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STABLE ISOTOPE COMPOSITION OF ENVIRONMENTAL WATER AND FOOD PRODUCTS AS A TRACER OF ORIGIN

Ryszard Wierzchnicki, Andrzej Owczarczyk, Wojciech Soltyk
Institute of Nuclear Chemistry and Technology, Warsaw, Poland

Abstract: The paper is the review of Institute of Nuclear Chemistry and Technology (INCT) activity in application of stable isotope ratios (especially $^{2}H/^{1}H$ and $^{18}O/^{16}O$) for environmental studies and food origin control. INCT has at disposal, since 1998, a high-class instrument - Isotope Ratio Mass Spectrometer, Delta Plus, Finnigan MAT, Germany - suitable to perform such measurements.

1. INTRODUCTION

In our paper a special attention has been paid on the topics being studied during period 2000-2003 by Isotope Ratio Mass Spectrometry (IRMS) technique:

- $^{18}O/^{16}O$ for identification of pollution source on the base of SO_4^{-2} observed in rivers being supplied by drainage waters pumped around the strip lignite mine and power plant exploitation field;
- checking the possibility of the isotope ratio $^{2}H/^{1}H$ and $^{18}O/^{16}O$ use as a tracer of mixing processes of two rivers (Narew River and Bug River) supplying the Zegrzyn Lake, as a test of pollution transport in the lake;
- application of $^{2}H/^{1}H$ and $^{18}O/^{16}O$ for authenticity control of some food products (wine, fruit juices, honey).

The methods of sample preparation for IRMS measurement being suitable for particular problems have also been presented.

2. ISOTOPE STUDY OF DRAINAGE SYSTEM

The Bełchatów lignite deposit consist of two exploitation fields: Bełchatów and Szczerców. The first is being exploited now, while the second is actually prepared for future exploitation. It has been predicted the exploitation of Bełchatów Field resources will be completed in 2019. That is the reason why the Szczerców Field, which is going to be exploited in the period 2007-2038, is already prepared starting from 1999. A very important stage of the preparation process is drainage of opening out excavation and surroundings. The drainage system of Szczerców Field began to work at the end of 2002. It consists of 174 wells, pumping the groundwater permanently with a total efficiency of about 5.5 m^3/s that results in the depression of groundwater table. The natural hydrogeological equilibrium is entirely disturbed due to the drainage process.

The changes of water flow patterns in the ground is the reason of accelerated leaching of minerals, mixing of different water bodies and causes hydrochemical and isotope characteristic of pumped waters being received by rivers and natural reservoirs in the region.

Aim of the present work was to investigate the isotope and hydrochemical background for the existing groundwater system before starting drainage pumping for the Szczerców Field. The water samples for investigation were taken from 112 piezometers localized in the region of the opening out excavation, salt deposit Dębina at the east edge of lignite deposit and inside the preliminary depression cone. The depth of control wells (piezometers) was in the range 23-269 m so the water samples taken from them were representative for all aquifers (from quaternary to Mesozoic formation).

Determination of chemical water composition (macro- and microelements) as well as environmental isotopes concentration ^{3}H, ^{222}Rn ratios $^{34}S/^{32}S$ and $^{18}O/^{16}O$ have been preferentially measured at hydrologic contact zones of aquifers bearing waters of different age and in geologically important regions e.g. waterbearing falts and mineralogical boundaries existing in the region under observation. Results of the hydrochemical background for the groundwater in the opening out excavation of the Szczerców Field are presented at the poster. The hydrochemical changes, which are expected after starting and further development of the drainage system, will be monitored successively in the future.

3. MIXING PROCESSES OF TWO RIVERS (NAREW RIVER AND BUG RIVER)

This work is aiming at using the naturally existing differences in the isotope ratios $^{18}O/^{16}O$ and D/H of waters, to investigate the transport and accompanying dispersion processes as well as mixing of various waters in the tributary - receiver system. The originating differences in isotope composition of waters are determined by isotope ratio mass spectrometry.

Preliminary studies were undertaken on the use as a tracer-the naturally existing differences in isotope composition of waters of a tributary and a receiver to follow and to describe dispersion and mixing processes in natural waters. Included also was the description of transport and dispersion of pollutants introduced into the receiver by the tributary. Conventional studies of this type require introducing into the studied system of large amount of an external tracer in the form, for example, of radionuclides, fluorescent dyes, etc. Such studies have been performed in the INCT in the years 1970-1990, usually on a local scale, in the system discharge of pollutants - river. The recent rigorous environmental regulations practically excluded in the whole world the use of these conventional tracer methods. The application of naturally existing tracer, which are the differences in isotope composition of stable oxygen and hydrogen isotopes in waters of the examined system, gives the possibility to study the transport and mixing processes as well as verification in natural conditions of mathematical model describing the studied phenomena.

We propose to carry out studies on large hydrological systems as, for instance: river - lake or tributary - receiving - river.

The real localization concerns the following system: the Bug and Narew rivers - the Zegrzyn Lake and the Bugo-Narew River - the Vistula River.

The intended studies include mathematical modeling which describes mass transport in both systems and two field sessions (separately for each selected hydrological systems) performed in two consecutive years in order to investigate real transport and mixing processes of waters. Measurements of the stable isotope ratios $^{18}O/^{16}O$ and D/H are carried out according to the earlier designed net of measuring points in the field.

Results of these studies should allow verifying the proposed mathematical model. They could also be a basis permitting to forecast the dispersion of pollutants and to evaluate the space-time scale of ecological hazard, for example, for potable water intakes appearing in the area of their interaction.

4. STABLE ISOTOPE COMPOSITION IN FOOD ORIGIN CONTROL

Food products are mixtures of basic organic elements: carbon, hydrogen, oxygen and nitrogen. Stable isotope composition these elements provides useful information for food authenticity control. Their isotopic fractionation in the environment follows complex patterns allowing to established the correlation between the food (fruits, vegetables etc.) and raw materials (water, air and soil)[1].

The aim of the study is to explore the relationship between isotope composition of different sorts of food and its geographical origin. The purpose of the study is to compare the data from different regions of Poland. The samples are received directly from a producer.

Hydrogen, oxygen, nitrogen and carbon composition is measured in many sorts of food. The collected data gives a possibility to find the relationship between time and place of origin and isotope ratio: $^{18}O/^{16}O$, $^{13}C/^{12}C$, $^{15}N/^{14}N$ and D/H.

The composition of water presented in the food is tested. Hydrogen is measured by H/Device and oxygen isotope ratio by GasBench II (both instruments connected with mass spectrometer)[2]. For the comparison the water samples from the region of plant growing are tested.

In this study for measurements of carbon and nitrogen composition in food, we use Elemental Analyzer Flash 1112 NCS (Thermo Quest, Italy) which is coupled with Mass Spectrometer DELTA plus and ConFloIII. This system is a very useful research tool for many fields of environmental science, agriculture and medicine. Application of EA-IRMS to solution of wide variety of environmental problems is still growing in recent years. This analytical method is most popular for study stable isotope composition in food.

Samples should be prepared in dry matter by drying raw material from food.

The measurements are fully automated and data are restored by powerful data system.

The correlation between stable isotope composition $^{18}O/^{16}O$ $^{13}C/^{12}C$, $^{15}N/^{14}N$, D/H and geographical origin of food will be presented in the next works.

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CONCLUSIONS

We have demonstrated that the stable isotope composition its a good tool for study different processes. The three examples have presented our (INCT) activity in the area of environmental study. In the future, the study will be continued and additional parameters, as a sulfur and nitrogen isotope composition in food and in surrounding environment (in precipitation, surface and ground water), will be compared.

Reference:

[1]. Rossmann A.: Food Reviews International, 17(3), 347-361 (2001)

[2]. Werner R.A., Brand W.A., Rapid Commun. Mass Spectrom.2001; 15; 501-519