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Contrasting transit times and water-rock interaction in Australian upland catchments draining peatland and eucalypt forest

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Abstract

Catchments draining upland peat in the Victorian Alps, Australia contain water that has ^{3}H activities closely similar to modern rainfall implying very short transit times (<2 years). By contrast the water that drains adjacent eucalypt forest has mean transit times of several years to decades. The differences in transit times most likely reflect the higher evapotranspiration rates in the eucalypt forests that results in lower infiltration rates and slower rates of flow. Major ion concentrations reflect a combination of evapotranspiration and water-rock interaction and may be used to provide first-order estimates of transit times. The short transit times in the peat imply that it does not represent a long-term store of water for the river systems during drought. The peat is also highly susceptible to drying during low rainfall periods, which renders it vulnerable to the periodic bushfires that impact the region.

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1. Introduction

Peatlands are commonly developed in upland reaches of rivers. Because they commonly contain distinctive flora and fauna, degradation of peatlands is a major environmental concern. Degradation can be directly due to anthropogenic activities such as peat extraction or conversion to agricultural land or forest. Alternatively, since peatlands form in high rainfall environments, degradation can also occur due to a reduction in rainfall. Dried peat is susceptible to bushfires that are common in peatlands globally in times of drought and which can cause long-term

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damage as well as releasing significant volumes of CO_2 to the atmosphere.

Peatlands occur in the alpine regions of southeast Australia. The peat generally occupies shallowly sloping areas in the upland plains that are poorly drained. Most of these upland peatlands are flanked by eucalypt forests that occupy steeper slopes and gullies. Eucalypts have high transpiration rates and groundwater recharge rates in eucalypt-dominated areas are low. This factor likely contributes to the relatively long water transit times (on the order of years to decades) through eucalypt-dominated catchments[1].

Understanding the water balance in the Australian peatlands is important for assessing the likely impacts of environmental change. If the water residence or transit times are short, then peatlands may dry significantly during drought periods. There are two consequences of significant drying. Firstly, peatlands in upland areas may not continue to be a source of water to the river systems that drain those areas. Secondly, drying of the peat makes it more prone to bushfires that are common in the region.

1.1. Determining mean transit times

Especially in the southern hemisphere, ^{3}H is an ideal tracer for determining mean transit times (the time required for rainfall to pass through the catchment to the stream) of shallow groundwater or soil water. Since ^{3}H is part of the water molecule, its abundance is controlled only by the initial activities in the recharging water and subsequent radioactive decay. Coupled with models that describe the distribution of flow paths through an aquifer[1,2], ^{3}H may be used to determine mean transit times of waters that are up to ~100 years old. Rainfall ^{3}H activities peaked in the 1950s to 1960s due to the production of ^{3}H in atmospheric nuclear tests (the so-called "bomb pulse"). The bomb pulse ^{3}H activities of rainfall in the southern hemisphere have now decayed below those of modern rainfall[3,4] permitting unique transit times to be estimated from single ^{3}H measurements, something that is not yet possible in the northern hemisphere[3]. Additionally, while there are uncertainties in calculating transit times, because the ^{3}H activities of the bomb pulse waters are below those of modern rainfall, the relative transit times are independent of assumed flow models (i.e., water with low ^{3}H activities has longer mean transit times than water with high ^{3}H activities).

Fig. 1. Google Earth image showing location of peatlands (circled) in Victorian Alps. Inset shows location of study area.

1.2. Objectives

Despite the interest in peatlands, the transit time of water in upland peat catchments is poorly known. Here we compare transit times from streams draining peatlands in the Victorian Alps, southeast Australia with those in adjacent areas containing eucalypt forests. Understanding transit times are important in assessing the relative importance of the peatlands and eucalypt forests in providing water during drought conditions to the local rivers which and also in assessing potential environmental impacts resulting from a drying climate. Secondly, we examine whether the major ion geochemistry of the water may be used as a first-order proxy for residence time.

2. Setting

Water from peatlands and adjacent eucalypt forests were sampled in the Mount Buffalo (Ovens Catchment), Falls Creek (Kiewa Catchment), and Dargo (Mitchell Catchment) regions of the Victorian Alps (Fig. 1). These upland areas consist of indurated metasedimentary rocks, granites, and minor basalts drained by numerous small streams. The bottom of the stream valleys have minor deposits of colluvium and alluvium and there are small alluvial fans at