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OIL REMOVAL USING PEAT FILTERS

Öljyn poisto turvesuodattimella

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The use of peat for the treatment of oil-in-water emulsions is gaining attention as a simple, economical means of environmental protection. The horticultural peat produced by Premier Peat Company Limited was assessed for its potential in removing oil from five representative oil-in-water emulsions of different stabilities. The emulsions were passed through a 300 mm peat filter bed at a flow rate of 12, 48 and 300 ml/min. Each test was conducted for 8 hours of continuous filter run. The results indicated that an average oil removal efficiency ranging from 34 to 99% can be obtained in a peat filter depending upon the flow rate and the type of oil-in-water emulsions.

Key words: Adsorption, filtration, oil-in-water emulsion, oil pollution, peat

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INTRODUCTION

Peat besides being plentiful and relatively cheap possesses several characteristics that makes it an ideal medium for treating different wastewaters. D'Hennezel and Coupal (1972) found peat effective in the removal of oil from oil-in-water emulsions. They indicated that peat moss absorbs up to 8 times its weight of oil. Ekman and Asplund (1975) reported that peat rendered hydrophobic by heat treatment compared very favourably with other oil-sorbing agents made of plastic, mineral wood, volcanic glass and the wood hydrolysis waste. Smith and Mark (1976) indicated that both dried and sulfuric acid-treated peat can efficiently remove oil from wastewater. The average oil removal capacity of activated/modified peat was reported to be 83 to 97 percent compared to 89 to 97 percent for a synthetic adsorbent. Asplund et al. (1978) observed that medium humified and adequately heat-treated peat was suitable as a filtering medium for treating oily waters. The efficiency of oil removal was reported to be 98 percent using 0.5 to 0.2 m thick peat bed and the oil binding capacity was found to be one to two kg oil per one kg of peat for commercial sorbing peat and 3.4 kg oil per one kg of peat for more effectively heat-treated peat. Environment Canada (1983) conducted experiments on the oil-binding capacity of various commercially available organic, inorganic and synthetic sorbents and the oil binding capacity of peat moss was reported to be 8:1 to 12:1 by weight.

The present study was conducted to examine the potential of Saskatchewan horticultural peat in removing oil from a variety of oil-in-water emulsions including produced waters. An earlier investigation (Viraraghavan and Mathavan 1988) examined in detail breakthrough column studies with peat and one oil-in-water emulsion using standard mineral oil.

MATERIALS AND METHODS

Peat was characterized for pH, moisture, organic matter, sand and ash contents, for particle size range, grain size distribution and oil holding capacity. The peat was washed and air dried for 24 h and used in a column. The oil-in-water emulsion samples were the following:

1) Medium viscous (130 C_p) standard mineral oil (SMO) marketed by Fisher Scientific Company;

2) Low viscous (50 C_p) midale crude oil (MCO);

3) Cutting oil (CO) collected from the Wascana Technical Institute, Regina;

4) Refinery effluent (RE) collected from the Co-operative Oil Refineries, Regina; and

5) Produced water (PW) collected from petroleum field operations using enhanced oil recovery techniques such as steam flooding.

In the case of synthetic emulsions using standard mineral oil and midale crude oil, a known weight of oil was mixed with tap water in a high speed blender for two hours and allowed to stand for 30 minutes. The floating oil was decanted and the emulsified sample was used in the experiments. The oily components were extracted from the dispersions with carbon tetrachloride and the net absorbances were measured using Beckman IR-11 spectrophotometer, to calculate oil concentrations (Simard et al. 1951, API 1958, Gruenfeld 1973, and American Public Health Association 1986).

Column studies were conducted in a 100 mm diameter 600 mm long cast acrylic pipe. The peat was supported at the bottom using 50 mm gravel packing over a circular perforated horizontal acrylic plate. A 25 mm thick gravel layer was placed on the top of the peat to prevent erosion of the medium from falling droplets. The blended dispersions were kept in a feed tank where the dispersions mixed using a 1/100 HP, 5000 RPM Geriner motor to maintain homogeneity of the dispersion being fed. From this feed tank, the dispersion was pumped and fed into the columns in down-flow mode using a motor generator with a standard Servodyne speed controller. Each cycle of test was conducted for a continuous period of eight hours and 200 ml of influent/effluent samples were collected for carbon tetrachloride extraction and oil measurement every one hour. Three different flow rates of 12, 48 and 300 ml/min were applied to the peat filter.

RESULTS AND DISCUSSION

The characteristics of horticultural peat used in the study are presented in Table 1. The peat has a moisture content of 50–70% and has an oil holding capacity of 7.5 to 7.8 times its weight. The filter effluent oil concentrations at every hour for the 8 hour run for five different oil-in-water emulsions investigated for three different flow rates are presented in Fig. 1 (a to e). The influent and the average effluent oil concentrations and the percentage of oil removal efficiencies using peat for the

Table 1. Characteristics of horticultural peat.

Taulukko 1. Tutkitun kasvuturpeen ominaisuuksia.

Characteristics	Value	Test Method
Particle size range		ASTM D2977-71
(a) Foreign matter	0	
(b) Coarse fibre (>2.36 mm)	14.1%	
(c) Medium fibre (2.36 to 0.85 mm)	26.1%	
(d) Fine (diam <0.85 mm)	59.8%	
pH at 21°C		ASTM D2976-71
(a) In distilled water	6.0	
(b) In $CaCl_2$	5.5	
Moisture content		ASTM D2974-71
(a) Method I	50–70%	
(b) Method II (at equilibrium temp. 21°C)	58.60%	
Sand content	2.6%	ASTM D2975-71
Ash content	4.8%	ASTM D2974-71
Organic matter content	37.5%	ASTM D2974-71
Grain size analysis		ASTM D421-58 & ASTM D422-63
(a) Coefficient of uniformity (D_{60}/D_{10})	3.33–4.4	
(b) Coefficient of concavity [$(D_{30})^2/D_{60} \times D_{10}$]	0.98–1.66	
(c) Effective size (mm)	0.15–0.24	
Oil holding capacity	7.5–7.8	ASTM D1483-60
von Post scale	H5–H6	von Post

various oil-in-water emulsions are presented in Table 2.

The results clearly indicate that for SMO and MCO which are mechanically prepared emulsions, maximum oil removal efficiencies of greater than 96 percent were achieved irrespective of influent oil concentration and flow rates. For CO which is chemically stabilized the efficiency dropped from 96 to 34 percent, when the flow rate was increased from 12 ml/min to 100 ml/min. A flow rate of 300 ml/min of this emulsion could not be applied to the peat bed in view of a build-up of very high water depth over the filter. This indicates the limitations of using peat in treating such chemically stabilized emulsions. In the case of RE, the average effluent concentration ranged from 0.6 to 1.8 mg/1. RE is a stable oil-in-water emulsion of low oil concentrations. This study indicated that for such emulsions, flow rate affected the oil removal considerably and at low rates (12 ml/min), removals were found to be greater than 90 percent.

Two different produced-water samples were used for the study: PW1 with low oil

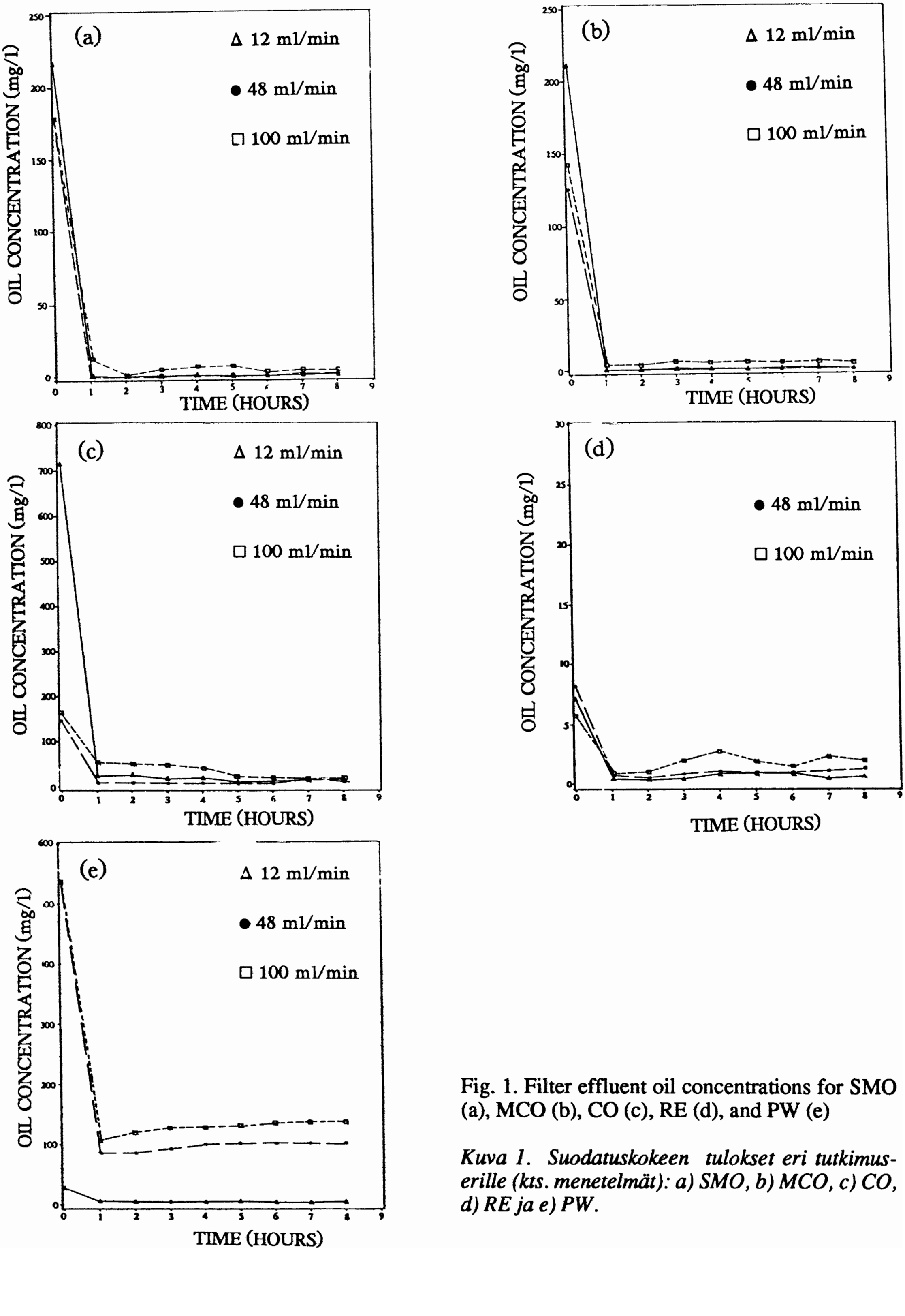

Fig. 1. Filter effluent oil concentrations for SMO (a), MCO (b), CO (c), RE (d), and PW (e)

Kuva 1. Suodatuskokeen tulokset eri tutkimus-erille (kts. menetelmät): a) SMO, b) MCO, c) CO, d) RE ja e) PW.

Table 2. Results of 8-hour Column Studies.

Taulukko 2. Kahdeksan tunnin kolumnikokeen tulokset.

Description	SMO	MCO	Oil-in-Water Emulsion CO	RE	PW1	PW2
1. Flow 12 ml/min (2.13 m/d)						
(a) Influent oil concentration (mg/1)	215.3	212.1	715.2	7.1	28.2	–
(b) Average effluent concentration (mg/l)	1.0	1.01	25.5	0.6	5.6	–
(c) Average percentage removal	99.5	99.5	96.4	92.2	80.2	–
2. Flow 48 ml/min (8.52 m/d)						
(a) Influent oil concentration (mg/1)	178.2	125.7	145.9	5.6	–	537.1
(b) Average effluent concentration (mg/1)	1.0	0.9	10.3	0.9	–	86.5
(c) Average percentage removal	98.6	99.3	92.8	86.6	–	81.8
3. Flow 300 ml/min (53.28 m/d)						
(a) Influent oil concentration (mg/l)	178.6	142.8	*	5.7	–	537.1
(b) Average effluent concentration (mg/l)	6.5	4.6	–	1.8	–	129.0
(c) Average percentage removal	96.4	96.8	–	68.5	–	70.0
4. Flow 100 ml/min (17.76 m/d)						
(a) Influent oil concentration (mg/l)	–	–	164.2	–	–	–
(b) Average effluent concentration (mg/l)	–	–	108.4	–	–	–
(c) Average percentage removal	–	–	34.0	–	–	–

* Run could not be conducted beyond 1 hour due to a build-up of high depth over the filter. Therefore for CO a flow rate of 100 ml/min (17.76 m/d) was used.

concentration (28.19 mg/l) and high salinity (50 g/l); and PW2 with high oil concentration (537.1 mg/l) and low salinity (4 g/l). In both cases, oil removal efficiencies exceeded 80 percent irrespective of flow rates. There was approximately 10 percent reduction in the oil removal efficiency for PW2 when the flow was increased from 48 to 300 ml/min. Even though produced waters are highly stable oil-in-water emulsions, the peat filter proved to be very effective in treating such emulsions.

CONCLUSIONS

1. In general oil removal efficiency through the peat filter decreased with increased emulsion flow rate.
2. For synthetic emulsions such as SMO and MCO, oil removal efficiency exceeding 96% was achieved in a 300 mm peat bed.
3. In the case of chemically stabilized emulsions like CO, the removal of oil varied from 34 to 96%.
4. In the case of RE, the stabilized emulsion with low oil concentration (< 10 mg/1), the peat filter removed 68 to 92% of oil from the influent.
5. Produced waters can be effectively treated in a peat filter to achieve oil removals greater than 70%.

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TIIVISTELMÄ:

ÖLJYN POISTO TURVESUODATTIMELLA

Turpeen käyttö öljyn ja veden sekaisen emulsion käsittelyssä on kiinnostavaa yksinkertaisuutensa ja halpuutensa vuoksi. Maailmalla on raportoitu useita tutkimuksia, joissa turpeen on ilmoitettu absorpoivan öljyjä useaan kertaan oman painonsa verran.

Tässä työssä tutkittiin Premier Peat Companyn kasvuturpeen kykyä suodattaa öljyä viidestä erilaisesta öljyn ja veden emulsiosta. Emulsiot johdettiin 300 mm pitkän turvesuodattimen lävitse 12, 48 ja 300 ml/min. nopeudella kahdeksan tunnin ajan. Keskimääräinen öljynpoistotehokkuus vaihteli 34–99% riippuen öljy-vesiemulsion laadusta ja sen kulkunopeudesta suodattimessa.

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