Influence of radioactivity present in ash from Thermal Power Plant Paroseni on plant development
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Abstract. Paroseni Thermal Power Plant provides electricity and heat and works with coal as fuel base. After burning coal from the power thermal plants results in a high quantity of slag and ash, a part of the ash fraught chimneys is dispersed directly in the atmosphere, and the rest is transported hydraulically to ash ponds. Slag and ash from coal combustion from the Thermal Power Plant Paroseni, is transported hydraulically to the Caprisoara pond. The coal used in the combustion contains a significant quantity of radioactive elements from the ore. Radioactive elements contained in coal will not burn, they accumulate in slag and ash. The radioactivity, due to the burning of coal and discharged in ash, is a major problem in the development of vegetation. Revegetation of ash ponds resulting from technological process, requires a study of plant development in the presence of radioactivity from ash. In this paper, our scope is, to study the behavior of plants used for revegetation process of ash ponds in the presence of ionizing radiation.

Key Words: radioactivity, plant development, energy, pollutant.

Introduction. Thermal Power Plan Paroşeni is a cogeneration power plant supplying heat and power generation. Works with coal as fuel base and provide heat for the residents of the four mining towns in the area, namely: Petrosani, Vulcan, Lupeni, Aninoasa.

For the electricity production, as the primary energy source, the Thermal Power Plant Paroşeni, is using solid fuels, coal base of the Jiu Valley. Solid fuels, in addition to fuel, contain more sterile, which will be found after the combustion process in the form of slag and ash. All products resulting from combustion represents pollutants in the sense that they are changing the balance in the external environment or act directly on the animals and plants.

The main pollutants emitted by chimneys of the power plants are sulfur oxides (SO$_2$ and SO$_3$), nitrogen oxides (NO and NO$_2$), carbon monoxide and carbon dioxide (CO and CO$_2$), dust (fly ash, unburned carbon particles, clay, earth) and in smaller quantities: tars, hydrocarbons, soot, sulfates, organic acids, etc. (Petrilean et al 2014).

Filters installed in chimneys of power plant stations not fully retain the flying ash and radon is fully released into the atmosphere, increasing atmospheric radioactivity. To this natural radioactivity increase is added $^{210}$Pb and its descendants contribution, $^{214}$B, which is fixed to the aerosol. These power plants with solid fuels as fuel base, for the production of energy burn large amounts of fuel, so that, the emanations of fly ash and radioactive isotopes released into the atmosphere they cannot be ignored to radioactive pollution of the environment. Radioactive pollution produced it should not be ignored, as is a continuous pollution. Population living in areas affected by radioactive pollution produced by power plants based on the combustion of solid fuels annually receive an additional dose of 300-500 μSv/year (Plecas & Arbutina 2013).

Theoretical considerations. Surface coal mining bring some radioactive elements in the earth's crust, resulting in increased surface of radioactivity. The radioactivity of coal is mainly given by the content of uranium, thorium, potassium, and radium (80%).

Uranium accumulations of coal can vary from place to place depending on the deposit and the date of geological region. The main radionuclides that we encounter in coals and ashes are: $^{238}$U, $^{235}$U, $^{232}$Th, $^{40}$K, $^{226}$Ra, $^{214}$Pb, but besides these radionuclides, we can find traces of bismuth, polonium, etc. These radionuclides are mainly responsible for the emission of radiation.

Uranium and thorium remain the main radionuclides that contribute significantly to human exposure to radiation. The concentration of the world's coal radionuclides in...
normal ranges are around 50 Bq kg\(^{-1}\) to 40K, 20 Bq kg\(^{-1}\) to \(^{238}\)U, 20 Bq kg\(^{-1}\) for the \(^{232}\)Th and 20 Bq kg\(^{-1}\). The coal from Romania were found six times higher values to 40K, and the \(^{238}\)U values were twice higher (Petrilean et al 2014).

Radioactive elements present in coal they burn and accumulate in slag and ash. In of Thermal Power Plant Paroșeni, ashes from the burning of coal is accumulated and transported hydraulically and deposited in ponds associated to the plant.

Due to the small particle size of the ash, that is driven by wind and is producing phenomena of contamination of neighboring areas of tailing ponds. Fauna and flora of the surroundings is affected by pollution from tailings ponds (Florou et al 2009).

The radiations emitted by radioactive elements influence the surrounding flora and fauna through their effects.

Initially, the effect of radiation occurs at the atomic level irradiated material. In this phase occurs energy transfer from photons to atoms of irradiated material.

In the second phase, the atoms ionized and molecules recombine, generally producing free radicals - chemical species with high reactive. Given the predominance of water in living matter, the most common free radicals found in this stage are free radicals derived from water radiolysis.

\[
\begin{align*}
H_2O &\rightarrow HO^- + H^+ \\
(1)
\end{align*}
\]

Due to the high reactivity of free radicals they have a short lifetime and recombine. In the case of compounds with simple composition, they are recombined or they form radiolysis products, generally micro molecular.

\[
\begin{align*}
HO^- + H^+ &\rightarrow H_2O + Q \text{ (călușă)} \\
(2)
\end{align*}
\]

In the case of macromolecules, this is cleaved, or either participates to curing radiation-induced reaction, or to an intermolecular bond formation (Moise et al 2009).

The crystal structures have a special behavior, they are less affected by radiation, but free radicals can be trapped in these structures and gradually released, contributing to long-term effects of radiation.

Following recombination processes free radicals act in an irreversible way on macromolecules, resulting on this way biological effects of radiation on living organisms. It was found that the first effect that is occurring is the cleaving of DNA molecules. To restore them contribute enzymatic processes in the living cell.

Enzymatic mechanisms of the cell can restore DNA molecule in a form which preserves the genetic information needed cell multiplication and we deal with resistance to radiation, and when reunification of DNA molecule is genetically incorrect or not can be made in good time before the onset mechanisms of multiplication of cells the next generation will not be viable.

Depending on the number and complexity of the affected cells of the body it can lead to biological death of it. It is known that simple organisms radio resistance is much higher than that of complex organisms and depends on the dose of radiation.

**Results and Discussion.** To study the behavior of plants to radiation was used three containers with cotton support that where left for sprout 20 wheat grains in each. One of the containers was kept irradiated for control and the other two containers were irradiated to a source of Americium ($^{241}$Am): one was radiated for one minute, and the second for five minutes, weekly, during 5 weeks, before and after germination. This was made in order to observe the effect of radiation on the whole cycle of growth and development.

Activity of source is 20 mCi, and the irradiation dose produced is 0.5 mrem h\(^{-1}\). Wheat seeds were first irradiated at a distance of 25 cm from the source, reducing the activity to that distance to 0.032 mCi.

The temperature conditions at which they were hold was 18°C and, were watered with 20 ml of water every 2 days.
A week after the start of the experiment was observed sprouting seeds, and more importantly was observed a very small number of sprouted grains in the container subjected to radiation for 5 minutes.

During the 5 weeks, was observed that in the control vessel, sprouting was largest number of seeds 18, and the container irradiated for a period of 1 minute - 16 seeds had sprouted, which shows that the radiation dose was not sufficient to hopelessly distorting embryo cells (Figure 1). The container irradiated for 5 minutes it was observed that only half of the seeds had sprouted, and they have germinated later, with a slow initial increase due to the high proportion of cells affected by the received radiation.

![Figure 1. Development of wheat in the fifth week.](image)

In terms of plant growth, has been observed that those treated with a low dose of radiation, the growth was slowed in comparison with plants treated with a higher dose of radiation at the same time of germination, which brings to mind a possible positive influence of radiation on the plant growth, and at the same time that the dose of radiation is less damaging in the period of growth. Due to the higher mass of matter contained in the plant growth stage compared to its mass in its embryonic stage is understandable that the same amount of absorbed radiation had a significantly attenuated (Table 1).

<table>
<thead>
<tr>
<th>Days</th>
<th>Sample</th>
<th>No. of sprouted seeds</th>
<th>Minimum height (mm)</th>
<th>No. plants 1-9 cm</th>
<th>Maximum height (mm)</th>
<th>No. plants 10-20 cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Control</td>
<td>9</td>
<td>1</td>
<td>9</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>1 minute</td>
<td>8</td>
<td>0.5</td>
<td>8</td>
<td>2</td>
<td>0</td>
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<tr>
<td></td>
<td>5 minutes</td>
<td>5</td>
<td>0.5</td>
<td>5</td>
<td>2.5</td>
<td>0</td>
</tr>
<tr>
<td>14</td>
<td>Control</td>
<td>12</td>
<td>9</td>
<td>3</td>
<td>15</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>1 minute</td>
<td>10</td>
<td>8</td>
<td>2</td>
<td>12</td>
<td>8</td>
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<tr>
<td></td>
<td>5 minutes</td>
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<td>5</td>
<td>3</td>
<td>14</td>
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<tr>
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<td>19</td>
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<tr>
<td></td>
<td>1 minute</td>
<td>15</td>
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<td>2</td>
<td>14</td>
<td>14</td>
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<tr>
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<td>5 minutes</td>
<td>10</td>
<td>2</td>
<td>2</td>
<td>18</td>
<td>8</td>
</tr>
<tr>
<td>28</td>
<td>Control</td>
<td>18</td>
<td>2</td>
<td>2</td>
<td>22</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>1 minute</td>
<td>16</td>
<td>1</td>
<td>1</td>
<td>19</td>
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<td>5 minutes</td>
<td>10</td>
<td>10</td>
<td>0</td>
<td>20</td>
<td>10</td>
</tr>
</tbody>
</table>

Another observation made in the this study is increased cell death, just visible at the top of the leaves treated with high radiation during 5 minutes (Figure 2). Due to their growth, peaks were much closer to the source, being very close to the source mentioned of 20 mCi activity, in comparison with shorter plants.
Starting on these considerations, and knowing that besides ponds radioactivity atmosphere is big, over limit, we studied how is the development of vegetation, and plant behavior in the radioactivity contained in the ash. In this study we used wheat and grass seeds that were planted in the ashes taken from the tailings pond of Thermal Power Plant Paroșeni. To have the control plants, these were sown in gardening soil.

Wheat and grass samples were watered with spring water at room temperature and one sample from each plant for each soil were helped with complex fertilizers. The conditions of temperature, humidity and light were identical and watering was done once every 3 days with 120 mL of water.

In Figure 3 is observed growth of wheat in ash compared to natural increase in garden soil.

Germination of wheat grain was more pronounced in the case of wheat sown in the garden soil, in comparison width the wheat grain sown in the ashes. Although humidity of ash was higher due to small granulation that retains water, germination was lower due to soil radioactivity. A similar effect occurred and on the grass seed.

Radioactivity measured above garden soil used in the experiment is 0.018 mrem h\(^{-1}\) and of the ash is 0.03 mrem h\(^{-1}\).

Studied plant growth is influenced by the lack of nature biological natural nutrients of the ash. Although in a small amount, radiation of ash produce light radiobiological effects, combined with the lack of nutrients and alkalinity of ash, results shorter and thin plants, with low vegetal mass compared to those grown in garden soil (Figure 4).

Although were used complex fertilizers in the phase of germination, no changes were observed at this level, germination the plants in ash is much weaker, as consequence of the influence of radiation on plants at embryonic level (Figure 5).

In Figure 6 you can see the growth and development of wheat and grass vegetation in the two supports used, but this time being used complex fertilizer (1.2 g pot\(^{-1}\)). Due to nutrient inputs from fertilizer, may be observed a difference in mass of plant produced during plant growth and development. In the same time we observe that wheat grown on sterile this time, has a thickness comparable to that of wheat grown in
garden soil but without fertilizer. The influence of radiation on plant growth is less harmful, influence being more important in embryonic stage.

![Wheat and Grass](image1)

**Figure 4.** Plant growth and development.

![Wheat in Ashes and Grass in Ashes](image2)

**Figure 5.** Germination of wheat and grass in the presence of complex fertilizer.

![Wheat and Grass](image3)

**Figure 6.** Plant growth and development in the presence of complex fertilizer.

**Conclusions.** Radiation is acting on plants, especially on germination stage, reducing it. Another moment, longer is the radiation dose, more plants are affected.

From observations made, plant growth and development is less affected if radiation dose is not very high. It is worth mentioning that with increasing radiation intensity, even larger bodies cannot support radiobiological processes, and begin to show visible signs of cell death.

Following comments made grass and wheat sown in ash and garden soil is visible that in the ash germination is lower, even when in the base is added complex fertilizers. This low germination is due to the presence of radioactive elements in the ash.

Plant growth is less affected by the presence of radioactive elements in the soil, is not noticed is a very big difference between the basis of the ash samples with added complex fertilizers and garden soil.
Investigated plants can be used for the revegetation of ash ponds of Thermal power Plant Paroşeni. For the revegetation of soil must be taken into account the fact that plant germination is reduced due to the presence of radiation in the soil.

References


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