VERTICAL MIGRATION OF IODINE, TECHNETIUM AND NEPTUNIUM IN PEAT

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INTRODUCTION

Peat bogs, as well as moose mineral licks, may be recipients of deep groundwaters discharging from the plutonic rocks of the Precambrian Shield (Frape et al., 1984). Bogs resulting from accumulation and decomposition of organic material in a topographic low can have little flowthrough capacity (Ingram, 1983). In this type of bog, the solutes carried by groundwater, surficial overland flow and rainfall all contribute to the porewater composition. If the contributing water sources contain dissolved radionuclides, they may, upon reaching a different chemical environment, sorb onto the organic matter, precipitate out of solution, or form more or less mobile complexes or colloids in the bog. Little is known about the groundwater composition of swamps and fens, particularly how the composition changes over the season as evapotranspiration increases and water-table levels subside (Keough and Pippen, 1984). Furthermore, little is known about the rate of vertical water and dissolved solute transport from the base of a bog when lateral transport is minimal. The first objective of this study was to investigate water use, groundwater composition and seasonal water-table level fluctuations in two types of bogs typical of the Precambrian Shield. The second objective was to investigate the rate of vertical water migration and compare the transport of I, Tc and Np through two different peat types. This included in situ determination of sorption coefficients (K_d) for three peat types, including the living layers near the surface of a sphagnum bog.

METHODS

Two low moor deposits, one a floating sphagnum bog several metres deep (50°11′N, 96°01′W), the other a reed/sedge fen with a compact clay deposit at 35 cm (50°11′N, 96°03′N), were studied. In the winter, frozen blocks of peat ($0.01 m^3$) were cut out of the bog and put into 20-L plastic pails. After spring thaw, cores were dug with a shovel in the fen and also put into pails, and the pails were buried back in their respective mires so that the core and mire surface were level. Perspex access tubes placed down the centre of the cores were used for the radionuclide spike and further groundwater additions. Eight pairs of cores (0-40 cm and 40-80 cm) were studied in the bog and eight surface (0-40 cm) cores were studied in the fen. Three cores of each set were spiked with $0.2\ mCi \cdot mL^{-1}$ tritiated water, to track the water flow, and the remaining five cores in each set were spiked each with a solution containing 2 µCi Tc-99, 10 µCi Tc-95m, both as ammonium pertechnetate, 50 µCi I-125 as NaI, 4.02 g Na I-127, 7.2 g U-238 as uranyl nitrate and 1.0 µCi Np-237 in aqua regia.

Two weeks following spiking in the spring, surface porewater was extracted and analysed, to track the surface appearance of all the nuclides and the tritiated water. Groundwater levels were monitored in the hole where the cores were lifted out, and this groundwater was routinely analysed for composition and used to keep the water table in the pails similar to that in the mire. At freeze-up in the fall, the pails were lifted out of the mire and sectioned. The soil and porewater were analysed separately to calculate K_d values.

RESULTS

Water Use and Water-Table Fluctuations

Water-table fluctuations were quite minor in the bog, but a dramatic drop in the water table was observed in the fen (see Figure 1). Water-use peaks, signaled by large groundwater additions in early August, indicated large evapotranspirational losses, which would promote the upward transport of dissolved radionuclides from the bottom of the core.

Groundwater Composition

Calcium concentrations over the season indicated that these deposits are both minerotrophic, with the fen varying from 10.2 $mg\ Ca \cdot L^{-1}$ in early June to 70 $mg\ Ca \cdot L^{-1}$ in early September, and the bog varying from 8.9 to 42.7 $mg\ Ca\ L^{-1}$. Comparison of the major groundwater elements between the mires showed much less variation in the bog than the fen. The highest SO_4 levels are reached in the fen with the rise in water-table levels in September and a return to more anoxic conditions near the fen surface. Concentrations of Na, Mg and Ca all rose in late August as the water-table level began to drop and the free-water surface coincided with the clay layer.

Nuclide Migration

Tritium was detected at the surface of all the peat cores just 14 days after the spike was introduced, and reached the maximum concentration 34, 48 and 78 days after spiking in the sedge, surface sphagnum and deep sphagnum cores, respectively. Technetium was never detected in the surface porewater of any of the cores. Neptunium was detected in two surface sphagnum cores but just at the detection level, so is subject to question. Iodine, however, was detected in the surface porewater of all cores 14 days after spiking, similar to the tritiated water. Although the travel time of I was similar to that of water, maximum I concentrations occurred 13 to 30 days after those for ^3H_2O.

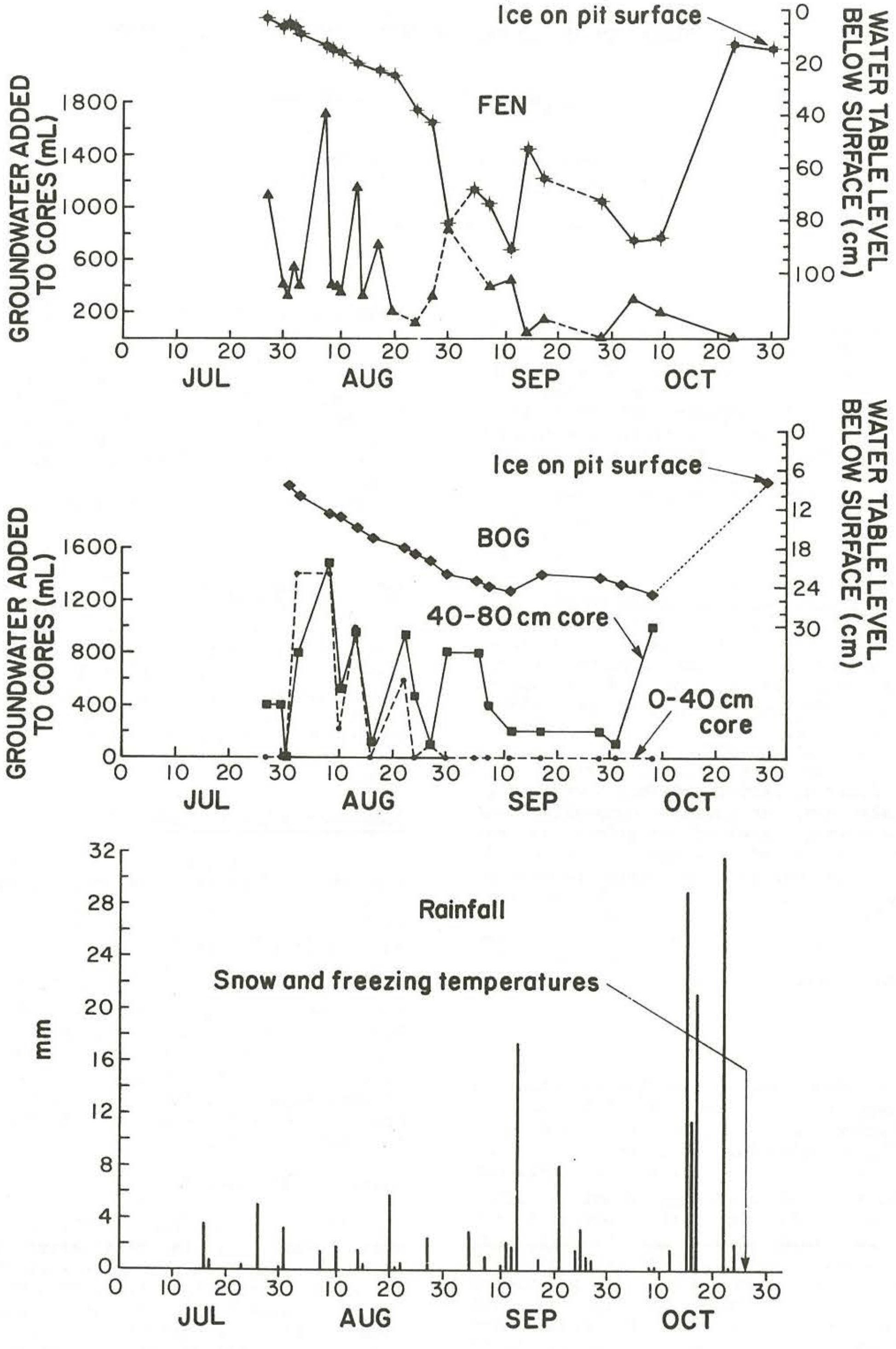

Figure 1: Groundwater amounts added to the cores (upper figures, using the left hand scale) for the 0 to 40 cm bog core (•), the 40 to 80 cm bog core (■), and the fen cores (▲), depict water loss with time through evaporation and transpiration. Groundwater table fluctuations (right hand scale) with time are also shown for the bog (◆), and the fen (✦).

DISCUSSION AND CONCLUSIONS

Seasonal groundwater composition and fluctuation with respect to the mire surface show that more dramatic changes occur in reed/sedge fens than in typical sphagnum bogs. Sedge fens are more strongly tied to regional groundwater systems and, as a result, are more subject to contamination via groundwater. Technetium entering a mire near its base from an underground nuclear disposal vault will tend to be immobilized by reducing conditions at the base of the deposit and Np will be retarded significantly by the organic matter. Iodine travels with the bog porewater, but the difference in the lag time for the maximum concentrations of ^3H_2O and I indicates that some retardation of I does occur. In the three peat systems, the surface sphagnum cores were the least effective and the deep sphagnum cores the most effective in I retardation. Redox potential may have strongly influenced the mobility of I since the deep cores were the most anoxic. Results of the in situ K_d data are required to confirm the retardation of I.

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