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THE USE OF ORGANIC POLYMERS AS COAGULANT AGENTS IN THE CHEMICAL PURIFICATION OF PEAT DERIVED RUNOFF WATER.

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SUMMARY

Peat extraction activities such as drainage and the exposal of peat layers are known to increase the leaching of pollutant substances resulting in the eutrophication and siltation of receiving water bodies, causing water quality deterioration. The effective treatment of discharging waters is therefore of fundamental importance. This study aims to develop the chemical purification of peat derived runoff water via application of organic polymers as coagulant agents in the treatment process. Obtained results show that organic coagulants, polyDADMAC and polyamine achieved fairly high purification levels (average: 90 % tot-P, 92% PO_4-P, 85% SS and 31% TOC). Furthermore, they required consecutively 60 to 75% lower dosages than the tested inorganic coagulant polyferric sulfate.

KEYWORDS: peat runoff water purification, coagulant.

INTRODUCTION

The drainage of peatland areas for peat extraction, agriculture and forestry has caused environmental concerns in several regions of the world including the boreal zone and the tropics with large peat deposits. Peat extraction activities such as drainage and the exposal of peat layers are known to increase the leaching of pollutant substances resulting in the eutrophication and siltation of receiving water bodies, causing water quality deterioration (Heikkinen, 1994; Kløve, 2001; Silvan et al., 2010). Although, in Finland, chemical treatment is considered one of the best available technologies for the purification of peat extraction runoff water (IPS, 2009) little research has been applied on the development of this treatment method for the purification of non-point source pollution. Metal salts of iron and aluminium are currently used in several treatment facilities in peat extraction sites. Nevertheless, variations in runoff water quality and the lack of development of field process parameters led to the application of high coagulant dosages, fluctuations in purification efficiency and high metal concentration in the discharging waters (Heiderscheidt et al., 2012, Manuscript).

Chemical purification is based on the ability of the chemicals to precipitate suspended solids (SS) and dissolved substances present in the water. It consists of three singular but well interconnected processes: coagulation, flocculation and sedimentation. Water quality characteristics (temperature, pH, concentration and type of pollutant substances, etc.) and process parameters (coagulant type and dosage, applied mixing, etc.) are factors known to influence the efficiency of chemical treatment (Gregory and Duan, 2001; Pernitsky and Edzwald, 2006). All over the world, due to their low cost and high performance, metal salts of

iron and aluminium are widely used as coagulant agents in the chemical purification of water and wastewater (Gregory and Duan, 2001). Organic polymers cost between 10 and 20 times more than metal salt coagulants and have until recently only been applied as flocculant agents in the clarification and dewatering phases of the purification process. Nevertheless, organic polymers with low to medium molecular weight (MW) and high ionic charges can efficiently replace metal salt coagulants in water and wastewater treatment processes (Bolto and Gregory, 2007). Observed economic advantages such as the reduction of produced sludge and required dosages have been reported to off-set to some extend the higher costs attributed to organic polymers (Bolto and Gregory, 2007).

This study aims to develop the chemical purification of peat derived runoff water via application of organic polymers as coagulant agents and thus reduce the environmental impacts related to metal based purification chemicals. Jar-test experiments have been designed to determine the purification efficiency achieved by low to medium MW and high cationic charged organic coagulants (polyamine and polyDADMAC) in the purification of peat derived runoff water.

For a more complete evaluation of the organic polymers performance, an inorganic metal salt coagulant (polyferric sulphate), was also tested. The coagulants dosage requirements and the settling characteristics of the obtained flocs were determined. The purification efficiency achieved by the identified optimum dosages of the tested chemicals was evaluated based on the percentage removal of pollutant substances such as: total organic carbon (TOC); total phosphorous (tot-P); phosphate phosphorous (PO_4-P); total nitrogen (tot-N) and SS.

METHODOLOGY

Water sample (Table 1) was collected in December 2011 from Kurkisuo peat harvesting site in Suonenjoki, Finland.

Table 1. Water quality characteristics (n = number of analyses)

pH	6.2 – 6.7 (range)	6
SS [mg/l]	24.8 ± 6.4	4
tot-N [µg/l]	2300 ± 294	4
tot-P [µg/l]	74.8 ±5.6	4
PO_4-P [µg/l]	42 ± 9	4
TOC [mg/l]	30 ±1	4

Jar tests were performed using the six jars programmable paddle stirrer equipment Flocculator 2000 (Kemira Kemwater). Applied mixing parameters were: 300 rpm for 10 s followed by 25 min at 50 rpm and 30 min of sedimentation. Three commercial quality coagulants were studied (Table 2). The purification efficiency achieved by the tested chemicals was firstly monitored and evaluated in laboratory via measurements of colour, turbidity, pH and temperature. Samples (2 replications) of the water purified with the coagulants optimum dosages were then selected and sent for further analyses (Table 3) after a total of 45 min of sedimentation. Supernatant water samples (2 replications) were collected at constant jar depth and at pre-determined time intervals during the sedimentation period for subsequent turbidity analyses.

Table 2. Characteristics of tested coagulants

Product	Chemical type	Characteristics	Manufacturer	Density (g/cm^3)
Coagulant Superfloc C-587	Poly(diallyldimethylammoniumchloride) (PolyDADMAC)	Liquid Medium MW, high relative cationic charge	Kemira Oyj, Kemwater	1.03-1.05
Coagulant Superfloc C-567	Epichlorohydrin-dimethylamine-copolymer (Polyamine)	Liquid Low MW, high relative cationic charge	Kemira Oyj, Kemwater	1.14-1.18
Coagulant PIX-115	Polyferric sulphate	Liquid Pre-hydrolysed	Kemira Oyj, Kemwater	1,50-1.56

Table 3. Water quality analyses performed and utilized standard methods

Analyses	Abbreviations	Standard
Total organic carbon	TOC	SFS-EN 1484:1997
Total nitrogen	tot-N	SFS-EN ISO 11905-1:1998
Total phosphorous	tot-P	In-house method 51b, FIA method
Phosphate phosphorous	PO_4-P	In-house method 55b, FIA method
Suspended solids	SS	SFS-EN 872:2005

RESULTS

Dosage requirements

The dosage requirements of tested coagulants differed greatly (Fig. 1). Polyferric sulphate (PFS) required considerably higher (60-75%) dosages than polyDADMAC (pDADMAC) and polyamine (pAMINE) to achieve similar removal efficiencies of colour and turbidity. All coagulants achieved very high turbidity removal (up to 95%) when dosages in the optimum range were applied. PFS presented slightly higher removal of colour (95%) than the organic coagulants (85 – 90%). The pH of the purified water decreased significantly with increasing dosages of PFS while no variations in pH values were observed for samples treated with organic coagulants. The coagulant dosage that produced the best removal of colour and turbidity and the lowest variations between experiment replications was selected as the coagulant optimum dosage. The coagulants optimum dosages were identified as follow: PFS 200 mg/l, pAMINE 50 mg/l and pDADMAC 80 mg/l.

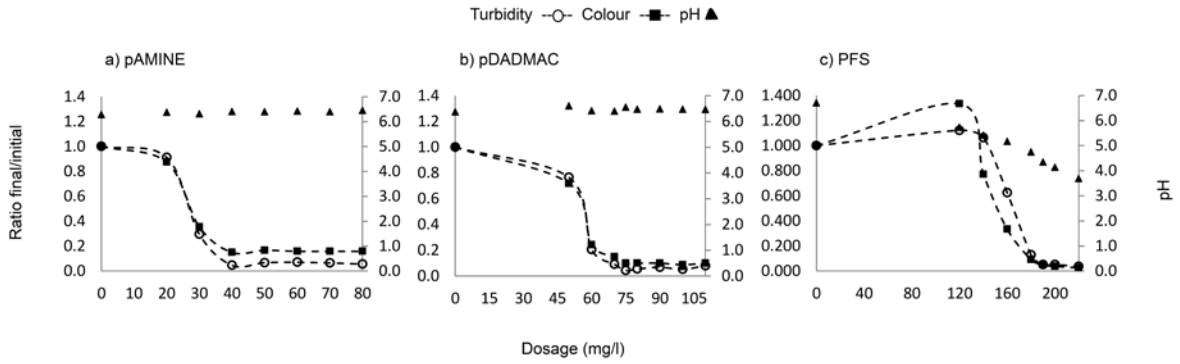

Fig. 1. Removal of turbidity and colour with increasing dosages of coagulants and purified water pH. Organic coagulants: (a) pAMINE and (b) pDADMAC. Inorganic coagulant (c) PFS.

Purification efficiency

The overall purification efficiency achieved in the samples treated by the coagulant's optimum dosages was generally high (Fig. 2). PFS achieved higher purification efficiencies than the organic coagulants however, at significant higher dosages. The most significant difference in purification levels was observed for the removal of TOC where PFS achieved over 75% removal efficiency while pAMINE and pDADMAC achieved consecutively 25 and 38%. High removals of tot-P, PO_4-P and SS were achieved by all coagulants with PFS outperforming the organic coagulants by narrow percentages. Samples treated with pAMINE presented an increase in nitrogen concentration while pDADMAC and PFS removed about 40% of the tot-N present in the water. Among the organic coagulants, pDADMAC performed slightly better than pAMINE especially in the removal of TOC and tot-N, it required nevertheless 40% higher dosages than pAMINE.

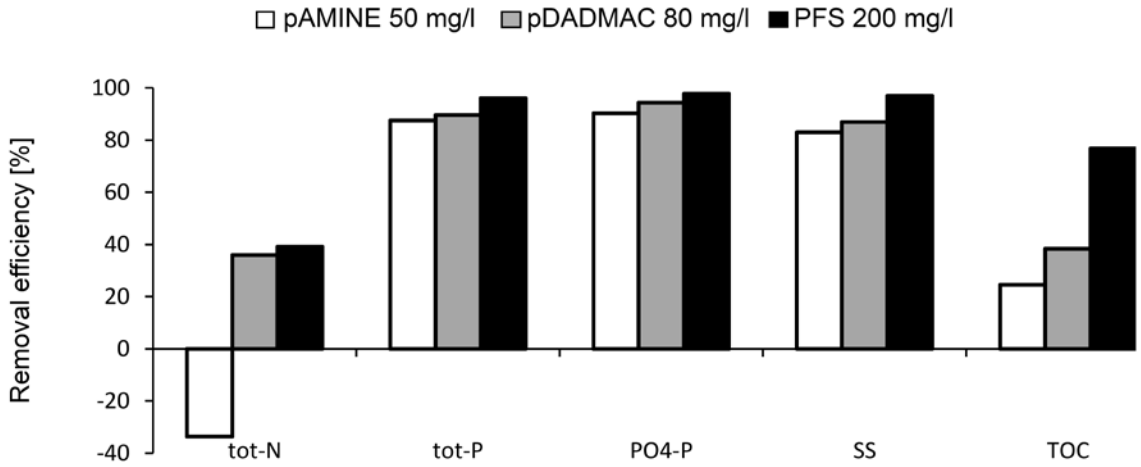

Fig. 2. Average purification efficiency achieved by the optimum dosage of tested coagulants.

Settling characteristics

The coagulant's settling characteristics represent their ability to produce, under the applied process parameters, suitable flocs which will provide short sedimentation time and clarified supernatant water. Among the tested coagulants PFS presented the fastest sedimentation rates (Fig. 3) reaching 60% turbidity removal or Tt/Ti = 0.4 after 6 min of sedimentation while pAMINE and pDADMAC required about 8 min. The organic coagulants presented very similar settling characteristics. pAMINE performed slightly better in the first and most intensive period of settling, from zero to 8 minutes, while pDADMAC presented slightly faster settling rates between 10 and 20 min.

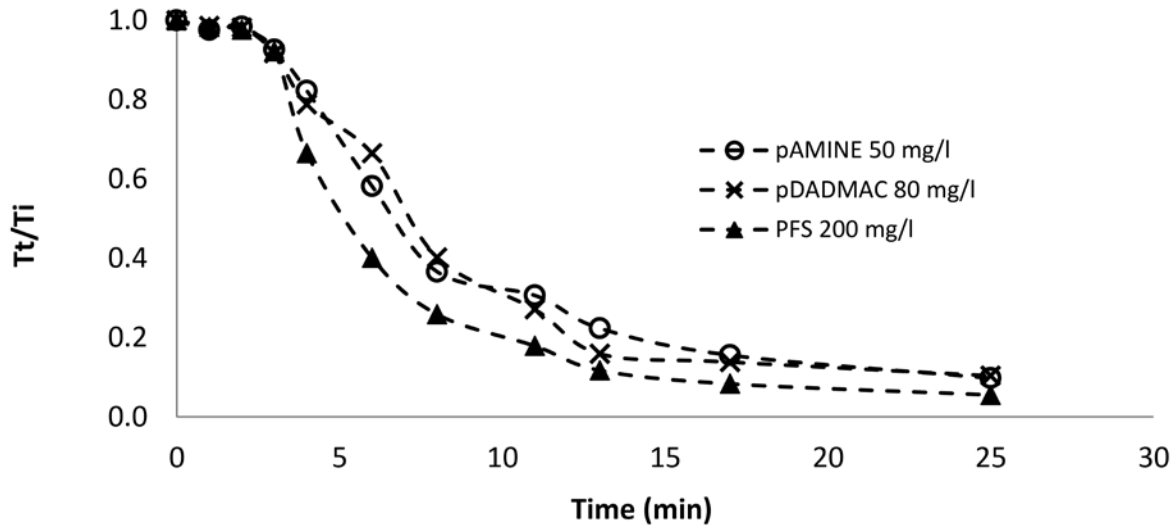

Fig. 3. Settling characteristics of tested coagulants at their identified optimum dosages.

CONCLUSION

Overall the purification efficiency achieved by the organic coagulants was high (90 % tot-P, 92% PO_4-P, 85% SS and 31% TOC) and in agreement with the purification levels expected from chemical treatment of peat harvesting runoff water. Furthermore organic coagulants required up to75% lower dosages than PFS. Among the organic coagulants pDADMAC achieved slightly better removal efficiencies although it required higher dosages (80 mg/l) than the pAMINE (50 mg/l). Further analyses are required to evaluate the increase in nitrogen concentration in samples treated with pAMINE.

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