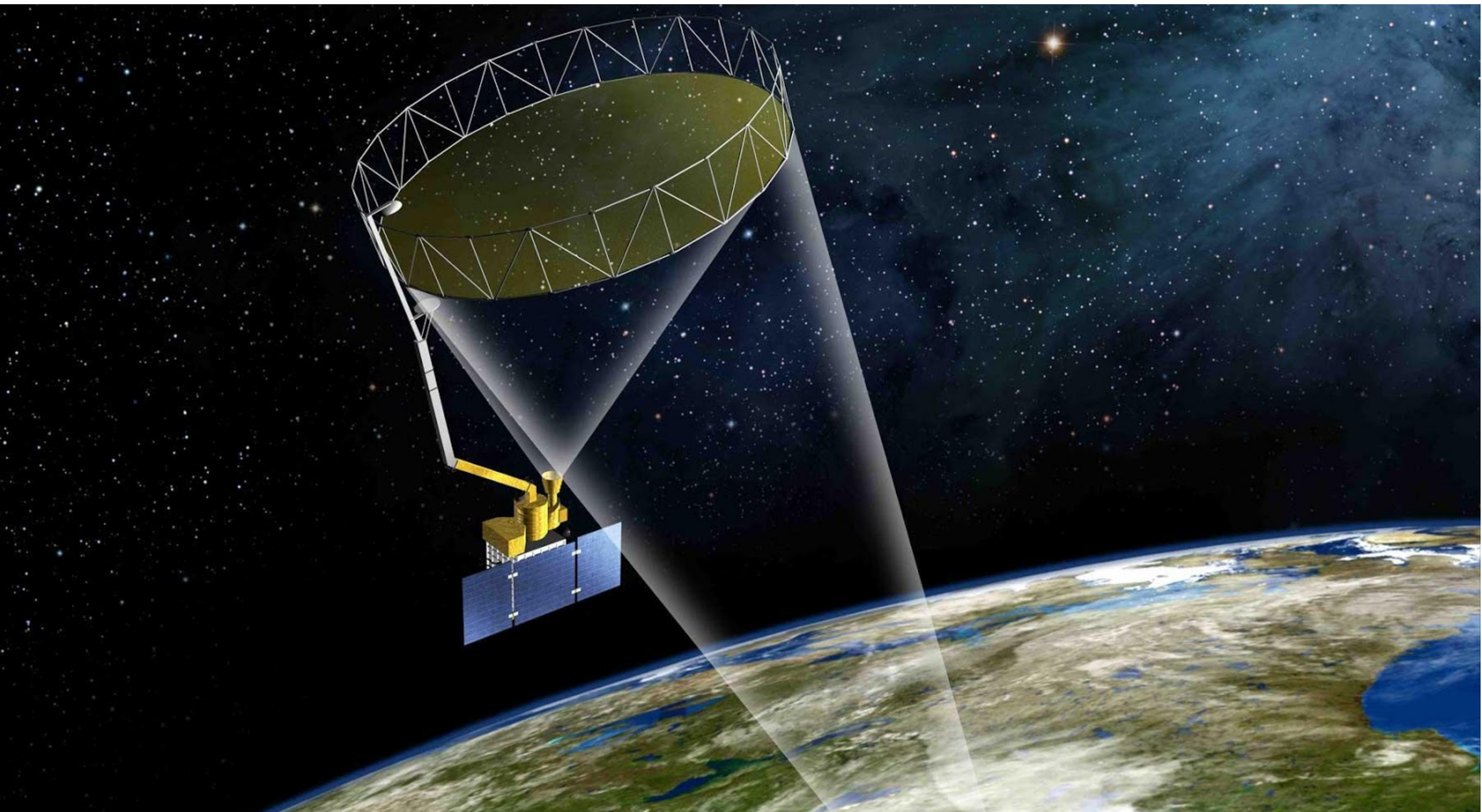
The effect of various circumstances on the soil moisture

Carthago Vlug, Esmée Mulder, Jasper van den Broek and Sara Langelaar

29-01-'18 - 17-02-'18



Preface

Because we, four students from Comenius College fancied extra challenge, we decided to join the Science Fair.

Our intended target audience is teachers and fellow students. Furthermore we target those who are interested in geography and want to learn more about the subject.

A total of four people worked on this report, we did most work together, and we were able to take measurements in different places at the same time.

We would like to thank our teacher, ms. L. Zwakhals, for informing us of the challenge that is the Science Fair and for providing us with feedback and guidance. Moreover, we would like to thank mr. N. Leeuwenburg for some additional feedback.

Carthago Vlug, Esmée Mulder, Jasper van den Broek and Sara Langelaar
Rotterdam, 15 May 2018

Abstract

Our initial motivation for this project was a contest called the Science Fair. In which students are challenged to carry out an experiment in the field of either geology or biology. However, during the process we started to gain more interest in the subject.

Nasa's SMAP satellite helps predict floods and droughts. Our role in this was to calibrate the satellite with dat we derived from measurements we took.

Our research consists of the analysis of field data. We took eight soil samples in three different locations which had different soil types. Our aim was to measure how various meteorological circumstance affected the soil moisture, such as: precipitation and humidity.
For our results we composed a number of tables containing the data we collected from our measurements. Furthermore, we derived graphs from those tables in order to clearly visualize our results.

We found out the presence of both precipitation and humidity increased the soil moisture. Besides the soil type can also drastically influence the soil moisture. For example our results illustrating the water quantity differed from 18% to 60% depending on the soil type.

Table of contents

Comenius College

Introduction

As we, four students from Comenius high school in Rotterdam, the Netherlands, fancied some extra challenge, we agreed on partaking in the Science Fair. We determined that we wanted to carry out an experiment that would grant us a newly found experience, in which we actively learned, and got inspired.

We focused especially on the relation between humidity and soil moisture in different soil types. The reason for this is that we are interested in meteorology and the way climate interacts with the soils of the earth. The soil types we fixated on in our experiment are clay, peat, and sand, considering all of these are common in the Netherlands, and easily found close to our homes.

The final purpose of the experiment was to calibrate NASA's SMAP (soil moisture active passive) satellite to assist them with analyzing weather circumstances to a more exact level, to be able to predict meteorological disasters like floods and droughts more meticulously. The SMAP satellite focusses especially on the hydrologic aspects of the weather, which elucidates why our experiment was fixated on acquiring data which correlates with the effects of water on soil.

Our experiment encompasses the following research question:

- ❖ *In what way is the soil moisture influenced by various circumstances?*

In addition, we composed the following sub-questions:

- *How does soil type affect the soil moisture?*
- *How is precipitation absorbed into different types of soil?*
- *What is the relationship between humidity and soil moisture?*

We composed the main research question in combination with our already present knowledge. We were aware of the fact that the soil types we had appointed to take samples of had different properties that were crucial in determining the water capacity of the soil.

We conducted our experiment between the 29th of January 2018 and the 17th of February 2018. In short, our experiment consisted of taking soil samples whilst the SMAP satellite flew over. We then measured the percentage of soil moisture in the lab.

The first sub-question was composed in order to clearly illustrate that the absorption of water by soil is reliant on the properties of the soil that is focused on.

We based the second sub-question on the observation that whenever precipitation takes place, certain soil types dry quicker than others. Therefore, one of the aims of our experiment was to find the cause for this.

Hypothesis

We think that the soil moisture is affected by the air humidity, precipitation the days before & the soil type. We also think that the precipitation the days before influences the soil moisture the most.

In order to develop a better initial understanding of the soil types we were planning to investigate, we carried out literary research. Here is, summarized, the main information that we assembled before carrying out the experiment.

Soil

The general definition used to define soil is: a natural surface that contains living matter and can support plants. Soil can contain its matter in all three states: gas, liquid and solid. However, you can also divide soil in either mineral or organic matter. Mineral matter is usually dissolved in water as nutrients for instance. Although water is mostly found in soil, gas is also present, mostly in the form of carbon dioxide. Carbon levels are high, because it is used by plants (organic matter) for photosynthesis. Thus, oxygen levels are generally quite low.

Due to the constant change of both the liquid and gaseous matter, soil is often seen as quite a dynamic layer compared to other layers of the earth's crust. But how did all these characteristics form? And do they differ between multiple soil types? Some of those characteristics include: soil colour, texture, colloids, structure and moisture. [1]

Clay

Clay forms as a result of the weathering and erosion of rocks. Clay particles, individuals at least, are always smaller than 0.004 mm. But they form suspensions when they are immersed in water, thus the clay particles clump and can survive in water. Other properties of clay include shrinkage under air drying, plasticity, fineness of grain and colour after firing. They are divided into classes or groups based on such qualities.

Clays have been used since the first civilizations formed. It's mostly been for making household objects for e.g. cooking. Nowadays the clay is used in a totally different way. For example, in the Netherlands we build dykes from clay, as sand or other types of soil would get washed away by the water. [2] [3]

<u>Soil colour and texture</u>

The colour of soil is mostly generated by the soil-forming process, but can also be formed due to the materials it is in contact with. The colour of clay soil is quite dark. This is mostly due to its property of easily absorbing water. When clay soil absorbs water, the colour turns darker and due to this the soil is occasionally darker than its actual colour, after rainfall.

While soil colour is mostly determined by the soil-forming process, soil texture is a different story. Soil texture often refers to the proportion of particles that fall into each of the following three size grades: sand, silt and clay. Clay particles generally have a size between 0.001 and 0.00001 mm. Furthermore, clay soil consists of only 45% clay, the other parts are 45% silt and 10% sand. But why is it important to know the soil texture?

---

[1] Strahler, A. (2005). Physical Geography. Boston, USA: John Wiley & Sons.
[2] What is clay? (2010, April 27). Retrieved March 18, 2018, from https://www.sciencelearn.org.nz/resources/1771-what-is-clay
[3] *Formation of Clay minerals*. 31st of December 2009. Consulted on the 17th of March by Esmée Mulder, through http://nptel.ac.in/courses/105103097/15.

The texture of soil greatly determines the ability of soil to retain water. For example, if the soil consists of unrefined and/or big particles, the passages and spaces between touching mineral grains are way bigger, thus water will penetrate more quickly and the soil won't retain the water as easily as soil consisting of fine particles. [4]

Soil colloids

Soil or mineral colloids are very fine particles of clay minerals, which are usually smaller than 0.000001 mm. They always consist of thin, plate-like bodies. Thus, when clay is mixed with water these particles will suspend indefinitely and therefore retain the water.

Besides, soil colloids are also very important because they can attract nutrients (ions dissolved in water). Ions are charged particles. Due to the remarkable molecular structure of colloid surfaces they tend to be negatively charged. Thus, they attract positively charged ions. Some of these ions are bases, which are also part of the plant nutrients. Although colloids hold the ions, when in contact with root membranes they give them to the plants to provide them with vital nutrients. If the soil colloids wouldn't hold and transport these ions they would be washed away with the water in the ground, thus the plants would get less nutrients and die faster. [5]

Soil structure

When we talk about soil structure we generally refer to the way in which soil grains are grouped together into larger masses. These masses are also called peds. Peds are bound together by soil colloids. Soils with a relative high clay percentage can lack peds. Thus, these soils will turn heavy and or sticky when wet. Thus, they are more difficult to cultivate when you compare this to soils with a well-developed granular or blocky structure. Moreover, when clay soil turns dry it becomes hard to be worked. [6]

Soil moisture

Next to soil structure the way soil can reserve water is also a key factor in determining how the soils of a region can support crops and other types of vegetation. This is because the soil layer serves both as a reservoir for the moisture and it provides nutrients and other minerals for plant growth. But how does the soil receive its water?

Most water that the soil receives comes from rain and other types of precipitation, but it may also come from melting snow. However not all water that touches the surface sinks in. Firstly, a part of the water runs off the soil surface into e.g. rivers and streams. This water eventually reaches the sea. Although the remaining amount of water all sinks into the soil a part of this will return to the atmosphere as water vapour. This happens when plant transport their water from the roots to the leaves. Water can only evaporate through the stomata. Stomata only occur on

[4] Strahler, A. (2005). Physical Geography. Boston, USA: John Wiley & Sons.
[5] Strahler, A. (2005). Physical Geography. Boston, USA: John Wiley & Sons.
[6] What is clay? (2010, April 27). Retrieved March 18, 2018, from https://www.sciencelearn.org.nz/resources/1771-what-is-clay

the back side of leaves. Lastly, only some of the water originally sunken in into the soil can flow completely through the soil layer.

This entire process is called the soil water recharge, which is that when precipitation infiltrates the soil the water wets the entire soil layer. However eventually the entire soil layer is saturated and the soil hold the maximum possible quantity of water. If no extra water infiltrates the soil, the extra amount of water slowly sinks to the further downward in the soil. Nevertheless, some water may stick to particular soil particles. Due to a force called capillary tension it can resist the pull of gravity. The water may remain attached to the soil particles until they either evaporate or are absorbed by other organic materials in the soil. [7]

Water capacity

Soil holds its storage capacity of water when after the soil was saturated all the water has been drained due to gravity and none of the water can move downward anymore. Clay soil has a large storage capacity as soils with finer textures can hold more water. Finer textures can hold this extra water, because finer particles have a larger surface area. Thus, more water can touch more particles and thus the soil can hold more water comparing it to e.g. sand.

The wilting point of a plant, the water storage level below which plants will wilt, also greatly depends on the soil texture. As we know more water is held in soil types with finer textures. As there is more water present in between fine particles the water is also held more tightly. Thus, it is harder for plants to extract moisture from soil types with finer textures compared to more coarse textures. This is mostly because without enough water pressure the turgor pressure of a plant will drop to almost zero, causing the plant to lose almost all the water in its cells. The plant will die shortly.

When we calculate the difference between the storage capacity and wilting point we find the water capacity, which is the maximum amount of water available to plants. [8] [9]

[7] Strahler, A. (2005). Physical Geography. Boston, USA: John Wiley & Sons.
[8] Strahler, A. (2005). Physical Geography. Boston, USA: John Wiley & Sons.
[9] Formation of Clay minerals. (2009, December 31). Retrieved March 17, 2018, from http://nptel.ac.in/courses/105103097/15

Sand

Sand is a common type of soil, that can be found in all sorts of landscapes, from beaches to dunes to deserts. Sand is sedimentary rock that's in its last phase of a long journey of erosion or weathering. These are processes that take place over the course of thousands or even millions of years, in which larger rocks erode or weather into smaller rocks. This process repeats itself to the level of pebbles and eventually, sand.

Sand can be seen as a category of soil, but within this category, there are countless aspects of sand based on which it can be divided into subcategories. These aspects are *colour, grain size, texture,* and *structure*. It should be kept in mind that sand consists of rock, thus taking over some features of the rock it has eroded of weathered from.

<u>Colour</u>

There are many colours in which sand exists. The colour is mainly determined by the elements it contains. A red colour, for instance, can be created by the presence of iron-containing minerals. Black sand as it can be found in Hawaii consists of obsidian that has formed through violent disintegration of fluid rock in contact with water. Blue or green hues can be caused by copper-containing minerals.

The sand we have examined generally has a light brown colour, but when taking a closer look it can be noticed that it consists grains of multiple colours. As the composition of the sedimentary soil that is the sand we examined has formed over a long-time span and over the course of hundreds of kilometres down water streams, the sand carries a relatively wide range of elements (in comparison to for example Hawaiian sand that almost fully consists of obsidian). Thus, it is difficult to accurately determine the mineral composition of the sand we have examined, as many different sorts of rocks have been broken down into the sand grains that the sand consists of now.

<u>Grain size</u>

The grain size of sand varies from 0.05 mm to 2.0 mm. Soil containing grains with a diameter of below 0.05 mm is silt (0.002-0.05 mm) and soil containing grains with a diameter of over 2.0 mm is gravel, but it is debatable whether gravel can be considered soil or not. The grain size affects the soil moisture, because soils with larger grains have more and bigger gaps, thus they are less able to hold water.

<u>Texture</u>

The texture of sand is to be measured on two aspects: angularity and sphericity.[10] These factors are of great significance when it comes to analyzing the soil moisture through the characteristics of the sand. The grain size and the texture of sand altogether determine the flowability of water through the sand and of the sand itself. The flowability of water through the sand is an important factor which will be referred to again.

Angularity refers to the extent to which sand grains take an angular shape with sharper edges. Sphericity refers to the extent to which sand grains take the shape of a sphere. (see figure 1)

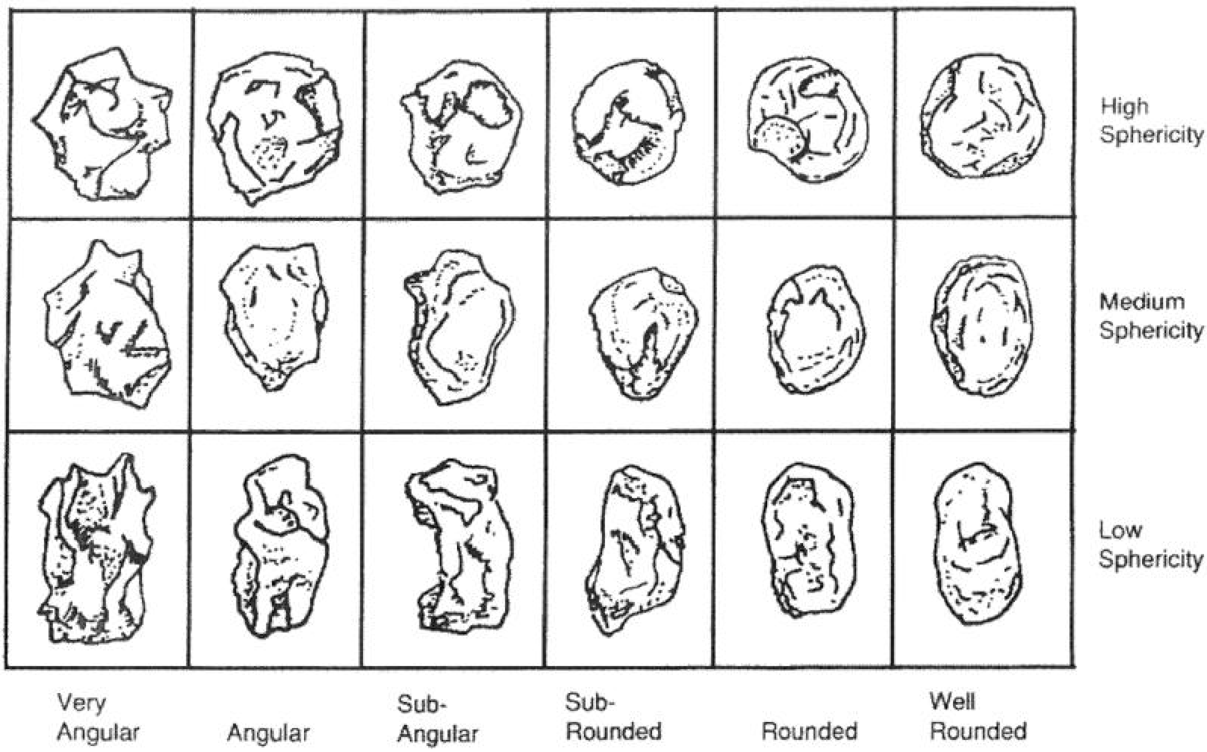


Figure 1 - The high, medium and low sphericity of different sand grain shapes

<u>Structure</u>

Soil structure refers to the way in which soil grains are grouped together into larger masses, called peds. Peds are held together by soil colloids, particles with a surface of negatively charged ions and a layer of positively charged ions held to the surface. Peds can vary in size and give the soil a granular or crumb structure.

As sand consists of relatively large grains, there is little to no formation of peds that take place in sand. Occasionally peds will form, for example on the beach. It creates a “stone” that disintegrates into loose sand when being put under pressure (for example, a child squeezing).

---

[10] SAND, SAND ADDITIVES, SAND PROPERTIES, and SAND RECLAMATION. (N.d.). Retrieved March 24 2018, from http://mimoza.marmara.edu.tr/~altan.turkeli/files/cpt-2-sand_sand.pdf

What mostly differentiates sand from other soil types is the grain size, and thus, the size of the cavities in between the grains. Out of the fact that sand has larger cavities, the conclusion can be drawn that water is held poorly by sand. In fact sand indeed is the soil type with the lowest capability of holding water. It flows right through. [11]

[11] Strahler, A. (2005). Physical Geography. Boston, USA: John Wiley & Sons.

Peat

Joosten and Clarke (2002) defined peatlands or mires (which are the same according to them) in a widely cited article as:

"...the most widespread of all wetland types in the world, representing 50 to 70% of global wetlands. They cover over 4 million square kilometres [1.5 million square miles] or 3% of the land and freshwater surface of the planet. In these ecosystems are found one third of the world's soil carbon and 10% of global freshwater resources. These ecosystems are characterized by the unique ability to accumulate and store dead organic matter from Sphagnum and many other non-moss species, as peat, under conditions of almost permanent water saturation. Peatlands are adapted to the extreme conditions of high water and low oxygen content, of toxic elements and low availability of plant nutrients. Their water chemistry varies from alkaline to acidic. Peatlands occur on all continents, from the tropical to boreal and Arctic zones from sea level to high alpine conditions."[12]

"When decomposition fails to keep pace with the production of organic matter" a dark and fibrous material known as peat is created. Peat is the very first stage in the transformation from plant matter to coal. The conditions required to create peat are quite specific. Nevertheless, peat is found in many types of wetlands, like marshes, swamps, floodplains and coastal wetlands.[13]

Peat is a type of soil in the group of histosols, it is a soil with a thick upper layer which is very rich in organic material as it is mostly an accumulation of organic matter or decayed vegetation. Soil that mainly consists of organic matter contains the elements, but isn't limited to, carbon, nitrogen, phosphorus, sulphur, hydrogen and oxygen. A quintessential property of soil organic matter is that it has the ability to absorb and hold a tremendous amount of water. The mass and volume of the water to be absorbed by soil organic matter often passes the mass and volume of the soil organic matter itself.[14]
The porosity of peat is furthermore relatively small, this is one of the reasons it can hold water rather well.

---

[12] Joosten, H., & Clarke, D. (2002). Wise Use of Mires and Peatlands: Background and Principles including a Framework for Decision-Making. Retrieved from http://www.peatsociety.org/sites/default/files/files/WUMP_Wise_Use_of_Mires_and_Peatlands_book.pdf
[13] Finlayson, M., & Moser, M. (n.d.). What is Peat? Retrieved March 24, 2018, from https://www.uow.edu.au/~sharonb/wingecarribee/peatlands/what.html
[14] Scharf, R. (n.d.). Soil Composition and Formation. Retrieved March 22, 2018, from https://webapp1.dlib.indiana.edu/virtual_disk_library/index.cgi/4928836/FID1596/html/envicond/soil/slform.htm

What is the relationship between humidity and the soil moisture?

First of all, humidity refers to the amount of water vapour in the air. The humidity can both influence the weather and the climate, although it may also influence indoor environments. However, humidity can be described in multiple ways.

Firstly, relative humidity is the amount of water vapour in the air relative to what the air can hold. For example, if a certain parcel of air can hold 50 grams of water vapour per cubic meter of air, but only 20 grams of water vapour is present in this same cubic meter. We can calculate the humidity in percentage by dividing the present amount of water (20 grams) by the total possible amount of water possible (50 grams) and then multiply it by a 100. So in this case $\frac{20}{50} \times 100 = 40\%$.

Relative humidity can also be influenced by the temperature of the air. The relative humidity of cold air is higher compared to warm air. The warm air expands; thus the same amount of water will give a lower percentage relative humidity. And the cold air compresses, so when the air is colder, the same amount of water vapour will produce a higher relative humidity. This is because we must consider the amount of water vapour relative to what the air can hold and warmer air can hold less water. [15]

<u>But how is the soil moisture influenced by the relative humidity?</u>

First of all, when dew occurs the soil moisture will increase. Due occurs when air that is saturated condenses at ground level. The excess water 'spills over' and therefore builds up on things like leaves, cars and also soil. Due mostly occurs in the mornings, because the air temperature goes down overnight, making it easier for due to occur. And as our measurements were mostly done in the morning our soil moisture was certainly affected by dew.

Besides, a study from 2004 by Sujith Ravi, Paolo D'Odorico, Thomas M. Over and Ted M. Zobeck, also showed the dependency of soil moisture on air humidity. They found out as soil had a higher percentage of clay, soil moisture became more and more dependent on relative air humidity. However, in each soil type they found that soil moisture was indeed affected by the relative air humidity. Therefore, we know that if the air humidity is higher than the soil moisture should also be higher. [16]

[15] Friedl, S. (n.d.). What is Humidity? - Definition, Measurements & Effects. Retrieved April 10, 2018, from https://study.com/academy/lesson/what-is-humidity-definition-measurements-effects.html

[16] Monroe, J. S., & Wicander, R. (2009). The Changing Earth. Michigan, USA: Brooks/Cole.
Ravi, S., D'Odorico, P., M Over, T., & M Zobeck, T. E. D. (2004, May 6). On the effect of air humidity on soil susceptibility to wind erosion: The case of air-dry soils. Retrieved April 10, 2018, from https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2004GL019485

Method

<u>Materials Used</u>

- Rubber mallet
- Spade
- Sampling jar
- Scale
- Drying cup
- Oven
- Spoon
- Oven mitts

<u>Process</u>

The process of taking the samples went as following:
Firstly the soil was cleared of any vegetation or other irregularities by scraping the side of the spade over the soil. Secondly, using a rubber mallet, the sampling jar was hammered until it was entirely in the soil. Thereafter, using the spade, the sampling jar was taken out of the soil and any excess was scraped off. Lastly the sampling jar was closed and taken to the laboratory

After we took a sample we went to the area we had further materials ready and we measured there, before continuing the experiment, the mass of the empty drying cups.

We continued the experiment with the drying process.
The first thing to be done is that the contents of the sampling jar must be transferred into a drying cup using a spoon. Secondly The sample's wet mass must be measured, while still in the drying cup. Thereafter the sample must be put into the oven at 110°C and dry in there for at least 24 hours before being taken out again with the oven mitts. Then the sample's dry mass must be measured, while still in the drying cup. Moreover, the sample has to be put back into the oven at 110°C and dry in there for a few more hours. Lastly the sample has to be taken out again and the sample's dry mass must be measured to verify the first measurement.

Results

With our research we made an attempt in answering the following research question: *In what way is the soil moisture influenced by various circumstances?* To be able to answer this question we formed some sub-questions. For each sub-question we will be pointing out what results are necessary to answer them.

How does soil type affect the soil moisture?
In order to answer this sub-question all of the results are necessary, but only to confirm the researched information on forehand. All the numerical results can be found in the tables and graphs on the following pages, creating a clear overview of all results.

How does precipitation affect the soil moisture?
In order to answer this sub-question the results about the amount of precipitation and the amount of water in the samples are of huge importance. This information can be found in figures 1.2, 2.2 and 3.2, located on the following pages.

What is the relationship between humidity and soil moisture?
In order to answer this sub-question the results about the humidity and the amount of moisture in the soil are of importance. This results can be found in figures 1.3, 2.3 and 3.3, located on the following pages.

In order to answer the main research question we used the answers of the sub-questions and by re-analysing the data we gathered. Therefore all information from the graphs and tables on the following pages has been used.

<u>Table Commentary</u>
For every location, and thus, every different soil type, we constructed a table (as seen on pages 16, 19 and 22) containing all samples' data: the factors we measured per sample that was taken. Vertically, the columns are divided into the eight different samples.
The measured data is horizontally divided into columns.

Firstly, we noted down the *dates* and *times*. These were derived from the satellite overflight calculator, in order to properly provide NASA's SMAP satellite with data that was measured right at the moment of overflight.

Secondly, we noted down the *drying time*. This illustrates for how long the samples were dried in the oven of our school's laboratory. The significance of this data is the assurance that the samples had in fact been dried for long enough. After all, all water had to be evaporated from our sample.

Immediately after that the table shows the *total wet mass* and the *total dry mass* in grams. The word "total" is included in regard to the fact that we weighed the samples in measuring cans that had a mass of its own. Thus, the *mass of the measuring cans* in grams along with their *volume* in milliliters is featured in the table as well.

Subsequently, the *mass of the soil* in grams *before and after drying* is noted down. This is the total wet mass and the total dry mass distracted by the mass of the measuring cans, and thus, the exact mass of the soil samples before drying and after.

Thereafter, the *mass of the water* is included. This data was derived by subtracting the mass of the soil samples before drying by the mass of the soil samples after drying. This method should make sense, as the amount of water that the wet soil contained before the water evaporated was calculated.

With this data we were able to eventually calculate the *water quantity*, or the mass percentage of the water in the soil sample, thus, the soil moisture. This was done by dividing the water quantity by the mass of the soil before drying; and then multiplying the acquired number by 100%.

Furthermore, the *rain in the previous two days* was noted down. We measured this by setting up a measuring cylinder close to the location of sampling, during the two days leading up to the sampling. Next to the amount of rain, the *humidity* at the moment of sampling is included in the table.

The three latest discussed factors - the water quantity of the soil (thus, the soil moisture), the rain in the previous two days and the humidity - were of greatest importance for our experiment, as these factors highly contributed to determining the answer to the main research question.

Lastly, the remarks. We highly value precision and thus we found it important to keep track of the circumstances the soil found itself in at the moment of sampling, as these too can influence the data results.

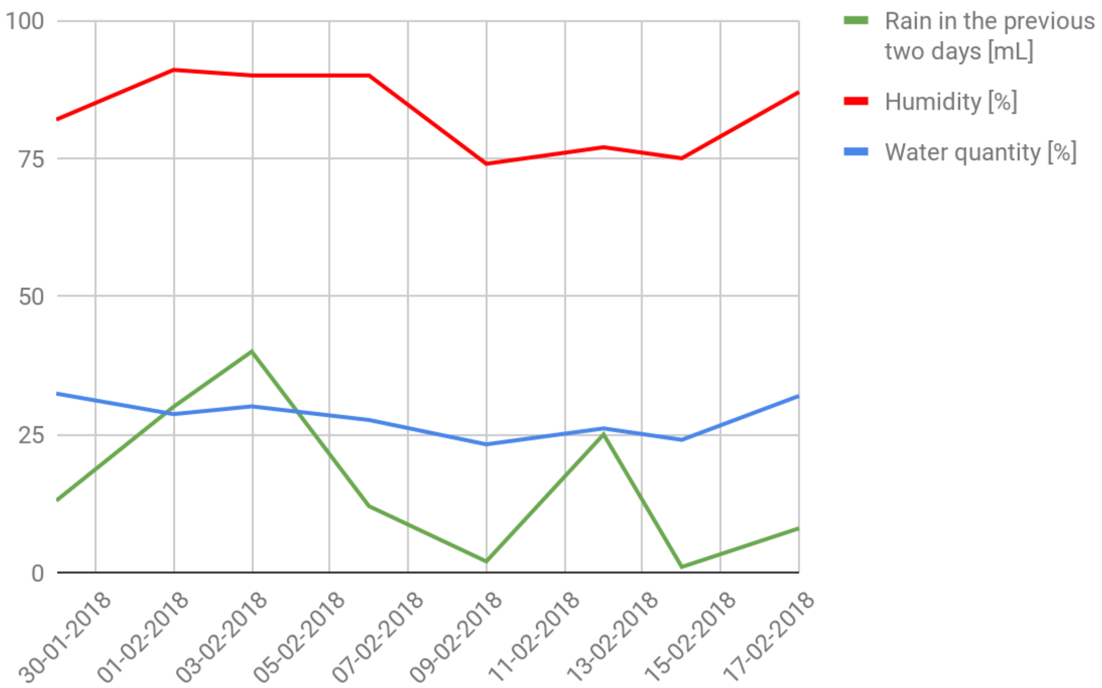
<u>List of measuring locations:</u>

Location Number	Location Name	Soil Type	Latitude	Longitude
1	Dyke	Clay	51.55011	4.34330
2	Hitland	Peat	51.56285	4.36430
3	Nesselande	Sand	51.97421	4.55936

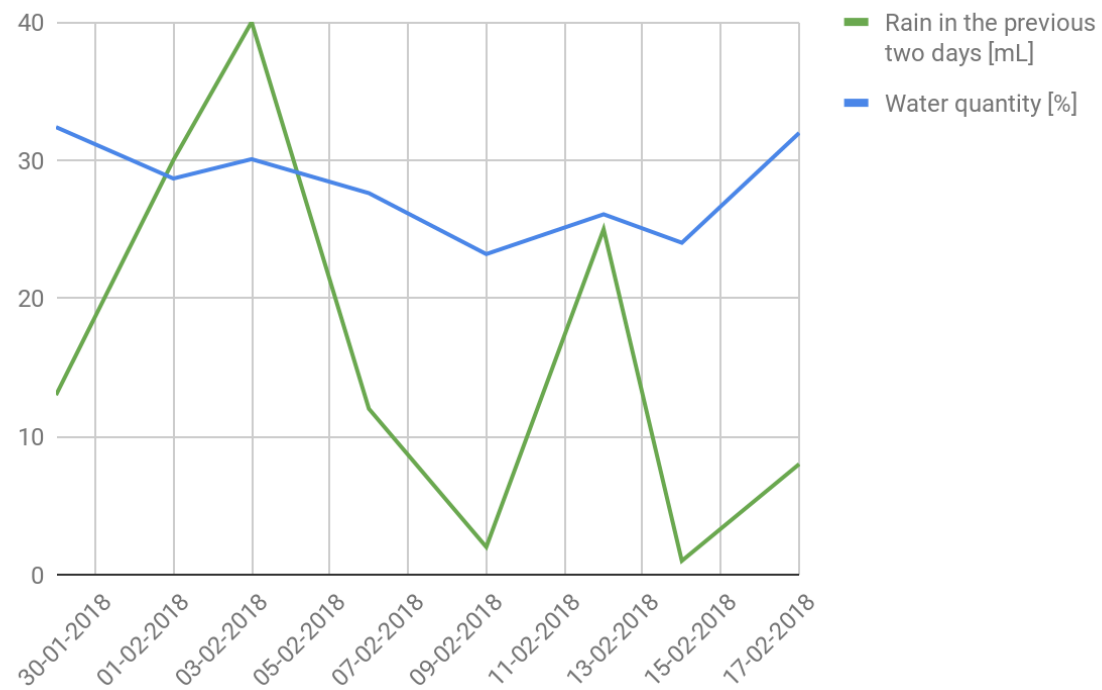
Table and graph numbers correspond to the location number.

Sample Number	Date [dd-mm-yyyy]	Local Time (UTC+1) [hh:mm:ss]	Total drying time [hh:mm]	Total wet mass [g]	Total dry mass [g]	Mass measuring can [g]	Sample volume [mL]
1	29-01-2018	07:15:12	29:41:00	197.6	163.8	82.2	120.0
2	01-02-2018	07:27:32	25:59:00	202.9	168.3	82.2	120.0
3	03-02-2018	07:02:36	25:48:00	246.8	197.3	82.2	120.0
4	06-02-2018	07:15:12	29:30:00	234.3	188.6	68.8	120.0
5	09-02-2018	07:27:32	77:50:00	225.3	192.1	82.2	120.0
6	12-02-2018	07:39:31	25:54:00	263.2	212.5	82.2	120.0
7	14-02-2018	07:15:12	27:39:00	232.9	196.7	68.8	120.0
8	17-02-2018	07:27:32	26:40:00	241.1	190.3	82.2	120.0
Sample number	Mass soil before drying [g]	Mass soil after drying [g]	Mass water [g]	Water quantity [%]	Rain in the previous 2 days [mL]	Humidity [%]	Remarks
1	120.7	81.6	39.1	32.39%	13	82	
2	120.7	86.1	34.6	28.67%	30	91	
3	164.6	115.1	49.5	30.07%	40	90	
4	165.5	119.8	45.7	27.61%	12	90	frozen soil
5	143.1	109.9	33.2	23.20%	2	74	frozen soil
6	194.4	143.7	50.7	26.08%	25	77	
7	150.7	114.5	36.2	24.02%	1	75	frozen soil
8	158.9	108.1	50.8	31.97%	8	87	

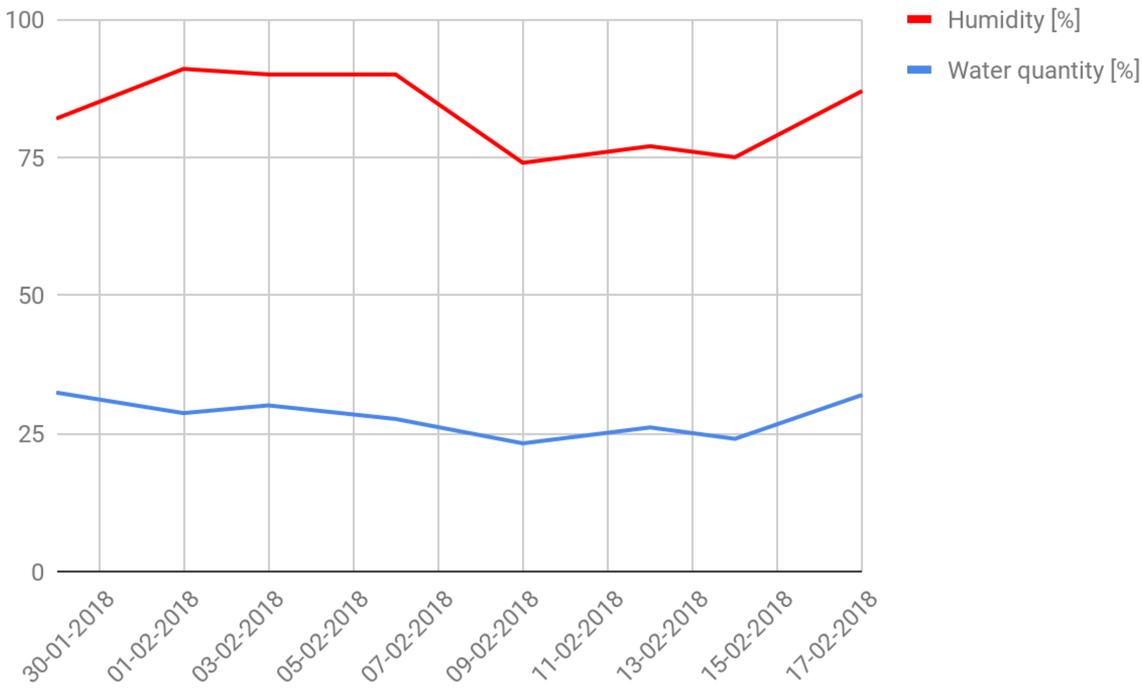
Table 1 - The measurements of the dyke location, clay soil



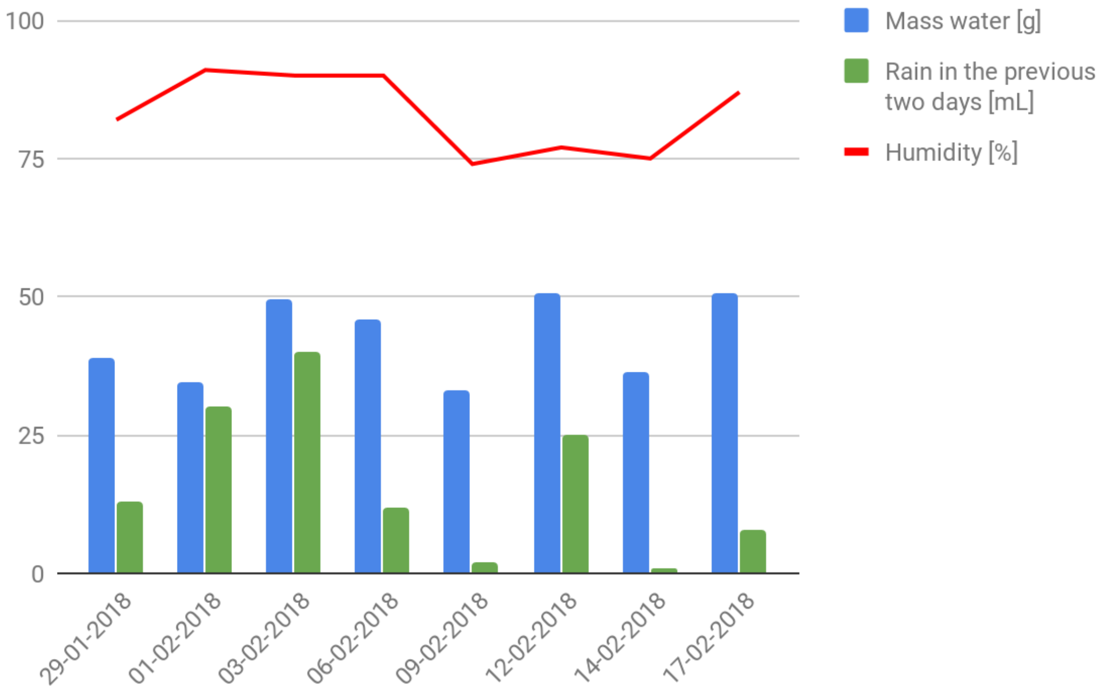
Graph 1.1 - The rain in the previous two days, humidity and water quantity at the dyke location



Graph 1.2 - The rain in the previous two days and the water quantity at the dyke location



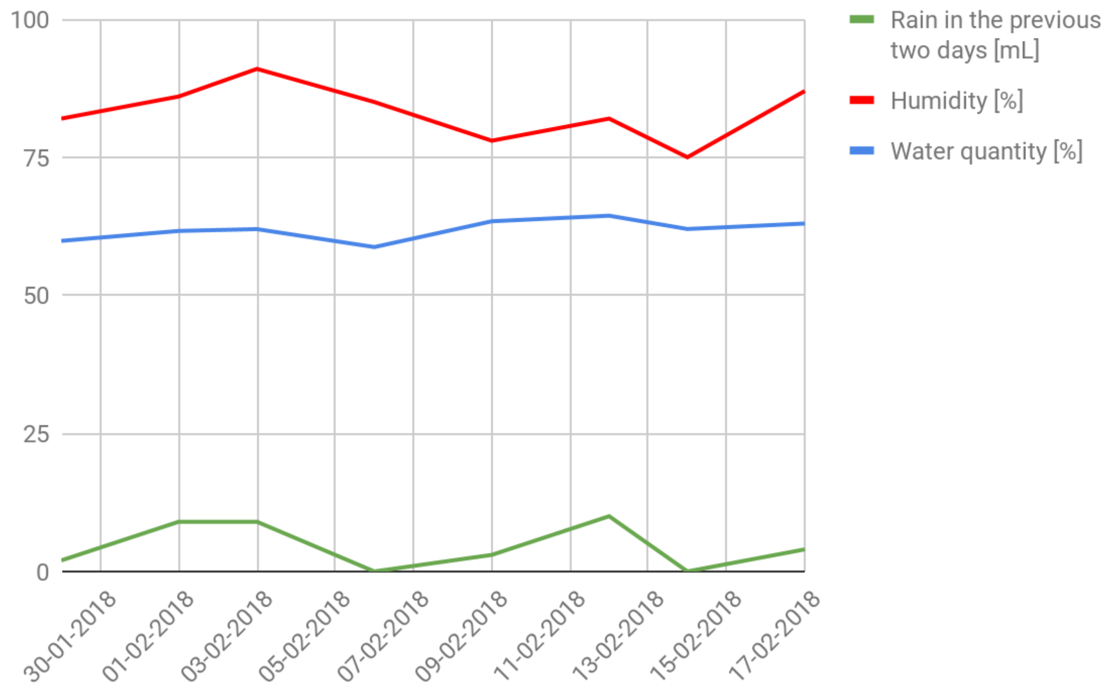
Graph 1.3 - The humidity and water quantity at the Dyke location



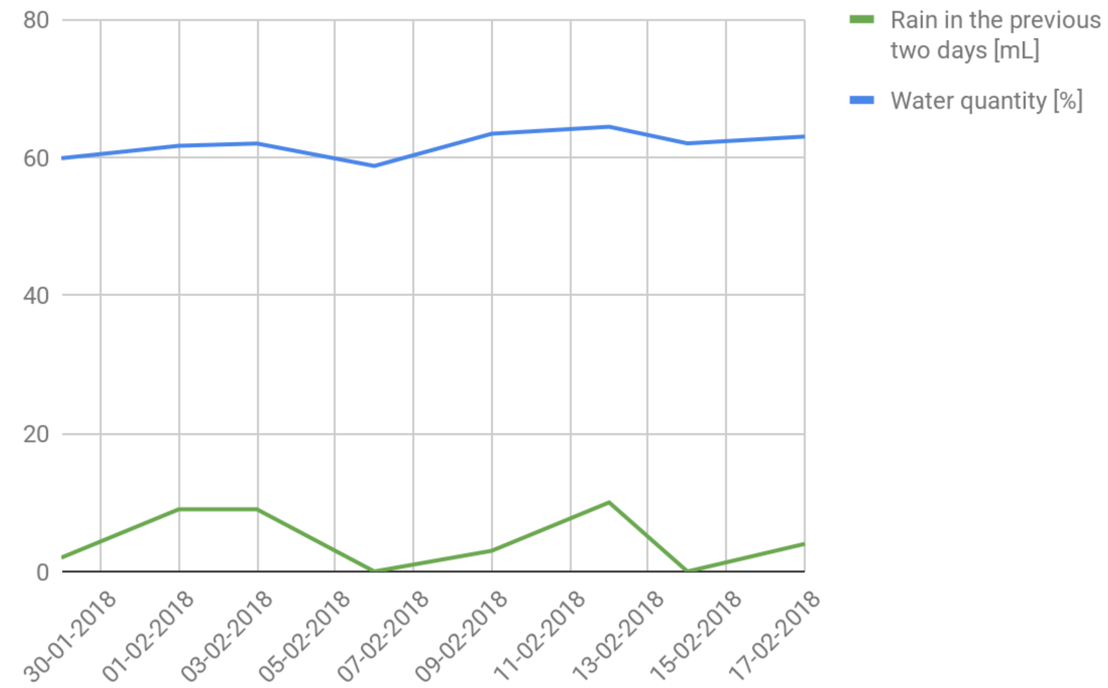
Graph 1.4 - The mass of the water, the rain in the previous two days and the humidity at the dyke location.

Sample Number	Date [dd-mm-yyyy]	Local Time (UTC+1) [hh:mm:ss]	Total drying time [hh:mm]	Total wet mass [g]	Total dry mass [g]	Mass measuring can [g]	Sample volume [mL]
1	29-01-2018	07:15:12	29:41:00	197.5	131.0	86.4	120.0
2	01-02-2018	07:27:32	25:59:00	202.2	130.8	86.4	120.0
3	03-02-2018	07:02:36	25:48:00	196.9	128.4	86.4	120.0
4	06-02-2018	07:15:12	29:30:00	169.2	116.1	78.8	120.0
5	09-02-2018	07:27:32	77:50:00	183.7	122.0	86.4	120.0
6	12-02-2018	07:39:31	25:54:00	202.2	122.7	78.8	120.0
7	14-02-2018	07:15:12	27:39:00	199.6	129.4	86.4	120.0
8	17-02-2018	07:27:32	26:40:00	210.2	132.2	86.4	120.0
Sample number	Mass soil before drying [g]	Mass soil after drying [g]	Mass water [g]	Water quantity [%]	Rain in the previous 2 days [mL]	Humidity [%]	Remarks
1	111.1	44.6	66.5	59.86%	2	82	
2	115.8	44.4	71.4	61.66%	9	86	
3	110.5	42.0	68.5	61.99%	9	91	
4	90.4	37.3	53.1	58.74%	0	85	frozen soil
5	97.3	35.6	61.7	63.41%	3	78	
6	123.4	43.9	79.5	64.42%	10	82	
7	113.2	43.0	70.2	62.01%	0	75	
8	123.8	45.8	78.0	63.00%	4	87	

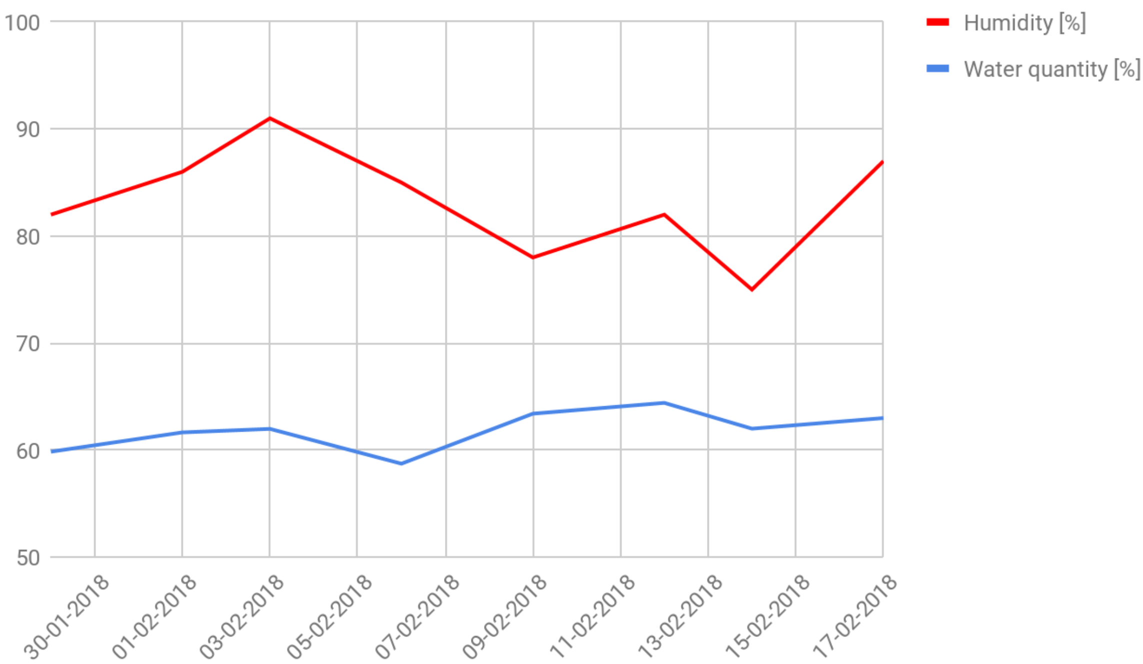
Table 2 - The measurements of the Hitland location, peat soil



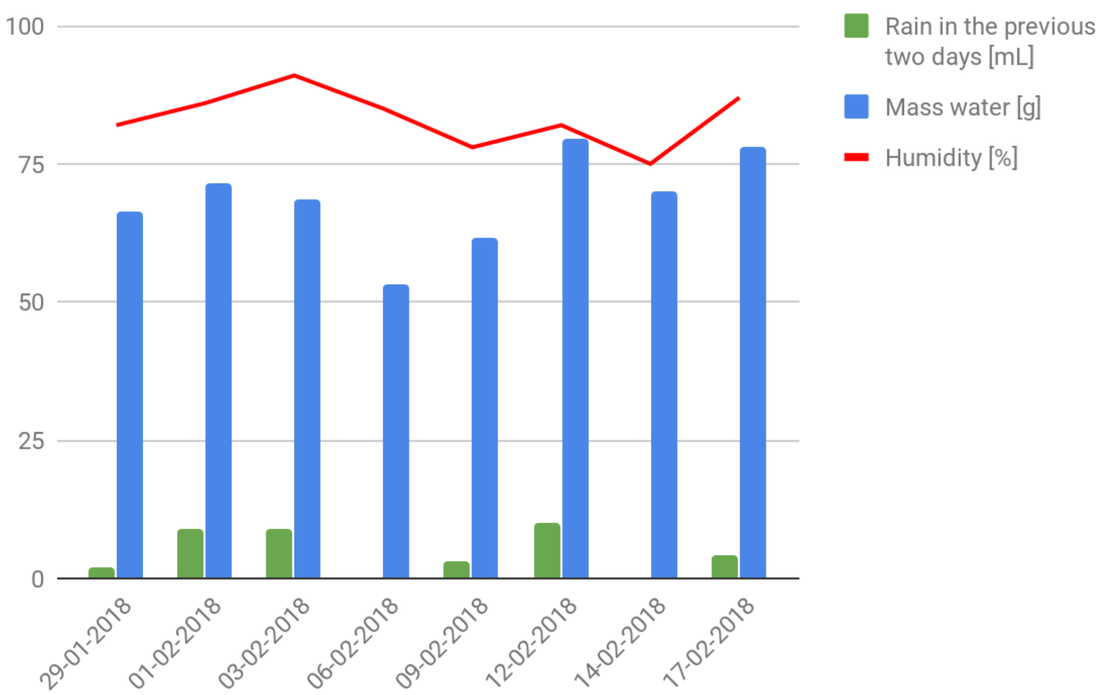
Graph 2.1 - The rain in the previous two days, humidity and the water quantity at the Hitland location



Graph 3.2 - The rain in the previous two days and the water quantity at the Hitland location



Graph 2.3 - The humidity and water quantity at the Hitland location

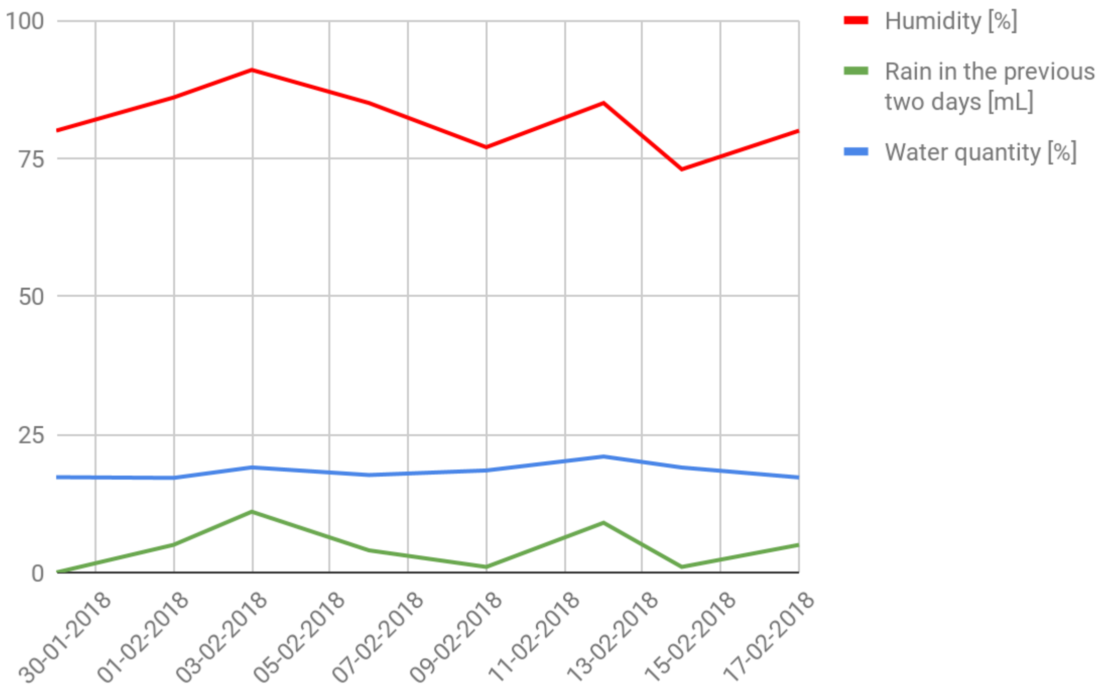


Graph 2.4 - The rain in the previous days, mass of the water and humidity at the Hitland location

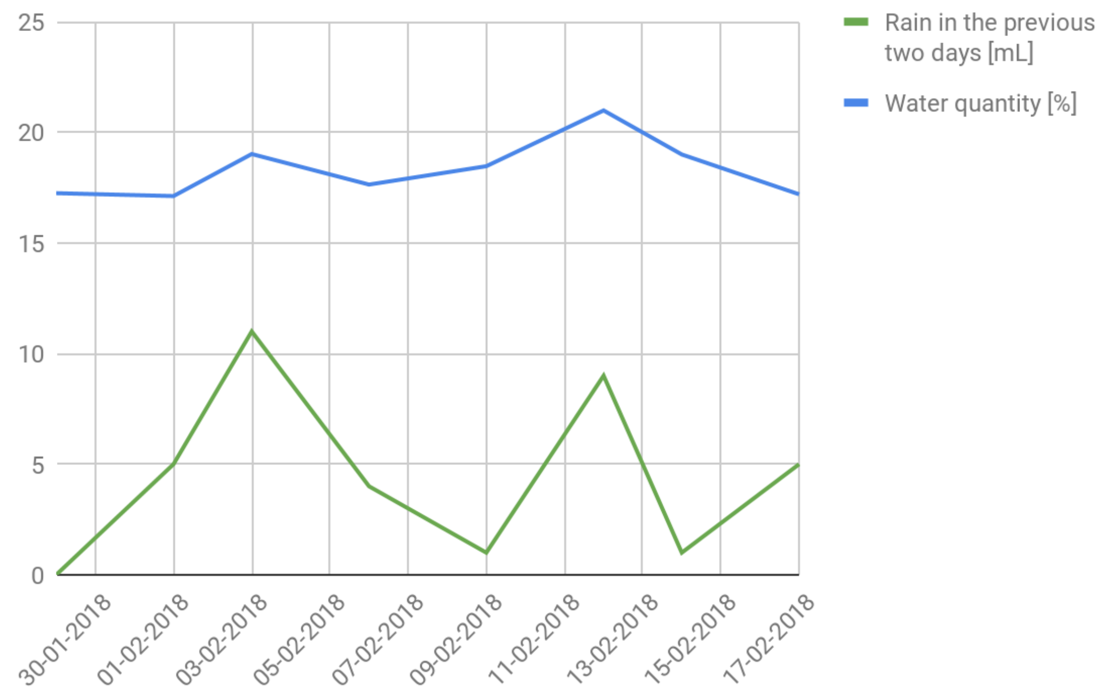
Sample Number	Date [dd-mm-yyyy]	Local Time (UTC+1) [hh:mm:ss]	Total drying time [hh:mm]	Total wet mass [g]	Total dry mass [g]	Mass measuring can [g]	Sample volume [mL]
1	29-01-2018	07:15:12	29:41:00	281.8	247.8	84.7	120.0
2	01-02-2018	07:27:32	25:59:00	329.4	287.5	84.7	100.0
3	03-02-2018	07:02:36	25:48:00	314.5	270.8	84.7	100.0
4	06-02-2018	07:15:12	29:30:00	288.8	250.0	68.8	100.0
5	09-02-2018	07:27:32	77:50:00	289.9	252.0	84.7	100,0
6	12-02-2018	07:39:31	25:54:00	297.5	249.5	68.8	100.0
7	14-02-2018	07:15:12	27:39:00	257.3	224.5	84.7	100.0
8	17-02-2018	07:27:32	26:40:00	308.0	269.6	84.7	100.0
Sample number	Mass soil before drying [g]	Mass soil after drying [g]	Mass water [g]	Water quantity [%]	Rain in the previous 2 days [mL]	Humidity [%]	Remarks
1	197.1	163.1	34.0	17.25%	0	80	
2	244.7	202.8	41.9	17.12%	5	86	it was raining
3	229.8	186.1	43.7	19.02%	11	91	
4	220.0	181.2	38.8	17.64%	4	85	frozen soil
5	205.2	167.3	37.9	18.47%	1	77	frozen soil
6	228.7	180.7	48.0	20.99%	9	85	hail on the soil
7	172.6	139.8	32.8	19.00%	1	73	frozen soil
8	223.3	184.9	38.4	17.20%	5	80	

Table 3 - The measurements of the Nesselande location, sand soil

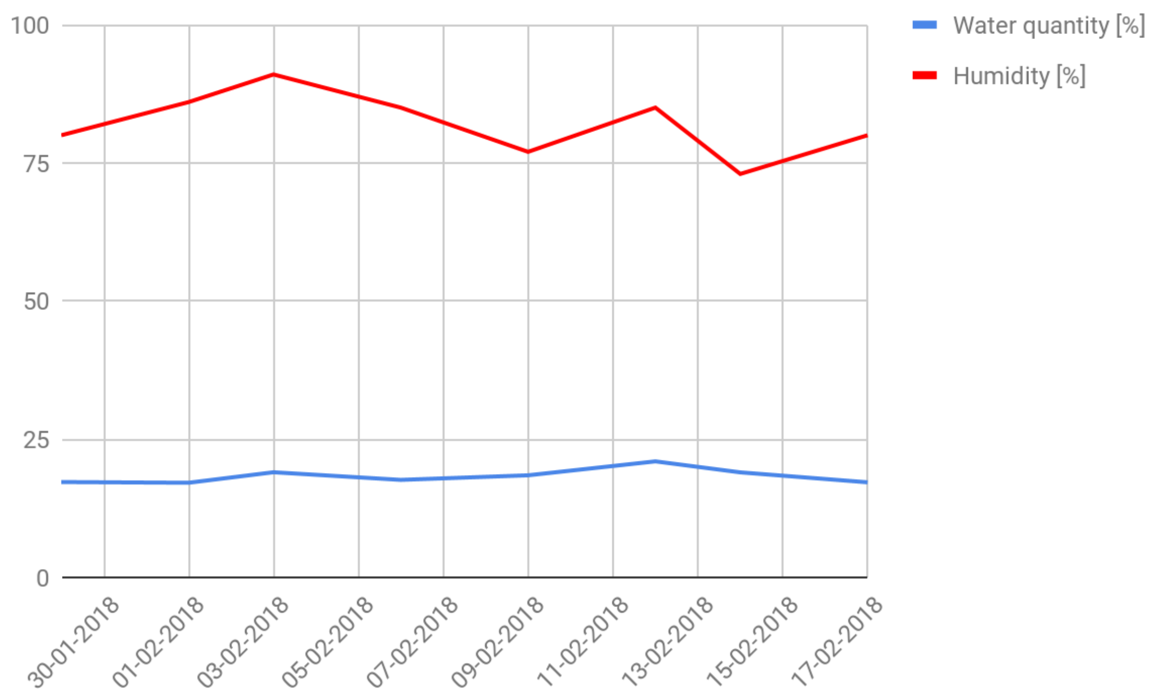
Comenius College



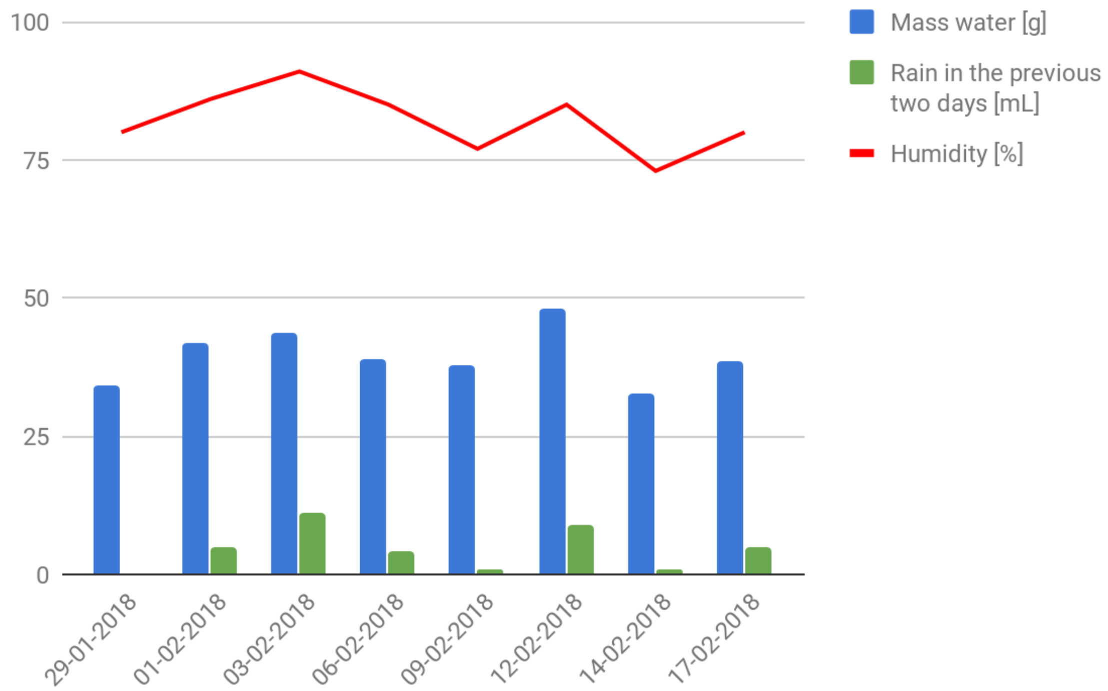
Graph 3.1 - The humidity, rain in the previous two days and water quantity at the Nesselande location



Graph 3.2 - Rain in the previous two days and the water quantity at the Nesselande location



Graph 3.3 - The water quantity and humidity at the Nesselande location



Graph 3.4 - The rain in the previous two days, humidity and mass of the water at the Nesselande location

Conclusion

We aimed to answer the following sub-questions:

- *How does soil type affect the soil moisture?*

With "soil type" we referred to the different properties a soil possesses, which determines the soil's capability of holding water.
First of all, a soil type with larger grains and thus larger cavities, has a lower capacity, as there is more space for water particles to flow freely through the soil grains.
Thus, the larger the cavities between soil particles, the lower the water capacity and the soil moisture. This can be recognized in our results. The soil types in order of grain size or particle size from small to large, is peat - clay - sand.

In *table 2 - The measurements of the Hitland location, peat soil* we can see that the water quantity in the peat soil was around **60%** with every measurement.
In *table 1 - The measurements of the dyke location, clay soil* we can see that the water quantity in the clay soil was around **28%** with every measurement.
In *table 3 - The measurements of the Nesselande location, sand soil* we can see that the water quantity in the sand soil was around **18%** with every measurement.

These results logically correspond with our research on soil properties. They prove that the larger the soil particles, the lower the soil's ability to hold water.

The fact that the water quantities we measured in sand and clay are relatively close to each other in comparison to peat, which water quantity measurements rise much higher, can be explained. Sand and clay are both soils that have formed through the erosion of rock, while the formation of peat is another story: it's formed through the decomposition of plants.

Secondly, the colour of the soil can contribute to the soil moisture, as darker colours absorb more radiation from the sun and, therefore, have a higher temperature in comparison to lighter coloured soils. This contributes to the water capacity of the soil as the higher the temperature of a soil, the more water can evaporate out of it. This factor is rather insignificant, though, in determining the soil moisture.

- *How does precipitation affect the soil moisture?*

Generally speaking we can say that an increase in precipitation also results in an increase in soil moisture. This might be a miniscule or enormous difference, which is influenced by mainly the soil type and the amount of precipitation.

This can be seen in graphs 1.2, 2.2 and 3.2. These graphs show the *rain in the previous two days and the water quantity* at the three measuring locations.

- *What is the relationship between humidity and soil moisture?*

In most situations a higher humidity ensues in an amount of soil moisture superior to the amount of soil moisture when the humidity is lower. This as well can have a minor or huge effect on the soil moisture depending again on the soil type.

This can be seen in graphs 1.3, 2.3 and 3.3. These graphs show the *water quantity and humidity* at the three measuring locations.

To answer our main research question:

- *In what way is the soil moisture influenced by various circumstances?*

We know that the soil moisture is influenced by the air humidity, the precipitation and soil type. In the experiment we carried out these factors were of significant consequence in the soil moisture we measured in every sample. Graphs 1.1, 1.4, 2.1, 2.4, 3.1 and 3.4 clearly visualize the relationship between precipitation, humidity and soil moisture. Generally, the precipitation and the air humidity increased and decreased with an equal ratio. The soil moisture (measured as the water quantity or water mass in the soil) visibly increased and decreased with the precipitation and the humidity.

Discussion

<u>Error assessment</u>

Even though we attempted to minimize errors we unfortunately have some in our process. Firstly, we were unable to dry our samples immediately on the 3rd of February 2018 and on the 17th of February 2018 due to the school being closed and thus there was no access to the oven.

Secondly, the sample volume was different for every location, because two of the original sampling jars were broken after the first measurement. Therefore, we could only reasonably compare the different types of locations when the amount of water was converted into a mass percentage.

Furthermore, the measurements on location 3 (Sand, Nesselande) were taken in a beach-like area. The first measurement may have been too close to the water line. Therefore, the first measurement may be incorrect, due to water from the lake flowing into the soil, manipulating the experiment as the experiment solely focuses on the influence of humidity on the soil moisture.

Moreover, the cylinders used as precipitation measurement devices broke after the second measurement, therefore we had to replace said cylinders. The new cylinders were all a different size; thus the precipitation collection surface varies across measurements, rendering the measurements less accurate.

Finally, the temperature and air humidity were not measured by ourselves, they were adapted from a website, therefore decreasing accuracy.

<u>Further research</u>

In further experiments, the factor climate could also be researched. This would give one an even broader view on the properties of the different soil types. For this the SMAP website could be utilized.

Besides, to expand this research one could also eliminate the influence of precipitation by covering a part of the soil. Thus one could get more information on the influence of air humidity and soil type alone.

Literature

Corboz, Y. (2011). Meteorologie- 100 experimenten om HET WEER te begrijpen... Diemen, Nederland: Veen Magazines.

Esri Nederland. (N.d.). Actueel Hoogtebestand Nederland. Retrieved March 14, 2018, from https://ahn.arcgisonline.nl/ahnviewer/

Finlayson, M., & Moser, M. (n.d.). What is Peat? Retrieved March 24, 2018, from https://www.uow.edu.au/~sharonb/wingecarribee/peatlands/what.html

Formation of Clay minerals. (2009, December 31). Retrieved March 17, 2018, from http://nptel.ac.in/courses/105103097/15

Friedl, S. (n.d.). What is Humidity? - Definition, Measurements & Effects. Retrieved April 10, 2018, from https://study.com/academy/lesson/what-is-humidity-definition-measurements-effects.html

Joosten, H., & Clarke, D. (2002). Wise Use of Mires and Peatlands: Background and Principles including a Framework for Decision-Making. Retrieved from http://www.peatsociety.org/sites/default/files/files/WUMP_Wise_Use_of_Mires_and_Peatlands_book.pdf

Monroe, J. S., & Wicander, R. (2009). The Changing Earth. Michigan, USA: Brooks/Cole.
Ravi, S., D'Odorico, P., M Over, T., & M Zobeck, T. E. D. (2004, May 6). On the effect of air humidity on soil susceptibility to wind erosion: The case of air-dry soils. Retrieved April 10, 2018, from https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2004GL019485

SAND, SAND ADDITIVES, SAND PROPERTIES, and SAND RECLAMATION. (n.d.). Retrieved March 24, 2018, from http://mimoza.marmara.edu.tr/~altan.turkeli/files/cpt-2-sand_sand.pdf

Scharf, R. (n.d.). Soil Composition and Formation. Retrieved March 22, 2018, from https://webapp1.dlib.indiana.edu/virtual_disk_library/index.cgi/4928836/FID1596/html/envicond/soil/slform.htm

Soil Science Society of America. (n.d.). Soil Horizons. Retrieved March 22, 2018, from http://soils4teachers.org/soil-horizons

Strahler, A. (2005). Physical Geography. Boston, USA: John Wiley & Sons.

What is clay? (2010, April 27). Retrieved March 18, 2018, from https://www.sciencelearn.org.nz/resources/1771-what-is-clay