Construction of Bioparks on Devastated Land In Urban Areas

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Abstract

Lukavac, as many other Bosnian and Herzegovinian industrial cities, especially in the winter period, has deteriorated air quality and the greatest polluters are industry, individual heating and transportation. Considering that Lukavac is situated in the valley in which numerous industrial facilities are installed, in the periods of unfavorable weather conditions the town and its surroundings are naturally predisposed for additional air pollution.

In this paper we analyze the possibility to form bioparks, which would have positive impacts on the ecological and economic conditions in Lukavac and similar environments. To establish the bioparks, the degraded and abandoned land surfaces, caused by soil erosion or the surface exploitation of mineral resources, could be used. These are located at numerous locations and cover large areas, both in Lukavac and in other industrial areas in Bosnia and Herzegovina.

This paper presents the basic biological characteristics of paulownia and possibilities of planting this tree in areas that are now unused, in the space which is characterized by extreme pollution of atmospheric complex. The selected method is bioremediation, and in this case it is the planting of biological material or woody plant species Paulownija elongata. In this way the degraded surfaces would get the function of biological parks, that is, they would become "oxygen producer" surfaces, and absorbers of CO2 which is emitted from industrial plants. This species has rapid growth and development of biomass, so the bioparks could be used to serve as the surfaces for alternative fuel with minimal amounts of sulfur, and also as eco - educational parks.

Key words: air quality, air pollution, Biopark, bioremediation, paulownia, Lukavac

1. Introduction

With the rise in energy production and consumption, economic recovery, an increasing number of cars on the roads and a larger number of households and business facilities in need of heating and electricity, there is an increasing adverse impact on the environment. In the area of Lukavac town in Bosnia and Herzegovina, in addition to a series of geoecological problems, of which the most emphasized are the degradation of agricultural land, water pollution, many landslides, there is also a pronounced air pollution.

The subject of this research is the analysis and evaluation of air quality in the city area of Lukavac that was made in the period 2005-2014. The task of the research is to determine the level of air pollution by individual pollutants, their comparison with the permissible concentrations and limit values as well as providing guidelines on remedial of the quality of atmospheric complex.

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The hypothesis of this paper is: The state of air quality that has been deteriorated by industrial production in the industrial zone of Lukavac can be significantly improvedby biological methods, that is, by establishing bioparkswith selected plant species. From the above are derived six sub-hypotheses, which are:

1. The state of air quality in Lukavac is not at satisfying level;
2. Paulowniais a plant that with its biological cycle has a positive impact on the atmospheric complex;
3. There is a wide usage value of Paulownia in industry;
4. Paulownia is the type of wood that can be used as an alternative fuel to industrial production, thus reducing emissions of harmful gases;
5. Paulownia has a large consumption of CO_2;
6. The area of Lukavac has known considerable surfaces of unused land and a favorable climate for planting out Paulownia.

Given the complexity of the studied subject here we applied more scientific methods and procedures, which are the statistical method that is used to process the data obtained by the established monitoring of air quality, the comparative method used for comparing the air quality data measured at measuring stations, also used for data comparison between earlier periods and new values and for comparing the value with the legal limits. We carried out experiments and laboratory studies in the evaluation of the calorific value of paulowniaand conducted field observations, that is, we directly observed the terrain and visitednursery garden which grows paulownia.

2. Results and Discussion

2.1. The state of air quality in Lukavac

The state of air quality of Lukavac and other bosnian-herzegovinian industrial cities are not at a satisfactory level. In the analyzed period (2005-2014), SO_2 concentrations were elevated significantly during the cold period of the year. The increased concentration of sulfur dioxide (SO_2), in the winter, is the result of, in addition to industrial production, combustion of fossil fuels, especially coal (brown coal and lignite) due to the large number of boiler rooms in the city and its surroundings as well as the impact of industry in the city, or in its immediate vicinity. During this period the warning thresholds of hourly valueswere exceeded eight times and 20 times the alert threshold values. The concentrations of NO_2 in the area of Lukavac are, similarly to the values of SO_2, increased during the cold period of the year, but in the analyzed period there were not recorded hourly exceedingsof the threshold of warning and alarm of this pollutant. The concentration of carbon monoxide (CO) reached high values during the entire monitoring period. The content of CO is increased during the fall and winter.

The concentration of deposited dust ($PM_{2.5}$) was increased during the cold period of the year, ie. during the heating season, which indicates that the main reason for the high content of deposited dust is its emission from individual furnaces and boiler rooms. It was noted that it exceeded the alert threshold 3 times, and the value of $PM_{2.5}$ reached the threshold of alarm 2 times. It is estimated that 1,337 households have individual boiler rooms and spend ten tons of lignite and six m^3 of wood in one heating season, warming the total residential area. (State of the Environment of Lukavac report 2012).

The main problem in the field of air pollution by industry is the use of geoecologically unacceptable production technologies that are not in accordance with best available technologies (BAT). Pollutants emitted from agriculture to the environment are ammonia (NH_3), methane(CH_4) and nitrous oxide (N_2O) (LEAP Lukavac, 2011).

Anticyclonic weather situation in the colder times of the year also adversely affects the air quality. Then there are frequent occurrences of fog, mist and temperature inversions, which contributes to the retention of pollutants in the ground layer of air. Smog rises to the height of the inversion layer and forms a smoke screen or "cap" over Lukavac.

2.2. Recommendation for growing the woody species *Paulownia elongata* SY Hu

The tree *Paulownia elongata SY Hu* reaches a height of over 10 meters, with a wide conical crown. The leaves are large, green, their lower surface pubescent. Paulownia wood has the color of honey. It produces small seed, 1.4 mm to 3 mm, located in pods. The pod has oval shape andit is woody, with a size from 2.5 to 5 cm. It is a noninvasive type that thrives also in very sparse soil.

Paulownia elongata is a hard wood, but at the same time it is the lightest known wood weighing 272 to 336 kg/m^3 (average 304 kg/m^3). The wood is light in color and almost without knots, with resistance to bending and twisting making it perfect for carving. Fire-resistant point - the point of lighting is twice the size of pine's, which is especially interesting for coastal areas which are in summer exposed to increased risk of fire (Popović et al., 2008; Perović et al., 2008).

Paulownia can not survive on poorly drained soils. The most favorable are lands toward the south (sunny side). The soil should be drained, or may not accumulate or hold water. Underground water flows should not be closer than 1.5m to the ground. In heavy clay soils paulownia grows more slowly. Paulownia does not tolerate acidic soils. The pH should be between 5 and 8. If it is possible,the autumn plowing is suggested, but it will be enough to have early spring deep plowing only. When plowing, it is good to additionally fertilizethe land in order to accelerate the growth of paulownia. Before setting up the foil with pipes for drip irrigation to drop, it is necessary to chop the ground. The role of the foil is multiple:it ensures a higher temperature of the soil, retains moisture, prevents weed growth ... Rows of foil are placed at every 4 meters (Ates et al., 2008).

Planting begins by wetting the soil beneath the foil and drilling holes in the ground through the foil. It is necessary to dig a hole with a diameter of 60 cm and depth of 80 cm. In this excavated hole a part of excavated soil that is mixed with manure and fertilizers should be returned back in the the hole until it is deep 30-40 cm. The tree should be cut to 2-3 cm above the ground and buried with the rest of the soil. Distance between seedlings of paulownia under the foil is 4 meters.Planting of paulownia is made only in the spring!

Year Zero - There is no need for major interventions in the plants because they will be anyway cut to ground level next spring. If they occur, possible excess shoots from the same root (more stems) can be disposed of.It is necessary to control the grass and weeds between the foil, so as not to escalate and choke seedlings. If there is no rain in the spring it requires watering 1-2 times a week. In summer, if it is dry, 2-3 times.

The first year - at the beginning of April it is necessary to cut down the tree / stem of paulownia at a height of 1 cm above ground level and cover the cut part witha thin layer of soil (1-2 cm) to reduce drying out the roots.From each root will appear a few shoots. When they grow up to 10 cm is necessary to keep the strongest, and have the rest removed. In this year, watering is as important as in the zero year. It is also important to mow the grass and weeds so that would not initially be higher than seedlings. Before falling leaves, the stems will have already become woody (Jovanović et al., 1974).

The second year - in the spring the stems/tree of paulownia which became woody will begin to leaf through. From below we should rip off all the leaves except for the last half a meter at the top. By this we achieve that a tree in the early years grows as much in height. In the following years, we are waiting for the tree to reach a diameter of 35-40 cm when it is ready for harvesting. This should be after 7-10 years (depending on conditions). After cutting, from the existing root, in the fall, will spring up a few new shoots of paulownia. The cultivation is then continued as instructed for the first year. Since now the root is very strong (even 10 m deep), the growth of paulownia will be even faster.

One hectare of land with 625 trees of Paulownia elongata for three years brings a staggering 57 tons of timber, and for 8-10 years even 190 tons are possible. At about the eighth-tenth year the tree has an average of 1 m^3 of timber and it is possible to be exploited 3 times because after each cutting it will drive a new seedling which in 8-10 years again reachesthe same amount of wood in ideal conditions. By comparison, a poplar tree usually takes 15-20 years to maturity, oak 30-40 years, and pine 70-75 years. Every two years one can expect up to 100 tons of wood biomass per 1 hectare(Krussmann et al.,1986; Vasiljević et al., 1983). A cubic meter in the industrial mode of planting, on the world market reaches the price of up to 1100 USD (Paulownia is at the world's stock markets mostly sold under its Japanese name: Kiri.)

2.3. The use of Paulownia

Because of the resistance to humidity, paulownia tree is used for the production of furniture which is resistant to deformation. Because of its low resin content, wooden material of paulownia has a low level of risk of fire, because it is difficult to initiate it to burn. In addition to the mentioned characteristics, an essential feature of paulownia wood in furniture production is being resistant to attacks of wood-eaters. Because of its softness, paulownia wood is possible to be decoratedwith most complex carvings. Another characteristic of paulownia is its decorative use. Namely, because of the beautiful flowers that adorn the wide treetop of this tree it is often used for landscaping parks. The flowers are rich in nectar and antioxidants. The leaves absorb up to 10 times more carbon emissions than other types of trees. Abundant blooms and size of leaves also help in successful reforestation and recovery of burned forests, and for its branched root the tree is used against soil erosion. Extremely important and valuable use of paulownia comes out from its honey-bearing properties. Its importance as honey-bearing type, in addition to the quality of honey, lies in the fact that the bees do not need to visit a lot of flowers to be 'filled', since the flowers are extremely rich in nectar. From one hectare bees can collect between 900 and 1000 kilograms of nectar that is by the quality in the rank of acacia and sage honey. It has bright colors and is quite light in weight, with a strong odor. It also serves as a healing agent (Cvjetičanin et al., 2009; Barton et al., 2007);

KYOTO program of environmental protection ranks paulownia in the first place among the plants, like a mine of oxygen and air cleaner. Given that it is harder and harder to follow the prices of energy sources we use every day and that are in constant increase due to reduced reserves, paulownia as a wood biomass presents an energy source that renews itself, because after cutting it grows back from the stump. Additionally, Paulownia gives high calorific value of 4,700 kcal / kg with negligible sulfur content during combustion. The whole planet seek to reduce greenhouse gas emissions, and paulownia absorbs significantly more CO_2 than other tree species (Table 1). (2ha of paulownia absorbs in one year up to 13 tons of CO_2 from the atmosphere)Therefore, Paulownia is suitable for green investment schemes and trading with green certificates. Paulownia turns untreated land into green fields. It is environmentally acceptable solution for cultivating manure and restoring land destroyed by human activities. Paulownia is ideal for reinforcement of river banks and in the fight against erosion. Cities and municipalities could implement, with the support of the public, environmental projects using paulownia, while for forestry purposes could be used programs for rural development.

Figure 1. *Paulownija elongata*, d.o.o Voćni rasadnik, Srebrenik, July 2016

Table 1. Binding of CO_2

Tree species	**kg CO_2/ha**
Alpine pine	48000
Paulownia	8181,73
Cork oak	4500
Eucalipto	491,21

Paulownia tree is a "small manufacturer" of heat taking into account a cubic meter of wood biomass. By comparison, 1 m^3 of paulownia with the humidity of 15% gives about 1069 kWhs of thermal energy, while the same amount of oak in combustion produce almost twice the energy - 2,363 kWh. These results are a consequence of lower density paulownia, but also the fact that 1 kg of any tree of the same moisture content gives about the same amount of heat energy because the chemical composition of all kinds areabout the same.The possibility of using Paulowniain industry is wide. It can be used as technical wood, but also as an alternative fuel with significantly lower emissions of SO_2 (Osmanović et al., 2016). (Table 2).

Table 2. Paulownia as alternative fuel

<table>
<tr><td>Type of energy source</td><td colspan="3">SO_2 (t/day)</td><td colspan="3">CO_2 (t/day)</td></tr>
<tr><td>Coal</td><td colspan="3">1,73</td><td colspan="3">206,34</td></tr>
<tr><td rowspan="3">70 % coal +30 % alternative fuel</td><td>Coal</td><td colspan="2">Alternative fuel</td><td>Coal</td><td colspan="2">Alternative fuel</td></tr>
<tr><td>1,21</td><td colspan="2">0,66</td><td>144,44</td><td colspan="2">65,23</td></tr>
<tr><td colspan="3">1,87</td><td colspan="3">209,67</td></tr>
<tr><td rowspan="4">70 % coal +30 % (15 % alt. fuel +15 % paulownia)</td><td>Coal</td><td>Alternative fuel</td><td>Paulownia</td><td>Coal</td><td>Alternative fuel</td><td>Paulownia</td></tr>
<tr><td rowspan="2">1,21</td><td>0,33</td><td>0,02</td><td rowspan="2">144,44</td><td>32,65</td><td>32,61</td></tr>
<tr><td colspan="2">0,35</td><td colspan="2">65,27</td></tr>
<tr><td colspan="3">1,56</td><td colspan="3">209,71</td></tr>
<tr><td rowspan="3">70 % coal +30 % paulownia)</td><td rowspan="2">1,21</td><td colspan="2">Paulownia</td><td rowspan="2">144,44</td><td colspan="2">Paulownia</td></tr>
<tr><td colspan="2">0,03</td><td colspan="2">65,31</td></tr>
<tr><td colspan="3">1,24</td><td colspan="3">209,75</td></tr>
</table>

2.4. Potentially usable areas for planting Paulownia

Usable areas for planting paulownia in the area of Lukavac are: free farmlands, conditionally stable and unstable slopes that have got developed (standard) lands, lands in industrial zones that are unoccupied by infrastructure facilities, as well as areas where is present surface exploitation of mineral resources and landfillsof tailings with prior pedological reclamation.

Surface exploitation of coal and other mineral resources degraded vast areas. Examplesare the Tuzla and Zenica coal basin. In accordance with legislation that addresses the exploitation of mineral resources and environmental protection, mines are required to recultivate degraded areas, however, this is not the practice in our country.

3. Conclusions

Based on the conducted analyzes, it was concluded that in Lukavac, as well as in other industrial cities in Bosnia and Herzegovina, air quality is not at a satisfactory level. It is particularly expressed increased concentration of SO_2 due to extensive use of fossil fuels.

Paulownia is a plant that with its biological cycle has a positive effect on the atmospheric complex.With biological methods, that is, by planting the selected plant species status of air quality in the industrial zone of Lukavac can be significantly improved.This type of wood can be used as an alternative fuel in industrial production, thus reducing emissions of harmful gases, and at the same time it is a major consumer of CO_2.

The area of Lukavac has considerable areas of unused land and favorable climatic conditions for planting Paulownia, or establishment of Bioparks which would have economic, environmental and educational function (Paulownia elongata S. Y. Hu).

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