ECOTOXICOLOGICAL RESPONSE OF POPLAR IN THE PRESENCE OF MULTIPLE POLLUTANTS FROM LANDFILL LEACHATE

Pohonţu Corneliu Mihăiţă*, Stungaru Ştefan, Plăvan Gabriel, Nicoară Mircea**

*"Ştefan cel Mare" University of Suceava, Faculty of Forestry and Environmental Protection, University Street, No. 13, 720229
Suceava, Romania, e-mail: corneliu.pohontu@yahoo.com
**"Alexandru Ioan Cuza" University of Iasi, Faculty of Biology, Department of Biology, Ecotoxicology and Animal Behavior Laboratory, 700505 Iasi, Romania, e-mail: gabriel.plavan@uaic.ro

Abstract

This study proposed to quantify ecotoxicological response of poplar derived from intensive plantations for biomass (SRC), named Short Rotation Culture, in the presence of a diversified range of pollutants. Souce of pollutants are in this case landfill leachate, which can reach ground level either: landfill leachate diposal techniques, accidentally leach or used as a natural fertilizer for its high nutrients content. At laboratory scale was exposed at five different concentrations of two type leachate solution (0%; 6.25%; 12.5%; 25%; 50%; 100%) in 5 replicates, during minimum 4 weeks. The aim of this study was to establish the phytotoxicity of landfill leachate on young poplar cuttings by quantify evapotranspiration rates and at the same time to determine the range of values of no-toxic effect concentration (NOEC) and the lowest effective concentration causing toxic effects (LOEC). It is known the fact that evapotranspiration is a vital physiological process for plant development, and by interpreting of this phenomenon have an important bioindicative role with implications in process most phytoremediation processes modeling. Thus, LOEC values for the two types of leachate are: 6.45% for leachate stabilized and 7.65% for unstabilized leachate with the biodegradable organic fraction higher.

Key words: phytotoxicity, poplar, landfill leachate, evapotranspiration, waste, by-products

INTRODUCTION

Environmental friendly solutions enter into the global concerns of all sustainable development strategies. These include: inteligent waste management and treatment by reusing some by-products from waste, bioremediation techniques, using renewable energy sources, and reducing greenhouse gases emissions (Jassal el al., 2013).

In many countries management of municipal solid wastes consists only in waste disposal into landfill, without selective collection of some by-products from waste fractions including plastics, paper, glass, metals, electronic waste, or organic fraction treatment. Thus, remains the unsolved problem of contamination of numerous organisms from biota and abiotic environmental facts, such as: air, soil, surface and ground water (Lavagnolo et al., 2016). Landfill leachate is a liquid waste resulted from municipal solid waste disposal with high ammonia, heavy metals and organic content (Pohonţu, 2011). The necessity of knowing landfill leachate composition is extremely useful for critical in long-term atrophic impact evaluation of landfills on human health and the environment as well as for prevention of negative outcomes and environmental risk assessment (Lavagnolo et al., 2016). Heavy metals Cr, Ni, Cu, Zn and Pb are most commonly found in landfill leachate composition (Mavakala et al., 2016) (Pohonţu, 2011).

The efficient methods for landfill leachate treatment include soil – plant system or phytoremediative processes in different crops (Bialowiec et al., 2010a). Constructed wetland represent a low-cost alternative technology to treat wastewater and landfill leachate (Mojiri et al., 2016).

The ability of landfill leachate as a by-product, is determined by the fact that can be provide an important nutrients source for plant growing (Pohonţu, 2011). Nitrogen and phosphorous in the leachate have been used as nutrients for plants growth (Bialowiec et al., 2010b).

Bio-indicative processes have an important role in bio-procedure. Considering the fact that evapotranspiration is a vital physiological process far plants development and last but not least to obtain biomass or carbon storage (Jassal el al., 2013). A good knowledge of the partitioning of evapotranspiration is particularly important for indicate the degree of phytotoxicity (Bialowiec et al., 2010b). With this to be able to improve controlling environmental factors and modelling biological remediation processes in an ecosystem (Mojiri et al., 2016).

Poplar plantations are used for biomass production in many countries (Folch and Ferrer, 2015). Hybrid poplar is an important fast-growing crop with the good potential to provide a reliable supply of biomass for bioenergy sources while also carbon storage in the soil (Jassal el al., 2013).

Poplar and willow in short-rotation coppice (SRC) system have been proven to be suitable to wastewater treatment quality by vegetation filters (Pistocchi et al, 2009).

Environmental sustainability and economic viability of a bioenergy for biofuels industry from intensively cultivated short rotation woody crops (SRC) requires improving yield growth under various environmental conditions (Lavagnolo et al., 2016). The physiological processess for predicting growth is needed to evaluate the growth and yield of coppiced poplar (*Populus spp*) (Hart et al., 2015).

The aim of this work was to estimate the toxic effects of two type of landfill leachate on cuttings poplar by quantify evapotranspiration process.

MATERIAL AND METHOD

The tests were performed in 2016, at laboratory scale, under controlled conditions. The experimental conditions included: controlled temperature at 25°C ± 2°C, humidity established at 75% and a dark-light system which alternates 12/12 hours.

Poplar cuttings derived from energetic poplar short rotation culture (SRC), Dornesti – Suceava. For reducing influence of genetic diversity in experimental procedure, all cuttings were taken from one poplar plant. The cuttings having 20 – 25 cm long and 0.5 – 1 cm diameter were immersed in different concentrations of leachate solutions.

In 1 liter glass bottles, were introduced 5 different concentrations of landfill leachate solutions (0% - tap water; 6.25%; 12.5%; 25%; 50%; 100%), which represented independent variables. To track evapotranspiration process was marked level of the leachate solution in every bottle, at ¾ level height. To prevent evaporative loss solution, the bottles are covered with a membrane made of polyethylene, which will be pierced only by cuttings.

Landfill leachate was sampling from two different municipal solid waste landfills. A first source is from Botosani, an old landfill whose leachate is stabilized. Initial properties of this leachate, at all dilutions are shown in table 1.

Table 1

Initial properties of the landfill leachate from Botosani landfill

Parameters	Landfill leachate solutions (%)				
	6.25	12.5	25	50	100
COD (mg O_2/L)	698	1327	1885	3159	4773
pH	7.29	7.55	7.62	7.74	7.81
Electrical conductivity (mS/cm^{-1})	6.37	13.8	21.3	36.4	51.5
Ammonium (mg/L^{-1})	165	401	593	1136	2079
Total phosphorus (mg/L^{-1})	1.9	3.7	5.3	8.0	11.8
Fixed residue (mg/L^{-1})	89	192	386	615	903

A second source of leachate was from Iasi, a relatively new landfill with unstabilised leachate, as shown in table 2.

Table 2

Initial properties of the landfill leachate from Iasi landfill

Parameters	Landfill leachate solutions (%)				
	6.25	12.5	25	50	100
COD (mg O_2/L)	387	755	1231	1996	2875
pH	8.16	8.21	8.29	8.42	8.67
Electrical conductivity (mS/cm^{-1})	3.1	6.5	11.9	15.3	19.7
Ammonium (mg/L^{-1})	46	79	137	276	545
Total phosphorus (mg/L^{-1})	1.1	2.5	4.0	6.9	9.5
Fixed residue (mg/L^{-1})	57	92	173	239	459

Bottles with leachate solutions content and poplar cuttings were exposed in laboratory for a period of 4 weeks. Every concentration was placed in five replicates, overall for a single experiment using 55 poplar cuttings.

In this period, was monitored weekly evapotranspiration process by evaluation of electrical conductivity of the leachate solution and taking into account decrease the level of the leachate. For electrical conductivity measurements was using waterproof multiparameter tester HI 98129.

The mean values of the evapotranspiration process was performed with ANOVA Tukey`s test, at a 95% confidence interval. The LOEC value of landfill leachate, was obtained calculating inhibition rate using equation [1] (Bialowiec and Raderson, 2010a) (Bialowiec and Raderson, 2010a).

$$I = \frac{C-T}{C} \times 100(\%) \; [1]$$

Where,

I – Inhibition rate of evapotranspiration process;

C - Mean value of measured parameter for reference variant with tap water;

T - Mean value of measured parameter for each landfill leachate concentration.

RESULTS AND DISCUSSION

After exposure period, were analyzed electrical conductivity values separately for each replicate. Electrical conductivity is an indicator of total ionic concentration in landfill leachate. Based on these values and the formula number 1, it was determined the degree of inhibition of the evapotranspiration process. In table 3 these values are presented.

Table 3

LOEC values of two types of leachate

Type of leachate	LOEC (%)
Stabilised landfill leachate	6.45
Unstabilised landfill leachate	7.65

Concentrations of leachate exceeding the above mentioned values, slows evapotranspiration process. Electrical conductivity values increased during the experiment in many cases, because were affected by evapotranspiration by the reduction of water volume and finally, concentrated the solution.

For leachate solutions from Botosani landfill, evapotranspiration is absent for concentrations above 50%. The best yield of the evapotranspiration process is available in range of leachate concentration 0% - 6.25%, after this concentration, efficiency of evapotranspiration process, decreases sharply. It is noticed that the concentrations of leachate solutions that eliminate a larger amount of water, in the rest of solution quantity of ions are concentrated and thus increase the electrical conductivity measured, as can be seen in figure 1.

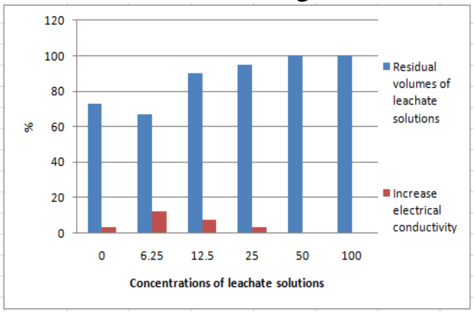

Fig. 1. Dynamics of the evapotranspiration of the leachate from Botosani landfill

By comparison, leachate from Iasi landfill, being unstabilized, therefore having a biodegradable organic content and a greater amount of dissolved ions (including heavy metals), measured by the electrical conductivity smaller, manifest a bit lower toxicity, after 4 weeks. This is explained by turn, prevents the increase evapotranspiration efficiency of the concentrations in the range 0-25%, even 50% is a decrease insignificant volume of leachate solution. This can be explained in terms of toxicity at this concentration uptick of leachate and physiological processes are significantly hampered, which indicates a tolerance of poplar cuttings at high toxicity. The leachate concentrations below 50%, evapotranspiration are higher compared to the same amounts that were used leachate from Botosani landfill. According to figure 2, at 100% the phenomenon is absent, considering the strong toxic character.

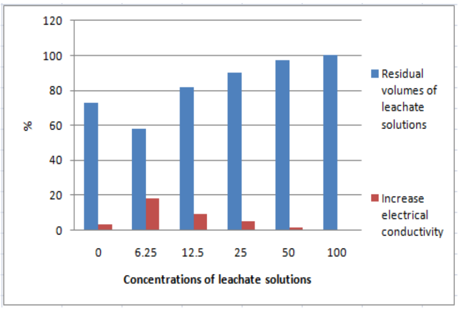

Fig. 2. Dynamics of the evapotranspiration of the leachate from Iasi landfill

At lower leachate concentrations develops greater foliar surface, which facilitates evapotranspiration proces. Through its complex content and variable composition with dissolved organic and inorganic substances, heavy metals and xenobiotic compounds other potentially toxic, leachate may have a fairly high even at low concentrations, which may occur in different modes.

CONCLUSIONS

The lowest effective concentrations causing a toxic effect on poplar cuttings was calculated for the two types of leachate studied, as follows: 6.45% for Botosani landfill leachate and 7.65% for Iasi landfill leachate. At concentrations higher than LOEC values, evapotranspiration process stagnating or is reduced. Greater foliar surface facilitates evapotranspiration. In both cases, electrical conductivity of leachate solutions increased, concomitant with reducing water volume. Evapotranspiration can be used as a good indicator of the response of plants to different environmental conditions. Finally, landfill leachate is suitable in certain concentrations for manage by SRC systems or in reconstructed wetlands, through evapotranspiration reduce the water volume of leachate and this is important when it operates with large amounts of leachate.

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