

# Investigation of the Jerubaičiai landfill leachate

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According to the data provided by the Plungė Municipality, all old waste accumulation sites have been closed and are undergoing re-cultivation. The only operating landfill is the new landfill of Jerubaičiai. The new landfill of Plungė town was opened in Jerubaičiai village in 2001. Currently, the first 2 sections are being filled. The site is used for the disposal of household waste only, whereas other types of waste are sorted out in a specially designated site near the industrial zone. Operation of the landfill results in the formation of landfill leachate, which is directed to treatment plants.

An experiment was carried out in order to determine the trends of the permeability of the leachate formed in the soil.

Concentration of heavy metals was determined in the Jerubaičiai landfill leachate, samples of soil were taken from the landfill area, and nickel concentration was investigated.

**Key words:** landfill, pollution with heavy metals, soil pollution

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## INTRODUCTION

The Jerubaičiai landfill is a relatively new landfill set up in Plungė district. Preliminary evaluation of the landfill shows that the landfill base and the leachate collection and treatment systems do not meet all of the current EU standards. However, this landfill is the only one in Telšiai County with a base that has a layer of clay and an ATPP membrane as well as leachate treatment installations. Thus, this landfill is the most suitable location in the region (Jacobs GIBB Ltd., 2003, Tričys, 2002).

The main elements of the base system of the landfill are described below, comparing them to the EU standards:

- The location of the landfill is above the subsoil water level and remote from houses and outbuildings. It is on a slightly inclined foundation that allows control of the surface waters around the location.

- The landfill base consists of 500 mm of bed soil with the ATPP membrane insulation layer. The EU Landfill Directive requires the use of a membrane isolation layer for non-hazardous waste, but it also requires the presence of a natural or artificial 1 m thick layer of clay with a permeability coefficient of  $1 \times 10^{-9}$  m/s. The minimum layer covering the ground may be 500 mm, if the permeability coefficient is  $5 \times 10^{-10}$  m/s. At the location of waste depositing in the landfill, an ATPP 2 mm thick film screen has been set up, because the permeability of the clay at the bottom is  $1 \times 10^{-7}$  m/s (COWI, 1999; Gasiūnas, 2002).

- The leachate collecting layer above the ATPP membrane is 30 mm thick, from sand and gravel, with collection tubes. The leachate collection lines stretch to the landfill slopes and the ends are closed with blanking flanges and marked with columns. If necessary, they may be unearthed, while the leachate collection lines may be rinsed and blown. The EU Landfill Directive requires that the minimum layer of sand / gravel for leachate collection should be 500 mm. Good working practice usually requires placing geotextile fabric above the sand layer, so that the waste residue does not block the sand layer (MERL, 2001).

- Leachate treatment takes place with the help of bio-instruments in three open reservoirs. The first one is covered, yet without any active treatment. The other two reservoirs contain cane layers for leachate treatment. The leachate may also form in winter, when all the other plants in the leachate reservoirs are dead. Therefore, a long period of time may be needed for at least a minor natural leachate treatment to occur. Perhaps, a ventilation system could be installed in the first reservoir to improve BOD / COD. The reservoir use cycle must be checked as it will be used as a basis for draining and treating sludge.

The evaluation of geological research data has revealed that the filtration characteristics of the prevalent clayey sand soil do not correspond with the characteristics and requirements of a natural clay screen. The filtration coefficient of silt loam that is found under the site is estimated at around  $1 \times 10^{-7}$  m/s. The subsoil water is found from altitude 120 m

to altitude 125 m. The altitudes of the base of the set up heap sites range from 121.60 m to 123.48 m. The direction of the aquifer is to the south from the heap, towards the Plungė–Medingėnai road.

Throughout the base of the site, a leachate collection system from PVC corrugated-perforated tubes is installed. Every section has gas collection wells, which are heightened as the heap grows. On the ridges of the site mounds, gravel roads for transportation and for unloading of site waste were built. Biological treatment installations were set up for leachate treatment. A building for the operators' work and a garage for the consolidation and servicing machines have been constructed. A water body for fire prevention purposes has been excavated next to the service building.

A weighing-machine to weigh the waste, a pit for the disinfection of sanitation truck wheels and a container cleaning system have been set up. A site for temporary storage of hazardous waste is available.

The Jerubaičiai landfill, with the total area of 9.827 ha, has been operating since 2001. The landfill is fitted up with 4 sections, taking a 2 ha area, which are used for the disposal of municipal waste generated in the territory of Plungė and Rietavas municipalities. The 1st section has been filled up and currently the 2nd one is being used, both these sections can store over 80,000 tons of waste.

A waste unloading zone in the landfill is a non-covered territory of a limited area the arrangement of which on a landfill pile constantly changes with the accumulation of increasingly bigger amounts of waste in it. The size of the unloading zone is selected considering a likely number of trucks arriving to unload waste at a time. With growing amounts of waste in the landfill, the unloading zone dynamically increases in height with the level of waste in the landfill.

With the help of transport regulators, waste from sanitation trucks is unloaded in the specified unloading zone by placing waste right-to-left or vice versa. A compacting machine spreads this waste in a layer of around 50 cm thick. Later, the compacting machine compresses the waste by driving over it at least 3 times thus increasing the density of the waste to the maximum extent, maintaining an even slope of the unloading zone and the surface of the horizontal part, and ensuring the minimum need of soil for intermediate covering, a good run-off of surface water and efficient use of the landfill space. If possible, prior to compacting, damp and dry waste as well as different sorts of waste are mixed up.

## BUILDING A TEST MODEL

An experiment was carried out in order to determine the trends of the permeability of the leachate formed in the soil. Chemical elements contained in the leachate migrate together with it (Čepinskis, 2001).

Soil for the experiment was taken from a specific territory, in this case from the Jerubaičiai household waste landfill, which is located in Plungė district. The aim of that was to

bring the experiment conditions closer to the natural ones. The soil was poured into special boxes. The dimensions of the boxes are 60 × 60 cm, 50 cm in height (Fig. 1).

Test boxes have special gaps every 10 cm for knives to be inserted. These knives are used to separate the respective soil layers, which, when poured over with the leachate, are used to observe its dispersion and to analyze the nickel salt migration. Thus, the vertical section of nickel salts distribution in the soil is obtained.

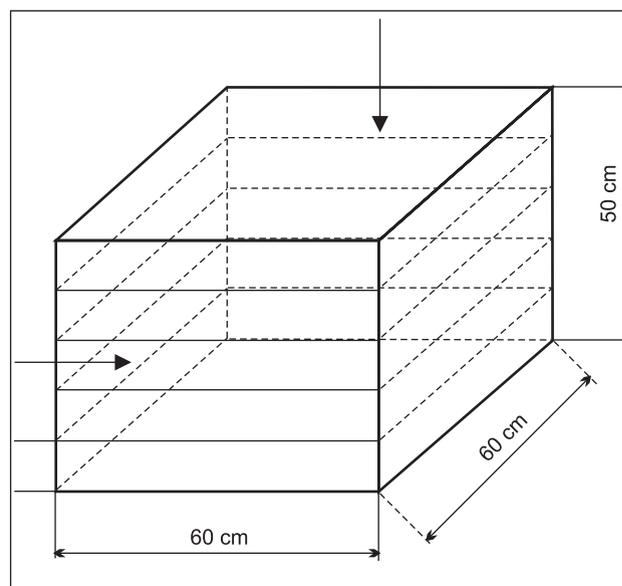


Fig. 1. Test box for the analysis of leachate permeability in the soil

Building the leachate model relied on the previous analyses of leachate contamination with heavy metals. The research was conducted at the Department of Environment Protection of Vilnius Gediminas Technical University. The objective was to obtain the leachate model of the following composition (Table).

1 l of leachate, produced under laboratory conditions based on the concentrations of contaminants specified in Table, was used in the experiment. The experimental ambient conditions were chosen to reflect those of a real location: soil moisture was relatively stable at  $35 \pm 5\%$ . Ambient conditions:  $t = 18 \pm 3 \text{ }^\circ\text{C}$ ,  $p = 770 \text{ mm}$ .

Hg column, relative air humidity:  $45 \pm 5\%$  (Girčienė, 1995; Idzelis, 2004).

Table. Concentration of some metals in the leachate

Element	Concentration, mg/l
Iron(Fe)	12.201
Manganese (Mn)	0.438
Nickel (Ni)	0.395
Zinc (Zn)	0.123
Lead (Pb)	0.097
Chromium (Cr)	0.074
Copper (Cu)	0.051

The clayey sand used in the experiment was taken from a real location, i. e. the Jerubaičiai household waste landfill, Plungė district. The aim was to maintain the natural qualities of the soil under investigation as uniform as possible. The pH of the clayey sand is around  $4.84 \pm 0.5$  (Fig. 2).

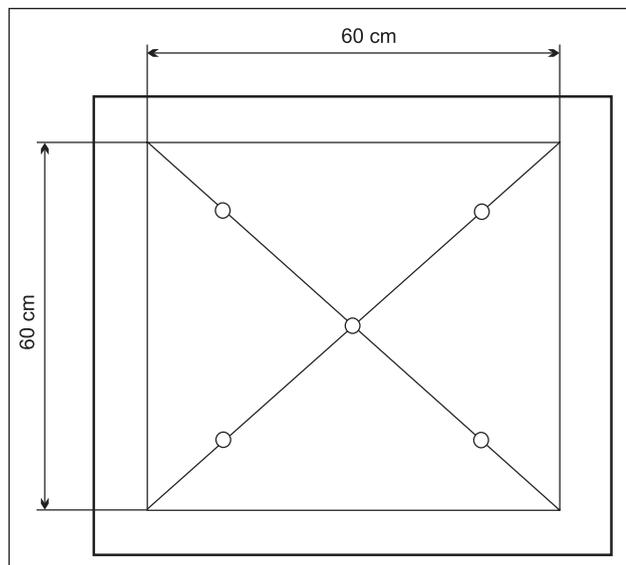


Fig. 2. Sampling points distribution in the test box layer

The leachate was poured into the test box on the points illustrated in Fig. 2. Leachate dispersion in the soil was observed 1, 2 and 3 hours after the start of the experiment (the limit is 3 hours because the preliminary analysis showed that permeability significantly declines to several millimeters per hour, or disappears altogether). The samples were taken from the vertical sections represented in Fig. 2. The experiment was repeated three times. The samples were analyzed with an atomic absorption spectrometer at the Department of Environmental Protection of Vilnius Gediminas Technical University, using the methodology of detecting heavy metals in soil. 10 grams of soil were dried at  $105\text{ }^{\circ}\text{C}$  for 2 hours. After drying, the sample was sieved through a sieve with a 1-mm mesh, and dried at  $105\text{ }^{\circ}\text{C}$  for 30 minutes. Then the weighed sample was put into a plastic package, later 0.5–1.0 ml of distilled water and 21 ml of concentrated HCl and 7 ml  $\text{HNO}_3$  acid solution were added to it. The samples were mineralized following the methods setting the required temperature and time approved by the European Union and applicable in Lithuania. Upon completion of mineralization, the sample was taken out and cooled to  $50\text{--}70\text{ }^{\circ}\text{C}$ . Next, the solution from the vessel was filtered through a glass strainer to vessels of 50 ml each. The vessel was washed with 5 ml of diluted  $\text{HNO}_3$  (1 : 1) and afterward with 5 ml of distilled water. The liquids used for washing were also filtered through the glass strainer. Upon completion of the filtering, the vessel was supplemented with distilled water up to the mark. Then the concentrations of metals were

determined using a Buck Scientific 210 VGP spectrometer with an air-acetylene flame. If the organic part in the sample content is big, 10–20 grams of the sample have to be put into a porcelain vessel and burnt at  $450\text{ }^{\circ}\text{C}$  for 12 hours. Afterward 1.0–1.5 grams of the soil undergo mineralization with “royal live water” according to the previously described methods (Sabienė et al., 2004; Idzelis, 2004). The concentration is calculated according to the following formula:

$$W(\text{Me}) = (C_{\text{Me}} \cdot f \cdot V) / W, \quad (1)$$

where:  $W(\text{Me})$  – metal concentration, mg/kg;  $C_{\text{Me}}$  – metal concentration in solution, mg/l;  $f$  – dilution factor;  $V$  – volume, l, taken for research, 0.05 l;  $W$  – sample mass, kg, recalculated for the mass of a dry sample.

### ANALYSIS OF THE RESULTS

Cu, Cr, Mn, Ni, Zn and Pb concentrations in treated and untreated leachate are calculated from calibration curves. They are presented and compared in Fig. 5. Figures 3 and 4 present the percentage of heavy metals for untreated and treated leachate (Figs. 3, 4).

As we see, in untreated leachate, the largest shares are those of Mn = 37.2% and Ni = 33.6%, while the smallest are those of Cu = 4.3% and Cr = 6.3%. The percentages of Zn and Pb are 10.5% and 8.1%, respectively (Fig. 3).

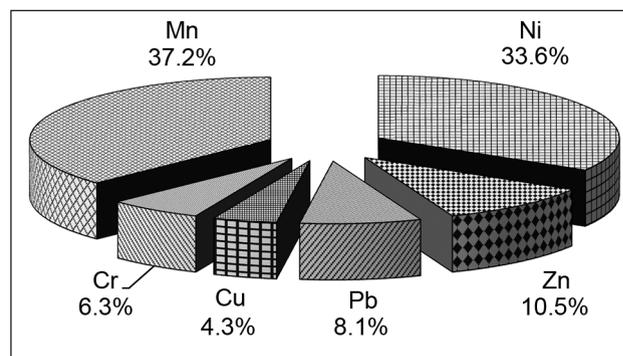


Fig. 3. Percentage of heavy metals in untreated leachate

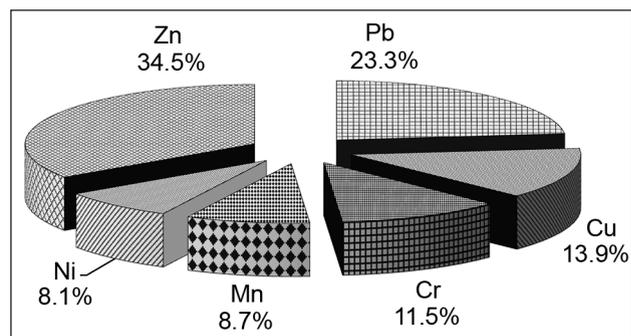


Fig. 4. Percentage of heavy metals in treated leachate

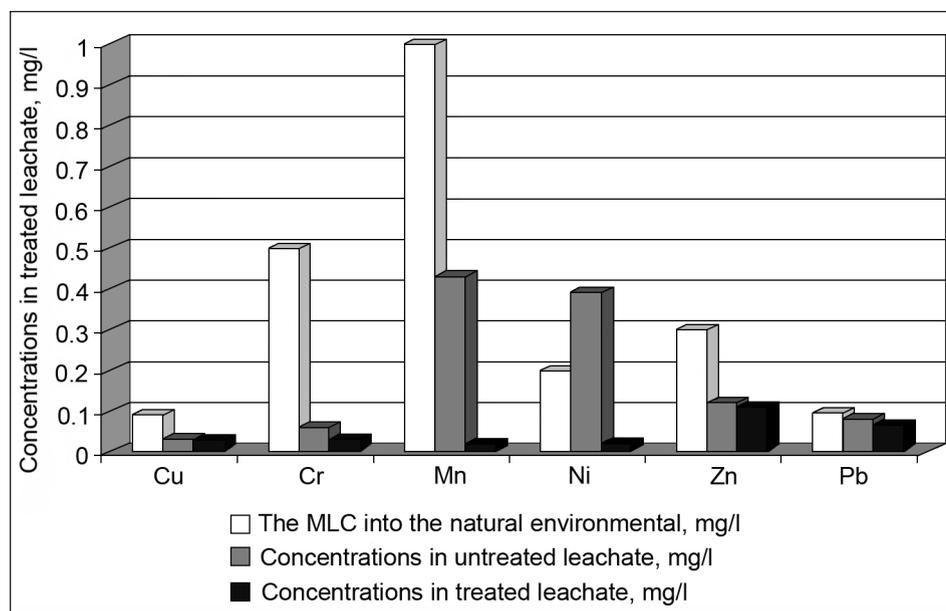


Fig. 5. Comparison of the concentrations of heavy metals in treated and untreated leachate with the MLC into the natural environment of substances hazardous to the aquatic environment

As we see in Fig. 4, in treated leachate the largest shares are those of Zn = 34.5% and Pb = 23.3%, while the smallest are those of Ni = 8.1% and Mn = 8.7%; the percentages of Cu and Cr are 13.9% and 11.5%, respectively (Fig. 4).

As we see, the leachate is mainly polluted with Mn and Ni, as their concentrations are the highest:  $C(\text{Mn}) = 0.438 \text{ mg/l}$ ;  $C(\text{Ni}) = 0.395 \text{ mg/l}$ . In addition, nickel concentration in untreated leachate is 2.19 times above the maximum permissible concentrations into the natural environment of materials hazardous to the aquatic environment ( $\text{Ni} = 0.2 \text{ mg/l}$ )

However, treatment reduces their concentrations in the leachate by up to 15 times.  $C(\text{Mn}) = 0.029 \text{ mg/l}$ ;  $C(\text{Ni}) = 0.027 \text{ mg/l}$ .

The lowest concentrations are those of  $C(\text{Cu}) = 0.051 \text{ mg/l}$  (in untreated leachate);  $C(\text{Cu}) = 0.047 \text{ mg/l}$  (in treated leachate) and chromium  $C(\text{Cr}) = 0.074 \text{ mg/l}$  (in untreated leachate);  $C(\text{Cr}) = 0.039 \text{ mg/l}$  (in treated leachate). Neither Cu nor Cr concentrations exceed the maximum permissible concentrations of materials hazardous to the aquatic environment ( $\text{Cu} = 0.1 \text{ mg/l}$ ,  $\text{Cr} = 0.5 \text{ mg/l}$ ).

The concentration of copper  $C(\text{Cu})$  was 1.1 times smaller and that of chrome  $C(\text{Cr})$  was 2 times smaller after treatment.

Zinc concentration  $C(\text{Zn}) = 0.123 \text{ mg/l}$  (in untreated leachate);  $C(\text{Zn}) = 0.116 \text{ mg/l}$  (in treated leachate). Zn concentration does not exceed the MPC of materials hazardous to the aquatic environment ( $\text{Zn} = 0.3 \text{ mg/l}$ ).

The same tendencies of pollutant spread are mentioned in other authors' works. Like in our research, W. Wilcke (W. Wilcke, 2000) pointed out that change of Zn and Pb concentrations before cleaning and after it is not noticeable if special cleaning means are not applied.

From the findings obtained, it can be concluded that the highest successful treatment percentage was recorded for manganese (around 94%), nickel (around 93%), while the smallest ones were recorded for zinc (mere 6% approximate-

ly) and copper (around 7%). The productivity of biological treatment plants ranges from 94% to 6%, thus it can be 15.6 times larger or smaller. Based on the above analyses, it may be stated that treatment installations are sufficiently effective, and the leachate released into surface waters does not exceed the permissible norms.

It was decided also to determine soil permeability to salt, because it turned out to be problematic after the determination of the leachate composition. Fig. 6 represents the findings of field research on the concentrations of the metal in question, i.e. nickel, at various depths of the soil (10, 20, 30 cm). The choice of nickel was not accidental. It was preceded by research into heavy metals in landfill leachate, which revealed that this metal is a problematic one, i. e. its concentration in untreated leachate exceeds the MPC into the natural environment of materials hazardous to the aquatic environment.

The research was carried out at the Jerubaičiai household waste landfill, Plungė district. Three samples were taken from each of the three depths (Fig. 6).

The analysis of the samples shows that the obtained nickel concentration at a 10 cm depth in the soil is 19.5 mg/kg. It is 1.2 times above the natural background characteristic of the location  $\text{Ni} = 16 \text{ mg/kg}$ , however it does not exceed the MPC approved by the Lithuanian hygiene norms ( $\text{Ni} = 75 \text{ mg/kg}$ ).

The analysis of soil samples from a 20 cm depth showed that the nickel concentration was 18.9 mg/kg. As in a 10 cm depth, it is also 1.2 times above the natural background characteristic of the location  $\text{Ni} = 16 \text{ mg/kg}$ , however it does not exceed the MPC approved by the Lithuanian hygiene norms ( $\text{Ni} = 75 \text{ mg/kg}$ ).

The analysis of soil samples from a 30 cm depth showed that the nickel concentration was 18.3 mg/kg. The background concentration is exceeded by around 1.1 times ( $\text{Ni} = 16 \text{ mg/kg}$ ), however it does not exceed the MPC approved by the Lithuanian hygiene norms ( $\text{Ni} = 75 \text{ mg/kg}$ ).

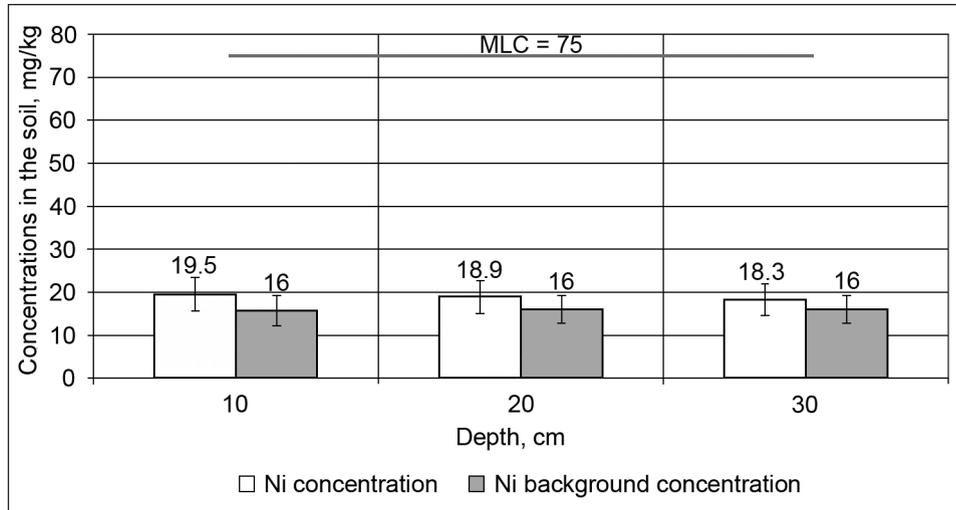


Fig. 6. Comparison of nickel concentrations at 10, 20 and 30 cm depths in the soil

As illustrated by Fig. 6, the highest nickel concentration can be found in the upper layer of the soil, i. e. at 10 cm, where it amounts to 19.5 mg/kg. With the depth changing, the nickel concentration tends to decline as the depth increases. Ni concentration is 18.9 mg/kg at a 20 cm depth and 18.3 mg/kg at a 30 cm depth. As we determined, nickel concentration obtained at a 10 cm depth is roughly 10% above the concentration obtained at a 20 cm depth and about 1.1 times above the concentration obtained at a 30 cm depth.

A conclusion may be drawn that nickel concentration in soil decreases with depth. At all the three depths, the determined nickel concentration is about 1.2 times above the background concentration characteristic of the location (Ni = 16 mg/kg), however, none of the samples is above the MPC (Ni = 75 mg/kg) set by the Lithuanian hygiene norms.

At the laboratory, a pH meter was used to determine the pH reaction of the leachate samples taken. The pH reaction was found to be 7.6 in untreated leachate and 7.4 in treated leachate. We therefore conclude that the media of both the treated and the untreated leachate are acid (pH > 7).

During the experiment, clayey sand was poured into a wooden box after being taken from a landfill to which 1 l of leachate produced in laboratory conditions was poured after determining heavy metal concentrations. Leachate dispersion in the soil was observed in terms of time. Additionally, nickel salt migration in the soil was observed.

Fig. 7 illustrates leachate penetration into the soil depending on time (Fig. 7).

As illustrated in Fig. 7, half an hour after pouring the leachate, it penetrated roughly 7 cm into the soil. An hour past pouring, the leachate had already penetrated around 14 cm. One hour after pouring, the leachate permeability acquires linear dependence on time: 7 cm after 30 minutes and 14 cm after an hour.

One more hour past the pouring, compared with the first hour, the leachate had penetrated only 1 cm. The same trend remained three hours past the pouring. Compared with the first hour, the leachate had penetrated 2 cm. Meanwhile, compared with the second hour after the pouring, it had penetrated 1 cm into the soil.

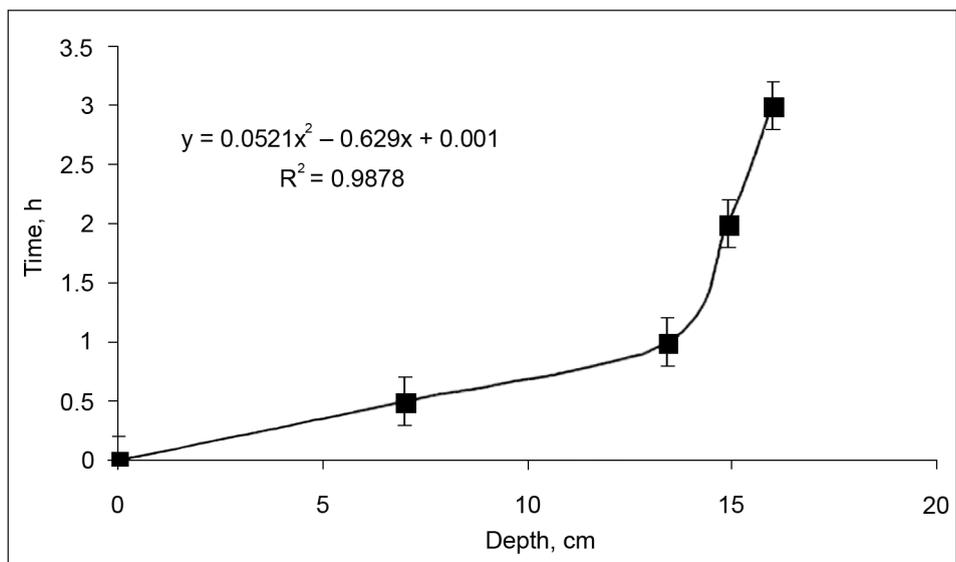


Fig. 7. Leachate permeability depth depending on the time of pouring. Samples were taken after 1, 2 and 3 hours

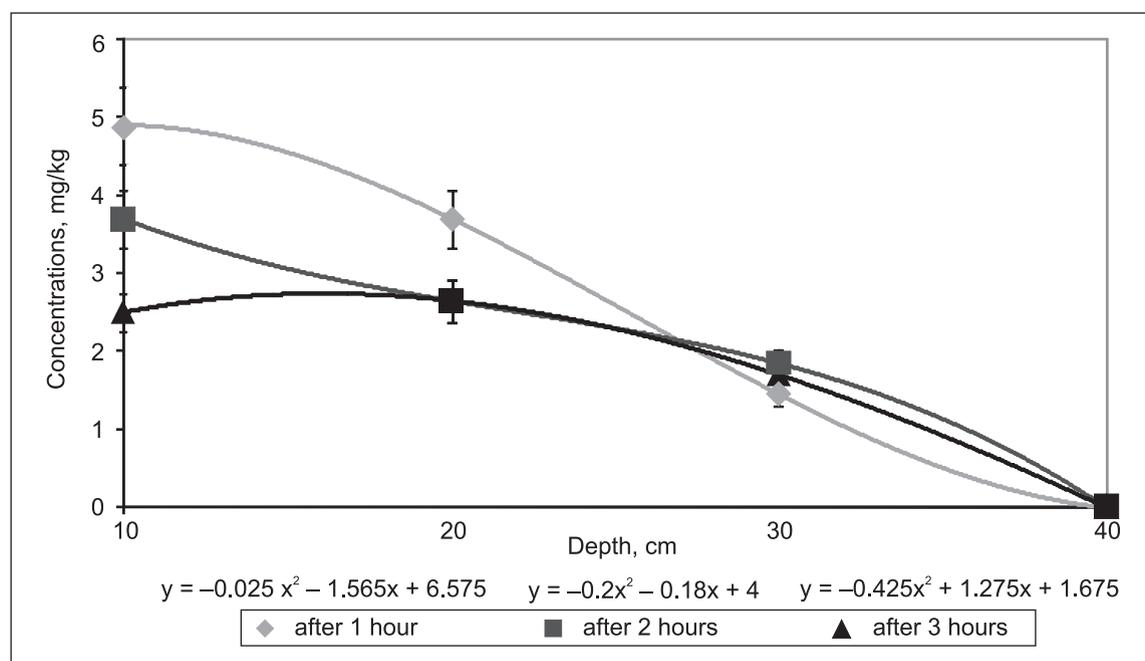


Fig. 8. Distribution of vertical nickel salt concentration in the soil 1, 2 and 3 hours past the leachate pouring

A comparison of leachate permeability during the first hour with that during the second and the third hours reveals that the leachate permeability into the soil during the first hour was 7 times stronger compared with the other two hours.

It must be concluded that leachate permeability into the soil was the highest during the first hour – about 14 cm. After 2 and 3 hours, leachate permeability was insignificant and amounted to just a few centimeters (Fig. 8).

Most authors notice that the biggest concentrations of Ni and Mn (Prabpai et al., 2007; Wilcke, 2000) are measured. It is also highlighted that these are most easily eliminated pollutants form of filtrate. In our case concentration of Ni was 19.5 mg/l before cleaning and 0.2 mg/l after it, most authors indicate that concentrations after cleaning are 25 mg/l, and it differs from 1.2 to 1.5 times. As we can see, the trends determined in our work are similar to the results of other researchers.

It appears that the highest concentration of nickel salt in the soil during the research was found 3 hours after the experiment: 4.9 mg/kg. The maximum concentration was in the upper layer of the soil and it declined consistently towards the bottom. At the 10 cm layer the concentration totaled 2.5 mg/kg after an hour. With time, the nickel concentration in the surface layer begins to accumulate and increases from 2.5 mg/kg one hour past the pouring to 4.9 mg/kg 3 hours past the pouring, i. e. it rises almost 2 times.

Two hours after the leachate was poured, nickel concentration at a 10 cm layer rose from 2.5 mg/kg to 3.7 mg/kg, i. e. became 1.5 times higher.

Two hours after the leachate was poured, the nickel salt concentration at a 30 cm depth began to decline consistently. The experimental research concentrations are measured above the background – Ni = 16 mg/kg.

## CONCLUSIONS

1. From the findings obtained, it can be concluded that the highest successful treatment percentage was recorded for manganese (around 94%), nickel (around 93%), while the smallest ones were recorded for zinc (mere 6% approximately) and copper (around 7%). The productivity of biological treatment plants ranges from 94% to 6%, thus it can be 15.6 times larger or smaller.

2. The analysis of the soil samples taken shows that nickel concentration at a 10 cm depth in the soil is 19.5 mg/kg. It is 1.2 times above the natural background characteristic of the location – Ni = 16 mg/kg, however it does not exceed the MPC approved by the Lithuanian hygiene norms (Ni = 75 mg/kg).

The analysis of soil samples from a 20 cm depth showed that nickel concentration was 18.9 mg/kg. As in the 10 cm depth, it is also 1.2 times above the natural background characteristic of the location Ni = 16 mg/kg, however it does not exceed the MPC approved by the Lithuanian hygiene norms (Ni = 75 mg/kg).

The analysis of soil samples from a 30 cm depth showed that the nickel concentration was 18.3 mg/kg. The background concentration is exceeded by around 1.1 times (Ni = 16 mg/kg), however it does not exceed the MPC approved by the Lithuanian hygiene norms (Ni = 75 mg/kg).

Monitoring of leachate permeability in the soil depending on time showed that leachate permeability into soil was at its peak during the first hour, approximately 14 cm. After 2 and 3 hours, leachate permeability was insignificant and amounted to just a few centimeters.

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## Egidijus Petraitis

## JERUBAIČIŲ SĄVARTYNO FILTRATO TYRIMAI

## Santrauka

Plungės savivaldybės duomenimis, visos senos atliekų kaupimo aikštelės yra uždarytos ir rekultivuojamos. Vienintelis veikiantis yra naujasis Jerubaičių sąvartynas. Naujasis Plungės miesto sąvartynas atidarytas 2001 m. Jerubaičių kaime. Šiuo metu pildomos pirmos 2 sekcijos. Aikštelėje šalinamos tik buitinės atliekos, kitos atliekos rūšiuojamos tam tikslui įrengtoje aikštelėje prie ūkio zonos. Sąvartyno eksploatavimo metu susidaręs sąvartyno filtratas nukreipiamas į valymo įrenginius.

Darbo tikslas – nustatyti sąvartyne susidarancio filtrato skvarbos dirvožemyje tendencijas.

Darbe nustatytos Jerubaičių buitinio sąvartyno, kuris geriausiai atitinka Telšių regioniniam sąvartynui keliamus reikalavimus, filtrate esančios sunkiųjų metalų koncentracijos, paimti dirvožemio ėminiai iš sąvartyno teritorijos, ištirtos nikelio koncentracijos.

**Raktažodžiai:** sąvartynas, tarša sunkiaisiais metalais, dirvožemio tarša