Open Soil Atlas

Citizen Science Project
for
Testing and Measuring Soil Fertility in Berlin

Final Paper

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OPEN SOIL ATLAS

ABSTRACT

Soil degradation around the globe is growing at an exponential rate while speeding up climate change and impacting ecosystems' health. Governmental and societal decisions lack sufficient communication and engagement of the population around the importance of a healthy, living soil, its long-term ability to slow down climate change and the potential to restore ecosystems' health and integrity. This is partly caused by the absence of open datasets on soil and ecosystem health. In March 2021 the Open Soil Atlas started with the aim to face these problems by building a citizen scientist platform that collects soil relevant parameters in Berlin. For this purpose a soil-testing methodology was developed that includes 10 soil tests for gaining insights on 7 soil health indicators: amount of non-biodegradable litter polluting the landscape, erosion, biological activity, soil profile, soil colour, soil texture and soil pH.
Within the project time, 77 datasets were collected by citizen scientists. In a final analysis it was concluded that mostly all sites that are not being actively regenerated show a certain amount of soil degradation. As soil samples were taken only at specific points, they are still not representative of the overall state of soils of Berlin. Further testing is needed and the possibility for scaling up the results achieved in this 6-months accelerator are promising.

1. INTRODUCTION

The degradation and destruction of ecosystems caused by human activities is taking place on a global scale. 60% of Earth's ecosystem has been degraded in the past 60 years. The exponential population growth along with the urbanization and industrialization have changed the way humanity interacts with the environment. [1] This has led to a disconnection to nature and a competitiveness on an individual, organizational and political level.
The Open Soil Atlas project aims to generate a biodiverse, self-sustaining and organically growing Soil Data Atlas, enriched by citizens working together to balance and heal the Earth.
Supported by the ACTION Team and a wide network of experts and cooperators. The Feld Food Forest community developed an open-source co-learning centre for the local community of Berlin. It consists of a website presenting guidelines in a textual and infographic form. Its overall goal is to educate the public and to raise awareness about soil fertility and the known correlations between healthy soil and healthy communities. This online material was combined with a series of free-of-charge workshops, where citizens were trained on how to make observations, test the soil, interpret results and draw conclusions. Combined with GPS locations, data about soil fertility have been then uploaded in a digital entry form, which, in the long term, will generate a high-resolution soil map of the city.
Our findings aim furthermore at providing policymakers and urban ecology initiatives with indicators as to which areas are best suited for urban agricultural purposes and which require remediation activities for tackling climate change related issues.

This entire research and data collection process is made available in an open source way, so to be replicated and expanded in other cities worldwide, in order to engage different communities and adapt to the most needed analysis in new and different sites all over the world. The project builds on the Feld Food Forest citizen initiative and is promoted by its community.

2. STATE OF THE ART

In modern society there is a lack of awareness of the importance of soil health for mitigating climate change. Policy makers look for reliable data within the academic world, or refer to independent studies that are often involved with corporate interest, for generating policies that the environmentalists demand.
During our direct cooperation with academics we have come to learn how large the current gap is between the need for topic studies and the capacities of academic institutions to support them. [2]
For instance, there are few studies concerning the uptake of heavy metals by edible plants in ex-industrial or urban areas, and these studies do not cover wide geographical areas. To put it simply, there is a lack of data at the scale necessary to tackle soil pollution in diverse areas [3] with different contamination and soil degradation histories.
Academics themselves, even when they achieve funding and find cooperation for specific studies, struggle to obtain legitimate permission to conduct scientific surveys at the level their knowledge and laboratories could support for producing updated data. [4]
Open data, on which to base and relate independent studies, are often out of date, based on single studies dating back decades [5]. They may be periodically updated, however this is not often new, widespread ground surveys done in the field by trained professionals. Rather these updates are often extrapolated in a speculative way from sparse new measurements, low-resolution satellite data, and through machine-based predictions. or approximated at too big scales to realistically inform the urgent interventions needed. [6]

As a consequence of this, climate-change and soil-remediation policies tend to dismiss citizen-engagement initiatives, while shifting the solution of pollution-related issues towards potential private investors, and leaving the engaged public disempowered and uninformed. What could support effective bottom-up strategies to tackle issues related to pollution and environmental regeneration ends up in a loop between political rhetoric and corporate interests. [7]
A solution to the issue of soil data quality and data dissemination can be found in citizen science. This is a nascent field for soil science, because soils can be complex to measure, requiring a high level of expertise. Nevertheless, several recent studies have indicated the high potential for citizen science in this realm. [8]
Furthermore, open source data -- not held by private companies or academic institutions can better inform the public and increase support in a feedback loop growing the database.

The main goal of the Open Soil Atlas accelerator has been to conduct an ecological- measurement campaign: Soil-relevant environmental data have been gathered by citizen scientists, trained through workshops and engaged in the discourse about urban soil health. These Data have been uploaded into the Epicollect App. The resulting datasets can be used for visualization of soil maps, teaching, student projects, as a base for further research and ultimately for policy decisions regarding soil remediation. During the data collection process citizens have interacted with ecosystems and soils, while creating awareness about

landscape degradation, different land-uses, biological processes and the importance of protecting natural cycles and ecosystems. Aim of the project is to help shift societal norms toward a healthier environmental, social, and economic sustainability.

3. SOIL PROTOCOLS

Our soil testing protocol is the result of an accurate selection of 10 simple soil tests, studied during our initial research. [9]
The tests have been organised to be easily accessible and presented within workshops engineered by the OSA Workshop department. [10] The selected tests train the citizen scientist bringing her/him hand-in-hand through a journey of observation, starting from the outest zoom of a satellite view of the chosen area, then guiding her/his gaze towards the surrounding landscape and its characteristics, then inviting to observations at the surface of the soil where s/he is standing and only afterwards inviting to dig a hole and learn how to collect data about the fertility of this soil.
The information these tests teach to collect are about:
-GPS Loaction,
-Land Use
-Anthropogenic Impact (in terms of non-biodegradable human litter)
-Soil Erosion
-Biological Activity
-Soil Profile
-Soil Colour
-Soil Texture (ribbon method)
-Soil Texture
-Soil PH
A detailed Soil Protocol is presented in **Table 01**.

3.1 Citizen scientists engagement strategies: Workshops and Soil MeetUps

Workshops: Our workshops aimed at inviting the participants to connect with their senses (view, touch, hear, and smell). The first toolkit they needed to feel empowered to become citizes scientists, therefore, was based on the discovery of what all of us already have at hand all the time. A kitchen-tools toolkit was then revealed as our zero-waste, effordable and accessible physical kit to bring to the sampling area for creating their open air laboratora. Technology was the third element of the toolkit: with the use of a common smartphone the users could integrate the collected information with precision GPS location and take pictures of their samples.

Due to the pandemics and Lockdown situation at the beginning of 2021, the first three workshops took place online. The platforms used were:
-Video Conference Platform: Jitsi (March); Zoom (April and May)
-Interactivity and Design: Miro
-Showcase of detailed soil protocol: Notion page of OSA (March and April) and User Manual PDF (from May on).

For a detailed description of the online workshop protocol, see **Table 02**, and find a copy of the printable version of our User Manual on **Table 03**.

In June a workshop with the students of a 4° class (between 9 and 11 years old) took place in the district of Neukölln, where also most of the team lives and works. In July, 2 workshops a week were offered by the driver of the OSA Workshop Department with the support of the Networking and Outreaching department for wht concerns online visibility and invitations. In August, only representative meetings to spread the word about the project and gather and celebrate the citizen scintists community took place. These events have been key to the consolidation of the relationships the OSA team has collected in the last 6 months ad in perspective of a follow up and scaling up of the project after the end of the accelerator.

Soil Meetups: started on May 1st, and were aimed at supporting an effective data collection: The response of citizens with a single online appointment for free-learning of the soil protocol was satisfying (16 participants in March, 17 in April and 7 in May) but didn't lead to any data collection. We attribute this to the difficulties posed by the security measures to be respected when in public spaces, and to the different empowerment impact of a theoretical introduction to the subject -for as much as accompanied by visual examples and Q&A sessions- and the actual clarity only accompained praxis can offer.

Soil Ambassadors: The aim of this strategy was based on the attempt for a snowball effect to spread out circles of knowledge:
First hand trainees involved in direct training with our facilitator were introduced to citizen science through our soil-testing-protocol during a live meeting. Their role wanted to then become the one of an empowered knowledge-spreader multiplying our outreach strategy in a concentric and progressive expansion. The Epicollect tool, our online platform on Notion, our User Manual Guide and our Telegram Chat were the tools made available for networking, exchange about soil-testing excursions plans in the city and experience sharing. [11]

3.2 Online Platforms

Notion: We have created a project-space with the online tool Notion. It became our online educational platform, where the citizen-scientists engaged by our workshops could get involved in the discussion about soil, share knowledge, deep-dive into our selected and inclusively translated for broad public soil-testing methods, find graphical examples and links to other sources and tutorials about the subject.
For our internal work, we tried to use it as an internal organisational tool. It has been used as well for communication with the public, along with our social media platforms (mainly Instagram and Twitter, along with targeted E-mails to the participants to respond to their specific interests and questions) and for representation of Open Soil Atlas.

EpiCollect: Citizen Scientists used EpiCollect to upload the results of their Tests. The questions they were invited to answer were aimed at training visual, haptic, acoustic and olfactory engagement with some of the very physical aspects of soil, which, if informedly red, give out a lot of information about its fertility. The App acted as an interface: translating the citizen scientist' sensorial experience and personal evaluation into

consistent data. This data was then downloaded and visually elaborated for driving conclusions. The Dataset was then uploaded on a .cvs format into a google sheet and processed for data visualisation.
Map elaborations are the result of graphic work based on the Leaflet access of OpenStreetMap, embedded in Epicollect combined with further manual graphic elaboration by the OSA R&D department.

Coney: coney has been used as a user survey tool for the OSA impact assessment.
The visualisations in **Table 04** were as well elaborated by this tool.

Webpage: The webpage of our supporting community Feld Food Forest hosts a page solely dedicated to the Open Soil Atlas project, where fans of the mother project can find indications on how to join the Open Soil Atlas practical-education offer.

4. RESULTS

Within the project timeframe of six months a total of 77 datasets were uploaded by citizen scientists around Berlin. These dataset can give a broad overview about the soil fertility and degradation and different points around the city. Nevertheless, the datasets represent point data for specific locations in Berlin and are not representative for identifying the overall soil quality of the city.

For a visuslisation of the following results, see **Table 04**.

26.08.2021 - 77 Datasets uploaded
Table 3 Collected Data visualization

4.1 Soil Tests results analysis

4.1.1 Types of green Areas analysed

Of the 77 soil samples, the most have been taken in park areas (41,5%); second in rank of testing area choice come community gardens (31,8%); Cemeteries and ex-cemeteries are present as a third choice of tested area (9,2%). [12]
3,1% of the samples have been collected in allotment gardens, 10,8% in private gardens and 1,5% in an otherwise unspecified different type of area. 0% of the tests were conducted in forest areas.

4.1. 2 Human Trash amount in the tested Areas

3,9% of the tests were conducted in areas where the anthropogenic impact in terms of human litter (non biologically deteriorable) was considered massive; 41,6% gouged the trash covering the ground as relevant, 54,5% found it negligible. [13]

4.1.3 Soil Erosion

46,8% of the sampled soils were surrounded by little or no eroded Hummus layer on the landscape. 32,5% found a slightly apparent soil erosion; 20,8% found the surrounding Humus layer very eroded or even completely absent. [14]

4.1.4 Earthworm Count

This parameter is important for citizen scientists to understand the vitality of biological activity and its key function in soil regeneration. Earthworms are the fastest decomposers of biomass and the humus they produce is one of the best natural fertilizers Nature has engineered.

The record for Earthworms count is unsurprisingly held by a community garden project, where the soil is being regenerated for one year by an engaged community of neighbours and engaged gardeners, thanks to the community's connections for importing organic matter on top of previously desertifying urban soil. Holder of this record is Gartenlabor, in the Northern part of Neukölln. Here, 24 Earthworms have been found within a volume of 20 cm3. Second in rank is another urban gardening project, where, like in the first one, edible and friendly plants are being planted in companion-clusters directly in the ground. Here, in Fischerstraße Kiezgarten, 11 Earthworms have been counted in the same volume of soil. The 3rd position on this podium goes to a high-bed composed by sole anthropogenic humus in a depth 0-80cm. In this high bed in Himmelbeet, in the northern district of Wedding, 8 earthworms were counted. Only another sample presented a non-worrying finding, with 5 Earthworms counted in the allotment garden area of Kolonie Stolz von Rixdorf, in the east Friedrichshain district. 52,6% of the conducted tests gave the worrying results of finding 0 Earthworms working the earth. As you can see in Table

4.1.5 Soil Profile

4.1.5.1 Hummus Layer Presence

In 53,9% of the samples no distinguishable humus layer was found. The remaining 46,1% recorded the presence of Humus on top of the A Horizon.

4.1.5.2 Evaluation Errors

At a backend analysis (Observation of the photo documentation collected for each sample's soil profile) 4 Soil Samples (3,1%) appear to have recorded a difference in soil colour that doesn't correspond to Humus Horizon presence. (Test Nicknames: Allmende Kontor Rot Kompost; trash baumscheibe; Wolf ring Park 15/7/2021 Nördlich Springbrunnen Buschgebiet; Wartenburg).

4.1.6 Soil colour

The general carbon content of the soil of Berlin can be red by the darkness of its colour: The closest to black, the more carbon it contains. Our findings reveal a general richness in carbon content, ranking as following: 42,1% Light black, 28,9% dark brown, 18,4% light brown, 3,9 dark black, and 1,3% yellow.

This carbon content when combined with soil compaction, signs of erosion, poor biological activity and the absence of a covering humus layer (O Horizon of the topsoil) will be eventually released in the atmosphere and add to glasshouse gasses. On compacted or tilled soils, where micelia, earthworms, nematodes and other important microorganisms of the Wood Wide Web cannot thrive, bacteria proliferate rapidly and easily, unopposed by other established biotopes that could limit their expansion. Bacteria overpopulate such soils, emitting immense quantities of CO2 as a consequence of their nutritional cycle. This is why unhealthy soils potentially emit CO2 in the atmosphere, rather than realizing their huge potential as carbon-sponges and locking carbon into healthy and growing ecosystems.

4.1.7 Soil texture

Berlin is known for being characterized by a very sandy soil. This contributes to the rapid rainwater drainage towards the underground waterways and lakes on which the city builds. Our results confirm this observation easily observable with the naked eye. In fact, the soil texture that was mostly detected is a type of loamy sand (46,7%). Toghether with the 2,7% of findings detecting pure sand, types of sand have been found in approximately 1/2 of the samples tested for soil texture (49,4%). The remaining 50,6% are types of loam. Loam is a soil with roughly proportioned content of sand, silt, and clay. Along with our soil protocol, these proportions have been grouped in more defining cathegories of soil textures: 17,3% silty clay loam, 9,3% sandy sandy loam, 6,7% sandy clay loam, 6,7% silty loam, 2,7% clay loam and 2,7% loam.

4.1.8. Soil PH

Of the 77 collected samples,16,9% gave a very alkaline PH result to the vinegar test, aimed at measuring the approximate basicity of the soil. 46,8% gave a slightly alkaline result and only 36,4% gave a possibly neutral result (no fizzing of the soil sample when mixed with an acidic reactor: Vinegar).

4.1.8.1 Soil alkalinity and the problematics it represents

These results draw a picture where 63,7% of the tested samples appear unsuited for average plant growth. See the discussion about soil fertility for details about these results.

4.1.8.2 Soil acidity and soil fertility

In case of negative results to the vinegar test, our citizen scientists were invited to follow up verifying if the soil presented a neutral or rather acidic PH. This can be done with any basic reactor. For the accessibility of our "kitchen tools based toolkit" we chose to invite to make this experiment with baking soda. Such results were found in 28 Tests, representing the above mentioned 36,4%. Of this 36,4%, 64,3% samples were found to present a neutral PH (No reaction with either of the two substances) and only 35,7% presented a slightly acidic PH value. This latter is the most suitable for most plant growth. Of the 77 tests conducted, therefore, only ca. 10 gave results that can be interpreted as good soil fertility potential.

4.2 Impact assessment analysis

The impact assessment was conducted to measure the effectiveness of the project activities and decisions made. Before starting with this project a canvas for impact assessment was filled out and the goals, areas of impact and dimensions were defined. Open Soil Atlas designed a survey to define the baseline situation of the participants. Another survey at the end of the accelerator was conducted and will be validated.

4.2.1 Description of Participants

Graph 1 - 22 show the results of the demographic and motivational survey conducted with the online tool Coney. The survey was sent to the participants before conducting the soil tests to get to know them better and understand the general background and motivation of the citizen scientists while measuring the possible impact on individuals. In total 22 participants started the survey and of these 14 have completed all questions.

4.2.2 Demographic

See **Table 05** for details on: **Graph 1** identifies that 15 women conducted the survey. Most of the participants were between 25 and 60 years old (**Graph 2**) and from Germany (17). Apart from two participants all participants have either a high school (6), bachelor's (6) or master's degree (6). (**Graph 3**) [15]

4.2.3 Background and motivation

The results of the Coney survey underline that the majority of participants didn't have much knowledge about soil before (**Graph 7**) and weren't conducting soil tests prior to the project (**Graph 12**) but were motivated to learn more about soil fertility (**Graph 9**). The participants joined the Open Soil Atlas project to learn more about soils (**Graph 8**), do something new (**Graph 10**), feel good while doing something good (**Graph 13**), improve skills (**Graph 14**), do something meaningful (**Graph 15**), and to meet new people (**Graph 17**). It can be stated that mostly all participants didn't expect any return for their participation in the Open Soil Atlas project (**Graph 16**).

4. DISCUSSION

5.1 Maps

The map shows a lack of collected data in the western part of the city. The initial focus of fully covering the urban area faced challenges in applying the methodology designed by the OSA Networking and Outreaching Department. Although the project's KPI of full geographical coverage has not been achieved, the application of different outreach approaches showed that the promotion of Open Soil Atlas to individuals and communities had to be supported by a network of contacts and alliances throughout the city. Approximately 80% of the initial map coverage KPI (100 soil samples spread out throughout the whole city area) has been achieved and the remaining 20% was included in the Data Quality Assurance Document as a predicted range of error.

5.2 Parks

Lacking satisfying findings for what concerns biological activity and Hummus layer presence. The latter is characterized by a dark colour -O Horizon- between 0 and -10cm, progressively changing into a lighter colour between -10 and -30 cm of depth, when shifting towards the A Horizon -topsoil- and eluviation Zone -E Horizon- before showing another change in colour when touching Subsoil -B Horizon-.
Berlin soil is famously sandy. Its often recorded dark colour reveals its high carbon-content. This carbon, though, is mostly present in a mineral state (e.G. car pollution deposit. Organic matter in these cases gets atomized by mechanical friction instead of by the biological activity of important decomposers like earthworms. Draughts VS floods and evident desertification impede Carbon sequestration into healthy or at least long-living ecosystems.
Carbon atoms are so made available for restitution to the atmosphere, adding to air pollution.
So basically, the green lawns of a frequented park represent at a microscale already a sort of desert.

5.2.1 The infertility of soil

The soil examined in the berliner parks has proven to be as well highly compacted. Where people constantly walk, play or dance, where heavy machines are frequently used to export organic matter like grasscut, dying wood and autumn leaves, the soil is compacted, desertifying in front of our very eyes. Soil compaction impedes the progressive absorption of water into the landscape and its slow release to plants and microorganisms. These soils, even if they look like green and healthy fields on the surface, work instead like sealed soils: Rainwater flows on the surface, rapidly increasing in speed and erosive power, washing away the minimal soft humus produced by the activity of the few present microorganisms. When these heavy rains ceise, all water and newly built Humus Layer rapidly leave the landscape. The left superficial humidity evaporates quickly. Almost no water is kept available for plant, fungi or microorganic-networks growth.
The unusual quantity of superficial flowing water lands then onto the sealed urban soils (concrete, asphalt and pavings), potentially flooding Berlin's underground infrastructures and creating apocalyptic damages like we could observe for example during the floods in the central-northern european area during Summer 2021.

5.3 Gardens

5.3.1 Community Gardens

Where it is allowed or at least temporarily tolerated to intervene with plant activity directly in the soil, and where there is a special attention for promoting biodiversity and inclusiveness in the garden-system, we clearly found a thick layer of topsoil covering the typical drainy sand that characterizes Berlin's geology. Here earthworms thrive and plants prosper, supported by the network this healthy soil promotes.
Healthy topsoil works like a living being. It breathes, it is immensely biodiverse, lets water flow and microorganisms prosper, evolve and adapt. It captures CO2 from the atmosphere and locks it into living beings which, as long as they live and grow, are going to accumulate more and more carbon molecules within themselves, sequestering them from the air we breathe.
In the typical Berlin based community garden case study, it is not allowed to plant directly into the ground.

One of the compromises urban gardeners in Berlin cannot avoid to face sooner or later, is the pollution of the soil. It is supposed to be so high and so diffuse, that no healthy food is supposed to be able to grow from there. Rats invasion is another strong argument used by policy makers against the responsabilisation of citizens about the maintenance of green spaces in the city. These two arguments have been circumvented using some of the high bed technique's stacked functions. A higher plane from the floor avoids massive rat invasion and its pests accessibility in general. Above that, The soil in high beds can be 100% controlled, monitored, changed and defended. A sort of isolation in situ, instead of in a glasshouse -which isolates plants as well from the air and even the daily rhythms thanks to artificial lightning, not only from the soil and water like a high bed.

5.3.2 Allotment gardens

"Allotment gardens didn't take place so much in groups. It was more privately interested people, working in different gardens, who took part. They liked it as a useful tool to observe and understand the conditions of their surroundings.
The workshops helped for adult environmental education and raised awareness about permaculture principles and regenerative ways of interacting with the landscape.
The participants were as well curious to know more about soil contamination, especially in the city area"

5.4 Engagement and knowledge-sharing strategies

Our soil testing protocols received an overall positive feedback. The simplicity of the tests was welcomed as an easy and accessible way to learn how to understand the health of soils and how to support healthy ecosystems wherever soil is present and factually or potentially hosting plant growth. Our workshops contributed to environmental education and raised awareness about permaculture principles and sustainable ways of using land. Permaculture is a holistic land management philosophy. Its revolutionary self-sustainability and the potential empowerment and autonomisation from the commercial consumer-based cycles that support the food chain in cities, make it still inaccessible: permaculture courses are usually very expensive and therefore exclusive. Offering such knowledge in a round-table format. Furthermore, a lot of interest has been shown in better understanding the possibilities to improve the state of the ecosystem in urban areas. [16]

5.5 Community building

The role played by relationships among the OSA team and newly engaged citizen scientists interested in urban soil has been of support for the development of the community around the citizen science we tried to develop and devulgate, making human relationships and citizen empowerment an important factor among the results we have achieved as a whole. The strategy of the OSA Networking and Outreaching Department during the first months of the accelerator has continuously adjusted. The response showed interest in the project particularly within the urban garden communities and supporter networks in the districts of Neukölln, Friedrichshain and Wedding, which represent the central eastern part of the city.

6. CONCLUSIONS AND FURTHER DEVELOPMENT

Urban areas in general are characterized by a strong horizontal and vertical heterogeneity of soils.The results obtained during the Open Soil Atlas project show a diverse spectrum of site specific ecosystem and soil conditions. However, chapter 4 (Discussion) outlines that the soils tested in Berlin are in general identified by low fertility, with a high sand content (46,7% loamy sand, 6,7 % sandy clay loam, 9,3 % sandy loam, 1,3 % sandy clay, 2,7 % sand), low or no topsoil layer (53,9 %), low or no presence of worms (52,6 %) and polluted by trash (45,5 %).

6.1 Added value and impact of the research and data collection

During the development of the accelerator, several beforehand unpredicted factors revealed the importance of such research and the key role of citizen science in the urgently needed societal transformation for what concerns diffused climate change tackling. Important actors in the city have been outreached by us and academics and experts have contacted us, finding us thanks to our online and local visibility, and have added valuable insights to our research.

6.1.1 Policy making

Overall, our analysis of the results shows that the soil fertility in Berlin is low and in need of regeneration. This has been communicated and agreed on by many stakeholders of different sectors that were included in the research, and it is shown by the data we visualize in Table 3. While extending the outreach of the findings that soils around Berlin are in need of improvement a wide range of people including politicians and policy makers are and can be reached. While providing a growing set of data and information about soil pollution, degradation, and the need for soil health restoration it is aimed to incentivise evidence-based decisions. Within the project implementation time of 6 months an outreach and network team focused on strategically reaching out to politicians and policy makers.

6.1.2 Academia

The strategies implemented during the six-month accelerator by the communication and outreach and networking teams allowed the qualities of the Open Soil Atlas project to be visible in different fields of academic research. In particular, the concern to investigate the relationship between soil, city design and urban social-ecological transitions was confirmed by the interest of some ongoing academic studies.
The interdisciplinary master seminar “Soilidarity” [17] (Humboldt University of Berlin, Faculty of Geography), coordinated by Dr. Laura Kemmer and Prof. Sandra Jasper, integrated the Open Soil Atlas methodology to theoretically and in practice explore the soil from the engagement perspective of citizen scientists, by highlighting the role of counter-mapping in the analysis of the urban environment. With the intention of tracing how the role that citizen scientists have contributed to some fundamental mapping of the city of Berlin [18], the Open Soil Atlas team was called upon to develop a workshop [19] with students from the “Soilidarity” seminar in which lectures were integrated with practical activities to recognise the extreme variability of soil qualities in spaces not normally mapped in institutional cartographies. The workshop was carried out through the test of three different locations within a limited area with a strong multifunctional

vocation and characterised by different natural assets.
The collected data aimed to discuss the different soil qualities according to varying spatial uses and management. The soil analysis was accompanied by a meeting with a number of citizens responsible for green care practices in the survey area. In this way soil was investigated not only as a matter from which taxonomic data could be derived but as a field of exploration of social and ecological unity.
How the survey approached by Open Soil Atlas can be extended to academic research in different international contexts was verified in the interest in the project of Prof. Ana Luiza Nobre (Department of Architecture and Urbanism at the Catholic University of Rio de Janeiro). As part of the research "Tanto chão" ("So much ground") [20] Prof. Nobre repositions the investigation of urban soil in the Brazilian context through the relationship of built spaces and ground, extending the reflection to today's debate around the concept of the commons. Open Soil Atlas was reported as one of the projects in line with this study. [21]
The attention devoted by academics to the Open Soil Atlas project during the six-month accelerator indicates its possible application within multidisciplinary research. It also sheds light on how soil health is incrementally considered as a multi-dimensional element within the analysis of the city, which intersects ecological, social, political and spatial questions.

6.1.3 Community Gardens and agricultural spaces

The aim of this research was to include a diverse group of people, among which horticulturists and community gardens experts around Berlin (see list of gardens in Acknowledgements). Community gardens are a point or encounter for citizens and a social gathering space for everybody to connect, learn and engage with food production and care for agriculture as a key factor for socialization around survival necessities. During the project, gardeners from several berliner community gardens were invited to join our research hosting workshops, hosting advertisements of our activities on their networks and social media channels and physically helping gather data joining collective actions.

6.1.4 Societal Education

The data and results out of the project will help to build the base for actionable recommendations and educational resources. The goal is to translate these outcomes into a clear and easily understandable message in different languages. This will be used to inform citizens not only about the state of the soil and ecosystem health but also about clear actions and suggestions for restoring and improving natural systems. The strategy and methods for societal education still need to be defined.

Here is a list of potential steps towards societal education:

-Cooperating with a non-governmental organisation (NGO) by producing knowledge resources that are shared with their network
-Using Notion as a knowledge library to inform about soil degradation and solutions
-Visiting educational spaces (schools, universities, etc.) and host workshops, lectures and classes about the ecological value of soils
-Attending public events and representing the Open Soil Atlas project
-Creating regional soil working groups that meet on a regular base to collectively find solutions for the soils surrounding them

6.1.5 Impact Assessment

The impact of the OSA accelerator has been assessed by collecting feed-back from the users of our platform and the citizen scientists and members of our community. For insights about this subject, see table 5.

6.2 Outlook: Replicability and Scalability

The Open Soil Atlas project took the urban border of the city of Berlin as a case study site, in order to obtain results representative for an urban area. Certainly with the start of the project the mission was to create replicable frameworks for the project management, organizational structure, decision making processes and the soil testing protocol. Especially the soil testing protocol and data collection methods are designed in a way that they can be adapted to soils and ecosystems on a global scale.

6.2.1 Structure

The soil protocol has a flexible application architecture that allows it to be expanded with research, testing methods and features. The current soil protocol consists of a list of proposed soil testing methods that cover general soil properties and soil health indicators. Further research and development is needed here to validate and verify the chosen methods regarding their relevance to represent meaningful indicators for soil fertility and soil degradation. These indicators can differ between climate zones and therefore, the soil protocol structure is suggested to be flexible and adaptable to be used for different contexts.

6.2.2. Language

Currently the soil testing protocols, surveys and project information are available in English and German. To extend the outreach of the soil testing protocol and reach more citizens on a global scale further work needs to be done to cover as many different languages as possible.

6.2.3 Calibration of Satellite data

The collected data by citizen scientists is referred to as ground truth data. Ground truth data is defined as real or true data provided by field measurements and direct observations. This data is important for the calibration of remote sensing data and Geospatial information systems (GIS) as it is used for the correction of datasets by validating sensor and system performance. [22] Open Soil Atlas's vision is to share the data freely to improve systems that strive for global restoration efforts. For this purpose the Team has been in touch with Restor and Climate Farmers:

"Restor is a map-based, open-source platform created so that people can better plan, manage and monitor restoration projects. The locations of more than 50,000 restoration and conservation initiatives are now registered on the platform." [23]

"Climate farmers is building the infrastructure to support a large-scale transition towards regenerative practices by implementing and supporting self-regulating systems that protect biodiversity while producing healthy and nutritious food." [24]

6.3 Call to Action

The research and work out of this project can and should be used by anyone interested and motivated in starting up a citizen science project anywhere in the world that focuses on teaching the collection of soil health relevant parameters.

Here are some **facts about the potential of soil regeneration through socially inclusive activities**.
Such activities have proven to rapidly and effectively contrast climate change related issues and improve societal reliability:

-Carbon sequestration from the atmosphere into living soil
-Water retention, draught and flood mitigation
-Biodiversity enhancement and promotion of species co-evolution and adaptation in times of climate change.
-Diffused Urban gardening has the potential to solve many mental health issues and improve societal reliability
-The reconciliation of humans with Nature within cities can simply start by educational inclusion and training to observation
-Gardening should be considered as a human right
-Holistic Understanding adaptable and applicable to other fields in life, survival of our species within climate change.
-Synergic thinking instead of competitive dynamics inspiration.

For more information about our ongoing co-work, please visit our Feld Food Forest webpage [25] and our online educational platform. [26]

NOTES

(1) https://www.theworldcounts.com/stories/impact-of-ecosystem-destruction

(2) Dr. Jennifer Schulz,PhD Landscape Architecture, project manager of the food forest garden project in Britz, Berlin Neukölln, and developer of successional regenerative agroforestry plant-companion agroforestry techniques. Online interview about possible cooperation with OSA R&D and N&O working groups, April 2021

(3) e.g., Khan, A., Khan, S., Khan, M.A. et al. The uptake and bioaccumulation of heavy metals by food plants, their effects on plant nutrients, and associated health risk: a review. Environ Sci Pollut Res 22, 13772–13799 (2015). https://doi.org/10.1007/s11356-015-4881-0

(4) M.Sc. Kolja Thestorf, PhD candidate at Mathematisch-Naturwissenschaftliche Fakultät | Geographisches Institut, HU Berlin, during the seminar about Soil Mapping where OSA PM and R&D were invited to share input with students on research.

(5) Almost all information on Berlin's soil is from one doctoral thesis from 1987: Grenzius, R. 1987:
Die Böden Berlins (West), Dissertation, Technische Universität Berlin, 522 S. https://www.berlin.de/umweltatlas/en/soil/soil-associations/1990/literature/

(6) Dr. Ben Purinton, AG Geologische Fernerkundung, Uni Potsdam, about Berlin's Soil Quality Maps and Citywide open source maps during a co-work session with M.Sc. Sara Busnardo, head of the OSA Workshop Department. OSA Research & Development Working group, March, 2021.

(7) Shared experience of the Feld Food Forest community between 2019 and 2020. Data about the soil pollution surveys outsourced by the Senate of Berlin to the corporation GrünBerlin GmbH about the contamination levels in the soil of the ex-airport Tempelhofer Feld area "alte Gärtnerei" were not to be found on their Open Source Platform as required by law. In cooperation with Prof. Kaupenjohan, head of the Soil Science Department of Technische Universität Berlin, the FFF community complied with the invitation by GrünBerlin GmbH to propose a soil-testing strategy to help accelerating the accessibility to the area and explore permaculture-based regenerative techniques. The proposal was rejected as an input to the funded work of Grün Berlin GmbH. The motivation was that such strategy was exploring urban gardening based soil regeneration only, not including other people-to-land parameters required by law for the access of the public to the area. As a result of this active engagement, at least, the partial existing Data collected as early as 2012 were uploaded on the open source platform. The FFF community was invited to independently look for fundings to support their proposal and in any case, alerted about the delaying ongoing process to first conclude the necessary surveys GrünBerlin GmbH had started 8 years before and not yet brought to conclusion. Current commissions for the finalisation of these surveys are still not in place at today's. This pushback was one of the key generators of the Open Soil Atlas Project.

(8) e.g., Maynard, JJ, Salley, SW, Beaudette, DE, Herrick, JE. Numerical soil classification supports soil identification by citizen scientists using limited, simple soil observations. Soil Sci. Soc. Am. J. 2020; 84: 1675– 1692. https://doi.org/10.1002/saj2.20119

(9) Main sources for the selected soil tests are:

- Forest Gardening in Practice: An Illustrated Practical Guide for Homes, Communities and Enterprises Taschenbuch – 20. April 2017

-Soil testing methods, Global Soil Doctors Programme_A farmer-to-farmer training programme. FAO, Food and Agriculture Organization of the United Nations, Rome, 2020.

(10) M.Sc. Sara Busnardo, Architect and sustainable urban designer; co-driver of the OSA Research & Development Department and driver of the OSA Workshop Department. Her soilcare workshops which inspired the OSA ones are summarized in a booklet, shared on the open-source Feld Food Forest community archives: https://drive.google.com/drive/folders/1QMXr7e7eLFYS1rx2Da6xfktR9wGFWDmp?usp=sharing

(11) Our first and most enthusiastic Soil Ambassador is Miss Birgit Sanders and deserves a mention for her engagement, outreach and experience, which are shared by her personally during an interview in our OSA's final video-report.

(12) In this regard it is worth mentioning that this specific choice reflects a specific contemporary urban development trend in the city of Berlin, and more in general in Germany: Cemetery areas are being progressively dismissed because of two main factors: First of all, the general acceptance of cremation as mourning ritual, because of its economical and spatial benefits. Secondly, urban development policy-making and an actively engaged population are pushing for more living space within the city centre. The potentially excellent good quality of the soil derives by a German regulation impeding to use any kind of pesticide within areas considered sacred. The diffused growing Urban Gardening movement welcomes these factors as great opportunities for re-using ex-cemetery areas for urban gardening as a reconciling practice improving mental health and community belonging projects and, more in general, sustainable educational approaches to holistic and circular cycles.

Sources:

-https://www.dwenteignen.de/was-wir-fordern/

- https://www.meinkiez-meinfriedhof.berlin.de/

- https://www.berlin.de/sen/uvk/natur-und-gruen/stadtgruen/friedhoefe-und-begraebnisstaetten/

(13) This parameter mainly indicates the preference of our citizen scientists for areas of potential urban gardening interest and it is not necessarily indicative of the hygienic conditions of the urban green areas in Berlin.

(14) The evaluation was instructed by three graphical examples training the eye of our citizen scientists to recognise signs of erosion like uncovered tree root, uncovered ground, soil compaction and consequent superficial water overflow.

(15) See results of Coney survey on Table 05

(16) Fenja Freiin Grote, from the OSA Network and Outreach department, interviewed about the impact of Soil Meet Ups which took place in allotment gardens, July 2021.

(17) Masters Seminar (Summer Semester 2021): Soilidarity: Exploring human-environment relations in Berlin 'from the ground'. Academic fields involved: Urban Geography, Gender Studies, Global Change Geography

(18) From the earliest studies in Urban Ecology to the most recent cartographies of natural community spaces.

Sukopp, H. and Weiler, S. (1988). Biotope Mapping and Nature Conservation Strategies in Urban Areas of the Federal Republic of Germany. Landscape and Urban Planning, 15(1-2), pp.39–58.

Lachmund, J. (2014). Greening Berlin. the co-production of science, politics, and Urban nature. Cambridge: The Mit Press.

Kollektiv Orangotango and Transcript (Firm (2019). This Is Not an Atlas : a Global Collection of counter-cartographies. Bielefeld: Transcript Verlag.

(19) Workshop organised on 16th June 2021, coordinated by Elena Ferrari (PhD candidate in Urbanism at Iuav University, Venice, Italy) with Anna Verones, Fenja Freiin Grote together with students Arne Thiemann and Ronja Senkpiel from the Soil Science Department of the Humboldt University of Berlin.

(20) The project is supported in the last 3 years by public funds from CNPq (Brazilian National Council for Scientific and Technological Development) and Faperj (Carlos Chagas Filho Foundation for Supporting Research in the State of Rio de Janeiro).

(21) In October 2021, Open Soil Atlas will be presented by Elena Ferrari (PhD candidate in Urbanism at Iuav University, Venice) in a seminar about mapping and counter-mapping at the Department of Architecture and Urbanism at the Catholic University of Rio de Janeiro, at the invitation of Prof. Nobre.

(22) https://www.malvernpanalytical.com/de/products/measurement-type/ground-truthing

(23) https://news.mongabay.com/2021/07/global-restoration-now-has-an-online-meeting-point/

(24) https://www.climatefarmers.org/

(25) https://www.feldfoodforest.org/

(26) https://www.notion.so/Open-Soil-Atlas-7c203a31f562463393249b601d6fcec4

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Himmelbeet
WartenGarten
Projektes KuBiZ
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TABLES AND GRAPHS

Table 01_OSA Soil Protocol

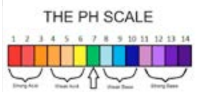
Soil Test Nr.	Test Name	Data Type	What is the meaning and importance?	What is the method for collection?	How long does it take to collect?	Citizen Scientist Evaluation Parameters (If applicable: 1=good; 2=fair; 3=poor)	Difficulty 1. Human Interface + Smartphone 2. Some tools (shovel, vinegar, etc.) 3. Lab/professional tests	User	Toolkit	Pictures	References / Sources / Links	Comments	Back-end FFF evaluation (possibly comparison with existing open-source Data for actual impact of OSA)
1	Soil Coordinates	GPS location	Spatially reference the soil data for making maps. Without a location, the data is meaningless!	Using a smartphone and map app. For instance in Google Maps you can hold your finger on your current location and drop a pin, then you can read the Latitude and Longitude coordinates and write them down. Alternatively: both iPhones and Androids have a "Compass" app built in. This compass shows the latitude and longitude.	1 minute: One data point (GPS point)	Not applicable	1	Soil beginner	Smartphone				Distribution around Berlin. This is possible to check only after the first workshop. Needs review for targeted invitations to the next workshop, in case of poor distribution in the city area.
2	Land use	Photo and 1-3 rating	Land use can higly influence some values of the analyzed soil like pH and clay content.	One picture of the area and a comparison with representative photos or cartoons. Maybe 3-10 photos or cartoons ranging from traffic median or other urban settings near roads to middle of the Gruenewald / urban gardens	1-5 minutes: One data point (photo and rating)	**1:** Area is already planted and in a less urban setting **2:** Area is in an urban area and the plants do not look healthy **3**: Area is very urban with lots of trash, nearby roads, and there are no plants	1	Soil beginner	List of Landuse + description possibly taken from here 3-10 pictures or cartoons of representative land use area tied to the 1-3 rating system		https://fbinter.stadt-berlin.de/fb/index.jsp?loginkey=showMap&mapId=fnp_ak@senstadt	It can then be compared to existing and uptodate Landuse Maps like for Berlin here	Types of green area sampled. This will define if we can speak about urban soils or if we rather have collected more rural/agricultural/forest soil samples. The final results will give us indications about the choices made bu users for
3	Anthropogenic impact	Description	Citizen scientists may notice other things about the soil, like the presence of human pollution (e.g. plastics) or they may have notes about the testing. It would be good to have a place to hold such notes that don't fit in other categories	Description and note taking	5 minutes	Nr. of pieces observable on 10x10m on the surface	1	Soil beginner	Camera				Evaluation of chosen areas: do CSs look for information about the impact of evident pollution e.G. in landfills? Do CSs chose areas that potentially look clean and healthy for their tests?
4	Soil erosion	1-3 rating	Soil erosion reduces the productive potential of soils through nutrient losses, loss of organic matter, reduced potential rooting depth, and lower available water-holding capacity.	Comparisons with representative photos or cartoons. Maybe 3-10 photos or cartoons ranging from healthy topsoil with grasses and plants to heavily eroded bare topsoil (easy to find in many parks in Berlin!)	1-5 minutes: One data point (rating)	**1:** Little or no erosion of the topsoil **2:** Some erosion of the topsoil is apparent **3:** The topsoil is very eroded or non-existant	1	Soil beginner	3-10 pictures or cartoons of representative soil erosion states tied to the 1-3 rating system.				CSs evaluation deriving from newly learned observational skills
5	Biological activity	Rating and number of bugs	The biological activity is an important factor indicating the quality and health of the soil. A healthy soil has more biological activity, meaning more bugs improving nutrient cycling and availability and also working to decompose soil organic matter, thus	Count the number of bugs visible in the soil during all the previous steps (photographing, soil profile, soil texture, pH). Also provide an approximate percentage of organic matter using cartoons showing percentage.	5 minutes: One data point (number of bugs and percentage of organic matter)	**1**: Many bugs are present (> 10) **2:** A few bugs are present (4<x< 10) and there is some organic matter (> 5%) **3**: Few to no bugs were found >4	1	Soil beginner					showing the proportion between CO2 capturing (rich in BA) VS CO2 emitting soils (poor in BA)
6	Soil profile	Photo and 1-3 rating	The soil profile is an important tool in nutrient management. By examining a soil profile, we can gain valuable insight into soil fertility. As the soil weathers and/or organic matter decomposes, the profile of the soil changes.	**We will analyze only HO,HA(Organic Topsoil) and HE,HB(EluviationH,SuBsoilH)** Dig a ~20*20*20 cm hole with a spade / small shovel. This hole will also be used for the next steps. Take one photo of the proile. Using comparison photos, rate the topsoil to subsoil transition: -Check depth and abundance of soil life and root matter -Topsoil contains organic matter, soil life and feeding roots -The deeper the topsoil layer, the better -Gradual paling of soil towards subsoil -Subsoil is wholly mineral, with occasional deep taproots	5-10 minutes: One data point (photo and rating)	**1:** Good layer of topsoil (> 10 cm); dark colour; the deeper, the better. Abundant, varied soil life and root matter. Visible pores for water, air and other gases; soil is soft and non compacted, roots extend vertically along A horizon **2:** Compacted topsoil, low biological activity and organic matter, topsoil is patchy and under developed **3:** No visible topsoil or poor quality of topsoil	2	Soil intermediate	Shovel and measuring tape. 3-10 pictures or cartoons of representative soil profiles tied to the 1-3 rating system. Please see Chapter 7, Figures 7.1 and 7.2 here: https://drive.google.com/file/d/1DFO2cl4_t9eFr2zKSQO0_sYcQp3ytrlO/view?usp=sharing		Please see Chapter 7, Figures 7.1 and 7.2 here: https://drive.google.com/file/d/1DFO2cl4_t9eFr2zKSQO0_sYcQp3ytrlO/view?usp=sharing		Anthropogenic soils (in Berlin >53%) and their self-regeneration indicators
7	Soil Color	Photo and description	Soil color is given by a combination of organic matter and minerals in the soil. Color alone can give a lot of information about the soil type and fertility. For instance, more yellow or red soils indicate the presence of iron oxides and more dark or brown soils tend to be higher in organic matter content. Without any chemistry lab, the soil color alone can already tell us about what's in the soil at the microscopic level. The amount of organic matter in a soil can tell us whether the soil is acting as a carbon sink or not.	If there is a clear difference between topsoil and subsoil after digging the ~20 cm hole, then scoop two separate samples from each horizon. Take a photo of each soil horizon separately against a solid colored background (e.g. piece of plain paper). Also compare the soil color to ~12 other colors (brown, black, red, yellow, etc.) and select the closest match	5-10 minutes: One data point if only topsoil, two data points if there is a clear different colored subsoil present	Assign a color to the soil (red, brown, black, gray, tan, etc.)	2	Soil intermediate	Shovel. 12 color options to choose from, see page 3 point 15 here: http://btckstorage.blob.core.windows.net/site12695/Soil%20&%20Earthworm%20Survey.pdf				Dark Indicates carbon content. Combined with BA, erosion and compaction measurements, will show the potential for CO2 capturing VS CO2 emission of the soils.
8	Soil Texture(I) Ribbon Method	Description and type	Soil texture is the way a soil feels in your hand and describes the percentage of sand, silt, and clay in the soil. These three types of material have different sizes (sand is coarsest, clay is finest). Soil texture has a big influence on soil quality and fertility, affecting water retention, soil structure, biodiversity, and the supply and retention of nutrients. For example, a soil with more sand does not hold water as well and has low organic matter, whereas a soil with more clay holds water very well and often has much higher organic matter.	The ribbon test is done on the topsoil and the subsoil (unless only one is present): **Step 1**: Take a handful of soil, around 25 grams, wet the soil and start mixing the two until the soil feels moldable. If too wet, add some dry soil and if too dry, add some more water. **Step 2**: Try forming a ball with the moldable soil. Can the soil form a ball? If not ? Sand **Step 3**: Try forming a ribbon by placing the soil between your thumb and index finger and squeezing the soil upwards to form a ribbon. Can the soil form a ribbon? If not: Loamy sand **Step 4**: The soil can form ribbons, but how long can they get? If the ribbon breaks at 2.5 centimetres or below, the soil is a type of loam. If the ribbon is between 2.5 and 5 cm, it is a type of clay loam, and if it reaches over 5 centimetres, it is a type of clay. **Step 5**: For this step, take some of the soil, wet it, handle at the palm of your hand, and determine whether the soil feels gritty, smooth or neither gritty nor smooth. This will help you determine the textural class of your soil.	10-15 minutes: One data point if only topsoil, two data points if there is a clear different colored subsoil present	**Types of loam** Does the soil feel gritty? > Sandy loam Does the soil feel smooth? > Silt loam Neither gritty nor smooth? > Loam **Types of clay-loam** Does the soil feel gritty? > Sandy clay loam Does the soil feel smooth? > Silty clay loam Neither gritty nor smooth? > Clay loam **Types of clay** Does the soil feel gritty? > Sandy clay Does the soil feel smooth? > Silty clay Neither gritty nor smooth? > Clay **1:** The soil has a high clay content indicating fertility	3	Soil expert	Shovel, water, chart showing the steps; see page 3 and 4 here: http://btckstorage.blob.core.windows.net/site12695/Soil%20&%20Earthworm%20Survey.pdf			Here we could also include the approximate percentage of rocky material (larger than sand). This would be done by comparison with simple cartoons of percentage rockiness.	Sandy soils will mostly be found. Combined with results about the humus layer on top of them (O Horizon) , will indicate if soil regeneration is happening. Moreover, it will give indications to gardeners about the presence of clay for water retention in their soil.
9	Soil Texture(II) Jar Test	Picture with meter measuring Jar results and percentages	To establish the proportion of clay, silt and sand in your soil. It also visualizes an approximate % proportion of OM present in your soil (=floating material). This can as well give an overview on the **% Carbon sequestered** from the atmosphere into this soil.	**1.Take half a jar of soil 2.Break up if necessary 3.Remove stones>2mm. Stir in water until ¾ full, then shake well 4.Leave for 10 seconds then mark level of settled material: Sand 5.Leave 10 minutes and mark: Silt (visible grain) and organic fraction (floating on top) 6.Leave until all particles have settled and mark clay (no structure visible) 7.Write down fractions as percentages 8.The table below gives an indication of soil types. Your soil might fall between these categories**	min 30 minutes optimal: 24h	**Rocks<5mm=% (out of Jar)** **MINERAL COMPONENTS Sand=% Clay=% Silt=% Sand=%** **OM (Organic Matter)=%**	2	Soil intermediate	-Your Eyes -Your Hands -Glass jar -Timer (cellphone) -Water Ruler/tape measure -A fine-tip marker pen		Forest Garden in Practice (book) Soil Test Handbook. - Permaculture Association | https://www.permaculture.org.uk		Verification of Test 8 and indicator of the amount of Organic Matter (OM) currently present.
10	Soil PH	Rating	The pH tells us how alkaline (basic) or acidic a soil is (how many free ions of hydrogen there are). This is an important factor for healthy plant growth and for the availability of nutrients. A very basic or very acidic soil will not be fertile and will not support plant growth.	Do vinegar and baking soda test, as shown on page 47 and 48 here: https://drive.google.com/file/d/1JcxYAbndTzAvUya1CCxlX1jNE4XVE3NM/view. **Does the soil fizz with vinegar?** Yes, a bit = slightly alkaline (pH = 8-9). Yes, a lot = strongly alkaline (pH = 9-10). **Does the soil fizz with baking soda?** Yes, a bit = slightly acidic (pH = 5-6). Yes, a lot = strongly acidic (pH = 5-6). **No reaction:** The soil is approximately neutral, which is good.	5-10 minutes: One data point if only topsoil, two data points if there is a clear different colored subsoil present	**1:** There is no reaction **2:** The soil fizzes a little, with either vinegar or baking soda **3:** The soil fizzes a lot with either vinegar (Alkaline) or baking soda (Acidic)	2	Soil intermediate	A shovel, a container to hold soil (a ceramic cup or anything that can hold the soil without interfering with the reaction), vinegar, baking soda, water filled container (deionized water if possible), anything to stir the soil water mixture with (a spoon or even a wooden material)				The best PH for most of plant growth is between 7 and 5,5: slightly acidic. Basic or bneutral soils can be acidified adding organic matter. Too acid soils can be equilibrated with elements like for example ashes.

Table 02_Online Workshop flow

1_Wilkommen

Hallo allerseits!
Hier ist unsere Agenda für heute:

Begrüßung (10 min)
- Wer bist du und warum bist du hier?

Einführung (10 min)
- Unsere Organisation
- Open Soil Atlas

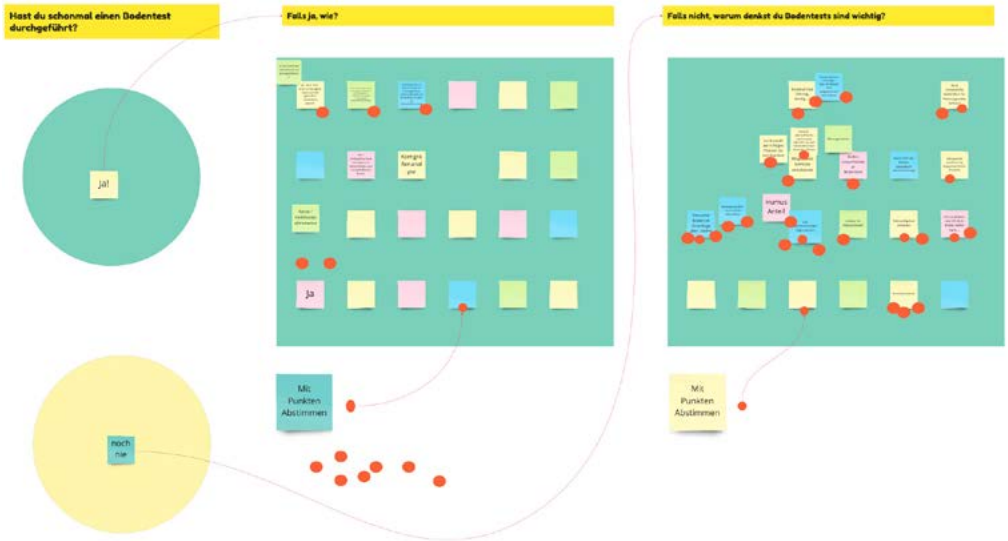
Über Boden (20 min)
- Hast du schonmal einen Bodentest durchgeführt?
- Falls ja, wie? Falls nicht, warum denkst du Bodentests sind wichtig?

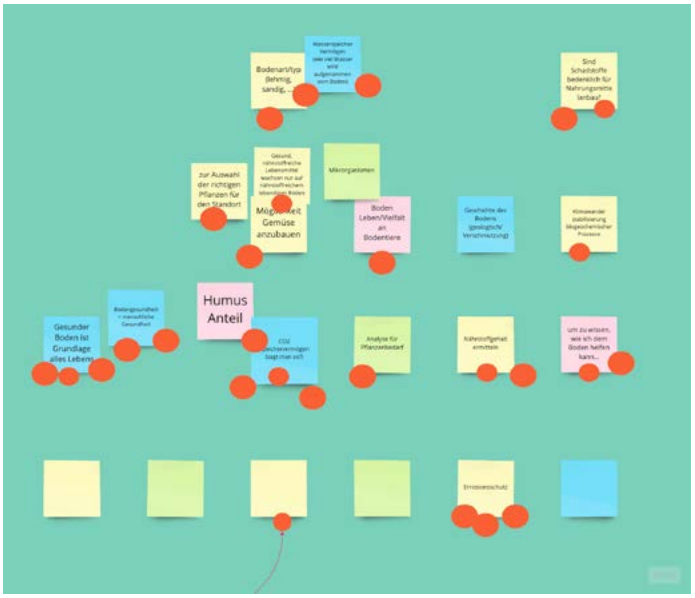
Open Soil Atlas (60 min)
- Ein Überblick über deine Zusammenarbeit mit uns (Miro)
- Bodentest Beschreibungen (Notion)
- Daten hochladen (Epicollect)

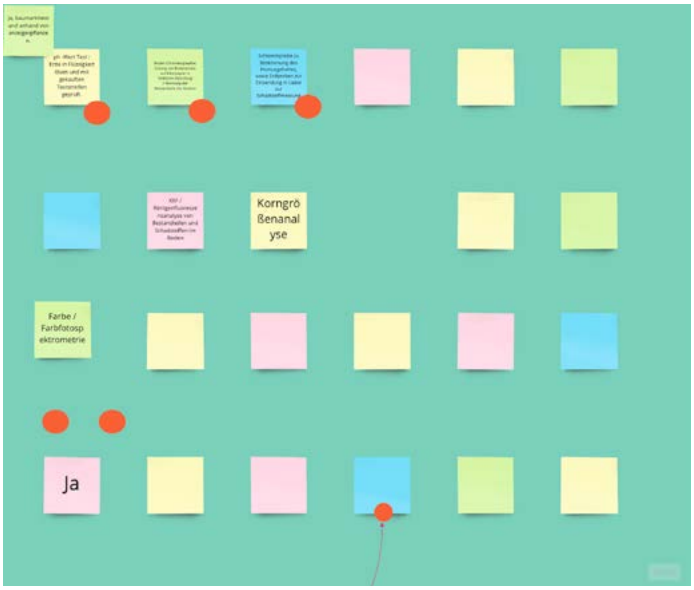
Abschluss (15 min)
- Q&A (15 min)
- Feedbackrunde (10 min)
- Teilnehmer*innen Check-out

2_Aufwärmübung in Miro

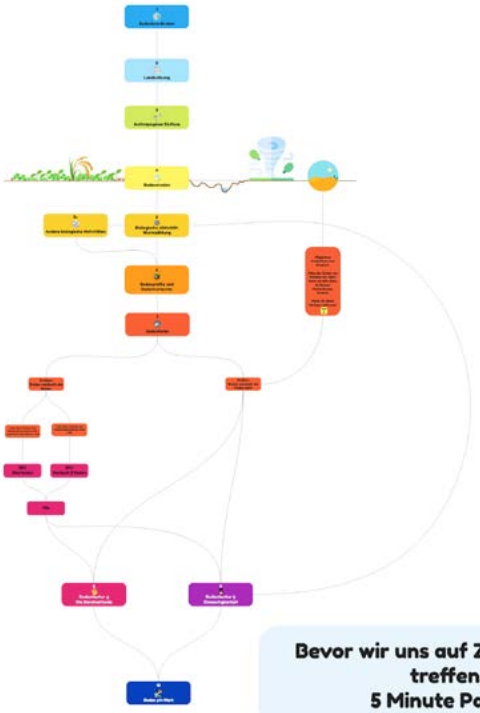
3_Lasst uns beginnen!



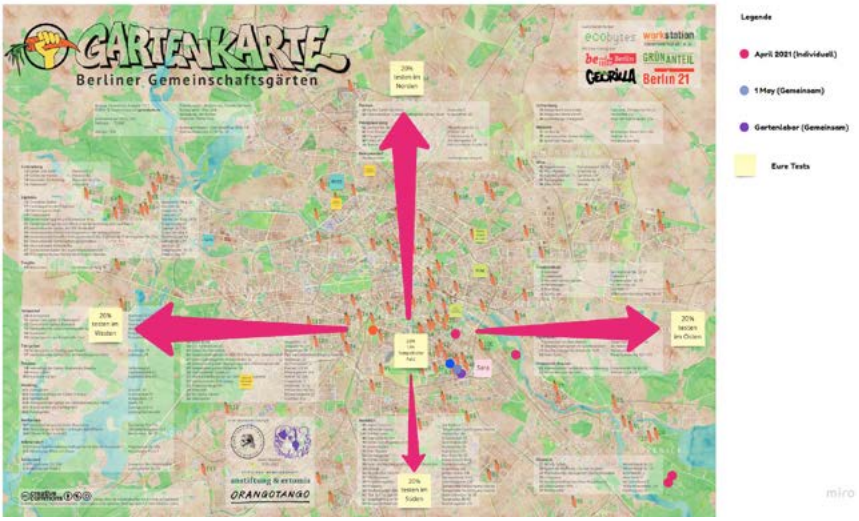




4_Bodentests

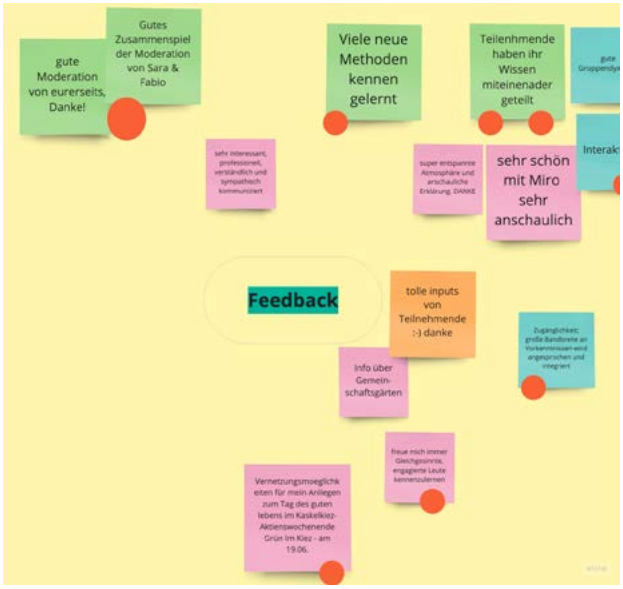


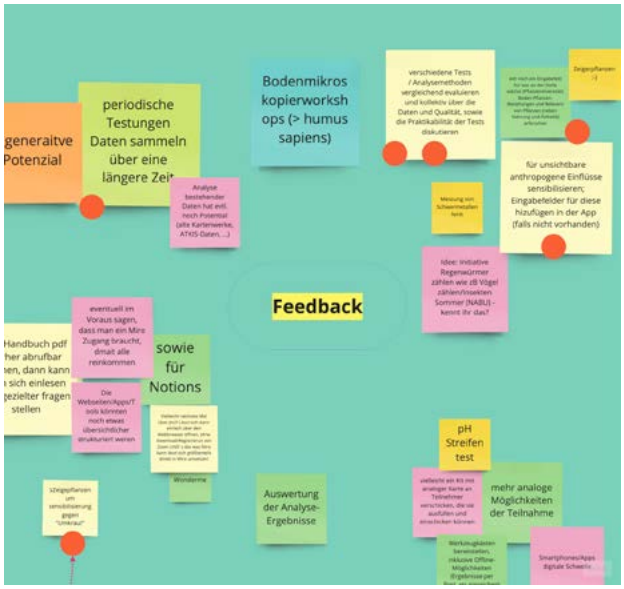
Unsere Raum Strategie



Bevor wir uns auf Zoom wieder treffen,
5 Minute Pause!

5_Feedback





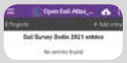
Open Soil Atlas
Soil Testing Manual
-Smartphone Edition-

Head outside and find the location where you would like to test the soil, then follow this simplified manual.

Full details of the tests can be found on our webpage:
https://www.notion.so/Overview-of-tests-88e713d1eca943f5a51556db6a89e5ac

1 Find the Open **Soil Atlas_ACTION 2021** Project on youEpiCollect App

2 Select **+Add entry**

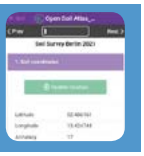


3 Enter an Entry Name in the form: Nick**name, Today's Date.** Then click **Next**

At any time, you can navigate through the test to change or correct answers with the **Next** and **Prev** buttons!

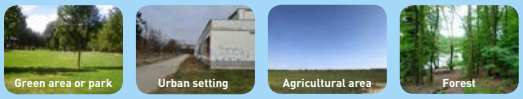
4 GPS Location

Enter the soil coordinates by clicking **Update location**



5 Land Use

Select the **Land Use** from the available options: Here are example images to guide your selection.



5a Land Use

If you selected **Green area**, select the specific type

6 Land Use

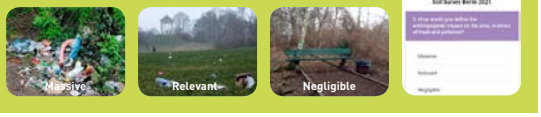
Add any other notes (optional)

7 Land Use

Take or upload up to four photos of the area facing approximately to the North, East, South, and West

8 Anthropogenic Impact

Record the **anthropogenic impact** (human pollution) in the area measuring 10x10 meters around your sample location.

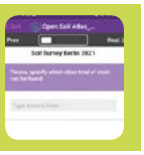


8a Anthropogenic Impact

If you selected **Massive** or **Relevant**, then record the type(s) of pollution

8b Anthropogenic Impact

If you selected **Other**, then add some notes of the type(s)

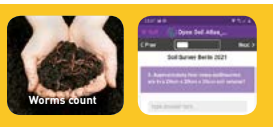


9 Soil Erosion

Erosion erosion is evidenced by parts of „bare" soil- Record the amount of **soil erosion**. Here are example images to guide your selection:

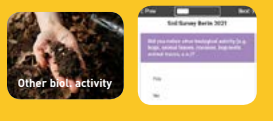
10 Biological Activity

Using a spade, shovel, or other tool, dig an approximately 20 x 20 x 20 cm hole where you want to test. Estimate the **number of earthworms** in the soil you remove and record the number.



11 Biological Activity

Record if there is any **other biological activity** in the soil. Here is an example of other biological activity.

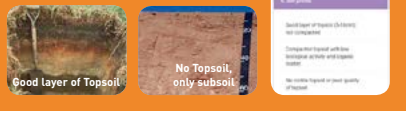


11a Biological Activity

If you select **Yes**, please and specify the type

12 Soil Profile

Record the **soil profile** (whether there is a healthy **topsoil** and/or **subsoil** present)



13

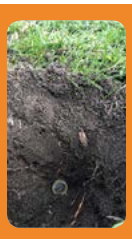
Soil Profile

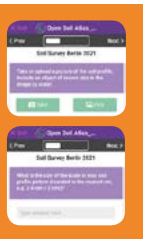
1. Create a flat surface, on a well lit side of the soil pit (ideally, facing the sun).

2. Place a scale (a pen, bottle cap, coin, **ruler**, or anything else) nearby this flat side of the pit.

3. Record a photo of the **soil profile** including the scale in the image.

4. Record the length or diameter of the **scale** in cm (round to the nearest cm, e.g. 2.4 cm = 2 cm).

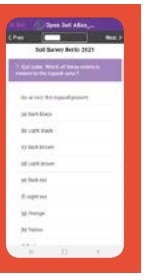




14

Soil Colour

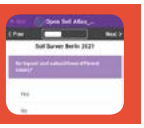
Record the approximate **topsoil color**.
You can select **No or very thin topsoil present**, which will take you to the **subsoil color** selection.
Here is the guide for soil color:



15a

Soil Colour

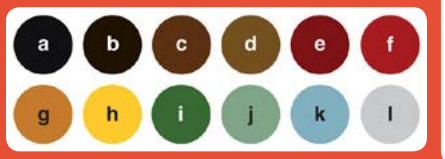
For the color difference between topsoil and subsoil, select **No** to use the same color you entered in the previous step.
Select **Yes** to select a different color for the subsoil.

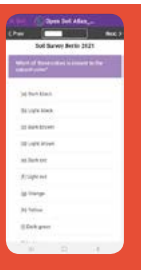


16

Soil Colour

Here is the guide for soil color:





17

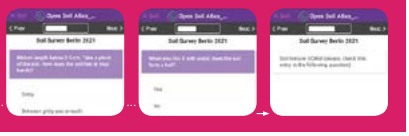
Soil Texture Ribbon Test

Now we will make the **soil texture ribbon test**.
Start by taking an approximately egg-sized soil sample and get it moist.
When you are satisfied with the moldability of your soil, squeeze a ribbon out of it.
Here is an example image to guide you in how to squeeze the ribbon:

18

Soil Texture Ribbon Test

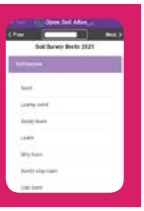
EpiCollect will guide you clearly through the steps to determine the texture, which you will record on the last page of this test.
Follow the steps and enter your results.



19

Soil Texture Ribbon Test

Select your results among the possible answers



20

Soil Texture Jar Test

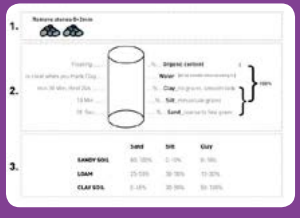
Do the optional **soil texture jar test**.
!requires at least 30 minutes, and it's much fun!
If you select **No** then you will go to the final pH test.
If you select **Yes**, then follow these steps and record the results in EpiCollect:

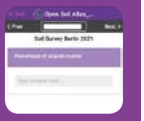
21

Soil Texture Jar Test

1. Break up all lumps if necessary.
2. Remove any large stones (>2mm) or large organic matter (sticks, roots, etc.). Record the approximate percentage of stones in the sample as: less than 5%, 5-20%, or more than 20%.
3. Using your fingers, pack the soil down as much as possible to reduce pore space and mark the level of soil on the side of the jar with a pen.
4. Stir in water until ¾ full, then shake well for 3 minutes or until the sample is fully suspended in the water.
5. Leave for 10 seconds then mark on the side of the jar the top level of settled material —> this is the volume of sand.
6. Leave for another 10 minutes and mark the top level of newly settled material —> this is the volume of silt (grains are visible). Also mark the bottom and top level of the floating material —> this is the volume of organic matter.
7. Leave until all particles have settled (this can take over 24 hours) and mark the final top level of settled material —> this is the volume of clay (no structure visible).
8. Using a ruler, measure the lengths between each marking from the bottom of the jar to the top (excluding the length between the top of the settled material and bottom of the floating organic matter, which is the water volume that we can ignore). From these numbers you can calculate the relative proportion of each component: sand (bottom level), silt (second from bottom), clay (third from bottom), and organic material (floating on top)
9. Determine the percentage of each component. As an example: You record 5 cm sand, 1 cm silt, 0.5 cm clay, and 0.5 cm organic matter.
The total is 5 + 1 + 0.5 + 0.5 = 7. The percent sand is 5/7 x 100 = 71%; The percent silt is 1/7 x 100 = 14%; The percent clay is 0.5/7 x 100 = 7%;
The percent organic matter is 0.5/7 x 100 = 7%.
Since we rounded the numbers the percentages only add up to 71 + 14 + 7 + 7 = 99%, but that's okay!

Here are two example images for the jar test:





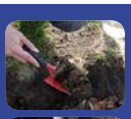
22

Soil PH

To make the soil pH test, follow these steps to prepare the soil sample:

1. Get a small handful of soil
2. Look for any plant roots or debris and try to remove them from the soil sample as much as possible.
3. Put the soil into a cup or container.
4. Add some water to the soil to turn it into a soil paste (not too wet nor too dry, it should have some consistency).

Here are some example images for the PH Test:

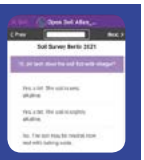


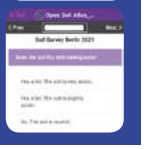
23

Soil PH

When the soil sample is prepared, follow the steps in EpiCollect by first adding vinegar (**alkalinity test**).

If there is a fizzing reaction and you select **Yes, a lot** or **Yes, a bit**, then you will be brought to the end of the form.
If you select **No**, then you will be brought to the next test, where you will add baking soda to **a new** sample (**acidity test**). Again record if there is **a lot** of fizzing reaction, **a bit** of fizzing reaction, or **no** reaction.



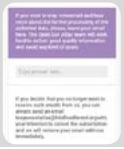


24

Now **save entry** on the last page and **sync the results.**

Congratulations! now you have coillected some useful informations about the fertility of your soil!

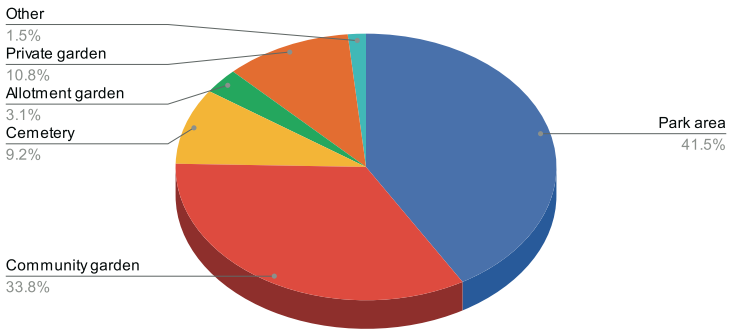
Stay connected with us for learning how to improve your soil, next exciting steps are being cooked for our **Open Soil Atlas community** of soil-caretakers!



25

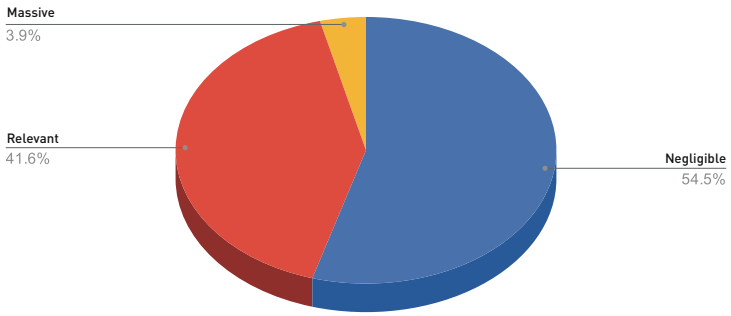
Don't forget to cover the holes you digged with soil and then some organic matter (leaves, cut grass, woodchips, etc). This will protect soil from drying out and will improve its biological activity.
If possible, leave the sampling area cleaner, and the ground more covered than what you found it!

Types of tested green areas

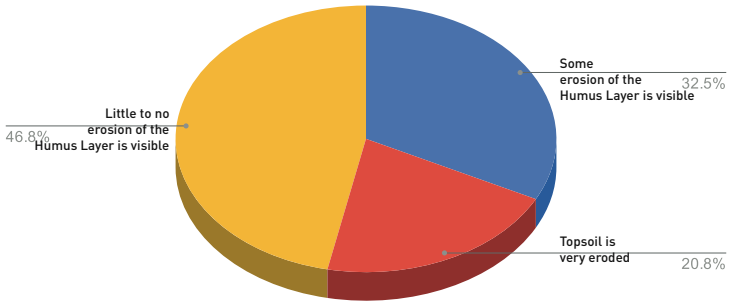


Anthropocenic impact

in terms of presence of non-biodegradable human litter

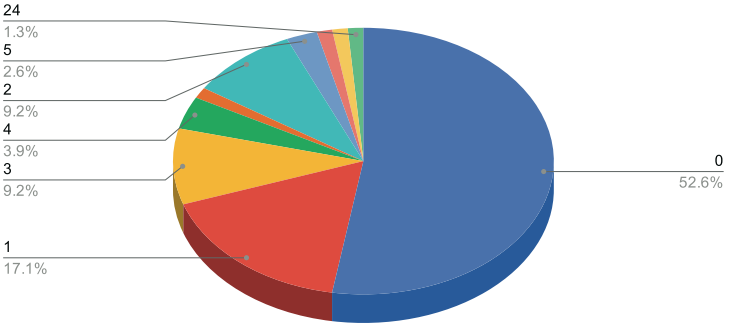


Soil erosion

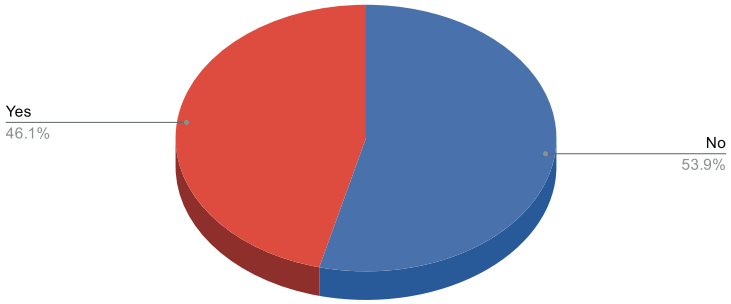


Biological activity

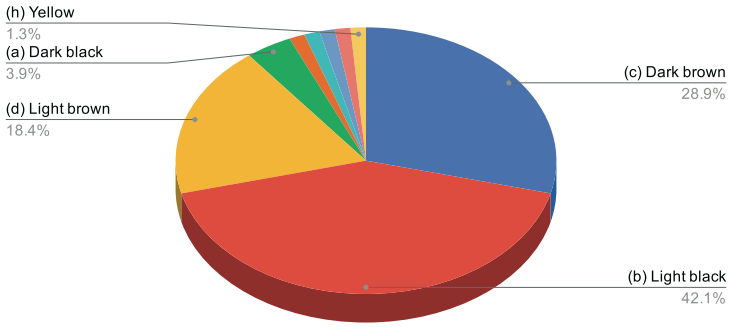
Earthworm count



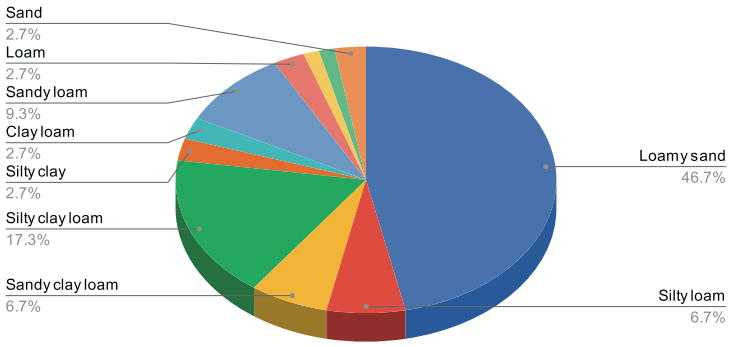
Soil profile
revealing the stratification of humus layer on geological soil.



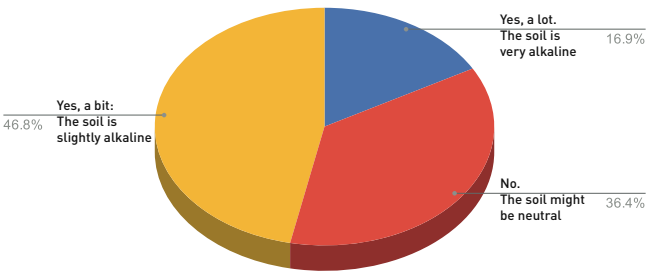
Soil colour
The darker, the more carbon content in the soil.



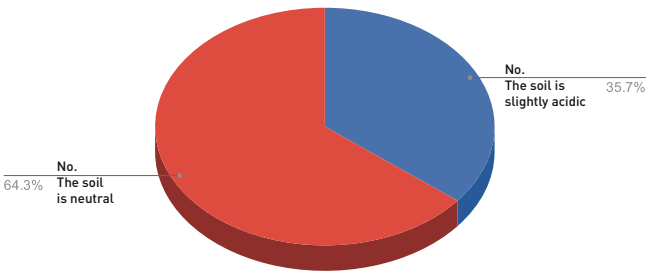
Soil texture
revealing the physical structure of the soil



Soil PH
Vinegar Test for soil alkalinity

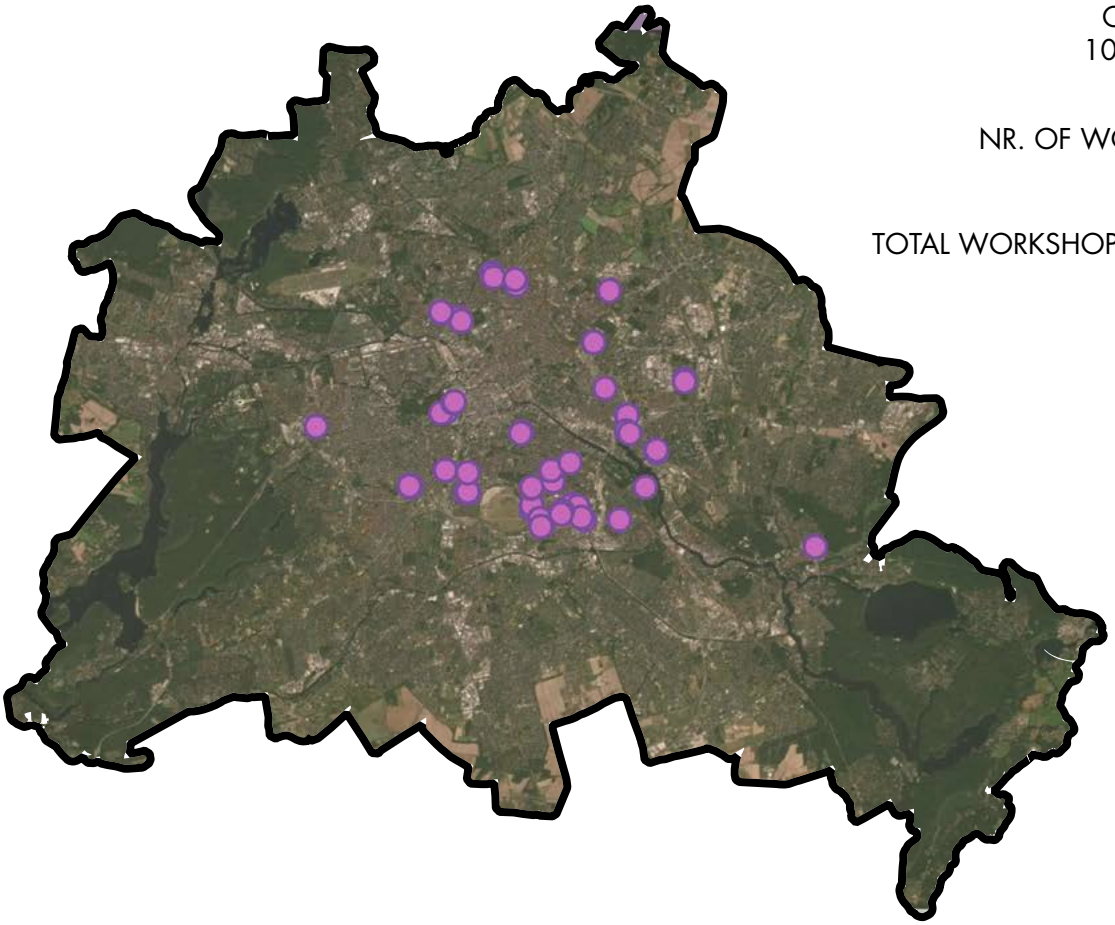


Soil PH
Baking soda Test for soil acidity



Berlin Map
Source: EpiCollect5, Open Soil Atlas_ACTION 2021

77 ENTRIES COLLECTED IN THE URBAN AREA OF BERLIN



OSA PROJECT'S KPI:
100 TESTS (MET 77%)

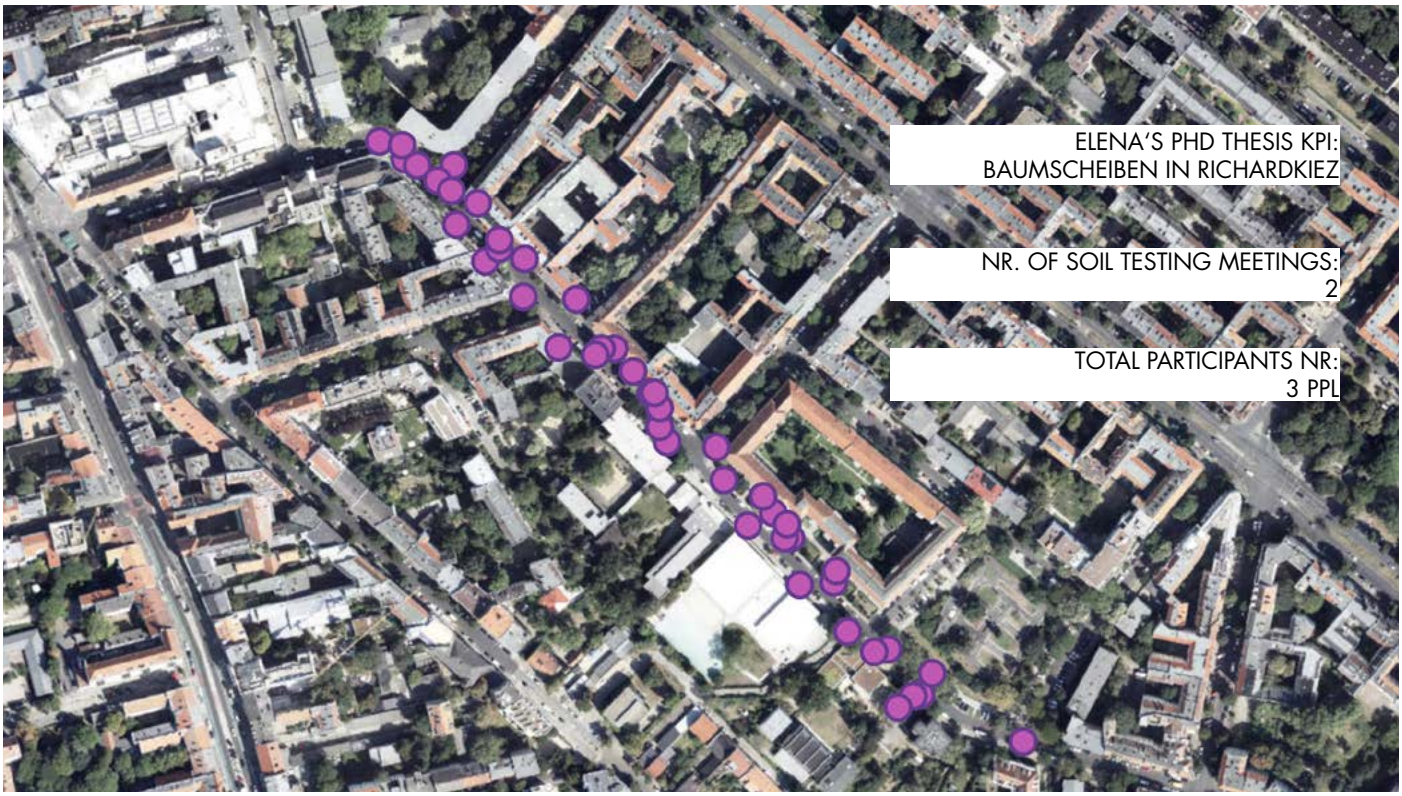
NR. OF WORKSHOPS GIVEN:
15

TOTAL WORKSHOP PARTICIPANTS NR:
70 PPL

TIMEFRAME_28TH MARCH - 26TH AUGUST 2021

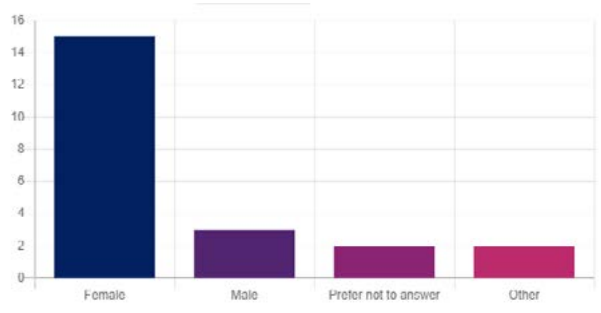
HD Map Example
Source: EpiCollect5, Open Soil Atlas_Street Greenery

44 ENTRIES COLLECTED IN SOUTHERN DONAU STRAßE, BERLIN

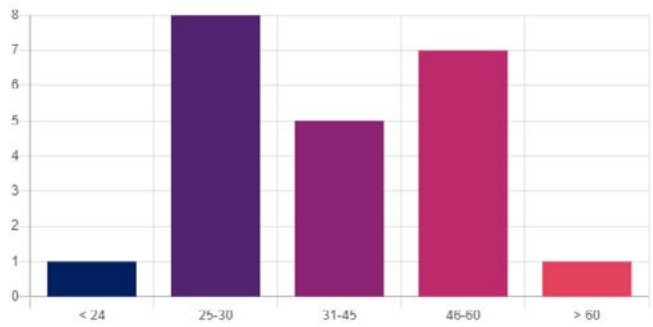


TIMEFRAME_19TH-20TH AUGUST 2021

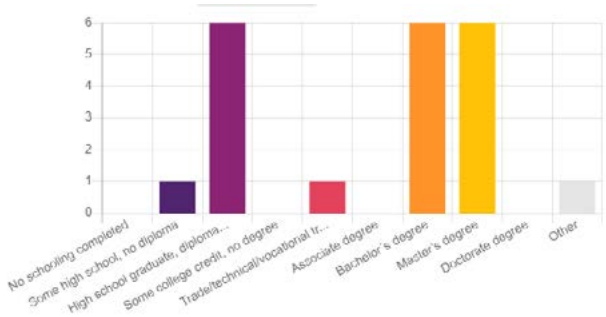
Table 05_Impact Assessment Survey Visualisation (Coney)



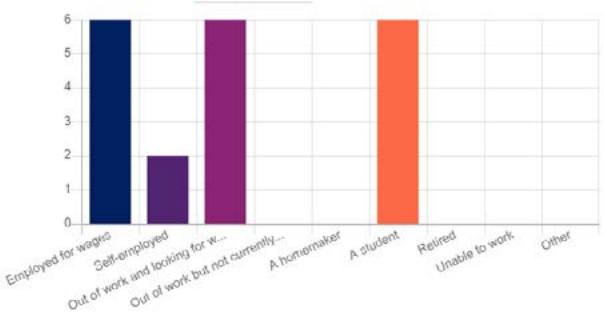
Graph 1: Gender distribution from participants who took the Coney survey



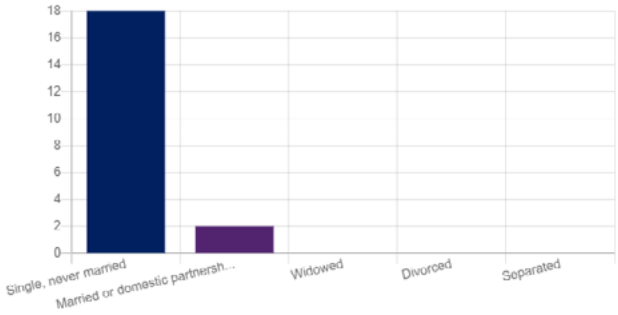
Graph 2: Age distribution from participants who took the Coney survey



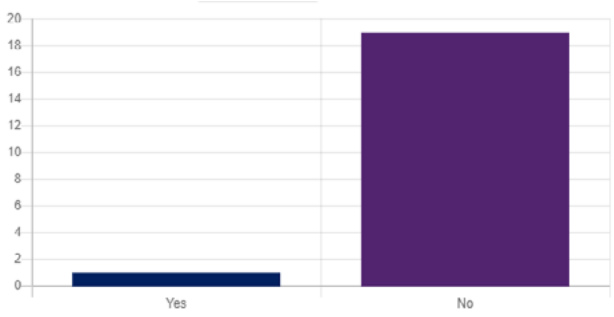
Graph 3: Educational background from participants who took the Coney survey



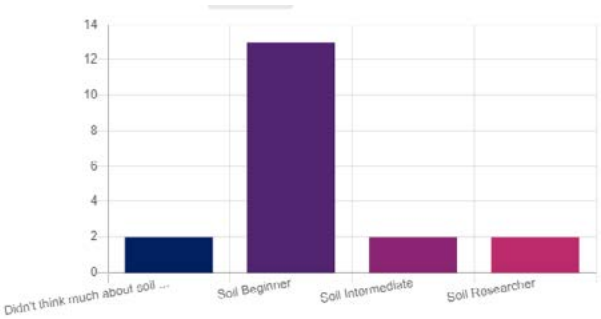
Graph 4: Employment from participants who took the Coney survey



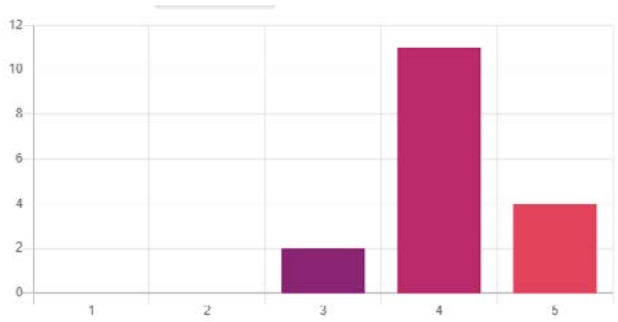
Graph 5: Marital status from participants who took the Coney survey



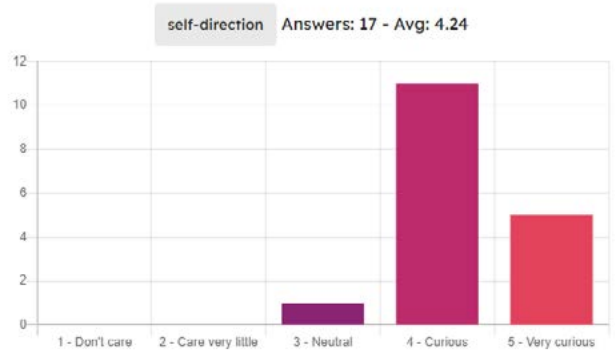
Graph 6: Amount of children had by participants who took the Coney survey



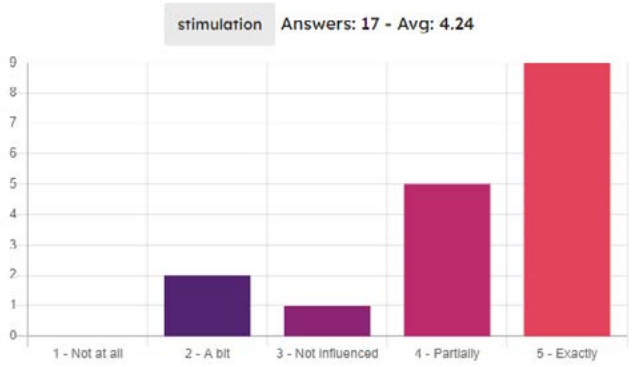
Graph 7: Background soil knowledge from participants who took the Coney survey



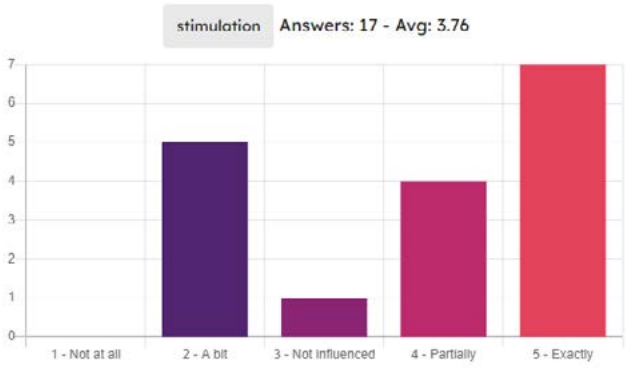
Graph 8: Expectation on how much to learn during the participation on the Open Soil Atlas project



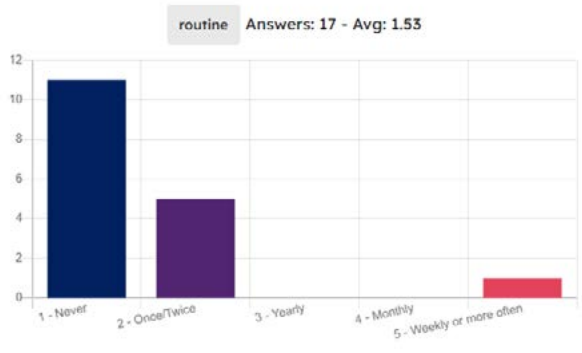
Graph 9: Interest in soil fertility and soil health from participants who took the Coney survey



Graph 10: Responses to the question: Did you join the Open Soil Atlas project to have the possibility to do something new?

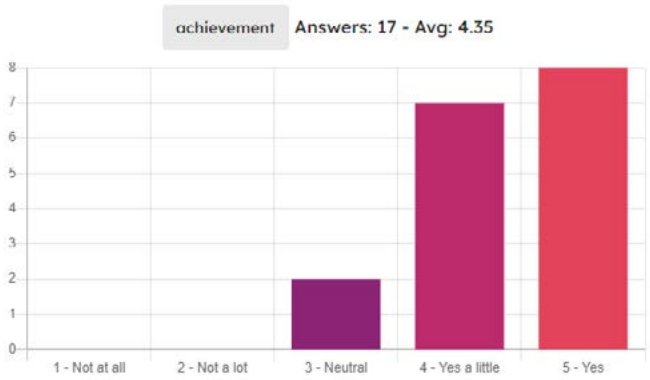


Graph 11: Responses to the question: Do you think your participation is an opportunity to challenge yourself?

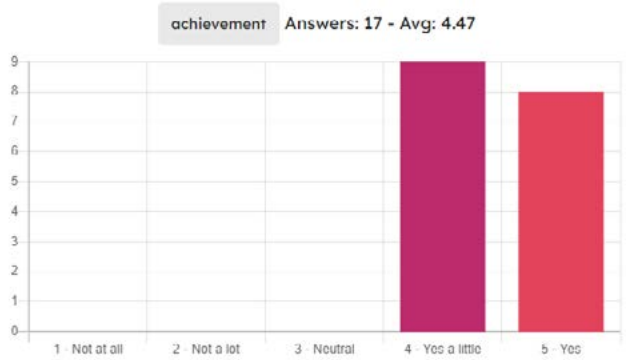


Graph 12: Responses to the question: Have you ever done soil testing before joining Open Soil Atlas?

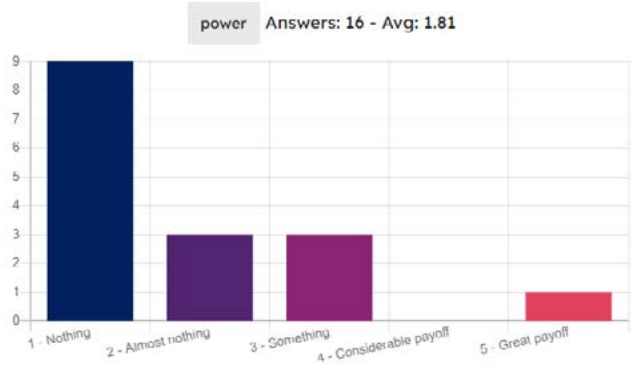
Graph 13: Responses to the question: Does your participation in the Open Soil Atlas project make you feel good about yourself?



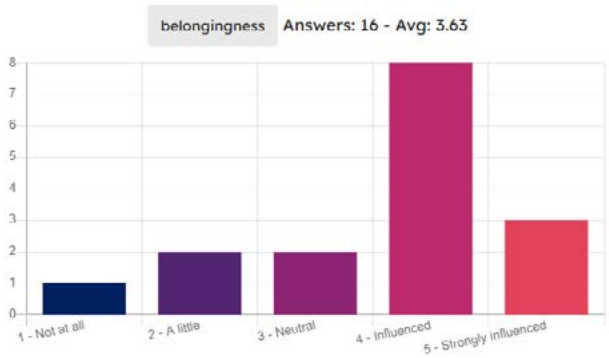
Graph 14: Responses to the question: Does participation in the Open Soil Atlas project help you to improve your skill sets?



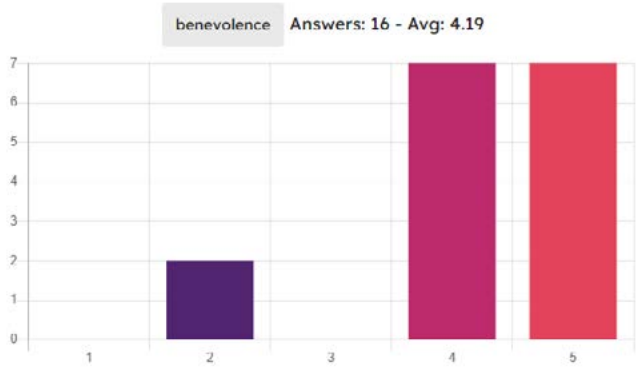
Graph 15: Responses to the question: Does your participation in the Open Soil Atlas project represent an opportunity to do something meaningful?



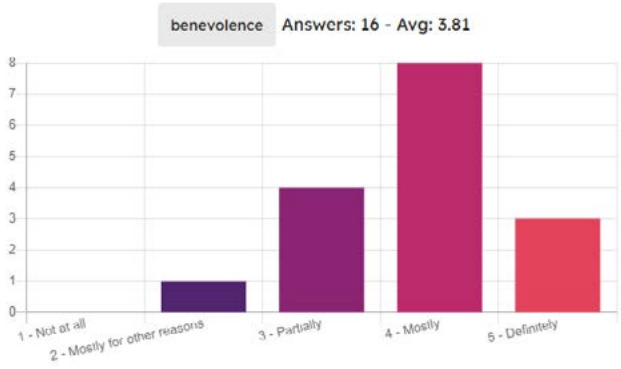
Graph 16: Responses to the question: Do you expect something in return from your participation in the Open Soil Atlas project?



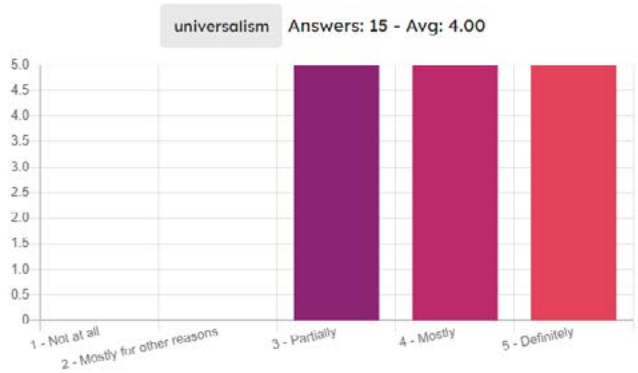
Graph 17: Responses to the question: Is your participation in the Open Soil Atlas project influenced by the desire to meet people with similar interests?



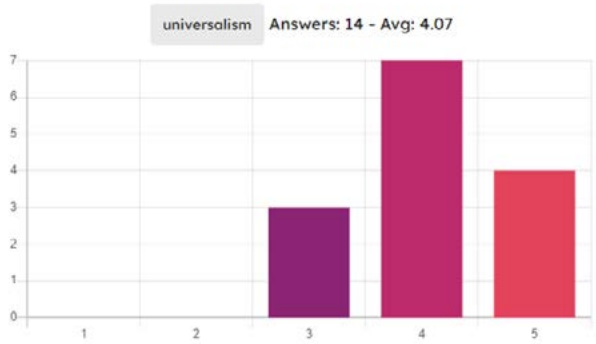
Graph 18: Responses to the question: How much do you see your participation in the Open Soil Atlas Project as a good thing to do?



Graph 19: Responses to the question: Do you participate to contribute and help scientific research?



Graph 20: Responses to the question: Do you participate in the possibility of making data about soil testing more accessible?



Graph 21: Responses to the question: How much do you see your participation as a possibility to raise public awareness to the soil health, fertility and degradation topics?

Graph 22: How much are you motivated in participating in the Open Soil Atlas project?

Graph 23: Durations (seconds), Dates, Hours and Languages for taking the survey