EFFICIENT TREATMENT OF PHARMACEUTICAL RESIDUE AT SOURCE - EPIC

FINAL REPORT: Cost-effectiveness of waste water treatment solutions at different sources (WP3)

Finnish Environment Institute (SYKE) &
Subcontractor Law and Water

Jyrki Laitinen/SYKE
26.2.2020

Further information of WP3:

Jyrki Laitinen
jyrki.laitinen@ymparisto.fi

http://www.syke.fi/hankkeet/epic
http://www.syke.fi/projects/epic
http://www.syke.fi/projekt/epic

Partners - Cost-effectiveness of waste water treatment solutions at different sources (WP3)

- Work Package Coordinator: SYKE
  - Jyrki Laitinen
- Partners: Hospital District of Southwest Finland (TYKS) and Laki ja Vesi Oy
  - Niina Vieno (Laki ja Vesi Oy)
  - Kari Kandelberg (TYKS)

Needs - Cost-effectiveness of waste water treatment solutions at different sources

1. Knowledge of costs of treatment of pharmaceutical residues in wastewater
   - Investment costs
   - Operation costs
2. Knowledge of cost-efficiency of different methods and approaches in pharmaceutical residue purification
   - What are important pharmaceuticals to be removed? (WP1)
   - What are additional unit costs of different treatment methods?
   - What are benefits of treatment of pharmaceutical residues in wastewater?
   - Is it more cost-efficient to have specific treatment at the pollution source where the concentration is high?

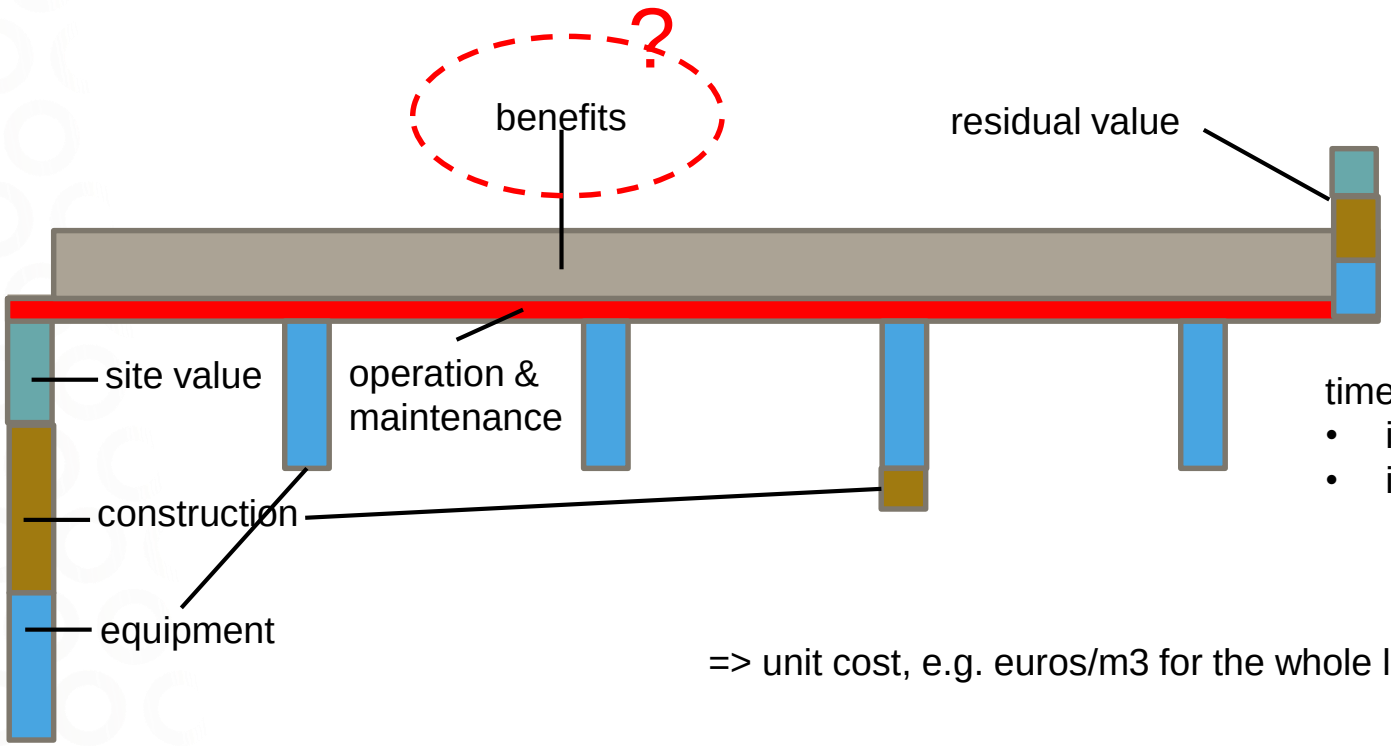
Approach - Cost-effectiveness of waste water treatment solutions at different sources (1/3)

1. Assessment of investment and operation costs
   - VVY, 2016 (Teknis-taloudellinen tarkastelu jätevesien käsittelyn tehostamisesta Suomessa)
   - THL, 2018 CONPAT-project, (Juomavesien epäpuhtauksien poistotekniikat talous-ja jätevesilaitoksilla)
   - Other studies and treatment implementations

2. Life Cycle Costing assessment LCC
   - SYKE, LUT, HY, 2019, EPIC-project

Approach - Cost-effectiveness of waste water treatment solutions at different sources (2/3)

Life cycle cost assessment LCC



time/a
- interest %?
- inflation %?

=> unit cost, e.g. euros/m3 for the whole life cycle

Approach - Cost-effectiveness of waste water treatment solutions at different sources (3/3)

1. Pulsed corona discharge PCD + membrane filtration
2. Enzyme methode pCure

Costs are assessed using following assumptions:

- Electricity 0,10 €/kWh
- No personnel costs
- Buildings are assumed to be extensions to current buildings and no basic infrastructure is needed
- pCure blocks 7 €/pc

Depreciation of investments:

- Constructions 50 years
- Equipment 15 years
- Interest rate 3 %
- Inflation 0 %

Main outputs - Cost-effectiveness of waste water treatment solutions at different sources (1/7)

Operation cost estimates (euros/m^3) vary a lot in previous studies

1. Activated carbon
   - 0,0039 – 0,5 (GAC)
   - 0,036 - 1,1 (PAC)
2. Ultrafiltration (UF) 0,08
3. Nanofiltration (NF) 0,35
4. Reverse osmosis (RO) 0,52
5. Ozonization 0,06 – 0,07
6. AOP (H2O2+UV) 0,14 – 0,32

Main outputs (2/7)

Method	Type of wastewater	Cost, €/m^3	Additional information
PCD oxidation	Treated	0,12-0,14	EPIC project, tertiary treatment
PCD oxidation + UF	Treated	0,16-0,18	EPIC project, tertiary treatment
Enzyme treatment	Not treated	1,4-1,7	EPIC project, source
Active carbon, GAC	Treated	0,27	Literature (Vesilaitosyhdistys, 2016)
Active carbon, PAC	Treated	0,24	Literature (Vesilaitosyhdistys, 2016)
Membrane filtration, UF	Treated	0,08	Literature (Conpat project, 2018)
Membrane filtration, NF	Treated	0,35	Literature (Conpat project, 2018)
Reverse osmosis	Treated	0,72	Literature (Vesilaitosyhdistys, 2016)
Ozonization	Treated	0,18	Literature (Vesilaitosyhdistys, 2016)
Other oxidation, AOP	Treated	0,45	Literature (Vesilaitosyhdistys, 2016)
Treatment plant in Herlev hospital in Copenhagen	Not treated	about 2	Includes mechanical pretreatment and biochemical treatment + MF + O_3 + GAC + UV

Main outputs (3/7)

Preliminary assessments with period of 50 years, capacity of 750 m3/d

	Year		
	1-15	16-30	31-50
Building	3 887	3 887	3 887
Equipment	6 819	6 819	6 819
Pumps	0	0	0
Operation costs	31 900	35 659	39 866
Cost €/a	42 605	46 365	50 572
Cost €/m3	0,16	0,17	0,18

	Year		
	1-15	16-30	31-50
Buildings	0	0	0
Equipment	0	0	0
Pumps	0	0	0
Operation costs	379 167	417 083	458 792
Cost €/a	379 167	417 083	458 792
Cost €/m3	1,39	1,52	1,68
	0	0	

UF + PCD

- Tertiary treatment after an activated sludge process

Enzyme method pCure

- Treatment at the source; hospital

SYKE

Main outputs (4/7)

Total treatment plant, example Herlev Hospital in Copenhagen

Discharge	550 m3/day
Process	screening, biological process, membrane filterig, activated carbon, ozone and UV
Costs	Investment costs 3,3-4,7 million euros Operation and maintenance costs 1,45 euros/m3

Very good result in removal of pharmaceutical residues. The operator notices that good removal of phophorous would need additional chemical precipitation.

Main outputs (5/7)

Assessment and discussion about the methods

According to this study one unequivocally good solution cannot be found. The method must be chosen individually to each site. In some situations it is cost efficient to treat water at the source, and then the method must be suitable to turbid water. This kind of method is e.g. enzyme treatment, like pCure.

In wastewater treatment plants, as tertiary treatment when water is already clear, methods like PCD, membrane filtering and activated carbon treatment can be applied. The unit cost (€/m3) of these methods is lower than with the enzyme treatment, but the volume is also significally higher due to all other wastewater and storm water that are mixed into the wastewater from e.g. a hospital.

Main outputs (6/7)

Assessment of the space needed

In several cases all additional treatment methods that need more space, are difficult and expensive to organise. Activated carbon treatment and also membrane filtering need additional room in existing treatment plant. PCD is quite small equipment, as well as ozone treatment units.

The most simple treatment to organise is enzyme method, when it is installed to be used early in the sewage route, eg. in the toilet. Then it needs almost no additional space, only a storage cabinet for the treatment blocks.

Main outputs (7/7)

Assessment of benefits of treatment

- Removed or reduced materials and their impacts
- Benefit gained from the process; site, significance to sludge reuse
- Benefits compared to possible limits
- Costs of damage if not implemented

It was found out that it is very difficult to calculate benefits in euros, due to actual environmental impacts of pharmaceutical residues are not explicitly known. However, efficiency and costs of various treatment methods have been studied, and better analyses can be made when more information in further studies is gained.

Main outputs: Publications & Presentations - Cost-effectiveness of waste water treatment solutions at different sources

- Articles
  - Article in Vesitalous 1/2020 ”Jätevesien lääkejäämien käsittelyn kustannustehokkuus”

- Presentations
  - Presentation in Vesihuolto 2019, Jyväskylä 15.-16.5.2019 “Jätevesien lääkejäämien käsittelyn kustannustehokkuus”

Benefits and influence - Cost-effectiveness of waste water treatment solutions at different sources

- Understanding of long term costs and benefits of treatment of pharmaceutical residues in wastewater helps to plan treatment strategy in future
- Different treatment methods and approaches affect differently; at pollution source when concentration is high, cost-efficiency might be high
- Some methods need clear water, so they are applicable as tertiary treatment after chemical and biological treatment in wastewater treatment plants
- It is possible to assess the effect of treatment costs to water fee . The water fee is, however, a political decision and cannot be precisely estimated according to additional cost calculations.

Collaboration/Stakeholders – Cost-effectiveness of waste water treatment solutions at different sources

- Financers (steering group)
- Healthcare operators: hospitals, factories
- Authorities: YM, regional authorities, municipalities
- FIWA, MWWTPs
- Technology providers, consulting companies, other related enterprises
  - Wapulec Oy, Pharem Biotech Ab, Grundfos Biobooster A/S, various discussions with representatives of several companies
- Scientific community: research institutes, universities

Collaboration

Partners

BUSINESS FINLAND

SYKE

HELSINGIN YLIOPISTO
HELSINGFORS UNIVERSITET
UNIVERSITY OF HELSINKI
FARMASIAN TIEDEKUNTA
FARMACEUTISKA FAKULTETEN
FACULTY OF PHARMACY

LUT University

LAKI & VESI

Vantaanjoen ja Helsingin seudun vesiensuojeluyhdistys ry

Vesihuoltolaitosten kehittämisrahasto

Kymen Vesi Oy

HSY

Lappeenrannan energia oy

Turun seudun puhdistamo Oy

HUS

eksote

VARSINAIS-SUOMEN SAIRAANHOITOPIIRI

Rinnekoti-Säätiö

SYKE

WatMan

Watrec

WAPULEC
Water and air treatment

Further information

SYKE (firstname.lastname@ymparisto.fi)

- The Consortium of The Project: Taina Nystén
- WP1: Lauri Äystö
- WP3: Jyrki Laitinen
- WP4: Jukka Mehtonen

LUT (firstname.lastname@lut.fi)

- WP2: Mika Mänttäri

UH (firstname.lastname@helsinki.fi)

- Tiina Sikanen

http://www.syke.fi/hankkeet/epic
http://www.syke.fi/projects/epic
http://www.syke.fi/projekt/epic