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Development and optimization of chemical treatment method for the purification of peat extraction runoff

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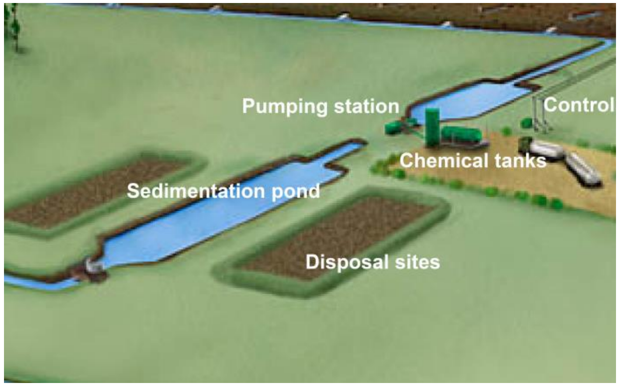
22/05/2014

TOPICS

- **Chemical purification of peat extraction runoff water**
- **Challenges of chemical purification**
- **Optimization studies**
- **Results**
  - The influence of variations in runoff water quality in purification efficiency
  - Suitability of organic polymers for the purification of peat extraction runoff water

CHEMICAL TREATMENT

- **Chemical purification** consists on the addition of coagulation/flocculation chemicals used for treatment of water and wastewater;
- Considered by Finnish authorities as one of the BAT for the purification of peat extraction runoff;
- High removal efficiencies of nutrients and DOC are possible;
- High maintenance and control required for good performance. Does not perform well in the winter months (Mostly not applied).



http://old.peatsociety.org/user_files/files/jkl%20seminars%202010/technology/vayrynen_water_treatment11%206%202010.pdf

CHEMICAL TREATMENT: CHALLENGES

Chemical treatment as applied in wastewater treatment plants:

Significant control of process parameters; from incoming water quality, chemical dosages, mixing, flow through units, retention time, etc.

High purification results are achieved but it is very expensive!

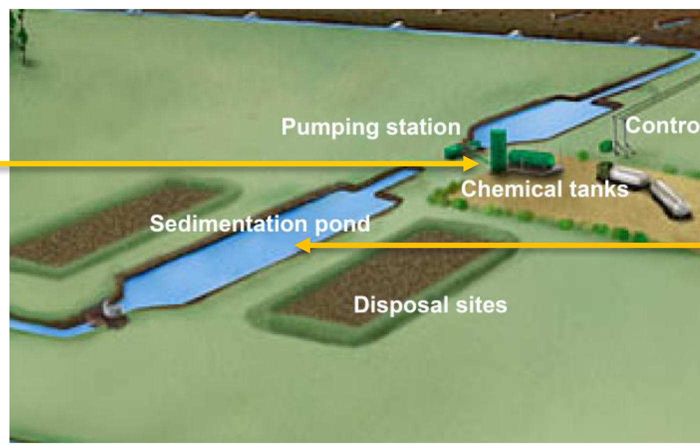
https://www.google.fi/search?q=Waste+water+treatment+plants&rlz=1C1SKPL_en-gbFI486FI486&espv=210&es_sm=93&tbm=isch&tbo=u&source=univ&sa=X&ei=ORfhUrbUO8uIyAPEr4C4Bw&ved=0CC0QsAQ&biw=1366&bih=667

CHEMICAL TREATMENT: CHALLENGES

Simplified structure

In the purification of peat extraction runoff, cost effectiveness can only be achieve if the chemical treatment method is applied in its simplest configuration.

As a result of this configuration, purification levels suffer with the lack of control and optimization of critical parameters such as dosage, mixing, retention time, etc.



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CHEMICAL TREATMENT: CHALLENGES

Variations in runoff water quality

Due to the geochemistry, hydraulic and hydrological characteristics of peat soils, as well extraction activities, the quality of peat extraction runoff water is known to oscillate with time, location and also with variations in runoff and peak discharge occurrences.

Oscillation in runoff water quality result in significant variations in purification efficiency hence the adaptation of treatment process parameters such as retention time and dosage in response to these oscillations is a difficult, costly and in most cases not a feasible task.

CHEMICAL TREATMENT: CHALLENGES

Other challenges:

- **Low water temperatures have a detrimental effect on purification results;**

- **Treatment with metal salt coagulants result in discharging waters with low pH and high metal residual;**

- **Purification requirements established in % removal.**

  High % removals for highly polluted waters are easily achieved while the removal of pollutants for only slightly polluted water is difficult, costly and might prove environmentally undesirable.

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DEVELOPMENT AND OPTIMIZATION OF THE CHEMICAL PURIFICATION METHOD

- Evaluation of metal salt coagulants (Laboratory);
- Optimization of process parameters for best performing coagulants (Laboratory);
- **Evaluation of chemical treatment response to variations in runoff water quality (Laboratory);**
- **Evaluation of the suitability of alternative coagulants (organic polymers - Laboratory);**
- Evaluation and optimization of hydraulic conditions within treatment facilities (water sampling, field measurements, CFD modelling, development of design improvements);
- etc.

EVALUATION OF CHEMICAL TREATMENT RESPONSE TO VARIATIONS IN INCOMING WATER QUALITY USING A FULL 2^K FACTORIAL TEST DESIGN

(Collaboration with Tiina Leiviskä – Chemical process engineering)

- 2^4 (e ... els); Labo
- The ... and coag
- Leve ... f monitoring data. Dosage levels selected via dosage requirement tests;

Factor	Level	
	Low	High
COD (mg/L)	20	70
SS (mg/L)	10	60
pH	4.5	7
Dosage (mg $Fe_2(SO_4)_3$ /L)	35	100

EVALUATION OF CHEMICAL TREATMENT RESPONSE TO VARIATIONS IN INCOMING WATER QUALITY USING A 2^4 FACTORIAL TEST DESIGN

Samples	Controlled factors		
	COD (mg/L)	SS (mg/L)	pH
1	L	L	L
2	H	L	L
3	L	H	L
4	H	H	L
4	L	L	H
6	H	L	H
7	L	H	H
8	H	H	H

- Natural water san ted (dilution, centrifugation, ba les with the required water qu

- 8 samples were c and low level of COD, SS a urified with the low and high runs (3 replicates)

- Evaluation of purification results:

  Analysis of variance (ANOVA) = significance of factors

  Factors effect determination = magnitude and direction (orthogonal contrasts)

- **Purification = Removal of total phosphorus**

INFLUENCE OF WATER QUALITY (FACTORS) VARIATION IN THE
% REMOVAL OF TOTAL PHOSPHOROUS

Table 1 – Statistical results

	Main factor effect				Interaction effects										
Factor/Factor interaction	COD	SS	pH	DOS	COD SS	COD pH	COD DOS	SS pH	SS DOS	pH DOS	COD SS pH	COD SS DOS	COD pH DOS	SS pH DOS	COD SS pH DOS
F test ANOVA for equality of treatment means: F0	3055	217	4	2744	3	0.06	2650	15	19	3	0.1	6	0.2	9	2
Significance: α	.000	.000	.055	.000	.095	.816	.000	.000	.000	.107	.730	.024	.696	.006	.193
Contrast - Factors effect tot-P removal	**-40**	11	-1	**38**	-1	0	**37**	3	-3	1	0	-2	0	-2	-1

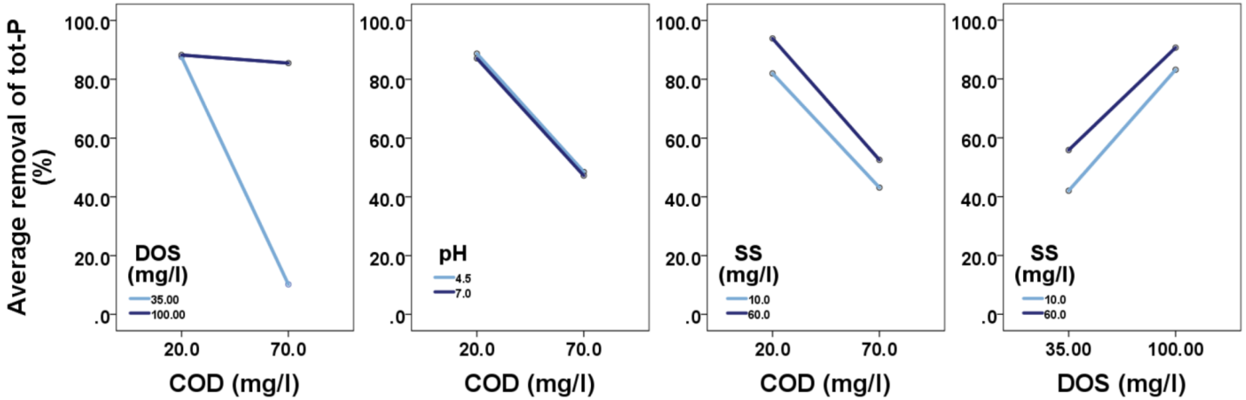

Figure 1. Influence of main factors (COD, SS, pH and DOS) and factors interaction on tot-P removal.

INFLUENCE OF WATER QUALITY (FACTORS) VARIATION IN THE % REMOVAL OF TOTAL PHOSPHOROUS

Conclusions

- The % removal of tot-P was found to be:

- Significantly influenced by the COD concentration of the sample and applied coagulant dosage. The interaction effect between these 2 factors dominated purification results.

- Overall higher concentration of SS improved tot-P % removal. BUT higher tot-P residuals were observed!

- The effect of initial pH was not significant in the % removal of tot-P.

- COD controls dosage requirements and so dosage adjustments should be based in COD variations.

SUITABILITY OF ORGANIC POLYMERS IN THE PURIFICATION OF PEAT EXTRACTION RUNOFF

(COLLABORATION WITH TIINA LEIVISKÄ – CHEMICAL PROCESS ENGINEERING)

Aims and methodology

Compare the performance of selected organic polymers to the widely used metal salt coagulant Ferric sulphate.

Table 2. Characteristics of tested coagulants

Coagulant	Molecular weight	Dry solids	Charge density
C587 PolyDADMAC (liquid)	200 000 g/mol	20 %	Cationic 6 meq/g (dry solids)
C567 PolyAmine (liquid)	10 000 g/mol	50 %	Cationic 7 meq/g (dry solids)
Coagulant	**Density**	**% $Fe_2(SO_4)_3\,nH_20$**	**Active substance**
Ferric sulphate (PIX 115) (liquid)	1550 kg/m^3	42 %	2.1mol/Kg

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SUITABILITY OF ORGANIC POLYMERS IN THE PURIFICATION OF PEAT EXTRACTION RUNOFF

Aims and methodology

Runoff water was collected from **Kurkisuo** peat extraction site in Suonenjoki.

Experimental design was based on jar test procedure

Figure 2. Jar test equipment

Table 3. Water quality characteristics

Water quality Parameters	Mean ± Std. dev
TOC (mg/l)	30.7 ± 0.9
SS (mg/l)	20.8 ± 5.2
tot-P (µg/l)	74.7 ± 4.6
PO_4-P (µg/l)	44.2 ± 5.9
tot-N (mg/l)	2.2 ± 0.4
Fe (mg/l)	6.7 ± 0.49
Al (mg/l)	0.9 ± 0.19
pH	6.2 – 6.7 (range)

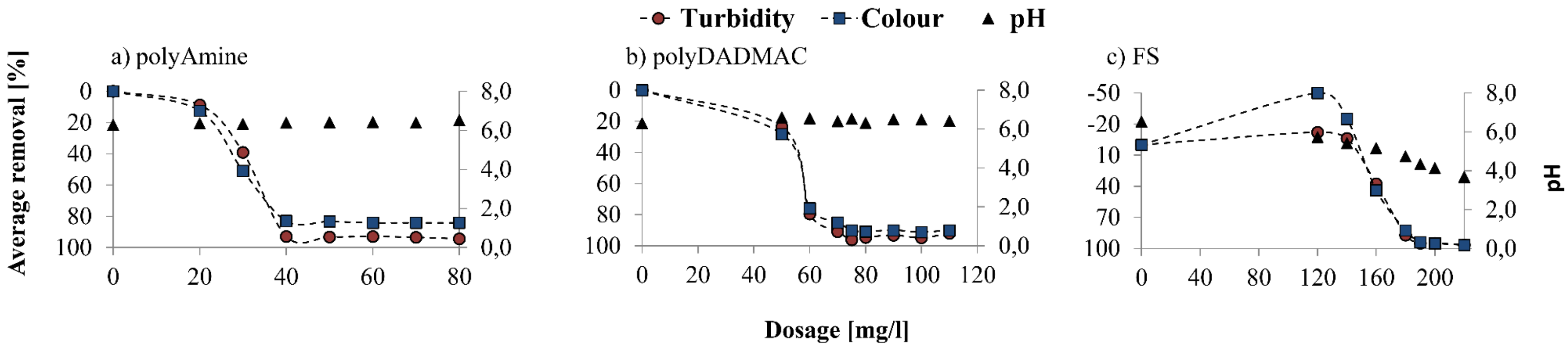

Figure 3. Removal of turbidity and colour with increasing dosages of coagulants and resulting water pH.

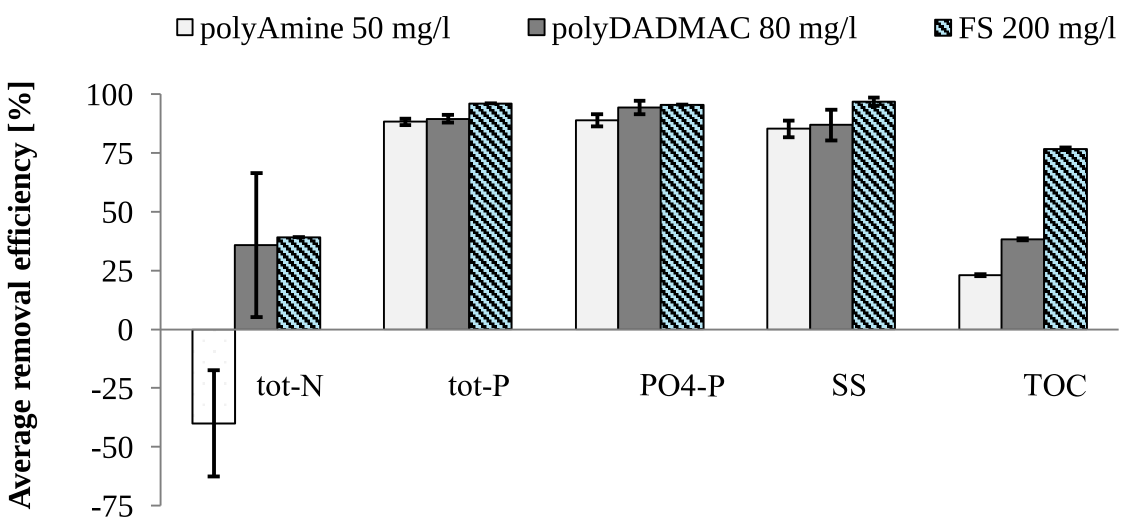

Figure 4. Average removal efficiency achieved by the optimum dosages of tested coagulants

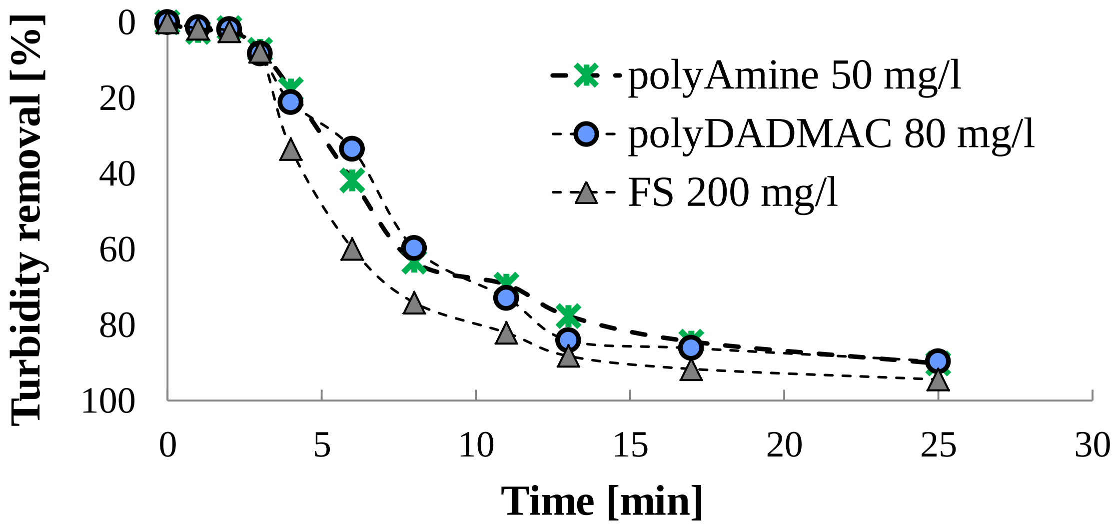

Figure 5. Settling characteristics of formed flocs (removal of turbidity with time).

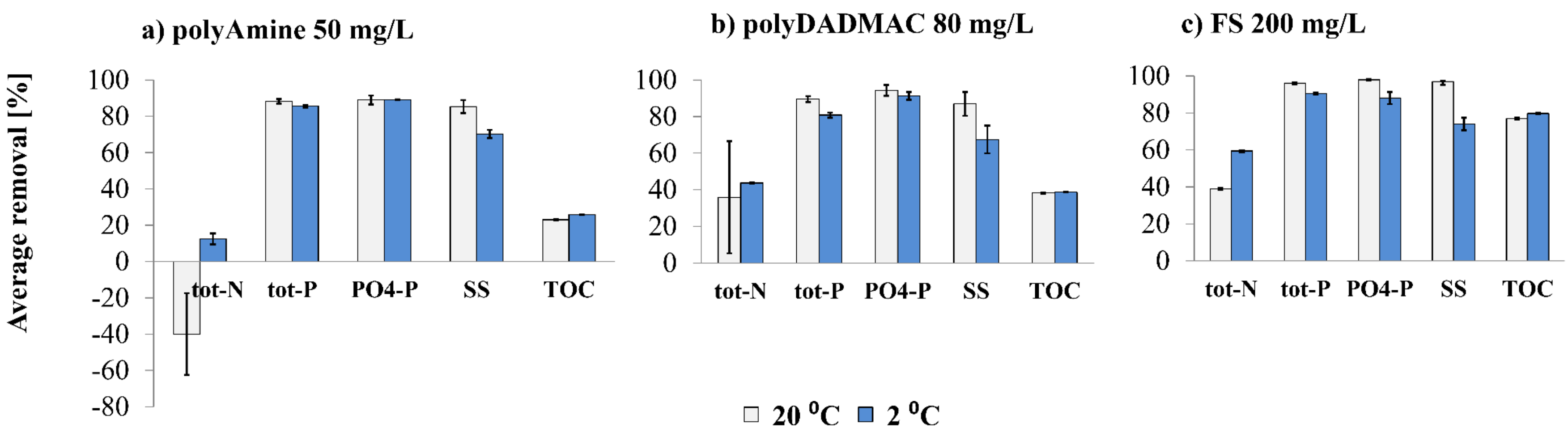

Figure 6. Average removal efficiency achieved by the optimum dosages of tested coagulants

Conclusions

Organic polymers have the **potential** to replace metal salts as **primary coagulants** in the treatment of peat extraction runoff.

However, further research is necessary where products with varying CD and MW are evaluated with the objective of achieving higher organic matter removal. Cost/benefit and practical handling aspects also need to be addressed.

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Acknowledgements

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Finnish Environmental Institute (SYKE)
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