# Strategical planning of introduction of advanced wastewater treatment in Switzerland

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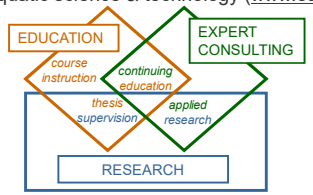
# Nature Needs No Pill

**Eawag**, Swiss federal institute of aquatic science & technology (www.eawag.ch)




- Integrated in ETH Domain
- focus on applied research and knowledge & technology transfer to practice
- Department of Environmental Chemistry deals with organic pollutants in natural and engineered aquatic environments

VSA PLATTFORM VERFAHRENSTECHNIK MIKROVERUNREINIGUNGEN

**VSA Platform «Process Engineering Micropollutants»**

- Collection and processing of technical information regarding the reduction of micropollutants from municipal and industrial wastewater into water bodies
- Dissemination of knowledge to stakeholder, support exchange between stakeholders, implement projects
- www.micropoll.ch, info@micropoll.ch

## Table of content



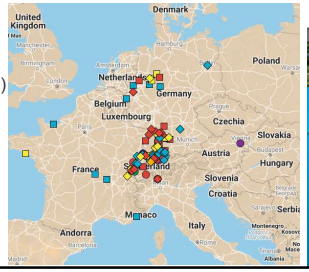
*Eggen et al. ES&T (2014) 48, 7683 dx.doi.org/10.1021/es500907n*

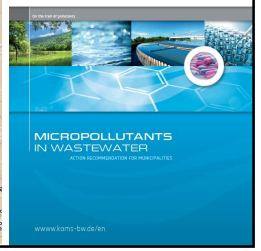
## Development and current status in Europe

**Germany**:
- Report of KomS (Kompetenzzentrum Spurenstoffe Baden-Württemberg) https://koms-bw.de/cms/content/media/Projektbroschuere%20Spurenstoffe%20KomS%20Englisch_Ansicht.pdf
- Nordrhein Westfalen: http://www.masterplan-wasser.nrw.de/das-kompetenzzentrum/

**Other countries** (France, Austria…)

**Switzerland:**
(collection of information other countries)
VSA (Swiss Water Association):
www.micropoll.ch



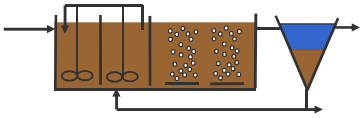



## Situation in Switzerland

97% of the people are connected to a wastewater treatment plant (WWTP)

Treatment at WWTP (effluent requirements):

- BOD degradation (<10 mgDOC/L, 85%)
- + P precipitation (<0.8 mg$P_{tot}$/L, 80%)
- + Nitrification (<2 mg$NH_{3+4}$-N/L, 90%)
- At some locations:
  + Denitrification / + Biological P elimination / + Sand filtration



➔ Good water quality (future: more denitrification)

➔ prerequisite for advanced treatment (low DOC, $NO_2$)

But: micropollutants are not well removed

## Background and development of Swiss strategy

Several international research studies (e.g. EU projects POSEIDON, NEPTUNE)

Large research projects in Switzerland (endocrine disruptive substances):

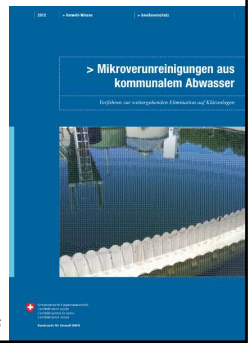
- «**Fischnetz**»: impact on fish reproduction (1998 – 2003)
  e.g. Burkhardt-Holm (2005) ES&T39(21), 441A-447A
- NFP50 (national research program) (2003 – 2007)

➢ **Project Micropoll:**

- Based on pilot tests in Regensdorf, Lausanne and Kloten-Opfikon
- report about which processes are suitable to eliminate micropollutants and how a solution for Switzerland could look like

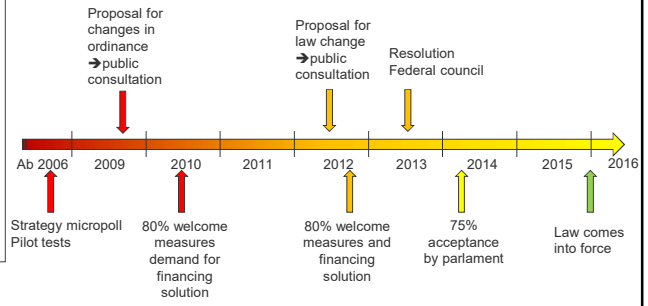
*In German only!*

- *Abegglen C., Siegrist H. 2012, FOEN, Bern, Umwelt-Wissen Nr. 1214: 210 p., www.bafu.admin.ch/uw-1214-d*
- *Hunziker Kostenstudie, 2008, and BG Kostenstudie 2012, www.micropoll.ch/dokumente/berichte*
- *Abegglen C., Beier S., Pinnekamp J., Mauer C., Siegrist H. (2011) GWA 7, 479-486*




## Political approach

- 10 year process
- Pilot tests (project Micropoll)
  => basis for decision finding and new legislation
- Collaboration with authorities and all relevant stakeholders
- Two public consultations
- «willingness to pay»




**Cost-Benefit Analysis of the Swiss National Policy on Reducing Micropollutants in Treated Wastewater**
*Logar et al. ES&T (2014) 48, 12500−12508*

## Swiss strategy: Focused upgrade

The new Swiss Water Protection Act is in force since January 2016
**Goal:** Abatement of micropollutants by 80% with advanced treatment until 2040

**Load-reduction + «up-stream» responsibility**

Large WWTP > 80'000 inhabitants

**Quality control of drinking water resources**

WWTP > 24'000 inhabitants discharging into lakes
WWTP > 8'000 inhabitants in special hydrogeological situations

**Protection of sensitive water bodies**

WWTP > 8'000 inhabitants discharging into stretches with inadequate dilution (>10% share of wastewater)

- ~130 WWTPs upgraded
- 70% of inhabitants

## Target of abatement in Switzerland

**Average 80% elimination of 12 leading substances**

| substance | |
|---|---|
| Amisulpride | Selection of at least 4 substances |
| Carbamazepine | |
| Citalopram | |
| Clarithromycin | |
| Diclofenac | |
| Hydrochlorothiazide | |
| Metoprolol | |
| Venlafaxine | |
| Benzotriazole | Selection of at least 2 substances |
| 4/5-Methylbenzotriazole | |
| Candesartan | |
| Irbesartan | |

2 : 1

**Amount of samples and derogations**
(acording to Water Protection Act GSchV 814.201):
Surveillance by cantons

| Size of WWTP | Amount of samples 1. year | Amount of samples from 2. year (if conform in 1. year) |
|---|---|---|
| 2'000 p. | 8 (*2) | 4 (*1) |
| 10'000 p. | 12 (*2) | 6 (*1) |
| 50'000 p. | 24 (*3) | 12 (*2) |

*allowed derogations

*Götz et al., AQUA&GAS (2015), 2, 34-40*
*https://micropoll.ch/Mediathek/ueberpruefung-des-reinigungseffekts-auswahl-geeigneter-organischer-spurenstoffe/*

## Reasoning for selection of 12 substances

12 substances are **representative** for organic micropollutants
**Not** based on high risk chemicals (but, e.g. hormones are also abated)

- Only parents compounds (no transformation products)
- Can be easily and routinely measured in one analytical method (at cantonal or private labs)
- Occurring in bigger WWTPs at measureable concentration (influent concentration 10x LOQ in effluent)
- Degraded to less than 50% in biological treatment
- Similar abatement in advanced treatment (not favoring ozone or AC)
- Continuous discharge into WWTP

➢ Mainly pharmaceuticals fulfill these criteria

## Process development

**Biological**

**Physical**
- Nanofiltration
- Reverse osmosis

Adsorption
- PAC UIm
- GAC

Oxidation
- Ozone
- Ferrate
- AOP*

* advanced oxidation processes

combinations (Oxidation + Adsorption)

Adsorption
- PAC UIm
- PAC into sand filtration
- PAC into biology
- GAC filtration
- GAC in moving bed
- Extrafine PAC

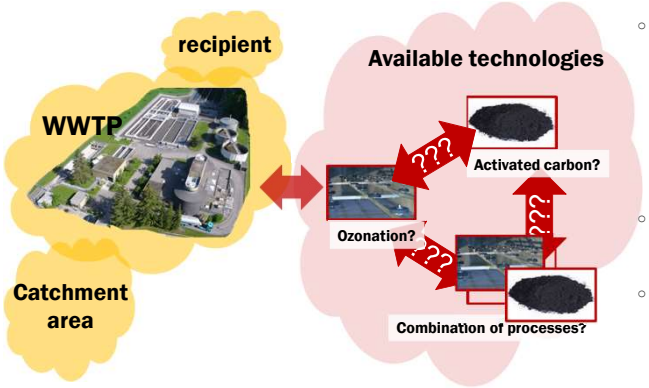
Oxidation
- Ozone

Future development?

2016 — 2040

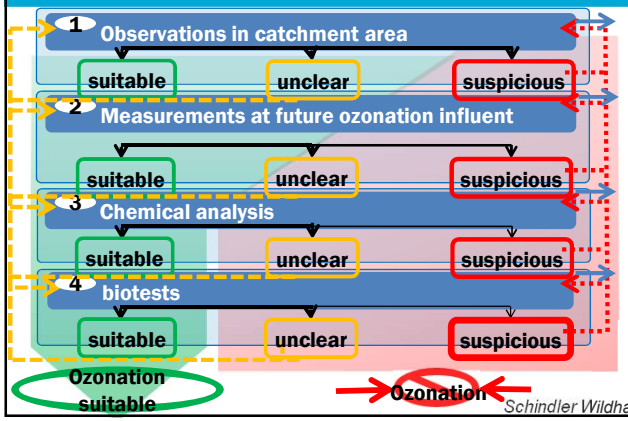
- ➢ 80% elimination of MPs
- ➢ Reasonable cost-benefit ratio
- ➢ Technically feasible and easy to operate

## Process selection




- Collaborative decision: Authorities, WWTP operators, Engineers, suppliers, scientific experts (Eawag, other research institutes)
- Often pilot scale experiments (reports and publication)
- VSA ensures knowledge transfer **(www.micropoll.ch)**

## Advanced decision tool for ozonation

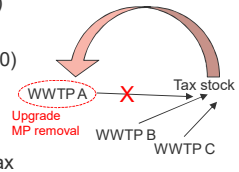



- Industries, incineration?
- Future developments?
- Bromide (Chrome)
- NDMA
- $O_3$ and OH• exposure in a "normal" range ?
- Elimination of reference compounds?
- Ames test
- combined algae assay
- *C. dubia* reproduction test

*Schindler Wildhaber et al. Wat Res. 2015, 75, 324*

## Legal basis – financing and control

- Total investment costs: about 1'200 million CHF (1'100 million Euro)
- Financing: Polluter pays Principle (**National strategy**)
  - Government introduced a wastewater tax for WWTP (2016-2040) of 9 CHF (about 8 Euro) per person and year
  - WWTPs get paid 75% of investment costs for upgrade (from wastewater tax)
  - **Incentive**: Upgraded WWTPs do not have to pay wastewater tax (but have higher operating costs)
- Costs: 0.02-0.25 CHF/m$^3$ (will be evaluated in detail by VSA in 2022)
- Increase of costs for wastewater treatment: about 10-15%
- Elimination goal:
  - 80% (inflow WWTP – outflow WWTP) for a list of 12 substances
  - At any time (also during heavy rain)




## Annual costs Germany

Specific capital annual costs of advanced treatment

*Antakyali D. 2017, kompetenzzentrum-mikroschadstoffe.NRW*

***Fig. 4.*** *Specific capital annual costs of CECs abatement (selected process options only) (Antakyali, 2017).*
*From: Rizzo et al. 2019, STOTEN 655, 986–1008*
*https://doi.org/10.1016/j.scitotenv.2018.11.265*

*Rizzo et al. 2019, STOTEN 655, 986–1008*

## Conclusions

**Success drivers**:
- Strong collaboration among researchers, regulators and practitioners
- Accepted financial plan (financial risk not at water managers)
- Simple measures to evaluate treatment
- Willingness to proactively invest towards a clean and sustainable environment
- VSA Platform supports all stakeholders involved (www.micropoll.ch)

**Barriers**:
- Knowledge gaps, remaining uncertainties (research is still ongoing)
- Other priority issues
  - General bad water quality (well performing WWTP with nitrification as first step)
  - Rather use money for something else?