Stress induced changes of Fluorine concentration in soil-plant-insect ecosystem of Aluminum plant zone

E. Kamilova & G. Rakhmatkariev
Institute of General and Inorganic Chemistry Academy of Sciences of Uzbekistan, Uzbekistan

Abstract

The main goal of this research was the creation of scientifically based recommendations for predicting the level of damage for the surrounding ecosystems by the aluminum plants and for taking adequate measures to protect the Great Silk Road. With the purpose of study of Fluorine as possible reason of silkworms destruction in a zone of emission of Fluorine pollution of an Aluminum plant the investigations have been conducted by the evaluation of fluoride accumulation in the ecosystem components (soils, Mulberry’s leaf, Mulberry’s stick, apricot-tree’s leaf, apricot-tree’s stick, caterpillars of silkworm and excrements of silkworm) by the distance limit from the objects by the wind rose. Concentrations of fluoride were detected by method of alizarinechelatometry photometry.

The accumulation of fluoride more than 25 % in comparison with the standard chestnut soil and more than 45 % with chernozemic soil respectively in soils nearby Aluminum plant has been observed. The increase by more than 25 times of fluoride content in silkworm’s excrements from a zone undergone to harmful action of emissions of an aluminum factory has been discovered. Whereas authentic increase of the fluoride contents in Mulberry’s leaves was not revealed, and in body of silkworm’s caterpillars was lower than a limit of detection by this method.

Hence, the control of pollution of fluoride in a zone of emission can be done by analysis of soil samples and excrements of silkworms, instead that of Mulberry’s leaves and body of silkworm's caterpillars.
Introduction

The fluorine content in the environment has significant influence on human and animal's health. The average content (Clark) of fluorine in terrestrial earth crust is rather significant — 0.027 Yo. Fluorine has high migration ability, as chlorine. Therefore, this chemical element is easy leaking from underlying rock and migrating to surface waters. Fluorides, hydrogen fluoride, and fluorine are chemically related (Nikitin [1]). Fluorine is a pale, yellow-green gas that has a strong, sharp odor. It combines with hydrogen to make hydrogen fluoride, a colorless gas. Hydrogen fluoride dissolves in water to form hydrofluoric acid. Fluorine also combines with metals to make fluorides like sodium fluoride and calcium fluoride, both white solids. Sodium fluoride dissolves easily in water, but calcium fluoride hasn't such ability. If drinking water supplies are low in fluoride, many communities add fluorides to help prevent cavities. Some skin medicines and cancer treatment drugs also contain fluorides.

However, depending on geographical conditions, the fluoride contents in natural water change in high range from 0.001 mg per litre up to 10 mg per litre and more. For optimum in drinking water the contents from 0.6 mg per litre up to 1.0 mg per litre are accepted.

The major task of this work is the creation of scientifically based recommendations for predicting the level of damage for the surrounding ecosystems by the aluminum plants and for taking adequate measures to protect the Great Silk Road.

Extra high concentration of fluoride causes different non-infectious people diseases: fluorosis disease, "Darman" disease disrupts teeth of people and animals in some regions of Morocco (Murray, [2]).

Hazard effect of fluoride are the following:

1. Fluoride exposure disrupts the synthesis of collagen and leads to the breakdown of collagen in bone, tendon, muscle, skin, cartilage, lungs, kidney and trachea (Sharma [3], Susheela [4], Drozd [5]).

2. Fluoride stimulates granule formation and oxygen consumption in white blood cells, but inhibits these processes while the white blood cell is challenged by a foreign agent in the blood (Robert A. Clark [6]).

3. Fluoride depletes the energy reserves and the ability of white blood cells to properly destroy foreign agents by the process of phagocytosis. As little as 0.2 ppm fluoride stimulates superoxide production in resting white blood cells, virtually abolishing phagocytosis. Even micro-molar amounts of fluoride, below 1 ppm, may seriously depress the ability of white blood cells to destroy pathogenic agents (Gabler, W. L. [7]).
4. Fluoride confuses the immune system and causes it to attack the body's own tissues, and increases the tumor growth rate in cancer prone individuals (Taylor [8], Gibson [9], Jaouni [10]).

5. Fluoride inhibits antibody formation in the blood (Jain, S. K., [11]).

6. Fluoride depresses thyroid activity (Hillman [12]).

7. Fluorides have a disruptive effect on various tissues in the body (Vilber [13], Yoshisa [14]).

8. Fluoride promotes development of bone cancer (Hrudley [15], Cohn [16], Mahoney [17]).

9. Fluorides cause premature aging of the human body (Leone [18], Erikson [19], [20]).

10. Fluoride ingestion from mouth rinses and dentifrices is extremely hazardous to biological development, life span and general health of children (Augenstein [21], Waldbott, [23]).

Fluoride deficit also has negatively influences on human metabolism, results in destruction of enamel of teeth. This phenomenon is wide spread in desert regions of USA and is known as "mottled enamel" or "Texas teeth". In such regions drinking water needs fluorine addition for fluoridating of water (Dobrovolsky [24], Dean [25]).

Other countries argue that even 1 ppm is not a safe concentration. Canadian studies, for example, imply that children under three should have no fluoride whatsoever. The Journal of the Canadian Dental Association states that "Fluoride supplements should not be recommended for children less than 3 years old." Since these supplements contain the same amount of fluoride as water does, they are basically saying that children under the age of three shouldn't be drinking fluoridated water at all, under any circumstances. Japan has reduced the amount of fluoride in their drinking water to one-eighth of what is recommended in the U.S. Instead of 1 milligram per liter, they use less than 15 hundredths of a milligram per liter as the upper limit allowed.

Unfortunately, the authors did not find the references describing action of fluorine and fluorides influence on growth and development of Mulberry (Morus alba L.) and silkworm.

The research focused on an Aluminum plant zone in Surkhandario velayat of the Republic of Uzbekistan. The Tadjiksky Aluminum plant is the biggest leak source of fluorine (F) in Surkhandario velayat of Uzbekistan in recent years, that leads to wide spread of this toxic pollutant to Surkhandario valley.

Fluorine destroys the gardens that are situated in the area close to the aluminum factory. There are also large concentration of fluorine in grass and pasture for domestic animals. The consequences of this phenomenon is reducing of the number of domestic animals in the area of the factory and the milk and meat became inedible.
Fluorine destroys grown and development of silkworms in surrounding area and lead to high rate of their mortality.
2 Material and methods

For study of Fluorine as possible reason of silkworms destruction in a zone of emission of Fluorine pollution of an Aluminum plant, the investigations have been conducted for the evaluation of fluoride accumulation in the Ecosystem components (soils, Mulberry’s leaf, Mulberry’s twigs, apricot-tree’s leaf, apricot-tree’s twigs, caterpillars of silkworm and excrements of silkworm) by the distance limit from the objects by the wind rose.

Concentrations of fluoride as possible cause of silkworm's perish in aluminum plant zone and accumulation of fluorides by insect and plant tissue was measured twice during the study period. The first run was undertaken in May 1999 and the second in June 2000. Samples were placed at the same sites in Surkhandario velayat of Uzbekistan (fig.#1). The evaluation of fluoride accumulation was investigated in 3 tumans of Uzbekistan by the distance limit from the a zone of emission of Fluorine (Tadjiksky Aluminum plant):

1. Saryossio- location 27.5 km from Aluminum plant (-polluted zone, silkworms perish appeared),
2. Denov- location 41 km from Aluminum plant (-intermediated zone, destroying of grew and development of silkworms appeared),
3. Djarkurgan- location 134 km from Aluminum plant (-non-polluted, control zone).

The Surkhandario Valley situated between two mountain ranges. As a result, there is some kind of wind tunnel along the valley. The air flow transfers harmful emissions from the Tadjiksky Aluminum plant from Saryossio up to Djarkurgan.

We chose the following objects for the research:
1. Soils in the whole area of research.
2. Leaves of Mulberry (-Morus alba L.), which serve as a forage for caterpillars of silkworm.
3. Leaves of an apricot-tree with the burns caused by harmful emissions of hydrogen fluoride.
4. Twigs of Mulberry (Morus alba L.) and apricot-tree.
5. Caterpillars of silkworm.
7. Excrements of silkworm.

Concentrations of fluoride were detected by the alizarinechelatometry photometry method (Leonard, [26]).
Results

Fluoride content in the soil samples (400-450 mg/kg) exceeds that in the Standard Chernozemic (280 mg/kg of fluoride) and Chestnut (360 mg/kg) Soils by 150% and 110% respectively.

Besides, disturbance of silk worm's growth and development around aluminum plant has been detected (in Saryosio tuman and some parts of Denov tuman).

Therefore, we consider that the reason of silk worm morbidity is fluoride poisoning in this regions.

It is necessary to note, that Fluorine has very low factor of biological accumulation ratio ($K_b = 0.01$). It is known, that healthy plant has an ability to keep and support chemical structure of plant's organism at the certain level.

The fluoride content in standard plant species samples is 10 mg/kg of dry
weight for Grass mixture Standard , -6 mg/kg of dry weight for potato bulb and 3 mg/kg of dry weight for wheat's kernel.

In our research it was not possible to reveal natural accumulation of fluorides in a twigs of Mulberry (Morus alba L.) depending on affinity to an aluminium factory. The fluoride content in the twigs of Mulberry, as well as in the apricot-tree twigs was close to the standard at any distance from the site - 10 mg/kg and less.

Stable fluorine content’s increase was not determined in Mulberry's leaves by any distance from aluminum plant.

Fluoride content in the Mulberry and apricot-tree leaves was measured as 10 mg/kg of dry weight without any relation to the distance from the object (figures: 2 and 3).

Our investigation detected fluoride accumulation in leaves of plants only in the analysis of ash of leaves (table 1). One can see difference between Saryosio tuman located by 27.5 km distance from aluminum plant. Content of fluoride here is 70 mg/kg. Ash of leaves from Djarkuran tuman situated 134 km far from aluminum plant contents 30 mg/kg of fluorides.

The stability of fluoride content in a vegetative material can be explained by the ability of the plant to support chemical structure at the certain level, and low factor of biological migration of fluorides. This phenomenon of ability of plant to safe and hold total chemical composition on the appointed level and by low biological accumulation ratio of fluorine is attributed. All poisonous elements (including, fluoride), are characterized by low biological accumulation ratio.

Fluoride maximum permissible concentration (MPC) in a vegetative forage for cattle is 30 mg/kg of dry weight (Bunce [27]). However, fluoride MPC for silkworm’s alimentation was not observed in literature and research. So, that’s unknown how Fluoride maximum permissible concentration in a vegetative forage...
for the cattle can be accorded to the problem. Silkworms are very gentle insects, they die under slightest adverse conditions.

Silkworm population die by the poisoning with very small amounts of pesticides and another poisonous chemicals. However, less when fluoride maximum permissible concentration (MPC) for vegetative forage for the cattle were determined in Mulberry’s (Morus alba L.) leaves in all territory has been investigated.

The data of fluoride content in silk worm’s body less than sensitivity Check for this method (5 mg/kg dry weight) in all investigations has been determined. High fluoride content in silkworm's excrements in possible pollutants zone is presented (in Saryosio tuman and some parts of Denov tuman, table :1).

It is necessary to note, that fluoride content of silkworms’ excrements from this area is 100 mg/kg dry weight, which is 25 times higher than in the reference area (figure 4).

Table 1: Fluoride accumulation in the Ecosystem components in a zone of emission of Fluorine pollution of an Aluminum plant.

<table>
<thead>
<tr>
<th>#</th>
<th>Objects</th>
<th>Fluoride content, mg/kg (average)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Saryosio, polluted zone 27.5 km</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dry weigh</td>
</tr>
<tr>
<td>1</td>
<td>Soils</td>
<td>450.0</td>
</tr>
<tr>
<td>2</td>
<td>Leaves of Mulberry (Morus alba L.)</td>
<td>10.0</td>
</tr>
<tr>
<td>3</td>
<td>Leaves of apricot-tree.</td>
<td>10.0</td>
</tr>
<tr>
<td>4</td>
<td>Twigs of Mulberry and apricot-tree.</td>
<td>10.0</td>
</tr>
<tr>
<td>5</td>
<td>Caterpillars of silk-worm.</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>Cocoons of silk-worm.</td>
<td>20.0</td>
</tr>
<tr>
<td>7</td>
<td>Excrements of silk-worm.</td>
<td>30.0</td>
</tr>
</tbody>
</table>
Conclusions

1. The fluoride content in the soils samples at all studied (134 km, 41 km, 27.5 km) distances from the Aluminum plant is up to 25% and 45% higher than in the standard chestnut and chernozemic soils) respectively.

2. The increase of fluoride content in silkworm's excrements from the zone undergone the harmful emissions of an aluminum factory by more than 25 times has been observed.

3. Authentic increase of the fluoride contents in Mulberry's leaves was not revealed, and in the body of silkworm's caterpillars it was lower than a limit of detection by this method.

4. Hence, the monitoring of fluoride pollution in a zone of emission can be done by the analysis of soil samples and excrements of silkworms, and not by analyses of Mulberry's leaves and silkworm's caterpillars.

References


420  Air Pollution X


