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Research Article

USING PHYTOREMEDIATION AND BIOREMEDIATION FOR PROTECTION SOIL NEAR GRAVEYARD

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ABSTRACT
The aim of present research was to assess the usefulness of Basket willow (*Salix viminalis*) to phytoremediation and bioremediation of sorption subsoil contaminated with pesticides. Studies upon purification of sorption material consisting of a soil and composting sewage sludge were conducted under pot experiment conditions. The study design included control pot along with 3 other ones polluted with pesticides. The vegetation season has lasted since spring till late autumn 2015. After acclimatization, the mixture of chloroorganic pesticides was added into 3 experimental pots. After harvest, it was found that pesticide contents in sorption subsoil (from 0.0017 to 0.0087 mg kg DM) were much higher than in control soil (from 0.0005 to 0.0027 mg kg DM). Achieved results initially indicate that Basket willow (*Salix viminalis*) can be used for reclamation of soils contaminated with pesticides, particularly for vitality prolongation of sorption barrier around the pesticide burial area. In future, it would allow for applying the sorption screen around pesticide burial area, which reduces pesticide migration into the environment, and grown energetic plants – through phytoremediation – would prolong the sorbent vitality and remove pesticides from above ground parts by means of combustion.

Keywords: pesticides, phytoremediation, Basket willow *(Salix viminalis),* compost, bioremediation

INTRODUCTION

Waste dumps with outdated and useless plant protection means are the most serious threat for natural environment, the agriculture chemization could cause in Poland. In the case of corrosion and damage of pesticide burial site construction, a continuous supply of contaminants to open waters occurs and will occur for many years. [Biegańska 2013; Ignatowicz 2008, 2015] Therefore, there is a need to search for methods to reduce pesticide migration to the environment and incorporate new concepts. Thus it is purposeful to perform studies upon the application of sorption process on selected natural and waste materials as the shield for penetration of pesticides and metals (as pesticide constituents) into the environment, and to reduce their migration from other pesticide burial sites and stores. [Ignatowicz 2008; 2015] Phytoremediation on energetic plants was additional element that should limit the contaminants migration. The success of phytoremediation depends mainly on the properly selected plant species. [Antonkiewicz 2006; Borkowska 2003; Parzych 2016]] Desirable features making possible to apply a given plant are: fast growth, producing large amounts of biomass in short time, developed root system, higher tolerance to pollution, great ability to accumulate toxins in above ground parts, resistance to diseases, pests, and weather conditions. All above requirements are met by energetic plants, the representative of which if Jerusalem artichoke. This species does not require special soil conditions, thus its cultivation may be performed on chemically contaminated areas where production of consumption plants is not necessary. Jerusalem artichoke is utilized for energetic purposes as the fuel, for chipboards and compost production.

Soil fungi are an additional factor in pesticides degradation. Two reasons of soil fungi high activity can be describe. First is higher durability for vegetation conditions in compare with other soil microorganisms, and second one is activity of enzyme production due to organic compounds in soil. Soil microbes with higher activity for pesticides degradation are: *Penicillium, Aspergillus, Fusarium Trichoderma* [Różański 1992; Ignatowicz 2015].

Present study was aimed at evaluating the usefulness of Basket willow (*Salix viminalis*) to phytoremediation and bioremediation of sorption subsoil (consisting of the soil and composting sewage sludge) contaminated with pesticides. In future, it would allow for applying the sorption screen around pesticide burial area, which reduces pesticide migration into the environment, and grown energetic plants – through phytoremediation – would prolong the sorbent vitality and remove pesticides accumulated in above ground parts by means of combustion.

MATERIAL AND METHODS

Investigations upon phytoremediation of sorption material were conducted under pot experiment conditions. The experimental design included 4 objects: control pot and 3 other pots containing soil amended with pesticides. The initial studies confirmed [Ignatowicz 2008; 2009, Ignatowicz at al. 2015] the usefulness of soil mixture collected from pesticide burial area and composting sewage sludge (tab. 1) to make a sorption shield around that site. Basket willow (*Salix viminalis*) was grown in 4 pots of 0.3 m^2 area and 90 dm^3 capacity filled with above mixtures (Figure 1).

Research were conducted in four pots (0.3 m^2 each, volume of 90 dm^3) filed with sorbent and planted with *Salix viminalis*. The vegetation period has lasted since spring till late autumn 2015. After acclimatization, mixtures of chemically pure chloroorganic pesticides (HCH, DDT) were continuously added (which imitated surface supply) onto 3 experimental plots. During the whole experimental period, 5 mg of each active substance per pot was administered. After harvest, samples of soil, above and underground parts of plants were collected. Pesticide concen-

Figure 1. Basket willow (*Salix viminalis*).

Table 1. The characteristic of composting sewage sludge.

Sorbent	Properties						
	Manurial [g/kg dm]						
Compost	Ca	Mg	Nog	$N-NH_4^+$	Pog	K	
	56.1	4.6	13.9	0.09	14.7	4.5	
Compost	Metal [mg/kg dm]						
	Pb	Cu	Cd	Cr	Ni	Zn	Hg
	7.0	22.7	0.63	9.9	5.8	210	2.5
Permisssible standard	500	800	10	500	100	2500	5
Sludge	Organic master [%]						
	67.5						

trations were determined in collected samples in accordance to obligatory methodology using gas chromatograph coupled with mass spectrometer (GC/MS/MS 4000) as well as gas chromatograph AGILENT6890 equipped with ECD1 and NPD2 columns.

RESULTS AND DISCUSSION

Achieved results confirm observations made by Borkowska [2003] and Styk [1984], who found that Jerusalem artichoke and Basket willow (*Salix viminalis*), as perennial multipurpose species, is characterized by great yielding potential despite of poor soil and climatic requirements. Plants set in the first experimental year (set as several-year-old seedlings from a plantation) revealed high yields of above ground parts. Opportunity to get high yields allows for proposing Jerusalem artichoke as one of the species useful for chemically degraded areas reclamation, particularly phytoremediation of pesticides from the sorption barrier.

Studies of Lunney at all [2004] were to compare the ability of five plant varieties to mobilize and phytoremediation DDT and its metabolites. The potential and limitations of phytoremediation for removal of pesticides in the environment have been reviewed by Chaudhry at all. [2002].

High plant growth of steam and leaves were observed in first year of research experiment. Heavy yielding of plants such as *Salix viminalis* confirms its use for recultivation of chemical degraded soil especially for phytoremediation of pesticides from sorption barrier. Studies of Antoniewicz and Jasiewicz [2006] revealed high yielding potential of Jerusalem artichoke on the soil with varied heavy metals contamination, which proves its great resistance and fast adaptation to polluted soils. Own studies were also confirmed by Borkowska [2003] and Xia [2006], who observed more abundant yields of Jerusalem artichoke on subsoil amended with sewage sludge than on mineral soil. It referred both to plant height and yield biomass (Figure 1).

Besides high yield-forming potential, Basket willow (*Salix viminalis*) also shows a great ability to intake pesticides from the subsoil (Table 2). Much higher levels of absorbed pesticides were recorded in soil mixed with composting sewage sludge (0.0017–0.0087 mg kg DM) than in native soil (0.0005–0.0027 mg kg DM). Similar dependence was observed in samples of Basket willow (*Salix viminalis*) above ground parts. Both leaves and stems of plant cultivated on sorption subsoil accumulated more pesticides. Higher toxins concentrations were detected in stems (DDT 0.0087, HCH 0,0029 mg kg DM) than in leaves (DDT 0.0027, HCH 0,0017 mg kg DM), regardless the subsoil Basket willow (*Salix viminalis*) was cultivated

During own researches 20 of fungi species were isolated (Table 3). Results were close to to Wagner [2004] and Mietkiewicz [1997]. They were detemineted fungi in pesticides wastes. *Penicillium and Trichoderma* were dominated as responsible for pesticides degradation in soil as *Chrysosporium, Wardomyces i Oidiodendron.* [Ignatowicz 2015, Różański 1992]

CONCLUSION

Achieved results allow for concluding that Basket willow (*Salix viminalis*) can be used for phytoremediation of soils contaminated with pesticides, and particularly to prolong vitality of sorption barrier around a pesticide burial area. More abundant yields of Basket willow (*Salix viminalis*) on the subsoil amended with composting sewage sludge than mineral soil allows for predicting large amounts of a biomass for energetic purposes, thus removing accumulated pesticides by means of combustion.

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Table 2. Mean concentration pesticides in Basket willow *(Salix viminalis)*

Pesticide [mg kg sm]	Limit detection	Control test			Test 1-3		
		Soil	*Salix viminalis*		Soil	*Salix viminalis*	
			stem	leaves		stem	leaves
HCH	0.001	0.0599	0.0005	0.0006	0.1345	0.0029	0.0017
DDT	0.005	0.1710	0.0027	0.0017	0.3815	0.0087	0.0027

Table 3. Fungi species in the sorption solum.

No	Fungi	Fungi number
1	*Acremonium potronii* Vuill.	9
2	*Chrysosporium pannorum* (Link) Hughes	38
3	*Cladosporium cladosporioides* (Fres.) de Vries	1
4	*Fusarium sacchari* (Butler) W. Gams	2
5	*Helicosporium vegetum* Nees	1
6	*Mortierella alpina* Peyronel	1
7	*Mortierella humilis* Linnem.	2
8	*Oidiodendron tenuissimum* (Peck) Hughes	16
9	*Paecilomyces carneus* Duche & Haim	2
10	*Penicillium fellutanum* Biourge	6
11	*Penicillium citreonigrum* Dierck	6
12	*Penicillium daleae* Zaleski	8
13	*Penicillium decumbens* Thom	15
14	*Penicillium glabrum* Westling	12
15	*Penicillium lividum* Westling	12
16	*Phoma oculo-hominis* Punithalingam	3
17	*Scopulariopsis brevicaulis* Bain	3
18	*Trichoderma koningii* Oudem.	16
19	*Trichophyton tonsurans* Malmsten	3
20	*Wardomyces humicola* Henneb. & Barron	24
	Total	192

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