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Bio-recalcitrant Pollutants Removal from Wastewater with Combination of the Fenton Treatment and Biooxidation

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Introduction

The pollution load to the water bodies in Estonia was constantly decreasing during last 20 years. However, the total values characterizing the pollution load in year 2013 remained notable:

814 tons of BOD_7 6650 tons COD

2461 tons of suspended solid 1228 tons of N_{total}

66.4 tons of P_{total} were discharged into receiving water bodies.

Some industrial wastewaters in Estonia contain considerable amount of organics that are totally refractory to biotreatment or their biotreatment efficacy is quite low.

The biodegradability of wastewater could be enhanced by introduction of chemical oxidation or other chemical-physical processes as an additional step in wastewater treatment schemes.

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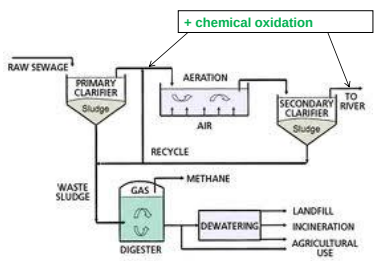
Conventional wastewater treatment – biotreatment



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Objective of the study

To develop strategies for implementation of combined chemical and biological treatment: upgrade the classical wastewater treatment scheme (primary settling – aerobic biotreatment – secondary settling – anaerobic biotreatment of sludge) introducing the chemical treatment step for degradation of recalcitrant organics, improvement of biodegradability and wastewater purification degree, and, thus, lowering total pollution load.

The target was to remove over 80 % of organic load (COD) and improve other wastewater characteristics at least by 50 %.

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Chemical treatment

Coagulation (iron- or aluminum salts)

Fenton-process

$Fe^{2+} + H_2O_2 \rightarrow Fe^{3+} + HO\bullet + HO^-$ (1)

$Fe^{3+} + H_2O_2 \rightarrow Fe^{2+} + HO_2\bullet + H^+$ (2)

Persulphate

$S_2O_8^{2-} + 2e^- \rightarrow 2SO_4^{2-}$ (3)

$S_2O_8^{2-} + \text{activator} \rightarrow SO_4\bullet^- + (SO_4\bullet^- + SO_4^{2-})$ (4)

Ozonation (O_3)

Direct reaction with ozone (acidic conditions)

Reaction with (hydroxyl)radicals (basic conditions)

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Tabel 1. Main Characteristics of Studied Wastewaters

Parameters	Municipal landfill leachate (MLL); landfill operated since 2003	Hardwood soaking basin wastewater from plywood industry (PWW)	Leachate from oil shale processing semicoke landfill area (SCL)	Discharge limits set by Estonian legislation
COD, mg/L	5900-15700	5100-7800	1000-2100	125 (250; 1250)
BOD_7, mg/L	3100-10970	1600-3500	175-196	15 (125)
Recalcitrant COD, %	15	7	15	
Total nitrogen, mg/L	710-2000	11-69	10-42	10-60 (75)
Total phosphourus, mg/L	19	33-60	40-42	0.5-2
Inhibition of oxygen consumption, I_{50}%	No	25.5	No->20	
Inhibition of nitrogen consumption, I_{50}%	5.9	17	16	

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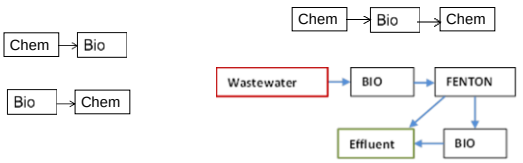
The treatment schemes tested:



Chemical (the Fenton) Treatment
High potential for degradation (mineralisation) of organics

Biological Treatment
Sustainable, cheap and efficient when operating under suitable conditions

The target is high efficacy and low (acceptable) cost!

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The Fenton treatment

Cost of the chemicals 4-25 EUR/m³!!!

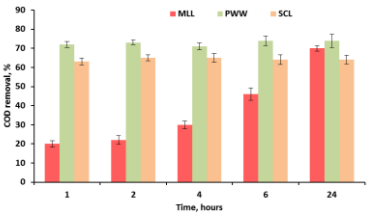

Fig.1. COD removal with the Fenton treatment (MLL – municipal landfill leachate, COD/H_2O_2/Fe^{2+}, g/g/g, 1/3,45/0,7; PWW – pre-coagulated hardwood soaking basin wastewater from plywood industry , COD/H_2O_2/Fe^{2+}, g/g/g, 1/1/0,2; SCL - leachate from oil shale processing semicoke landfill area, COD/H_2O_2/Fe^{2+}, g/g/g, 1/1/0,2).

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Municipal landfill leachate (MLL)

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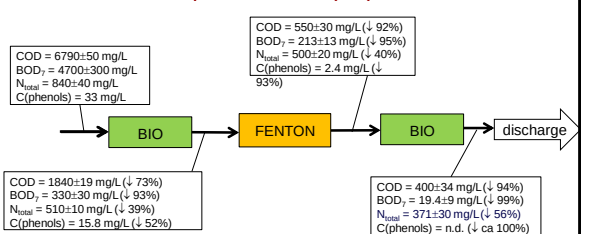
Municipal landfill leachate (MLL)



The cost of the treatment (7.5 €/m³ ↓70 %) compare to 4.33 €/m³ + transportation for the local WWTP

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Hardwood soaking basin wastewater from plywood industry (PWW)

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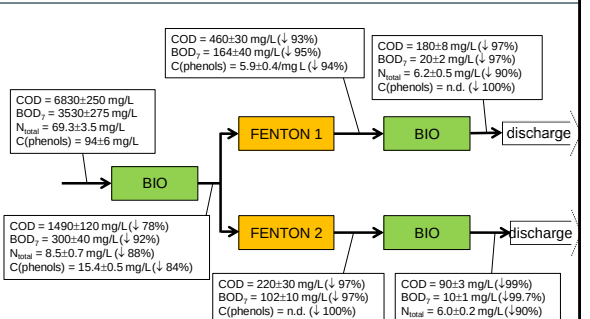

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Leachate from oil shale processing semicoke landfill area (SCL)

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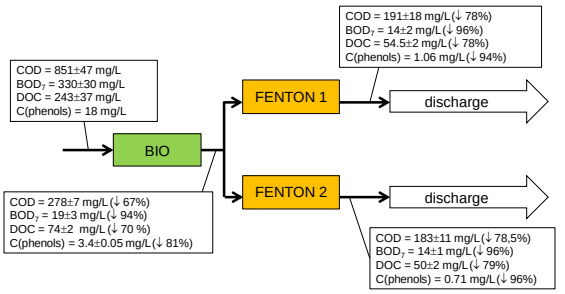

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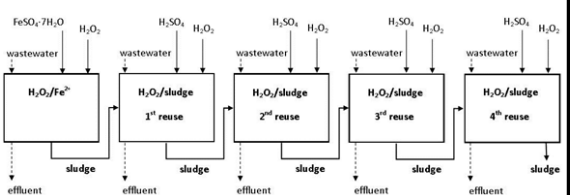
The Fenton-based treatment – sludge reuse



The high efficacy of the iron-containing sludge without any regeneration enables to carry out the Fenton-based treatment waste-free!

More details in Bolobajev et al., *Chemical Engineering Journal*, 2014, 255:8–13.

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BIO-CHEM-BIO scheme has been successfully applied for MLL in pilot scale. The removal efficiency was even higher compared to the lab-scale study.

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Thank you for your kind attention!