

VILNIUS GEDIMINAS TECHNICAL UNIVERSITY

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EXPERIMENTAL INVESTIGATIONS OF CLOGGING PROCESSES AND IMPLEMENTATION OF MITIGATION MEASURES IN LANDFILLS

SUMMARY OF DOCTORAL DISSERTATION

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VILNIAUS GEDIMINO TECHNIKOS UNIVERSITETAS

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Introduction

Topicality of the problem

Waste management is one of the core environmental protection problems, which occurred right after the establishment of the first settlements and which has become extremely acute nowadays. The most popular method of municipal waste management is its collection and dumping in municipal waste landfills. Precipitation, passing the waste in the landfills, forms the leachate which is collected by drainage system. Leachate collection systems are made of drainage layer, the main constituent part of which is rubble (mainly of 32–60 mm nominal particle size) and perforated pipes for leachate collection. Leachate quantities are directly dependant both on waste dampness and on precipitation quantities, but the decrease of leachate levels might depend on the decreased conductivity of drainage filling.

Due to its multi-component nature, clogging processes develop in the drainage filling layer when leachate is collected by drainage systems over an extended period of landfill operation. Clogging is the inflow of very fine particles into porous soils diminishing filtration properties. Fine particles deposit on the surface of drainage materials. The growing volume of deposits forms solid, non-porous substance. Leachate composition, depending on landfill age, installation technologies, climatic conditions and waste composition, has a direct impact on clogging processes. Clogging processes cause the decrease of drainage layer conductivity due to the cementation of porous particles.

Summing up, it may be concluded, that suspended solids, iron and calcium compounds have a major impact on clogging processes. Various technologies had been created to protect drainage layer against clogging, e.g., using of geotextile, geosynthetic drainage layer, of various collecting drain layout schemes. However it has been observed that these measures do not prevent the decrease of drainage layer conductivity, especially when municipal waste landfills are in operation for more than 10–15 years.

The increased consumption in many parts of the world lead to steady growth of municipal waste quantities, which are, most frequently, deposited in landfills. Due to the increasing waste volumes in landfills, the leachate composition becomes more diverse. Such leachate, passing the drainage layer, affects its functionality. Leachate debits in landfills become lower due to decreased conductivity of drainage layers, waste pile slides occur, water ponds stay on waste piles due to the excessive dampness – these are the main consequences of drainage layer clogging.

Leachate collection over an extended period of time exposes drainage layer to the impact of clogging processes, leading to the decreased layer

conductivity. The monitoring of municipal waste landfills had revealed that leachate collection systems are operational over a limited period of time and their functionality decreases. Fine particles (of sludge and sand) deposit on drainage filling materials, thus decreasing porosity. Such processes as drainage layer pollution, resulting in the decreased leachate conductivity, are analysed.

Object of the work – clogging processes occurring in drainage filling of municipal waste landfills.

Aim and tasks of the work. The main aim of the work is to investigate clogging processes in different fillings by using municipal waste leachate, evaluate the leachate chemical compound concentration changes, and, based on the results of researches, to offer an efficient composition of drainage filling, capable to maintain the conductivity function. The following tasks are to be fulfilled to achieve the aim of the work:

1. To perform column research of the fillings having different composition, by using municipal waste landfill leachate, and to identify the regularities of clogging process.
2. To identify parameters, identifying the clogging processes of fillings: porosity and porosity ratio, as well as to analyse their changes.
3. To analyse the concentrations of chemical compounds in municipal waste landfill leachate, having an impact on drainage layer clogging.
4. To evaluate, by applying modelling software, the column filling porosity changes over a period of time.

Methodology of research. Cylinder method is used to establish the filling porosity. Photometric chemical analysis method is used to establish iron concentrations in leachate, titrimetric chemical analysis methodology – for calcium concentration in leachate, filtering methodology – for suspended solids, while Bioclog software package was used to evaluate the filling porosity changes in columns over the period of 30 years.

Scientific novelty of the work. The integrated theoretical and experimental researches of leachate drainage filling clogging in municipal waste landfills had been made evaluating the potentials to use various materials to form the layer. The modelling results obtained could be used for the forecasting of the clogging processes in landfills. The following results, new to the environmental engineering science, were obtained in the course of the development of the dissertation:

1. Integrated researches of the fillings chosen were made in order to establish their efficiency for the mitigation of clogging processes in the leachate drainage of municipal waste landfills.
2. New leachate drainage filling for municipal waste landfills was proposed.

Practical value. The analysis of the composition of the municipal waste landfill leachate (quantity changes of suspended solids, calcium and iron) after its filtration through various fillings had enabled to propose a material suitable for the drainage layer fillings in municipal waste landfills. The results of laboratory tests may be applied when designing and installing leachate drainage layer in municipal waste landfills.

Defended propositions

1. Suspended solids, calcium and iron compounds, present in the filtrate, have a considerable impact on clogging processes.
2. The use of the tyre shreds and rubble mix for the installation landfill drainage layer slows down clogging processes.
3. Long-term clogging processes in municipal waste landfill may be forecasted by applying modelling software Bioclog.

The scope of the scientific work. The dissertation consists of introduction, three chapters and results, general conclusions and recommendation. The scope of the work is 116 pages; 12 numbered formula, 59 figures and 8 tables were used. 119 literature sources were used when writing the dissertation.

1. Literature review of clogging investigations

The conductivity of drainage layer in municipal waste landfills decreases due to clogging. Clogging or colmatage (from French *de colmatage*) is the inflow of very fine particles into porous soils, diminishing filtration possibilities. The leachate drainage filling conductivity decrease in municipal waste landfills is researched and various solutions are offered, but the problem remains, as over a longer period of municipal waste landfill operation the composition of municipal waste changes, thus affecting the composition of leachate which, in its turn, has a direct impact on clogging.

The world's attention was drawn to the problems only when the waste stayed dumped in the landfills for several decades. It was researched and various solution possibilities were analysed by I. R. Fleming, R. K. Rowe, D. R. Cullimore, J. F. Van Gulck, R. McIsaac, M. D. Armstrong, A. J. Cook. Latter scientists made wide and detailed analyses of Canadian landfills. German

scientists L. Peeling, M. Brune, J. P. Giroud, as well as A. Paksy, W. Powrie, A. Knox from the United Kingdom also deal with the problems related to municipal waste landfills, and while the first group mentioned give more attention to the analysis of the problems and their causes, the second one develops new technologies to improve drainage layer functionalities. Leachate composition and its environmental impacts were analysed in Lithuania by V. Gasiūnas, Z. Strusevičius, S. Vasarevičius and E. Petraitis, but the clogging in Lithuanian landfills has not yet been analysed, as the operation of new landfills with leachate collection systems was started in 2007, so at the moment there are no conductivity decrease problems, but they are sure to occur after 15 years or more.

The scientific research had revealed that clogging begins from the very beginning of landfill operation, the main reasons being big quantity of suspended solids, big concentrations of calcium, iron, carbonates and sulphates in the leachate.

The researches by using glass beads as filling had shown that clogging intensity depends on the properties of the leachate used. When using the leachate with high concentrations of calcium and iron, the layer conductivity had became two times less over the period of 365 days, while no clogging was observed in 860 days when using methane leachate from old landfill. The use of tyre shreds and asphalt waste for the formation of landfill drainage layers has not been substantially analysed until now.

Clogging processes are long-term ones, therefore it is important to employ mathematical models, describing clogging processes in the drainage layer of municipal waste landfills, to forecast the results of the researches made as well as for the evaluation of their reliability.

2. Methodology of clogging investigation

This section describes the experimental testing of column physical clogging as well as the porosity of the above materials by applying measuring cylinder method.

The objective of these tests is to establish the filling porosity change over a certain period of time by filtering the leachate from municipal waste landfills through experimental test columns, filled with various fillings. The experimental column test, determining the clogging level (porosity change over a year) is performed in all columns identically as follows:

- granulometric composition and porosity of the filling tested is measured and porosity ratio is calculated;

- leachate from the Kazokiškės landfill is passed through the columns at the speed of 3.65 l/month. The quantity is increased by 10 times to enable the experiment. The methodology was chosen based on the works already done (McIsaak and Rowe 2008);
- at the end of the experiment, the porosity at three different column heights is measured to make the conclusions on the potentials of the clogging process.

For the experiment, the leachate is taken from the leachate collection well of the municipal waste landfill. At the beginning of the column test the concentration of calcium, iron and suspended solids in the leachate is established. The leachate passes through different column fillings and is collected individually under each column. 120 ml sample is taken from under each column every month and the concentrations of the main leachate elements causing clogging is measured. 220 ml of the leachate from the landfill is added to the total leachate, and the leachate is passed through the column again. The leachate from the landfill is added every month, as the sample of 100 ml is to be taken, following the methodology, for the analysis of suspended solids. The leachate is recirculated every 30 days. The method allows to observe the changes in calcium, iron and suspended solids concentration. When their quantities decrease in the concentrate, it is possible to conclude, that the materials were trapped in the drainage filling, depositing on the surface of its materials. Thus the pores became smaller, porosity decreases and clogging occurs.

3. Investigation and analysis of colmatation

Different composition of materials, used for the formation of drainage layer, had been chosen for the experimental laboratory tests: two natural materials (rubble and gravel) as well as mixes of various origin materials (rubble and tyre waste shreds, rubble and asphalt waste, gravel and tyre shred mixes) (Fig. 1). The particle sizes of rubble used is 32–65 mm as the best possible conductivity is to be achieved. The gravel of the same sizes contains up to 50% of calcite rock. The mixes of various origin materials enables the recycling of the waste materials (asphalt and tyre shreds).

Experimental research of clogging was performed composing column fillings of different material layers: landfill rubble drainage and tyre shreds layers of different height. As the containers were filled with the materials of various compositions, the overall material porosity was measured and calculated before the filling of the columns (Fig. 2). The porosity was also measured after 365 days of experimental testing. After the experiment the

porosity at different column height was measured, and afterwards the total filling porosity was calculated.

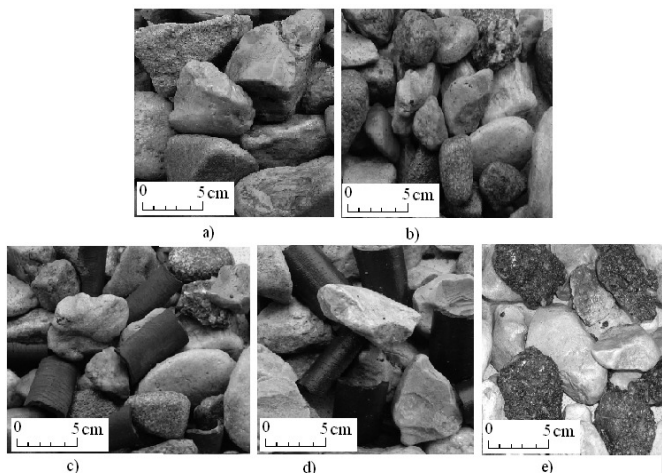


Fig. 1. Materials used in the filling of columns: a) rubble used in landfill, b) gravel mined at Lithuanian quarries; c) mixture of gravel and tired shreds mixture; d) mixture of drainage rubble and tired shreds; e) mixture of drainage rubble and asphalt

The porosity measuring of all materials chosen for column filling had led to the observation that the most suitable is the mix of landfill rubble drainage and rubber waste (relation 3:1) of 45% porosity. Tyre shred and asphalt waste used to the mixes, had increased their porosity from 7% to 8%: the higher the porosity, the smaller is the probability of the conductivity decrease.

The porosity of the tyre shred and rubble drainage mix (relation 1:3), used for laboratory experiment, had decreased from 45% to 42%, and the change by 5% is the smallest change compared with other fillings. The greatest porosity change of 9% was observed in gravel (particle sizes 32–65 mm) sample, so it should be concluded that this material is not suitable for the formation of municipal waste landfill drainage.

The greatest porosity coefficient decrease from 0.538 to 0.428 over the period of 365 days was observed in rubble drainage and asphalt waste mix. This shows that the use of this filling would lead to the most rapid development of clogging.

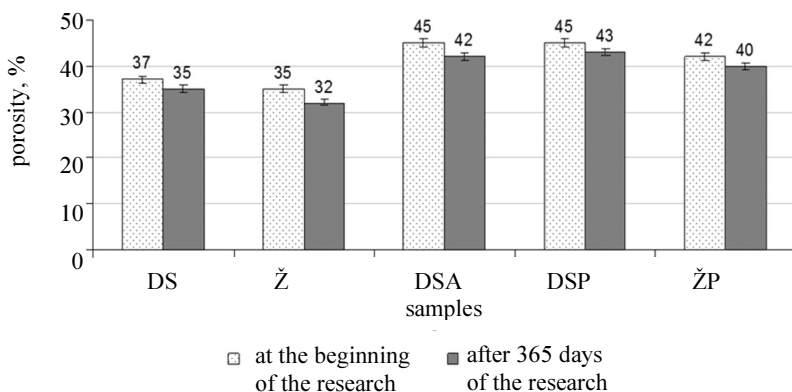


Fig. 2. The porosity of different materials before and after experiment (DS – rubble used in landfill; Ž – gravel mined at Lithuanian quarries; DSA – mixture of drainage rubble and asphalt waste; DSP – mixture of drainage rubble and tired shreds; ŽP – mixture of gravel and tired shreds mixture)

The porosity decrease was slowest in the mixes of rubble drainage with tire shreds and of gravel with tyre shreds, where the porosity rate decreased by 0.06 of its value over 2/3 of the column length.

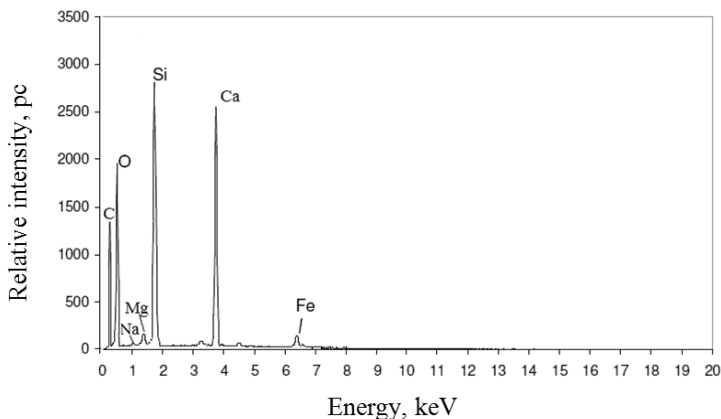


Fig. 3. The X-ray spectrum of the dispersion of the sediments on drainage rubble granular

The analysis of the qualitative composition of the accumulated material, shown in Figure 3, reveals, that silicon, calcium and iron compounds have a major impact on the clogging processes. Figure 3 shows that the dominating elements, identified in all deposit samples, are silicon and calcium; smaller quantities of sodium, magnesium, potassium and iron had also been found. Prominent oxygen and carbon peaks are observed in all sample spectra. The latter elements are present in various compounds, therefore their percentage is rather substantial. The results obtained support the conclusions also made by other scientists that the main elements causing the clogging if landfill drainage layer are made of Si, Ca and Fe compounds (silicon and iron oxides, calcium carbonates).

The evaluation of the results obtained through the experiment leads to the conclusion that the used of the tyre shred for the formation of the drainage layer of municipal waste landfills is beneficent for the increased recycling potentials. In order to identify the most optimum thickness of tyre shred layer, individual porosity change researches were made for each layer. The analysis of the upper rubble drainage layer had shown the porosity dependence front her layer thickness as high as 0.98 (correlation factor) (Fig. 4).

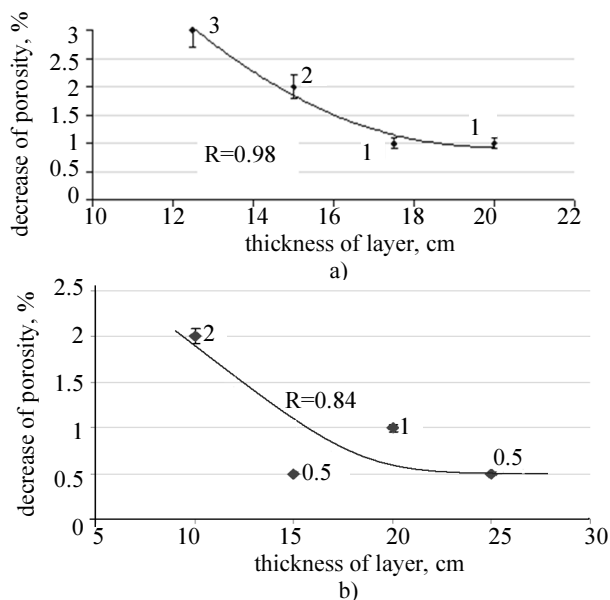


Fig. 4. Dependency of thickness of the different layers and porosity in 180 days: a) top rubble layer of column; b) middle tired shreds layer of column

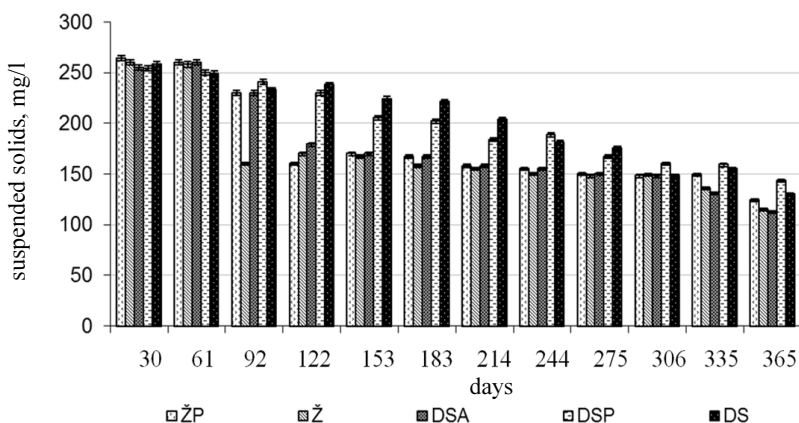


Fig. 5. Change of volume of suspended particulates in the leachate after filtering through drainage rubble (DS), gravel fillings (Ž), mixture of drainage rubble and asphalt waste (DSA); mixture of drainage rubble and tired shreds (DSP); mixture of gravel and tired shreds mixture (ŽP)

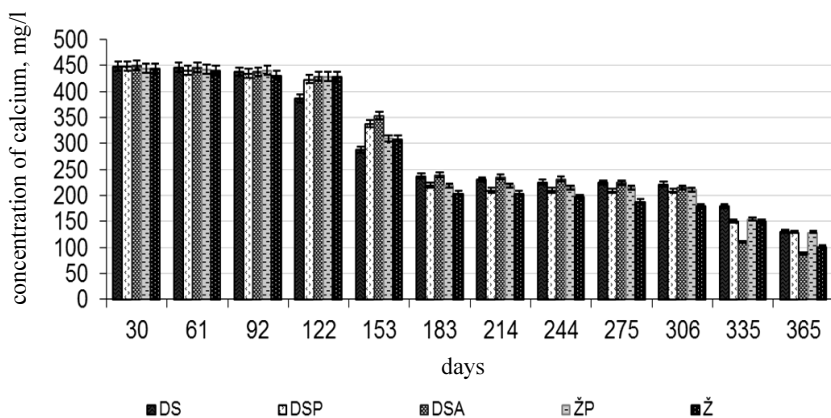


Fig. 6. Change of calcium concentration in the leachate after filtering through drainage rubble (DS), gravel fillings (Ž), mixture of drainage rubble and asphalt waste (DSA); mixture of drainage rubble and tired shreds (DSP); mixture of gravel and tired shreds mixture (ŽP)

The research results had led to conclusion that the concentration of suspended solids had decreased on average by 50% (i. e. by 130 mg/l) over the 365 days of research (Fig. 5). The greatest decrease of suspended solids was observed when filtering the leachate through rubble drainage and asphalt waste mix (up to 108 mg/l, and the smallest change was found in the rubble drainage and tyre shred filling mix. This leads to conclusion that the use of asphalt was not a good solution and, vice versa, the results of tyre shred choice were positive.

The analysis of the concentration change of all leachate elements having an impact on clogging had shown the greatest change of calcium concentration after filtering through different drainage levels, as this is one of the elements causing the greatest sedimentation (Fig. 6). The greatest calcium concentration decrease from 454 mg/l to 75 mg/l was observed after the filtration through rubble drainage and asphalt waste mix filling, i. e. by 83%. The smallest quantity change of suspended solids and calcium from 454 mg/l to 174 mg/l, i. e. by 62%, was observed when filtering through rubble drainage and tyre shred mix filling.

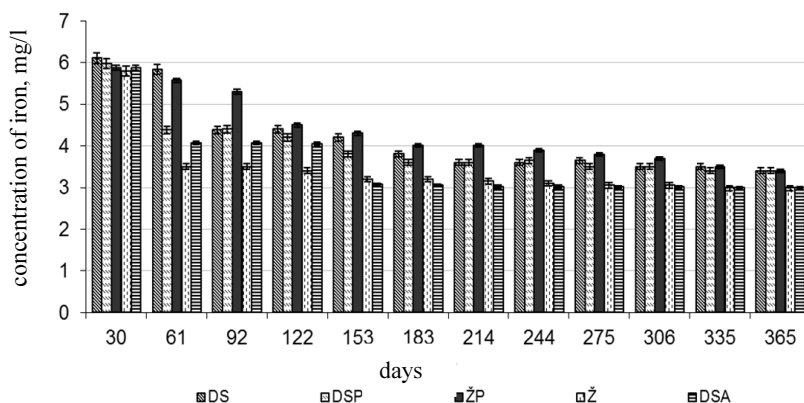


Fig. 7. Change of iron concentration in the leachate after filtering through drainage rubble (DS), gravel fillings (Ž), mixture of drainage rubble and asphalt waste (DSA); mixture of drainage rubble and tired shreds (DSP); mixture of gravel and tired shreds mixture (ŽP)

The iron concentration change was measured after experimental testing: the greatest decrease of 20% was observed in the column containing the drainage layer composed of rubble drainage and asphalt waste mix, therefore

such mix is not recommendable (Fig. 7). Iron concentration change in leachate passing rubble and tyre shred mix the period of 365 days was the smallest, of 10%, therefore the material of such composition is suitable for the formation of drainage layer in municipal waste landfills. The laboratory tests and the analysis of their results had led to conclusion that tyre shreds are a suitable material for the formation of drainage layers, mitigating the clogging processes. On the opposite, asphalt waste is not recommendable for the use as, according to the results obtained, it contributes to the development of clogging processes.

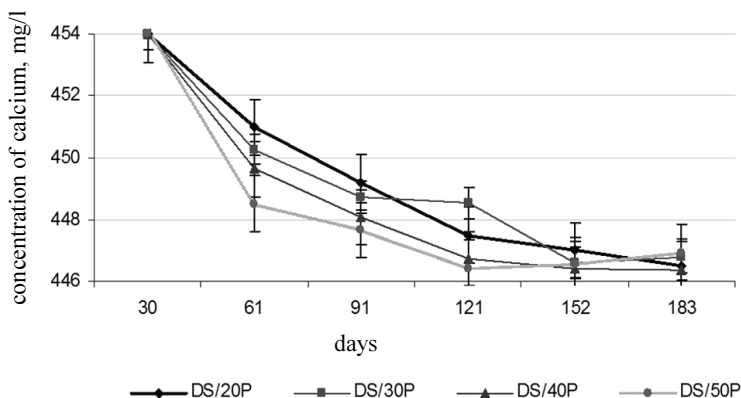


Fig. 8. Changes of concentration of Ca (calcium) in leachate during 180 days (DS/20P – 80% of drainage rubble and 20% of tired shreds; DS/30P – 70% of drainage rubble and 30% of tired shreds; DS/40P – 60% of drainage rubble and 40% of tired shreds; DS/50P – 50% of drainage rubble and 50% of tired shreds)

The layer of tyre shreds, inserted into rubble filling, mitigates the change of leachate components. The general trend was observed in all samples of leachate passing the columns filled with rubble drainage and tyre shred layer insert (Fig. 8).

The conductivity decrease of drainage systems in municipal waste landfills manifests itself not earlier than after five years of operation or even later making the modelling of conductivity decrease so important.

Calcium concentration change, quantity of suspended solids and porosity measuring results obtained during the research were used to compute the forecasted conductivity decrease of the fillings analysed by applying Bioclog software. The in situ and laboratory tests served as the basis of the

mathematical model, but the clogging processes were modelled in the saturated medium. The clogging develops much slower in non-saturated media.

The section describes the methodology applied to compute the decrease of column filling porosity with BioClog model. The software evaluates the porosity decrease depending on the quantity of materials deposit on the pore surface. The following parameters are inputted into the software to solve the porosity change problem: column height and diameter, size of filling granules, initial filling porosity, one day leachate quantity, calcium concentration in leachate, concentration of suspended solids. The detailed computation results are graphically plotted by SigmaPro 8.0 software (Fig. 9).

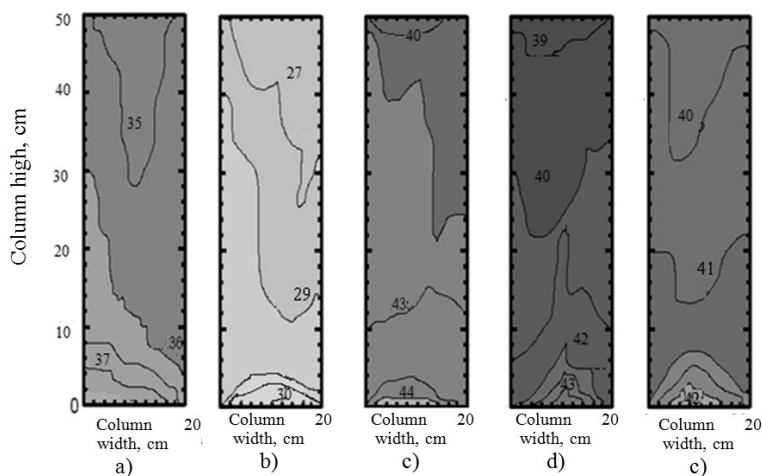


Fig. 9. Changes of porosity after one year in different fillers: a) – rubble used in landfill; b) – gravel mined at Lithuanian quarries; c) – mixture of drainage rubble and asphalt waste; d) – mixture of drainage rubble and tired shreds; e) – mixture of gravel and tired shreds mixture

The mathematically calculated filling porosity after 365 days, computed by modelling software Bioclog, was in the range from 30% to 42% depending on the material. The porosity of rubble drainage, rubble drainage and asphalt, rubble drainage and tyre shred as well as of gravel and rubble shred fillings was higher by 2% per cent as the one obtained during laboratory testing. It was only the gravel filling porosity, obtained by the modelling software, which was by 2% lower compared with the test results. The results obtained by the modelling software may not only be compared with the ones of the actual tests; they also arrive to forecast

the date after 10, 15 or 20 years. As the difference between the data of laboratory testing and modelling was only 2%, it could be maintained that computation of the clogging process development by the software is very precise (Fig. 10).

The drainage layer structure developed, intended for the decrease of clogging processes in municipal waste landfill drainage systems, allows provides for the use of recycled materials (wasted tyre shreds).

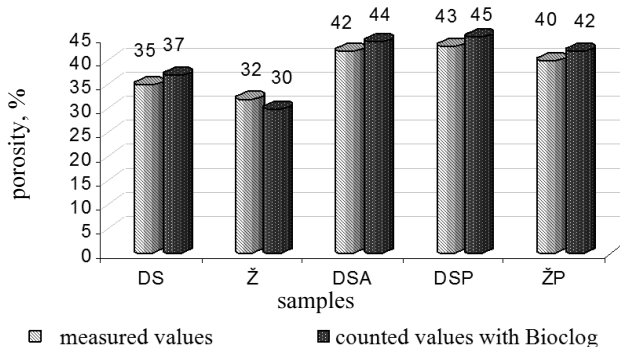


Fig. 10. Comparison of simulation and investigation results (DS – rubble used in landfill; Ž – gravel mined at Lithuanian quarries; DSA – mixture of drainage rubble and asphalt waste; DSP – mixture of drainage rubble and tired shreds; ŽP – mixture of gravel and tired shreds mixture)

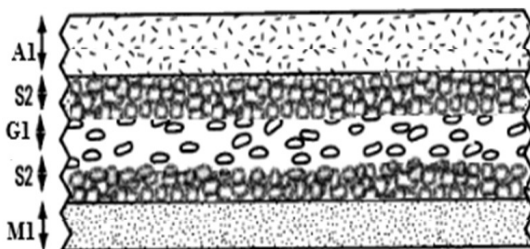


Fig. 11. Construction of the proposed landfill drainage layer (M1 – compacted clay base; S2 – rubble of drainage; G1 – tired shreds; A1 – mass of waste)

The structure (Fig. 11) is composed of compacted clay layer (M1), the total conductivity rate of which is $\leq 1.0 \times 10^{-9}$ m/s and thickness is ≥ 1 m. Geomembrane is to be installed over the compacted clay layer to prevent the leachate getting into environment. Both precipitation and waste humidity filter through drainage layer composed of three layers:

- rubble drainage (particle sizes 32–60 mm) layer 150 mm thick (S2),
- tyre shreds (70 x 100 mm) layer 200 mm thick (G1),
- rubble drainage (particle sizes 32–60 mm) layer 150 mm thick (S2).

The porosity of landfill drainage system filling composed of rubble tyre shred is by 8% higher as compared with the porosity of the filling composed of rubble alone. The filling proposed may be employed for the formation of landfill leachate drainage systems thus efficiently using the shred tyres. Such a filling improves filtration properties and slows down the clogging.

General conclusions

1. The analysis of scientific literature had revealed that the most rapid development of the clogging processes in the filtering drainage layer filling of municipal waste landfills is observed when the filling particles are fine (sizes 19–32 mm), and it is considerably slower when the sizes are larger (32–65 mm). The municipal waste landfill operation time also has an impact on the speed of the development of clogging processes: much higher leachate aggressiveness and faster clogging processes are observed in new landfills compared with the ones that are twenty years old or older.
2. Experiments had revealed that mixing of rubble (particle sizes 32–65 mm) with tyre shreds (sizes 70–100 mm) increases drainage filling porosity from 37% to 45%. The use of tyre shreds for the installation of drainage filling decreases clogging processes: 30% of tyre shreds in filling layer slow down porosity decrease over the period of 365 days by 1%.
3. The composition of the material depositing on the surface of drainage filling granules and consisting of calcium, silicon and iron compounds, has a decisive impact on the clogging processes. The largest part of the above compounds get into the filling together with the leachate and deposits in it, forming solid conglomerate.
4. The researches had revealed the most significant decrease of suspended solids, calcium and iron concentrations in the leachate, passing the column filled with rubble drainage and tyre shreds, proving, that tyre shreds is an efficient material for the installation of leachate drainage layer in municipal waste landfills.
5. The researches performed had revealed the most significant decrease of the sieved gravel porosity (9% during 365 days). This proves that the sieved gravel is not a suitable material for the formation of leachate drainage layer in municipal waste landfills.
6. The use of computer software *Bioclog 12* for modelling had allowed to establish the smallest change (decrease) of the leachate collection system

porosity over 30 years of landfill operation when it is composed of rubble drainage and tyre shred mix (by 24%). The largest porosity change (decrease) over the same period was observed in the sieved gravel filling (by 62%).

7. Both experiments and computer modelling results confirms the conclusion that tyre shreds are a material recommendable for the formation of leachate drainage layer in municipal waste landfills

Recommendation

It is recommended to form leachate drainage layer in municipal waste landfills from rubble (sizes 32–65 mm) and tyre shreds (sizes 70–100 mm) to slow down clogging processes in the leachate drainage layer filling of municipal waste landfills. The upper layer is formed of ≥ 150 mm of rubble, middle layer – ≥ 200 mm of tyre shreds and lower layer – ≥ 150 mm of rubble.

List of published works on the topic of the dissertation In the reviewed scientific periodical publications

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KOLMATACIJOS PROCESŲ EKSPERIMENTINIAI TYRIMAI IR LĖTINIMO PRIEMONIŲ TAIKYMAS SĄVARTYNAMS

Mokslo problemos aktualumas

Atliekų tvarkymas – viena pagrindinių aplinkos apsaugos problemų, atsiradusi vos įsikūrus pirmosioms gyvenvietėms ir tapusi ypač aktuali dabar. Labiausiai paplitęs komunalinių atliekų tvarkymo būdas yra jų išvežimas ir šalinimas komunalinių atliekų sąvartynuose. Filtrato surinkimo sistemos sudarytos iš drenažo sluoksnio, kurio pagrindinė sudedamoji dalis (daugiausia nominalaus 32–60 mm dalelių dydžio) skalda bei perforuoti vamzdžiai, kuriais filtratas surenkamas. Filtrato kiekiai sąvartyne tiesiogiai priklauso tiek nuo atliekų drėgmės tiek ir nuo atmosferos kritulių kiekio, tačiau filtrato kiekio sumažėjimas gali būti sąlygojamas sumažėjusio drenažo užpildo laidumo.

Surenkant filtratą drenažo sistemomis, per ilgą sąvartyno eksploatavimo laiką užpildo sluoksnyje dėl daugiakomponentinės filtrato sudėties vyksta kolmatacijos procesai. Kolmatacija – labai smulkių dalelių įplovimas į poringus gruntus sumažinanti filtracijos galimybes. Smulkios dalelės nusėda ant drenažo sudedamųjų medžiagų paviršiaus. Didėjant nuosėdų kiekiui formuojasi

vienalytė medžiaga be porų. Kolmatacijos procesai sąlygoja drenažo sluoksnio laidumo sumažėjimą dėl poringų dalelių susicementavimo.

Daugelyje pasaulio šalių didėjant vartojimui, nuolat didėja ir susidarantių komunalinių atliekų kiekiai. Daugėjant atliekų kiekiui sąvartynuose formuojasi sudėtingos sudėties filtratas, kuris tekėdamas per drenažo sluoksnį veikia pastarojo funkcionavimą. Dėl drenažo sluoksnio laidumo sumažėjimo sąvartynuose susiformuoja mažesni filtrato debitai, atsiranda atliekų kaupimo nuošliaužos – tai pagrindinės drenažo sluoksnio kolmatacijos pasekmės.

Surenkant filtratą per ilgesnį eksploatacijos laiką drenažo sluoksnis yra veikiamas kolmatacijos procesu, kurių įtakoje sumažėja sluoksnio laidumas. Smulkios (dumblo ir smėlio) dalelės nusėda ant užpildą sudarančios medžiagos dalių, tokiu būdu mažėja porų dydis. Tokie procesai nagrinėjami kaip drenažo sluoksnio užsiteršimas, kuris sąlygoja filtrato laidumo sumažėjimą. Lietuvoje iki šiol neanalizuota, nes nauji su filtrato surinkimo sistemomis sąvartynai pradėti eksploatuoti nuo 2007 metų, kur laidumo sumažėjimo problemos dar nėra, tačiau po 15 ir daugiau metų ji neišvengiamai atsiras.

Tyrimų objektas

Darbo tyrimų objektas – komunalinių atliekų sąvartyno drenažo užpilde vykstantys kolmatacijos procesai.

Darbo tikslas ir uždaviniai

Šio darbo pagrindinis tikslas – ištirti kolmatacijos procesus skirtinguose užpilduose, naudojant komunalinių atliekų sąvartyno filtratą, įvertinti filtrato cheminių junginių koncentracijų pokyčius bei, remiantis tyrimų rezultatais, pasiūlyti efektyvią drenažo užpildo sudėtį.

Darbo tikslui pasiekti reikia išspręsti šiuos uždavinius:

1. Ištirti skirtingos sudėties užpildus, naudojant komunalinių atliekų sąvartyno filtratą ir nustatyti kolmatacijos proceso eigos dėsninumus.
2. Nustatyti užpildų kolmatacijos procesus apibūdinančius parametrus: poringumą ir poringumo koeficientą bei įvertinti jų kitimą.
3. Ištirti komunalinių atliekų sąvartyno filtrato cheminių junginių, turinčių įtakos drenažo sluoksnio kolmatacijai, koncentracijas.
4. Taikant modeliavimo programą įvertinti kolonėlės užpildo poringumo pokyčius laiko bėgyje.

Tyrimų metodika

Užpildų poringumui nustatyti taikomas tūrio metodas. Geležies koncentracijoms filtrate nustatyti naudotas fotometrinis cheminės analizės

metodas, o kalcio koncentracijoms filtrate nustatyti taikyta titrametrinė cheminės analizės metodika. Skendinčių medžiagų koncentracijai nustatyti naudota filtravimo metodika. Užpildų poringumo pokyčiams per 30 metų laikotarpį kolonėlėse įvertinti naudotas *Bioclog* programinės įrangos paketas.

Mokslinis darbo naujumas

Tai kompleksiniai teoriniai bei eksperimentiniai komunalinių atliekų sąvartyno filtrato drenažo užpildo kolmatacijos tyrimai, įvertinantys įvairių medžiagų panaudojimo galimybes šio sluoksnio formavimui. Gautus modeliavimo rezultatus galima naudoti sąvartynų kolmatacijos procesų prognozavimui. Rengiant disertaciją buvo gauti šie aplinkos inžinerijos mokslui nauji rezultatai:

1. Kompleksiškai ištirtos ir įvertintos kolmatacijos procesų sąvartynų drenažo sluoksnio užpilde mažinimo galimybės.
2. Pasiūlytas naujas komunalinių atliekų sąvartynų filtrato drenažo užpildas.

Praktinė reikšmė

Ištyrus komunalinių atliekų sąvartyno filtrato komponentinę sudėtį (skendinčių medžiagų, kalcio ir geležies kiekio kaitą) po filtravimo per skirtingus užpildus, parinkta tinkama medžiaga komunalinių atliekų sąvartyno drenažo sluoksnio užpildui. Laboratorinių tyrimų rezultatus galima taikyti projektuojant ir įrengiant komunalinių atliekų sąvartynų filtrato drenažo sluoksnį.

Ginamieji teiginiai

1. Ženklią įtaką kolmatacijos procesams turi filtrate esantys skendinčių medžiagų, kalcio ir geležies junginiai.
2. Smulkintų padangų ir skaldos mišinio panaudojimas įrengiant sąvartyno drenažo sluoksnį sulėtina kolmatacijos procesus.
3. Ilgamečius kolmatacijos procesus komunalinių atliekų sąvartyne galima prognozuoti taikant modeliavimo programą *Bioclog*.

Darbo apimtis. Disertaciją sudaro įvadas, trys skyriai ir bendrosios išvados ir rekomendacija. Darbo apimtis 116 puslapių, panaudota 12 numeruotų formulių, 59 paveikslai ir 8 lentelės. Rašant disertaciją buvo panaudota 119 literatūros šaltinių.

Įvadiniame skyriuje aptariama tiriamoji problema, formuluojamas darbo aktualumas, aprašomas tyrimų objektas, formuluojamas darbo tikslas bei

uždaviniai, aprašoma tyrimų metodika, darbo mokslinis naujumas, darbo rezultatų praktinė reikšmė, ginamieji teiginiai. Pirmas skyrius skirtas literatūros analizei. Šiame skyriuje nagrinėjami kolmatacijos procesai, vykstantys komunalinių atliekų sąvartynuose. Antrajame skyriuje pateikiamos skirtingų medžiagų kolmatacijos tyrimų metodikos. Trečiame skyriuje pateikiama atliekų tyrimų rezultatų analizė. Buvo išmatuoti ir apskaičiuoti pagrindiniai kolmatacijos procesus apibūdinantys parametrai: poringumas ir poringumo koeficientas.

Bendrosios išvados

1. Išanalizavus mokslinę literatūrą nustatyta, kad komunalinių atliekų sąvartynų filtrato drenažo sluoksnio užpildo kolmatacijos procesai sparčiausiai vystosi esant smulkioms drenažo užpildo granulėms (19–32 mm frakcija) ir ji ženkliai lėtesnė kai naudojamos didesnės (32–65 mm frakcija) granulės. Kolmatacijos procesų greičiui įtakos turi ir komunalinių atliekų sąvartyno eksploatavimo laikas: naujame sąvartyne filtratas bus daug agresyvesnis ir jame intensyviau vyks kolmatacijos procesai nei dvidešimties metų ar senesniame sąvartyne.
2. Eksperimentinių tyrimų metu nustatyta, kad sumaišius skaldą (32–65 mm frakcija) su smulkintomis padangomis (70–100 mm frakcija), drenažo užpildo poringumas padidėja nuo 37 % iki 45 %. Smulkintų padangų panaudojimas drenažo užpildo įrengimui sulėtina kolmatacijos procesus užpildo sluoksnyje. Užpildui naudojant 30 % smulkintų padangų ir 70 % skaldos, poringumo mažėjimas sulėtinamas 1 % per 365 paras.
3. Ant drenažo užpildų paviršiaus nusėdusios medžiagos, susidedančios iš kalcio, silicio bei geležies junginių, turi lemiamą įtaką kolmatacijos procesams. Didžiausia dalis minėtų junginių į užpildą patenka su filtratu ir jame nusėda suformuodami vientisą konglomeratą.
4. Tyrimų metu nustatyta, kad skendinčių medžiagų, kalcio ir geležies koncentracijų kiekio sumažėjimas žymiausias filtrate, kuris buvo leidžiamas per kolonėlę, užpildytą drenažo skaldos ir smulkintų padangų užpildu. Tai įrodo, kad smulkintos padangos yra efektyvi medžiaga komunalinių atliekų sąvartynų filtrato drenažo sluoksniui formuoti.
5. Atlikus tyrimus nustatyta, kad ženkliausiai sumažėjo sijoto žvyro užpildo poringumas (9 % per 365 paras). Tai įrodo, kad sijotas žvyras nėra tinkama medžiaga komunalinių atliekų sąvartyno filtrato drenažo sluoksniui formuoti.

6. Modeliavimui naudojant kompiuterinę programą Bioclog nustatyta, kad per 30 sąvartyno eksploatacijos metų mažiausiai poringumas sumažėja (24 %) drenažinį sluoksnį formuojant iš skaldos ir smulkintų padangų mišinio. Didžiausias poringumo sumažėjimas (62 %) per tą patį laikotarpį apskaičiuotas sijoto žvyro užpilde.
7. Tiek eksperimentinių tyrimų, tiek ir kompiuterinio modeliavimo rezultatai patvirtina išvadą, kad smulkintos padangos yra rekomenduotina medžiaga komunalinių atliekų sąvartynų filtrato drenažo sluoksniui formuoti.

Rekomendacija

Siekiant sulėtinti komunalinių atliekų sąvartyno filtrato drenažo sluoksnio užpildo kolmatacijos procesus rekomenduojama minėtą sąvartyno filtrato drenažo sluoksnio užpildą formuoti iš skaldos (32–65 mm frakcija) ir smulkintų padangų (70–100 mm frakcija) sluoksnių. Viršutinį sluoksnį siūloma formuoti iš ≥ 150 mm skaldos, vidurinį sluoksnį – iš ≥ 200 mm smulkintų padangų ir apatinį sluoksnį – iš ≥ 150 mm skaldos.

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EXPERIMENTAL INVESTIGATIONS OF CLOGGING PROCESSES AND
IMPLEMENTATION OF MITIGATION MEASURES IN LANDFILLS

Summary of Doctoral Dissertation

Technological Sciences, Environmental Engineering (04T)

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