Geophysical Research Abstracts, Vol. 8, 01444, 2006
SRef-ID: 1607-7962/gra/EGU06-A-01444

The use of tritium in river base flow to understand long-term changes in water quality

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It has been over 50 years since thermonuclear weapons began producing tritium in large quantities, and over 40 years since the peak production of tritium by weapons testing in 1962. Since then, the tritium concentrations in the atmosphere have decreased close to pre-bomb levels and have been nearly constant in many areas for the past few years. This has led to a perception that tritium has no value for determining physical parameters of surface waters and is mainly confined to determining whether there is a component of young water in aquifer systems. However, surface waters are frequently composed of a mixture of recent precipitation and baseflow which can have ages on the order of weeks to decades or higher. The fraction of groundwater in surface flow and its age will impact the tritium concentrations of the surface flow. This makes it possible to use tritium concentrations in surface waters to estimate the age of the groundwater component in the surface flow. If the ratio of the tritium concentration in precipitation/surface water is less than one, it indicates that older water from the bomb-transient is present in the surface water. With the exception of systems dominated by lakes with long residence times, the older water is likely the result of inflowing groundwater (i.e. baseflow). The extent that the ratio is less than one is a function of the percentage of groundwater in the flow and the mean age of that groundwater. This approach can be applied to both recent data and historical data if a reliable tritium input function for precipitation is available. The International Atomic Energy Agency (IAEA) has developed a tritium source function on a monthly basis for precipitation across the world. It has also compiled a surface water data base of almost 8000 tritium analyses for the world since the late 1940s to present. Using measurements and

estimates of tritium in precipitation, it is possible to apply the above approach to the surface water data base. Any of a series of different methods can be used for modeling the tritium concentrations in the baseflow. In this paper, a simple lumped-sum parameter model was applied to estimate tritium concentrations in baseflow at a given location for a series of different timescales. It is evident that the approach works best if average yearly tritium concentrations in precipitation are used instead of monthly precipitation data. This is due to the extremely variable nature of the tritium input function resulting from weather patterns and the yearly spring leak of stratospheric water vapor into the troposphere. This approach has been applied to long-term data bases to compare its results with prior work on those data sets and the results were found to be comparable. Using the IAEA precipitation source function, it is now possible to estimate the tritium concentrations in baseflow at the present time for a series of different groundwater residence times. This has been carried out for selected sites and timescales at a series of different locations, the results of which will be presented. The timescales estimated by this approach for the groundwater portion of the baseflow are important for assessing management strategies for maintaining or restoring water quality in a system. This timescale is also needed to understand long-term changes brought about by climatic or land-use factors.