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同位素水文学与水资源、水环境

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同位素水文学(isotope hydrology)是20世纪50年代发展起来的一门新兴学科，它主要利用同位素技术解决水文学中一些关键问题. 众所周知，同位素是指原子核内质子数相同中子数不同的那些原子，可分为稳定同位素和放射性同位素2种. 前者指目前尚未发现存在放射性衰变的同位素，而后者则指具有放射性衰变的同位素. 存在于自然界的上述2种同位素称为天然同位素或环境同位素，目前在水文学中常用的环境同位素有^{2}H、^{3}H、^{3}He、^{4}He、^{13}C、^{14}C、^{18}O、^{34}S、^{36}Cl等. 不同类型的水(海水、湖水、河水、地下水，……)，其化学成分会有很大变化，但同位素组成却相对稳定. 因此，水的同位素成分可视作水的"指纹"(finger print)或"DNA". 也正是基于这一点，水同位素或同位素水文学技术被广泛用来解决或帮助解决各类水资源、水环境问题，诸如水的成因、各类水(雨水、地表水、地下水)的相互作用及转化、地下水系统的封闭程度及水交替强度、各类水体的污染程度及污染源问题等. 正是由于同位素水文学的重要性，目前在国际原子能机构(IAEA)内建有同位素水文学部，并设有一个设备齐全、技术先进的同位素水文学实验室. 20世纪50年代后期，国际原子能机构(IAEA)与国际气象组织(WMO)共同建立了"全球大气降水同位素监测网"(GNIP)，自1961年起即向世界各国公布有关数据. 最近，IAEA正拟与联合国教科文组织(UNESCO)联手，在全球42条大江大河(包括我国长江在内)建立类似的水同位素监测网，这对推动同位素水文学的发展将起到不可限量的作用. 我国同位素水文学的工作始于20世纪60年代，当时在珠峰地区曾取冰、雪样品做^{2}H、^{18}O同位素分析. 之后，不同学者在北京、上海及我国东部地区对大气降水的^{2}H、^{18}O及^{3}H进行了测定，得出一些很有意义的结果. 1988年，在水利部的大力支持下，我国首批建立的10个大气降水同位素监测站开始运转，并纳入IAEA/WMO的GNIP之中. 目前，在GNIP中的中国网站已增至30个.

当前，水资源短缺及水环境恶化已成为全球性的大问题. 据世界银行(World Bank)预测，若按现有的耗水模式及耗水速率继续下去，则至2025年全球2/3的人将生活在水资源短缺的窘迫状态之中. 目前世界银行为解决水资源、水环境问题而投放到发展中国家的资金为每年700～800亿美元. 全球对水资源的需求量在未来15年内将增加2倍. 为此，包括IAEA在内的联合国下属24个机构正在制定世界水资源评价计划，以根本解决水资源短缺问题. 水多(洪水)、水少(短缺)、水脏(污染)亦是我国水资源、水环境面临的三大问题. 黑河流域水资源短缺，太湖地区水环境退化、水污染问题严重已引起国务院的重视并要求切实加以解决. 同位素水文学技术对解决上述问题将起到独特甚至是不可替代的作用. 总之，机遇与挑战并存，风险与希望同在. 目前正是我国在加速同位素水文学发展及水同位素技术中大显身手的大好时机.

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Isotope Hydrology and Water Resources plus Hydro-Environment

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Abstract: Isotope hydrology is a new discipline in earth sciences developed since 1950s. Its main target is to use isotope technique to solve various problems in hydrology. It is well known that isotope refers to those atoms whose numbers of proton are the same but whose numbers of neutron are different. Isotopes can be divided into two types: stable and radioactive. For stable isotopes, no radioactive decay has been found so far. But for radioactive isotope, there exists radioactive decay. Usually, the term "natural" and/or "environmental" isotopes were used for the two types of isotope mentioned above. The environmental isotopes commonly used in hydrology are: ^{2}H, ^{3}H, ^{3}He, ^{4}He, ^{13}C, ^{14}C, ^{18}O, ^{34}S, ^{36}Cl, etc. It must be noted that for different types of water, such as sea water, lake water, river water and ground water, the isotope composition seems to be quite different but relatively stable, although the water chemistry varies greatly. Therefore, the isotope composition can be, to certain degree, regarded as the "finger print" and/or "DNA" of the water. Also for this reason, the isotope composition in the water and the isotope hydrology technique are widely used to solve various problems in water resources assessment and hydro-environment evaluations such as the origin of water, the interaction of surface and groundwater, the rain-off water, the degree of openness of a groundwater system, the intensity of water cycling, the pollution degree and the pollution source of a water body. In recognition of the importance of isotope hydrology, an isotope hydrology section has been established in the International Atomic Energy Agency (IAEA) and an isotope hydrology laboratory is set up simultaneously with advanced technique and equipment. Since late 1950s, a Global Network for Isotopes in Precipitation (GNIP) has been initiated jointly by IAEA and WMO (World Meteorological Organization) and all the data have been published since 1961. Recently, sponsored by IAEA/UNESCO, a similar global network for isotopes in the large rivers in the world is under the way to set up. It is of significant importance in promoting isotope hydrology development worldwide.

In China, isotope hydrology studies can be traced back to the late 1960s. In the scientific investigation of water resources in Jolmo Lungma region, ^{2}H and ^{18}O were determined in snow and ice samples. Since then, ^{2}H and ^{18}O have been analyzed for precipitations in Beijing, Shanghai and East China by different researchers with great achievement. In 1988, Supported by the Ministry of Water Resources, the first 10 stations, for monitoring the isotopes in precipitation in China were established and now they have been included in the IAEA/WMO GNIP. At present, the total number of stations has increased to 30.

Nowadays, water resources shortage and hydro-environments degradation become more and more serious worldwide. According to the prediction by the World Bank, 2/3 world population will live in a serious water-shortage environment if we follow the present water-consuming model. At present, 70—80 billions of US dollars has been offered to the developing countries to alleviate the annual water resources shortage. The global demand for water resources will be doubled in the coming 15 years. For this reason, altogether 24 international organizations including IAEA are working on a World Project for Water Resources Assessment to reduce the global water shortage. "flood", "water shortage" and "water pollution" have become three main problems in China nowadays. Both the water shortages in the Heihe river region and the degradation of hydro-environment in Taihu lake area have attracted great attention from the State Council. The isotope hydrology technique may play a particular role in solving these problems. All in all, opportunities and challenges co-exist and it is a right time to expedite the development of isotope hydrology in China.