Ecological state of honey plants in apiaries of the Tyumen region

S A Pashayan
Northern Trans-Ural state agricultural university, 7 Republiki Str., Tyumen, 625003, Russia
E-mail pashakirak7@list.ru

Abstract. The paper is devoted to the problems of the ecological state of honey plants of the Tyumen region. It is shown that the local conditions are very prominent for locating the apiary and its branches in the most advantageous place. As a result of the research, it was found that the flowers of the yellow clover, meadow clover and coltsfoot exhibit low cumulative properties to pollutants. Studies have shown that honey plants in the spring and summer flowering periods show different cumulative properties of pollutants. The regularity of the content of heavy metals, radionuclides and pesticides in honey plants of beekeeping areas has been established.

1. Introduction
Performing the pollination of various agricultural plants - fruit, berries, vegetables, melons, grains, oilseeds, technical, fodder, the bees thereby ensure their yield and efficiency of further use [1]. Since honey plants serve as the only natural food source for bees, each specialist and beekeeper should carefully study the local conditions in order to locate the apiary and its branches in the most advantageous place in the sense of a bribe. It should be borne in mind that, although the bees fly off for a bribe at a distance of more than 3 km, it is much more profitable if the plants rich in nectar are located no more than 2 km from the apiary. In this case, the bees will not have to spend time on unproductive flights, which will give them the opportunity to bring more honey into the hives, and, in addition, they will be guaranteed against mass death in the event of the rapid onset of adverse weather (thunderstorms, cold, rain, etc.) [2].

Honey harvest, above all, depends on the composition of the surrounding apiary flora. The most favourable is the location of the apiary among the various lands where intensive pollution of the soil and atmosphere by radioactive substances, heavy metals, occurs, they accumulate on the surface of the earth, enter plants. When moving along food chains, some substances are dispersed, other ones are accumulated.

2. Materials and research methods
The work was carried out at the Department of Anatomy and Physiology of the State Agrarian University of the Northern Trans-Urals. The objects of the study were samples of flowers of honey plants from apiaries of beekeeping areas of the Tyumen region. Samples were previously subjected to autoclave mineralization using the ANKON-AT-2 device. Mobile heavy metal (HM) forms in soil samples were extracted with an acetate buffer solution with a pH of 4.8, after which the HM content and mineralization
were used to determine the HM content by an atomic absorption method on an AAS-3 and Kvant-ZETA spectrophotometer (GOST 30692-2000).

The determination of the presence of radionuclides in samples of soil, plants and bee products was carried out in accordance with the methodological guidelines “Radiation monitoring. Strontium-90 and cesium-137. Food products. Sampling, analysis and hygienic evaluation”. Determination of cesium-137 radionuclides was performed by scintillation gamma spectrometry, and strontium-90 by scintillation beta spectrometry in native material on the Progress spectrometric complex on beta and gamma spectrometers using the native method according to the “Methodological guidelines for determining strontium-90 and cesium-137 in soils and plants” (MG 2.6.717-98) [7].

The indicator for calculating the migration of HM along the biological chain was taken into account: soil - plants - bees - beekeeping products, biological absorption coefficient (BAC), which is equal to the ratio of the element content in the ash of organisms to the element content in the previous environment.

3. Research results

The importance of determining the levels of heavy metals in plants increases every year due to the intensification of the processes of anthropogenic impact. The study of the penetration mechanisms of heavy metals into plants and their influence on the growth and development of plants, as well as the amount of crop production is of great importance [8].

The accumulation of heavy metals in plants, especially elements such as lead, cadmium, arsenic, depends on the area geographical location. Pollution of the atmosphere, soil and plants man-made substances occur depending on the prevailing winds. The amount of chemical elements in plants depends not only on the geographical location of plants, but also on their biological characteristics, including the flowering period.

In terms of honey plant flowering the following species are distinguished: spring honey plants with a short flowering phase, excluding only a few ones; summer ones - with longer flowering periods, giving the main honey collection; and autumn, having already a small value for bees, as weak and rarely visited due to lower air temperatures, rains and cold winds. Willow, coltsfoot, lungwort, dandelion, forest apple and yellow acacia flowers were used as flowers of spring honey plants.

Tables 1 and 2 show the average chemical indicators in spring honey plants. As a result of the research it was found that the flowers of honey plants have high cumulative properties for pollutants, with the exception of dandelion, which exhibits lower cumulative abilities.

| Samples  | Pb  | Cd   | As   | Cu    | Zn    |
|----------|-----|------|------|-------|-------|
| Coltsfoot | 0.71±0.04 | 0.03±0.001 | 0.14±0.004 | 5.83±0.25 | 13.24±0.72 |
| Willow   | 0.76±0.03 | 0.03±0.002 | 0.02±0.005 | 6.65±0.17 | 13.94±0.84 |
| Lungwort | 0.75±0.23 | 0.03±0.003 | 0.03±0.007 | 6.46±0.24 | 21.38±1.83 |
| Dandelion | 0.49±0.03 | 0.01±0.001 | 0.03±0.001 | 6.78±0.32 | 13.20±1.43 |
| Apple tree | 1.23±0.06 | 0.03±0.001 | 0.03±0.002 | 6.70±0.22 | 17.22±1.21 |
| Acacia   | 1.24±0.06 | 0.03±0.003 | 0.032±0.003 | 6.3±0.43 | 17.05±1.06 |
| On the average | 0.89 | 0.035 | 0.047 | 6.453 | 15.91 |

| Samples  | $^{137}$Cs, Bq/kg | $^{90}$Sr, Bq/kg | HCH, mg/kg | DDT, mg/kg |
|----------|------------------|------------------|------------|------------|

Table 1. Indicators of heavy metals in spring honey plants, mg / kg.

Table 2. Content of radionuclides and pesticides in spring honey plants.
order in spring honey plants can be expressed as follows: Zn > Cu > Pb > As > Cd, in summer honey plants properties to lead, arsenic and cadmium species had a higher content of zinc and copper. 

Flowering and the state of the environment of their localities are of great importance. Flowers of all plant species had a higher content of zinc and copper.

Studies have shown that honey plants in the spring and summer flowering periods show different cumulative properties to pollutants. At the same time, the species properties of plants, the timing of flowering and the state of the environment of their locality are of great importance. Flowers of all plant species had a higher content of zinc and copper. Honey plants of the spring period exhibit low cumulative properties to pollutants. At the same time, the species properties of plants, the timing of flowering and the state of the environment of their localities are of great importance. Flowers of all plant species had a higher content of zinc and copper.

As a result of the research, it was found that the flowers of the yellow clover, meadow clover and cloverfoot exhibit low cumulative properties to pollutants. On this basis, the flowers of these plants were used in the preparation of feed additives.

**Table 3.** The content of heavy metals in summer honey plants, mg/kg.

| Honey plants | Pb     | Cd     | As     | Cu     | Zn     |
|--------------|--------|--------|--------|--------|--------|
| Linden       | 0.69±0.02 | 0.03±0.002 | 0.03±0.003 | 5.45±0.34 | 17.49±1.04 |
| Chistets     | 0.51±0.02 | 0.01±0.001 | 0.05±0.01 | 5.59±0.33 | 15.49±2.32 |
| Blooming Sally | 0.65±0.06 | 0.02±0.001 | 0.05±0.03 | 5.59±0.25 | 21.49±2.45 |
| Pink Clover  | 0.79±0.07 | 0.04±0.003 | 0.03±0.01 | 5.19±0.31 | 19.38±1.34 |
| Field Thistle | 0.71±0.02 | 0.02±0.001 | 0.02±0.03 | 7.09±0.63 | 14.63±2.73 |
| Clover white | 0.23±0.02 | 0.04±0.002 | 0.03±0.001 | 5.65±0.25 | 14.63±2.43 |
| White clover | 0.12±0.01 | 0.01±0.001 | 0.01±0.001 | 7.21±0.43 | 22.62±1.32 |
| Yellow clover | 0.13±0.01 | 0.01±0.001 | 0.01±0.001 | 5.49±0.22 | 14.95±6.31 |
| Burdock      | 0.21±0.02 | 0.01±0.001 | 0.01±0.001 | 6.29±0.21 | 22.33±3.12 |
| Mouse peas   | 0.18±0.01 | 0.01±0.001 | 0.03±0.005 | 6.81±0.47 | 16.62±1.34 |
| Red clover   | 0.46±0.04 | 0.02±0.001 | 0.04±0.005 | 5.61±0.34 | 14.91±5.52 |
| Crescent     | 0.78±0.05 | 0.02±0.001 | 0.04±0.003 | 6.80±0.73 | 21.88±2.74 |
| On the average | 0.46 | 0.02 | 0.048 | 6.63 | 23.60 |
- Zn > Cu > As > Pb > Cd. As for pesticides (HCH and DDT), they accumulate in almost the same amount in spring and summer honey plants.

**Table 4. The content of radionuclides and pesticides in summer honey plants.**

| Honey plants        | $^{137}$Cs, Bq/kg | $^{60}$Sr, Bq/kg | HCH, mg/kg | DDT, mg/kg |
|---------------------|-------------------|------------------|-----------|------------|
| Linden              | 7.9±2.23          | 3.9±0.45         | 0.0035±0.0001 | 0.0023±0.0002 |
| Chistets            | 13.6±0.31         | 1.6±0.05         | 0.0043±0.0002 | 0.0026±0.0004 |
| Blooming Sally      | 12.6±0.25         | 1.9±0.06         | 0.0050±0.0004 | 0.0035±0.0002 |
| Pink Clover         | 11.4±2.34         | 2.3±0.54         | 0.0040±0.0001 | 0.0039±0.0002 |
| Field Thistle       | 5.4±0.04          | 1.8±0.04         | 0.0047±0.0001 | 0.0033±0.0003 |
| Clover white        | 4.9±0.05          | 1.2±0.04         | 0.0041±0.0001 | 0.0023±0.0003 |
| White clover        | 5.9±0.13          | 1.6±0.01         | 0.0022±0.0001 | 0.0021±0.0001 |
| Yellow clover       | 12.4±2.43         | 2.6±0.03         | 0.0058±0.0003 | 0.0032±0.0005 |
| Burdock             | 9.3±0.21          | 1.3±0.05         | 0.0054±0.0004 | 0.0031±0.0003 |
| Mouse peas          | 12.3±0.41         | 1.2±0.04         | 0.0049±0.0002 | 0.0045±0.0003 |
| Red clover          | 10.4±1.32         | 1.4±0.62         | 0.0041±0.0002 | 0.0038±0.0003 |
| Crescent            | 9.7±1.23          | 1.3±0.03         | 0.0049±0.0003 | 0.0035±0.0002 |
| On the average      | 10.02±0.12        | 1.67±0.03        | 0.0043       | 0.0040      |

It was established that the coefficient of biological absorption of lead by flowers of spring honey plants in the region ranged from 0.01 to 0.92. Flowers of apple and acacia (0.92) showed high activity of absorption, low - mother-and-stepmother - 0.01. The coefficient of biological absorption of cadmium ranged from 0.075 to 0.25, high rates were in apple flowers. Arsenic was more actively absorbed by the flowers of acacia (0.83), copper - apple trees (1.49), acacia (1.32), zinc — lungwort (1.44), apple trees (1.21), acacia (1.19) and willow (1.10).

The coefficient of biological absorption of TM summer honey plants in the area also varied in different limits. Flowers of clover rose (0.57) have a high level of lead absorption, and burrs field (0.08) have a low level. Cadmium was more intensively absorbed by linden flowers (0.18), weakly flowers of chiset (0.06), clover pink and white (0.06), clover white and yellow (0.06). Arsenic was actively absorbed by the colours of mouse peas (1.81), zinc - by willow tea (2.42), copper - by the colours of yellow clover (1.34). All honey plants exhibit high CBP to copper (0.97 - 1.34).

Thus, it was revealed that Coltsfoot flowers, dandelion, chisette and blooming Sally have a low biological absorption coefficient (BAC) to pollutants than honey plants. This is an important indicator of the use of honey plants in honey harvesting by bees.

The migration of heavy metals from soil to honey plants was determined using BAC, which is equal to the ratio of the element content in the honey plant ash to the element content in the soil on which these plants grow. With an increase in the BAC, the elements move more actively from the environment to the plants (table 5).

**Table 5. BAC of heavy metals in spring honey plants of the south of the Tyumen region.**

| Honey plants | Pb | Cd | As | Cu | Zn |
|--------------|----|----|----|----|----|
| Coltsfoot    | 0.01 | 0.18 | 0.054 | 0.93 | 0.70 |
| Willow       | 0.57 | 0.18 | 0.001 | 0.91 | 0.74 |
We have established that the coefficient of biological absorption of lead by the flowers of spring honey plants in the region was in the range of 0.01 to 0.92. Apple and acacia flowers showed a high degree of absorption (0.92), and a coltsfoot (0.01) showed a low degree. The coefficient of biological absorption of cadmium ranged from 0.075 to 0.25, high rates were in apple flowers. Arsenic was more actively absorbed by the flowers of acacia (0.83), copper - apple trees (1.49), acacia (1.32), zinc - lungwort (1.44), apple trees (1.21), acacia (1.19) and willow (1.01).

The accumulation of heavy metals spring honey plants can be built following descending series:

- Pb - acacia = apple > willow > lungwort > dandelion > coltsfoot
- Cd apple tree > dandelion > lungwort > willow > coltsfoot > acacia
- As - Acacia > Dandelion > Apple Tree > Medunitsa > Coltsfoot > Willow
- Cu - apple tree > acacia > coltsfoot > dandelion > willow > lungwort
- Zn - lungwort > apple tree > acacia > willow > dandelion = coltsfoot

The coefficient of biological absorption of TM summer honey plants in the area also varied in different limits. Flowers of clover rose (0.57) had a high level of absorption of lead, low level - field burdock (0.08). Cadmium was more intensively absorbed by linde flowers (0.18), weakly flowers of Pistac (0.06), clover pink and white (0.06), clover white and yellow (0.06). Arsenic was actively absorbed by the colors of mouse peas (1.81), zinc - by willow tea (2.42), copper - by the colors of yellow clover (1.34). All honey plants exhibit high BAC to copper (0.97 - 1.34).

According to TM accumulation in summer honey plants, one can build the following descending series:

- Pb - pink clover > crescent crescent > field thistle > linden > dandelion > ivan tea > red clover > chisel > white clover > burdock > mouse polka dot > white clover > sweet clover yellow
- Cd - Linden > Field Thistle > Red Clover > Crescent Crescent > Ivan-Tea > Scioner = Pink Clover = White Clover = White Clover = Clover Yellow = Field Burdock = Mouse peas = Dandelion
- As - mouse peas > red clover > crescent crescent > field thistle > chistets > linden > blooming Sally > pink clover > dandelion > white clover = field burrow > white clover > yellow clover
- Cu - yellow clover > white clover > red clover > crescent crescent > mouse peas > dandelion > meeza > blooming Sally = pink clover = dandelion > linden > chistets > field thistle
- Zn - blooming Sally > clover yellow > mouse peas > clover white > burdock field > honey crescent > clover pink > linden > scab > red clover > field thistle > white clover = dandelion.

| Honey plants     | Cd   | Pb   | As   | Cu   | Zn   |
|------------------|------|------|------|------|------|
| Linden           | 0.18 | 0.50 | 0.67 | 1.01 | 1.15 |
| Chistets         | 0.06 | 0.36 | 0.94 | 1.01 | 1.02 |
| Blooming Sally   | 0.12 | 0.47 | 0.40 | 1.04 | 3.04 |
| Clover pink      | 0.06 | 0.57 | 0.35 | 1.04 | 1.28 |
| Field Thistle    | 0.13 | 0.51 | 1.21 | 0.97 | 0.96 |
| Clover white     | 0.06 | 0.16 | 0.05 | 1.31 | 0.95 |
| White clover     | 0.06 | 0.08 | 0.03 | 1.05 | 1.49 |
| Clover yellow    | 0.06 | 0.09 | 0.02 | 1.34 | 2.97 |
| Field burdock    | 0.06 | 0.15 | 0.05 | 1.11 | 1.47 |
| Mouse polka dots | 0.06 | 0.13 | 1.81 | 1.17 | 1.83 |
| Red clover       | 0.13 | 0.33 | 1.64 | 1.27 | 0.98 |
| Crescent crescent| 0.13 | 0.51 | 1.21 | 1.26 | 1.44 |
4. Conclusion
Thus, the analysis of the obtained results showed that mother-and-stepmother flowers, dandelion, chistets and blooming Sally have a low or relatively low biological absorption to the pollutants from honey plants. This is an important indicator of the selection of honey plants for honey collection of bees. The regularity of the content of heavy metals, radionuclides and pesticides in honey plants of beekeeping areas has been established:

\[ \text{TM - Tyumensky} > \text{Yalutorovsky} > \text{Yarkovskiy} > \text{Nizhnetavdinsky} > \text{Isetsy} > \text{Vagaysky} > \text{Armizonsky} > \text{Aromashevsky} > \text{Uporovsky} > \text{Sladkovsky} > \text{Berdyuzhsky}. \]

\[ ^{137}\text{Cs} \text{ and } ^{90}\text{Sr} - \text{Nizhnetavdinsky} > \text{Tyumen} > \text{Yalutorovsky} > \text{Yarkovsky} > \text{Vagai} > \text{Isset} > \text{Armizonsky} > \text{Aromashevsky} > \text{Uporovsky} > \text{Sladkovsky} > \text{Berdyuzhsky}. \]

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