BIOMASS PRODUCTION USING LANDFILL LEACHATE AS A NATURAL FERTILIZER FOR ENERGETIC POPLAR

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Abstract

This paper proposed an integrated method for efficient and low cost management of liquid waste, in this case, landfill leachate, concomitant with its using as a natural fertilizer for energetic poplar in SRC (Short Rotation Culture) system, because it can be an important source of nitrogen and other nutrients, for plant growth. The aim of this study was twofold: on the one hand, to determine the range of values of no-toxic effect concentration (NOEC) and the lowest effective concentration causing toxic effects (LOEC) for leachate, on the other hand to gauge the growth of biomass. We took into account the landfill leachate phytotoxicity quantified by appearance of buds, stem, roots and number of leaves, exposed at five different concentrations of leachate solution (0%; 6.25%; 12.5%; 25%; 50%; 100%) in 5 replicates, during 6 weeks. After that, was established the LOEC value, the leachate concentration that doesn't produce any toxic effects on the plant growth, in range of 6.25 - 6.95%. It has been observed that poplar sprouts at 6.25% concentration grow much better, compared to the ones that have been kept in water at lower concentrations, due to the proper amount nitrogen contained by the leachate. At higher concentrations the leachate turns to be toxic and cannot be used as fertilizer.

Key words: biomass, poplar, phytotoxicity, landfill leachate, waste, bioenergy

INTRODUCTION

Biomass production, carbon storage and waste management are the main environmental worldwide problems of our own day (Corton et al., 2016). Some agricultural sites are suitable for the production of woody biomass, when use fast-growing trees in short-rotation culture plantations (Liesenbach et al.,1999). The continued rising price of fossil fuel and the increasing interest for environmental concern, in the last period, encourage the use of biomasses as renewalbe energy sources (Manzone and Calvo, 2016), or other alternative green sources of energy (Corton et al., 2016).

The sustainable production of woody biomass in Short Rotation Coppice (SRC) systems in the effective context of bioeconomic development, demands an ever greater understanding of the plant species material. (Sixto et al., 2015)

The genus of *Populus* in reaching impressive growth performance (Ceulemans and Deraedt, 1999) concomitant with the great possibility for good productivity levels (Pari et al., 2015). This is partly based on our improved insight in its production physiology at different levels, and last but no least that genetic variability has been optimally tapped and combined with the cultural management regime of short-rotation culture forestry (Ceulemans and Deraedt, 1999).

Biomass and bioenergy as well as other product obtained using these feedstocks (Corton et al., 2016), could simultaneously support for biodiversity (Liesenbach et al.,1999). Thereby reducing fossil fuels and greenhouse gases emissions through carbon storage (Pari et al., 2015) (Manzone and Calvo, 2016).

Waste biomass is an important biomass souce, generated during the conservation management of semi-natural habitats (Sixto et al., 2015) (Andreottola and Cannas, 1992). Represents an unused resource with high potential bioenergy feedstock that does not compete with food production (Corton et al., 2016).

Some by-products, could then be valorised as functional ingredients for various processes (Manzone and Calvo, 2016) (Andreottola and Cannas, 1992). Landfill leachate is a liquid waste, resulting from water rainfall after it passes through layers of solid waste landfill (Pohonţu, 2015). Landfill leachate may represent an important source of nutrients for plant growth, especially nitrogen and carbon (Andreottola and Cannas, 1992).

The aim of this study was to proposed a low cost and efficient, integrated method for landfill leachate management and using its as a natural fertilizer for woody biomass production.

MATERIAL AND METHOD

The experiment was carried out in open green space, located at the University “Stefan cel Mare” of Suceava, Romania, under the naturally conditions. The period in which was conducted the experiment was situated between May and June 2016. The general outside condition including mean temperature at 25°C ±7°C and atmospheric humidity situated at mean value 70% ± 8%. The substrate for experiment consists in a five different concentrations of landfill leachate solution, such as (0% - tap water; 6.25%; 12.5%; 25%; 50%; 100%), which are independent variables.

Landfill leachate was taken from the municipal solid waste landfill Botosani, Romania, an old waste landfill whose leachate stage is stabilized. Exposure period lasted at least 6 weeks, in five replicates, overall for a single experiment using 30 poplar cuttings.

Glass bottles of 1 liter were noted properly with landfill leachate concentrations used. Poplar cuttings having 20 – 25 cm long and 0.5 – 1 cm diameter were inserted in leachate solutions.

Bottles with leachate solutions content and poplar cuttings were placed outside, in naturally environment conditions, for a period of 6 weeks. During this period were followed daily morphological parameters take into account, such as: buds, stems, roots and leafs which represented dependent variables.

The initial physic – chemical characteristics of leachate is presented in table 1.

Table 1

Initial properties of the landfill leachate used in the experiment

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
Nitrate (mg/L^{-1})	8	10	14	20	29
Total nitrogen (mg/L^{-1})	0.34	0.68	0.93	1.42	1.91
Total phosphorus (mg/L^{-1})	1.9	3.7	5.3	8.0	11.8
Sulphates (mg/L^{-1})	39	87	112	163	218
Fixed residue (mg/L^{-1})	89	192	386	615	903

Biometric evaluation occurred by weighing at the balance, separetly all vegetative organs, after removal from the bottles, for every cutting.

The mean values of this parameters 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, 2010).

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

Where,

I – Inhibition rate of vegetative processes;
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

Evaluation of biomass potential was based on morphological and biometric evaluation. Poplar cuttings capacity to allow different concentrations of leachate has emphasized through inhibition rate calculation according to equation [1].

Thus, concentrations of leachate solution that exceediing the valuees from the table 2, one can see a yield reduction of plant development.

Table 2

Lowest effective concentrations causing a toxic effect

Parameter	LOEC (%)
Total bud weight	6.95
Total stem weight	6.55
Total root weight	6.25
Total leaf weight	6.70

It can be observed, the LOEC value for each parameters, have no significant differences.

Related to each leachate concentrations studied, the lethal effects were noted in the poplar cuttings at concentrations of 50% and 100%, caused high toxicity.

Appearance and development vegetative organs, is closely related to the concentration of leachate solution administered. According to graph on the figure 1, with increasing concentrations of leachate solution over the LOEC values, vegetative organs, decrease in numerical terms, reducing their weight or even become absent.

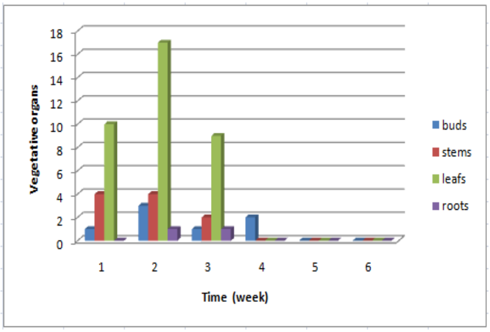

Fig. 1. Apearance and development vegetative organs

Also, at the administred leachate concentration of 6.25%, the number of leaves and buds is clearly superior to the other concentrations. This demonstrates the potential for fertilization of leachate at the optimum concentration, which do not exceed the LOEC values, compared to control samples in which was used only water. Moreover, a greater leaf area increases photosynthesis process, so biomass accumulation, while storing carbon from the atmosphere. Presence of root is encountered only in cuttings which were administered landfill leachate in at concentration of 6.25% and respectively 12.5%. At administered landfill leachate concentration of 25%, taking into consideration only the presence of buds, which indicates the fact that because of high toxicity, vegetative processes are significantly hampered. All the same reason there is likelihood that those buds not to develop vegetative organs.

Regarding biomass estimation, as can be seen in figure 2 with as concentration of the landfill leachate solution is higher, the vegetative process is affected because of high toxicity, along with the reduction in biomass.

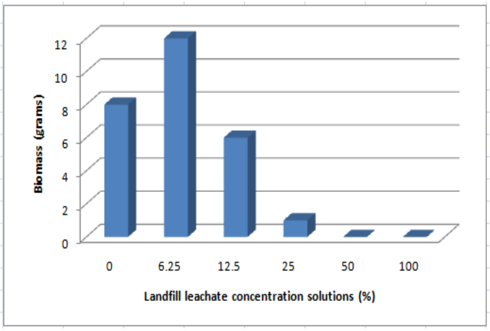

Fig. 2. Biomass evaluation

Taking into account the reference values, the best yield on increases in biomass meets the landfill leachate concentrations not exceeding LOEC values, for exemple, the concentration of 6.25%. Furthermore, one can observe the fact that efficiency of growth process is higher when is administered landfill leachate solution at concentration of 6.25%, compared to control samples in which was used only water. At the same time there was an increase in biomass in the case of cuttings which were administered a concentration of leachate 12.5%, but this is lower due to toxicity, even cuttings in the controls sample to which was administered only water.

CONCLUSIONS

LOEC (Lowest effective concentrations causing a toxic effect) values was calculated for each measured vegetative organ and established in range of 6.25% and 6.95% of the leachate concentration. Between these ranges of concentrations was observed that doesn't occur any toxic effects on the plant growth. More than that, be seen that poplar sprouts grow much better, compared to the ones that have been kept in water at lower concentrations, or in only tap water. Due to the proper amount nutrients contained by the leachate, can say that at a certain concentration and dilution can be used as natural fertilizer with good results in getting biomass. However at higher concentrations the leachate turns to be toxic and cannot be used as fertilizer.

Also, landfill leachate is managed by integration in naturally biogeochemical circuit.

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