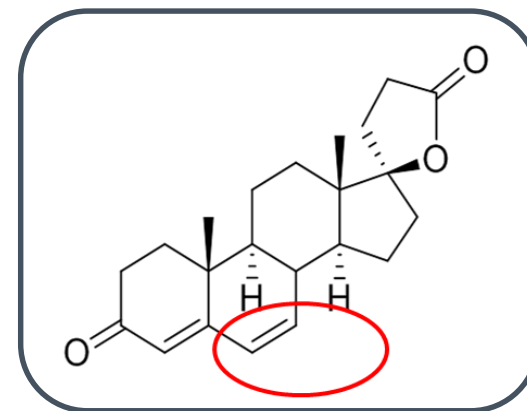
Consumption in GER
(2014):
9150 kg



**Spironolactone
(prodrug)**

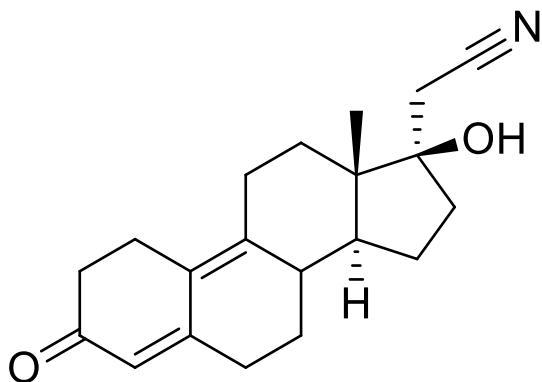


**7α-Thiomethyl spironolactone
(metabolite)**

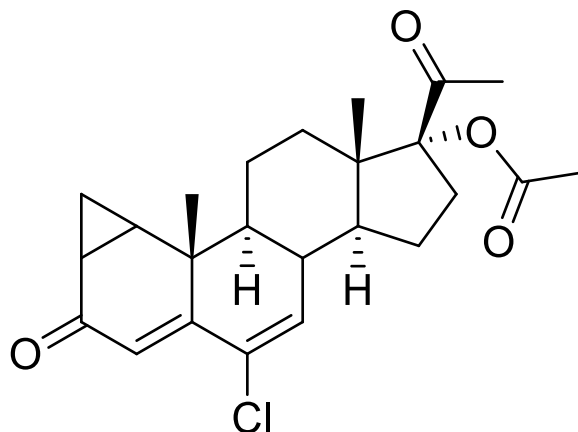


**Canrenone
(active metabolite)**

Prescriptions calculated based on: Schwabe, U.; Paffrath, D. Arzneimittelverordnungsreport 2015; Springer-Verlag, 2015 & whocc.no. ATC/DDDIndex. <https://www.whocc.no>.

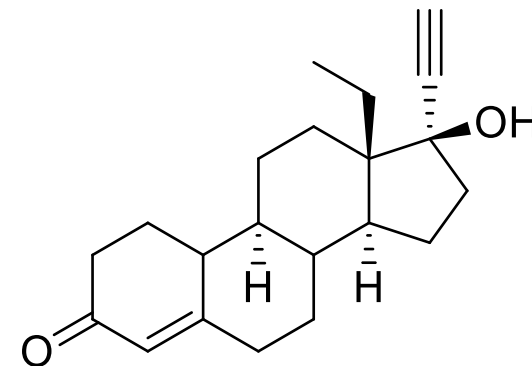


Dienogest



Cyproterone acetate

LOEC: 1.0 ng/L [1]



Levonorgestrel

LOEC: 0.8 ng/L [2]

LOEC: Lowest Observed Effect Concentration

Progestogens

- Medical Indication

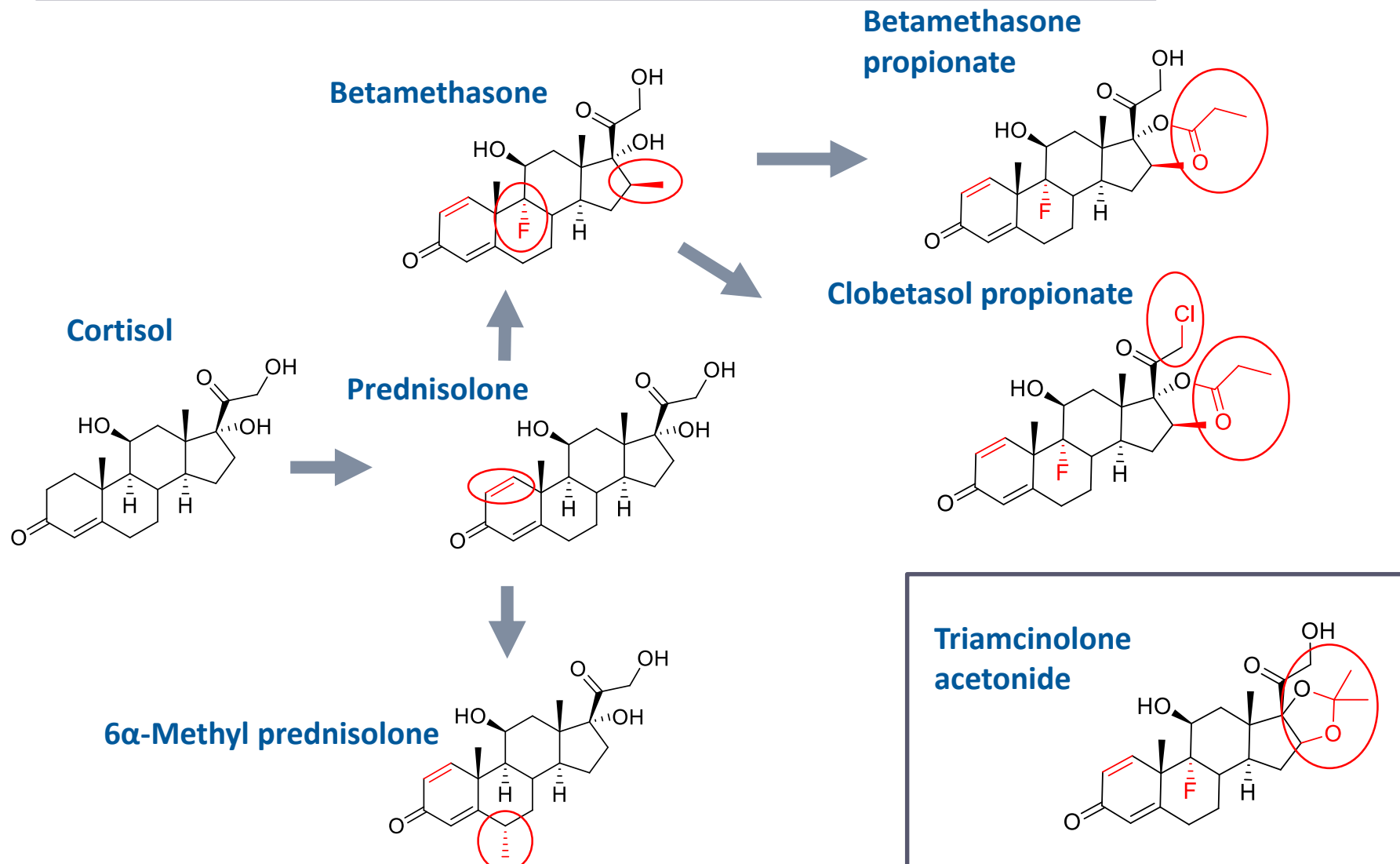
- Hormonal contraception
- Hormone replacement
- Treatment of cancer

- **Unknown ecotoxicological risks
for several progestogens!**

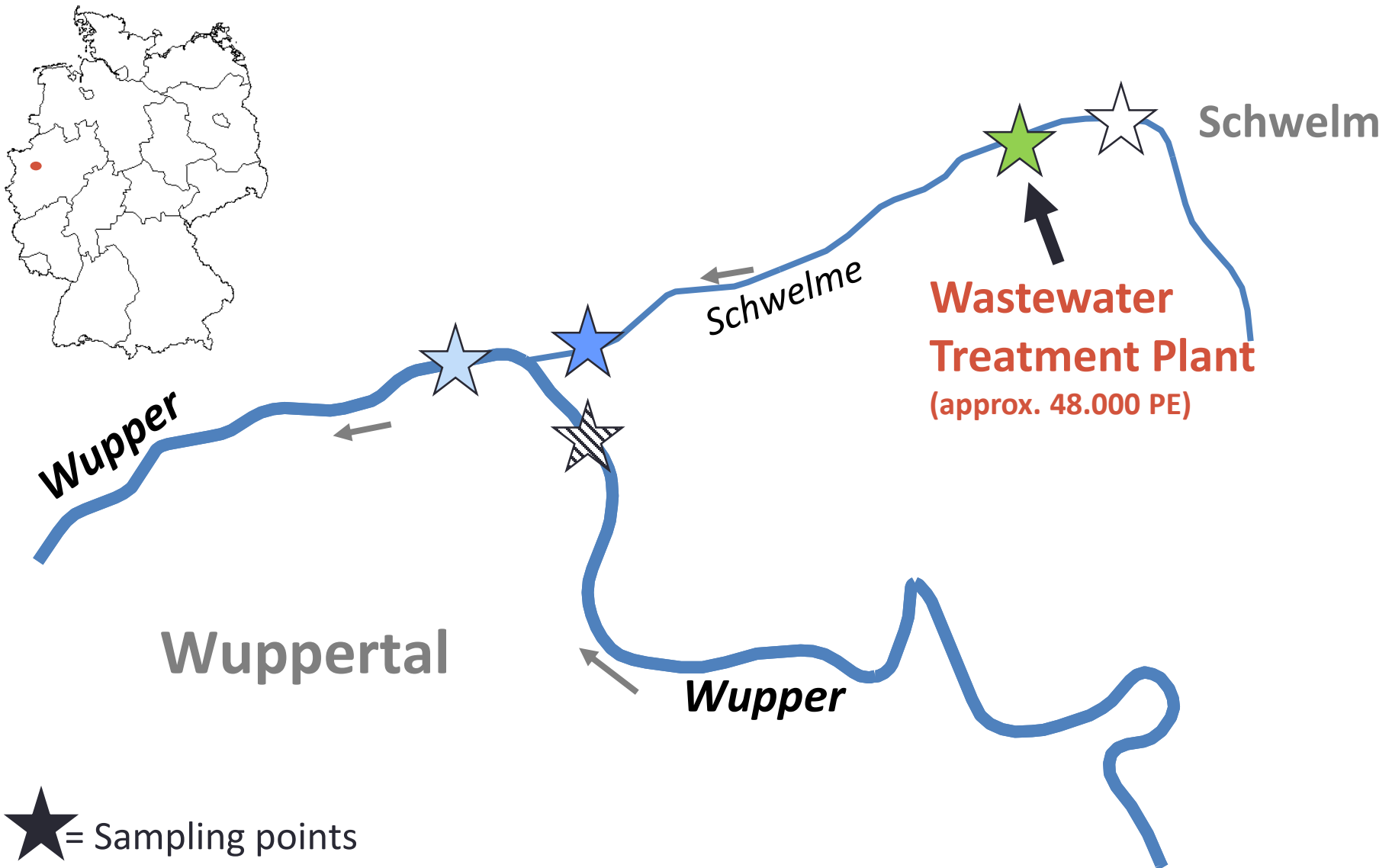
[1]: Sharpe et al., *Aquat. Toxicol.* **2004**, 67, 203–215.

[2]: Zeilinger et al., *Environ. Toxicol. Chem.* **2009**, 28 (12), 2663–2670.

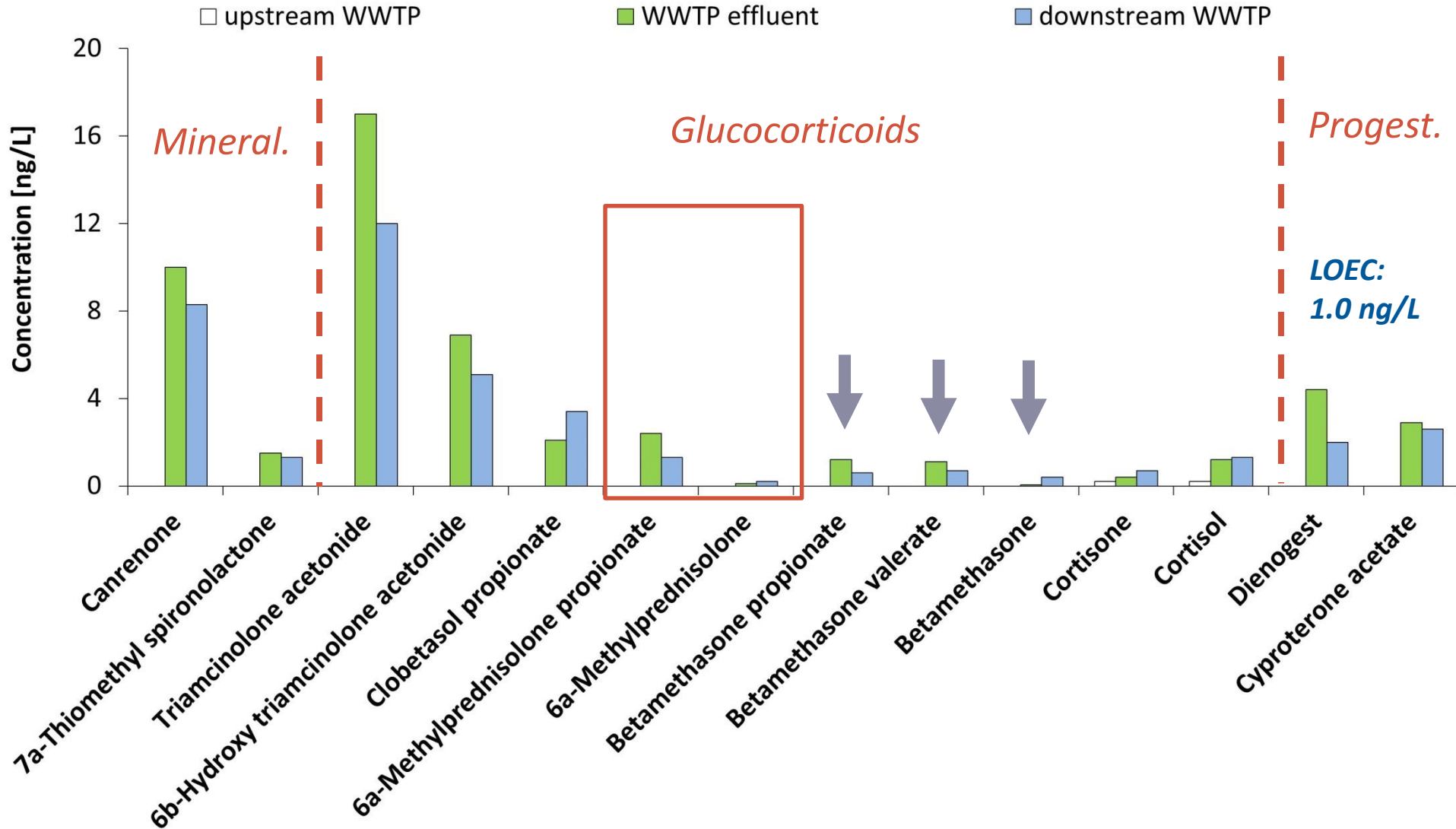
Target Analytes - Glucocorticoids



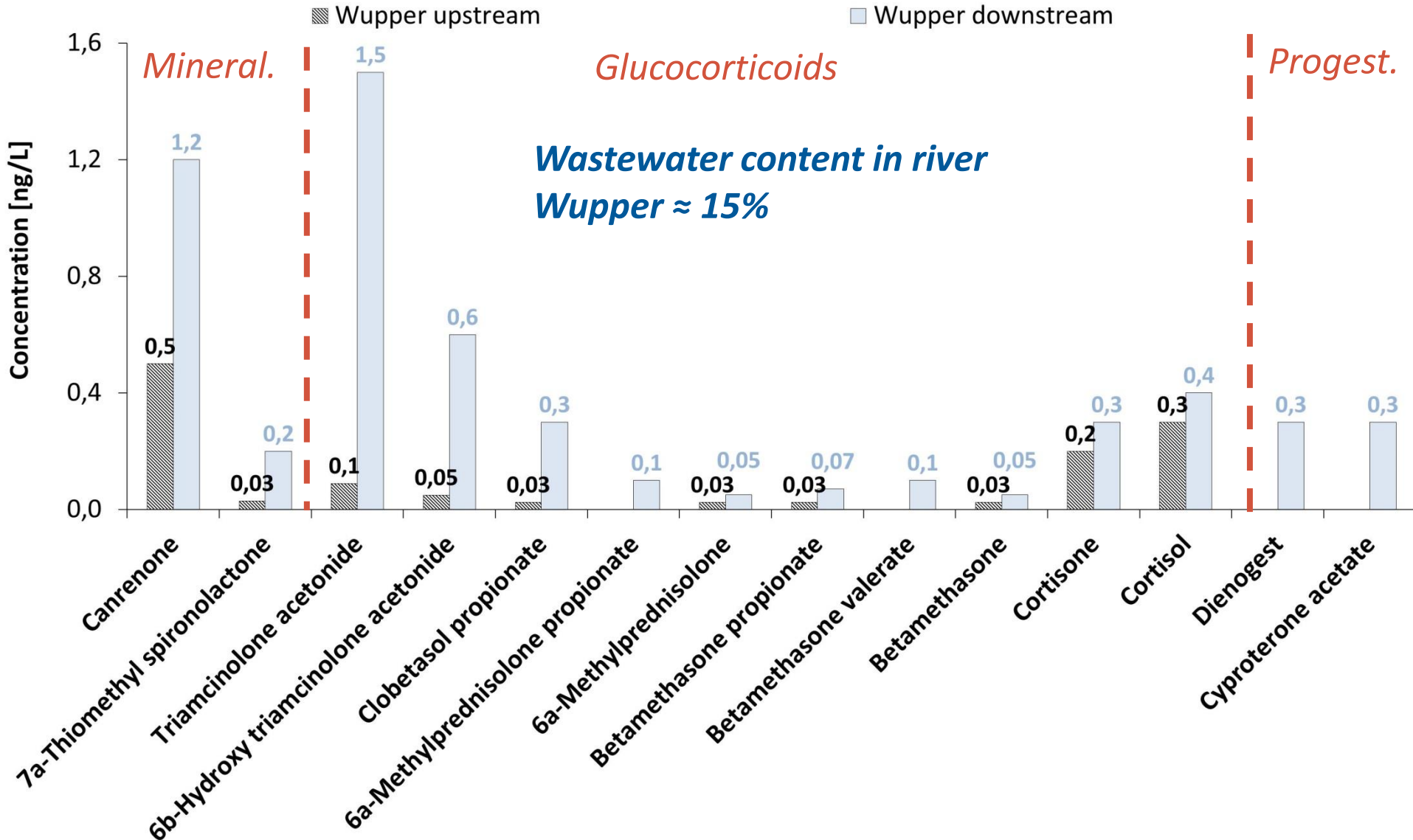
Occurrence of Steroid Hormones



Occurrence of Steroid Hormones



Occurrence of Steroid Hormones



- *Comparable occurrence pattern in Germany*
 - ✓ 14 municipal WWTP effluents
 - ✓ 25 rivers and streams
- *Mineralocorticoids*: Canrenone and 7 α -thiomethyl spironolactone frequently occurred in appreciable concentrations (up to 22 ng/L)
- *Progestogens*: Dienogest and Cyproterone acetate were found to be the prevalent representatives of this class in WWTP effluents and wastewater-affected waterbodies (up to 5 ng/L) LOEC: 1.0 ng/L!
- *Glucocorticoids*: 23 different steroids detectable
 - *High concentrations for Triamcinolone acetonide and Clobetasol propionate* (up to 28 ng/L)
- *Monoesters* used for application on skin were ubiquitous present, partially at higher concentrations as their alcohol derivatives



- *Novelty*
 - Determination of lesser and not studied steroids on the base of consumption and metabolism
- *Impact*
 - Detection of 10 steroids for the first time: *Dienogest*, *6 β -hydroxy triamcinolone acetonide*, *mometasone furoate*, *7 α -thiomethyl spironolactone*,...
 - Occurrence data for many steroids for the risk estimation and assessment
- *Future research directions*
 - Prioritization of compounds of concern for monitoring and ecotoxicological studies
 - Investigation of the fate during wastewater treatment

Acknowledgements

Umwelt
Bundesamt

- The study was founded by the *German Federal Environment Agency (UBA)*
- Special thanks to all involved colleagues from the BfG and partners from the UBA

