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# Elongata Sy Hu In Function of Improving the Quality of the Environment

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**ABSTRACT**

Interest in paulownia got its momentum around the world. With its fast-growing nature and large leaf surfaces this species can absorb significant amounts of sulfur dioxide and dust particles.
The cities of Tuzla and Lukavac, as most other Bosnian-Herzegovinian towns, have a number of geo-ecological problems, and the most pronounced one is negative anthropopressing on the atmospheric complex and pedospheric cover. This area, especially during the winter period, has a disrupted air quality where the greatest polluters are individual heating places, transport, industry, and energy sector. The pedologic cover of the wider area of Tuzla and Lukavac has suffered significant changes and is largely devastated. The processes of destruction of soils lead to complete destruction or formation of a new land with modified characteristics. High rainfall is a major cause of destabilization of slopes, but also is the negative anthropogenic activity in the area. Landslides have caused significant material damages, particularly in the residential structures of slope zones of the mentioned cities and suburban areas. This paper presents the basic biological characteristics of woody species paulownia elongata, and the possibility of planting it in areas that are now unused so to improve the quality of air, as well as on surfaces that are threatened by landslides.

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## 1. Introduction

The area of Tuzla City and Lukavac municipality is located in the basin of Spreča and its right tributary Jala, in the region of northern Bosnia, or more accurately in the sub-region of Spreča-Majevica with Semberija, in the northeast of Bosnia and Herzegovina. This field has pronounced air pollution, and other geo-ecological problems as well, of which the most important are: water pollution, degradation of agricultural land, and the emergence of numerous landslides. The subject of this research is the analysis and assessment of environmental quality in the city area of Tuzla and the municipal area of Lukavac. The first task of the research is determining the level of air pollution by individual pollutants; their comparison with the permissible concentrations and limit values, as well as providing guidelines for remedial of the quality status of atmospheric complex. Another task of the research is identifying factors for reactivation of old landslides and the emergence of new ones, especially on slopes with increased human activity.
This paper hypothesis is: The state of air quality and soil cover, deteriorated by industrial production in the industrial area of Tuzla and Lukavac and by other anthropogenic activities, can be significantly improved by

biological methods, i.e. by establishing bioparks with selected plant species. The above derives six sub-hypotheses which are:

1. The state of air quality in Tuzla and Lukavac is not at a satisfactory level;
2. *Paulownia* is a plant that with its biological cycle has a positive effect on the atmospheric complex;
3. *Paulownia* is a wood species that can be used as an alternative fuel in industrial production, thereby reducing emissions of adverse gases;
4. Paulownia is a major consumer of $CO_2$;
5. The areas of Tuzla and Lukavac have considerable surfaces of unused land, and favorable climatic conditions for planting out paulownia;
6. *Paulownia elongata*, with its root system, can have a positive impact on the stability of slopes.

## 2. Material and Methods

This work consists of theoretical and practical parts. In the theoretical part are defined biological and physiological characteristics of *Paulownia elongata* S.Y. Hu. The practical part of the work includes several scientific methods and procedures. The statistic method is used to process data obtained from the established monitoring of air quality, then the comparative method is 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. The method of field research is applied when considering pedogeographic traits and seeing how the use of certain soils. In addition to the above, the paper used a cartographic method to obtain the data about the area.

We carried out experiments and laboratory studies in the evaluation of the calorific value of *Paulownia*. Also, we implemented field observations, that is, made direct observation of the terrain and visited the nursery that grows the mentioned species.

## 3. Research results

### 3.1. Some geo-ecological problems of Tuzla and Lukavac

The area of Tuzla and Lukavac, especially in winter period, has got damaged quality of air, but the biggest polluters are individual heating places and boiler-rooms, transport, industry and energy sector. As the mentioned urban areas are located in a valley, in periods of unfavorable weather conditions, the area is naturally predisposed to air pollution. The biggest problem is the increased concentration of $SO_2$ and fly ashes, due to the widely spread usage of coal (brown coal and lignite).

Based on the determined average annual values of $SO_2$ in Tuzla, it appears that concentrations of this pollutant generally exceed the legally prescribed annual limit value of 50 $\mu g/m^3$. Following the movement of this pollutant, we can notice that it varies from year to year, falling and rising. Very high average annual values of $SO_2$ were determined in 2008 (112.10 $\mu g/m^3$), 2011 (116.36 $\mu g/m^3$) and 2013 (84.15 $\mu g/m^3$), indicating that the city's inner core was highly contaminated by this pollutant. Fly ashes are considered key indicators of air quality. From the data on average annual concentrations of dust deposits in Tuzla, it is evident that their value in all years is well above the prescribed annual limit value (25 $\mu g/m^3$). The highest average annual concentration of this pollutant was recorded in 2011 and amounted to 86.40 $\mu g/m^3$ [3].

In the analyzed period (2005-2014), $SO_2$ concentrations were significantly increased in Lukavac too. During this period the hourly values of warning threshold were exceeded eight times, and the value of alert threshold 20 times. The concentrations of $NO_2$ in the area of Lukavac, similarly to the values of $SO_2$, increased during the cold period of the year; however in the analyzed period were not recorded hourly exceedings over the threshold of warnings and alerts for this pollutant. The concentration of carbon monoxide (CO) reached high values during the entire monitoring period. The content of CO was increased in autumn and winter [1].

The concentration of deposited dust ($PM_{2,5}$) was increased during the colder period of the year, i.e. during the heating season, which indicates that the main reason for the high content of deposited dust is its emission from individual heating places and boiler-rooms. It was noted that the alert threshold was exceeded 3 times, and the value of $PM_{2.5}$ reached the alert threshold 2 times. It is estimated that 1.337 households have individual boiler-rooms and that they spend ten tons of lignite and six $m^3$ of wood in one heating season, warming the total residential area [4, 7, 21].

Anticyclonic weather situations in the colder times of the year also affect 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.

The modern period of this region is marked by closely related processes of urbanization and deruralization characterized by industrialization and deagrarization. These very processes of urbanization, industrialization and deagrarization have contributed most to pollution, degradation and devastation of soils in this area. Pollution and devastation of the soil can be the consequence of several causes, namely: biological contamination (infection), chemical contamination, anthropogenic degradation and physical destruction of land [18].

Thus, in the area of Tuzla city there is 40.75 $km^2$ in landslides, or 13.44%, and under unstable slopes is 29.97 $km^2$ or 9.89% of the total area. In total, landslides and unstable slopes cover 70.72 $km^2$, or 23.33% of the total area of Tuzla city, which is a problem of enormous proportions for the population and housing, as well as to the very quality of pedologic cover. According to the Cantonal Administration of Civil Protection of TK, in the city of Tuzla in 2014 were registered 2,170 landslides [21].

The highest number of landslides appeared in the eastern and central part of the city area (known as "municipal area" by 2014) where occurred landslides that threatened material goods, with a lesser risk of endangerment of human life. The landslides were formed on slopes with inclination, mainly between 5° and 30°. Human activity had been expressed on these slopes, that is: the forest vegetation was removed, a number of suburban and rural settlements were built (those that do not have adequate infrastructure), and a large number of buildings were made without building permits. The terrain is further destabilized by cutting the slopes, during treatments of soil or inadequate agricultural production [1].

### 3.2. Biological characteristics of Paulownia (*Paulownia elongate* SY Hu)

The tree *Paulownia elongate* 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 and it is woody, with a size from 2.5 to 5 cm (Figure 1). It is a noninvasive type that also thrives in very sparse soil [11].

Figure 1. Paulownia elongata SY Hu

Because of the high percentage of tannin it has developed a resistance to various pests, hence protection against insects and diseases is almost not needed. 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 [12]. *Paulownia* wood swells very little. The change in volume with change of 1% moisture amounts to 0.290%, while with the poplar that coefficient is 0.397%, and with beech and oak 0.550% and 0.592%, respectively. These results indicate that the paulownia wood is very stable in variable climatic conditions (Figure 2).

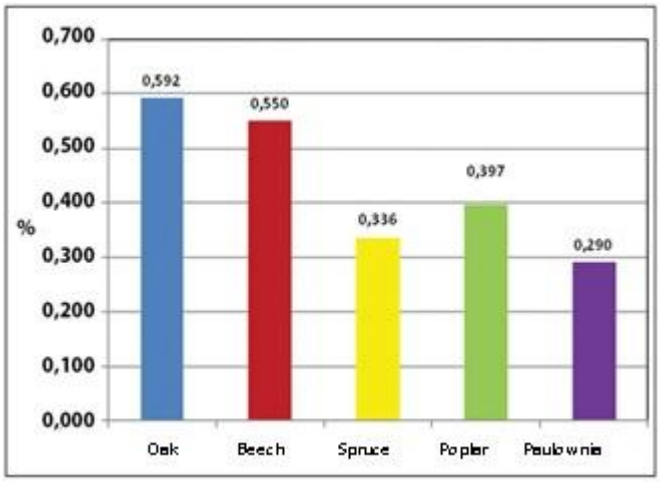


Figure 2. Percentage of wood volume change with the moisture change of 1%

*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 kWh 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 are about the same.

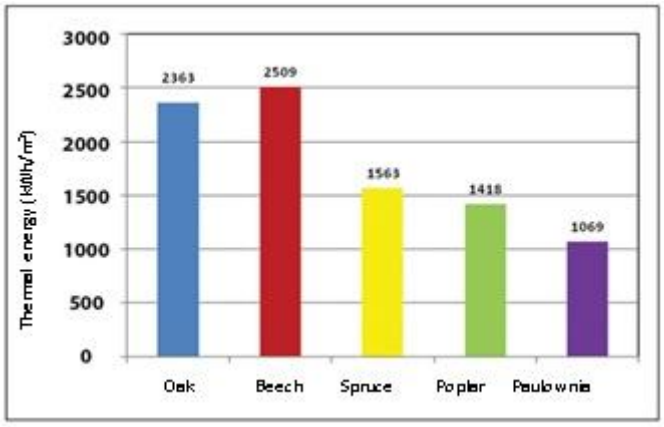


Figure 3. Thermal energy (in kWh) obtained by burning 1 $m^3$ of wood (moisture content 15%)

Table 1. Elemental analysis of the species Paulownia elongata

| | Paulownia elongata |
|---|---|
| dry matter | 25,52 |
| organic matter | 16,24 |
| C | 43,68 |
| N | 2,74 |
| C: N | 15,83 |
| pH | 5,46 |

Table 1 presents the elemental analysis of the species *Paulownia elongata*. The possibility of using *Paulownia* in industry is wide. It can be used as technical wood, but also as an alternative fuel with significantly lower emissions of $SO_2$ [10]. (Table 2).

Table 2. Paulownia as an alternative fuel

| Type of energy source | $SO_2$(t/day) | | | $CO_2$(t/day) | | |
|---|---|---|---|---|---|---|
| Coal | 1,73 | | | 206,34 | | |
| 70 % coal +30 % alternative fuel | Coal | Alternative fuel | | Coal | Alternative fuel | |
| | 1,21 | 0,66 | | 144,44 | 65,23 | |
| | 1,87 | | | 209,67 | | |
| 70 % coal +30 % (15 % alt. fuel +15 % paulownia) | Coal | Alternative fuel | Paulownia | Coal | Alternative fuel | Paulownia |
| | 1,21 | 0,33 | 0,02 | 144,44 | 32,65 | 32,61 |
| | | 0,35 | | | 65,27 | |
| | 1,56 | | | 209,71 | | |
| 70 % coal +30 % paulownia) | 1,21 | Paulownia | | 144,44 | Paulownia | |
| | | 0,03 | | | 65,31 | |
| | 1,24 | | | 209,75 | | |

## 4. Discussion

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 (eg. 4 acres of *Paulownia* absorbs in one year up to 13 tons of $CO_2$ from the atmosphere and it affects climatic changes).

Thanks to the large leaf surface and the fact that the underside of the leaf has dense hair, this species can absorb significant amounts of sulfur dioxide and dust particles. Results of the analysis of heavy metals (Zn, Fe, Pb, Cu, Ni, Cr, Mn, Cd, As, Hg) in the leaves of woody species *Paulownia elongata* SY Hu growing in urban areas clearly show that *Paulownia elongata* SY Hu is a tolerant species, and can be recommended for forming tree lines along urban and regional roads as well as for the formation of wind protection zones along the main roads [5, 17]. *Paulownia* can absorb heavy metals from the soil and from the air.

Heavy metals in the soil may be the result of natural pedogenetic processes [20], as well as of anthropogenic factors that lead to environmental pollution. A very important source of heavy metals and other polluters of soil and plants is traffic [8, 14]. Plants bring in heavy metals constantly during the vegetation period. The highest values are reached at the end of the growing season [6, 15]. Also, there are many literature references that point to the impact of heavy metals on morphological, anatomical and physiological characteristic of woody species among others [9]. Species of the genus Paulownia, according to many literature data, indicate the possibility of adopting heavy metals [13, 19]. The level of tolerance of this species to pollution of air, is the basis for its development and survival in the urban environment.

Paulownia species are very suitable for decoration and enriching environment, and the need of reforestation. They are also equally suitable for landscaping of urban and industrial areas [22].

Paulownia is a tree that has the capabilities of very high intake of nitrates, heavy metals and other elements from shallow and deep layers of the earth. It has a unique root system where the roots grow at a depth of over 2m. Due to, even several meters deep rooting system, it is used for the rehabilitation of landslides. Such a root system, in combination with the rapid growth of paulownia enables interchange of much more nutrients as opposed to other species, thus giving a great potential in bio-remediation of contaminated soil.

Paulownia also has a significant role in the rehabilitation and protection of soil from erosion. Usable surfaces for planting paulownia, in the area of Tuzla and Lukavac, are: free farmlands, conditionally stable and unstable slopes that have got developed (standard) soil, lands of industrial zones that are not occupied by infrastructure facilities, as well as areas with present surface mining of mineral raw materials, and tailings dumps with prior soil reclamation.

By surface mining of coal and other mineral resources, vast areas were degraded. An example is the Tuzla and Zenica coal basin. In accordance with legislation that treats the exploitation of mineral resources and

environmental protection, mines are required to recultivate degraded areas, however, it is not the practice in our country.

## 5. 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. Particularly expressed is 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.
Because of its high growth rate, this wood has a high ability to absorb carbon.
With biological methods, that is, by planting the selected plant species, the status of air quality in the industrial zone of Tuzla and Lukavac can be significantly improved.
*Paulownia elongata* SY Hu has a large degree of tolerance to air pollution, which is the basis for growing and survival in urban conditions.
This type of wood can be used as an alternative fuel in industrial production, thereby reducing emissions of adverse gases, and is a major consumer of $CO_2$.
Paulownia has an important role in land reclamation and protection of soil from erosion, and because of its deep root system it can have positive impact on the stability of slopes.
The area of Tuzla and Lukavac has considerable surfaces of unused land and favorable climatic conditions for planting Paulownia, or establishment of bioparks which would have economic, environmental and educational function.

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