Original Research

Potential of Plant Applications in the Initial Stage of the Landfill Reclamation Process

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Abstract

Our paper presents a method of remedial planting works designed for the old Radiowo sanitary landfill. The landfill (embankment type) was established in 1962, without any environment protection systems installed at the site. The initial reclamation works on the landfill have been carried out since 1996, and were aimed at the limitation of the landfill impact on Kampinoski National Park and two nearby reserves. The vegetation cover decreased the effect of soil dusting and enhancing erosion control were the primary reclamation works introduced at the landfill site. The objectives of the whole process were mainly: stabilization of capping soil-compost layers, accelerate the processes of mineralization, and increase the evaporation of leachate from the landfill and the local composting plant. A planting of carefully selected vegetation species within the protection zones (with existing biological potential and biotic preconditioning) of the landfill slopes also is presented.

Keywords: sanitary landfills, remedial works, planting for slope stabilization, wastewater irrigation

Introduction

The remedial works on sanitary landfills, among others, require solutions concerning utilization of leachate [1, 2]. On individual landfills, it could be achieved by using appropriate plant species requiring intensive fertilizing and irrigation. The establishment of vegetation for the landfill reclamation purpose mainly depends on its tolerance of various soil compositions and on tolerance capability of highly mineralized available water [3, 4]. In the present paper, the recommended plants having all of the required properties, e.g.: trees, shrubs, and highly transpiring perennials, plus some shielding species common in land reclamation applications, are presented. Additionally, our paper presents species that have recently passed biological tests aimed to verify their suitability to be applied at the Radiowo landfill site (Fig. 1), where the reclamation process consisted of the application of the compost waste prepared with Dano technology. The aim of these tests was to assess the suitability of select grasses, papilionaceous plants, and other species intended for sowing on the surface of sanitary landfills. Radiowo landfill is located in the northwestern part of Warsaw. The southern and eastern areas are bordered by Bemowo Forest Park. A part of the waste body has extended toward Bemowo Park as a result of landslides. In 1962-91 mixed municipal waste from the northern districts of Warsaw (volume up to 1,000 tons/day) were disposed of there. The nearest real estate is located to the north, at a distance of 0.7 km, and furthermore there were no protection systems against environmental pollution installed within the surrounding area.

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Water-Trophic Conditions on Radiowo Landfill

One of the reclamation solutions introduced on the Radiowo landfill was the application of a compost layer produced from mixed waste, and additionally a vegetation cover was created [5]. In order to choose species appropriate for the habitat, water and trophic conditions at various points of the landfill were determined. The waste body of the landfill was divided into 4 zones of different retention capabilities, e.g: zone I – 1.9 ha, zone II – 2.6 ha, zone III – 5.37 ha, and zone IV – 4.13 ha [6]. The total area intended for irrigation (with the use of leachate) equals ca. 14 ha. The select retention capacity zones are presented in Fig. 1, while components of the landfill water balance are shown in Fig. 2. Taking into consideration the containment system installed at the landfill (consisting of a bentonite cutoff wall), it was assumed that: H_4=0, H_3=0, K_g=0, O_g=0 and $R_1+R_2+R_3=\Delta R$ (Fig. 2). Thus, the water balance equation could be described as follows [5]:

$$P+H_2=Er+\Delta R \qquad (1)$$

...where:
P – precipitation
H_2 – surface flow
Er – evaporation from slopes and landfill crest
ΔR – efective capability of retention.

The estimated annual water input is ca. H_2+P = 90,000 m^3 (leachate, precipitation, and technological water from the composting plant). The calculated average retention capability balance of the landfill is ca. ΔR = 110,000 m^3, and the water output contributed to evaporation, assuming intensive irrigation is ca. Er = 95,000 m^3. It was noticed that the resulting difference between ΔR and Er (15,000 m^3) corresponds directly to the retention capability reserve for wet years.

The calculations for irrigation rates [8] for wastewater have been conducted:

$$D=\frac{Z_N}{Cu_N Rn_N 10} \qquad (2)$$

...where:
D – irrigation dose
Cu_N – coefficient of available nitrogent concentration in wastewater
Z_N – maximum nitrogen demand for plants
Rn_N – coefficient of fertilizer equivalent.

The calculated values of Rn_N coefficient are presented as follows:

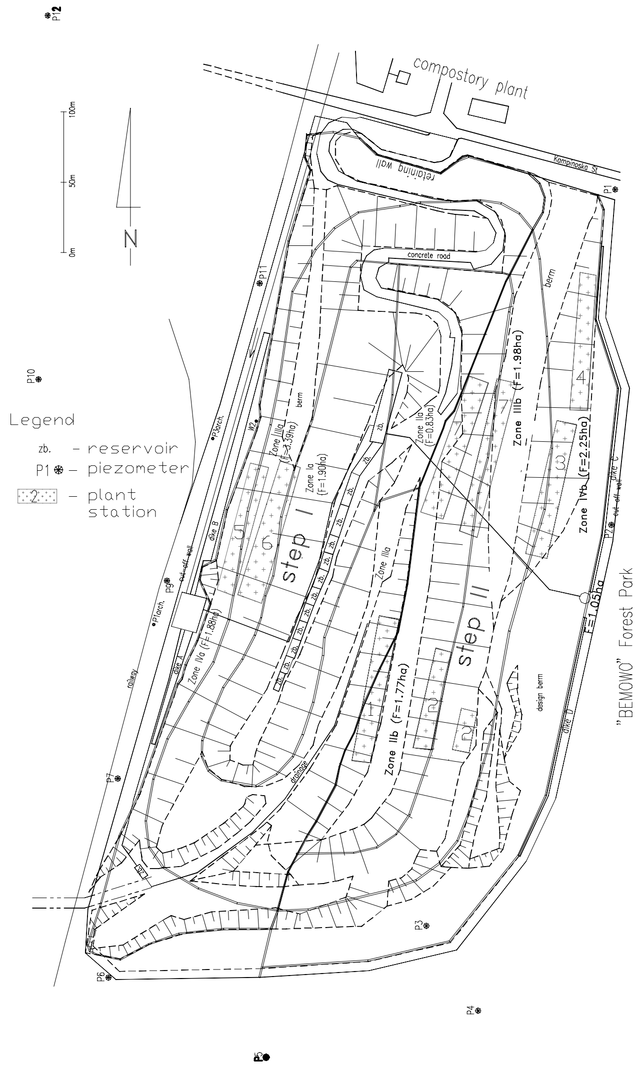

Fig. 1. A view of Radiowo landfill with zones of different retention capacities, and location of vegetation plots.

- for mechanically treated wastewater during the vegetation period, Rn_N = 0.7-0.85, and beyond the vegetation period, Rn_N = 0.6-0.7
- for biologically treated wastewater during the vegetation period, Rn_N = 0.55-0.7, and beyond the vegetation period, Rn_N = 0.45-0.60

The nutrition requirements of trophic plants, in terms of nitrogen, vary significantly, e.g. for perennial grasses the range is from 150 to 300 $kgN{\cdot}ha^{-1}$, whereas for papilionaceous plants it is from 250 to 350 $kgN{\cdot}ha^{-1}$. The parameter, which determines the available nitrogen concentration in wastewater is Cu_N coefficient. For the purpose of the present study the value of 30 $mg{\cdot}dm^{-3}$ nitrogen volume (available in wastewater for irrigation) was assumed for further calculations. This is the overall nitrogen (N_{og}) volume for treated wastewater transmitted to soil and water. According to the Polish Standard the overall nitrogen volume equals:

$$N_{og} = NNH_4 + NNO_2 + NNO_3 + N_{org} \tag{3}$$

...where: N_{og} – overall nitrogen and N_{org} – organic nitrogen.

The irrigation dose has been calculated assuming the maximum nitrogen demand for perennial grasses (Z_N=300 $kgN{\cdot}ha^{-1}$), and fertilizer equivalent (wastewater rich in nitrogen) for the full vegetation period (Rn_N=0.8, Cu_N=30 $gN{\cdot}m^{-3}$):

$$D = \frac{300\ kg \cdot ha^{-1}}{0.03\,kg \cdot m^{-3}\,10} = \frac{300\,m^3}{0.24 ha} = 1{,}250\,m^3 \cdot ha^{-1} \tag{4}$$

$$D' = 1{,}250\ m{\cdot}ha^{-1} \quad 14\ ha = 10{,}000\ m^3 \tag{5}$$

...where: D' – irrigation dose multiplied by the area of the investigated site.

When calculating the average water balance for the Radiowo landfill, a total water volume resulting from precipitation and technological wastewater discharge have been determined. The wastewater, initially treated, meets all the requirements for plant irrigation water specified in the Polish Standard, and may be used for plant irrigation systems. According to obtained results, it could be stated that the application of irrigated suspension of the volume of 20,000 m^3, with above-mentioned assumptions to maintain nitrogen levels lower than 30 $mg{\cdot}dm^{-3}$, will make plants receiving double fertilizer doses. Due to the non-uniform structure of the landfill filling and occurrence of landfill gases, the stronger local eutrophication and disturbances of physiological processes could be expected [8-10]. Moreover, some of the plant species may not resist the eutrophication stress and may be dismissed from the habitat. The significant changes to the current condition of biotic community and inhibition of the reclamation process could be observed. In order to accelerate the process of the vegetation cover establishment it was necessary to provide a double dilution of wastewater and implement supplementary plants that could easily adopt to the new landfill conditions.

The Methodology of Research

It was initially assumed that the landfill surface is covered with municipal compost waste of a thickness of several dozen centimetres, obtained in a process of Dano accelerated composting. The second layer from the top is a clay deposit (of 2 m thickness), and a deeper material is a non-composted waste of a relatively small organic content (ballast waste from the composting plant, such as shredded plastics, glass, rubber, etc.). Additionally, it has been assumed that in order to close the circuit of matter flow, the vegetation cover will be irrigated with wastewaters (leachate) from the landfill.

The laboratory tests included such trials as seed sprouting and seedling implantation. The tests were performed on

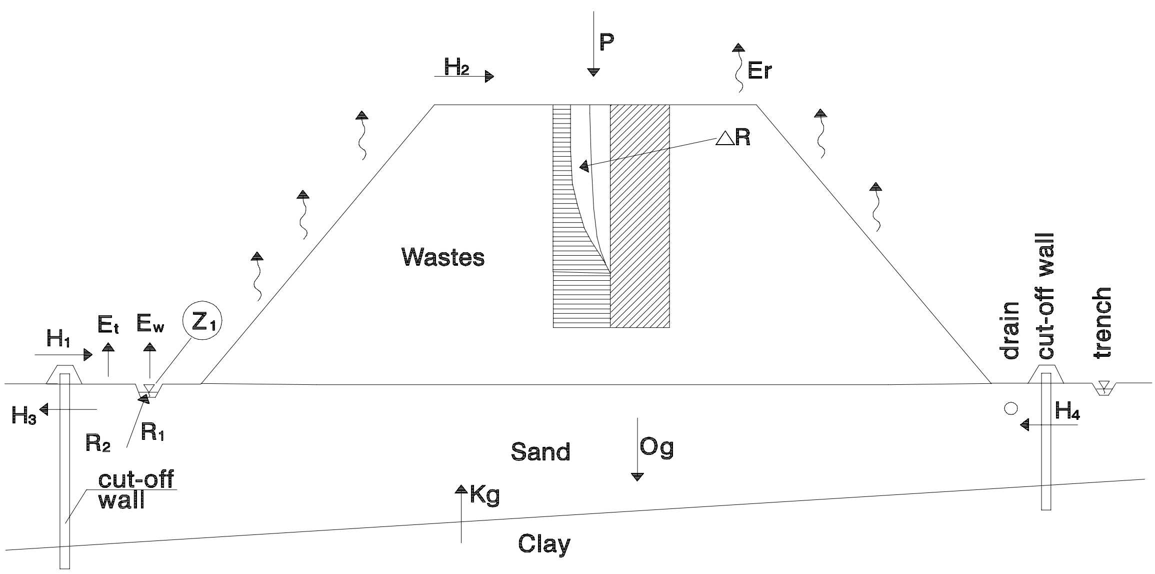

Fig. 2. Scheme of Radiowo landfill water balance components [8]. (P – precipitation, H_2 – surface flow, Er – evaporation from slopes and landfill crest, ΔR – efective cappability of retention, Kg – capillary rise, H_4 – ground flow, Og – ground leachate, E – evapotranspiration).

Table 1. Application capability of various plant species recommended for reclamation of ditches and reservoirs collecting wastewater.

No.	Plant name	Properties		Propagule type	Propagule acquisition	Capability		Economic factor
		Reclamation	Aesthetic			Cultivation	Implantation	
1	*Nuphar luteum*	++	+++	plant	hard	++	++	average
2	*Iris pseudoacorus*	++	+++	rhizomes	v. hard	++	++	high
3	*Butomus umbellatus*	+	+++	rhizomes	hard	++	+	low
4	*Glyceria fluitans*	+++	+	rhizomes	easy	+++	+++	high
5	grass mixture*	+++	+	seeds	v. easy	+++	+++	high
6	*Typha angustifolia* and *Typha latifolia*	+++	+++	rhizomes	hard	+	++	high
7	*Berula erecta*	++	++	plant	v. easy	+++	+	high
8	*Juncus effusus*	++	++	plant	hard	++	++	average
9	*Cicuta virosa*	+	+++	plant	easy	++	+++	average
10	*Rumex aquatilis*	++	++	plant	easy	+	+++	average
11	*Acorus calamus*	+++	+++	rhizomes	easy	+++	+++	v. high
12	*Phragmites australis*	+++	+	rhizomes	easy	+++	+++	v. high
13	*Salix viminalis*	+++	++	cuttings	v. easy	+++	+++	v. high
14	*Alisma plantago-aquatica*	+	+++	plant	v. hard	+	+	low

+ – a grade between 1 and 3 (according to Polish Standard); propagule type – which parts of the plant are used for propagation;
* – a mixture of grasses recommended for environmental engineering purposes.

select plant species of the following parameters: environmental protection capability, long vegetation period, resistance to diverse conditions, adaptability, costs and availability of seeds, and an aesthetic factor (these are i.e. *Deschampsia caespitosa*, *Trifolium repens*, *Kochia scoparia*, *Leontopodium alpinum*). To cover the ballast waste stored at the landfill, two types of compost material were applied (a fresh one – 6 weeks of deposition, and a seasoned one – 12 weeks of deposition). The one part of trials plots was irrigated with water, which did not contain any cantaminants coming from the landfill environs, whereas the remaining part of plots was irrigated with leachate (reflux diluted in water, of a 1:4 ratio).

During the experiment, the vegetation establishment trials were performed in three stages: sprouting 10 seeds on Petri plots (Stage I – mid April, Stage II – end of May), implantation of 14-18-day-old seedlings to vegetation containers (Stage II at the turn of April/May), 4-time repetition of each experiment. During the experiment 1,440 seeds and seedlings were used and 10,080 observations of results were recorded.

Plants Recommended for the Initial Stage of Landfill Reclamation

The location of different landfill irrigation regime zones is presented in Fig. 1. On the basis of irrigation plans, current research, vegetation establishment trials, and observation of plants rapidly growing on Radiowo landfill, the same plant species, of biological properties suitable for each biotype, have been selected with the assumption of a recreational and landscape forming purpose of the landfill [9].

For wet zones and marsh habitats (W) the following plant species are recommended: *Typha angustifolia* and *T. latifolia*, *Lemna minor*, *Phragmites australis*, *Salix viminalis*, *Wolfia arrhiza*.

For the landfill slopes, crest and toe (S), for nested, hedges and serial planting the following trees and shrubs were proposed: *Robinia pseudoacacia*, *Sambucus nigra*, *Betula verrucosa*, *Padus avium* = *Prunus padus*, *Cornus* sp., *Caragana arborescens*, *C. frutex* etc., *Lycium* sp, *Alnus glutinosa* and *incana*, *Populus deltoides* and its hybrids, *P. canadensis* and other poplars (*P. alba*, *P. tremula*, *P. nigra*), *Salix viminalis*, *Salix cordata* and other willow species (hybrids of *Salix alba*, *S. aurita*, *S. cinerea*, *S. caprea*, *S. purpurea*, *S. pentandra*, *S. fragilis*), *Parthenocissus quinquefolia,* and shielding plants *Trifolium* sp., *Lupinus* sp., *Vicia* sp., and *Lolium perenne*. For the landfill surrounding area (O) *Hedera helix*, *Cornus* sp., *Sorbus aucuparia*, *Viburnum* sp., *Tilia* sp., and *Picea excelsa* were recommended. All the plant species recommended to be applied on the Radiowo landfill surface are listed in Table 1.

Table 1 presents ecological and biological properties of selected hydromacrophytes recommended for the reclamation purpose applied on border zones in reservoirs containing highly contaminated eutrophic waters. Additionally, to establish the vegetation cover on bare zones, between trees and shrubs, the following plants were recommended:

Table 2. Results of sprouting trials on compost-made material (Dano technology composting plant) and on reference ground.

Species	Stage 1					Stage 3				
	Reference trial	Fresh compost		Seasoned compost		Reference trial	Fresh compost		Seasoned compost	
		irrigated w/ water	irrigated w/ leachate	Irrigated w/ water	irrigated w/ leachate		irrigated w/ water	irrigated w/ leachate	irrigated w/ water	irrigated w/ leachate
Edelweiss *Leontopodium alpinum*	1st day 92.5%	1st day 70%	1st day 50%	1st day 25%	1st day 35%	7th day 80%	none	none	7th day 40%	none
Tufted hair-grass *Deschampsia caespitosa*	4th day 55%	14th day 40%	14th day 45%	3rd day 80%	3rd day 70%	1st day 30%	1st day 40%	none	none	none
White clover *Trifolium repens*	1st day 85%	14th day 40%	14th day 50%	3rd day 45%	3rd day 55%	1st day 70%	7th day 20%	7th day 80%	7th day 20%	7th day 80%
Kochia *Kochia scoparia*	1st day 85%	5th day 55%	5th day 40%	2nd day 15%	2nd day 30%	2nd day 40%	none	none	2nd day 60%	2nd day 40%

Trifolium repens, *Deschampsia caespitosa*, *Kochia scoparia*, and *Leontopodium alpinum*. The species presented above have been subjected to implement testing sprouting on compost material, irrigated with the landfill leachate.

Results of Performed Biological Tests

The final results for most efficient sprouting for all species, depending on the underlying material (fresh or seasoned compost), period of sprouting, and the percentage rate of sprouted seeds are presented in Table 2.

The most efficient sprouting was achieved for *Leontopodium alpinum*, which was planted on fresh compost in Stage I, and the sprouting began as early as on the 1st day of the experiment and reached 70% of all planted seeds for plots irrigated with water, and 50% on plots irrigated with leachate, (the sprouting rate in the reference trial was 92.5%). On the same ground and in the same stage other species also achieved similar values, within 50% tolerance. The differences usually concerned the day on which sprouting started: *Deschampsia caespitosa* and *Trifolium repens* sprouted on the 14th day, and *Kochia scoparia* on 4th-5th days, the same percentage results of sprouted seeds was achieved for *Trifolium repens* and *Kochia scoparia* (85% sprouting of all planted seeds in the reference trial), and *Deschampsia caespitosa* (55%). In all trials of tested species, the results obtained during repeated tests (water and lechate irrigated plots), were comparable.

In the case of the seasoned compost in the Stage I *Deschampsia caespitose* was the most efficient sprouting species. The sprouting started on the second/third day and reached 80% of all planted seeds, concerning water irrigated plots, and 70% for leachate-irrigated zones. *Trifolium repens* also sprouted on the second/third day, but the result was twice as bad, e.g. only 45% of all planted seeds have sprouted (water irrigation), and 55% was achieved for leachate-irrigated plots. *Leontopodium alpinum* and *Kochia scoparia* sprouted on the first to second day with results of approximately 20%.

To sum up Stage I, it was established that all tested species yielded positive results for two types of compost soils and, furthermore, no significant discrepancies between water- and leachate-irrigated trials plots were noticed. Finally, the recorded sprouting rates, after 18 days of observation for Stage I, were as follows:

1) fresh compost ground:
- leachate irrigation:
  - *Leontopodium alpinum* (50%) vs. (92.5%) for reference trial
  - *Trifolium repens* (50%) vs. (85%) for reference trial
  - *Deschampsia caespitosa* (45%) vs. (55%) for reference trial
  - *Kochia scoparia* (40%) vs. (85%) for reference trial
- water irrigation:
  - *Leontopodium alpinum* (70%) vs. (92.5%) for reference trial
  - *Kochia scoparia* (55%) vs. (85%) for reference trial
  - *Deschampsia caespitosa* (40%) vs. (55%) for reference trial
  - *Trifolium repens* (40%) vs. (85%) for reference trial;

2) seasoned compost ground:
- leachate irrigation:
  - *Deschampsia caespitosa* (70%) vs. (55%) for reference trial
  - *Trifolium repens* (55%) vs. (85%) for reference trial
  - *Leontopodium alpinum* (35%) vs. (92.5%) for reference trial
  - *Kochia scoparia* (30%) vs. (85%) for reference trial
- water irrigation:
  - *Deschampsia caespitosa* (80%) vs. (55%) for reference trial
  - *Trifolium repens* (45%) vs. (85%) for reference trial
  - *Leontopodium alpinum* (25%) vs. (92.5%) for reference trial
  - *Kochia scoparia* (15%) vs. (85%) for reference trial

For the fresh compost ground, irrigated with leachate, comparable sprouting results were obtained: 40-50% for all species. For the fresh compost irrigated with water, 40% sprouting of all planted seeds was recorded for

Deschampsia caespitosa and *Trifolium repens*, whereas slightly higher sprouting of 55% was noticed for *Kochia scoparia*. The highest sprouting rate of 70% was recorded for *Leontopodium alpinum* seeds.

The highest sprouting rate on seasoned compost irrigated with leachate was obtained for *Deschampsia caespitosa* (70%) and *Trifolium repens* (55%). A sprouting slightly above 30% was recorded for only two species (please refer to Table 2). The highest sprouting rate for seasoned compost irrigated with water was obtained for *Deschampsia caespitosa* (80%), and for *Trifolium repens* (45%). Sprouting rate of ca. 20% were recorded only for two species (Table 2).

Stage 2 of the research brought no positive results. The planted seedlings atrophied during the first days of observations. The plant establishment in a compost material could not yield any results as none of the species has rooted in any of tested ground plots. One of the causes for failure was seedling molding and fungal appearance, which proved that the composting process has not yet stopped. It would be recommended to repeat these trials to determine the exact duration of compost maturing, and so if the ground is appropriate for establishment, and whether the implementation in a compost environment is actually possible at all, and if so, what plants are suitable for such purposes.

During Stage 3 of the experiment the best results, concerning fresh compost ground, were obtained for *Trifolium repens*. It began sprouting on the 7th day of a trial, and reached 20% sprouting rate after water irrigation treatment and 80% the leachate irrigation. Bearing in mind the fact that 70% of seeds sprouted in the reference trial, the result was recognized as a comprehensive one, as the sprouting occurred on the 1st day of seeding. *Trifolium repens* was the only species that sprouted on fresh compost plots irrigated only with leachate. However, *Trifolium repens* and *Deschampsia caespitosa* sprouted on plots irrigated with pure water. *Deschampsia caespitosa* growth started on the 1st day of the trial and reached 40% of total seeds planted. The result was found to be a very good one, as only 30% of seeds have sprouted in the reference trial.

During Stage 3 seeds of *Deschampsia caespitosa* did not sprout on the ground made of seasoned compost. The most reasonable results were obtained for *Trifolium repens* and *Kochia scoparia*. Thus, *Trifolium repens* sprouted on the 7th day, reaching 20% for water-irrigated plots, and 80% for plots irrigated with leachate. *Kochia scoparia* sprouted during the 2nd day of observation and reached 60% (water irrigated plots) and 40% for the leachate irrigation. Another sprouting species for pure water irrigation was *Leontopodium alpinum* – which has sprouted during the 7th day and reached 40% of all seeds planted on the plot.

After 14 days of observations, for Stage 3, the following sprouting rates were recorded:

1) fresh compost ground:
- leachate irrigation:
• *Trifolium repens* (80%) – vs. 70% for reference trial
• *Leontopodium alpinum*, *Deschampsia caespitosa*, and *Kochia scoparia* – no sprouting observed
- water-irrigated:
• *Deschampsia caespitosa* (40 %) - vs. 30% for reference trial
• *Trifolium repens* (20%) – vs. 70% for reference trial
• *Leontopodium alpinum* and *Kochia scoparia* – no sprouting observed

2) seasoned compost ground:
- leachate irrigation:
• *Trifolium repens* (80%) – vs. 70% for reference trial
• *Kochia scoparia* (40%) – vs. 40% for reference trial
• *Leontopodium alpinum* and *Deschampsia caespitosa* – no sprouting observed
- water irrigation:
• *Kochia scoparia* (60%) – vs. 40% for reference trial
• *Leontopodium alpinum* (40%) – vs. 80% for reference trial
• *Trifolium repens* (20%) – vs. 70% for reference trial
• *Deschampsia caespitosa* – no sprouting observed

For the ground made of fresh compost irrigated with leachate the only sprouting species was *Trifolium repens* (80%), and on fresh compost material irrigated with water 40% sprouting was recorded for *Deschampsia caespitosa* and 20% for *Trifolium repens*.

For the seasoned compost irrigated with leachate, 80% sprouting for *Trifolium repens* and 40% sprouting for *Kochia scoparia* were recorded. Other species did not sprout at all. On the seasoned compost irrigated with water, three species finally sprouted, whereas the highest sprouting rate of 60% was recorded for *Kochia scoparia* and 40% for *Trifolium repens*.

Leontopodium alpinum and *Kochia scoparia* did not sprout on fresh compost irrigated with either leachate or water. *Deschampsia caespitosa* did not sprout on trial plots where water irrigation was provided.

The complete lack of sprouting noticed in several cases of Stage 3 may be attributed to intensified compost "respiration" during warm May days, e.g. when excessive volumes of landfill gases were released and caused seed atrophy.

In summary for Stages 1 and 3, it may be concluded that plants subjected for testing are suitable for landfill land reclamation, but the appropriate conditions for each species must be provided.

Discussion

The landfill development plan takes into consideration recommended plant species vs. physiochemical characteristics of polluted water intended for landfill body irrigation [11].

The landfill reclamation process, including vegetation establishment, should be started in zones, where naturally existing turf is observed, and where trees or shrubs already occur [12]. The landfill body irrigated with wastewater from the composting plant and with leachate collected will cause over-fertilization of soils and plants, silting-up the soil and depositing the pathogenic and lethal components. The number of nutrients contained in landfill leachate will

increase eutrophization of the environment [13]. To obey such negative effects it is necessary to:
- ensure at least double dilution of water used for plant irrigation
- accelerate the mineralization of the organic matter by using bio-preparations
- remove the biomass residues
- create new soil layers or provide local replacement of soils
- improve the soil with currently required components and nutrition
- introduce changes or improve vegetation diversity of landfill biotic communities and landfill surroundings.

To obtain the required biodiversity it was necessary to ensure the improvement of habitats and perform engineering works to create conditions required for water, meadow, steppe, and forest biotopes. It is very important to obtain both horizontal and vertical diversification of habitats. Bioengineering ditch banks and reservoirs, and surfaces of landfill slopes could be a solution [14-17]. Moreover, the open water reservoirs shall have sufficient area for installation of aerators.

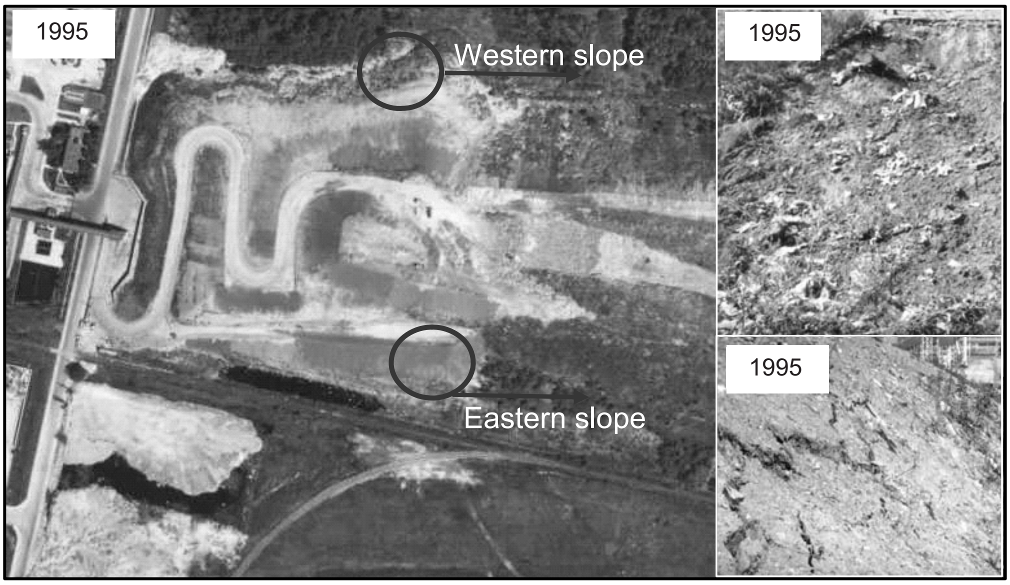

Fig. 3. Radiowo landfill surfaces and slopes in 1995 – before starting remediation works and vegetation establishment.

Fig. 4. Radiowo landfill slopes in 2012 – after accomplishment or remedial works and vegetation establishment.

The significant part of the landfill reclamation plan was the water purification process, which could be accomplished by using water plants and rush plants settled in reservoirs within the landfill area. The most suitable species are hydromacrophytes, which for this particular case study were *Typha angustifolia* and *T. latifolia*, *Lemna minor*, *Phragmites australis*, *Salix viminalis*, and *Wolfia arhhiza*.

For various habitats of the landfill area like slopes, crest and toe 11 types and a dozen of species of trees, shrubs, a climbing plant and 4 species of green plants were proposed. For the landfill surroundings 3 species of trees, 2 species of shrubs and 1 climbing plant were recommended.

Concluding experimental works in terms of engineering applications, all tested species have been classified as suitable for the reclamation purpose. As proof a comparison of landfill surfaces before reclamation works and after its accomplishment is presented in Figs. 3 and 4.

Conclusions

The establishment of the vegetation cover on the landfill surface is aimed at preventing dusting off slopes, limiting a transport of bio-aerosols, binding and stabilizing landfill's capping layer and to increase evapotranspiration. On the other hand, the utilization of the organic matter content in compost and in leachate, and created biomass will allow closure of the matter circulation of the landfill and composting plant.

The tested plant species are suitable for Radiowo landfill reclamation plan. Assuming that the compost seasoned for at least twelve weeks will be used as a growth base, and that plant seeds will be sown directly into engineered slopes. It is recommended to use water or highly diluted wastewater irrigation. The irrigation suspense with 1:4 diluted leachate can only be sustained to a limited extent by *Trifolium repens* and *Kochia scoparia* with losses of 20% and 60%.

In Stages 1 and 3 of the experiment, comparable results were obtained. The most promising sprouting rates were recorded for *Trifolium repens*, which exceeded 50% on average both in Stage 1 as well as Stage 3 of the experiment. It was also noticed that *Leontopodium alpinum*, which also exceeded 50% and started sprouting as early as during the 1st day of observations.

Very promising results were obtained for *Trifolium repens*. High sprouting rates on leachate-irrigated trial plots indicated that leachate contained appropriate concentration components required for growth of this species. Even for fresh compost ground irrigated with leachate, 80% sprouting rates were obtained. On the other hand, for the other tested species the leachate irrigation suspense needed to be diluted even more intensively.

The atrophy of seedlings in Stage 2 of the experiment may indicate that probably other species not included in the research, however similar to tested ones, cannot be implemented directly on a fresh compost material utilized in the experiment.

Both on the fresh compost as well as on the seasoned one the best results were obtained for *Trifolium repens* seeds. Because of losses that reached 30-40% (vs. reference trial) the best solution would be to use it as a mixtures of *Deschampsia caespitose*, on fresh compost and on seasoned compost, with positively responding species such as *Kochia scoparia* or *Leontopodium alpinum*.

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