RADIOLOGICAL MONITORING OF BEEHIVES AND HONEY FOR GROUND RADIOACTIVE POLLUTION ASSESSMENT

Róbert Hinca, Martin Petriska

Institute of Nuclear and Physical Engineering (INPE), FEI SUT in Bratislava
E-mail: robert.hinca@stuba.sk

Received 30 April 2017; accepted 25 May 2017

1. Introduction

Honeybees have been used as monitors of variety of environmental contaminants, including trace metals, low level radioactivity, and pesticides because of their ability to reflect the conditions of the immediate environment. Pollutants from plants and various sources of water from relatively large area are collected in the bees themselves and as beehive components including wax, pollen and honey. Honeybees forage over area approximately 7 km^2 in well-fed situations and up to 100 km^2 under natural foraging situations [1,2]. Environmental engineering group of INPE STU Bratislava propose two monitoring programs. The first one is online beehives monitoring system and second one is the offline radiological monitoring system of honey.

Honeybees are unique environmental sampler of pollutants transported over area in a form of gases, liquids or particulates. Pollen, nectar or honey and water are used in beehives as forage. All of the forage components are potentially contaminated by pollutants and radionuclides.

The bee visits flowers in search of nectar and pollen, or visit trees for harvesting resin to make propolis. The propolis is used as glue and caulk to seal cracks in the hive. Bees also collect honeydew secreted by insects of the family Aphididae. Pollen is stored in broodcomb cells and is the main supply of protein and vitamins for the hive. Pollen is 6 to 28 percent protein by weight and usually contains the 10 amino acids essential for bees. Nectar is from 5 to 80 percent sugar but is less than 0,2 percent in protein, so nectar is the carbohydrate supply for the hive. The conversion of nectar into honey requires the physical removal of water by rapid movements of the wings of the bees and the addition to nectar of the enzyme invertase included in the salivary glands of the bees. When the amount of water remaining in the nectar is less than 18 percent, the mixture is called honey and the bees cap off the cells. A mixture of honey and pollen is called '"bee-bread" and is the food for most larvae and bees. Future queens are fed with large quantities of "royal jelly" which is similar to bee-bread but contains more mandibular gland secretions and more honey (34 percent vs. 12 percent). Finally, water is also collected by bees and used primarily as a diluent for thick honey, to maintain optimum humidity within the hive, and to maintain appropriate temperatures in the brood area. The amount of water required and collected by a colony is generally correlated with the outside air temperature and relative humidity, strength of colony, and amount of brood rearing in progress [4].

Flower pollen is good indicator of air contamination. By simply fitting a pollen trap to a honeybee hive, and measuring the radiocaesium content of the pollen species present, it is possible to produce models to give accurate and precise estimations of concentrations in leaves and flowers of plants within the forage area [3].

The results of many experiments demonstrating that honey bees are good indicators that contamination is bioavailable. At a fundamental level, bees are useful indicators of radionuclide contamination. However, it is apparent that an effective environmental monitoring program would have to do more than simply collect samples of honey bees and

use those data at face value. The findings of the experiments suggest that there is a complicated interplay of many physical and chemical factors that influence the radionuclide concentrations within an individual honey bee [3].

2. Honey monitoring after Chernobyl accident

After Chernobyl accident campaigns of measurement were performed in former Soviet Union, in most European countries, Canada, Japan and United States. Bioindicators were also used to assess biological and ecological risks brought about this accident.

Between 1986 and 1989 the maximum levels of radionuclide concentration of radiocaesium ^{134}Cs and ^{137}Cs in French honey was 165±20 Bq/kg and 425±20 Bq/kg respectively in sample of fir (honeydew) honey collected in june 1986 from the south-east of France. Similarly in honey samples of the same type (honeydew) collected in different regions of Italy in May-July 1986 that activity of ^{137}Cs ranged between 31,4 to 362,7 Bq/kg. Honey from Gorski Kotar (Croatia) ranged from 4,8 to 36,2 Bq/kg [4].

Comparison of the levels of radioactive contamination found in the honeys produced from the different species of trees also provides interesting information. Thus fir honey seems to highly concentrate radionuclides. The ^{134}Cs and ^{137}Cs concentrations in chestnut honeys are also generally high. Conversely, acacia honey appears as a weak indicator of radioactive pollution. The mean concentrations of ^{137}Cs found in Italian chestnut honey and acacia honey in May-June 1986 were 70.2±58.7Bq/kg (222 to 180) and 27.3±19.6Bq/kg (5.1 to 65.5), respectively.

Measurement indicates, that honeydew honey is suitable as radiocaesium pollution indicator, even a long time after the radioactive contamination.

3. Online beehives radiation monitoring setup

Modern radiation detection technique enable development of portable remote controlled measuring systems with autonomous solar energy supply. Such monitoring system can be interconnected by other monitors. Commercially available are monitoring systems of beehives state used to gather for audio and video data collection called “Field data logger” [5]. Generally it is solar powered and streams the data via WiFi or GSM to beekeeper smart phone application. The auxiliary beehives condition measurement as external and internal temperature and humidity, beehive gross mass and external radiation background are necessary for radioactivity measurement corrections. Placements of internal detectors are shown on Fig. 1.

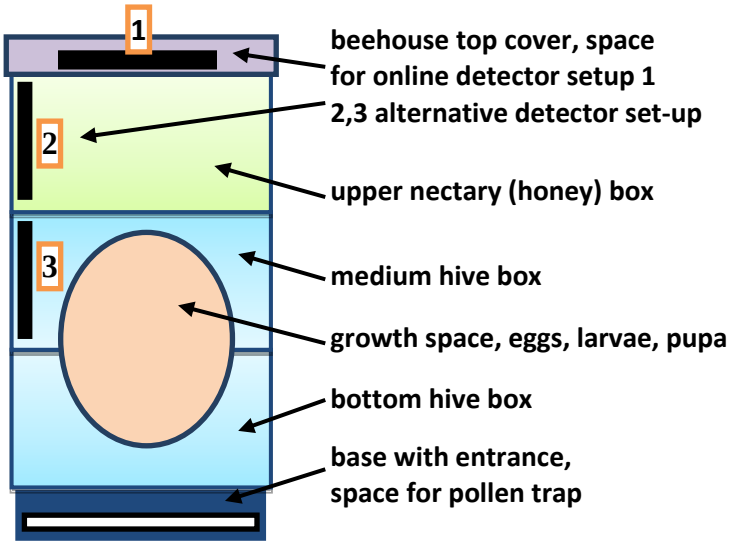

Fig.1. *Placements of internal detectors*

4. Offline honey monitoring system

Offline honey radioactivity monitoring is provided by standard gamma spectrometric equipment, calibrated for routine geometry used in beekeepers practice. The most common vessel in retail trade is 0,7L honey bottle. For honey storage of small producer are used 30L vessels. For 0,7L honey bottle measurement we use no movable HPGe detector (Fig. 2a) installed in low background chamber in laboratory of low activity INPE and transportable measurement setup with scintillation detector (NaI or LaBr) in lead shielding (Fig. 2b). Geometry and setup of HPGe detector allow in 2 hours measurement achieve MDA less than 1Bq/kg.

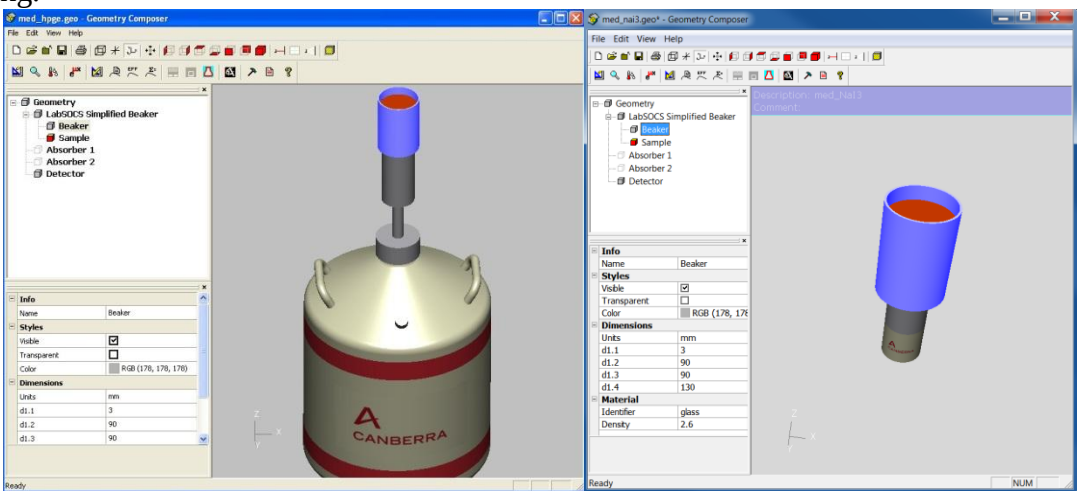

Fig 2 *Honey bottle 0,7L measurement setup with HPGe (2a) and scintillation (2b) detector*

5. Conclusion

Beehives and bee honey monitoring for radioactive contaminants give us information on immediate conditions of the radioactive pollution of environment. Levels of measured activity are very low. Already just after Chernobyl accident observed activity levels of honey in Europe were under the limit of intake for this type of foods. Consequently honey activity measurement is not subject-matter of public radiation protection because of honey consumption, still radioactive environment pollution.

Despite the relative low detection limit of our laboratory measurement, which gives minimal detectable activity less than 1 Bq/kg we, at this time, don't find honey sample which overreach this level.

References:

[1] Tonelli D at all.: Honey bees and their products as indicators of environmental radioactive pollution. *Journal of Radioanalytical and Nuclear Chemistry* **141**(2):427-436, January 1990

[2] Simmons M. A. at all.: Honeybees as Monitors of Low Levels of Radioactivity. PNL-7348 study for U.S. DOE, www.osti.gov/scitech/servlets/purl/6702610, July 1990

[3] McGee, E. J.; McGarry, A.: The uses of bioindicators in radionuclide contamination assessment. 24th Annual ESNA/IUR Meeting: Soil-Plant Relationships. Varna (Bulgaria); 12-16 Sep 1994 http://www.iaea.org/inis/collection/NCLCollectionStore/_Public/31/021/31021223.pdf

[4] James Devillers, Minh-Ha Pham-Delegue: Honey Bees: Estimating the Environmental Impact of Chemicals. CRC Press, 2003 - 352 strán, ISBN 0203218655, 9780203218655

[5] The Open Source Beehives Project, https://opensourcebeehives.com/, April 2017