AL1523
Group 2
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Sulfide Soil

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Abstract

Some of the modern world's pressing sustainability problems can potentially be addressed by technology or at least their effects can be mediated through technology. One such issue deals with Sulfide soils that can be found in Northern Sweden and Finland around the gulf of Bothnia. The aim of this project is to provide an easy-to-use tool that helps with the detection of such soils based on imputed soil data. The design process consisted of first understanding the technical tool that was initially provided to us, then choosing the implementation technology, finishing the first draft, adjusting it based on feedback, and then adding minor changes. There were a handful of steps that were taken in the design process but the end result was a technical implementation that met two out of three technical requirements specified by the customer. The implementation can be further refined by adding an option to upload documents with several inputs to be analyzed or adding a map functionality.

1. Introduction with background and problem formulation

A sustainability challenge that exists, but is not as well known as many others, is a problem that arises when soil is not handled thoughtfully. Different areas of nature contain different kinds of soil, and they can react differently when being moved. It is very common to move soil as it is often needed to make room or to use somewhere else, for many different reasons. Although, it is also very common that this is executed without the proper knowledge about how the soil can be harmful to the environment.

One type of soil that is very common in specific areas, is soil that contains microscopic crystals of iron sulfide minerals mentioned in “Acid sulfate soils explained | Environment, land and water.” by the Queensland Government [1]. The soil in itself is harmless and a part of nature, but when disturbed and in contact with oxygen, sulfuric acid is released into the environment. This causes damage to both the environment and mainly aquatic life, but also to metals and therefore buildings and structures. Even a small increase in acidity in nature will impact all life in water, and lead to a higher death rate and possible extinction in the long run.

Acidity also is not the only toxic waste that comes from disturbing sulfide soil. Multiple metals are released with the oxidation of the sulfite, such as iron and aluminum. Both of these have severe consequences on the environment and can be toxic to many different life forms.

In Sweden sulfide soil mainly exists along the Norrlands coast and along Mälardalen. Sulfide soil is also found in other places around Sweden, however, it is often named mud clay and the soil contains other properties mentioned in Sulfidjord (Greencard) [2]. Additionally, sulfide soil exists along the Finland coast and in other places around the world. There currently exists an enormous uncertainty regarding sulfide soil and how it is classified and managed. This leads to big operations such as Trafikverket, as well as consults and entrepreneurs having trouble managing the problem.

1.1. Sulfide soil as a sustainability problem

Today piling, stabilization or excavation and removal are done to provide a stable foundation. Sulfide soil has a poor tendency to settle and gives poor bearing capacity. However, if the soil contains high levels of sulfide soil when excavating occurs it could lead to acidification of the surface and groundwater. As a consequence, it leads to increased levels of aluminum which causes damage to aquatic organisms and the destruction of vegetation mentioned in “Selektiv hantering av sulfidjord” [3]. Sulfide soil could lead to corrosion of infrastructure.

From an economic and environmental perspective without the knowledge and possibility to decide in place if the soil contains sulfide or not, large volumes of sulfide soil are unnecessarily disposed of with long transports. Transport provides a negative effect on the climate due to increased carbon dioxide emissions.

Furthermore, there is no existing fast and easy-to-use technology solution to manage and calculate if the soil contains sulfide or not. There is an urgent request for comprehensive ICT solutions. Partly in which to accurately detect and monitor sulfide soil. There is currently a need for increased knowledge and information for stakeholders/clients on sustainability practices for mitigating the impacts of sulfide soil.

How can an ICT solution be developed to easily detect sulfide soil and in addition make the technology solution easy to utilize and increase knowledge about sulfide soil for the stakeholders?

1.2. Background about the company Ecoloop

Ecoloop is a small company based in Sweden and Norway. It started as an environmental engineering and tourist organization in 2002. In 2004, the name changed to Ecoloop and their work shifted primarily to developments within civil engineering. Together with Luleå technical university, they have developed the website Optimass. Optimass is primarily used as a helpful tool to locate nodes, propose efficient transport and logistics solutions, optimize recycling and reuse, and make climate, energy and disturbance analyses and market studies or thematic additions to region and overview plans mentioned in “Masshantering - Ecoloop” by the company Ecoloop [4]. This is the website where our application tool will later be accessible.

On their website, it is explained that their vision is a society with a supply system that preserves and regenerates resources. Their mission is to challenge change by driving development for sustainable use of water, materials and energy. In Sweden there is a negative trend with the United Nations' goal ‘’ecological sustainability and climate’’, this is what drives Ecoloop’s work. Ecoloop’s use of resources is a strong contributing factor to our ecological footprint. They provide useful help to key actors to ensure that they work together around resource management in civil engineering. The help Ecoloop offers is:

- Process management and innovation support, Project management and leading expertise for analyzes and investigations.
- Communication strategists and support and assist their clients with strategies, plans and implementation of activities.

Optimass does not yet have a tool to calculate sulfide soil in the ground. However, there is an existing complicated and ineffective excel tool that only Ecoloop workers have access to. There is a need to develop a smart, easy and effective tool. The development of such a tool will lead to key actors and consults being able to easily access this by themself directly on the website. This new tool solution will hopefully save time and money for both the clients and Ecoloop workers. From our research, we have not found any similar website or tool about this subject since the problem of sulfide soil is not well known.

1.3. The current classification of sulfide soil

Sulfide soil is currently being classified into seven different classes with a range from not acidifying soil to high acidification potential. How it is classified is assessed by means of soil analyses from labs with regard to the contents of iron, calcium, sulfur and the earth's pH. The test answers from the lab analysis provide information on how to determine which soil it contains on a scale. The process is then evaluated by an excel-based assessment system with a number of inputs, such as the content of sulfate, iron, calcium and two pH measurements. The excel tool delivers what kind of sulfide soil exists in the examined soil to the clients mentioned in "Selektiv hantering av sulfidjord." [3]. However, this solution is time-consuming and expensive for clients. In the future, the goal is to be able to classify sulfide soil directly in a place and reutilize sulfide soils without endangering the environment.

Table 1: The seven different classes of classifying soil. [3]

A0	No sulfide soil	No special restrictions. Can be used as building soil.
A1	Negligible risk of acidification	No special restrictions. Can be used as building soil.
B and C	Sulfide soil. Low risk of acidification.	The acidification risk is assessed as small. The soil must be covered with other soil, so that it is not directly exposed to air. Covering soil must have such properties that dry cracks do not occur.
C2, D1 and D2	Sulfide soil with low buffering capacity. High to very high risk of acidification.	The soil is managed as sulfide and sulfate soil with a high risk of acidification. Cover with 0.5m of soil with such properties that dry cracks do not occur.

2. Aim and objectives

The aim and objectives section of this report outlines the goals and purpose of the project which is to create a website version of Ecoloop's sulfide soil detection excel tool. The aim of the project is to increase the accessibility and usability of the tool, making it available to a wider range of users. The project will be designed to collect user input, feedback and improve the accuracy of the tool.

2.1. Aim/Purpose

The purpose of this project is to improve the accessibility and usability of Ecoloop's sulfide soil detection excel tool by creating a website version. The aim is to make the tool available to a wider range of users, including those without expertise in excel. The development of this website will not only increase the tool's accessibility but will also enhance user experience and improve overall efficiency. This project will serve as a platform to collect user input and improve the accuracy of the tool.

The project's overall objective is to broaden the usability and efficiency of Ecoloop's sulfide soil detection tool. Users will be able to input their soil measurements on the website and get a clear, understandable result. Because of this more individuals are expected to use the tool which will increase the awareness of sulfide soil and its possible risks. The overall goal of this project is therefore to provide easily available tools for soil analysis to benefit the environment and promote sustainability. Because of this, the users will be able to make informed decisions about how to manage their soil and take steps to promote sustainability. The tool will help to identify areas where sulfide soil is present, allowing users to take action to reduce the impact on the environment

<u>Concrete Objectives / Goals</u>

1. Create a website that allows users to input soil metrics and receive a clear result indicating if the soil is sulfide or not.
2. Ensure the website is user-friendly and accessible to individuals with little to no expertise in excel or soil analysis.
3. Collect user data and feedback so that in the future the data can be used to fine-tune the tool's algorithms for soil detection.

<u>Long-Term Objectives / Goals</u>

1. To enhance the sulfide soil detection tool's precision using the user data and feedback gathered, enabling better decision-making with regard to the soil.
2. To expand the tool beyond sulfide soil detection to include other tools for soil analysis that promote sustainability in other areas.
3. To contribute to the development of sustainable practices and environmental protection by providing users with the resources and knowledge to make informed decisions about soil management.

2.2. Future Proofing

Because the sulfide soil detection tool will exist in just one location as a website, there will not be multiple versions of the tool floating around in Excel spreadsheets. This means that Ecoloop can focus on managing just one version of the tool and ensure that all users have access to the most up-to-date and accurate version of the tool. By centralizing the tool in one location, Ecoloop can easily update and modify the tool as needed, without worrying about the confusion of multiple versions.

Furthermore, the project will be designed in a way that allows for the addition of other tools besides sulfide. By designing the website to be a scalable and modular approach, additional tools can be added to promote sustainability in other areas. This will give Ecoloop a platform to develop and introduce new tools as required, ensuring that the website stays relevant and beneficial to its users. The future-proofing measures implemented in this project will ensure that the sulfide soil detection tool remains a valuable resource for years to come.

3. Project Design

3.1. Project Information

When familiarizing ourselves with the issue of Sulfide soils as well as the company. The process of researching the issue was done with the help of Google scholar in parallel with other academic online search engines as well as standard online search engines. The standard online search engines were used for getting a holistic hawk-eye view of the issue and academic sources were used for getting more specific information.

After the group had gotten a better understanding of the existing problem and a detailed description of the requirements of the project it was then time to start researching the technologies which would be relevant to this innovative solution.

3.2. Understanding the excel document

In order to properly understand the problem at hand, we got a technical demonstration of the current version of the tool which is implemented in Microsoft Excel (Figure 1,2). This was done in the first supervision meeting in which both the environmental problem that this program that was at the time implemented tried to solve. The environmental problem at hand was sulfide soils in areas of northern Sweden and Finlands such as in Haaparanta, and this piece of software would allow one to quickly classify whether a sample is a sulfide soil. This is done based on eight different measurement inputs that produce a classification output. The back-end also needed to be simple and lightweight and so the choice was made to use Google's Firebase. Moreover, hosting this database is free.

Kontroll A0-D2	KontrollD2-A0	Logisk test	Beskrivning/klassning av jorden (auto)	Gränszon mellan A
B) Sulfidjord låg försurningsrisk	B) Sulfidjord låg försurningsrisk	OK	B) Sulfidjord låg försurningsrisk	-
A1) Sulfidjord med försumbar försurningsrisk	A1) Sulfidjord med försumbar försurningsrisk	OK	A1) Sulfidjord med försumbar försurningsrisk	-
A1) Sulfidjord med försumbar försurningsrisk	A1) Sulfidjord med försumbar försurningsrisk	OK	A1) Sulfidjord med försumbar försurningsrisk	-
#N/A	#N/A	#N/A	#N/A	#N/A
#N/A	#N/A	#N/A	#N/A	#N/A
#N/A	#N/A	#N/A	#N/A	#N/A
#N/A	#N/A	#N/A	#N/A	#N/A
B) Sulfidjord låg försurningsrisk	D1) Sulfidjord utan buffringsförmåga, hög försurningsrisk	Gränszon	Kontrollera (gränszon)	B) Sulfidjord låg försurningsrisk
B) Sulfidjord låg försurningsrisk	B) Sulfidjord låg försurningsrisk	OK	B) Sulfidjord låg försurningsrisk	-
B) Sulfidjord låg försurningsrisk	D1) Sulfidjord utan buffringsförmåga, hög försurningsrisk	Gränszon	Kontrollera (gränszon)	B) Sulfidjord låg försurningsrisk
A0) ej sulfidjord	C1) Sur sulfatjord låg försurningsrisk	Gränszon	Kontrollera (gränszon)	A0) ej sulfidjord
A0) ej sulfidjord	C1) Sur sulfatjord låg försurningsrisk	Gränszon	Kontrollera (gränszon)	A0) ej sulfidjord
C1) Sur sulfatjord låg försurningsrisk	C1) Sur sulfatjord låg försurningsrisk	OK	C1) Sur sulfatjord låg försurningsrisk	-
C1) Sur sulfatjord låg försurningsrisk	C1) Sur sulfatjord låg försurningsrisk	OK	C1) Sur sulfatjord låg försurningsrisk	-
C2) Sur sulfatjord med försurningsrisk	C2) Sur sulfatjord med försurningsrisk	OK	C2) Sur sulfatjord med försurningsrisk	-
C2) Sur sulfatjord med försurningsrisk	C2) Sur sulfatjord med försurningsrisk	OK	C2) Sur sulfatjord med försurningsrisk	-
C2) Sur sulfatjord med försurningsrisk	C2) Sur sulfatjord med försurningsrisk	OK	C2) Sur sulfatjord med försurningsrisk	-
C2) Sur sulfatjord med försurningsrisk	C2) Sur sulfatjord med försurningsrisk	OK	C2) Sur sulfatjord med försurningsrisk	-
D2) Sulfidjord utan buffringsförmåga, mycket hög försurningsrisk	D2) Sulfidjord utan buffringsförmåga, mycket hög försurningsrisk	OK	D2) Sulfidjord utan buffringsförmåga, mycket hög försurningsrisk	-

Figure 1: The result of the inputted soil metrics

Lokal	Id3	Djup	Jordart	S (mg/kg T S)	Ca (mg/kg TS)	Fe (mg/kg T s)	Fe/S	Ca/S	pH(init)	pH(ox)	A0) ej sulfidjord	A1) Sulfidjord med försumbar försurningsrisk	B) Sulfidjord låg försurningsrisk	C1) Sur sulfatjord låg försurningsrisk	C2) Sur sulfatjord med försurningsrisk	D1) Sulfidjord utan buffringsförmåga, hög försurningsrisk	D2) Sulfidjord utan buffringsförmåga, mycket hög försurningsrisk
'est Uppsal	Torrskorpa	0,5-1,0	suSi	1900	5000	41000	21,6	2,6	7,3	5,2	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
'est Uppsal	Mättad zon	2,0-4,0	suSi	1010	8470	41400	41,0	8,4	7	6,5	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
'est Uppsal	Mättad zon	2,8-4,0	suSi	1150	9470	41600	36,2	8,2	6,6	6	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
'est Uppsal	Mättad zon	0	suSi	6000	27000	35000	5,8	4,5	8,9	0	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
'est Uppsal	Mättad zon	3,8-5,0	suSi	6000	34000	32000	5,3	5,7	8,8	0	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
'est Uppsal	Mättad zon	2,0-3,0	suSi	7900	41000	35000	4,4	5,2	8,8	0	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Umeå	1,1 0,5-1m	0	0	2200	961	6410	2,9	0,4	7,1	6,9	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Umeå	22	3,0-4,0	Le	1910	4860	26800	14,0	2,5	8	8	FALSE	FALSE	TRUE	FALSE	FALSE	TRUE	FALSE
Umeå	NB18	2,5-2,6	0	969	2200	8680	9,0	2,3	6,2	6,2	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
Umeå	NB2	3,0-4,0	0	2410	5470	29100	12,1	2,3	6,2	6,2	FALSE	FALSE	TRUE	FALSE	FALSE	TRUE	FALSE
Umeå	50	0,0-1,0	siLe(t)	536	3810	31600	59,0	7,1	5	4,9	TRUE	TRUE	FALSE	TRUE	FALSE	FALSE	FALSE
Umeå	54	0,0-1,0	Le(t)	397	3550	36500	91,9	8,9	5	4,9	TRUE	TRUE	FALSE	TRUE	FALSE	FALSE	FALSE
Umeå	0	1	0	243	1230	11500	47,3	5,1	4,5	4,5	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
Umeå	0	1	0	570	3320	28400	49,8	5,8	4,7	4,7	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
Umeå	7	1,0-1.5	gyLe	6600	4360	34800	5,3	0,7	5	5,1	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE
Umeå	38	0,5-1,0	gyLe	12000	5210	30300	3	0	5,6	5,4	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE
Umeå	0	2,5	0	10600	2650	26700	3	0	4,7	4,7	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE
Umeå	0	1,5	0	12700	3560	35100	3	0	4,5	4,5	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE
Umeå	NB1	1,8-3,0	0	11800	5140	26600	2	0	6,2	6,2	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE

Figure 2: Input section of the excel document

3.2. Choice of implementation technology

The second step in the development of this project was researching the available technologies in this area and selecting the one which suits our needs the best. It was evident that the tool would need to be a relatively lightweight tool that would run a web browser.

As a result, we ended up with a handful of candidates who were most applicable to our situation. Firstly, we needed a front-end user interface. Technologies for this purpose were Vue, React and Angular. Upon closer consideration, we decided to choose React with Typescript. This was due to it giving us the ability to construct a simple application very quickly.

3.3. First prototype

Having now understood the main principle behind the classification, it was now time to start prototyping the software itself. The very first prototype was a graphic Figma diagram. In it, one could see what the graphical user interface would look like, including the text, as well as the inputs. This prototype can be seen in Figure 3.

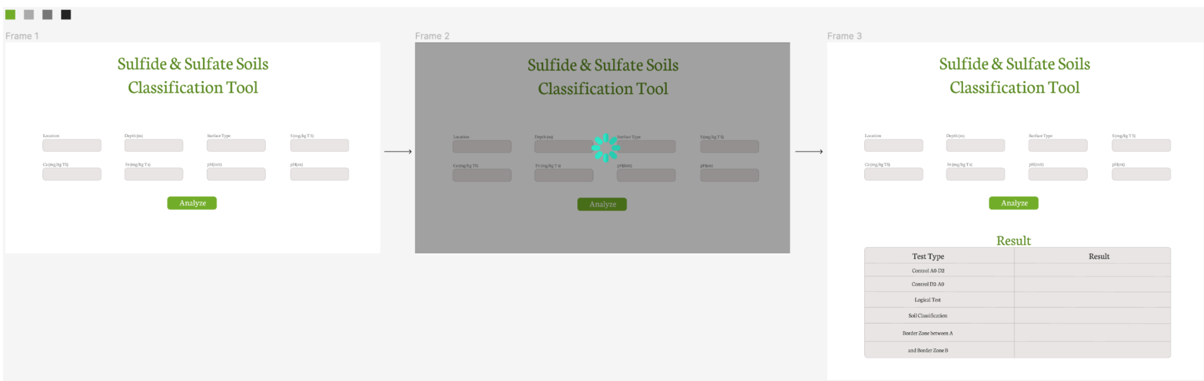

Figure 3: Figma designs as a first prototype

3.3. Development with design with feedback and improvements

Upon finishing the first demonstration, the next step was to translate this graphical prototype into a functioning piece of software in React. The process did not take long and the most time-consuming part was implementing the edge cases in classification logic. Having now completed the first actual functioning it was then time to meet with Ecoloop and get feedback on it. There were no major flaws in the first version and the feedback consisted mostly of minor tweaks that in themselves were not too time-consuming. It was mostly about removing the first three indicators from the output, changing the entire website's language to Swedish, allowing inputs of more than 10 samples, and connecting the front-end to a back-end database (Figure 4).

Figure 4: Final design of the application after the feedback

3.4. Final minor fixes

On the 21st of February it was time to present the final result of our work. We presented the work and the company staff was pleased with it. The minor tweaks we needed to implement were that we added a condition that would only allow a user to get results once we input in all fields of data (especially location) as well as a disclaimer that says that this is only an assessment and that the final decision is to be made by the user about the quality of soil

4. Results

In this section, we present the results of our project to create a tool for simplifying the classification of sulfide soil. The goal of the project was to develop a user-friendly and widely available tool that would make the process of classifying sulfide soil easier and more efficient. Mainly for the collaborating company Ecoloop, but also for geologists and other experts in the field. To achieve this goal, we used functionality developed by Ecoloop, defined in an excel sheet. The project resulted in a website, available for the public on optimass.se.

We had three concrete goals with the project, let us go through them in order.

1. Create a website that allows users to input soil metrics and receive a clear result indicating if the soil is sulfide or not.
2. Ensure the website is user-friendly and accessible to individuals with little to no expertise in excel or soil analysis.
3. Collect user data and feedback so that in the future the data can be used to fine-tune the tool's algorithms for soil detection.

4.1. Clear indication of soil type

The user of the website has made a lab analysis on the soil that should be classified. The lab results are in the form of different levels of indicators, such as iron level and pH level. The next step is to classify the soil based on this data, using the website-based tool. The tool takes the input, performs calculations and classifies the soil. The result is presented to the user in the form of a table, where the soil is put in category A and another category B, with their definitions presented in the table. Getting a letter-designation for the soil with a definition is as clear as it gets. It gives a precise indication of whether the soil should or should not be handled with care and allows the user to take appropriate actions. Some parameter inputs, however, can result in soil that cannot be classified to be in a single category. In such a case it is labeled as in-between two categories. This is of course not as clear, but is an unavoidable result of the current classification method. Further research and development on how to classify soil might improve upon the ambiguity of these cases. With the current classification system as it is, the results are shown as clearly as possible.

4.2. Focus on user friendliness

User friendliness was another of the goals for the project. To achieve it, the design was focused on simplicity and matching the existing design on optimass.se. This resulted in a straightforward user interface where the user can simply enter the data into the labeled fields, and press analyze to get the result. It is hard to imagine a more user-friendly system. Perhaps being able to directly upload the lab results to get the classification of the soil would be a way to make it easier, but as far as manually entering values goes, it is as simple as it gets. The design is made to work and be easy to use on both desktop and mobile, and to fit any display size. The result is printed in the form of a table that clearly tells the user about the soil and eventual exceptions. The tool is very easy to use and will not require any technical skills, which was one of the problems with the excel based tool.

4.3. Data collection

Part of the goal for the project was to have the user data collected for the purpose of making improvements and adding functionality to the algorithm to make it more accurate. The data collection should have been stored in a database that Ecoloop would have, and manage.

4.4. Overall result

Overall, our results indicate that the tool we developed is a practical and efficient method for classifying sulfide soil. The high simplicity of the model, combined with the ability to classify soil based on multiple properties, makes the tool an excellent tool for Ecoloop and other possible users. Furthermore, the user-friendly interface and ease of use of the tool make it accessible to a wide range of users, including those without extensive experience in soil classification.

5. Discussion

So to what extent were the goals met? Could something have been done better? What impact will the project have? And what can be done to improve the tool in the future? There is much to discuss. Let us begin with the goals and future development of the website.

5.1. Reflection on Goals and Future work

As stated in the result section two out of three of the concrete goals set were met. We have made the tool for classifying sulfide soil clear and easy to use. But the implementation of a database was not. In the future, there are various functions that could be implemented on the website-based tool to increase the functionalities, and usage of it and collect more substratum/information data about sulfide soil in Sweden.

Firstly, the goal that was not met, be able to save information in a database, so the owner of the website would be able to see all the samples of measurement values and the location. Our contact person at Ecoloop asked us in the late middle of the course if it is possible to add a function to save data. This function implicates connecting the website-based tool to a database. Unfortunately, we did not solve this problem because of the time limitation of the course and the complexity and uncertainty of accessing their database to investigate the possibility of connecting it to the website-based tool.

The future goal of this website-based tool is to implement this function of a database and be able to save measurement values from clients and the place of the measurement. This function could be helpful in a way to have all measurements collected at the same place and additionally, to get a greater overview of where sulfide soil exists. An additional thing to elaborate on is to have a map function based on previous measurements inserted into the tool. Mainly to get an overview both for clients and owners of where different soils exist in Sweden and especially sulfide soil. Also, if clients were able to directly see on a map the different contents of soil, it could lead to less unnecessary transport and a decreasing effect of carbon emissions. However, a map function can be added only if the website-based tool is connected to a database. Thus we need to have the saved measurement and the map function connected. Also, there is a problem to be solved on which measurements on the website-based tool will be added to the map function. If all the measurements that will be admitted and tested on the website-based tool are directly added to the map function there will be both unreliable data/measurements on the map function as well as possible duplicated shown measurements. A not-so-effective possible solution is the owner will have to accept all the income measurements and manually decide which are reliable and will be added to the front-end map function.

Secondly, being able to directly upload documents with many measurement values on the website-based tool would be more effective and easy to use for clients. Thus clients will not need to add the measurements manually on the website-based tool if there are many measurements. However, we encountered challenges that led us to decide not to implement this function. The labs' providing the measurements of the soil could have different formats on the documents. The probability is high that the tool will take the wrong measurement values and not be able to detect them due to the different formats on the document. This could have big consequences if the website-based tool delivers the wrong results. For instance, the website-based tool takes Ph as an iron value and provides the wrong result. The tool has to be reliable, and the reliability could be affected if it could deliver the wrong results.

Thirdly, in the future, an app could be developed. This could be beneficial because of an increased spread of knowledge and clients enabled to access information quickly and easily. This would be the next step for ease of use. An app could potentially lead to further use outside the industry and spread knowledge of this environmental issue beyond those with adept knowledge in the subject. Informing the general public is crucial for giving any sustainability problem political importance, and leading to societal changes.

Let us discuss how the project has improved from its predecessor and the basis for the project, the excel-tool developed by ecoloop. How has the website improved upon that?

5.2. Improvements in the website-based tool

The results of this project and the tool built have improved the excel based tool in multiple ways. The excel document contained functions that Ecoloop wanted to keep private as well as updateable with little to no complications. With the intention of keeping the functionality accessible for everyone, there was a concern about multiple versions being distributed and that there would be confusion regarding the different versions. The code for the website-based tool has the possibility of being updated and private as well as being accessible to the public, without distributing documents that are hard to keep track of.

The website tool is also designed in a way that reduces the complexity of classifying the soil and this is an improvement from the excel based tool because it will increase the number of users. The excel based tool can seem intimidating and complicated because of the raw and basic design, with complex functions visible and many unexplained data input fields. The more general design of the website will attract more users.

Furthermore, the website tool has the power to be further developed and is a good base for a useful and widely accessible tool. Several additional functionalities can be implemented that are also discussed in the report, and with the website tool as a base, these developments can be as accessible and simple to use from the beginning.

But that’s enough specifics. It is easy to lose sight of the bigger picture when focusing on the details of a single solution. Let us begin with the true underlying goal of the project, what effect is the project likely to have from a sustainability perspective?

5.3. Sustainability impacts

The tool is a small part of the mission to achieve better, more sustainable handling of soil. The hope is that the user-friendliness of the tool will let a bigger audience of users classify their soil, easily and efficiently, without a high cost. This will reduce the negative effects of the current handling of soil on the environment. The current lack of knowledge that exists in society and even people working in the field, with the soil, can be tackled with the classification tool developed for this project. It raises awareness, which is crucial for the future of soil handling and optimization.

As discussed, sulfide soil is known to contain potentially toxic substances such as heavy metals and sulfides, which can have adverse effects on the environment and human health if not properly managed. The tool developed and its improvements from its previous form can help identify areas where there may be a risk of environmental contamination, allowing for appropriate measures to be taken to mitigate this risk. With the amount of soil being moved and disturbed in different ways, in the majority of all construction work, the lack of knowledge is not sustainable. Widespread usage of a classification tool will affect the future of aquatic life, human life, and nature as a whole. The tool will also have an impact on reducing the indirect effects of this problem. Reducing the amount of sulfide soil being incorrectly handled, the number of resources required to deal with the consequences are reduced. Fewer metals used for buildings and other essential functions in society will be affected and their sustainability will increase. This also leads to a decrease in resources having to be used in order to rebuild and replace earlier than necessary.

While the possibility of determining the environmental danger of soil has been possible for a long time, it has been expensive and time-consuming. Many construction companies often opt to save time and money by not waiting for the result of extensive soil analysis to come back or doing no analysis at all, and simply choose to go the safe route and mark all their soil as hazardous, and transport it to special landfills made for the handling of such soil. This has negative consequences on its own because unnecessarily marking unharmful soil as hazardous wastes unnecessary energy. Trucks would need to transport a potentially vast amount of matter for longer than necessary distances, and the landfills made to store the hazardous soil would be overloaded with safe soil that does not belong there. This is where the tool shines the brightest. A cheap, quick and easy way to analyze soil on the fly could possibly eliminate this problem. If the soil was tested and classified from the beginning, no extra work would need to be done. Companies would save time and money by doing the environmentally friendly thing, and that might be the best motivator of all.

Additionally, the efficient and simple classification of sulfide soil can support environmental monitoring and management efforts by providing timely and accurate information on the distribution and presence of potentially toxic substances in the soil. Governments of different areas can benefit from using a classification tool to do research and gather data on the problem with sulfide soil and take appropriate action to preserve the environment. Since there is a lack of knowledge in society generally, there is a risk that the laws concerning the area are also lacking. With more research done and a broader collection of information, there is a potential for a stricter set of laws and guidelines for soil handling. Today their already exists some types of laws but these needs to be more strict as stated in “Legislation, policies and risk assessments relevant to acid sulfate soils” [5]. The classification tool that this project resulted in, has the power to impact decision-making processes related to land use and development, ensuring that the environment is protected and conserved.

The tool can also help reduce the time and resources required for soil classification, which can have a positive impact on the environment by reducing the carbon footprint associated with fieldwork and laboratory analysis. By simplifying the process of soil classification, the tool can also encourage more widespread and frequent monitoring of sulfide soil, leading to a better understanding of the distribution and potential impacts of toxic substances in the environment. All research in this area can be positively impacted by a more widespread knowledge about different soils and their impacts. A wider collection of knowledge leads to a more nuanced view of the problem and more accurate conclusions can be drawn, which in turn leads to solutions to problems that were not previously identified.

Overall, the development of a tool for simplifying the classification of sulfide soil has the potential to make a significant positive impact on the environment by improving our understanding of the distribution and potential impacts of toxic substances in the soil, and by supporting efforts to protect and conserve the environment.

6. Conclusion

Overall the project succeeded in its mission of creating a simple to use the website to assist classify sulfide soil. There were some setbacks and unmet goals, but the tool is developed, working, and ready to be used. It is certainly an improvement over the excel tool which was the basis of the project and a step in the right direction for more widespread soil classification and management. The path is made for even more work and improvements in the future. The possible effects of the project stretch far beyond the website and could have wide implications for the future of soil management. How effective it will be and how widely it will be used now lie in the hands of ecoloop. We can discuss the probable effects to our heart's content, but ultimately the full impact of the project remains to be seen. At least it seems the future is a little bit brighter than before.

7. References

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