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Mini Review

Verifying Research of Waste Landfill Environmental Impact Using Bioindicators

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Abstract

Our paper is focused on verification of research of the impact of waste landfills on the environment, using bioindicators. The goal of this study was to find how plants may be used to indicate some of the emissions from landfill sites. Sampling was carried out in 2007-09 and 2011-12. The obtained data were compared with a simple floristic list prepared in 1995. Selected bioindicators were used to estimate, confirm, or deny the impact of the landfill on the close vicinity.

Keywords: verification of research, bioindicators, landfill, waste

Introduction

Landfilling currently is the main option for the utilization of municipal solid waste (MSW) in the Czech Republic. Landfilling has been used for many years as the most common method for the disposal of solid waste generated by different communities [1]. Despite intensive efforts that directed at recycling and recovering solid wastes, landfills remain and will remain an integral part of most solid waste management plans. Solid waste disposed in a landfill usually is subjected to a series of complex biochemical and physical processes that lead to the production of both liquid and gaseous emissions [2].

MSW can be landfilled irrespective of their composition, calorific value, moisture, etc. However, landfilling needs to be limited, taking into account the hierarchy of waste management and other requirements of legislation. Furthermore, increasing costs and deficiency of areas suitable for landfills, disapproval of local communities to landfilling their neighbourhood, etc., makes it necessary to find a way to reduce the amount of landfilled waste [3]. Municipal waste deposition is relatively the least troublesome method of its utilization. However, this method is related to environmental risk issues, among which the most important are: leachate from the landfill, formation of landfill gas, landfill stability, dust, carried small materials, odor, the concentrated presence of rodents and birds, and noise due to landfill operation.

The potential impact of landfill on the near vicinity, particularly on plants, was evaluated on the basis of analysis of available materials [4]. Poor management of waste can lead to contamination of water, soil, and atmosphere, and to a major impact on the environment and public health [4, 5]. The impact can be evaluated in various ways. Among them a possibility to use living organisms as indicators of the environmental state – so called bioindicators – to evaluate the effect of human activities on organism health, functioning of ecosystems, and structure and functioning of the whole region. Changes in ecosystems or reasons for these changes can be evaluated on the basis of alteration in the behaviour, appearance, or occurrence of some organism or their concentration. Bioindication and biomonitoring are methods that enable us to evaluate these changes not being visible at first glance [4, 6].

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This work was undertaken in order to confirm the ecological assessment of environment in the vicinity of the landfill with the use of bionidication methods, e.g. lichen reactions and the response of some selected plant species on given pollutants from landfill. The aim of this study was to display results of research described in "Evaluation of waste landfills impact on the environment with the use of bioindicators" – how plants can be used to indicate some of the emissions from landfill sites. And, finally, this work attempts to compare current results with historical ecological background of this particular area.

Experimental Procedures

Study Site and Methods

Examined landfills (location and characterization) were described in detail in "Evaluation of waste landfills impact on the environment with the use of bioindicators" in *Polish Journal of Environmental Studies* [4, 7, 8].

Sample Collection

In 1995 and 2007-09, simple floristic tests were conducted in the vicinity of the landfill and the present list of vascular plants and lichens was elaborated. The studies covered the near vicinity of the landfill Štěpánovice from its fencing to 60 metres from the fence (Fig. 1) [4]. The profile of selected plants is taken from available literature data [9-11]. The photo documentation of selected and described taxa of vascular plants and lichens composes a part of floristic tests. A Braun-Blanquet cover scale was used to record the area (Table 1) [4, 12]. Vegetation was identified at the time of the survey and where species could not be identified in the field, samples were collected and pressed for later identification.

Particular details of methodology are not presented in this article. Detailed methodology of data collection is described in "Evaluation of waste landfills impact on the environment with the use of bioindicators" [4], and "Research into the occurrence of some plant species as indicators of landfill impact on the environment" [13].

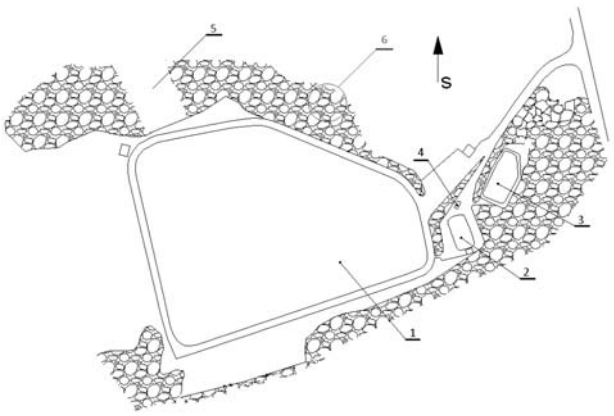

Fig. 1. Štěpánovice landfill and landfill surrounding [4].
1 – landfill, 2 – drained water tank, 3 – rainwater reservoir, habitat of *Triturus vulgaris*, 4 – entrance gate, 5 – forest maintenance, 6 – location of *Polygala chamaebuxus*.

Table 1. Braun-Blanquet cover scale [4, 12].

Class	Braun-Blanquet	
+	< 1%	Foliage sparsely or very sparsely present, cover less than 5%
1	1-5%	Plentiful, foliage cover 1-5 %
2	6-25%	5-25% foliage cover
3	26-50%	26-50% foliage cover
4	51-75%	51-75% foliage cover
5	76-100%	76-100% foliage cover

Discussion of Results

Selected Species of Plants Present in the Vicinity of the Landfill

At the first stage of our study we were focused on theoretical background and conclusions of previous research. In 2007-09 species such as: *Cladonia arbuscula*, *Juniperus communis*, *Epipactis helleborine*, *Populus tremula*, and *Polygala chamaebuxus* were selected as bioindicators of the landfill effect in the near vicinity. Bioindicators are characterized and described in the *Polish Journal of Environmental Studies* [4]. In 2009 it was found that waste management at Štěpánovice landfill complies with valid provisions of the law. Landfill location and optimization of transport route significantly minimize the effect of landfill exploitation and used technique on natural environment [4]. Landfill location and adjusted configuration of the area in the vicinity of waste landfill do not have a negative impact on inhabitants from the nearby village of Štěpánovice. Studies performed in 2009 did not confirm the negative impact of landfill on the nearby area [4].

Because monitoring by bioindication allows us to record changes occurring within a relatively long period of five and more years [13] research of the selected area was conducted again in 2011-12. Repeatedly sampling and research monitoring of the selected bioindicators allowed us to determine the rate, level, and range of present and future human-induced changes in the natural environment [14]. The broad spectrum of plant species allow us to utilize plants for detection of environmental pollution.

During the performance of field studies in 2011-12 (autumn, spring), 58 taxa of vascular plants and 2 lichens were identified in the landfill vicinity (Table 2) [4].

The research focused particularly on the taxa of vascular plants, which were identified in 1995 and 2007-09. Simultaneously, several new species were identified during the last research, such as: *Alliaria petiolata*, *Euphorbia esula*, *Leucanthemum Bulhare*, *Lotus cornicu-*

Table 2. Plant species observed in the vicinity of landfill (% cover abundance – BBcover) [4].

Scientific name	Braun-Blanquet Cover	Braun-Blanquet Cover
	2007-09 [4]	2011-12
Alliaria petiolata	-	1
Alopecurus pratensis	3	3
Amaranthus retroflexus	4	4
Armoracia rusticana	2	not found
Artemisia absinthium	3	not found
Betonica officinalis	2	2
Brachypodium pinnatum	5	5
Brassica napus	-	+
Calamagrostis epigejos	4	4
Calluna vulgaris	3	not found
Centaurea jacea	3	3
Cirsium arvense	4	4
Cirsium balustre	4	4
Cirsium oleraceum	4	4
Cladonia arbuscula	2	not found
Dactylis glomerata	3	3
Danthonia decumbens	3	3
Daucus carota subsp. carota	3	4
Epilobium angustifolium	2	2
Epipactis helleborine	2	2
Equisetum arvense	4	2
Eriophorum angustifolium	2	2
Euphorbia esula	-	3
Euphorbia peplus	3	4
Fragaria vesca	4	4
Frangula alnus	2	2
Galeopsis pubescens	2	2
Galium album	4	4
Galium verum	4	4
Genista tinctoria	3	3
Geranium pretense	2	2
Gnaphalium sylvaticum	4	4
Gnaphalium uliginosum	3	3
Hieracium pilosella	3	3
Hypericum maculatum	2	2
Hypogymnia physodes	3	2
Chenopodium album	4	4
Chrysanthemum leucanthem	3	3

Table 2. Continued.

Scientific name	Braun-Blanquet Cover	Braun-Blanquet Cover
	2007-09 [4]	2011-12
Juniperus communis	1	not found
Leucanthemum vulgare	-	+
Lotus corniculatus	-	3
Lychnis flos-cuculi	-	3
Pinus sylvestris	3	3
Plantago major	3	3
Poa pratensis	4	4
Polygala chamaebuxus	1	4
Populus tremula	2	2
Pteridium aquilinum	3	2
Quercus robur	2	2
Ranunculus repens	4	4
Rosa canina	3	3
Seneci inaequidens	4	2
Symphytum officinale	2	2
Symphytum tubersum	3	not found
Tanacetum vulgare	3	3
Trifolium arvense	3	3
Trifolium medium	4	4
Trifolium pretense	4	4
Urtica dioica	5	5
Verbascum thapsus	3	3
Veronica chamaedrys	-	2
Veronica persica	5	5
Vicia angustifolia	2	2
Vicia cracca	4	4
Vicia sepium	-	2
Xanthoria parietina	2	2

latus, *Lychnis flos-cuculi*, *Veronica chamaedrys*, and *Vicia septum*. In most cases they represent ruderal, synanthropic and nithrophilous species. These species are not very important for bioindication of the impact of landfill on its vicinity.

In contrast with the research conducted in 2007-09, no occurence of *Cladonia arbuscula* was recorded. This indicator shall be monitored in the following research. Furthermore, no occurence of *Juniperus communis* and *Calluna vulgaris* was recorded. The reason for the absence of these indicators was wood treatment, which was carried out in accordance with valid legal regulations and with the

strategy of sustainable development of woods. The wood treatment was carried out in 2011 and natural environment for these species was harmed (Fig. 1) [4].

Epipactis helleborine was found in the surroundings of the landill repeatedly. This species belongs to rare taxa of Czech vegetation, which requires further attention. This species also is protected under the CITES Treaty.

Major attention was dedicated to the occurence of *Polygala chamaebuxus*, which belongs to the endangered and legally protected species (C3/§3) in the Czech Republic and is placed on the Red List of vascular plants. In the Czech Republic it only occurs in the West Bohemia region. *Polygala chamaebuxus* appeared in previous years only in 2009. According to the landfill management description, this plant was commonly present in 1995 in the area of constructed landfills and in its near vicinity (particularly on the north side towards the landfill, in the wood) [4]. The construction of landfill caused changes in biotope and destruction of this plant's growing sites. Its reappearance in 2009 can demonstrate that environmental conditions in the vicinity of the landfill have been stabilized. As the soil seed bank contained undamaged diaspores (seeds) of *Polygala chamaebuxus*, it reappeared in its initial place [4]. In 2011-12 this species was found in more locations near the landfill (particularly on the north side) and in greater covering (Fig. 1) [4]. This may indicate that there were no significant alterations in the environment (air quality, dust, etc.) in the nearby area of the landfill compared to the year 2009. In 2009 the covering of *Polygala chamaebuxus* (according to the Braun- Blanquet scale) was 1%. In 2011-12 the covering was 4%.

In the surroundings of the landfill two lichens were identified: *Xanthoria parietina* and *Hypogymnia physodes*. Bioindication of air clarity is characteristic for both lichens, considering thier sensitivity to air pollution. On the basis of their occurence it can be stated that air quality was not aggravated compared to the preceding years in the monitored area.

In the rainwater reservoir in the vicinity of the landfill, the occurence of *Triturus vulgaris* was recorded. Despite this, it isn't a plant indicator, but it is necessary to mention it as its occurence may reflect correct operation of a landfill considering the sensitivity of *Triturus vulgaris* to the environment. This species is legally protected and, in accordance with Regulation No. 395/1992 Coll., belongs to a highly endangered species. Its presence in the rainwater reservoir water proves the clarity of this water and shows that no contamination of water by leachate from the landfill or from drained water tank has taken place.

Conclusions

Plant species used to test the degree of environmental pollution of areas such as landfill vicinities are mostly cultivated, which is only partially useful in field conditions.

Therefore, our research focused on wild plant species (particularly endangered and protected species) as bioindicators. The resulting method is efficient and easily applicable. Based on the data collected during these studies [4, 13] we are able to present a list of suitable bioindicators from species of the landfill vicinity as an operative, effective, and orientative front-line tool for evaluating waste landfills impact on the environment. This test can be used as the first step to recognize the current situation in regions of interest. This may be considered one of the main values of the presented method, which could thus be applied for broad practical use.

This method is useful, under specific conditions, for other landfills as well. The local flora of select landfill vicinities, through selection of species according to the basic criteria and their utilization in line with the recommendations made in this study, could serve as a reliable source of plant biondicators.

On the basis of conducted tests performed in 2007-09 and 2011-12, it was found that waste management at Štěpánovice landfill complies with valid provisions of the law. Landfill location and optimization of the transport route significantly minimizes the effect of landfill exploitation and used technique on natural environment [4]. The influence of noise and dust on environment and daily life of inhabitants from the nearby area is minimal. Technological processes at the landfill prevent small material carriage. The protection of surface and ground water against leachate from the landfill is provided by a special system of bottom isolation and drainage [4]. The landfill is monitored and inspected on a regular basis. In addition to a daily inspection of the landfill, there also is an independent inspection of negative effects on the environment (at least twice a year), especially the monitoring of ground water and leachate from the landfill as well as the analysis of landfill gas formation. The deterioration of measured indicators has not been observed so far [4]. Performed studies did not confirm significant negative impact of landfill on the nearby area.

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