Tampere University of Applied Sciences

Water characteristics of landfill leachate in Uusikaupunki

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CONTENTS

ABSTRACT

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The main aim of this bachelor thesis was to investigate the pH and conductivity of landfill leachate in Uusikaupunki, Finland. Landfill leachate varies from landfill to landfill and is governed by factors such as age, method of construction, region, and composition of the waste. Due to these factors, legislation often requires the leachate to be monitored to avoid potential harmful environmental impacts.

During this work the previous monitoring program was expanded. As required by the environmental permit of the site, the landfill leachate conductivity must be measured and recorded weekly. The company (Lassila & Tikanoja) who operates the site wanted to gain a better understanding of the leachate characteristics and therefore had the monitoring program expanded to record both pH and conductivity; and increased the testing frequency to 3 times per week. The increased testing frequency has given a more accurate picture of the leachate characteristics. The obtained values were then compared with other published works on landfill leachate pH and conductivity for context.

The results showed that the 2016 landfill ban on organic matter has an impact on the leachate of the Uusikaupunki landfill. Also, the leachate pH and conductivity values fall within normal ranges of other landfills in Finland and around the world.

Key words: landfill, leachate, uusikaupunki, waste management

1 INTRODUCTION

1.1 Background

The disposal of waste in landfills has been a common method of waste handling throughout the 20th century. Additionally, throughout the century the volume and hazardous nature of the waste has increased considerably (Westlake, 1995). However, the total number of landfills in Finland has decreased due to increased centralization, urbanization, waste to energy, and regulations pertaining to landfill construction and monitoring. Evidence of this can be seen in Figure 1, describing the amount of municipal waste treatment based on various methods.

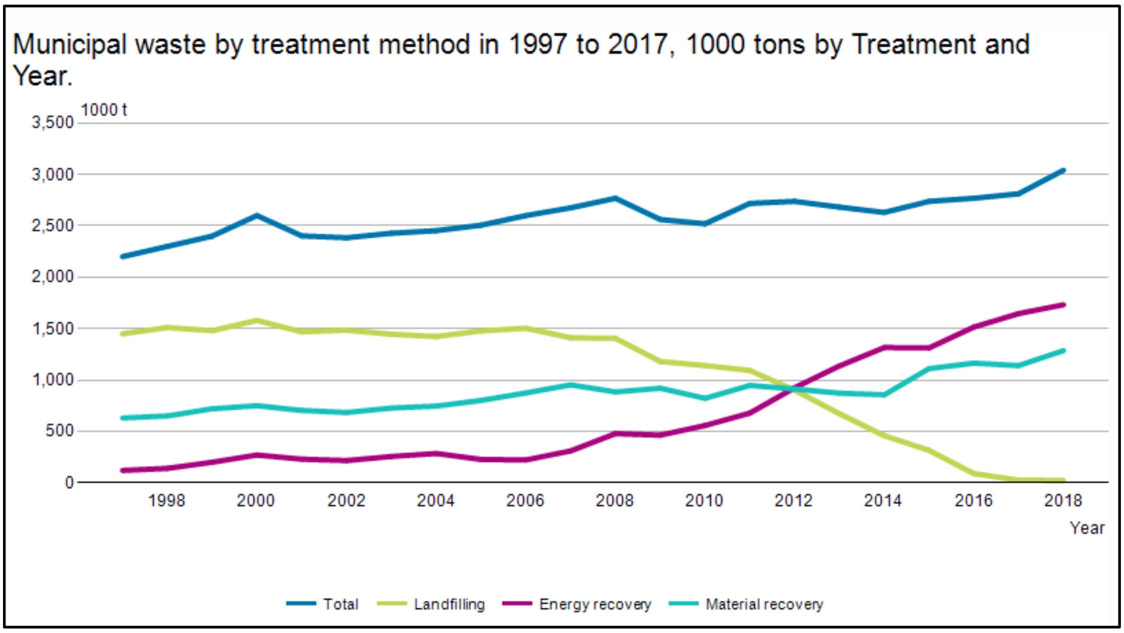

FIGURE 1. Treatment method of municipal waste in Finland from 1997-2017 (Published with the permission of Statistics Finland)

Due to modern society the requirement of some waste to be landfilled in unavoidable however the challenge is to ensure that the risks associated with landfill disposal are recognised, treated with caution, and properly executed with minimal human and environmental impact. A major concern for landfilling waste is that landfill leachate is produced which could contaminate of pollute groundwater. (Westlake, 1995)

Landfills constructed in the early 20th century often had little to no regulations or oversite. This has led to countless global examples of environmental degradation from Tampere's Härmälä case (Haapaniemi,2014), Helsinki's Myllypuro case (Korpilaakso, 2000), to the United States EPA estimating in 1993 that 55,000 landfills are polluting groundwater (Jones-Lee, 1993).

Due to contamination and pollution of soils and groundwater, landfill engineers began designing landfills to contain and collect the leachate to avoid negative environmental impacts. Furthermore, legislation was passed at various levels of government to ensure that these measures have been properly implemented, have proper oversight and or monitoring programs. Legislation relevant to Finland includes and but is not limited to the 1999 EU Landfill Directive, 2008 EU Waste Framework Directive, the Finnish Waste Act and Waste Decree, and Decree on landfills (Markkanen 2019).

1.2 Landfill leachate

According to the 1999 European Union landfill directive, "leachate" refers to: "any liquid percolating through the deposited waste and emitted from or contained within a landfill." (Council Directive 1999/31/EC) Landfill leachate is complex and depends on a number of conditions and factors relative to each specific landfill.

1.2.1 Composition of waste

Landfill leachate is highly dependent on the type of material that is sent to landfill. Different items and objects comprised of varying materials such as metals, plastics, food, insulation., etc all contain differing ratios of atoms which gives them their respective physical and chemical properties and creates complex and individualistic biodegradation in a landfill. Also, material with high organic matter content will produce leachate with higher levels of conductivity as nutrient salts are released as the material decomposes. (Manahan, 2006)
Similarly, landfills are often constructed and utilized for a specific waste stream such as industrial waste, municipal waste, hazardous waste, and waste from incineration power plants. (Youcai, 2018)

1.2.2 Age

The age of a landfill as a significant impact on both pH and conductivity. As materials breakdown they undergo different chemical processes which effects the leachate that is produced. As the landfill ages the amount of volatile organic acids, total organic carbon all decreases leading to older leachate having more basic pH, low chemical oxygen demand and low biodegradability (Ragazzi, 2016). Also, over time the methanogenic bacteria utilizes the available hydrogen causing the pH of the leachate to increase (Westlake, 1995).

The effect of age on landfills can be seen below in Table 1

TABLE 1. Leachate Quality of Different Sources in Shanghai Laogang Landfill

Leachate source	**pH**
Mature leachate from closed landfill	7.5 ~ 8.5
Fresh leachate from working landfill	6.0 ~ 7.5
Fresh leachate from incineration plant	5.0 ~ 6.0

(Youcai, 2018)

As one can view pH increases or becomes more alkaline as the landfill ages.

1.2.3 Landfill Construction Method

As mentioned previously, landfills are often built to different standards based upon the specific waste stream it will accepted. Various building designs will influence how much surface water can penetrate the landfill; as a result, this will influence the amount and quality of leachate (Rong, 2009).

1.2.4 Region

To add to the complexity different regions around the world have differing legislation, precipitation, temperature, moisture, and geology. All of these factors will impact the building process of the landfill, the biodegradation inside of the landfill, which in turn effects the quality of landfill leachate. (Youcai, 2018)

1.3 Harms caused by leachate

As mentioned previously, inadequate control of landfill leachate can cause severe environment damage.

1.3.1 Acidity and metal leaching

The scale is based upon the autoprotolysis of pure water and is approximated by the negative base 10 log of hydronium ions; giving a range of 0 to 14. As Bronsted and Lowry defined, an acid is classified as a proton donor and a base as a proton acceptor. (Harris, 2002)
A visual depiction on the pH levels of various substances can be viewed below. pH also plays an important role in governing reactions and reaction rates.

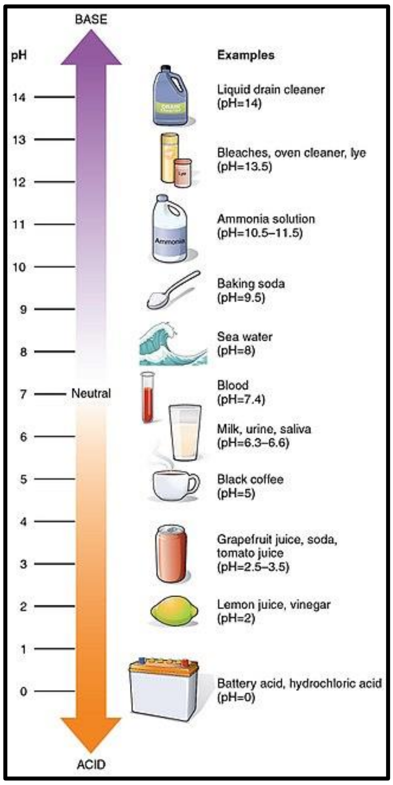

FIGURE 2. pH of various substances. (Wikimedia Commons)

The pH of any solution will affect the chemistry of its environment. As the pH decreases the ability of metals to leach increases and thus low pH solutions can contain more metal ions.

1.3.2 Potential harm of metals in groundwater

The relationship between heavy metals and health impacts have been well documented. Lead for example, “has many adverse health effects and is suspected of causing mental retardation in exposed children.” (Manahan, 2006)

Along with negative health and environmental impacts, heavy metals can be expensive to remove from groundwater. A 2019 report from Minnesota’s Department of Health estimated it would cost between 1.5 and 4.1 billion dollars to remove all the lead from drinking water (Minnesota Department of Health, 2019).

Therefore, it is necessary to monitor the pH of the inlets, pool, and outlets to be aware of any potential acidic conditions or a drastic change in pH levels. That could increase the heavy metal contents of the drainage pool.

1.3.3 Conductivity

Just as changes in pH are important to monitor, so are changes in conductivity. Conductivity is the measure of dissolved ionic material in a sample. The largest bulk of ions come from sodium, potassium, calcium, magnesium, chloride, sulphate, bicarbonate, and carbonate; these are known as the major ions. (Grafton & Hussey, 2011)

Although, conductivity does not tell the exact ion that is being detected, it still provides useful information and context which is why it is often required in environment permits. Also, similar to heavy metal but to a lesser extent, these ions can cause damage to groundwater and need to be removed or limited in drinking water which increases the waste treatment cost (Levlin, 2007)

1.4 Uusikaupunki situation

The Uusikaupunki landfill fill has gone through multiple expansions and continues to be expanded to keep up with current legislations and societal waste. As with many landfills in Finland and around the world the leachate from the landfill is

collected in a pool and then pumped to the local wastewater treatment facility. The treatment of the leachate at the local wastewater treatment facility is mandatory and adds to the operating cost of the landfill. The company is charged based on the amount of water as well as the quality of the water. The latest major change came in 2016 when waste containing high amounts of organic matter was banned from entering landfills. However, the "catchment area" of inlet 3 had received waste before this period and therefore contains a higher amount of organic content compared to the rest of the landfill. Currently, this part of the landfill is receiving non-hazardous waste, typically from construction sites. Due to regulations, landfills in Finland must have an environmental permit to be operational. The environmental permit of this site requires that the leachate drainage pool be monitored throughout the year. According to the environmental permit:
"Suotovesien määrää ja sähkönjohtavuutta on seurattava viikoittaisin mittauksin ja lisäksi ylivirtaamakausina aukiolopävittäin tehdyin mittauksin."
(Aluehallintovirasto, 2018)

A weekly monitoring program was in place to monitor the water conductivity, as a means of noticing any significant changes. This program is done as a cost-effective way to continuously monitor the pool. In addition to the weekly program, four times per year a more detailed water analysis is done to determine what particular substances have entered the pool.
In the company's interest, the weekly monitoring program was expanded by increasing the frequency of testing and to monitor the water's pH and conductivity values. With the increase in testing frequency the company stands to gain a better understanding of what activities affect the leachate pool water characteristics, decrease the risk to the company, and possible ideas for on-site remediation to lower operational costs.

The sampling plan consisted of taking measurements from six sites at the location. Four of the sites are considered "inlets" due to their flow into the leachate pool; one site is considered the "outlet" due to its external flow to the Uusikaupunki wastewater treatment center. Lastly, a sample was taken from the surface of the leachate pool itself.

One can observe below from Picture 1 the locations and numbers of the sampling sites.

PICTURE 1. Sampling locations and inlet numbers

As one can observe above the inlet sites are numbered 1-4 left to right to provide consistency throughout the monitoring program. The leachate pool sampling location is denoted by the blue and white circle on the right-hand side of the photo; while the outlet site (a well) is denoted by the blue and white square near the bottom of the photo. The above photo was taken on June 3rd, 2019; while all of the inlet pictures (below) were taken on August 7th, 2019.

The frequency of the sampling varied based on the location of the site. The four inlet sites were sampled once per week; while the leachate pool and outlet were sampled three times per week. The samples were always taken from the surface due to equipment, and other complications.

Herein one can view, in Figure 3, the “catchment areas” related to the various inlets of the leachate drainage pool.

FIGURE 3. Inlet catchment areas (Google 2019)

In Figure 3, the sampling sites of each catchment area is denoted by the color coded circle.

1.4.1 Inlet one

As one can observe above (Picture 1), Inlet 1 is the left-most sample site. A more detailed photo of the site can be found below (Picture 2).

PICTURE 2. Sample site of inlet 1

The catchment area related to inlet one can be observed above, in Figure 3. Generally, the contents of inlet one consists of rainwater runoff within the yellow highlighted area. The contents of rainwater runoff can vary due to particular activities done in the area such as, salting of the roads, blasting of rocks, and the expansion of the area. As well as, the amount of precipitation and water used on the road surfaces.

1.4.2 Inlet two

As one can observe above (Picture 1), Inlet 2 is the second left-most sample site. A more detailed photo of the site can be found below (Picture 3).

PICTURE 3. Sample site of inlet 2

The “catchment area” related to inlet two can be observed above, in Figure 3. This “catchment area” is situated under the current landfill and consists mainly of material breakdown happening inside of the landfill. The material in this section (highlighted in green) of the landfill contains, but may not be limited to, non-hazardous soils, insulation, asbestos, and various non-hazardous ash.

1.4.3 Inlet three

As one can observe above (Picture 1), Inlet 3 is the second right-most sample site. A more detailed photo of the site can be found below (Picture 4).

PICTURE 4. Sample site of inlet 3

The “catchment area” related to inlet three can be observed above, in Figure 3, and highlighted in blue. Inlet three also consists of landfill leachate, however, the “catchment area” of inlet three is from the older part of the current landfill. This section of the landfill consists mainly of municipal waste which entered the landfill between the years 2007 and 2016.

1.4.4 Inlet four

As one can observe above (Picture 1), Inlet 4 is the right-most sample site. A more detailed photo of the site can be found below (Picture 5).

PICTURE 5. Sample site of inlet 4

Although inlet four is not shown above in Figure 3, one can view inlet four in section 3.1.4. The contents of inlet four generally come from sewer waste, in particular, the sand and other particles left inside of the sewer system. The inputs were varied due to an inconsistent refilling/disposal schedule.

1.4.5 Drainage pool

One can observe the leachate drainage pool and sampling location spot above in Picture 1. No further picture is required.

1.4.6 Outlet

As one can observe above (Picture 1), outlet is the bottom most sample site. A more detailed photo of the site can be found below (Picture 6)

PICTURE 6. Sample site of the outlet.

2 SCOPE

The purpose of this work was to monitor the water characteristics of a leachate drainage pool at a landfill site in Uusikaupunki (Finland), that is the property of Lassila & Tikanoja Oyj. The main aim of this work was to gain a better understanding of this particular leachate area and to fulfil the legal requirements as part of their environmental permit.

3 MATERIALS AND METHODS

3.1 Equipment that was utilized

The equipment that was utilized during the timeframe of this work was provided by Lassila & Tikanoja Oyj.

All three of conductivity, pH, and water temperature were recording utilizing the same device. The device was manufactured by Hanna Instruments and the model is the HI 98130 Combo pH & EC (Picture 7).

The meter was cleaned between each sample with distilled water and then dried to avoid any contamination and increase the accuracy of the reading. Furthermore, the meter was calibrated 3 times on; May 23rd, June 26th, and July 26th.

The calibration intervals were done at the recommendation of Hanna Instruments. An example of the calibration process can be viewed below in Picture 9.

PICTURE 7. Photo of the calibration process from July 26th, 2019

The error of the device is reported as + or – 0.5°C, 0.01 pH, and 2% for the conductivity, by the manufacture. Other equipment included but may not be limited to; plastic cups, telescopic sampler, safety gloves, paper, safety glasses, and distilled water.

3.2 Recording the sample

The samples taken from the four inlets and the leachate pool were done utilizing the proper safety equipment and a plastic cup. One can view an example of a sample taken on June 12th, 2019 from inlet 1, below in Picture 8.

PICTURE 8. Example of a recorded sample

After, recording the data values the sample was discarded into the leachate pool. The meter was then properly cleaned with distilled water and dried to ensure accuracy and avoid contamination.

The samples taken from the outlet were taken with a telescopic sampler, due to the depth of the well.

4 RESULTS AND DISCUSSION

Herein, one can find the range and mean values as well as a graphical representation of the data. For a complete list of all data, please see the appendix.
As previously mentioned, pH is important for chemical reactions and is dependent upon the condition of the landfill. Therefore, for context one can view below the pH of leachate from several landfills around the world.

TABLE 2. pH and conductivity of various global landfill leachate (Kettunen 1997, Rong 2009, Sackey & Koci & Gestel 2020)

Location	pH range	Conductivity (mS/cm)
Tema (Ghana)	9.3 – 9.7	19.1 – 19.9
Mallam (Ghana)	8.2 – 8.4	19.1 – 20.3
Oblogo (Ghana)	7.4 – 8.2	18.4 – 19.0
Tarastenjärvi (Finland)	7.16 – 7.18	3.538 – 3.540
(Finland)	6.8 – 7.0	3.2 – 4.4
(Canada)	6.8 – 8.6	0.58 – 39.9
Uusikaupunki Inlet 1	6.67 – 8.20	3.62 – 5.01
Uusikaupunki Inlet 2	10.93 – 12.58	2.25 – 3.17
Uusikaupunki Inlet 3	6.75 – 8.20	5.73 – 7.48
Uusikaupunki Inlet 4	5.78 – 8.28	1.70 – 6.89
Uusikaupunki main pool	7.94 – 9.04	2.06 – 4.92

4.1 “Inlet one”

One can view below, the summary of the results obtained in table form.

TABLE 3. Summary of data from inlet 1

Inlet 1			
pH		Conductivity (mS/cm)	
Mean	Range	Mean	Range
7,32	6,67 -- 8,20	4,38	3,62 -- 5,01

As displayed in Table 3, the most alkaline and acidic recorded values of “inlet one” were 8.20 and 6.67 respectively. The change in pH can be expected due to the influence of rainfall and various activities in the catchment area of inlet one; such as road maintenance or using water to cool down ash to prevent fires.

The highest and lowest recorded conductivity values were 5.01mS/cm and 3.62mS/cm respectively. Despite the somewhat high conductivity values, the variation can be explained by the catchment area of inlet one and the how well runoff dissolves ions from activities such as salting the roads and cooling of ash. Further testing could confirm the following statement, there could be organic ions dissolved in the water flowing from inlet one due to the presence of photosynthetic organisms at the end of the pipe and along the water path to the leachate pool (Picture 2). The only source of nutrients for these organisms is the leachate itself, suggesting that important nutrients are dissolved in the leachate. Lastly, both the pH and conductivity values are well within the typical ranges displayed in Table 2.

4.2 “Inlet two”

One can view below, the summary of the results obtained in table form.

TABLE 4. Summary of data from inlet 2

Inlet 2			
pH		Conductivity (mS/cm)	
Mean	Range	Mean	Range
11,56	10,93 -- 12,58	2,64	2,25 -- 3,17

As one can view in Table 4, the most alkaline and least alkaline recorded values of “inlet two” were 12.58 and 10.93 respectively. The varied pH range was 1.65 over the duration of the testing period.
The unusually high pH values, compared in Table 2, resulting from inlet two appears to be from concrete and other building materials as they break down inside of the landfill; concrete and similar materials have high pH levels often in this range. (Peng, 2015)

Evidence for this hypothesis comes from the precipitated red-orange material at the site. This material can be observed in Picture 3. Although, further analysis of the material would be needed to completely identify the composition.

The highest and lowest recorded conductivity values were 3.17mS/cm and 2.25mS/cm respectively. The small variation in conductivity range suggests the fluid entering from inlet two was relatively uniform; this is consistent the age of the particular “catchment” area. Also, the lack of any noticeable photosynthetic organisms around the inlet suggest that either or both the conductivity and pH is preventing habitable conditions. Lastly, due to the physical surroundings of the inlet and the recorded pH and conductivity values of this work, I do not suggest bioremediation considerations for inlet two. The gradient of the asphalt would make the engineering work difficult and more costly.

4.3 "Inlet three"

One can view below, the summary of the results obtained in table form.

TABLE 5. Summary of data from inlet 3

Inlet 3			
pH		Conductivity (mS/cm)	
Mean	Range	Mean	Range
7,47	6,75 -- 8,20	6,49	5,73 -- 7,48

As one can view in Table 5, the most alkaline and acidic recorded values of "inlet three" were 8.20 and 6.75 respectively. These values fall into the range of leachate from MSW (municipal solid waste); in China pH leachate values from MSW ranged from approximately 5.53 to 8.29 and are consistent with the values detailed in Table 2. Of the 12 measurements taken from inlet three, 11 of them were above pH 7, this suggest that the MSW contained inside the "catchment" area of inlet 3 is reaching stabilization (Youcai, 2018).

Also displayed in Table 5, the highest and lowest recorded conductivity values were 7.48mS/cm and 5.73mS/cm respectively. These values constitute a range of 1.75mS/cm over the duration of the testing period. As mentioned in section 4.3.3, the "catchment area" of inlet three contains the decomposition of municipal waste which contained organic matter; thus, explaining the high conductivity values seen throughout the testing period. Further evidence for the high organic content in the solution is from the brown colour, malodorous smell, (Williams, 2005) and the activity of plants and insects in the surrounding area. Although, more thorough chemical analysis is needed to isolate the specific contains on the solution.

Due to the physical surroundings of the inlet and the recorded pH and conductivity values of this work, I do suggest bioremediation considerations for inlet three. The gradient surrounding inlet three allows for easy construction of soil beds; while the pH and conductivity values are in suitable ranges for plant life. The presence of the plants and soil beds would stop the flow of high amounts of organic matter entering the drainage pool and thus limit the amount of algal blooms observed over the duration of this work (Crouse, 2018).

4.4 “Inlet four”

One can view below, the summary of the results obtained in table form.

TABLE 6. Summary of data from inlet 4

Inlet 4			
pH		Conductivity (mS/cm)	
Mean	Range	Mean	Range
7,58	5,78 -- 8,28	3,51	1,70 -- 6,89

As one can view in Table 6, the most alkaline and acidic recorded values of “inlet four” were 8.28 and 5.78 respectively. These values are still consistent with Table 2, despite the varied natural and different source than the rest of the leachate. The pH value on 17.07.2019 is concerning as it is lower than pH 6. Furthermore, it must be noted that no measurements were conducted on 31.07.2019 due to the inability to take the sample.

Also displayed in Table 6, the highest and lowest recorded conductivity values were 6.89mS/cm and 1.70mS/cm respectively. These values constitute a range of 5.19mS/cm over the duration of the testing period. As mentioned in section 3.3.4, inlet four contains sewer waste such is added to a container periodic for drying before removal. The periodic filling of the container with new material is responsible for the wide variation in both pH and conductivity values. Although the values for 23.05.2019 are presented in this report they are statistical outliers compared to the rest of the measurements and were not factored in the average and range calculations.

Due to the physical surroundings of the inlet and the recorded pH and conductivity values of this work, I do suggest bioremediation considerations for inlet four. The close proximity to inlet three allows for the same soil bed to influence both inlets. The presence of the plants and soil beds would act as a buffer to the wide range of pH and conductivity values and to ensure an additional safeguard if acidic material is wrongfully added to inlet four (Crouse, 2018).

4.5 Leachate drainage pool

One can view below, the summary of the results obtained in table form.

TABLE 7. Summary of data from the drainage pool

Drainage pool			
pH		Conductivity (mS/cm)	
Mean	Range	Mean	Range
8,42	7,94 -- 9,04	3,63	2,06 -- 4,92

As one can view in Table 7, the most alkaline and least alkaline recorded values of leachate drainage pool were 9.04 and 7.94 respectively. The varied pH range was 1.10 over the duration of the testing period. Although the pH did not vary greatly over the duration of the testing period, known factors that can change the pH of the drainage pool, but are unquantifiable in this research, include but are not limited to, the leachate itself, amount of rainfall, and presence of algae.
As can be viewed in their respective sections, all of the inlets recorded mean pH values above 7 with “inlet 2” well above pH 7. The inlets would clearly work to keep the pool alkaline. Another factor working to increase the pH of the pool are the algae in the pool itself. As they use dissolved CO_2 in the water there is less CO_2 to convert to H_2CO_3 and thus working to increase the pH. (Gao, 2017) The samples showed a consist algal presence throughout the entirety of the testing period. However, the pool itself is exposed directly to rainwater so the amount of precipitation, especially rainfall with its pH around 5.6, will have an impact on the overall pH (Singh, S. Elumalai, S. Pal, S. 2016).

Also displayed in Table 7, the highest and lowest recorded conductivity values were 4.92mS/cm and 2.06mS/cm respectively. The conductivity values of the drainage pool are affected by the inlets, but they are well within the range of other landfills.

4.6 “Outlet”

One can view below, the summary of the results obtained in table form.

TABLE 8. Summary of data from outlet

Outlet			
pH		**Conductivity (mS/cm)**	
Mean	**Range**	**Mean**	**Range**
8,01	7,18 -- 8,80	4,52	1,50 -- 6,17

As one can view in Table 8, the most alkaline and least alkaline recorded values of the outlet were 8.80 and 7.18 respectively. The varied pH range was 1.62 over the duration of the testing period. Factors that can affect the pH of the outlet are similar to those mentioned in section 6.5; as the outlet and pool are connected.

Also displayed in Table 8, the highest and lowest recorded conductivity values were 6.17mS and 1.50mS respectively. The conductivity values of the outlet are affected by the same factors mentioned previously with the main pool. But because the pool is static there is a difference in values caused by stratification, the pool is deep enough for temperature and possible oxygen stratification which effects the chemical reactions taking place.

4.7 Comparative pH results from all locations

Herein, one can find comparative graphs of the pH of all four inlets and a comparative graph of the pH values of the leachate drainage pool and outlet

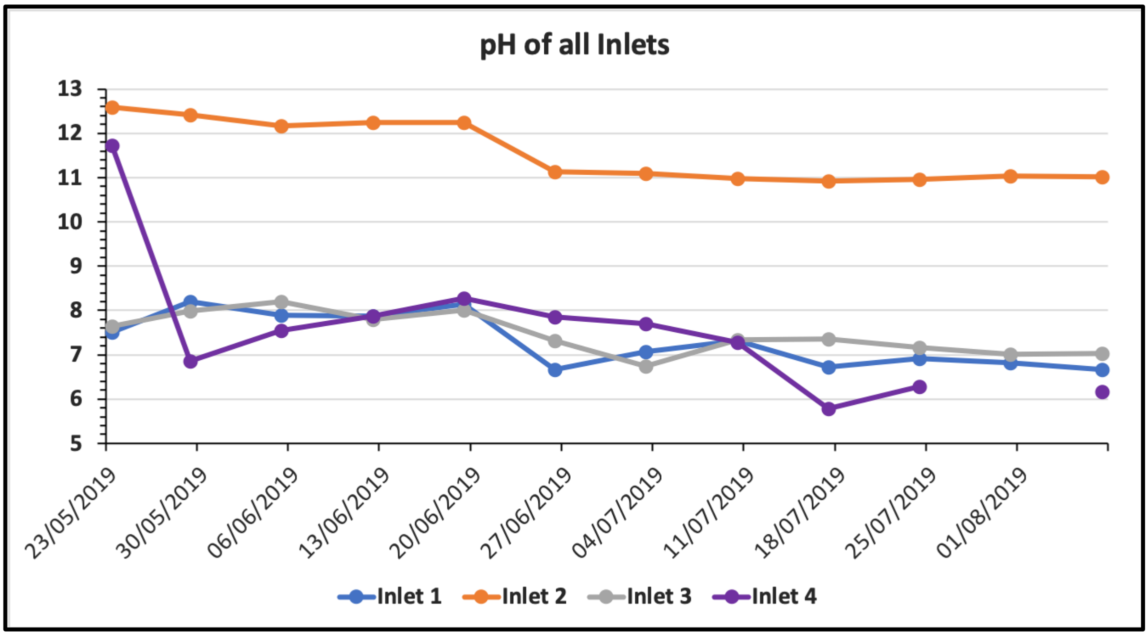

FIGURE 4. pH of all inlet locations

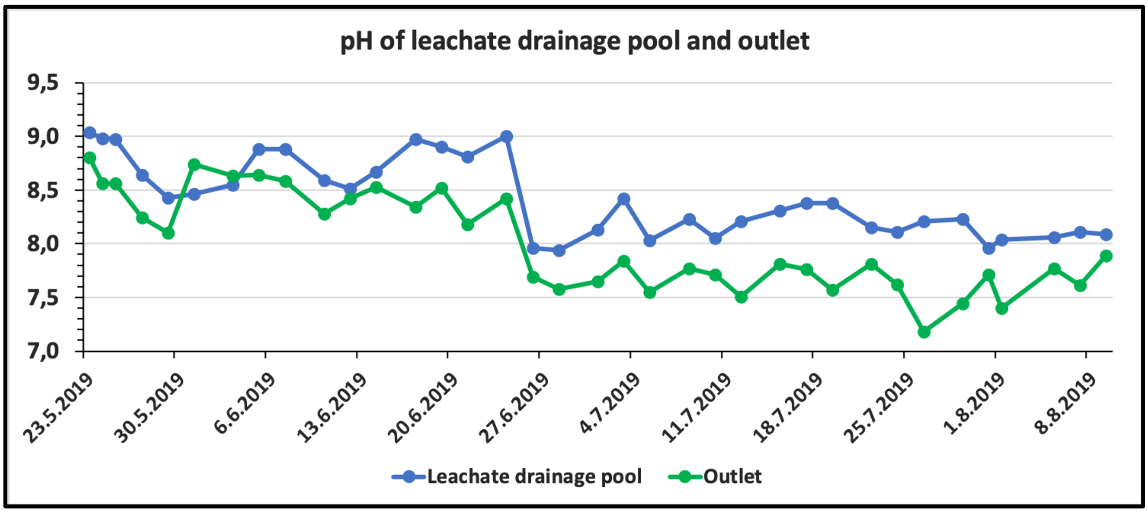

FIGURE 5. PH of the leachate drainage pool and outlet

As displayed in both Figures there is a slight downward trend as the summer progressed. The drainage pool and outlet typically were separated by a constant amount and the outlet almost always had a lower pH value than the pool itself.

5 CONCLUSION

In this work, the highest constant pH values were recorded from inlet two and the highest constant conductivity values were recorded from inlet three. Therefore, it may be advantageous to chemically analyse the contents of these inlets. Also, high frequency monitoring of inlet four is advised due to the variability of the recorded pH and conductivity values. All of the values recorded, besides “inlet 2” pH values, were well within normal ranges compared to other landfills in Finland and across the world. Therefore, one is left to conclude that the measures being taken from the company to ensure safe and proper waste disposal are being conducted in a responsible manner.

As for any bioremediation considerations; the most feasible way to implement a bioremediation strategy is to focus on the area surrounding inlets three and four. The asphalt is at its shallowest degree and the recorded pH ranges of inlets three and four are tolerable for most plants. The suspected organic matter coming from inlet three can be utilized by plants in the soil bed rather than entering the drainage pool. These inlets should be further chemically analysed for better understanding and selecting the appropriate remediation method.

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APPENDICES

Appendix 1. Total Data from Inlets 1-4

Date	ADT		Inlet 1			Input 2			Input 3			Input 4	
		pH	Conductivity	Temp	pH	Cond	Temp	pH	Cond	Temp	pH	Cond	Temp
23/05/2019	15	7,51	3,655	9,3	12,58	3,175	9,3	7,64	6,65	12	11,73	16,02	17,6
29/05/2019	11	8,2	4,75	9,9	12,41	3,07	8,4	7,98	7,48	11,2	6,86	6,89	18
05/06/2019	19	7,9	4,3	10,1	12,16	2,77	9	8,2	6,92	12,6	7,55	5,77	21,3
12/06/2019	15	7,87	4,6	11	12,24	2,73	9,9	7,79	6,55	13,1	7,88	5,88	19,4
19/06/2019	19	8,14	4,72	12,9	12,24	2,65	11,9	8,01	6,74	13,8	8,28	1,7	28,8
26/06/2019	14	6,67	4,75	12,1	11,13	2,73	10,2	7,31	6,73	12,4	7,86	1,86	17,8
03/07/2019	13	7,07	5,01	12,3	11,09	2,61	9,8	6,75	6,86	12,4	7,71	1,85	15,7
10/07/2019	16	7,31	4,27	12,1	10,97	2,65	9,6	7,34	6,71	13,4	7,28	2,05	22
17/07/2019	16	6,73	3,62	13,4	10,93	2,32	10,3	7,36	5,59	13,2	5,78	1,97	19,8
24/07/2019	20	6,92	4,51	14,3	10,96	2,36	11,7	7,17	5,94	13,8	6,29	3,78	23,4
31/07/2019	14	6,81	4,57	14	11,04	2,32	11,9	7,01	5,99	13,4			
07/08/2019		6,67	3,79	14,8	11,02	2,25	11,9	7,03	5,73	14,1	6,17	3,33	22,4

Appendix 2. Total Data from the drainage pool

DATE	pH	Conductivity (mS/cm)	Temperature (°C)
23.5.2019	9,04	4,92	19,00
24.5.2019	8,98	2,95	18,90
25.5.2019	8,97	3,69	14,60
27.5.2019	8,64	3,56	16,50
29.5.2019	8,43	3,81	19,60
31.5.2019	8,46	3,94	15,40
3.6.2019	8,55	3,31	16,90
5.6.2019	8,88	3,05	23,10
7.6.2019	8,88	3,44	27,90
10.6.2019	8,59	3,84	20,70
12.6.2019	8,51	3,99	19,10
14.6.2019	8,67	3,76	18,80
17.6.2019	8,97	3,84	25,20
19.6.2019	8,90	3,66	29,80
21.6.2019	8,81	3,58	25,60
24.6.2019	9,00	3,74	26,30
26.6.2019	7,96	4,89	15,60
28.6.2019	7,94	3,66	19,90
1.7.2019	8,13	4,07	24,30
3.7.2019	8,42	4,30	18,80
5.7.2019	8,03	3,21	16,90
8.7.2019	8,23	4,09	18,50
10.7.2019	8,05	3,49	21,20
12.7.2019	8,21	3,59	20,40
15.7.2019	8,31	3,12	23,90
17.7.2019	8,38	3,12	24,30
19.7.2019	8,38	3,08	23,10
22.7.2019	8,15	3,36	23,70
24.7.2019	8,11	3,32	26,80
26.7.2019	8,21	3,29	27,40
29.7.2019	8,23	3,54	26,80
31.7.2019	7,96	4,04	21,10
1.8.2019	8,04	3,97	23,90
5.8.2019	8,06	3,49	23,80
7.8.2019	8,11	3,80	22,20
9.8.2019	8,09	2,06	15,80

Appendix 3. Total Data from the outlet

DATE	pH	Conductivity (mS/cm)	Temperature (°C)
23.5.19	8,80	5,67	12,80
24.5.19	8,56	5,26	12,90
25.5.19	8,56	5,16	12,70
27.5.19	8,24	5,20	13,20
29.5.19	8,10	4,61	13,80
31.5.19	8,74	1,50	13,20
3.6.19	8,63	1,56	13,70
5.6.19	8,64	2,99	14,30
7.6.19	8,58	2,95	15,70
10.6.19	8,28	4,51	14,30
12.6.19	8,42	4,62	14,60
14.6.19	8,53	4,32	15,00
17.6.19	8,34	5,10	16,20
19.6.19	8,52	4,99	17,20
21.6.19	8,18	4,92	15,80
24.6.19	8,42	5,13	16,40
26.6.19	7,69	4,89	15,60
28.6.19	7,58	4,71	15,60
1.7.19	7,65	5,27	16,60
3.7.19	7,84	5,41	15,50
5.7.19	7,55	4,67	14,80
8.7.19	7,77	5,09	15,50
10.7.19	7,71	4,40	16,10
12.7.19	7,51	4,62	15,50
15.7.19	7,81	4,16	16,30
17.7.19	7,76	4,28	16,60
19.7.19	7,57	4,35	16,10
22.7.19	7,81	3,97	16,70
24.7.19	7,62	4,21	17,30
26.7.19	7,18	4,39	16,50
29.7.19	7,44	4,42	17,60
31.7.19	7,71	5,05	15,90
1.8.19	7,40	6,17	15,70
5.8.19	7,77	4,93	16,10
7.8.19	7,61	5,14	15,90
9.8.19	7,89	4,17	15,20