Research concerning the vegetation development on the ash and slag deposits of Thermal Power Plant Paroseni

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Abstract. Slag and ash wastes are produced from burning coal in Thermal Power Plants. Coal has radioactive elements that do not burn and are accumulated in slag and resulting ash, only a small amount is removed on the chimneys. Slag and ash contain chemical elements that can affect the growth of vegetation. It can also affect health by eating vegetal products from the vicinity of slag and ash deposits. In this paper we propose to study the way of absorption of the chemical elements by the plants from the slag and the ashes resulted from the burning of the coal in the Thermal Power Plant. Two varieties of grapes were used for this study. Plants have been chosen because of their high absorption capacity of the elements needed from soil, which are necessary for development, and also as they can develop in the most difficult conditions.

1. Introduction
Part of the electricity in Romania is based on obtaining it in thermoelectric power plants. Thermoelectric power plants are considered to be an important source of environmental pollution. These have negative effects on all environmental components. Thermoelectric power plants can operate with solid, liquid and gaseous fuels.

The most polluting plants are those that work with solid fuels, coal.

Slag and ash are waste from the combustion of coal in the Thermoelectric Power Plant. Coal has radioactive elements that do not burn and are accumulated in slag and resulting ash, only a small amount is removed on the chimneys.

The resulting slag and ash is deposited in slag and ash ponds. Slag and ash ponds pose great problems in terms of pollution. The problems are given both by the composition of the deposited material (chemical components and radioactive elements) and by the wind entrainment of the particles on the tailings pond surfaces. Wind-driven particles are transported at significant distances to tailings ponds and affect the development and quality of plants in neighboring areas. These particles can also have negative effects on health by inhalation of dust particles and consumption of vegetal products in the vicinity of slag and ash deposits.

In this paper we propose to study the way of absorption of the chemical elements by the plants from the slag and the ashes resulted from the burning of the coal in the Paroşeni Thermoelectric Plant. For this study two varieties of Vineyard, planted in garden soil and slag and ashes from the Căprioara Valley slag and ash deposit of Parosni Thermal Power Plant were used. This plant has been chosen because of its high absorption capacity of the elements needed for soil development and can develop in the most difficult conditions. [1, 3]

2. Theoretical considerations
The grapevine is a multiannual plant. Each year it repeats the growth pattern from the previous year. Each part of the pattern is in relation with the temperature. Temperature conditions vary from year to year. Apart from this, the stages of growth vary from one vineyard to another, according to conditions such as topography and aspect. One of important moments is root system structure. Distribution of roots is influenced by soil characteristics.

Plants are selective about the mineral nutrients they absorb. Only soluble mineral nutrients can be absorbed through the roots. When these dissolve in water, ions (very small charged particles) are formed. Mineral ions enter the roots by either diffusion or by the plant actively pumping them into the root cells.

The roots of a plant take in water (and dissolved mineral salts) by a process known as ‘osmosis’. Osmosis is nature’s way of levelling out the unequal ratio of salt between the plant cell sap and the soil water. Water moves into the plant via the hairs at the ends of new roots, diluting the salt concentration in the cell sap. Water intake is affected by the: size of the root system, availability of soil water, salt concentration in the soil.

Water and minerals are drawn mainly from about 30 cm to 80 cm below the surface. The number of vine roots decreases at about one metre. Roots from upper layer are mainly engaged in water absorption. Due to the lack of minerals and water only few roots penetrate much further—and only in very dry years could drawn up to 6 m.

During vine transpiration, which is the process of water loss in the vine, approximately 90% of water loss occurs.

Most important macro elements (required in higher amounts) necessary for the development of the vine are represented by: nitrogen (N) - Component in vegetative organs (shoots, leaves, clusters). Also important after harvest period for building of reserves (especially in roots), phosphates (P), potassium (K) is responsible for the regulation of water movement in the plant, calcium (Ca) is important for survival during cold winter, magnesium (Mg), sulfur (S)

Most important micro elements - required in small amounts: iron (Fe), boron (B), manganese (Mn), zinc (Zn) and copper (Cu). [2, 4]

3. Results and discussions

Slag and ash ponds raise major problems due to the amount of fine particles that are entrained by the air currents on their surfaces. Although the ponds are equipped with irrigation systems, the process still takes place. Dust particles are transported and deposited on the soil and vegetation in the vicinity of slag and ash ponds. Both the chemical and the radioactive elements can be absorbed by the vegetation, subsequently transmitted by the consumption of fruits and leaves by the population. In order for the surfaces of slag and ash ponds to be used after the completion of the deposition process, these must be ecologized and rendered in the natural circuit. The greening and rendering processes in the natural circuit of tailing ponds provide for the covering of their surfaces with a layer of vegetal soil to reduce the air pollution with fine dust particles. Due to the fact that the layer of vegetal soil used will be relatively thin, the root part of the vegetation to be used for the recirculation of the vegetation will still penetrate to slag and ash.

In order to study how the chemical and radioactive elements are transmitted to the plants and their fruits, we used two varieties of vines, one white and one red. The two varieties were planted both in the soil from the decantation bed as and normal soil. Vine varieties resistant to low temperatures and freezing were selected.

The vine is a plant with a root system that can penetrate the soil up to 6 m depths and will extract the chemical elements found in slag and ash. Soil and ash are soils with very few nutrients and which, depending on the chemical composition of the coal used in the burning process, can have significant amounts of chemical elements unfavorable to the development of the vine. [6]

White vine used is Vitis "Vroege van der Laan"
Vitis 'Vroege van der Laan' is a white grape, yellow, which is particularly suitable for growing outdoors. It belongs to old varieties. The plants are strong and quite resistant to fungal diseases. He is considered one of the best white grape for our outdoor climate. "Vroege van der Laan" always comes at a good production. Grapes ripe in late September-early October. The production is moderate to good. Although grapes are good to eat, they are mainly used for the production of juices and white wines. (Figure 1)

![Figure 1. Vitis "Vroege van der Laan"](image1)

Vine Vitis used is 'Boskoop Glory'. "Boskoop glory" is a disease resistant, cold-tolerant grape variety from the Netherlands. It is a hybrid between Vitis vinifera and Vitis labrusca. It was developed in the 1950s at Wageningen where American vines had been planted. It is therefore assumed to be a spontaneous crossing of two species from the vineyard. This variety usually ripens fruit in late August or early September and is resistant to fungal diseases and frost. It is a popular table grape in the Netherlands and it is popular among gardeners in the Netherlands, England, Germany and much of Northern Europe. The flavor is very aromatic and juicy. (Figure 2).

![Figure 2. Vitis "Boskoop Glory"](image2)

To determine the presence of chemical elements at both plant and fruit level, laboratory analyzes were performed. Samples were taken one year after planting the vine in the two soils. (Figure 3)

![Figure 3. Samples for chemical analysis](image3)

To perform the chemical analyzes, the performance and calibration equipment was used. Before carrying out the chemical analyzes the samples were prepared according to the requirements of the equipment used. [6]

The results of the analyzes obtained are shown in Tables 1 and 2.
Table 1. Results of chemical analyzes for variety Vitis "Boskoop Glory"

| Component | UM | Leaves Vitis "Boskoop Glor soil | Leaves Vitis "Boskoop Glory" ash and slag | Vitis "Boskoop Glory"soil | Vitis "Boskoop Glory"ash and slag |
|-----------|----|---------------------------------|------------------------------------------|--------------------------|-----------------------------------|
| U         | ppm| 0,00                            | 0,29                                     | 2,90                     | 3,58                              |
| MgO       | %  | 0,09                            | 0,16                                     | 0,00                     | 0,00                              |
| Al2O3     | %  | 0,11                            | 0,06                                     | 0,09                     | 0,10                              |
| SiO2      | %  | 0,77                            | 0,32                                     | 0,23                     | 0,26                              |
| P2O5      | %  | 0,36                            | 0,38                                     | 0,15                     | 0,13                              |
| SO3       | %  | 0,38                            | 0,35                                     | 0,14                     | 0,00                              |
| Cl        | %  | 0,03                            | 0,02                                     | 0,03                     | 0,02                              |
| K2O       | %  | 2,36                            | 2,46                                     | 0,92                     | 1,18                              |
| CaO       | %  | 5,49                            | 5,53                                     | 1,02                     | 1,22                              |
| MnO       | %  | 0,02                            | 0,00                                     | 0,00                     | 0,00                              |
| Fe2O3     | %  | 0,03                            | 0,02                                     | 0,03                     | 0,00                              |
| GeO2      | ppm| 10,10                           | 8,88                                     | 82,47                    | 0,00                              |
| As2O3     | ppm| 22,72                           | 28,49                                    | 61,57                    | 68,03                             |
| SeO2      | ppm| 3,09                            | 0,00                                     | 0,00                     | 0,00                              |
| SrO       | ppm| 34,03                           | 0,00                                     | 0,00                     | 0,00                              |

Table 2. Results of chemical analyzes for the variety Vitis "Vroege van der Laan"

| Component | UM | Leaves Vitis "Vroege van der Laan" soil | Leaves Vitis "Vroege van der Laan" ash and slag | Vitis "Vroege van der Laan" soil | Vitis "Vroege van der Laan" ash and slag |
|-----------|----|-----------------------------------------|-----------------------------------------------|-------------------------------|----------------------------------------|
| U         | ppm| 0,00                                    | 0,76                                         | 0,00                          | 0,97                                   |
| MgO       | %  | 0,29                                    | 0,23                                         | 0,00                          | 0,00                                   |
| Al2O3     | %  | 0,22                                    | 0,19                                         | 0,04                          | 0,22                                   |
| SiO2      | %  | 1,09                                    | 0,80                                         | 0,21                          | 0,44                                   |
| P2O5      | %  | 0,64                                    | 0,77                                         | 0,33                          | 0,16                                   |
| SO3       | %  | 0,52                                    | 0,59                                         | 0,25                          | 0,81                                   |
| Cl        | %  | 0,03                                    | 0,02                                         | 0,02                          | 0,05                                   |
| K2O       | %  | 2,22                                    | 2,91                                         | 2,39                          | 2,60                                   |
| CaO       | %  | 7,17                                    | 6,58                                         | 2,43                          | 1,08                                   |
| MnO       | %  | 0,04                                    | 0,00                                         | 0,07                          | 0,00                                   |
| Fe2O3     | %  | 0,03                                    | 0,06                                         | 0,00                          | 0,00                                   |
| GeO2      | ppm| 23,18                                   | 34,94                                        | 37,94                         | 0,00                                   |
| As2O3     | ppm| 20,50                                   | 39,79                                        | 43,16                         | 146,98                                 |
| SeO2      | ppm| 0,00                                    | 9,19                                         | 5,86                          | 31,92                                  |
| SrO       | ppm| 0,00                                    | 0,00                                         | 0,00                          | 392,69                                 |

From the analysis we can see that the vine plants have absorbed chemical elements from the soil where they were planted.
Some of these elements may have undesirable effects on plants. From the analyzes it can be seen that all types of vines have absorbed significant amounts of arsenic trioxide. Arsenic trioxide is present both in plants in the garden soil as well as in slag and ash. Plants cultivated in the garden soil have absorbed this compound from the air. In the case of plants grown in slag and ash, arsenic trioxide is absorbed and the soil significantly increases its concentration.

Elements of good development have been analyzed for calcium, iron and magnesium content. These elements were also absorbed by the leaves and fruits of the vine.

One of the most widespread diseases in the vineyards in our country is the lack of iron. The concentration of iron in slag and ash prevents the establishment of this disease, preventing premature eradication of the vine.

The presence of calcium in vine reduces the intensity of diseases and helps plants to survive during cold periods. The excess amount of calcium reduces iron solubility, which contributes to the formation of chlorophyll. The amount of calcium present in slag and ash is sufficient for the harmonious development of plants.

Another major problem is the radioactivity present in slag and ash resulting from combustion. Radioactive elements in coal do not burn and are accumulated in slag and ash. These radioactive elements can be transmitted to vegetation and implicitly to the population through consumption. One of these elements is uranium, which has been analyzed.

As a result of the analyzes we can see that uranium raises problems with the Boskoop Glory variety, which has a higher absorption capacity of this element. Uranium is present both in the leaf and in the fruit where it reaches a concentration of 27.67 ppm. White variety Vroege van der Laan absorbed a much smaller amount.

In order to study the level of radioactive pollution of slag and ash deposits and their transmission to the vegetation that develops on their surface, we analyzed the α, β, and γ radiation levels both on the surface of the slag and ash deposits as well as on the level of the vegetal part of the vines. [5, 6]

Measurements were made using the Geiger Gamma Scout Radiation Detectors. The Gamma-Scout is equipped with a Geiger-Muller counter that detects alpha, beta and gamma radiation. The average cosmic stock level recorded in the area unaffected by slag and ash ponds when measuring the dose for vegetation is 0.125381 μSv / h.

In the case of vine plants to study how radioactive elements are transmitted at plant level, we have made measurements on the plant part of the two varieties of vines from the two bases. The results obtained are shown in Figures 3-6.

![Figure 4. Value of the dose level recorded in "Vroege van der Laan" planted in soil](image1)

![Figure 5. Value of the dose level recorded in "Vroege van der Laan" planted in ash and slag](image2)
Figure 6. Value of the dose level recorded in "Boskoop Glory" planted in the soil

The average level of the cosmic stock recorded in the zone not affected by the slag and ash ponds at the dose measurement for the tailings ponds of the Paroseni Thermoelectric Power Plant is $0.082642 \mu Sv / h$.

The average value of the dose level recorded near the dam of Paroseni Thermal Power Plant is $0.28009 \mu Sv / h$, and for the Caprioara Valley dam Paroseni Thermal Power Plant is $0.379998 \mu Sv / h$.

Figure 8. Value of the dose level recorded on the Paroseni Thermoelectric Power Plant

The tailings ponds of the Paroşeni Thermoelectric Power Plant have an average radiation dose of $0.197448 \mu Sv / h$ for the dam and $0.297356 \mu Sv / h$ for the Caprioara Valley pond. These values represent the difference between the recorded value and the value of the cosmic pool. From Figure 8 it can be seen that the Boskoop Glory plant planted in the tailings absorbed a larger amount of radioactive selections from the soil, the radiation dose of this variety being higher.

The lower dose values recorded on the dam are due to the vegetation that covered the slag stored in it.

Figure 9. The value of the dose level recorded on the Valea Caprisoara Valley of the Thermal Power Plant Paroşeni
4. Conclusions

Vineyards can be grown in almost any type of soil, have a strong and deep root system, leading to soil fixation, and increased pond stability.

The varieties chosen for the study on the development of viticultural plants in slag and ash from the TMF tailings ponds are varieties resistant to low temperatures and frost. As a result of the study, it can be observed that slag and ash contain sufficient quantities of elements necessary for the development of vineyards such as calcium, magnesium and iron. The presence of these chemical elements helps to protect the vine against possible diseases.

The soils on which vineyards are grown in our country have a low iron content, while slag and ash have a high iron content, preventing premature eradication of the vine. Cultivating plants on these slag and ash ponds raises problems due to its radioactivity. Radioactive elements in the soil are accumulated in plants and can be transmitted by ingestion to animals and humans.

The radiation dose recorded for the TMF exceeds 3.5 times the natural background in the non-polluted area, and for the Caprioara Valley pond is 4.5 times higher. These soil characteristics make it necessary to choose plants that absorb as few radioactive elements as possible. The studies show that the vine variety "Boskoop Glory" absorbs a significant amount of radioactive elements against the Vroege van der Laan variety.

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