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FOREST PHYTOCENOTIC CHANGES IN IMPACT ZONE OF MUNICIPAL VILNIUS COUNTY (LITHUANIA) WASTE LANDFILL

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More than 800 municipal waste landfills were in Lithuania until 2007, most of which were closed and in 2009 and rehabilitated. Currently, mixed municipal waste is deposited at 11 regional landfills equipped in accordance with international requirements. Investigations were carried out in the potential impact zones of 2 regional landfills (operating since 2007 and rehabilitated in 2009). The observations were carried out in 30 mixed spruce - deciduous stands (A = 65-72 m), growing 50 to 650 m from the landfill boundary. The impact of spruce on the phytocenosis next to both landfills was similar and negative (~300-400 m). The most significant changes in the status of stand were observed up to 100 m, where the share of healthy trees was 25% (50 m) - 76% (100 m).

The highest density of undergrowth and underbrush was in 100-200 m from the landfill, and their species composition was relatively poorer than in healthy stands. The most significant changes of grass cover were identified up to 50 m. There in the zone occurs 6 herbaceous plant species uncharacteristic for forest phytocenosis *(Chenepodium album, Artemisia vulgaris, Rumex acetosa, Tussilago bugle, Plantago media, Medicago Falcata)*, and most of these plants reaches 0.5 to 0.75 m in height.

Key words: landfill, the zone of impacts, spruce stand, undergrowth, shrub layer, herbaceous cover.

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INTRODUCTION

Currently, one of the most pressing environmental issues is the municipal waste and waste management. It poses a serious threat to the environment and existing rehabilitated landfill leachate has accumulated which under the influence of precipitation, migrates and may have a negative impact on neighboring areas (Česonienė & Lukenskienė 2006).

There in Lithuania until 2007 were ~ 800 landfills partially or completely non-compliant with environmental requirements. The legal requirements were changed after Lithuania joined to the EU; in 2009 the absolute majority of landfills were closed and reclamation. Currently, mixed municipal waste is disposed on 11 regional landfills, equipped in accordance with international requirements. It should be emphasized that the majority (85%) of waste in those landfills consists of municipal waste (Baltrėnas et al.1996, Mieldažys et al. 2007, Strategic…2007).

Reclamation of the landfill is linked and dependent on the creation of a viable soil. It is generally recognized that the restoration of damaged ecosystems is a slow process and it may take 50 years or more (Chu 2008, Smidt et al. 2007, Mackay & Hesketh 1998).

The study of seven landfills rehabilitated at different times and cover was carried out in Lithuania in order to clarify the process of soil formation in rehabilitated landfill and environmental impact of leachate (Eitmanavičiūtė & Matusevičiūtė 2005).

The results show that only 15 years after rehabilitation begin to form a stable, prosperous diversity of pedobiontic species. However, 7 years after rehabilitation concentrations of heavy metals (Cd, Ni, Cr, Pb, Zn, Fe, Cu) accumulated in grass cover growing in surrounding area exceeds the limit values in 2-9 times. The filtrate migrates together with ground water and can result in contamination of area in 500 meters radius (Eitmanavičiūtė&Matusevičiūtė 2005, Eitmanavičiūtė et al. 2005, Eitmanavičiūtė et al. 2007).

Stands, growing in areas, surrounding landfills, may be damaged due to the soil contamination. It was found that in such damaged lands stand increment drops to 13 percent (Mackay & Hesketh 1998). Recorded decrease in tree radial increment in investigated *Quercus robur* stands up to 80 m distance from landfill (Sukopp & Starfiger 1999).

Altogether, both operating and closed and rehabilitated landfills emit to the environment a variety of harmful substances that accumulate in the soil and leachate to the surrounding areas (Žaltauskaitė & Čypaitė 2008). Forests, growing in their potential impact zones can be damaged (Mackay & Hesketh 1998, Sukopp & Starfiger 1999, Chu 2008). Therefore, studies of such forest phytocenosis changes around landfills are relevant and performed poorly before. Similar studies in Lithuania have not been carried out yet.

MATERIAL AND METHODS

Research goal - to investigate the situation and changes in the regional landfills (operating and rehabilitated) primary forest phytocenosis components (stand, undergrowth, underbrush and grass cover) in the potential impact area.

The study objects were selected next to 2 landfills up to 40 kilometers away from Vilnius (Lithuania). The first municipal waste landfill was operating in 1987-2008. The area covers 27.6 ha, it has gained ~ 2.93 million m^3 of waste with a pile height of 30 m.

The second landfill established in 2007 in accordance with EU standards. It covers area of 27.1 hectares, the design capacity up to 6.8 million m^3 of waste in 2024 (Regional…2014).

Around both landfills common and are in the majority mixed spruce - deciduous stands. The research covers 15 ripening - mature, potentially homogenous spruce stands (Table 1).

Similarity of investigated spruce stands communities rated by T. Sørenson coefficient, its average size of 0.68 ± 0.0014. Criterion, reflecting the homogeneity of separate spruce stands phytocenosis, range from 0.61 to 0.82.

Investigated stands were selected in different directions 50 - 650 m from the landfills boundary. Solid wood accounting made in each research plot established 100 m^2 sampling plots, assessing their sanitation status class (Guide… 2000). Moreover, carried out an stocktaking of understory and shrub layer, estimated cover of herbaceous layer and specie prevalence (%).In addition, close to the landfills, separated 50 m wide stretch, where in

Table 1. Characteristics of investigated stands

Stand species composition	Mean age (years)	Stocking level	Forest type	Number of investigated stands
Spruce 80 % Aspen 20 %	72	0.6	*Hepatico - oxalido*	6
Spruce 80 % Birch 10 % Aspen 10 %	70	0.7	*Oxalido*	8
Spruce 70 % Birch 20 % Aspen 10 %	68	0.7	*Oxalido*	8
Spruce 60 % Birch 20 % Aspen 20 %	65	0.7	*Oxalido*	8

Table 2. Distribution of trees by sanitary state classes at different distances from the landfill

Classes of tree state	Number of trees (%)in the possible impact on area			
	Up to50 m		Up to 650 m	
	At the operating landfill	At the rehabilitated landfill	At the operating landfill	At the rehabilitated landfill
I - healthy trees	29,4	20,9	84,5	83,7
II - debilitated	35,3	5,3	7,0	10,2
III- severely weakened	17,6	20,4	1,4	6,1
IV – drying trees	11,8	9,8	-	-
V –current year deadwood	5,9	13,6	7,1	-
Mean state score	2,29	2,99	1,38	1,22
Mean degree of damage	slightly damaged	moderately damaged	relatively healthy	

zigzag turn established 26 plots for herbaceous cover stocktaking**.**

Field research results are summarized in MS Excel and STATISTIKA programs.

RESULTS AND DISCUSSION

The state of stands in the zone of potential impact. Assessment of stands state was carried out in sample plots according to external morphological characteristics: crown defoliation, dry tops, mechanical damage (Table 2). As we can see, up to 50 m away from both the operating and dormant landfills the spruce stands are is slightly to moderately damaged. A large degree of damage is fixed at the rehabilitated landfill, because there the filtrate is spreading pollution and affects forests for longer period (from 1987). In the meantime, the operating landfill runs only since 2007. The potential impact zone of the two landfills is less than 600 m, and the impact on the stands status is similar.

In order to determine the dynamics of spruce stands state throughout the investigated area, the analysis of healthy trees volume relation to the distance from the landfill was carried out. Summarizing all investigated stands state, it can be said that it depends on the distance to the landfill (regardless of whether it operates, or is rehabilitated) (Fig. 1).

It is obvious that the biggest influence on the state of spruce stands is observed up to 100 m from the landfill. Effect declines with distance up to 300 m; and from 300 m the share of healthy trees in the stands consists of 83-89 %. Diseases and pests have not been recorded in all analyzed spruce stands. The main reasons for state changes - crown defoliation and number of drying trees.

The state of undergrowth and shrub layer in the landfill operating zone. Investigating the undergrowth at the sample plots were identified species of selfseeded and their abundance. Evaluating the results, we found that the mean density of the spruce undergrowth near operating landfill (up to 650 m) is 1000 ± 20.7 pcs. ha^{-1}, and near the inoperative - 833 ± 18.3 pcs. ha^{-1}. According to the Lithuanian national forest inventory data (Lithuanian… 2008), the average density of the spruce undergrowth reaches 944 pcs. ha^{-1} (Bartkevičius et al. 2008). In this way, significant difference in abundance of selfseeded was not revealed.

Thus, at the two landfills impact zones spruce stand undergrowth was found only 3 species: *Acer platanoides, Quercus robur* and *Picea abies*. Meanwhile, under normal conditions of growing spruce stand undergrowth average number of species is higher (10 and more).

In the mixed spruce stand undergrowth under usual growth conditions among the most prevailing species is spruce *(Picea Abies)*. Maple *(Acer platanoides)* was dominant specie in our sample plots, both near operating and dormant landfill, respectively, 72.4 and 62.5 % of selfseeded. In second place in terms of the abundance was oak *(Quercus robur)* ~ 18 %, while spruce took only 10-18 %.

The undergrowth area was rich in game animals damaged selfseeded: in the operating landfill impact zone they accounted for 52.4 % of the total amount, and in the inoperative - 25 %. In Lithuanian spruce stand undergrowth damage caused by game animals reaches 27.7 % on the average (Lithuanian…2008).

The highest undergrowth density was recorded in the distance of 100-200 m from both landfills. The overall relation of density with distance from the landfill is shown in Fig. 2.

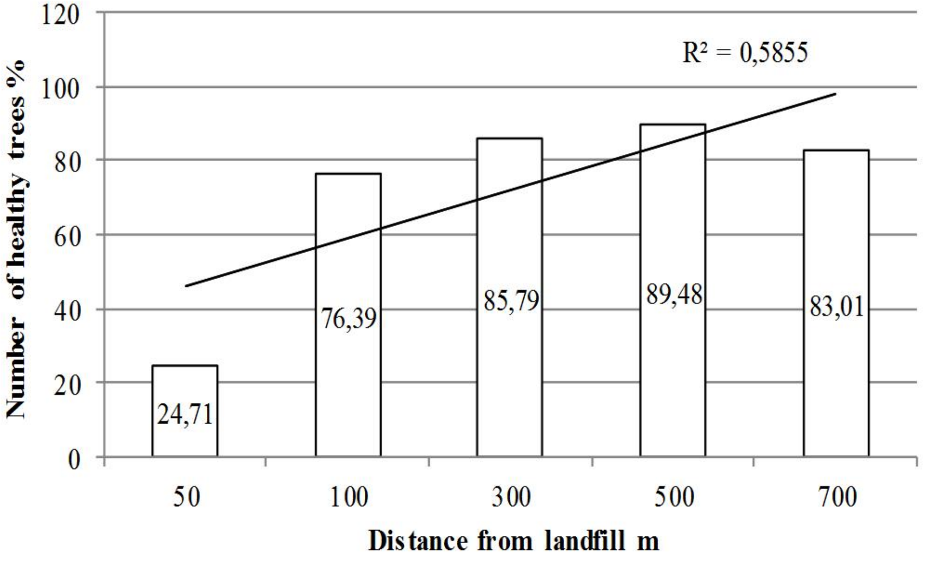

Fig. 1. The share of healthy trees in relation with distance from the landfill.

Summing up the state of the undergrowth in the landfill impact zone, we can see that selfseeded species composition is poor (3 species), their density (800-1000 pcs. ha^{-1}) is close to the medium-sized spruce stands, but less than is found in mature /15/ spruce stands(~ 3 thousand pcs. ha^{-1}). Significant differences of undergrowth state regarding the effects of operating and dormant landfills were not observed. In the outskirt zone was found only single individuals of undergrowth trees up to 50 m of both landfills. Very dense and high (0.5 to 0.75 m) covering grass and shrub layer hampered they germination.

5 species were found: *Sorbus aucuparia, Corylus avellanta, Euonymus verrucosa, Frangula alnus, Lonicera xylosteum* in the investigated spruce stand shrub layer in both landfills impact zones. Their mean density was 2,800 ± 41.21 pcs. ha^{-1} in the operating landfill impact zone and 1933 ± 21,21 pcs. ha^{-1} near a dormant landfill. The highest density of shrub layer was observed in the closest to the landfill (70-100 m) growing spruce stand and was up to 4.5 thousand pcs. ha^{-1}. Game damage was recorded in shrub layer – there was found 29-35 % of plant with browsed tops.

Summing up the state of shrub layer, should be highlighted the smaller (4 species) diversity of species in spruce stands growing in the landfill impact zone than under the normal conditions, and its maximum density was found in the closest to the landfills (70-100 m) stands.

Characteristics of herbaceous cover in the landfill impact zone. The research of herbaceous vegetation was carried out in the same spruce stands, distant from landfills from 50 to 650 m. It was noted that significant cover changes visually apparent in the nearest to landfill stands, due to that additionally investigated 50 m outskirts line. There obtained results analyzed separately.

Investigating the herbaceous covering in spruce stands growing in 50 to 650 m distance from landfill, found that in both landfills impact zones abundantly spread the same 3 species (Table 3): *Oxalis acetosella, Aegopodium podagraria* and *Rubus idaeus*.

13 herbaceous plant species was found in *Oxalidosa* and *Hepatica oxalidosa* type of spruce stands (in 50-650 m distance). Variety of herbaceous cover was smaller (9 and 13) in the impact zone of dormant landfill, but with same species. The majority of species (55.5 - 71.4 %) was characteristic to the spruce stands of investigated forest types. Mean projection of herbaceous cover was in 16.2 ± 0.46 and 20.8 ± 0.4 less than is characteristic for investigated

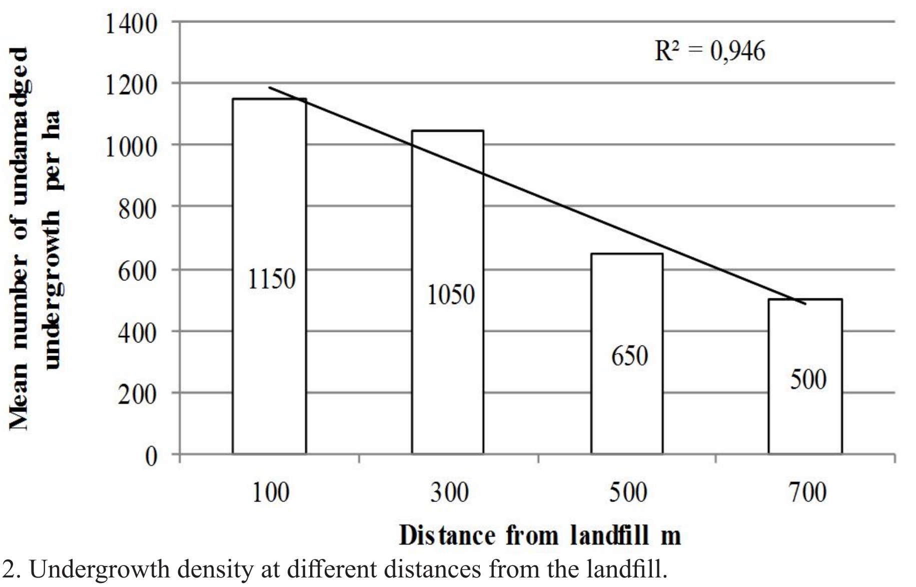

Fig.2. Undergrowth density at different distances from the landfill.

Table 3. Characteristics of herbaceous cover in 50 to 650 m distance from landfill

Ref. No.	Species of herbaceous plants	Mean projection cover and species abundancy %	
		Zone of operating landfill	Zone of dormant landfill
1.	*Oxalis acetosella*	81 (100)	43,3 (100)
2.	*Aegopodium podagraria*	62 (100)	63,3 (100)
3.	*Rubus idaeus*	43,3 (60)	12,5 (67)
4.	*Lamiastrum galeobdolon Huds.*	20 (60)	6 (100)
5.	*Hepatica nobilis Mill.*	17,5 (80)	6 (100)
6.	*Galium album Mill.*	13,8 (80)	-
7	*Urtica dioica L.*	10,5 (40)	7 (33)
8.	*Pteridium aquilinum L.*	8 (80)	3,3 (100)
9.	*Maianthemum bifolium L.*	7,5 (40)	-
10.	*Asarum europaeum L.*	6,7 (60)	3,3 (100)
11.	*Convallaria majalis L.*	5 (20)	-
12.	*Vaccinium myrtillus L.*	4 (40)	5 (33)
13.	*Fragaria vesca L.*	1 (20)	-
Mean:		**20,8±0,4 (58,6±0,45)**	**16,2±046 (81,1±0,61)**

Table 4. Characteristics of herbaceous cover in 25-50 m distance from the landfill

Ref. No.	Species of herbaceous plants	Mean covering projection and species abundancy %	
		Near to operating landfill	Near to dormant landfill
1.	*Cyperaceae*	67,5 (23,5)	62,9 (77,9)
2.	*Oxalis acetosella L.*	52,5 (47,1)	-
3.	*Aegopodium podagraria L.*	54,2 (64,7)	78,3 (66,7)
4.	*Rubus idaeus L.*	60,3 (70,60	40 (11,1)
5.	*Hepatica nobilis Mill.*	25,8 (23,5)	60 (22,2)
6.	*Galium album Mill.*	2 (5,9)	-
7	*Urtica dioica L.*	54,2 (64,7)	70 (77,9)
8.	*Pteridium aquilinum L.*	7 (11,8)	12,5 (22,2)
9.	*Maianthemum bifolium L.*	11 (5,9)	-
10.	*Convallaria majalis L.*	35 (11,8)	-
11.	*Vaccinium myrtillus L.*	1 (5,9)	-
12.	*Fragaria vesca L.*	11 (17,7)	-
13.	*Glechoma hederacea L.*	41 (29,4)	10 (22,2)
14.	*Ranunculus cassubrucus L.*	20 (5,9)	-
15.	*Artemisia vulgaris L.*	15,5 (11,8)	35 (55,6)
16.	*Chenepodium album L.*	15 (5,9)	20 (22,2)
17.	*Rumex acetosa L.*	10 (5,9)	20 (22,2)
18.	*Peucedanum palustre (L.) Moench*	7,5 (11,8)	-
19.	*Rubus saxatilis L.*	5 (5,9)	-
20.	*Lathyrus vernus (L.) Bernh.)*	3,3 (23,5)	-
21.	*Medicago falcata L.*	-	15 (33,3)
22.	*Plantago media L.*	-	15 (22,2)
23.	*Stellaria holostea L.*	-	10 (22,2)
24.	*Leontodon hispidus L.*	-	10 (11,1)
25.	*Tussilago farfara L.*	-	10 (11,1)
Mean:		**24,93±0,31 (22,65±0,3)**	**37,01±0,42 (37,61±0,42)**

forest types (47.1 ± 2 and 48.4 ± 2.8) /15/. The general patterns of herbaceous cover changes were similar in both landfills impact zones: operating and dormant. Assessing the distance impact on herbaceous cover, was discovered that closer to the landfill is higher herbaceous vegetation (up to 0.5 m) and lower (30 %) covering projection as in typical *Oxalidosa* and *Hepatica oxalidosa* types spruce stands. Altogether, these herbaceous cover changes recorded up to 100 m away from both landfills.

There has been observed in the herbaceous cover research the most prominent changes in the peripheral areas closest to the landfills stands bands. In this way, additionally was assessed herbaceous cover in 50 m wide strips. In this case, the distance from both landfills was 25-50 m (Table 4).

It may be noted that in the investigated spruce stands near both landfills (25-50 m distance) was richer (53-55 %) herbaceous plant diversity. There are abundant representatives of Cyperaceae in these outskirts bands (62.9 - 67.5 %) and 7 species extraordinary for forest phytocenosis. Next to both operating and dormant landfills spreads *Urtica dioica, Artemisia vulgaris, Chenepodium album, Rumex acetosa* with coverage from 20 to 78 %, an average height from 0.5 to 0.75 m. In addition to these species, close to dormant landfill occurs *Medicago falcata* and *Plantago media*. The average herbaceous covering projection in 5-11 % higher than in spruce stands growing 50 to 650 m away from landfill. Outskirts herbaceous covering projection is in 12 % higher near dormant landfill, and in 4 % higher next to operating landfill (50 to 650 m zone).

The effect of closed and rehabilitated (by sowing grass) landfill strongly modifies the herbaceous cover, especially close to the landfill (50 m). 6 herbaceous plant species which are not particular to forest phytocenosis occurred near dormant, and 3 – near operating landfill. It is likely that this leads because of longer leachate impact operation process.

Abundant and dense herbaceous cover hampers selfseeded regeneration and shrub layer plants. In early spring tall dry grasses pose a risk to forest fires, create favorable conditions for small rodents that destroy the seeds, seedlings. All of these shows negative both operating and rehabilitated landfills impact on spruce phytocenosis and may lead to the change in the future.

CONCLUSIONS

1. The impact of both operating and rehabilitated (since 2008) municipal waste landfills on maturing spruce phytocenosis is analogous and negative. Medium negative impact zone is up to 400 m.

2. A stand state directly depends on the distance to the landfill, increasing its state improves. The most obvious visual changes can be observed up to 100 m distance from both landfills.

3. Selfseeded abundance in undergrowth is lower (~ 0.82 to 1.0 thousand pcs. ha^{-1}) than in the average in similar *Oxalidosa* mature spruce stands types (~ 3 thousand pcs. ha^{-1}). Both the undergrowth and shrub layer highest density was in 100-200 m from the landfill. Growth of distance leads to decrease of density.

4. 13 herbaceous plant species was found in *Oxalidosa* and *Hepatica oxalidosa* type of spruce stands (in 50-650 m distance). Lower herbaceous cover variety and covering projection estimated in the impact zone of dormant landfill. The average herbaceous covering (16.2 and 20.8 percent) next to both landfills has been less than is typical for investigated forest types (from 47.1 to 48.4 percent).

5. Herbaceous cover species composition, covering and abundancy significantly altered up to 50 m from the landfill. In this area occurs uncharacteristic for spruce stands forest phytocenosis herbaceous plant species: *Artemisia vulgaris, Chenepodium album, Medicago falcata, Tussilago farfara, Plantago media,*

Rumex acetosa. Other representatives of the herbaceous cover *Urtica dioica* L., *Aegopodium podagraria* L. grows up to 0.5 to 0.75 m. Especially abundant are *Cyperaceae* (63-67 %), *Aegopodium podagraria* (54-78 %), *Rubus idaeus* (up to 60 %) and *Urtica dioica* (up to 70 %) covering and abundancy (up to 78 %.).

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