

AOP4WATER

Reducing fresh water consumption

Reducing fresh water consumption in high water volume consuming industries by recycling AOP-treated effluents “AOP4Water”

Zmanjševanje porabe sveže vode v industriji s ponovno uporabo (recikliranjem) očiščenih odpadnih voda

Predstavitev zaključnih rezultatov projekta

Gospodarska zbornica Slovenije, 19.6.2013

University of Ljubljana



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**Era-net Cornet projekt za industrijska združenja,
januar 2011- junij 2013 (www.cornet-aop4water.eu)**

Projekt se izvaja v okviru programa Cornet sofinanciranega s strani MGRT



REPUBLIC OF SLOVENIA
MINISTRY OF ECONOMIC DEVELOPMENT
AND TECHNOLOGY

Gefördert durch:



aufgrund eines Beschlusses
des Deutschen Bundestages



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Projektni partnerji



APO4WATER network

	Papiertechnische Stiftung (PTS), Germany (coordinator) www.ptspaper.de
	Centre de Recherche et de Contrôle agro-alimentaire, emballage, environnement, papetier et textile (Celabor), Belgium www.celabor.be
	CREA Hydro & Energy o.s., Czech Republic www.creacz.com
	AQUA PROCON s.r.o. (AQP), Czech Republic www.aquaprocon.cz
	Gospodarska zbornica Slovenije, Slovenia www.gzs.si
	Univerza v Ljubljani, Slovenia Profile www.uni-lj.si
	Institut za Vode Republike Slovenije, Slovenia www.izvrs.si

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Glavni cilji AOP4Water projekta:

- Zagotavljanje novih virov vode za potrebe industrije, ki so veliki porabniki vode, s ponovno uporabo očiščenih odpadnih voda iz papirne, tekstilne in živilsko predelovalne industrije ter očiščenih komunalnih odpadnih voda
- Ključ do ponovne uporabe (recikliranja) vode je izboljšana učinkovitost čiščenja odpadnih voda s pomočjo kombinacije različnih AOP in biološkega čiščenja
- Uporaba minimalnih količin O_3 z namenom prepustiti končno razgradnjo cenejši biološki stopnji čiščenja in tako zmanjšati celokupne stroške čiščenja odpadne vode.

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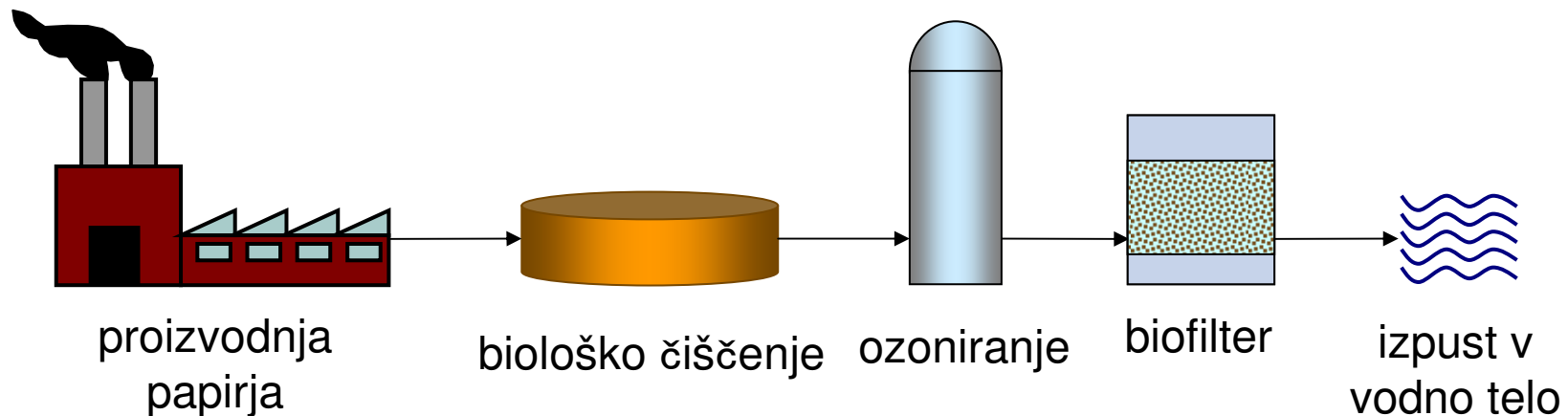
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Začetno stanje

- O_3 za napredno čiščenje odpadnih vod → veliko prednosti, dobri rezultati in izkušnje
- VENDAR: ni vedno ekonomična rešitev
- Da bi čiščenje z O_3 naredili bolj privlačno → kombinacija z H_2O_2 , UV, ultrazvokom
- Regije s pomanjkanjem pitne vode → potrebni so novi viri vode

AOP pri čiščenju odpadnih vod

- Ozon:
 - Spremeni preostanek KPK v biološko razgradljive komponente
 - KPK ↓ , BPK_5 ↑ , BPK_5/KPK ↑



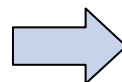
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Cilj

- Ponovna uporaba AOP-očiščenih odpadnih vod namesto sveže pitne vode
- Vir so odpadne vode iz:
 - proizvodnje papirja in celuloze
 - živilskopredelovalne industrije
 - tekstilne industrije
 - komunalne odpadne vode
- Ponovna uporaba v:
 - proizvodnji papirja in celuloze
 - tekstilni industriji



Ključ do ponovne uporabe:

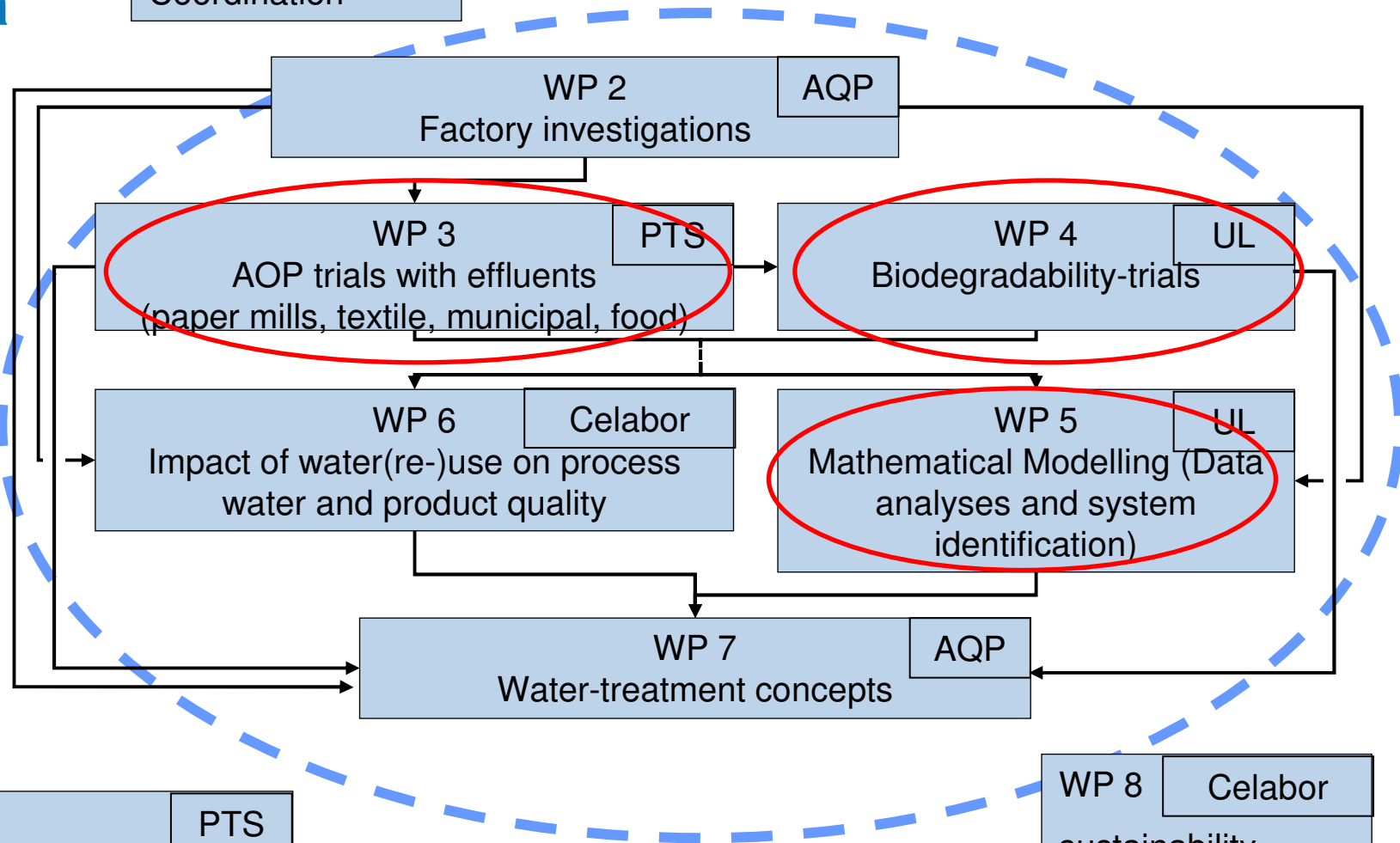
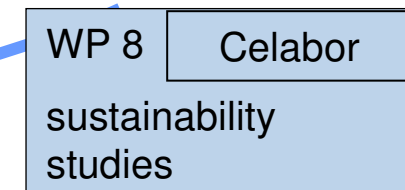
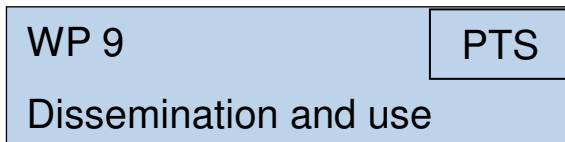
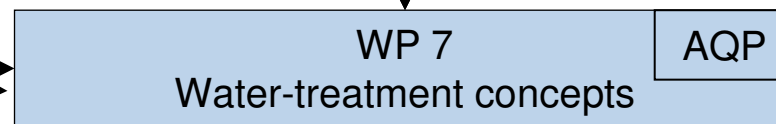
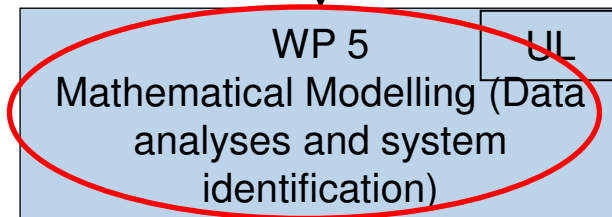
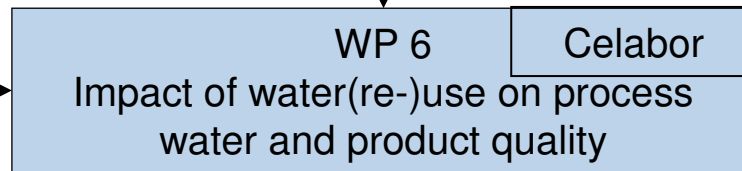
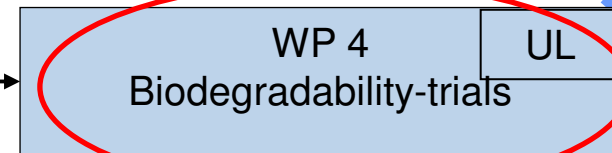
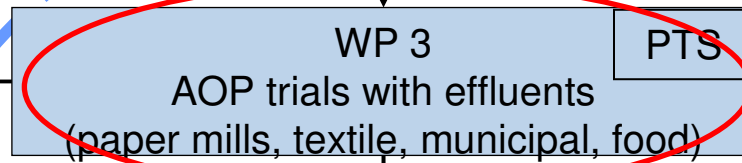
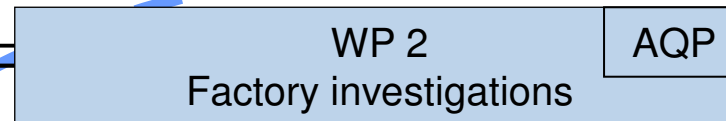
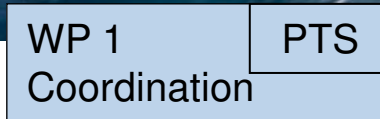
- Izboljšati učinkovitost AOP-čiščenja z namenom:
 - ➔ zagotoviti optimalno kvaliteto vode
 - ➔ pokazati možne uporabe očiščenih odpadnih vod.

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Izvedba

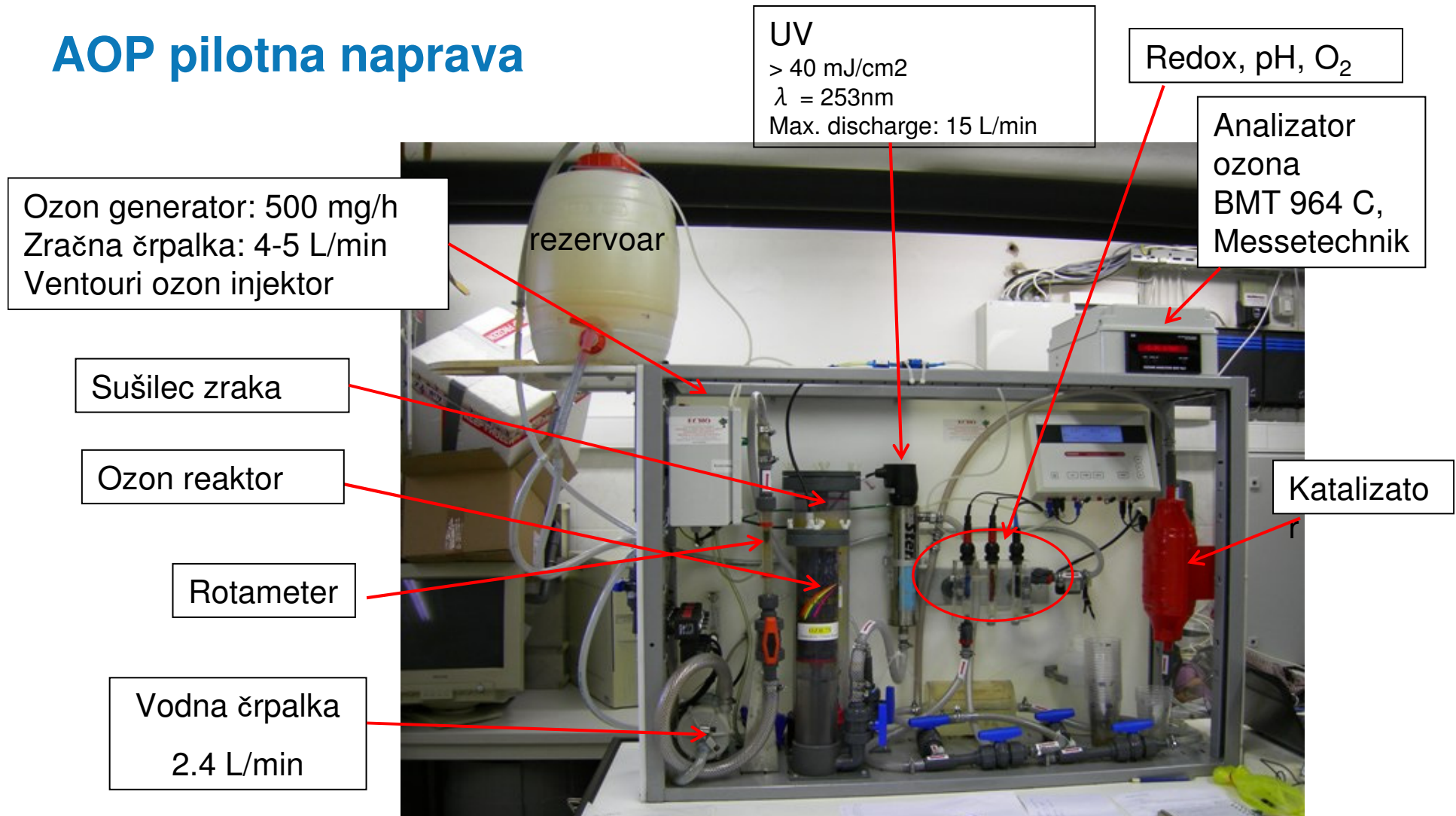


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AOP pilotna naprava

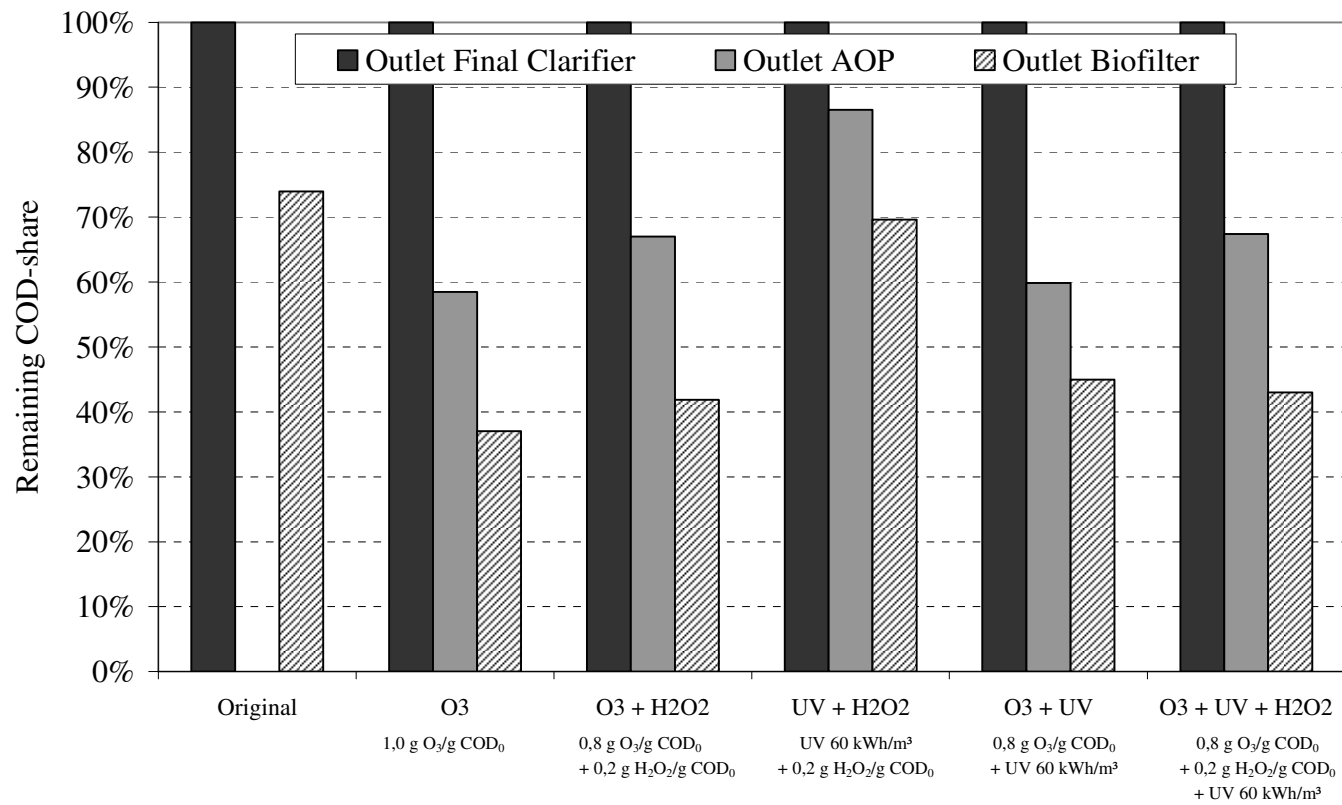


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Papirna odpadna voda

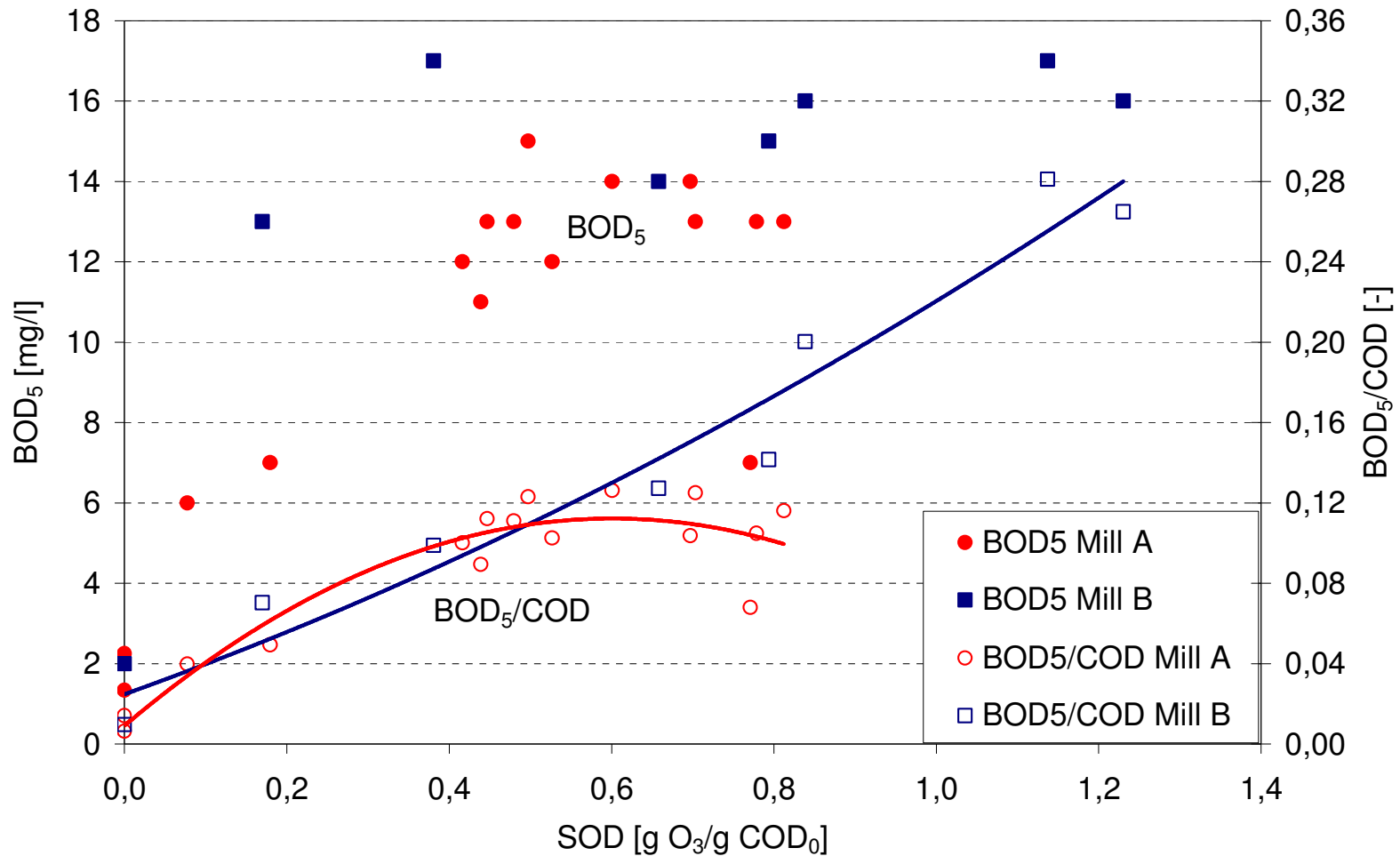


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Mill A +B: O₃ – BOD₅/COD

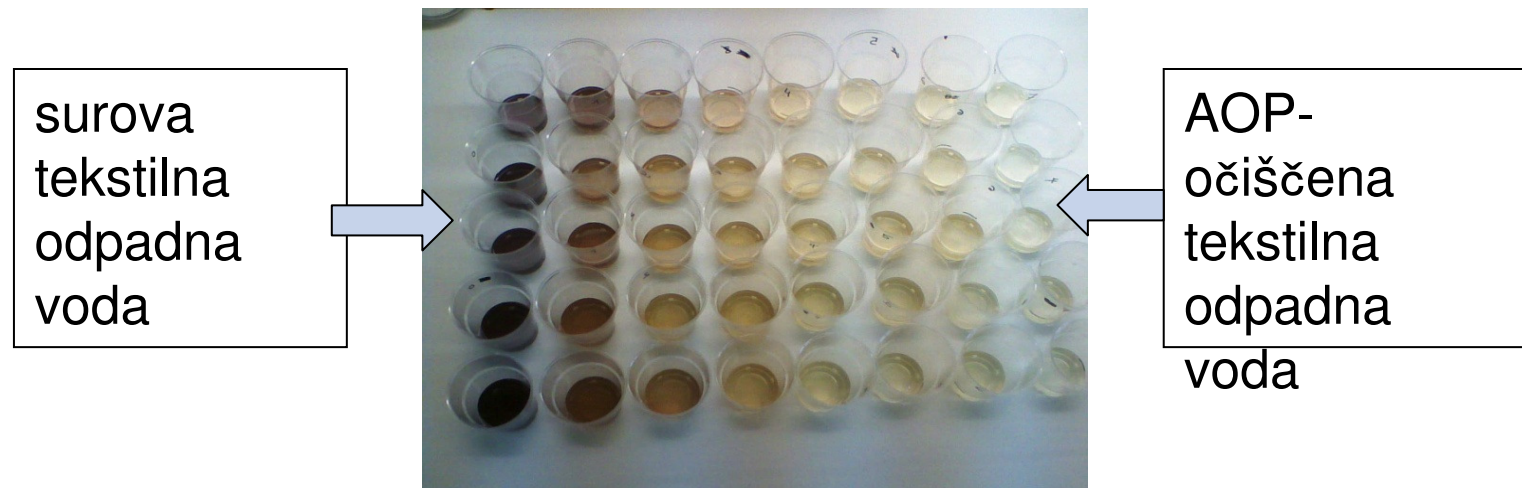


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Tekstilna odpadna voda

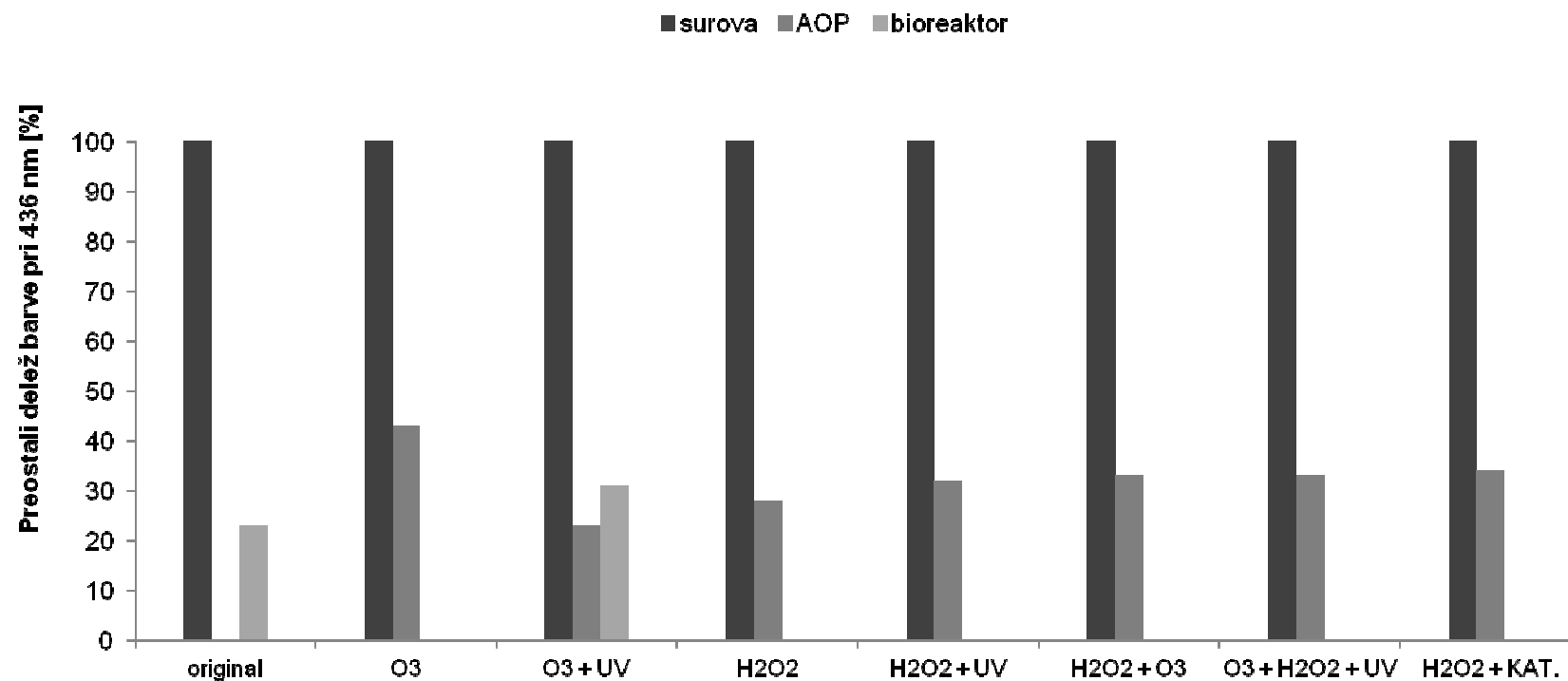


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Tekstilna odpadna voda

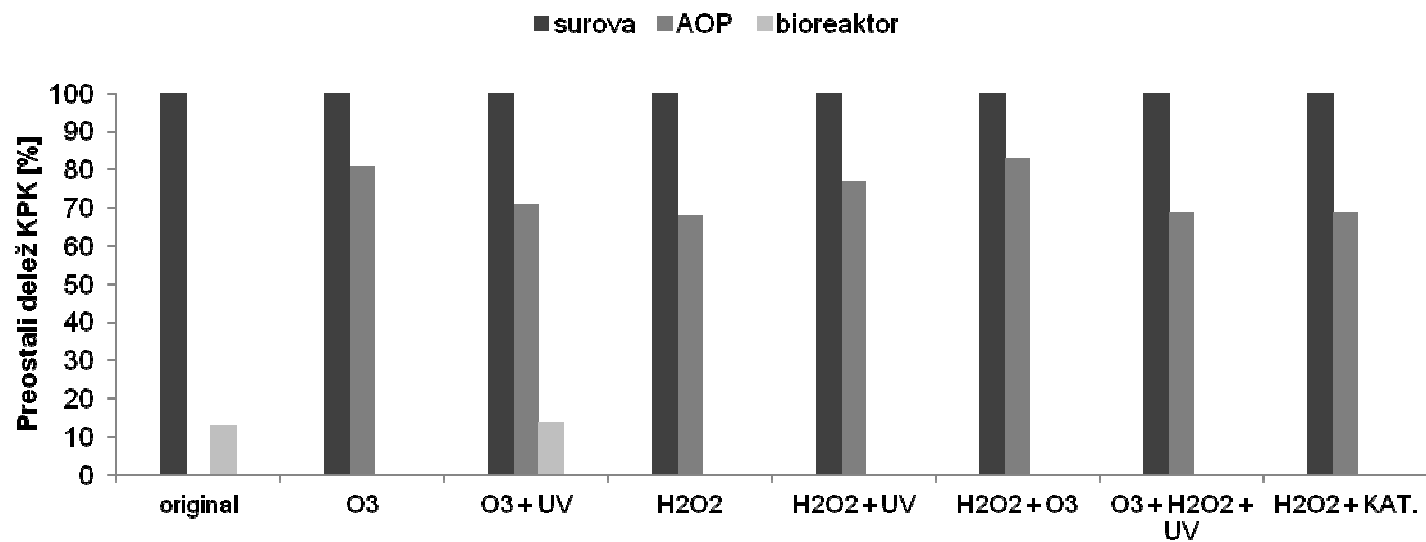


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Tekstilna odpadna voda

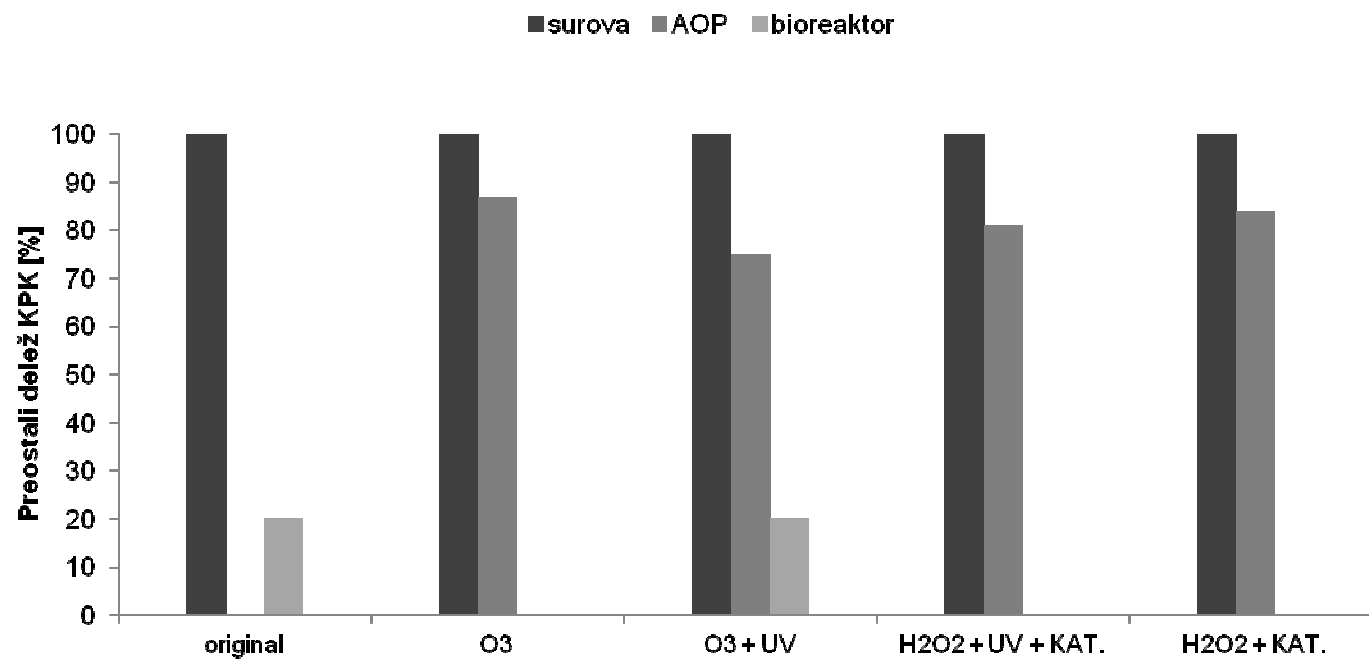


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Komunalna odpadna voda



Živilsko predelovalna odpadna voda

Najbolj učinkovita se je izkazala kombinacija ozona + UV

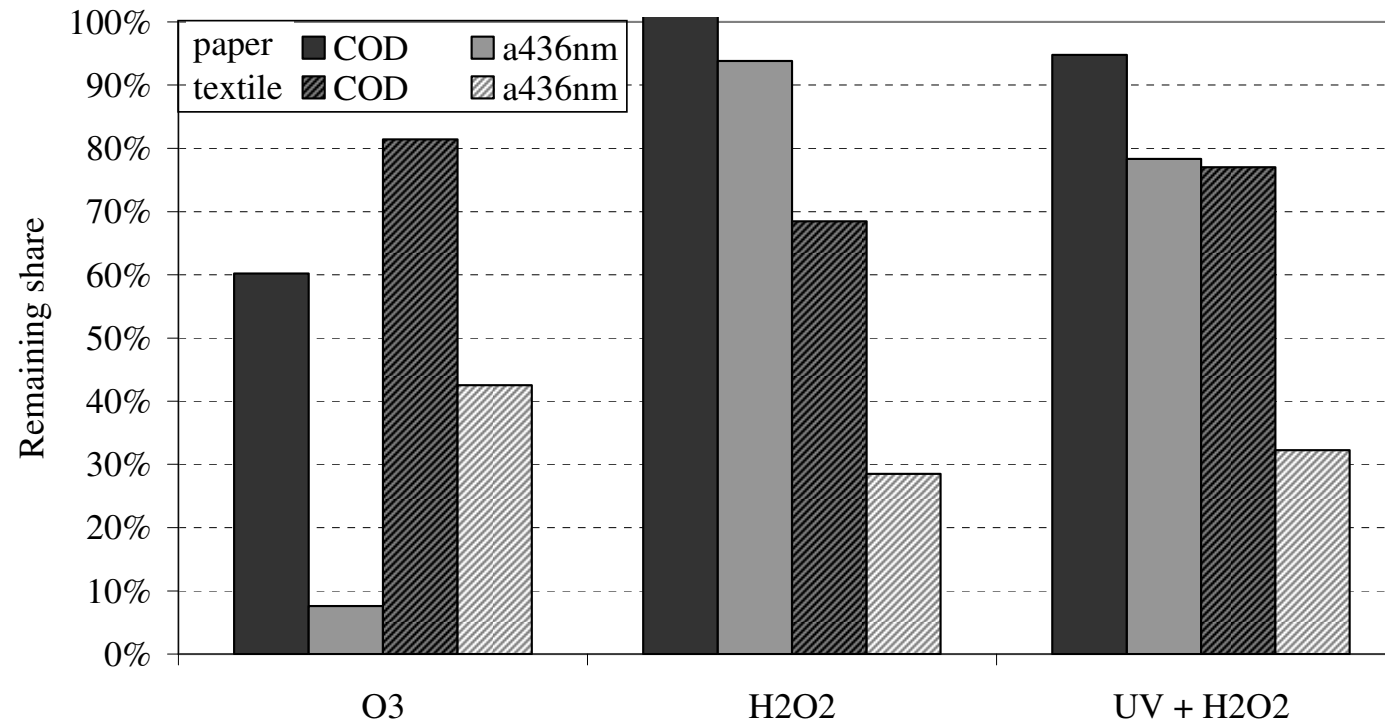
- Učinkovita dezinfekcija
- Učinkovito razbarvanje
- Zmanjšanje motnosti
- Zmanjšanje KPK in BPK5

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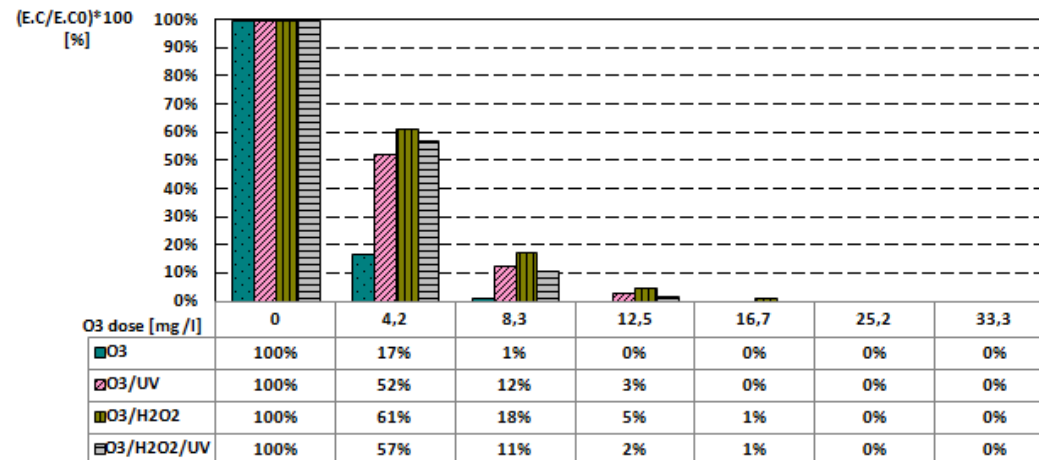
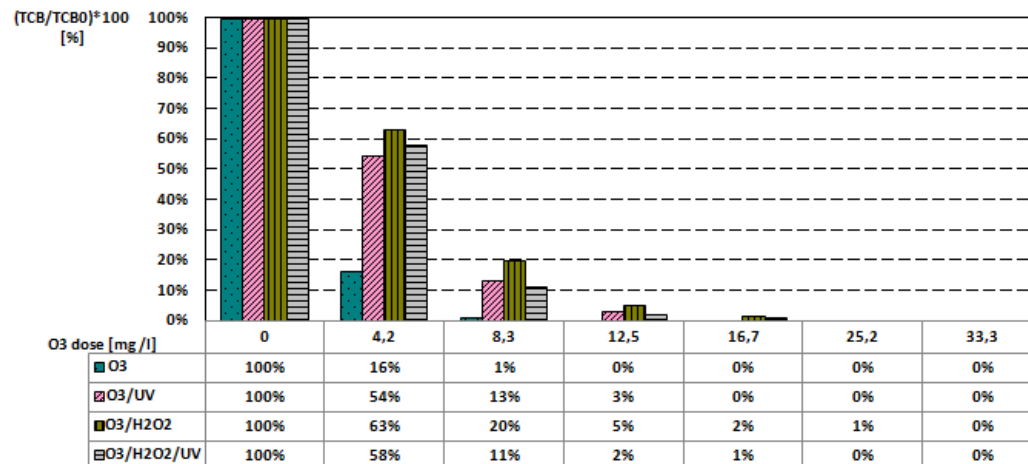
Primerjava papirne in tekstilne odpadne vode



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Dezinfekcija komunalne odpadne vode



Ozonation

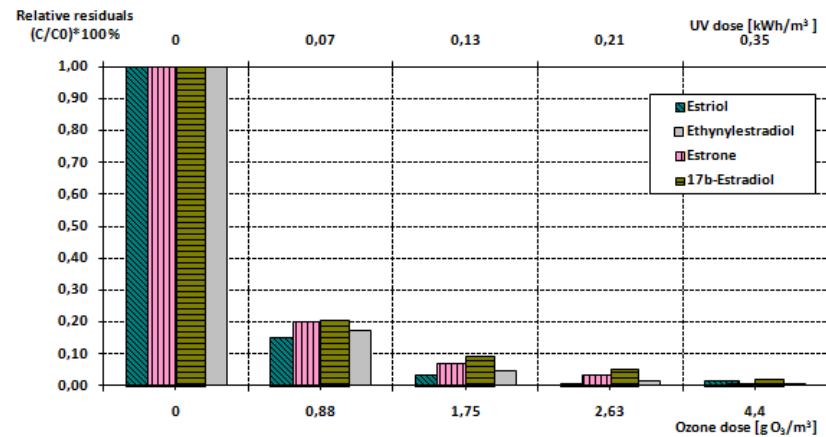
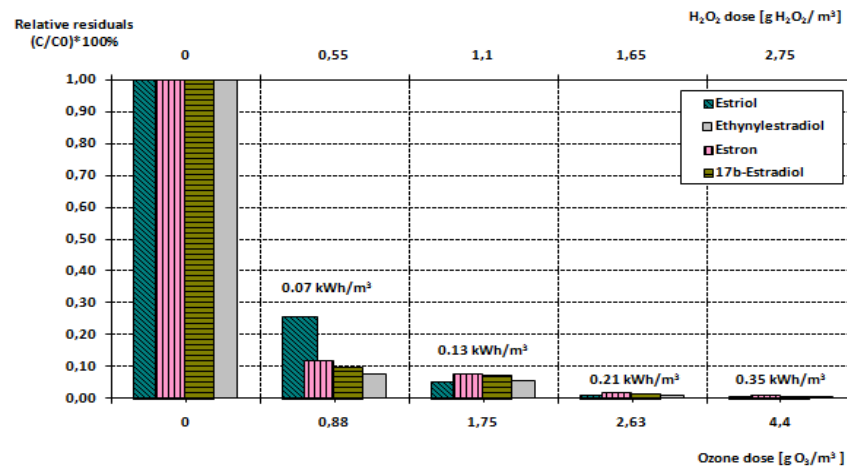
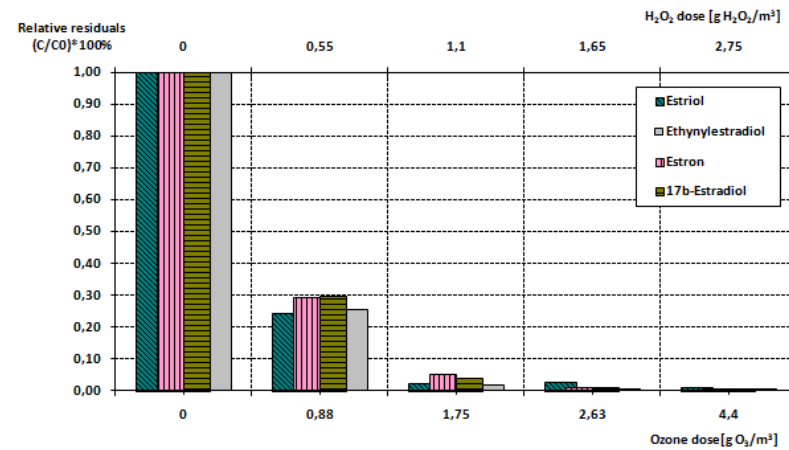
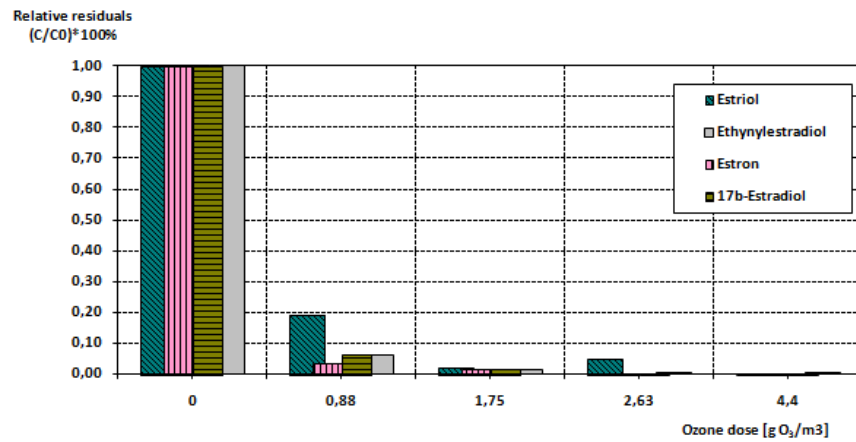
- TCB and E. coli – removal within 20 minutes (8,3 g O₃/m³)

AOPs combinations – higher efficiency for microbes removal not proven

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Estrogen hormones removal – overview of AOPs tested



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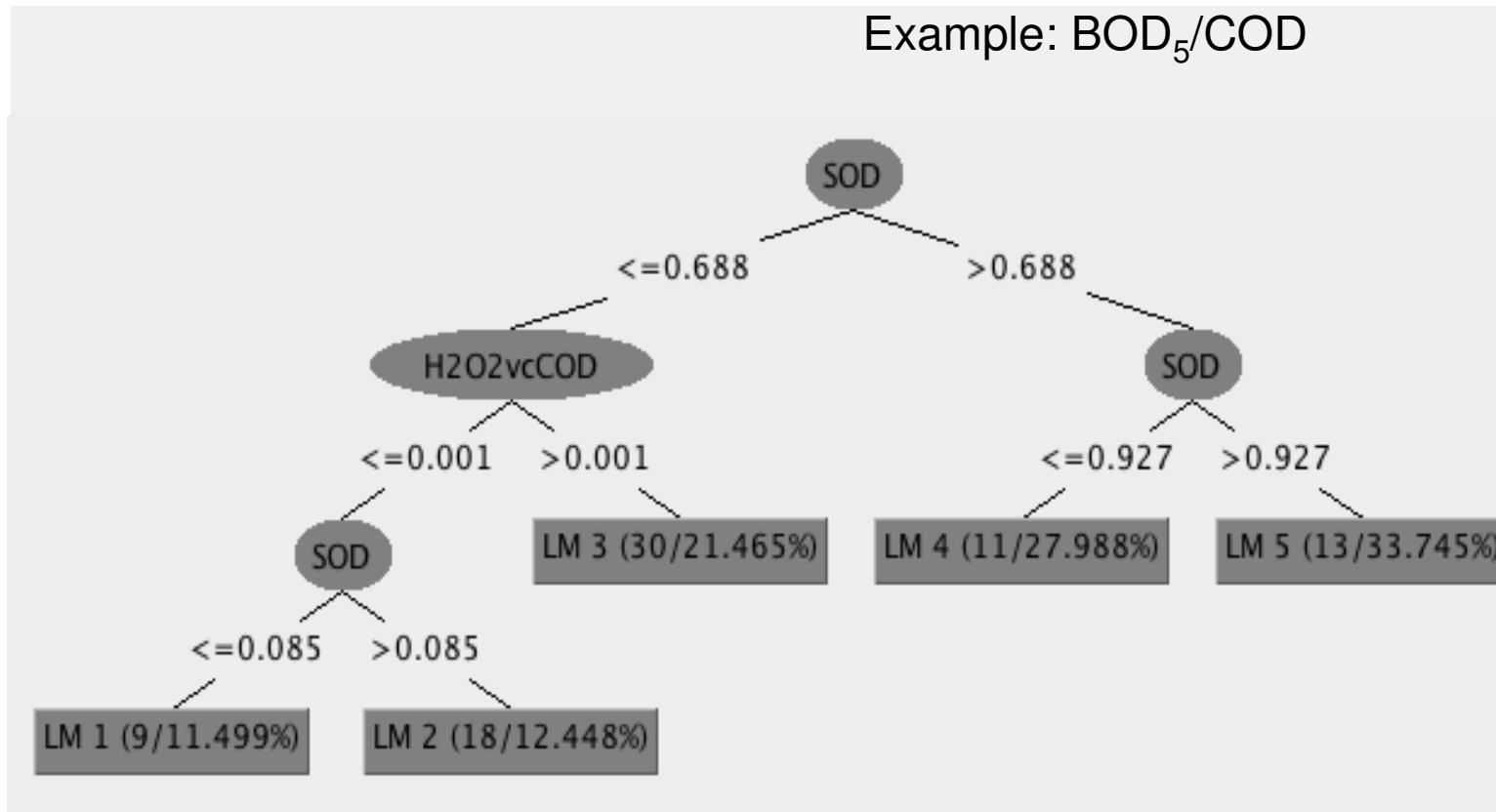
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Results of modelling with Weka

Construction of different ML models

Example: BOD₅/COD



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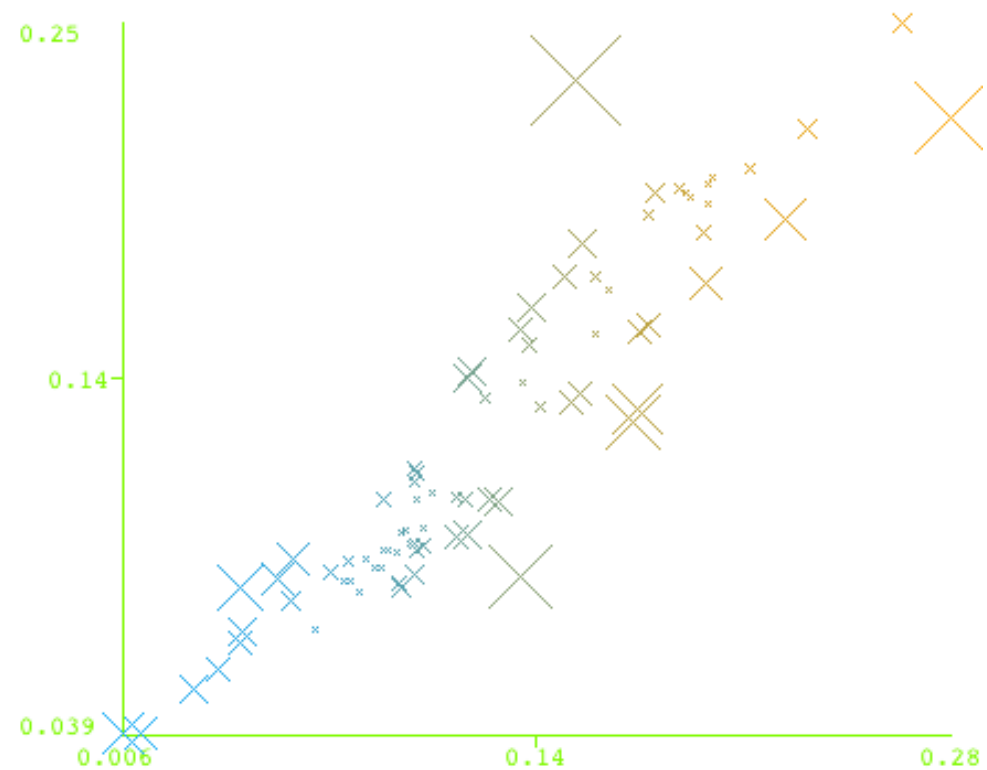
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Example: BOD₅/COD with M5P Model Tree

Rule: 4

$$\begin{aligned} \text{BODvsCOD}_r = & \\ & 0.1283 * \text{SOD} \\ & + 0.0135 * \text{UVvsCOD} \\ & + 0.0287 * \text{H2O2vcCOD} \\ & + 0.0054 * \text{CODvsDOC}_i \\ & - 0.4014 * \text{BODvsCOD}_i \\ & + 0.0493 \end{aligned}$$

Correlation coefficient
0.9295

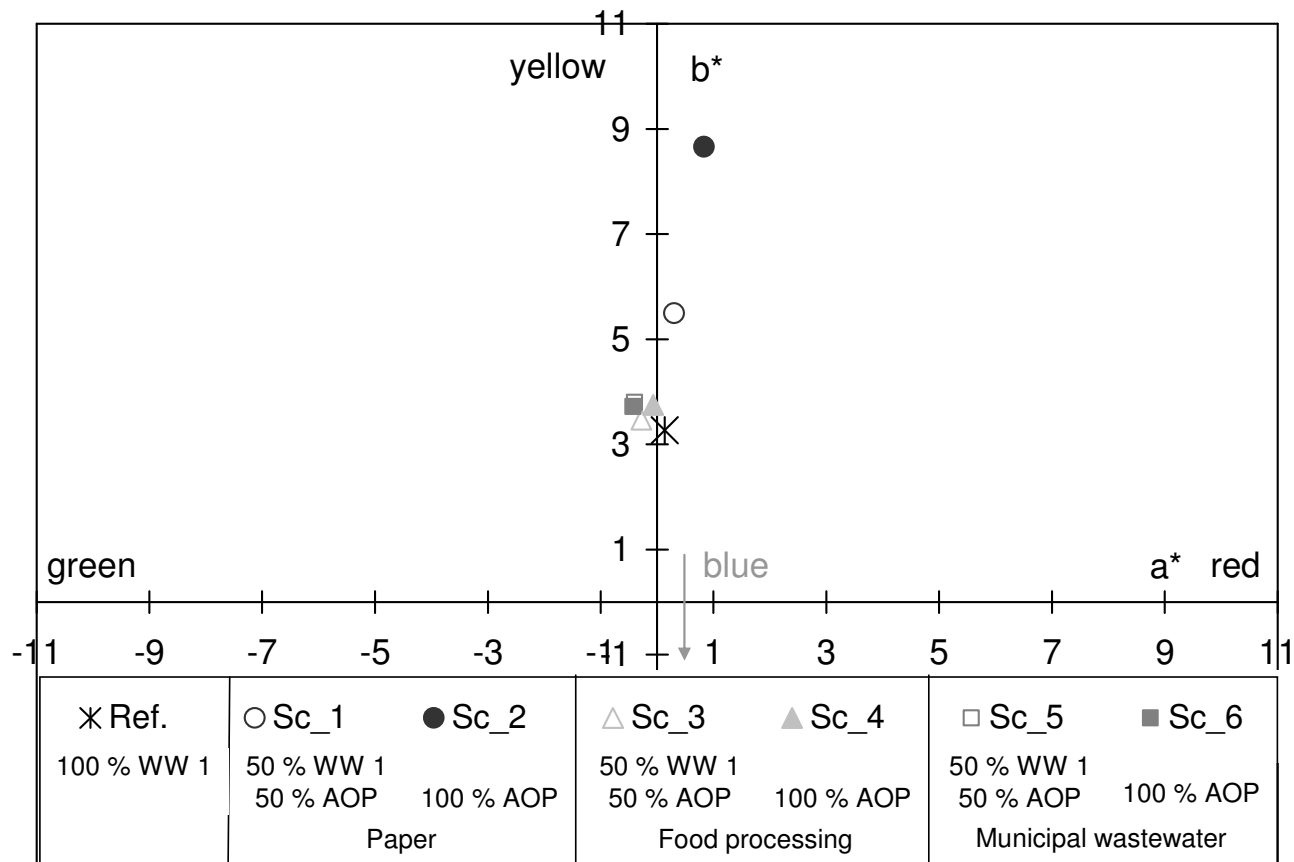


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Vpliv uporabe AOP očiščene vode na barvo papirja

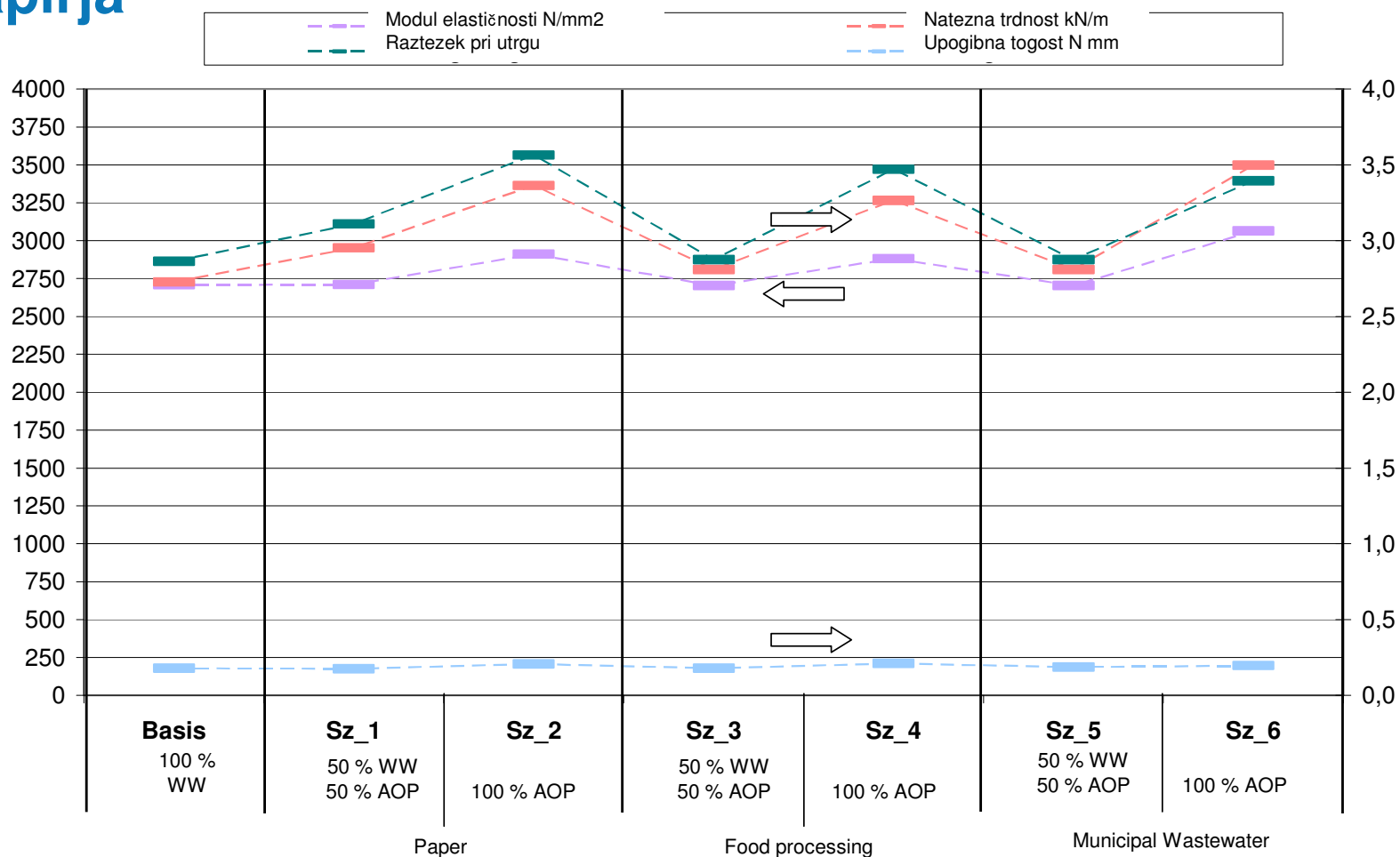


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Vpliv uporabe AOP očiščene vode na mehanske lastnosti papirja



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Vpliv uporabe AOP očiščene vode na beljenje in barvanje tekstila

Bleaching tests

H₂O₂ 35 % 5 hours at 80 ° C at pH 9 - **Unbleached cotton**.

Bleaching before light dye, no need if dark color

Check pH stability before and after bleaching

CIE whiteness at daylight (ISO11475 :2004)	CIE
Control tissue A (no bleaching)	21.33
Control tissue B (no bleaching)	20.61
Bleached with agro food treated water A	37.60
Bleached with agro food treated water B	37.98
Bleached with textile 2 treated water A	58.29
Bleached with textile 2 treated water B	58.04
Bleached with textile 1 treated water A	57.89
Bleached with textile 1 treated water B	57.58
Bleached with paper mill treated water A	28.22
Bleached with paper mill treated water B	27.64
Bleached with tap water A	57.31
Bleached with tap water B	57.78

0 black
100 white

} Duplicate comparable:
uniform bleaching

Treated water

- from textile = as tap water
- from agro food - paper = not for bleaching (color, hardness, particles), only re-used for dark dyes.

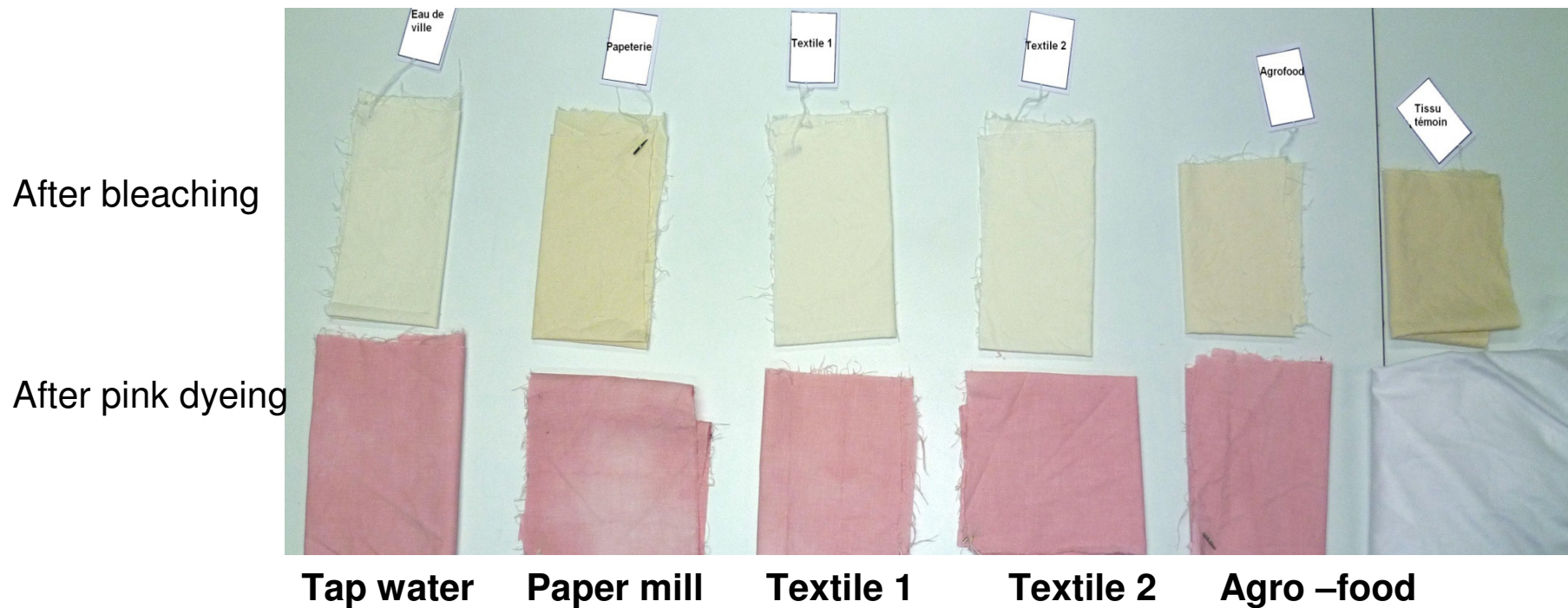
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Light dyeing test

Light dyeing **pink** with anionic dye – **polyester cotton**



Visual score:

3.5

2

4

4.5

4.5

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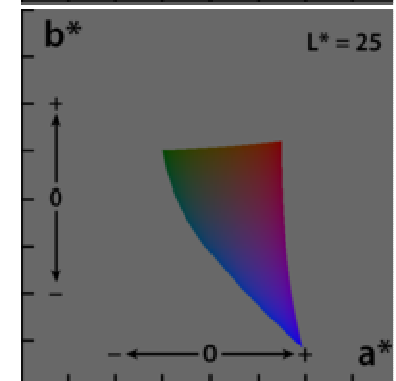
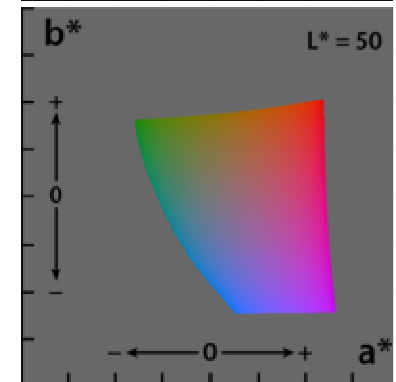
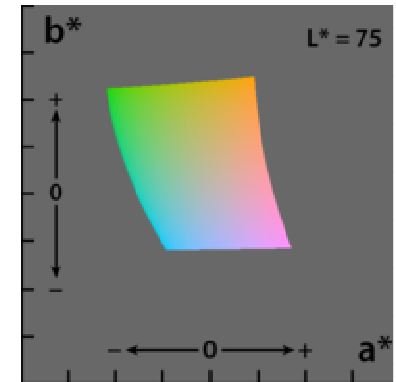
3. Light dyeing test

Colorimetric Lab test: L for lightness and **a** and **b** for the color-opponent dimensions

Tissue	L*	a*	b*
Tissue dyed with agro food treated water A	81.26	19.9	-5.99
Tissue dyed with agro food treated water B	81.34	19.74	-5.89
Tissue dyed with textile 2 treated water A	82.06	19.54	-6.7
Tissue dyed with textile 2 treated water B	81.6	20.14	-6.35
Tissue dyed with textile 1 treated water – Extreme pink A	80.73	20.18	-5.02
Tissue dyed with textile 1 treated water – Extreme pink B	80.83	19.91	-4.8
Tissue dyed with textile 1 treated water – Extreme white A	83.2	18.02	-5.36
Tissue dyed with textile 1 treated water – Extreme white B	83.57	17.64	-6.09
Tissue dyed with paper mill treated water – Extreme pink A	78.26	20.48	-4.59
Tissue dyed with paper mill treated water – Extreme pink B	79.51	20.26	-5.01
Tissue dyed with paper mill treated water – Extreme white A	85.48	13.64	-4.79
Tissue dyed with paper mill treated water – Extreme white B	85.19	13.96	-5.49
Tissue dyed with tap water – Extreme pink A	80.65	20.23	-5.1
Tissue dyed with tap water – Extreme pink B	81.3	19.99	-5.17
Tissue dyed with tap water – Extreme white A	82.35	18.51	-5.71
Tissue dyed with tap water – Extreme white B	82.5	18.69	-5.54

Uniform dye:
2 measurements

Non-Uniform dye:
4 measurements



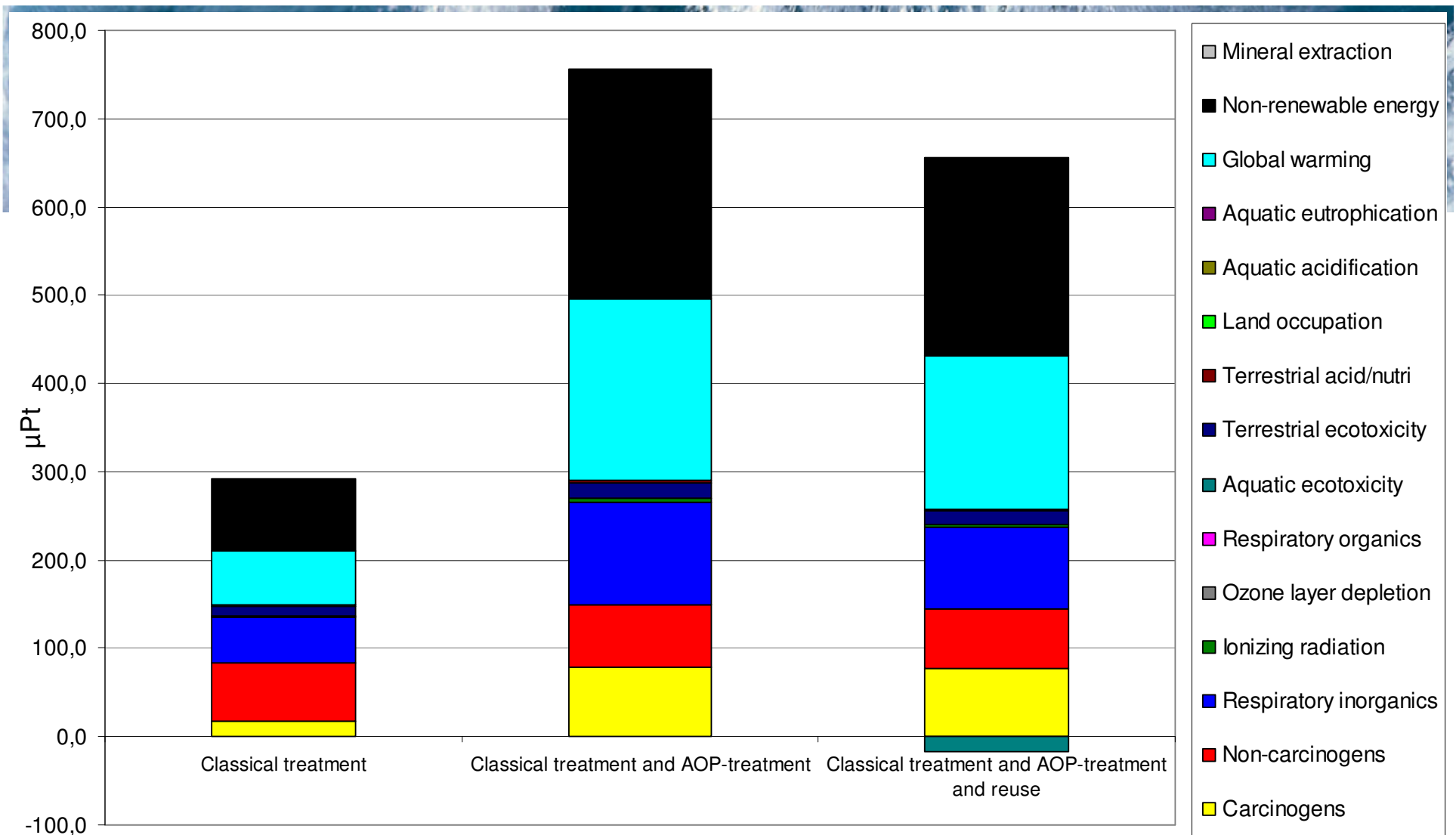
For light dyeing: tap water not the best uniform pink color

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- Important step in textile process = **bleaching = preliminary step for light dyeing**
- Different treated waters = different advantages depending on their use
 - For **bleaching tests** : good results for tap and textile water.
 - For **light dyeing**: agro food water and textile 2
 - For **bleaching + light dyeing**, AOP treated textile water 2 the best.
 - For **dark dyeing**, all treated waters ok.
- If **dark dyeing**, all treated waters ok. Characteristics needed:
 - stable pH with T
 - soft water (hardness precipitates the soap during washing).
 - few ions in solution
 - no heavy metals (catalyzer of bleaching, risks for tissues and human health)



The impact on the environment is more than doubled BUT the quality is higher!

If the treated water can be reused, 1 m³ of fresh water is avoided and the environmental impact is lower

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Zaključki

- ✓ Kombinacije O_3 in H_2O_2 , UV ter kavitacije bolj učinkovite kot samo ozon (izjema papirna industrija)
- ✓ Najbolj učinkovita kombinacija: O_3 + UV + biološka faza
- ✓ Z uporabo ozona smo zvišali razmerje BPK/KPK – težko biološko razgradljive snovi so postale lažje biološko razgradljive
- ✓ AOP očiščena odpadna voda iz vseh treh preiskovanih industrijskih sektorjev in AOP očiščena komunalna odpadna voda sta primerni za ponovno uporabo v proizvodnem procesu tekstilne in papirne industrije

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HVALA ZA POZORNOST!