
on
souls
and
soil
duy bui

on souls and soil

stories of radical entanglements

duy bui

for my mother

To bear and not to own;
to act and not lay claim;
to do the work and let it go:
for just letting it go
is what makes it stay.

— Lao Tzu
rendition by Ursula K. Le Guin

on souls and soil: stories of radical entanglements
duy bui

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I

F01

Introduction

Soil is a peculiar thing. It is the dirt beneath our feet; the thing we are all part of; the thing wars are waged over and the thing people are fleeing from. Soil is the source of the richest biodiversity on Earth (Blum 2005). It is a living thing and an essential actor in our terrestrial ecosystem. Seemingly static, soil is far from that: soil is in flux; its processes ever-changing. Processes and entanglements we have much to learn about.

This thesis is about my ongoing research, which is an inquiry into the (personal) past, learnings from current structures and developments of alternatives that include the more-than-human.

Between 2019 and 2020, I explored the landscapes of Cambodia and Hong Kong with additional observations from Vietnam. I investigated the stories of colonialism, exploitation and war that those landscape structures tell and cultivated a sensibility for my interactions with the environment. I learned about the historical, political and social entanglements of these places and consequently connected them with other structures. I focused specifically on the landscapes and people of Cambodia and Wang Chau, a village in northern Hong Kong. Furthermore, I studied the stories of social and environmental inequality and exhaustion that those places communicate.

In Switzerland in collaboration with the Swiss Federal Institute for Forest, Snow and Landscape Research WSL, I researched more about the science of soil, conducted experiments and built devices to probe and leverage soil processes. I learned about soil from a scientific viewpoint and developed a literacy that enabled me to better observe ecosystem dynamics. I learned working modes from science and how to combine them with design methodologies.

The experiences in Southeast Asia were profound and challenging. Through participation and being-with people, I built relationships, shared knowledge and collective memories with them. Noticing the stories and common responsibilities, I rethought and advanced my practice as a designer. These experiences and learnings highlight the importance of attunement to

landscape structures and of the knowing-with and knowing-otherwise (Haraway 2018; Tsing et al. 2019). This expands the current design practice that is all too often restricted only to humans. It stresses the importance noticing and going beyond the human towards a more-than-human approach; towards a design that benefits all beings and asks how insurrectionary acts and cultivation of shared responsibility dare us to imagine otherwise.

The thesis is structured in five parts. Part I encompasses the chapters about Cambodia and Hong Kong, reflecting on my experiences there. In Context, Ecological Imperialism and Attuning to landscapes I discuss notions of ownership, multispecies ethnography and how an attunement landscape structures informs us. Part II focuses on the science of soil and my experiences about working with scientists. Field research, related works, experiments and prototypes are presented and discussed. I explore what emerges from the space in-between the arts and science. Last, I highlight and discuss the aesthetics of the laboratory. Part III focuses on the exhibition concept and concludes the thesis. Part IV contains the bibliography and list of figures and Part V is the appendix.

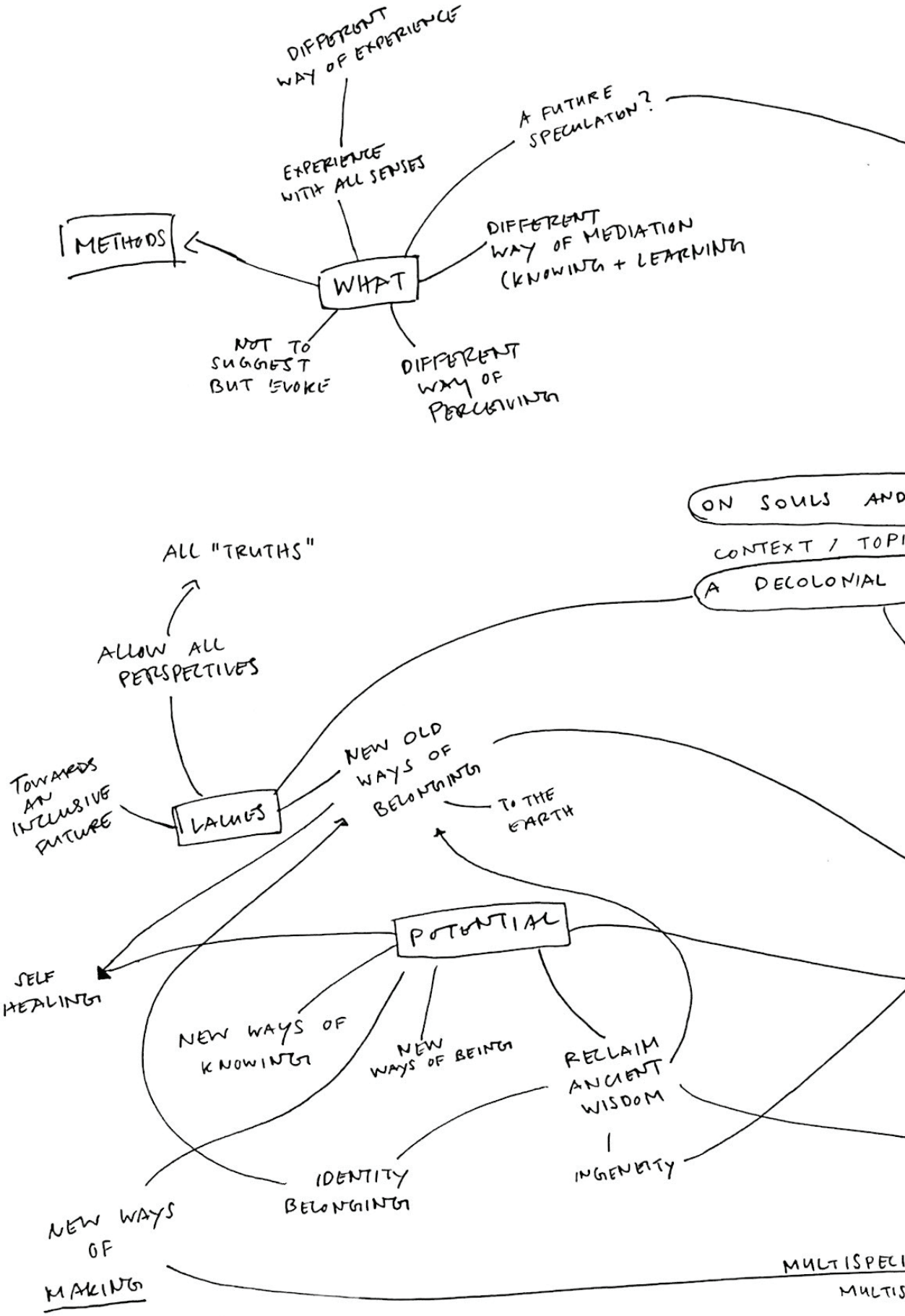
Complimentary to this thesis are the exhibition zines about Cambodia and Hong Kong.

Motivation and Intended Contribution

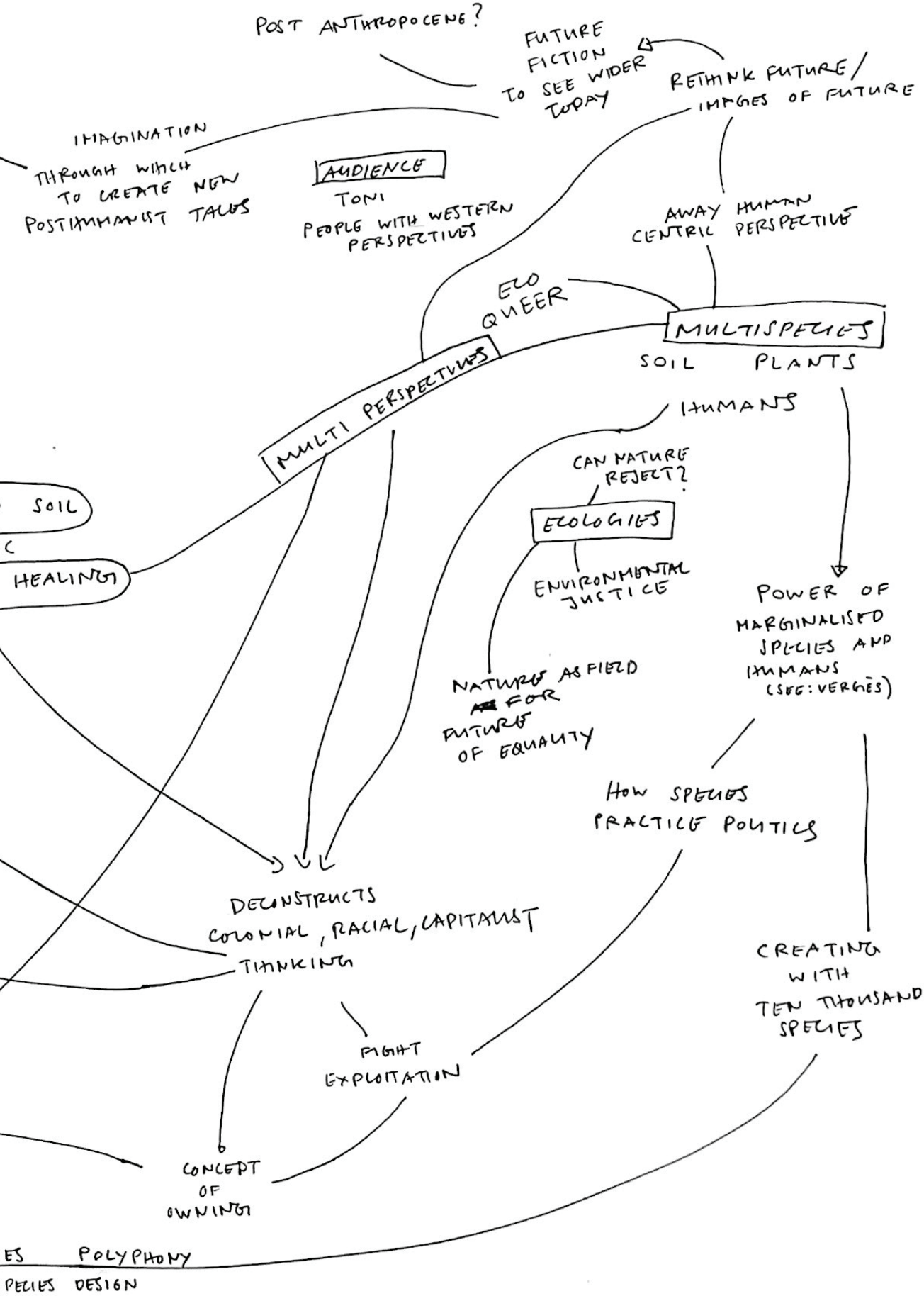
My motivation stems from my ongoing inquiry into my heritage of displacement. I have always subconsciously tried to make sense out of my Vietnamese roots and have therefore developed a certain sensibility to historical and political structures. The transforming experiences in Southeast Asia and an attunement to those landscapes helped me further sort out subconscious questions. The learnings and solidarity with the people have additionally reaffirmed my research motivation and were and are my motivation to work towards the common. I was interested in new ways of learning, teaching, measuring and naming — towards a *fluid* way of making sense. Not owning all the questions and answers beforehand, but learning through experiencing in a non-linear way. I hope to unearth old paradigms, deconstruct colonial, racial and capitalist structures towards new old ways of belonging. Wilful disobedience and reclaiming of one's own power, those insurrectionary movements are lived alternatives (Leung 2016). What radical visions of the future are currently in the making? Tackling these issues might prove difficult, let alone aiming to solve them (which I don't). Instead of providing a solution, I aim to generate and share the knowledge of my process and contribute to alternative fluid methods for research. In doing so, I hope to keep the discussion relevant and contribute to future works that might improve or change the situation.


SEX AS AREA WHERE PEOPLE BECOME MOST SENSITIVE TO POLITICS, EXPLOITATION,
HIGHLIGHTING COLONIAL AND RACIAL STRUCTURES
IDENTITY
"BELONGING"
LANGUAGE
NATION
LAND
FIGHT EXPLOITATION OF SOIL
METHOD
DECONSTRUCT COLONIAL AND RACIAL THINKING AND PERCEPTION
HOW TO CONVEY EXPERIENCES THAT PEOPLE NEVER EXPERIENCED?
LOOK CLOSELY AT RELATED WORKS
IMAGINATION ESSENTIAL IN CREATING NEW POSTHUMANITY TALES AND RONGSHU UNDER-STANDING OF LIFE
DECOLONIAL H
MATERIAL
CAN BE MORE CRITICAL IF I SPEAK FROM MY PERSPECTIVE
ISSUES/OBSTACLES
WHICH METHODS?
SOIL IN IMAGES OF THE FUTURE
WHY ME?
SELF HEALING
AWARENESS OF RIGHT WING USES OF "SOIL"
STRUGGLE FOR LAND
ENVIRON-MENTAL JUSTICE
NOT HUMAN-ONLY CREATIONS, BUT CREATIONS BY TEN THOUSAND BEINGS (ZHENG BO)
ANCIENT WISDOM
NO "DIRECT" CONNECTION TO SOIL
BUT AN EMOTIONAL ONE, TRANSCENDING GENERATIONS
INTERESTS:
- ASIAN COLONIALISM
- STRUGGLE FOR LAND
- SELF/HISTORY EXPLORATION
- MULTISPECIES
"AREAS MANAGED BY INDIGENOUS PEOPLES SAME BIO-DIVERSITY AS NATURE RESERVES." (ZHENG BO)
WHAT I
LAND POLLUTION IN VIETNAM
"DIFFICULT IMMENT PARA-DIGMS


CO-CREATING/
WORKING TOGETHER
CONTINUE
LEGACY OF
ACTIVISTS THAT
CAME BEFORE
LIAM YOUNG:
"POST-ANTHROPOCENE"
→ TECHNOLOGY AND
AI ARE CAPABLE
OF COMPUTING/CONSTRUCTING
OUR WORLD
CONDITIONING
SOIL PRACTICES
POLITICS OF
POLITICS OF SOIL
AESTHETICS OF
'DECOLONIAL HEALING'
'SOIL AS MATERIAL'
INTERESTING
FROM
COLONIAL MINDSET
SOIL MADE
BY HAND
(BIOSPHERE 2)
EALING
SOIL
SALT
MULTISPECIES
PERFORMANCE
NATURE
DOMESTICATED
HUMANS
ECO-QUEER THEORY
→ CONNECTING QUEER PEOPLE
AND PLANTS
FROM
DECOLONIAL
PERSPECTIVE
ULTISPECIES
PERSPECTIVE
DECOLONIAL
FEMINISM
CRITIQUE: STILL A PROJECTION
OF HUMAN NEEDS ONTO NATURE,
WHICH CANNOT OBJECT TO
WHAT IS DONE
SOIL
AND
IDENTITY
INGENUITY
RETHINK ECOLOGICAL FUTURE
HIGHLIGHTING POWER OF MARGINALISED
PEOPLE/PLANTS/OTHERS TO OVERCOME
IMPOSED STRUCTURES AND OFFER NEW
MODELS FOR RECONNECTING WITH PLANET
S SOIL
TO
INTERSPECIES
COMMUNITIES
NEW ECOLOGY
NATURE AS FIELD FOR EXPERIMENTATION FOR A FUTURE OF EQUALITY



F02.1 Preliminary Research


POST ANTHROPOCENE?
FUTURE FICTION
TO SEE WIDER TODAY
RETHINK FUTURE/ IMAGES OF FUTURE
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CAN NATURE REJECT?
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NATURE AS FIELD FOR FUTURE OF EQUALITY
POWER OF MARGINALISED SPECIES AND HUMANS (SEE: VERGES)
HOW SPECIES PRACTICE POLITICS
DECONSTRUCTS COLONIAL, RACIAL, CAPITALIST THINKING
CREATING WITH TEN THOUSAND SPECIES
FIGHT EXPLOITATION
CONCEPT OF OWNING
POLYPHONY
DESIGN

F03 One of many unfinished buildings, Kâmpóng Saôm

Cambodia

In March 2020, my travels led me to Kâmpóng Saôm[1], a coastal town in the south of Cambodia. From Phnom Penh, Cambodia's heavily transformed capital, it takes roughly five hours by bus to get there. Kâmpóng Saôm was supposed to be a popular holiday destination known for its pristine beaches. When I arrived, I was struck by the construction work going on that has churned up every last bit of the once sleepy village. Everywhere the soil was broken up, littered with garbage and construction materials. The tuk-tuk drivers charged double the fare to drive through (and up and down) the broken landscape. The locals could not answer our many questions about what was going on either. As our driver took us to the town center, we received our answers in the form of high-rise buildings adorned with bright LED signs in Chinese. Large-scale redevelopment is not unusual for Cambodia, but the scale at which it takes place in Kâmpóng Saôm was most jarring.

[1] Also known as Sihanoukville. I use the name Kâmpóng Saôm, derived from the local indigenous community.

China's Belt and Road Initiative (BRI) is a foreign policy and development project. The BRI is connecting China with Southeast Asia, Central Asia, the Pacific Islands, Africa and Europe. Aiming to establish a global network for trade, it includes massive infrastructure developments, involving "two-thirds of the global population and one-third of the global economy" (Ascensão et al. 2018). As Cambodia is one of Southeast Asia's least developed countries, it has become a strong ally of China and depends on its economic aid (Yu 2017). Due to the authoritarian nature of the regime, government decisions benefit (foreign) businesses at the expense of the local population. This has been leading to violent displacements (Hughes 2008). As the country's only deepwater port, the Sihanoukville Autonomous Port located in Kâmpóng Saôm plays a key infrastructure role and is managed by the Chinese and Japanese government (Calabrese and Cao 2021). With Chinese investment came also an increase in immigration of Chinese nationals. Those fill most of the new jobs that are offered at those casinos, hotels and restaurants. The shopkeeper of a Chinese groceries store told me about the hardships she experienced in China and she hoped for good business

F04 Construction site in Kâmpóng Saôm

F05 Chinese shop in Kâmpóng Saôm with prices fit only for tourists

F06 Construction site in Kâmpóng Saôm, 2020

F07 Girl from the floating village

in Cambodia through the increase in Chinese tourists.

The BRI is not only disrupting Kâmpóng Saôm but in fact plays out in various regions in Cambodia. Chinese financed infrastructure development is one of the key factors contributing to Cambodia's economic success (Calabrese and Cao 2021). All over the country, we witnessed forests being burned. Since 2001 Cambodia has lost 24 to 33 percent of forest area mainly for rubber plantations, timber logging and infrastructure projects (Grogan et al. 2019) The forest loss results in soil erosion, flooding and severe impacts on agriculture, fishing and carbon storage. The forests in Cambodia store over 2.37 gigatons of carbon, an unimaginable volume, with vast amounts already being released into the atmosphere as carbon dioxide (Kresek 2019).

With investments into and prioritisation of hydropower dating back to 1999, China is also controlling the flow of the Mekong. This interference results in disruptions of the flooding cycles of the Tônlé Sab (Williams 2019). Normally, the lake is flooded annually by the Tônlé Sab river, which reverses its course twice a year (Cristofoletti and Narciso 2021). The dams in interplay with climate change disrupted the flow cycle, causing the lake not to fill up. This causes damages to the ecosystem and destroys the way of life of the local population, which relies heavily on the Tônlé Sab as source of food and income. The Tônlé Sab freshwater ecosystem is one of the most productive in the world. It is a result of an intricate synergy between the high water temperature, annual flooding and the flooded forests that bring with them a vast biodiversity of microorganisms. The dynamics between the ecosystem and the local population have been established as far as back to the 13th century and are discussed to be the basis for the Khmer Empire (Lamberts 2006).

On the Tônlé Sab, I learned about the floating villages, visited floating markets, schools and even a floating basketball court. From the family I visited I learned first-hand about the effects these disturbances to the flow of the Tônlé Sab have. According to Cristofoletti and Narciso's (2021) report, this year is one of the most severe with one of the lowest water levels. The recent developments displaced hundreds of families and makes them dependent on relatives working in the cities. Along with

F08 Family I visited in their floating house, Tônlé Sab

vanishing biodiversity there is a vanishing of knowledge in younger generations about traditions and ecologies (Cristofoletti and Narciso 2021).

Conclusion

Cambodia's landscapes are entangled in dense political webs. They and their inhabitants have turned into playthings of capitalist extractivist politics. Deforestation, soil erosion and other ecosystem disturbances are seen and felt everywhere. The extensive devastation of the Tônlé Sab ecosystem and the destruction of Kâmpóng Saôm against the absurd backdrop of Chinese casinos and stores made me begin to inquire about the processes that unfold around us. Every place I went I learned from the locals through their personal accounts. Being confronted the first time with issues like these, I began to develop a sensibility for the relations of land destruction, displaced families and war.

F09 Wang Chau Village entrance


共生

Hong Kong

I returned to Hong Kong in late March 2020. I was in Hong Kong for the first time in 2019, where I studied as part of the Transcultural Collaboration Programme. 2019 marks a significant year in Hong Kong with the start of the Anti-Extradition Law Protests that would develop into the 2019-2020 Hong Kong Protests, which arguably are still ongoing as of this writing. Without prior knowledge of Hong Kong I had thought of it as one of the many Chinese megacities. Thus, I was surprised to find a place that I can still not grasp in its entirety — a place that is far from being *a* Chinese city. More than that, it is defying China and cultivating its own identity at an all too rapid pace (compare Tsang 2004; Ho 2019; Chenivesse-Wong 2019; Li 2020; The Civil Critique 清議 2020).

Gordon Mathews (2020) observes this new sense of belonging since 2011. However, I would argue that events such as the 1967 riots by local communists close to China, the disappointment in the British government (Cheng 2010) and the anxiety around and after the 1997 handover (Veg 2017) have already metabolised this new sense of identity. A belonging that is neither British nor Chinese but *Hongko*nger (香港人 : Hong Kong People).

The artist Tiffany Sia (2019) described Hong Kong as an imaginary place, existing on borrowed time on borrowed space. A fiction counting down. Hong Kong was conceived as a place meant for trade and transit, ceded to the British Crown by the Chinese Emperor in the Treaty of Nanking in 1843 (Tsang 2004). The focus on economic activity is still to this day deeply rooted in Hong Kong culture (Mathews 2020). Later, the city became a place of refuge during the unrest in China between the 50s and 70s and has now become a place deeply loved by Hongkongers — it has finally become home for so many; and that home is slowly slipping away (compare Chenivesse-Wong 2019; Li 2020; The Civil Critique 清議 2020; Mathews 2020).

During my studies, I investigated this developing identity. My main interests were the following: What is Hong Kong and why do the Hongkongers do what they do? Needless to say that

F10 Near Mapopo Community Farm, Hong Kong, also destined for eviction

the many interviews we conducted led to more questions than they answered. The Hong Kong society was and is truly at a melting point. Choosing between authoritarianism and (capitalist) freedom, neither of those are choices that will pave the way for society.

A discussion with a Hong Kong protester was especially memorable: She described the gamified and capitalist nature of the protest: Expensive equipment is used, costing the protesters and their sponsors a small fortune. Brand sneakers are worn to police clashes, the nature of those sometimes take on the nature of a game. Paradoxical mid-protest break snacks in McDonald's were not rare. With another friend, I discussed the discrimination and stigma she is facing as a protester born in Mainland China. It is ironic then that two of the most prominent Hong Kong democratic figures, Edward Leung and Nathan Law, are born in the Mainland and later immigrated to Hong Kong. Both have spearheaded the democratic movement and are now in jail and in exile respectively. All these paradoxes fuelled my interest in the question of belonging, especially to a place like Hong Kong that is essentially hostile to the environment as well as to its people.

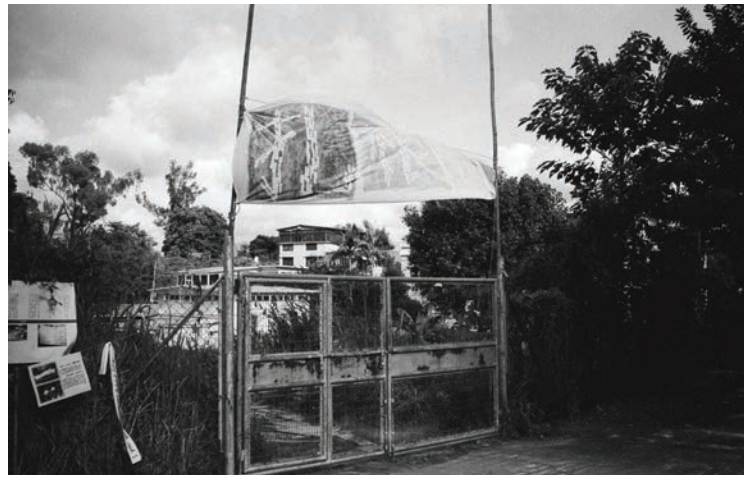
This short introduction into the identity and history of Hong kong should give a rough frame to situate my interest and work there. This rough summary shows already the many layers and interconnected webs that are Hong Kong and that are the basis for my research.

Wang Chau: a Brief Introduction

In June 2020, I was invited by Michael Leung, a friend and fellow artist and designer, to visit Wang Chau 橫洲, a settlement in the north of Hong Kong. At first, it seemed confusing to me that Hong Kong, a city, would have "villages". Later I learned that Western understandings of "village" do not apply there. Villages in Hong Kong tend to be small and loosely connected settlements. During my visits, Wang Chau was on its final notice of eviction. Since 2017, the villagers and the Wang Chau Green Belt Concern Group have been resisting dispossession and eviction under patriarchic and colonial logic. They are fighting power structures set in place by the former British colonial government

Wang Chau encompasses several small villages: Yeung Uk San 楊屋村*, Fung Chi* 鳳池村 *and Wing Ning Village* 永寧村*. For simplicity, I will refer to the area as Wang Chau Village.*

F11 Au Yeung Tai in her home together with a film-maker



F12 Gate to Au Yeung Tai's House

F13 Michael and Nanxi in a villager’s garden

F14 Michael, Kar Hia and a jackfruit tree

F15 Villager showing a sponge pumpkin

and that are continued by the current Hong Kong government. I visited Wang Chau several times more and took part in villager meetings and some of the creative practices that emerged. During my time there, I witnessed a commoning and a rural movement in the making. I began to connect the processes in Wang Chau with other topics such as colonial and postcolonial power structures, capitalist extractivist logics and the more intimate relationships and interdependences of humans, nonhumans and land.

To understand the cause of the dispossession and displacement, we have to look at the expansion of British territory in Hong Kong after the Island of Hong Kong was ceded to the British. The "New Territories" where Wang Chau is situated were claimed in 1898, surrounding the political instability in the region. British forces 'leased' the northern part above the Kowloon peninsula up to the Shenzhen river from the Chinese Emperor for the often quoted 99 years (Tsang 2004). As Tsang (2004) points out, the expansion of Hong Kong had less to do with imperialist motives but more as a "precaution" against French forces, who also occupied land in this region. Britain did not formally take possession for ten months after the lease and allowed Chinese to settle and farm in the New Territories. The farmers built simple wooden huts which they later gradually upgraded and expanded.

These newly settled farmers are the so-called “non-indigenous”, while the “indigenous” are the inhabitants before 1898 and their future descendants.

The indigenous villagers were granted land rights by the British colonial government that later manifested in the “Small House Policy” in 1972. This policy grants all male indigenous villagers aged 18 or older the right to build one three-storey house on government land (Hayes 2006). Considering the artificially constructed scarcity of land zoned for housing and the resulting excessive land and property prices (Ng 2018), there is little motivation to change the current conditions and eligible males are often misusing this right in various forms. Michael Leung (2020) explains how “Hong Kong indigenous villagers often profit from their land rights by illegally contaminating farmland into brownfield — concretising fertile soil to make way for car parks, waste recycling yards and container storage”. Male indigenous villagers are using their land rights for economic profits which led to claims of collusion between the Hong Kong government, land developers, local gangs (Triads) and rural strongmen (Leung 2020).

Development plans in Wang Chau follow a similar pattern. Instead of building on available brownfields that would provide more public housing units, the government decided to destroy the green belt and displace over 500 villagers while building less public housing units in the end (Leung 2018). This continued destruction of green belts and establishments of brownfields for business follow the colonial logic that the environment has to be defeated and made profitable (Noor 2019).

The unjust and lacking compensation contributed in part to the frustration of the villagers. Villagers received almost no compensation for their gardens and farmlands, with one villager telling me the government would compensate her 20HKD for a decades old jackfruit tree. As comparison: 20HKD (~2.35CHF) will barely buy a bowl of noodle soup or a cup of coffee in Hong Kong.

Visiting the Villagers

Michael invited me to join him for an overnight stay in Wang Chau, cautioning me that the process of eviction would be

in its last phase and they would expect the police in the morning. Hence the overnight stay to resist the authorities and support the villagers. Plans for eviction had been underway since 2017 and this year, under the guise of the COVID-19 pandemic, the process accelerated. When I accepted the invitation I did so not under academic motivation nor under sensational curiosity. On the contrary, I later questioned the "academisation" of the village. As I was doing extensive photography as a tool of research, I felt that it was important to document the events in Wang Chau. I also felt the need to support the villagers as I knew that places of injustice do exist in "patches" all over Hong Kong and to "resist injustice is to resist it everywhere" (Tsing et al. 2019). Still, there would always be an ambiguity when visiting the village, as I questioned my role with every time. In the end, it will always be a balancing act and one has to be aware of it.

I first met the villagers at a common dinner at Au Yeung Tai's house. I was readily accepted in the group. Especially Au Yeung Tai's warm welcome made me feel part of the community as opposed to being a mere visitor. This validation and affirmation from the villagers made my visits possible in the first place. I am especially indebted to Michael Leung and Nanxi Liu, who translated all the meetings and conversations. Without them, I would not have had access to Wang Chau at all.

The next morning we would meet and stay at a villagers house to support them should the police arrive. Luckily, they did not (yet) and we had time to chat with the villagers, who generously showed us their gardens. I continued to regularly visit the villagers with Michael and Nanxi and take part in their creative resistances. The threat of eviction has opened the eyes of many and formed a rural movement in the making that shed light on this valuable space that is being urbanised.

Creative Practices in Wang Chau

Over the years, various creative practices were developed such as workshops, sharing of produce, collective paintings, collective harvestings and cookings. These activities were important not only in raising awareness of the public, but were a commoning practice that helped share knowledge, educate the

young as well as the elderly and form kinships and alliances. For the villagers the nurturing of collective memory was especially valuable (personal communication with Michael Leung, March 3, 2020). As Silvia Federici (2019) describes it: "(the) reproduction of our collective memory and the cultural symbols (...) give meaning to our life and nourish our struggles".

The annual jackfruit festival was the most important activity. Every year hundreds of people would attend the festival with live music, performances, workshops and cookings. And of course harvesting and opening jackfruits, which grow abundantly in the village and gave name to the festival (Leung 2017; Leung 2018; Ho 2020). Michael Leung (2016) describes sites of resistances as heterotopias that gather people from different backgrounds and communities. They cultivate a space where alternatives are imagined and lived and where participation fosters an "insurrectionary experience", that are self-transformatory acts that render us capable to change the stories (Haraway 2016) and where "insurrection leads us no longer to let ourselves be arranged, but to arrange ourselves" (Leung 2016).

Those commoning activities do not disappear without leaving traces (Federici 2019), and they most certainly did not. Activist and artist had an important role in activating the community, facilitating a collaborative creativity, bringing issues to the broader public and learning mutually and together from and with each other while also providing comfort through these actions. This mutual learning, or knowing-with (villagers!) and knowing-otherwise (Tsing et al. 2019), shared a lot of wisdom and stimulated imaginations that there must be alternatives. These practices served a clear purpose of resistance but always relied on joy, play and storytelling, which are the qualities of an effective multispecies environmental justice (Haraway 2018).

Although there was a difference in position and status between artists and villagers (see Wang 2017), there were mutual trust, recognition and thin hierarchical differences. The artists provided a safe space and additional tools for villagers to speak and share their knowledge, while at the same time being participants themselves (see Li 2016). The artistic identity here is "based on their capacity to listen, openly and actively, and to organise

F16 Children painting a “jackfruit stone”

F17 Jackfruit opening at the Jackfruit Festival 2020

F18 Jackfruit Festival 2020

F19 Villagers meeting

F20 Banner making

F21 Makeshift barricade at the village entrance — the puppet represents the former chief executive, CY Leung, under whom the eviction process started

F22 Villagers and Green Belt Concern Group press conference

F23 Banners are put up at Au Yeung Tai's house

scenarios that maximise the collective creative potential" (Kester 2004). Cultural activism and socially engaged art demonstrate a performative and process-based approache that focus on building relationships with the villagers (Miner 2018).

Whatever the kind of engagement, the events always addressed belief systems in all participants. With many I talked, there was a rupture in how they see the political landscape and how they became increasingly aware of social environmental issues and entanglements. Thus, the chain of events is not critical, but simple acts of visiting, listening and being with the villagers are. This is not commodifying the relationships but offers a very "non-capitalist way of being in this world" (Miner 2018). In those "interrelated moments of discursive interactions" (Kester 2004), something new might emerge, kinships cultivated or forgotten things unearthed that will act as "handrails" for our collaborative liveability and survival (Tsing 2015; Tsing et al. 2019).

Developments Since

Since I left Hong Kong in September 2020, I have been following the developments in the villager's telegram group. By May 2021, Wang Chau has vanished, leaving behind only its ghost. It is returning to haunt us, reminding us about the colonial past of the village. This ghost affords us to notice how land, history and capitalism are interwoven. It is reminding us of the stories that need to be told; reminding us that despite the demolition, the collective memories, knowledge and symbols continue to live on (Tsing et al. 2017).

I initially wished to continue my research in Wang Chau. Because of the ongoing pandemic in 2021, I researched the possibility to contribute remotely. However, I soon I realised that my engagement is finished. My contribution was to listen and to build relationships with villagers and activists alike (see Miner 2018). This kind of work only exists outside of exhibition spaces (Kester 2004), so to forcibly continue the work from Switzerland and to "impose rather abstract concepts on the flux of existence" (Kester 2004), would devalue the contributions made. This is why I continued my research into other connected areas surrounding soil.

F24 Wang Chau, January 2021

Conclusion

The richness of activities and creative practices demonstrated that they were not merely defensive acts, but inventive acts, involving new strategies and cross-cultural, cross-class multispecies alliances and organisation (see Federici 2019). Much of our common knowledge of the surrounding world in Hong Kong and Cambodia is lost. This is the cost of technology and urbanisation (compare Wolff 2001; Federici 2019; Cristofoletti and Narciso 2021). Especially Hong Kong has developed so quickly, that there are barely any old buildings left. The memory of the city is vanishing over and over again, which is why cultivating collective memory and sharing of knowledge as demonstrated in Wang Chau have such an importance and urgency. This might be one of the answers to the question *what could be done?* To cultivate a shared responsibility for each other as we all depend on each other; to cultivate a "radical hope" and continue to imagine possibilities amidst catastrophes (Lear 2006) and to notice the patchiness that constitutes our world. The heterogeneity and flows of life in small situated areas such as Wang Chau teach us about the dynamics of this world. What we can learn from its struggles also conditions our collective survival on this damaged planet (see Tsing 2015). "Hope rests on staying with the trouble: the troubled pleasures of co-species collaboration and cross-disciplinary learning" (Tsing et al. 2019) and maybe one day we will be able to "re-enchant" the world (Federici 2019).

Further readings on Wang Chau by Michael Leung:
insurrectionaryam.tumblr.com

F25 North Vietnam, 2019

We see
A sea so cross it. We see a moon
So land there. We love land so
Long as we can take it.

— Jericho Brown

Context

Owning It

The concept of *owning* things, other beings and humans is a particularly odd one. The amassment of resources is also not exclusive to us humans, as hoarding behaviour can be observed with animals too. To a certain extent it is also arguable how this also applies to plants, as they too store resources. However, the human understanding of ownership spans far beyond accumulating resources for personal survival. Humans had the ambition to own the world. All land, waters and even the sky is divided and belongs to certain nations. As if owning one Earth and using the resources of multiple Earths is not enough, we strive to plant our flags on other moons and planets. Where does this hunger for ownership come from when it clearly cannot be sustained nor satisfied?

Christopher Ryan (2019) describes one perspective on ownership that came with the advent of agriculture. With the shift from a nomadic to a settled lifestyle, there was a certain level of plentitude and independence. With the amassing of resources, the concept of power and territorial claims emerged. Egalitarianism, commonness and way of living with the environment that characterised hunter-gatherer societies slowly disappeared. Those shifts are important when affiliating the concept of ownership of preagricultural societies with settled, agricultural societies. The key here is not the agricultural practice, but the accumulation of resources that needed to be organised, distributed and defended. Resources became worth fighting for, as they are easier

to steal than to hunt or collect. The Sng'oi people in Malaysia for example, one of the last remaining indigenous hunter-gatherer societies, understand themselves as simply "The People" in contrast to identifying with nationality, race or other belonging. The People do not have a concept of "owning" and understand themselves as part of nature. They are not interested in accumulating things but care about preserving the world. In a nomadic society, it is anyway a hindrance to possess many things that have to be moved (Wolff 2001). Settling down therefore required a certain abundance of resources as well as the logistics of owning material things.

Native Americans, as described by Silvia Federici (2017), and other indigenous communities, cultivated land in common without extracting all of its resources. They cultivated the land in such a way so it will last for generations to come. To them the notion of land ownership was alien. Federici goes on to describe how "private property was the condition of freedom in bourgeois political philosophy and the distinguishing mark between civilisation and savagery, liberty for the Native nations depended on its absence".

When introducing today's indigenous societies to "civilisation" and capitalism, they often fall into poverty and sickness (Wolff 2001). As urbanisation often enforces only one right mode of living, it disrupts and negates the patches of society in the pursuit for productive uniformity. This also destroys ecosystems and harms in the end all species (Kirksey 2017). The striving for the homogenous urban is at the same time deeply dividing, segregating the world into those who profit and those that work for those who profit (Vergès 2020).

Ecological Imperialism and Simplification

In the following discussion I will take a closer look at colonialism in the Americas and highlight it from multiple perspectives such as pathogens, plants and cattle. Colonial expansion in the 16th century fuelled the industrial revolution, manifested Europes hegemony in the world and propelled Western values (Crosby 1986). It redefined the world through what Homi Bhabha (1984) calls "objet trouvés", which are the basis for this

F26 Tsz Wan Shan, Hong Kong

new Western world. Françoise Vergès (2020) describes Europe as the "creator of the Third World" while at the same time being a creation of its colonies. Depending on which perspective one highlights it, Christopher Columbus either discovered or invaded the Americas. Fact is though that he never set foot on the American continent. What landed there were two papal bulls, Christianity, cattle, plants, pathogens and a claim on this piece of land (Crosby 1986). Regarding the Native Americans as wildlife, colonial powers declared the Americas as *terra nullius*. This is a "British legal fantasy", defining that if land is not inhabited by British or European settlers, it belonged by law to nobody and discoverers could declare ownership by first discovery (Winchester 2021). This history of systematically declaring vast parts of the world and humans as commodity went on, pushing millions out of the world and eliminating their existence (Wolff 2001; Vergès 2020).

Pathogens

This age of "modern" colonialism with sea routes around Africa und to the Americas brought with it the spread of diseases. Alfred Crosby (1986) argues that it were not guns that defeated the indigenous but pathogens along with crops and cattle. Bianchine and Russo (1992) describe that "not the European guns or fierce soldiers that conquered the Native Americans, but instead it was the common childhood illnesses". As such, smallpox presumably infected most European adults already. The Native Americans on the other hand contracted the disease during adulthood when it would express itself more severely. And: those diseases were crowd disease. Smallpox, for example, needs human vectors and spreads easily in grouped and dense populations as found in the Americas, while diseases of filth (typhoid) affected settled communities because hunter-gatherers moved too quickly (Crosby 1972).

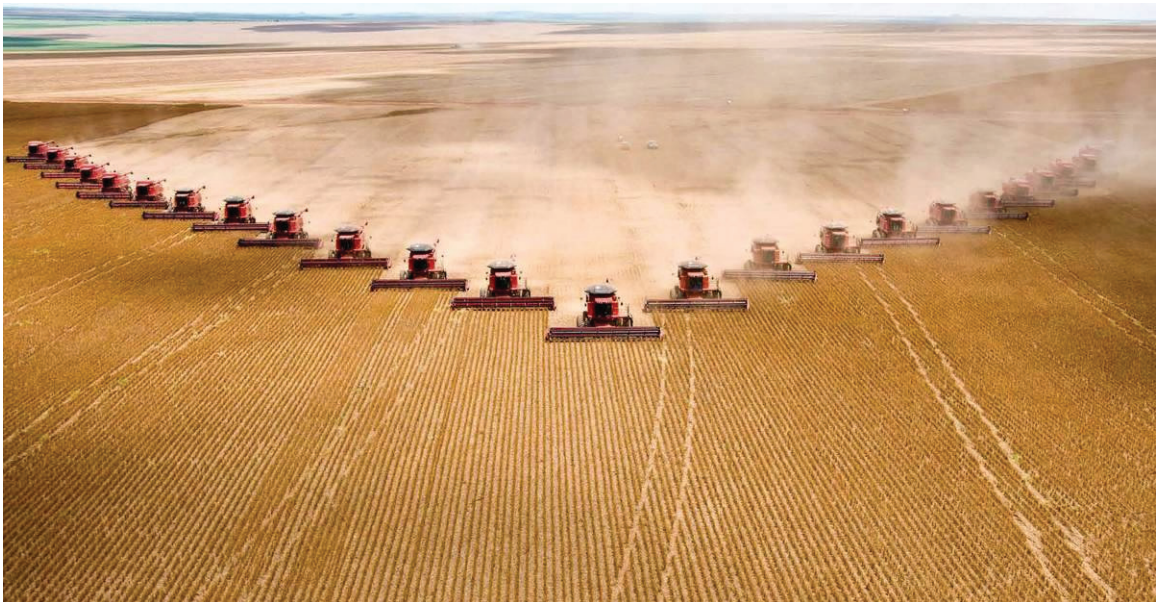
Their susceptibility may be attributed to lack of nourishment and hydration as well as lack of sanitation. A lack of healthy people to care for the sick may have further contributed to the devastation, as without immunity they contracted the disease all at the same time. Large malaria outbreaks in the Americas illustrate the significant effects that disruptions to the ecosystem

caused. Malaria appeared when forests were cleared. The resulting swamps were exposed to sunlight, creating massive open breeding grounds for mosquitoes. It is likely that two strains of the *Aedes aegypti* mosquito were brought to the Americas, one with slave ships from Africa, the other from the Mediterranean area. The African strain carried diseases like yellow and dengue fever while the Mediterranean strain specialised in living primarily in human water sources. Both came together to form a new strain, creating an organism that we could not have had and that is our responsibility (Bianchine and Russo 1992; Tsing 2019). Kirksey Eben's (2017) account of native Indonesians also illustrates how disruptions (in this case a forced settling of nomadic indigenous) caused a ripple effect leading to a spike in Malaria cases. The nomadic lifestyle of the indigenous communities had spared them of contracting Malaria as they moved along in sync with the lifecycle of the mosquito.

Crops and Cattle

Europeans brought a few hundred plants and cattle that destroyed and put out of balance whole ecosystems. These cattle found an environment that is most suitable to them. What they did not stomp barren, they ate down to the root. Spreading seeds from European plants, they altered the soil and flora of the Pampas, essentially terraforming landscapes (Crosby 1986). As those ecosystems eroded they opened up spaces for alien species, plants and animals. Making landscapes suitable for cattle went together with the "destruction of indigenous communities and native ecologies" (Tsing et al. 2019). Cattle became thus "feral proliferations" themselves, destroying the environment that nurtured them and are "always complicit in colonization and dispossession".

The loss of topsoil from the cattle stomped areas would have destroyed thousands of hectares of fertile soil if it had not been held together by "weeds". They can grow in disturbed soil and "thrive on radical change". They hold together the soil and thus can be regarded as first aiders in preventing soil erosion. As they stabilise the soil, they allow slower growing, taller and more robust plants to take over (Crosby 1986). The disturbed environments found in what we call "weeds" an ally. "Weeds are not good



F27 Harvesters in Brasil

or bad; they are simply the plants that tempt the botanist to use such anthropomorphic terms as aggressive and opportunistic" (Crosby 1986). The definition of "weed" also changes through time and culture and is as Crosby describes simply imbuing our view on plants.

On Plantations

Europe needed huge amounts of resources and food, which the colonies should provide. Europe had the capital, market demand and human resources to fuel an industrial revolution. Enough non-farming people were needed though to fill the factories. Therefore, agricultural produce had to come from these "offshore farms" so Europe did not have to rely on its soil any more (Crosby 1986). Today, colonialism turned the whole world into providers for the West, securing it freedoms and rights that are the result of the exploitations of other countries and beings (Vergès 2020). The plantations provided the much-needed resources and at the same time set in place structures that would have lasting effects on our world. They carry the history of slavery, displacement and destruction of families and communities. Colonialism racialised bodies and fuelled a capitalism of waste — humans as waste. Making certain people invisible it produced at the same time images of gender and race. This classification is at the basis of the invention of the "white world" (Tsing et al. 2019; Vergès 2020).

Plantations not only displaced countless species but also forced many beings like cattle and crops into existence for the benefit of a few (Haraway 2018). Anna Tsing et al. (2019) describe plantations as "elements of a topography of difference" and how landscape structures reveal histories and social relations. Plantations reduce species to just one kind and eliminate everything (e.g. "weeds") that is not required for economic activity.

They are also examples for what Tsing et al. (2019) call modular simplification and feral proliferation, "uneven conditions of more-than-human liveability in landscapes under domination". Plantations here are modular simplifications. They prescribe monocultures without regarding other lives and structures. In these simplified ecologies, diseases are brooding as they find the perfect conditions in those densely packed monocultures. This not only allowed plant diseases to spread quickly but also to mutate more easily, resulting in more resistant pathogens (Boyd et al. 2013).

Intensive livestock breeding also allowed diseases to spread and mutate. Animals held in such numbers, conditions and closeness to humans allowed the emergence of the avian and swine influenza, SARS and most recently (and ongoing as of this writing) the COVID-19 pandemic. Plantations not only facilitated diseases but also made increase in pesticide use necessary — ironically to combat those same diseases. Those toxins are seeping into the soil and the groundwater. This is truly a feral proliferation, an "unruly riot" (Tsing et al. 2019) that is caused by modular simplification inside those plantations and the ones outside have to suffer the consequences.

Landscapes therefore are shaped and become shaped by multispecies communities and reveal stories of the more-than-human. Tsing et al. (2019) propose an approach that begins with an attunement to landscape structures and an analysis of how human life is embedded in those landscapes. Those "patches" of the Anthropocene emerge between the relationships of simplification and proliferation, revealing themselves in those structures and throughout individual communities such as Wang Chau. The transformation of our world is often described as the Anthropocene, however Donna Haraway (2017) argues that humans

F28 Pesticide container near Dak To II Airfield, Kon Tum, Vietnam 2019

F29 “Charlie Hill”, near Dak To II Airfield, still barren after defoliation with Agent Orange

F30 American soldiers on a defoliated hill, Vietnam

F31 American soldiers marching through a rice field, Vietnam

as species are not responsible for this ecological and social crises. It is a group of people while the rest is suffering the consequences. Haraway thus regards the term as not accurate enough but still sees it as necessary for the ongoing discussion. As alternatives, she proposes terms such as "Plantationocene" or "Capitalocene".

Towards a Multispecies Ethnography

The practices revolving around multispecies reconnection and reestablishment aim to move away from an anthropocentrism towards a future that is not shaped by individualism (Zheng 2020). It is an understanding of knowledge generation that is symbiotic in regard to other species and entangled beings (Haraway 2016). Eduardo Kohn (2007) describes a practice of anthropology that situates the human world within larger processes and relationships and is concerned with the entanglements of ourselves with other kinds of selves. As all beings are engaging with the world and with each other they have a point of view and an embodied understanding that we need to inhabit.

Every life form represents some kind of significance and therefore practices politics. Kohn states that nonhumans are selves and as such they are not only represented, but they represent themselves. Thus, we should not reduce humans and other beings to their mere bodies and regard them as the only thing we share. As every life bears a kind of significance and a kind of agency in this world, it is not just the matter of our bodies that connect us, but the world and webs we share. Eben Kirksey and Stefan Helmreich (2010) describe these kinds of relationships as emerging through interactions of selves.

Alan Smart (2014) points out that we should not limit relationships to human-animal but must include microorganisms and plants as well. Multispecies ethnography is therefore not just about giving agency to the nonhuman and recognising them as 'others' (and through that establishing the human again as a central link). It is to radically rethink and undo our modes of categorisation and naming, abandoning human exceptionalism on the way (Kirksey and Helmreich 2010; Haraway 2017). Through an attunement to landscape structures, "beings-in-landscapes" and multispecies entanglements we expand our practice. Notic-

ing the interweavings of landscapes, humans and nonhumans allow us to learn about global relations and to bring stories of the "otherwise" into transdisciplinary discourses and practices (compare Haraway 2016; Tsing et al. 2019; Franinović and Kirschner 2021).

The question remains how we can — beyond the human — meaningfully learn from and interact with animals, plants and natural entities down to the smallest microorganisms. And how do we translate this heritage of colonialism, slavery and dispossession into a narrative? How do we "bring back to life what has been doomed to non-existence and worlds that have been thrown out of humanity?" (Vergès 2020). How can we speak for the marginalised and the nonhumans, represent agent beings without imposing? Bruno Latour (2004) highlights the importance of "making them speak" while not attributing the "speech of objects to scientists and the speech of subjects to politicians".

Conclusion

From the earliest human activities to the villages of Cambodia and Hong Kong, history vibrates through those landscapes. They tell stories of colonialism, capitalism, displacement and war. They reveal stories of multispecies interconnectedness. Landscapes and beings are interconnected through the webs they share and not only through their bodies. Therefore, it is not enough to give agency to nonhumans but we have to learn from their view without imposing. We must abandon our modes of classification and naming altogether and expand our practice with a multispecies approach and an attunement to the environment.

Personally, one of the most intense encounters with landscapes was in 2019 in Vietnam. The hills of Kon Tum are heavily contaminated with Agent Orange. They are the 4th most heavily sprayed areas in Vietnam (Aspen Institute 2021). Those disturbed landscapes have an eerie presence. The crooked or absent plants and barren soil are a heavy reminder of the sufferings of millions and the displacement of my family. The ghost of this place will haunt us for time to come, lest we forget.

F32 Khao, Laotian girl, suffering from the consequences of Agent Orange, photograph by Christopher Anderson

II

2021 was in many respects a challenging year. In April and May 2021, messages from Wang Chau reach me. Au Yeung Tai, who hosted me several times, was forced out of her house. The Cambodians I met in 2020 were already suffering under the COVID-19 pandemic and continue to do so with little to no government support. The pandemic continues to expose structures of dominance and oppression under which the marginalised are suffering. Unable to travel I shifted my focus on the science of soil and to learn more about soil's function in global biogeochemical processes. I reached out to Dr. Ivano Brunner from the Swiss Federal Institute for Forest, Snow and Landscape Research WSL, who generously invited me to work there.

Soil

What is soil? What is this dirt beneath our feet? The thing wars are waged over? The thing people are fleeing from? Often neglected or overlooked, soil is the source of the most significant biodiversity on Earth, greater than everything that crawls, walks and flies above it or swims in the lakes, rivers and oceans of this planet (Blum 2005).

Soil is not a single environment. Rather it encompasses myriads of environments, many of those in very proximity to another. Soil changes from place to place, even micrometres (1µm = 0.001 mm) apart, from aggregate to aggregate, each micro environment with different microbial communities and activities (Fierer 2017; Banwart et al. 2019). Soil is a living thing, an actor that breathes and practices politics. Soil is thus far from static and dead. It is transforming through myriads of parameters such as temperature, pressure, humidity, light, PH level, salinity, concentrations of carbon and nitrogen as well as physical properties such as texture, composition or density (Fierer 2017). And: *soil flows*. Its processes are fluid and ever-changing. It also flows quite literally (see Matsuoka 2001). However, with *soil flows* I describe not only

Aggregates or POM (particulate organic matter) are little compact pockets of soil. Through their different composition, they act as habitats for particular microbial communities and play a role in the water flow in soil (Banwart et al. 2019)

the physical process of flowing, but the transformative quality of soil, its layers of meanings and entanglements. Coming from the "patchy Anthropocene" there is also a patchiness that constitutes soil. How is soil is embedded into the webs of other ecosystems and species? And what methods are there to approach soil in a meaningful and material interaction?

The chapter *Soil* gives a broad overview and touches on some areas of soil research. However, the goal is not to give a comprehensive understanding of soil as this would clearly exceed the scope of this thesis. Rather, this overview should give an understanding of basic soil processes and reveals access points that may be used to engage with soil.

Soil Formation and Function

Swiss forest soil formed over 15'000 years ago after the last ice age. When the glaciers retreated, they left the rocks exposed to the weather. Soil developed through the chemical and physical decomposition of the rock and through the transformation of organic material through soil microorganisms (Walser et al. 2018). The dissolved nutrients helped nourish those organisms that formed a symbiotic relationship with plants and fungi, which in turn advanced the decomposition process. Microorganisms thus play an essential role with their ability to decompose rock and organic matter. Through that they allowed plants to populate the rock and soil to form (Banwart et al. 2019).

Soil is not a single mass but an open system with complex substance cycles. Disturbed soil is thus not easily renewable as a centimetre of soil can take up to 100 years to form (Walser et al. 2018). Soil is responsible for many processes, among others biomass production, support of plant growth, provision of nutrients such as carbon, nitrogen, phosphorus and potassium, water and substance storage and filtering and as a gene reservoir (Blum 2005, Banwart et al. 2019).

Soil Threats

The loss of soil is one of the greater threats we are facing. Soil is lost for example through floods, droughts, landslides, infertility and climate change (Banwart 2020). Karl Marx (1990) al-

F33 Flooding and Erosion at Bảo Lộc Hill during my travels in Vietnam, 2019

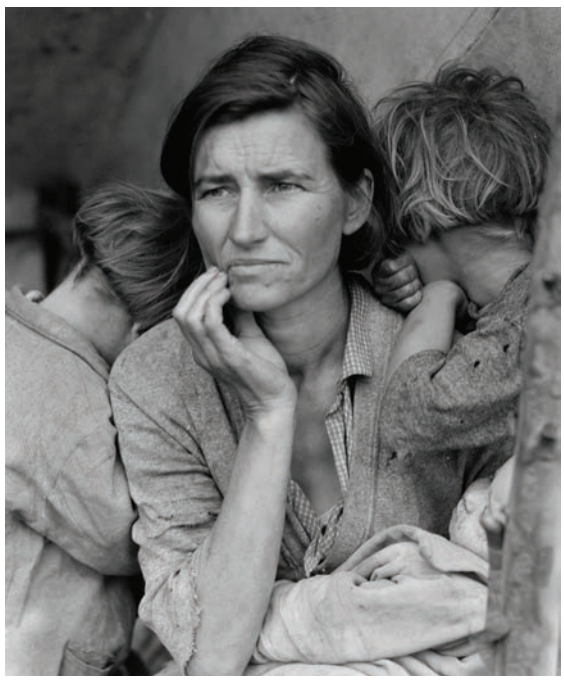
ready spoke at length of the capitalist exploitation of soil. Though, as Morton (2016) points out, Marx is not concerned about a multispecies thriving in soil rather than about soil's capacity to support human existence. However, all our economic activities and paradigms are "threatening ecological stability" (Haraway 2017).

Soil Erosion

Soil is usually held together and protected by vegetation such as forests which protect soil from the weather. Through the removal of forest area and extensive agricultural practices, soil lies exposed to rain and wind, which dislodge soil particles and washes or blows them away. Natural soil erosion occurs as well, but is easily overshadowed by agriculture caused soil erosion (Pimentel 2005). Soil erosion poses the most serious threat for the environment and human society. Humans obtain more than 99.7% of their food (in calories) from the land and "each year about 10 million ha of cropland are lost due to soil erosion". An estimate that Pimentel (2005) describes as a conservative one. Eroded soil releases vast amounts of CO_2 into the atmosphere through oxidation. In addition, the loss of nutrients reduces biomass and biodiversity, which negatively impacts ecosystem processes. Soil organic matter facilities the formation of aggregates, which in turn play an import-

F34 Dust Bowl, Texas, April 1935

ant role in carbon storage and sustaining soil porosity. Soil porosity is essential for aerating soil and for water drainage, facilitating soil microbiome processes (Pimentel 2005; Schaufler et al. 2010; Oertel et al. 2016; Banwart et al. 2019; Banwart 2020). Besides the loss of soil and land habitats it is not to forget that extreme and repeated drought, flooding, sea level rise, arctic greening, desert expansion and ocean acidification, warming and overfishing occur at the same time around the world (Romm 2011; Liu and Xue 2020)



F35 Dorothea Lange, *Migrant Mother,* 1936: One of the most iconic photographs connected to the struggle for land and soil erosion

Soil Microbiome

With likely over 95% of microbes (bacteria, fungi, protozoa, archaea and viruses) dormant at any point in time (Fierer 2017), soil microbial communities are in constant negotiation with each other. They change and become active depending on the conditions. Therefore, it is difficult to study soil samples as soil transforms as soon as it is taken out from its environment. Thus, soil processes seemingly withdraw themselves from observation.

The soil microbiome influences soil acidity, regulates soil carbon and soil water availability, while mediating nutrient cycles like iron, sulfur, phosphorus and nitrogen. Soil organisms and their secretions are essentially feeding the planet. These activities have an effect on the whole terrestrial ecosystem and global biogeochemical processes, while also maintaining soil health and the health of plants, animals and other species (Fierer 2017). The microbe's ability to transfer genes horizontally as opposed to vertical DNA transfer (parent to offspring), enables them to share genetic materials between organisms. This alters the microorganisms genome and thus broadens their ecological niche and potential (Heuer and Smalla 2007; Fierer 2017). A process that makes genetic identification even harder and demonstrates once

again the flowing state that soil is in. The transferring of genes also calls for a rethinking of interspecies relationship (see Kirksey and Helmreich 2010).

Difficulties of Quantification

Most microbe species are not described, for example the soil of Central Park in New York, where >80% of microbes are unknown. However, we have to be careful to consider relic DNA (extracellular DNA in cells found in soil, not coming from living cells), that can increase biodiversity measurements by as high as >40% (Fierer 2017). Soil samples of the same spot cannot be taken repeatedly, as taking soil out of its environment poses a disruption, causing changes in microbial and physical properties. Furthermore, adjacent samples may provide different results (ironically almost defying sciences requirement of repeatability and multi-samples probing). This ever-changing characteristic makes determining *a* soil microbiome and *a* microbial metabolic process an impossible feat and is what makes soil research inherently difficult. It is also laborious to follow microbial processes linearly, as each process may be the result of countless parameters and metabolic activities (Fierer 2017).

One of the biggest challenges in current research is also the understanding and assessment of soil microbiome processes (personal communication with Dr. Ivano Brunner, 6 April 2021). Besides scientific rigour to untangle and classify every species, there is a potential to engage with them through different methods of understanding. As soil evades attempts of taxonomies, there may be other ways of perception and interaction with the soil microbiome to understand its dynamics. Where science has difficulties in assessment and quantification, design and art could provide conceptual frameworks to make visible patterns of interactions with the soil microbiome, thus expanding our understanding and further developing a literacy of soil (Fierer 2017; Franinović and Kirschner 2020; Franinović and Kirschner 2021).

Exploration of Microbial Activity

There are several methods to determine microbial activity in soil. Electric conductivity and redox potential measurement

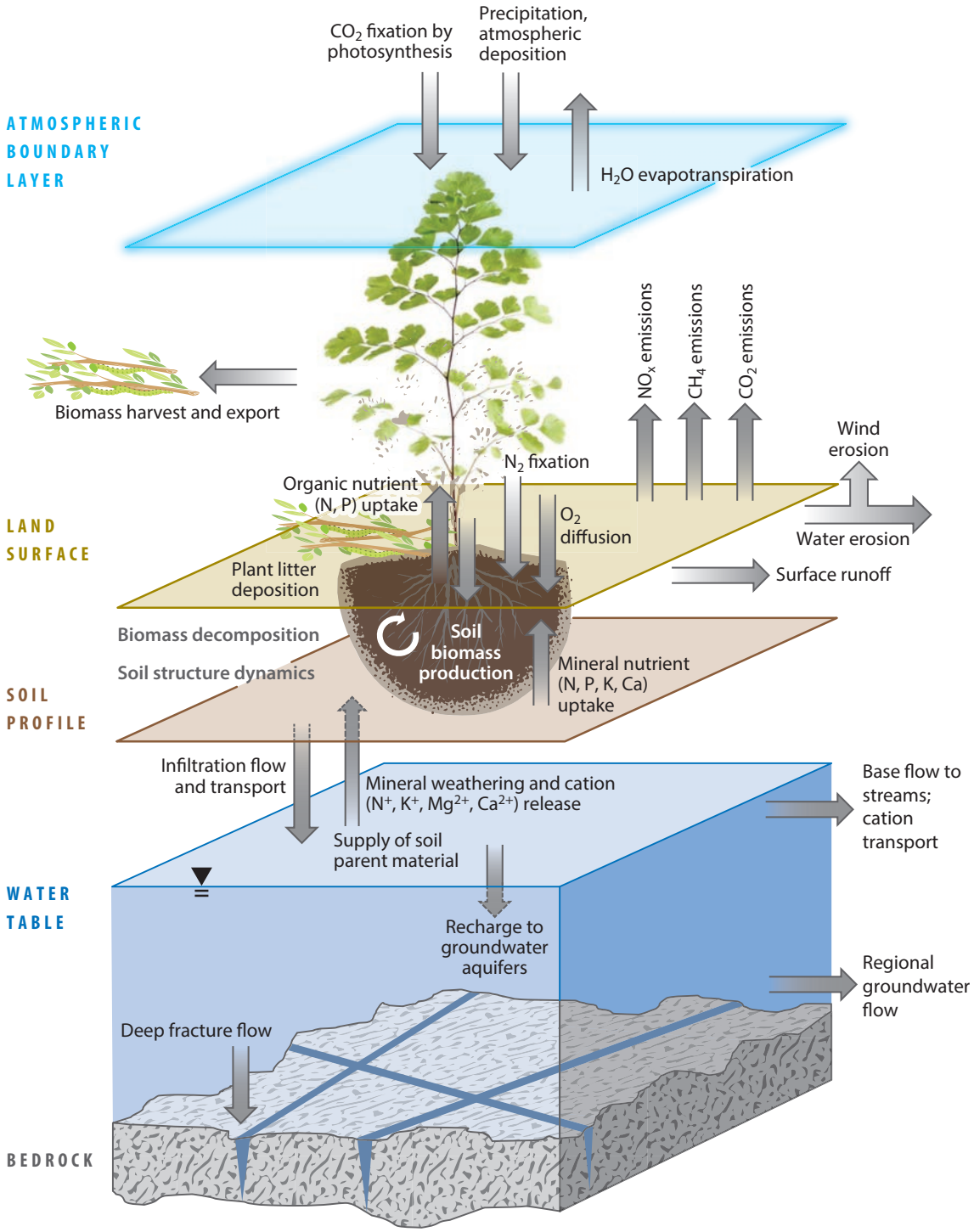
are methods of measuring cellular metabolism, as metabolism increases the electric conductivity. This method is highly accurate and was for example proposed to detect extraterrestrial life (Nazarious et al. 2020). Other methods are focusing on enzymes in soil, as a higher activity of enzymes suggest a high microbial activity and the presence of organic matter and nutrients. A device that is currently in development is for example the *Digit Soil* (digit-soil.com), which can measure enzyme activity for substances such as phosphorus. Bioindicators, while still underrepresented, have a potential to reveal soil properties. However, biological indicators are still limited to measurements such as biomass evaluation and soil respiration (Bünemann et al. 2018). As DNA analysis becomes more affordable it poses a "faster, cheaper and more informative measurements of soil biota and soil processes than conventional methods" (Bünemann et al. 2018). However, as described before, many factors have to be considered when analysing soil microbiome DNA. PH is also a good indicator of microbial community composition, however we have to consider the span of the soil sample, as well as the readiness of microbial species to respond to PH changes (Fierer 2017)

Finally, soil respiration is a basic method to assess soil microbiome activity, as CO_2 is being respired by all aerobe organisms. Substrate-induced-respiration (SIR) measurements (measuring CO_2 respiration before and after adding substrates such as glucose) are viable methods to assess the size of microbial biomass and test microbial response to stressors such as pollutants and toxins (Campbell et al. 2003). Roots of plants account up to 50% of soil CO2 respiration, while climate change increases soil and plant respiration. With an increase in deforestation and tree death due to global warming, forests are hindered in their ability to act as carbon sinks and will ultimately reverse the carbon cycle (Mitchard 2018).

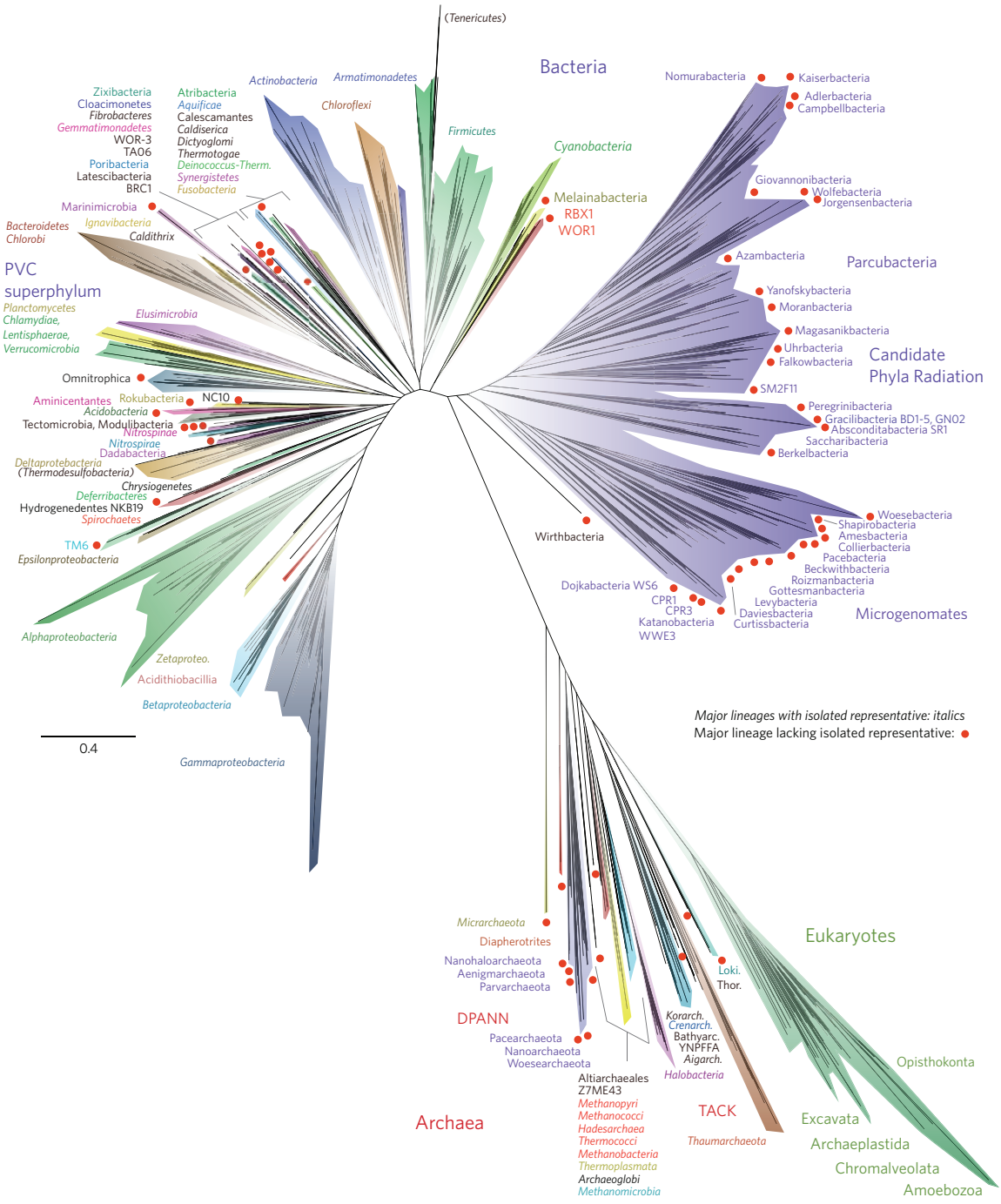
Essentially feeding microbes with a carbon source such as sugar.

Soil as Sink and Source

Soil respiration is one of the main sources of greenhouse gases (GHG) in the atmosphere, namely carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4) and nitric oxide (NO) (Schaufler et al. 2010). 35% CO_2, 47% CH_4, 53% N_2O, and 21% NO of the



F36 Flows of Soil and how it interfaces with different layers



F37 Tree of Life, demonstrating the scale between different species: humans are closer to plants (both eukaryotes) than to the domain of bacteria

respective total annual emissions relate to soil degassing (IPCC, 2007). Soil is therefore source of the largest terrestrial carbon and nitrogen deposit. Changes in its structures influence if soil acts as a sink (storing) or as source (emitting). GHG emitted from soil are thus key factors in the debate about global warming and the regulation of agriculture, forest and land management (Schaufler et al. 2010).

CH_4 and N_2O emissions by agricultural activities are largely compensated by the ability of grasslands and forests to sink CO_2, but this trend will reverse as agriculture, deforestation and destruction of soil is advancing (Oertel et al. 2016). Today, industrial agricultural practices are directly responsible for 18.4% of GHG emissions (Richie and Moser 2020) and for 70% of emissions through land use activities (Frank et al. 2017). Agricultural soil has the lowest ability to store carbon out of all soil types. As forests are cleared, 30-35% of total soil carbon in the top layers of the soil (0-7 cm) is lost within 30 years. This topsoil is the layer with the highest microbial activity and consequently high GHG emission (Schaufler et al. 2010). To conclude, soil gradually loses its ability to store carbon and the ability to act as sinks in global carbon cycles (DeGryze et al. 2004).

Physical change in soil structures such as compression, erosion, flooding or other influences will cause soil pores to close and facilitate the growth of anaerobic microbes that will produce N_2O and CH_4 (Lüscher et al. 2019). Oertel at al. (2016) even indicate that soil releases more carbon into the atmosphere than our consumption of fossil fuel. N_2O in the atmosphere has almost doubled since the industrialisation. It "has heat-trapping effects of about 298 times more powerful than that of CO_2", which makes it the most potent actor in global warming (Ussiri and Lal 2013). As a comparison, CH_4 has a 25 times higher potency than CO_2 (Oertel et al. 2016). CH_4 and N_2O are also indicators of soil disturbances. When N_2O is respired, it may hint towards a partial compression of the soil, whereas CH_4 respiration indicates heavily damaged soil. However, damaged soil is not always the cause of CH_4 and N_2O emissions. These gases occur under all anaerobic (CH_4) or semi-anaerobic (N_2O) conditions, occurring for example under heavy rainfall (personal communication with Dr. Ivano

Brunner, 30 April 2021; Lüscher et al. 2019).

To determine whether soil acts as sink or source, one has to look at the total net ecosystem exchange (NEE). It is the difference between CO_2 absorption through photosynthesis and ecosystem respiration. A positive NEE indicates a CO_2 source, whereas a negative NEE points to a CO_2 sink (Oertel et al. 2016).

Humidity is a key factor in regulating soil respiration, as activity of different microbes in- or decreases with different humidity levels. N_2O emissions occur when the water-filled pore space (WFPS) is between 30% and 60%, whereas CH_4 producing microbes require strict anaerobe conditions. Temperature and PH are also important factors, both regulating microbial activity. Lower soil PH leads to a decrease in soil emissions of CH_4 and N_2O, whereas CO_2 emissions are highest at a neutral PH of around 7. With CO_2, Temperature may be a better parameter. Other factors include age of forest and coverage of soil (Schaufler et al. 2010; Oertel et al. 2016).

Soil Health

Soil respiration measurements further help assess soil health and functions (Joshi Gyawali et al. 2019). However, the definition of *soil health* is rather vague and subjective to the points of view of human use and expectation, specifically in the context of biomass production and agriculture (compare Silvertown 2015; Jónsson and Davíðsdóttir 2016; Bünemann et al. 2018; Motiejūnaitė et al. 2019). Even under this definition, soil health is not easily defined as it relies on the context and intended use (Fierer 2017). Rather than trying to categorise soil with anthropocentric terms such as 'healthy', 'fertile', 'sustainable' and 'capable', we must expand our understanding of soil and be aware of the dynamics in terrestrial ecosystem processes. Therefore, we have to learn how to act together with soil rather than upon it.

Bünemann et al. (2018) describe the need for enhancing awareness and communication regarding the importance of soil. In regard to "Cultural Ecosystem Services" (CES) soil is described as having a tremendous contribution, but more in the context as being of service (Andersson et al. 2015; Motiejūnaitė et al. 2019). However, the benefits of soil described in CES are

humans centred and attested with recreational values. A rich biodiversity in soil ultimately benefits all species including humans. The research on CES through its human centrism reinforces the dichotomy of "nature" and "human".

Telling the Stories of Soil

Donna Haraway (2018) states that "multispecies environmental justice must be about play, storytelling and joy" and emphasises storytelling as a thinking practice. She argues that the knowing-with and knowing-otherwise are essential for imagining and fabulising outside the accustomed. Tsing et al. (2019) dare us to allow (anthropological) stories of the otherwise into transdisciplinary conversations. Telling the stories is inventing practices for making kin, cultivating a responsibility for each other and facilitating a multispecies environmental justice that can become the means for healing and flourishing.

Conclusion

This chapter gave a broad overview about the physical properties of soil such as formation and erosion. Furthermore, soil's interaction with the terrestrial ecosystem is described, which shows the importance that must be attributed to soil. The agency of soil comes from its smallest inhabitants: microbes. They have enabled the formation of soil in the first place and drive its processes forward. They represent the largest biodiversity on Earth but are yet to be fully understood. Finally, soil's role in multispecies storytelling was highlighted and the focus will be continued in the following chapters.

Concept

As this work is an ongoing process, the concept focuses on the part in Switzerland. Through the collaboration with the WSL, I focused on the fields of intersection between science and the arts. By bridging these fields, I involved critical perspectives on the relationship of culture and science. The collaboration also informed my process and taught me a scientific literacy (see Tsing et al. 2019). Overall, the aim was to foster mutual learnings and to search for what emerges in the in-between. Opening up this space between institutions might pave the way for future collaborations. At WSL, I will advance my soilKit and contribute a guideline for DIY soil respiration devices. It will be openly accessible and is a concrete example of sharing knowledge to the public, democratising tools and promote low-cost science. The guidelines will contain assembly instructions and application examples. Bringing tools to the mainstream and bringing science and the arts together fosters a reach and mobilisation at an effective performative and experienceable level. Besides further developing the soilKit the other aim was to learn more about soil research, in particular about microbial activity and how it can be made experienceable through other means than data.

Methodology

No methodology was "pre-chosen" (apart from standard methods such as desk research, interviews and experimentation). The complexity of the topic and the process of engaging with ecologies and identities began much earlier as part of an intrinsic interest. Methods were therefore spontaneously chosen to respond to certain research findings and directions.

Listening and Being-with

Creative resistances and socially engaged art and design require an embodiment and openness to the external world (Kester 2004). Dylan Miner (2018) describes the methodology of visiting, listening and being-with as important methods to build relationships and making kin. He describes these methods not as ways for data collection and commodification of relationships, but as ways of simply being with people in a non-capitalist way.

attune + -ment
1. to bring into accord, harmony, or sympathetic relationship; adjust
2. to tune or bring into harmony, as a musical instrument
(collins dictionary)

Attunement

Subconsciously, attunements to landscape structures and ecologies have been the primary method in Cambodia, Hong Kong and Switzerland (including my travels in Vietnam in 2019). The intrinsic motivation for an attunement process came from my family history of war and subsequent displacement from Vietnam. Through this, I developed a sensibility towards land struggles and questions of identity. Attunement is a powerful tool to notice and reveal influences and disturbances of history, politics and cultural activities in landscape structures (Tsing et al. 2019). It broadens our notions of social relations to the more-than-human space and time, expands our view and knowledge about the webs, the systems and global relations. On a macro level, we learn to perceive terrestrial biogeochemical processes. On a social level, we attune to relationship dynamics and on a micro level, we may attune all the way to microbial activities in soil. As described by Tsing et al. (2019) and Franinović and Kirschner (2021), attunements to ecologies reveal the consequences that our daily actions entail. It is about opening up not only to the human, but to the more-than-human, including plants, microbes and other

organisms, geological formations as well as to the relationships we build with them. It is not enough to just explore those, but to embed ourselves in them; to feel how we afford those processes as they afford us. The time spent in Cambodia and Hong Kong allowed for an attunement process to slowly build up, thus it required a certain length of engagement, patience and motivation.

Rapid (Electronic) Prototyping

Rapid electronic prototyping was used to quickly develop devices for soil respiration. These prototypes allowed me to verify hypotheses and express those processes in numbers. Furthermore, the resulting prototypes served as conversational objects — "leveraging objects" — to access and speak with scientists. These prototypes were more readily understood among them.

Material Research

Bringing in my knowledge of working with materials was an asset. Material translations of processes can be a more meaningful device of mediation than for example raw data. My knowledge with chemicals and lab work from the gymnasium has proven beneficial for gaining trust with the scientists. This allowed me to work in the lab independently and almost unsupervised.

Leveraging

Leveraging is a way of bringing insights of the attunement process back to the field of making, a making that is not limited to objects but to whole ecosystems. In intervening in terrestrial processes, leveraging proposes using "points of power" to stimulate flows and feedbacks of the ecosystem, gain further insights into ongoing processes and intervening in them (Franinović and Kirschner 2021).

Fabulation

In the rigid structures of science, I noticed a need for fabulation and speculation (see Haraway 2018). When talking to scientists, I tried to break open the conversation, to fabulise and wonder: *what if?* Especially for a design and artistic process it is essential to keep a certain ease of approach. Otherwise, I expe-

rienced to be confined within the structures of scientific knowledge production. For the last phase of my research I therefore limited my presence at the WSL to a minimum and engage more with fellow artists, designers and scientists with whom I could fabulise together.

Lab Journal

Dr. Ivano Brunner encouraged me to record every experiment in a lab journal. I expanded the journal to include sketches, prototypes, notes of readings and pictures. The journal has proven incredibly valuable to talk with new people about my research. I noticed that it allowed them to rapidly gain an overview about the process and the intentions (compare with Gaver 2011).

Coffee Breaks

At the WSL, the most interesting discussions with scientists take place during coffee breaks. The conversations are then most vivid and casual and the scientists would openly give inputs or tell about their research. It was also a good opportunity to bring forward and test concepts and ideas. Often, when reading scientific papers, there is a certain level of abstraction. Discussing topics and ideas in the round immediately after learning about them proved valuable in advancing my understanding. Many ideas were developed during coffee break chats, for example the indicator material was discussed in a lengthy coffee break with Beat Stierli and Dr. Beat Frey. Additionally, I would also often stay around for lunch. These “methods” are described by Rillig et al. (2020) and they certainly have parallels with being-with (Miner 2018). However, I would not "commodify" those common activities as methods, as I enjoyed them as personal interactions without ulterior motives. Nonetheless, these "methods" are important for artists and designers to integrate, build relationships and are ways to bring forward their research.

Freedom Farming, 2014

Li Binyuan
Video Installation

F38 Video still

Memorial Project Nha Trang, 2001

Jun Nguyen-Hatsushiba,
Video Installation

F39 Video still

They do not understand each other, 2014

Tsubata Kato
Video documentation of a performance

F40 Performance photograph

Li Binyuan focuses on different artistic and cultural production in Asia and tries to understand the transformation undergoing there. His video installation questions how forms, objects, and matter translate the contextual anxieties in Asia, as well as a search for an aesthetics outside Western modernity. With all that, questions of identity are always present. Li Binyuan explores his relationship to a plot of land in rural China, that was handed down to him after his father passed away.

Local Vietnamese fishermen are pulling those cyclos into the ocean towards the unknown. The cyclos, the same shape today as they are decades ago, represent a historical past that has to be viewed within the context of countries that struggle with modernisation.

A Korean and a Japanese artist are stranded on this island and have to work together towards a task that they can only accomplish together while not understanding each other (verbally).

Made In Taiwan, 2018

Cindy Cheng I-Hsin
Installation, Photography, Video

F41 Photograph of artwork

Lubricate Coil Engine - decolonial supplication, 2017

Tabita Rezaire
Healing Circle

F42 Photograph of performance

Sea State 9: proclamation, 2017

Charles Lim
Video Installation

F43 Video stills

The shoes leave imprints with “Made In Taiwan” in the soil. The artist, originally from Taiwan but living and traveling in Malaysia, explores her relationship with what it means to be Taiwanese. It is to grapple with one’s own identity and having a physical, visible reminder in the form of footprints. It affords a constant engagement with herself wherever she goes.

Tabita Rezaire performs in a healing circle and inquires on forms of decolonial healing processes.

Charles Lim's video installation focuses on the massive land reclamation practices around Singapore and show the force with which land is created as well as taken.

Sleeper, 2019

Hannah Walton
Sculpture

F44 Photograph of artwork

You, 2007

Urs Fischer
Excavation

F45 Photograph of artwork

Grasslands Repair, 2018

Baracco+Wright, Linda Tegg
Australian Pavillon, Venice
Biennale

F46 Photograph of artwork

Hanna Walton explores ways of working with materials so that it is "an end in itself rather than a means to an end" (RCA 2019). One critique that may be mentioned here is Walton's framing of the artwork and of soil as a "sculpture".

Urs Fischer being Urs Fischer and excavating a gallery space.

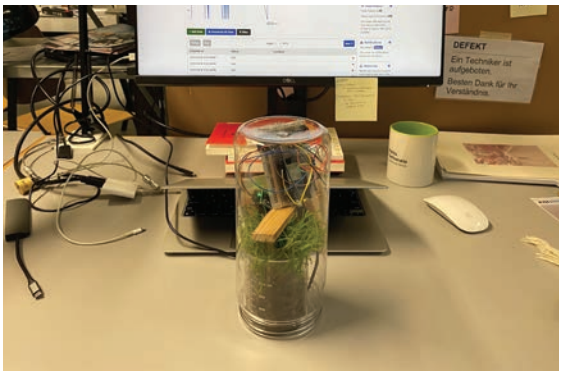
More than 60 species of Australian grassland plants are part of this installation at the Venice Biennale in 2018. It negotiates the relationship of the indigenous Australian ecology that has been disturbed through European settlers, their crops and cattle.

Field Research

soilKit

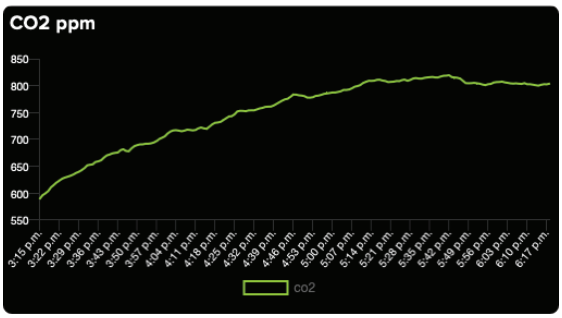
Before collaborating with the WSL, I already decided to develop a simple device to measure soil respiration. Inspired by the 2020/2021 Mars rover mission (Nasa 2021), I thought of the soilKit as a little soil rover to do field research in Hong Kong remotely. Hackteria (2018) developed during the RandeLab Soil Retreat 2018 a CO_2 measurement chamber that demonstrated the viability of a DIY approach. I decided to use the SCD30 sensor from Sensirion, which is also mentioned on their website and to further develop the chamber with wireless technology, additional sensors and input from Empa. The SCD30 uses NDIR technology and is effectively measuring CO_2 concentration. Lower cost sensors usually derive the CO_2 concentration (equivalent CO_2) from other measurements. An example for this type of sensor is the SGP30.

Nondispersive infrared sensors use molecules' light absorption properties for detection (see Mueller et al. 2019).



Testing the SCD30 with an Adafruit HUZZAH32, additional pressure sensor (BM280) and light sensor (VEML770) Data is collected and sent via Wi-Fi to io.adafruit.com.

F47 First prototype

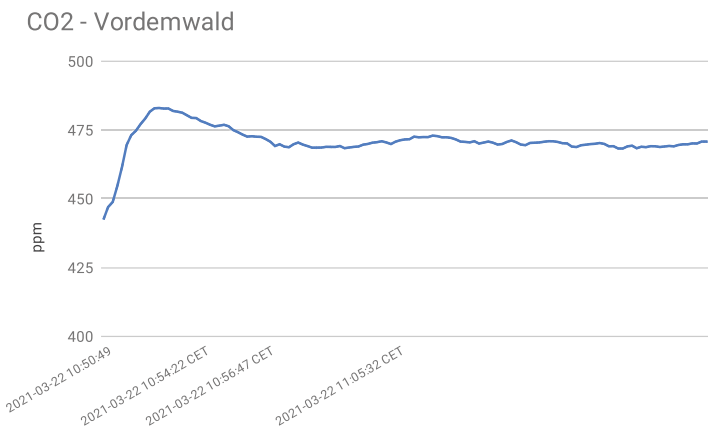


First test demonstrates that the plant and soil all in all respire more CO_2 than they absorb. This is often the case as plants do little photosynthesis in an indoor environment (see Suhaimi et al. 2017).

F48 First data sample of the first prototype

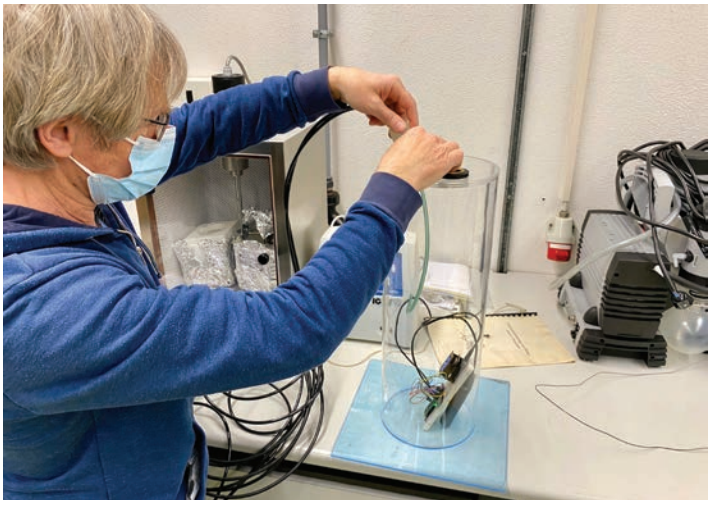
F49 Field Test, LWF Vordemwald, 22.03.21

Spring temperatures 8-12° C, in the shade and with dry conditions. The grey ring is used to put the LI-COR chamber on it.



F50 Data CO_2 respiration, Vordemwald, 22.03.21

Distinct respiration in forest soil.



F51 Comparing the SCD30 with the LI-COR

Under a controlled environment, the soilKit performs within ±50ppm in comparison with the LI-COR.

Talk with Michael Leung and Nanxi Liu

In March, I talked with Michael Leung and Nanxi Liu to evaluate if I could contribute or even continue the engagement from Switzerland. We discussed artefacts, soil and seeds from the abundant magic fruit plant (synsepalum dulcificum) they could send me. We also talked about possible applications of the soilKit to map the soil in Wang Chau. An idea they were open about. Furthermore, they connected me to activist groups in Europe such as Reclaim the Fields, ZAD and the activist group surrounding the Danneröder Wald, Germany.

I contacted them again in April to further discuss using the soilKit in Hong Kong and to ask them for soil and seed samples. As I did not receive any answers, I decided not to push them any further to contribute to my thesis. As the village was and is as of this writing in the process of eviction, they would have enough to do. Experimenting with the soilKit would be an additional burden with little to no additional use to the community. Therefore, I considered my activities in Wang Chau as completed (for the time being!). Continuing the work remotely would have devalued the contributions already made and would solely have had the purpose of advancing this thesis.

WSL

In March, I contacted Dr. Ivano Brunner, head of research unit forest soils and biogeochemistry at the Swiss Federal Institute for Forest, Snow and Landscape Research WSL. I asked him if I could get an insight into the labs and research activities as I wanted to learn how science approaches soil. He generously offered me a working space at the institute and connected me to many people who helped and supported me to advance my research. In the beginning, he was sceptical towards design and what it has to do with science. I introduced him to the field of interaction design and gave him concrete examples of my work. I also outlined how interaction design is tapping into many fields such as biology. Furthermore, I argued that artistic research is as valid as scientific research in cultivating knowledge (see Rillig et al. 2021). During my stay

at WSL, I discovered that the artistic research is indeed not all too different from a scientific one, as both scientists and artists inquire to make sense of the world we find ourselves in.

LWF

Together with Oliver Schramm, I visited three LWF sites (Langfristige Waldökosystemforschung, lwf.ch): Lägeren, Vordemwald and Othmarsingen. He introduced me into the probing they do, which are rain water, soil water, temperature, ozone, bark water and foliage collection and spot measurements of CO_2, CH_4 and N_2O.

The next day I helped Noureddine Hajjar in the lab to analyse the conductivity of the rain probes. The recent probes show the least conductivity Noureddine has ever measured, presumably because of lower emissions during the pandemic.

More on WSL learnings in the *WSL Diary* in the appendix.

F52 Oliver Schramm and three types of tree growth sensors

F53 Rain volume sensor

F53.1 Soil water collector

F53.3 Soil cross section for education

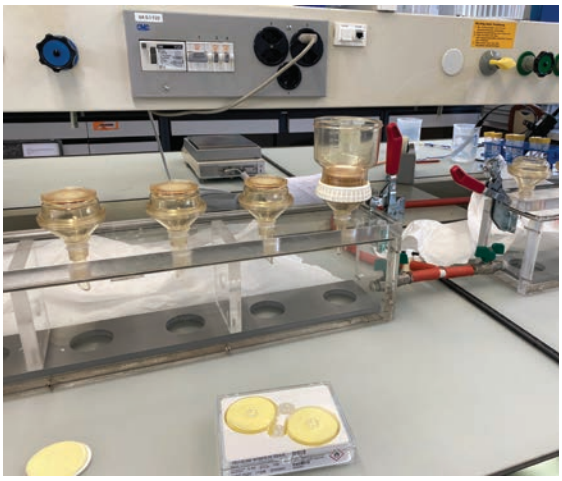
F53.4 Rain collector

F53.6 Indicator tree for ozone

F53.7 Sap-flow sensor

F53.2 Rain water conductivity measurements

F53.5 Rain water PH measurments



F53.8 Rain water filtering

MicroResp as Material Translation of Soil Respiration

Standard micro titration procedures to determine soil microbiome activity require the soil samples to be highly processed. Microbial communities are extracted from the soil before inoculation and propagation (example: Biolog, biolog.com). This poses an interference and change of conditions under which soil organisms normally live. The extraction of soil organisms into a different (aqueous) environment results in a change of the microbiome. This is a bias towards organisms that are readily extractable and can thrive quickly in this new environment (Campbell et al. 2003). Although now less used at the WSL as modern soil respiration measurement systems (LI-COR, licor.com) have supplanted the Biolog, this method is still viable and fast for providing information about the actions and characteristics of the soil microbiome (personal communication with Dr. Beat Frey, April 9, 2021).

The MicroResp method developed by Colin Campbell uses "whole soil" to obtain a metabolic fingerprint and does not require extraction and culturing of the microbes. This has the advantage of lesser disturbance to the soil microbiome

F54 Fully assembled MicroResp, note the pink indicator material on top

and considers the whole soil in its current condition. In doing so, it relies on so-called "indigenous" microbes. Despite analysis and interpretation of the data being complicated, such methods are shown to be as sensitive as microbial biomass or respiration measurements (Campbell et al. 2003).

Currently, the MicroResp is used to assess soil health and quality through toxicity testing, pesticide degradation profiles, community level physiological profiles (CLPP), pollution induced community tolerance (PICT), bioremediation evaluation, water ecology and toxicity with further potential and applications in microbe strain phenotyping (observing microbe characteristics), animal feedstuff digestibility and seed germination assays (assessing biochemical activity) (MicroResp 2015).

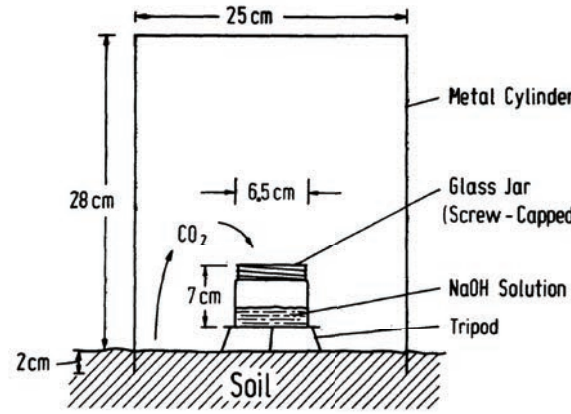
Campbell et al. (2003) further explain the expansion of the MicroResp with possibilities for detecting other respired gases such as NH_3 (ammonia), N_2O and CH_4 if adequate indicators are found.

Critique

The MicroResp method still poses a certain disruption of the soil. It calls for incubation (3-5 days at 25 °C) of the soil and adjusting its moisture content. Although a standard procedure to standardise soil samples, it is a disturbance nonetheless.

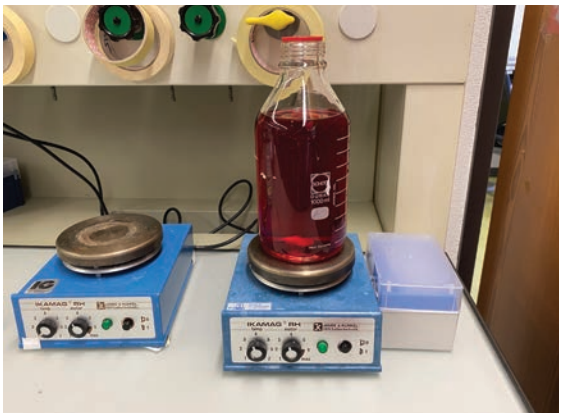
Indicator Gel

I upscaled the MicroResp method to make an indicator gel that would act as a material translation of soil's respired CO_2. It is quite a simple and straightforward, yet elegant method to make soil respiration visible. Anderson (1982) describes an early procedure that is similar to the MicroResp. The indicator solution is a mixture of KCl (potassium chloride), $NaHCO_3$ (sodium bicarbonate, baking soda) and cresol red, a PH indicator, in deionised water. This solution alone is al-



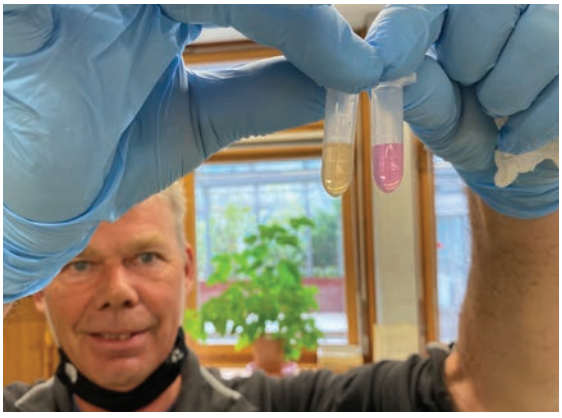
F55 Early "MicroResp", Anderson 1982

ready capable to indicate CO_2 concentrations. The higher the CO_2 concentration, the more is converted into H_2CO_3 (carbonic acid), which lowers the PH of the solution. The pinkish colour will turn yellow in response. This can be already achieved by simply breathing into a container with the liquid and closing it. This causes the solution to change colour within seconds, while thin strips of gel react within minutes.



F56 Mixed indicator solution

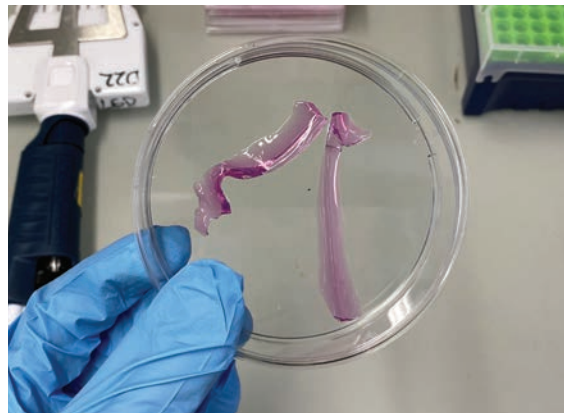
Mixed indicator solution:
18.75mg cresol red
16.77g KCl
0.315g $NaHCO_3$
1l dH_2O



F57 Color change of solution after breathing in

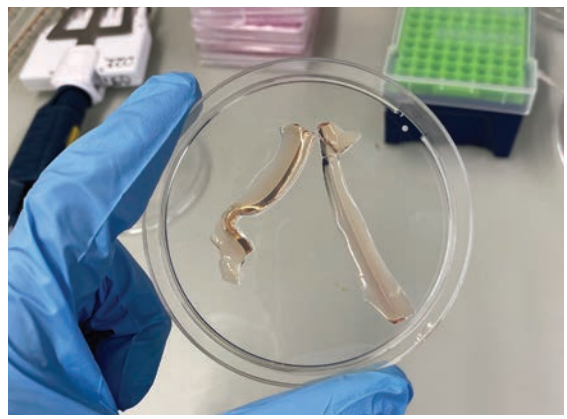
Left container was exposed to breath and changed colour within seconds.

Indicator gel (indicator + agar 2:1) is stable (pink) in normal environmental conditions.



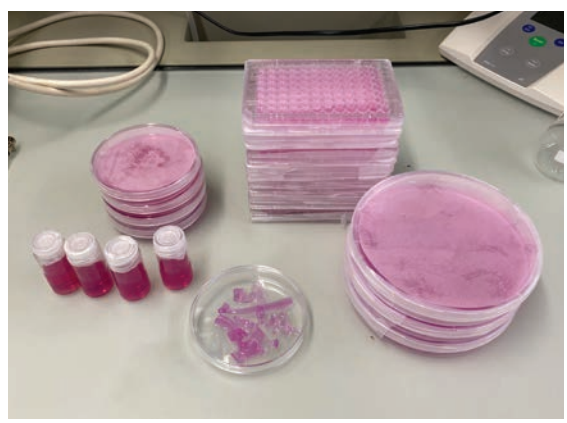
F58 Indicator gel before exposure to breath

After exposure to breath and closing the petri dish, the indicator gel turns completely yellow within minutes. When left open, the color reverses and it turns pink again.



F58.1 Indicator gel after exposure to breath

Different form of indicator gel poured: titration plates, 2 sizes of petri dishes and vials



F59 Different forms of indicator gel

F60 Indicator gel experiment

6h

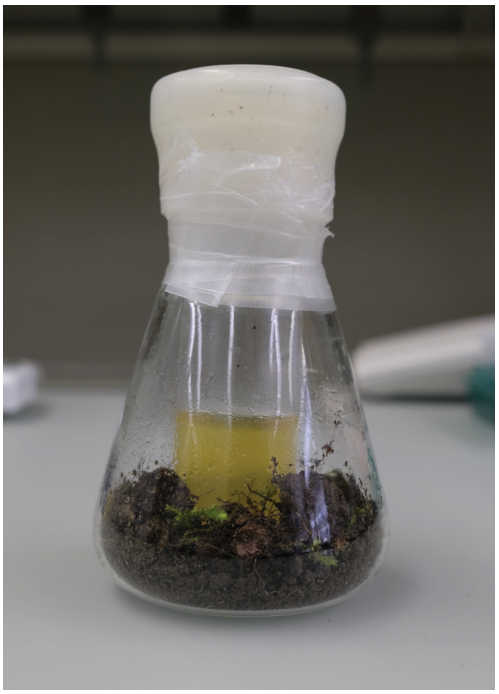
F61 Vial in closed environment

36

slight gradient visible

F60.1 Indicator gel after 6h

36h



F61.1 Indicator gel after 36h

F62 Indicator gel releasing stored carbon back into the atmosphere, creating a gradient

F63 Planted (but never germinated) synsepalum dulcificum seeds

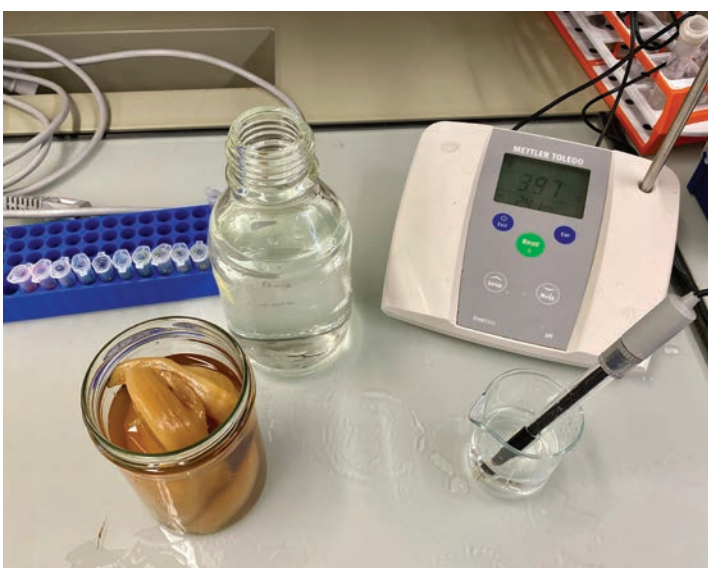
Synsepalum Dulcificum

Considering with Michael Leung the concept of giving plants from Wang Chau "refuge" in Switzerland, our discussion revolved around the magic fruit or miracle berry (synsepalum dulcificum). The plant was nicknamed by European "travellers", namely Reynaud des Marchais, who is better known as a cartographer than as a slave trader (Curran 2011; Nkwocha et al. 2014). He encountered the plant in the 18th century in West Africa, presumably around the region of today's Benin. At that time, however, it was the Kingdom of Whydah, which was greatly involved in the slave trading business. The Kingdom of Whydah beared a nickname as well: Slave Coast (Law 1991). Reynaud des Marchais gave the berry its nickname for its property to turn sour tasting food sweet. Responsible for this is a glycoprotein, miraculin, in the fruit's flesh. In Africa, the berries are well known for this property and have been used as a sweetener (Bartoshuk et al. 1974). While the plant has now been introduced to the USA, Australia and Southeast Asia and is reported by Michael Leung to be in France as well, not much is known about this species and how to cultivate it (Achigan-Dako et al. 2015). The plant requires special conditions such as acidic soil with a PH of around 4.5-5.8 and temperatures above 20 °C (Lim 2013).

The webs of entanglements this species is in was a surprising discovery. From a Western African plant, nicknamed by

a French slave trader, to a village in Hong Kong and now given refuge in Switzerland, while one has to transform Swiss soil to provide the conditions to keep the plant alive. While it would be an "invasive species", it is at the same time a (traditional Chinese) medicinal plant. These opposites are rubbing against each other in addition to the plant's charged history.

I ordered the seeds from Germany, as Wang Chau was being forcibly evicted. This demanded a lot from the people there and I did not want to unnecessarily burden them. Furthermore, the seeds would probably not have survived the shipment from Hong Kong due to their fragility (see Achigan-Dako et al. 2015; Tchokponhoué et al. 2019). The first try to germinate the seeds failed as mould formed. Beat Stierli advised me to germinate the seeds on filter paper as this would provide a more controlled environment. To water the seeds, I lowered the PH of deionised water to 4 by slowly adding kombucha.



F64 Lowering dH_2O to PH 4 with kombucha

F65 S. dulcificum seeds on filter paper

F66 S. dulcificum “care package” with water at PH 4

Project Development

Through accompanying Oliver Schramm and helping Noureddine Hajjar, I got an insight into soil research at WSL. There was clearly a hurdle of proving myself and making clear my purpose there. To acclimatise to the WSL I spent most of my time there instead of at ZHdK. My interest in the soilKit subsided as I was experimenting with other ways to probe into soil respiration. Nonetheless, I continued developing the soilKit, as it has become a discursive object that, in the beginning, validated my presence at WSL and at a later time became the common object to talk about.

While experimenting with the indicator gel, Beat Stierli, Dr. Beat Frey and Margharita Aiesi were present in the lab. As Beat Stierli demonstrated the colour change, we all were captured by this simple reaction. This reaffirmed the power of material performance in mediation. When I was developing the soilKit, hardly anyone was fascinated by the number it showed or the curve it drew. But the material through its agency and performance was able to reach people on a different level. It was also exciting to witness scientists engaging in this artistic experimental mode of working.

Further Development of the Chamber

The first chamber prototype delivered repeatable results in controlled conditions, however the system was too fragile in field use. With Alois Zürcher, I discussed how to improve the chamber. Alois is a lab technician at WSL, whose work focuses on CO_2 measurements. Following his inputs, I looked into different chamber types as described by Oertel et al. (2016) and decided to build an open chamber prototype. Open chambers are more sophisticated and expensive, as the gas flux is calculated by the difference of concentrations when air enters the chamber and when it leaves it. The advantage is that no accumulation of CO_2 in the chamber is needed.

In the end, all chamber systems are suitable for continuous monitoring, except in winter conditions and extreme humidity of >80%. Humidity in general interferes with the measurement

optics of the sensor. Data from a specific site is usually precise and reliable, yet cannot be upscaled for an entire region (Oertel et al. 2016).

I realised the potential of the soilKit for scientific use as I learned more about CO_2 measurements at the WSL. There they rely on the LI-COR, a device that costs around 20'000-50'000CHF. While the LI-COR is still "mobile", it can only be used for spot measurements. In the LWF sites, measurements are carried out selectively and require a person to be present. The soilKit could be a good alternative, as it is cheap, light and connected to a WiFi or LoRaWan network. This combination of features would allow it to be continuously deployed in great numbers in the field and provide a detailed map of microbial activity across Switzerland.

Long range low-power network

~ 12'000 (chamber only) vs. 100 CHF

F67 LI-COR CO_2 Flux Chamber 6800-09

Bigger sister of the soilKit: Mathias Mayer's CO_2 chamber which uses the LI-COR.

F68 Mathias Mayer with his "soilKit"

soilKit on one of Mathias' test trees.

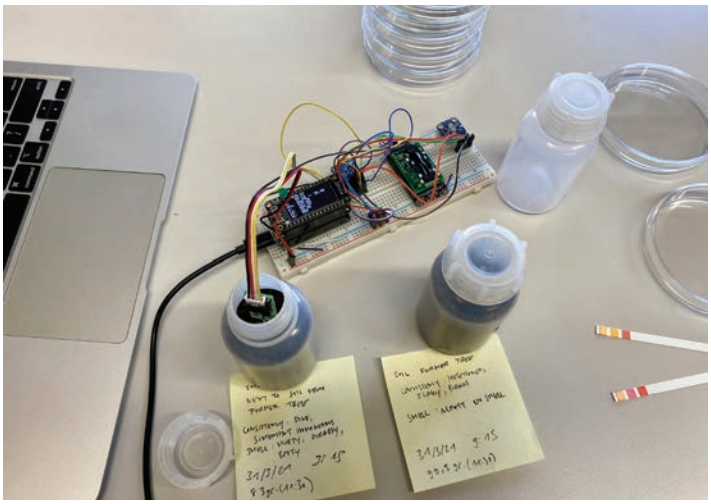
F68.1 Soil respiration on "extracted" forest soil

A distinct decrease in CO_2 was measured. The tree was fully exposed to the sun and photosynthesis was therefore high.

F68.2 NEE measurement with a baby fir

F69 In the warmth-drought climate chamber with Alois

Testing the soilKit in the warmth-drought-chamber, where climate scenarios are simulated. With such a soil, the respiration is too little to be picked up precisely by the soilKit.



F70 Soil conductivity and temperature sensor

Testing expansion of the soilKit with a soil temperature and capacity sensor.

F70.1 Sampling soil PH, conductivity and smell

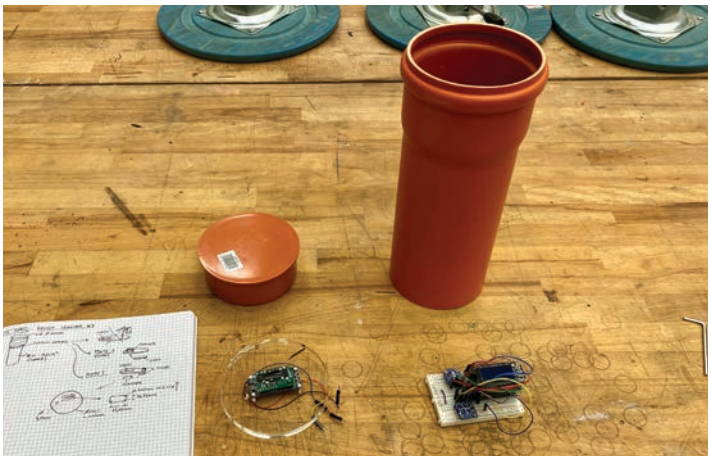
Soil sample tests, here PH is measured from disturbed and undisturbed (or less disturbed) soil.

Second Chamber Prototype

I prototyped a second chamber that is modelled after the LI-COR. Here, a vacuum pump circulates the air out of the chamber to the sensor and back. In initial tests, this prototyped turned out to be too complex. The pump was too heavy and required an additional battery and moreover weakened the construction. The airflow has to be precisely controlled as well. The unreliable data affirmed the unsuitable construction of this prototype.

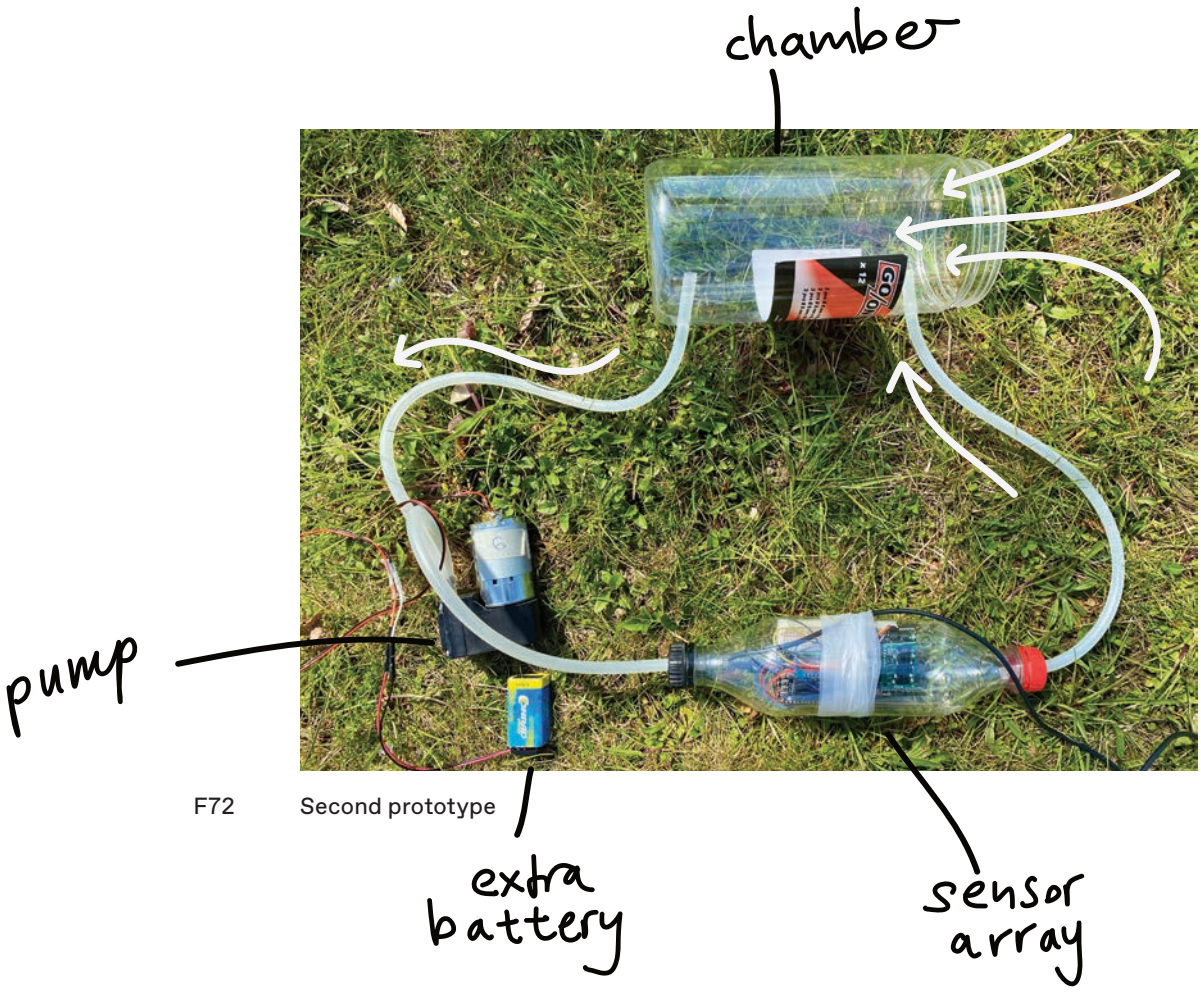
At Empa

I contacted Dr. Lukas Emmenegger, Head of Laboratory for Air Pollution / Environmental Technology, and Simone Baffelli, postdoctoral researcher and maintainer of the Carbosense network at Empa to have an exchange on low-cost CO_2 sensors. Empa has been conducting research with low-cost CO_2 sensors within their Carbosense network, which deploys over 300 battery powered sensors all over Switzerland. Their publication (Mueller et al. 2019) demonstrates the viability of deploying the sensors in the field. I received encouraging inputs from them, as they see low-cost sensors as an ideal application for soil respiration. Low-cost sensors do not measure "correctly" but "precisely", meaning they may start at different values, but they would be highly accurate when measuring the increase in CO_2 (Mueller et al. 2019). They also generously borrowed me an EmpAir CO_2 sensor to perform simultaneous measurements with the soilKit.



F71 Third prototype

Third iteration using a PVC drain pipe. The SCD30 is facing down, while the board is facing up.



F72 Second prototype

F73 At Empa with the third prototype

Third Chamber Prototype

Dr. Lukas Emmenegger and Simone Baffelli generally approved the rain pipe construction, but advised me to use a shorter tube. Drain pipes are also used at the WSL for CO_2 measurements, however they have been gradually discontinued as LI-COR sells fully automated chambers (like the one shown before). Another important feature is the robustness of the rain pipes against environmental influences. Previous prototypes were transparent, which is not ideal for soil respiration measurements. Intense light might interfere with the electronics and stimulate photosynthesis in plants such as grass in the chamber. The photosynthesis would absorb part of the CO_2, thus providing a NEE reading as opposed to a sole measurement of soil respiration.

The code and building instruction can be found on github.com/duuusen/soilkit

F74 Comparing the third prototype with the Vaisala

The Vaisala (vaisala.com) is an older model and was supplanted by the LI-COR. However, it is still accurate. Compared with the soilKit, the deviation is ±30ppm. Compared to the EmpAir, the soilKit is more accurate and responds quicker.

The soilKit in simulated tropical conditions: the Masoala Rainforest at Zoo Zürich.

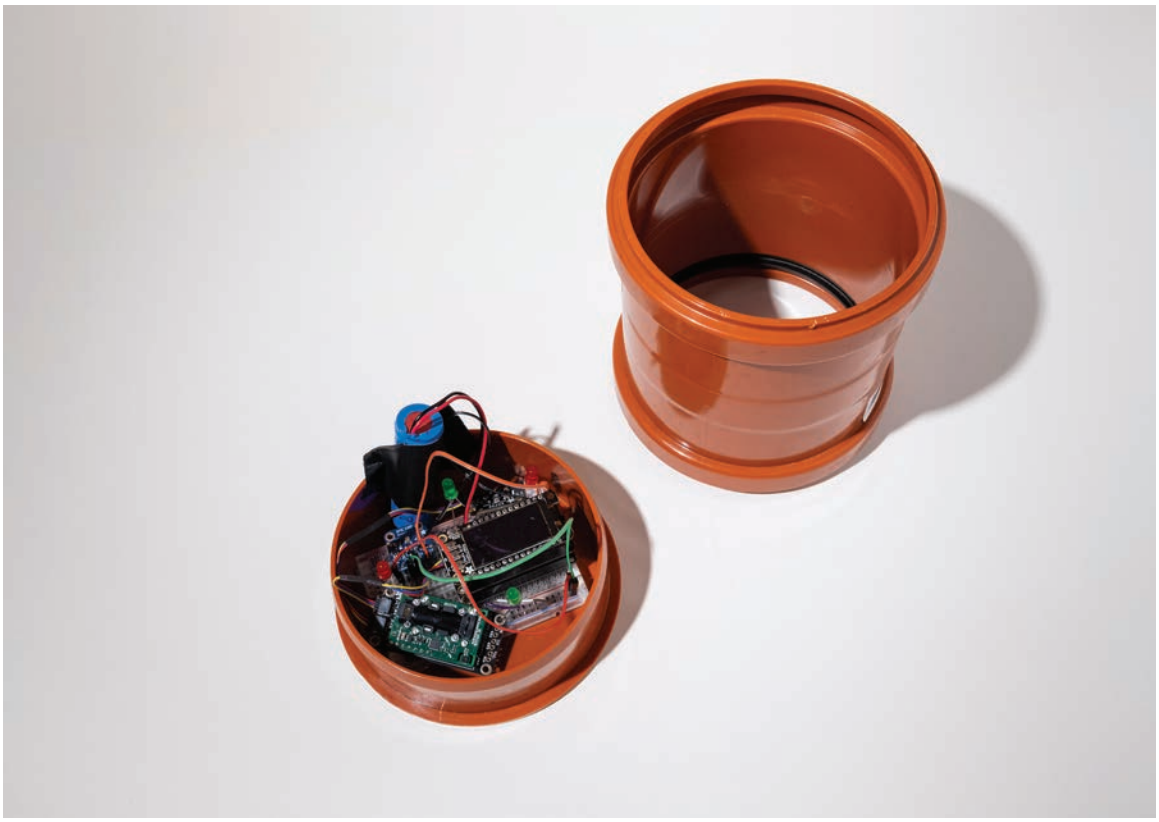
F75 soilKit in an artificial tropical forest

Two identical soilKits and the EmpAir as comparison unit.

F76 Three units of the third prototype

Simultaneous measurements with Dr. Ivano Brunner, comparing the three units with the Vaisala.

F77 Series of measurements



F78 Prototype 3.1 used for the measurement series

Data of First Simultaneous Measurement Series
2 soilKits unit 01 & unit 02, 1 EmpAir, 1 Vaisala GMP343
20 April 2021

	time	unit 01	unit 02	EmpAir	Vaisala	
	11:22	467	386	408	–	T = 290.15K
	11:23	472	387	412		RH = 34%
	11:24	474	402	418		P = 95300Pa
	11:25	–	440	425		
	11:26	543	451	460		
flux		**1.351**	**1.155**	**0.924**		

	time	unit 01	unit 02	EmpAir	Vaisala	
	11:32	467	386	408	–	T = 291.15K
	11:33	472	387	412		RH = 37%
	11:34	474	402	418		P = 95300Pa
	11:35	–	440	425		
	11:36	543	451	460		
flux		**0.584**	**0.746**	**1.671**		

	time	unit 01	unit 02	EmpAir	Vaisala	
	16:12	441	–	384	413	T = 292.15K
	16:13	450		385	419	RH = 34%
	16:14	481		391	430	P = 95100Pa
	16:15	510		403	447	
	16:16	538		427	463	
flux		**1.709**		**0.758**	**5.873**	

	time	unit 01	unit 02	EmpAir	Vaisala	
	16:23	460	291	395	433	T = 295.15K
	16:24	451	325	405	472	RH = 38%
	16:25	471	334	429	476	P = 95000Pa
	16:26	483	502	451	499	
	16:27	512	505	542	523	
flux		**0.906**	**3.728**	**2.561**	**10.452**	

	time	unit 01	unit 02	EmpAir	Vaisala	
	16:46	399	267	385	–	T = 295.15K
	16:47	431	275	388		RH = 35%
	16:48	472	285	395		P = 95000Pa
	16:49	513	302	408		
	16:50	521	332	425		
flux		**14.169**	**7.781**	**4.645**		

Measurement values in ppm
T: Temperature, RH: Relative humidity, P: Pressure

Formula used (Gyawali et al. 2019)

$$\int CO_2 = \frac{P_0 V_c}{R T_0 A} \cdot \frac{\Delta C}{\Delta t}$$

P_0	Pressure in chamber
V_c	Overall volume of chamber + tubes (if used)
R	Ideal gas constant
T_0	Air temperature
A	Area of exposed soil
ΔC	Change of CO_2 concentration
Δt	Change of time

Measurement and Data Discussion

This short discussion should further explain the framework of the measurements and will not discuss the data scientifically.

Soil CO_2 flux rather than absolute respiration is essential in understanding how organic matter is decomposed and informs for example climate models (Jensen et al. 1996). Gyawali et al. (2019) first described and built a low-cost soil respiration device. However, their device is rather rudimentary as it uses a standalone NDIR CO_2 sensor without additional sensors, such as those for humidity, temperature and pressure. As Gyawali et al. and the WSL both rely on CO_2 flux measurements in their research and because of the importance of the flux as described, I also focused on flux measurements.

The first measurement series took place in one day, once in the morning and once in the afternoon at the same spot. The sensors were placed on PVC rings that have been installed at least 24h prior to minimise soil disturbances.

The missing values are either inconclusive, missing or faulty data due to measuring errors (network disconnections).

Environmental data (temperature, relative humidity and pressure) come from the SCD30 and the BME280.

Sudden changes in the flux (data from the afternoon) stem from larger chambers used to better compare the units with the equally larger Vaisala (see F77.1).

F77.1 Vaisala (on PVC ring), unit 01 & unit 02 and the EmpAir (on cart)

Further Development of the Indicator Gel

I poured the indicator gels in different forms and conducted various experiments with the indicator material to test its action in different environments, especially when placed directly on soil.

One concern is cresol red that is used as indicator dye. It is not necessarily a toxic substance, however if it could be exchanged with a harmless dye, it would overall make the indicator gel safer. In discussion with Beat Stierli, we discovered that anthocyanin in red cabbage is a potent dye. It can take on almost any color, from red (low PH) to yellow (high PH). Convinced from the benefits of anthocyanin, I decided to extract the dye.

In experiments with anthocyanin I could produce a wide range of colours and could also induce a colour change by breathing at the KCl + $NaHCO_3$ solution. However, as anthocyanin has such a broad range of colours, it has finer gradients. This makes it hard to see the colour changes, as the PH of the solution changes only marginally by around 0.6 (measured). In addition, buffering the solution with HCl (hydrochloric acid) or KOH (potassium hydroxide) to achieve different colours is in the end more harmful than using a dye such as cresol red.

The extent of the indicator gel's response to exhaled CO_2 is most impressive. It is able to record and visualise breath from humans and other large animals down to the very smallest life forms such as bacteria. This scalability demonstrates potential for further experiments.

F80 Bigger indicator gel

I was curious how the material would react when placed directly on the soil.

The materials did not change considerably. My hypothesis: 1. soil respiration and photosynthesis of grass is almost in equilibrium. 2. the material in the open passes on the absorbed carbon directly into the atmosphere, therefore a closed system is needed for CO_2 to accumulate.

F80.1 Indicator gel placed directly on soil

F80.2 8h time-lapse

F80.3 Feeding the microbes with 10% glucose

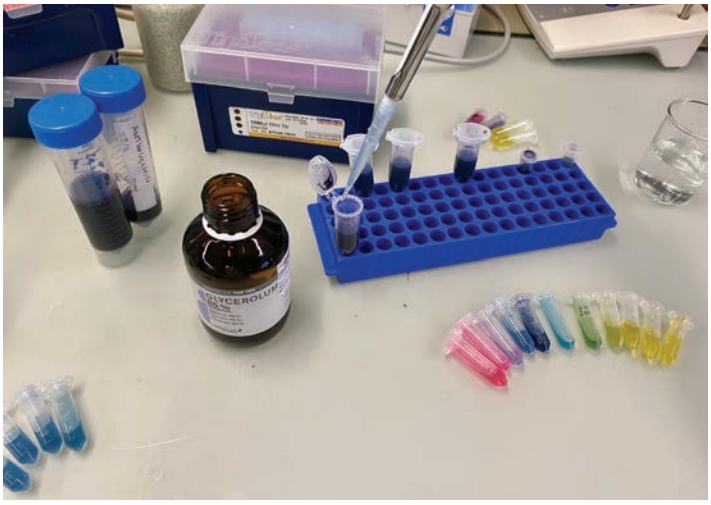
1kg red cabbage
1l dH_2O

reduced to 100ml

F81 Anthocyanin extraction

With KOH (base, high PH, yellow) and HCl (acid, low PH, red) the whole spectrum can be produced.

F81.1 Full spectrum of anthocyanin

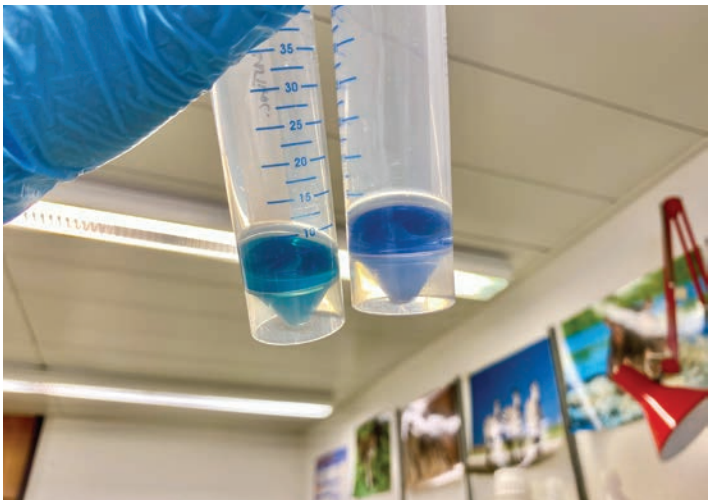


Preserving anthocyanin with glycerol (4:1) and freezing it at –20 °C.

F81.2 Pure anthocyanin in small tubes for preservation

Gradient from purple to blue, green and yellow is achieved. This represents PH levels from 7–13 in one environment.

F81.3 Strong acid (HCl) creating PH gradient



Left: with CO_2 from breath
Right: control sample

F81.4 Indicator solutions using anthocyanin

Right: sample with CO_2 degraded and turned yellow after 36h. It is unlikely that so much CO_2 was absorbed to increase the PH to 13.

F81.5 Indicator solutions using anthocyanin after 36h

Reflections on the Arts and Science

While working at the WSL, I had to negotiate between the fields and balance my engagement as well as claim and assert my position in it. I engaged with scientists and showed them my work to foster mutual learning and understanding. We prototyped, had lunch and coffee breaks together. These engagements served also the purpose of breaking preconceptions about the arts and to help validate artistic research. Interaction Design is inherently interdisciplinary, which brings advantageous skillsets already. Following are some reflections and findings while working at WSL.

Free after Rillig et al. (2021) the intersections between science and the arts bridge scientific research with fields of philosophy, anthropology, aesthetics and culture. By communicating and exchanging ideas and methods outside science and even outside the arts involve critical perspectives on their relationships. By thinking and acting in both and many fields, this generates knowledge and introduces new methods and means for reflections in research of both fields. I was particularly interested in the spaces in-between and to unearth the things that slipped through; things that did not fit in any categorisation or classification.

On Data and Classification

Data is of course the main driver of scientific research and with the soilKit, I have also been pursuing the collection of it. Focusing on information and data might be counterintuitive at first, because it leads us to this notion of quantification, numbering and naming — very rational approaches to environmental entanglements. Those classifications that we need for analysis and description of the environment need to be broken up and rethought, as they simplify and neglect the things that don't fall into a category (Kirksey and Helmreich 2010). We need additional ways of making sense of the environment. By paying attention to existing entanglements and dynamics, we develop an attitude of openness to engage with this complexity "beyond the numbers and models that have so often failed us" (Franinović and

Kirschner 2021). Heather Houser (2020) warns against the case when information becomes "central to environmental cultural production". Art and design can incorporate scientific information to understand this "positivist epistemologies" (only recognising information that can be verified and measured) that dominate the understanding of the environment. This positivism can be integrated with ways of knowing rooted in the body, in emotion, in sensing, ambiguity and speculation. Terrestrial models are essential methods to understand the Anthropocene, a "condition known through modelling of mass aggregated data" (Houser 2020). However, it is important to highlight that these models can be computed but not experienced. Data and information are here tools for literacy in observing earthly processes and informing artistic research (Tsing et al. 2019). Researching ways of meaningful interactions with terrestrial dynamics are then crucial to both science and the arts.

Edwards (2010) argues that "the routines of data gathering and model building undermine modellers' capacities to notice change, transformation, and historical specificity in the world". Models are, as Tsing et al. (2019) describe, "data infrastructures that both enable and deaden observation". Of course, we have to take those information and models seriously, but not for granted. When doing measurement tests with the soilKit I have experienced this "deadening" work which affords you to focus too much on a certain aspect or a certain thing or process.

Reflections on Working With Scientists

The most challenging experience has been to prove oneself among scientists. Challenging questions towards the roles of art and design were ubiquitous. They were demanding in the deliverance of clear arguments but also afforded thorough reflection on one's own practice. Other challenges next to the categorisation of knowledge were what Tsing et al. (2019) describe as a "hegemonic universal claim about the world". Further, Donna Haraway states that we are in need of an "insurrection, a revolt against those who think they know everything" (Terranova 2016).

My process-based work certainly was unusual and may have encouraged scientists to question fixed images through the

cumulative process of interacting with each other. In the end collaborating with scientists provided reflections on both sides and on both practices. Sometimes, there was a loose collaboration with scientists on common things of interest, like the indicator material, anthocyanin experimentation and the Hericium erinaceus fungus. For a future step, trying to engage in deeper collaboration with scientists despite the rigid system of scientific research could prove extremely rewarding.

In discussion with Margherita Aiesi she clearly and sharply pointed out that scientific research often revolves around a very niche topic that in the end is met with restrained interest unless it is truly groundbreaking. Often, the research does not involve any critical thinking about cultural relations and is usually not aimed at really improving something. In a conversation with Jasmin Fetzer, PhD student at WSL, there was even a moment of clear criticism towards some scientific research. Donna Haraway (2017) aptly describes how "the sciences of the Anthropocene are too much contained within restrictive systems theories and within evolutionary theories called the Modern Synthesis, which for all their extraordinary importance have proven unable to think well about sympoiesis, symbiosis, symbiogenesis, development, webbed ecologies, and microbes".

Every so often I would direct conversations towards the speculative and test fabulation against scientific rational. To bring in fiction allowed things to emerge that otherwise would not be considered or thought about. This often led to moments of wild curiosity.

On Reproducing Traditions

It has become a trend to use laboratory tools and vessels as aesthetic vehicles of an artistic work, especially in biodesign and bioart (see Myers 2012; 2015). Rarely does an open inquiry take place about where these aesthetics come from.

Scientific knowledge production and the aesthetic of the laboratory is closely tied with histories of colonialism and exploitation. In Vietnam, Michitake Aso (2018; 2021) illuminates the politicality of knowledge production through rubber plantations (and the establishment of domination through them) and

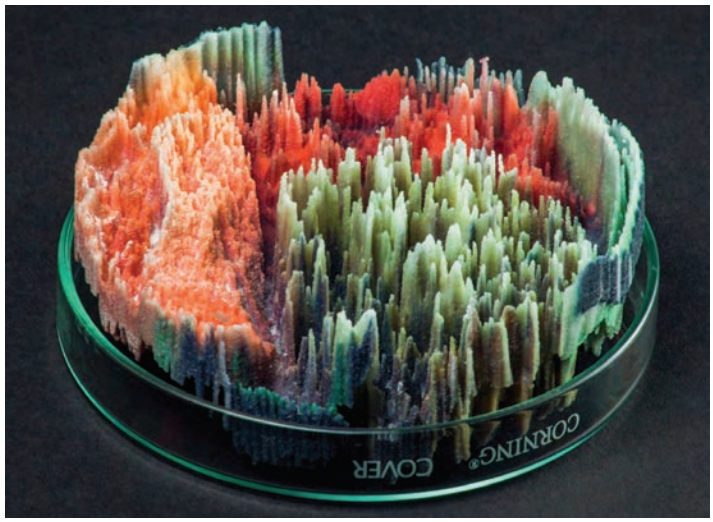
F82 *Objectivity [tentative],* exhibition view, Nurit Bar-Shai, 2012

F83 *Prometheus Delivered,* exhibition view, Thomas Feuerstein, 2017

explores the emerging independence of Vietnamese scientists from French colonial institutions. In Central Africa, forced medical examination and trials took place that lead from blindness to death. These "advances" in medicine went together with the increased European invasion in rural areas (Lowes and Montero 2021). The exploitation and abuse of the indigenous in the Congo Free State was one of the most horrendous crimes. When tropical diseases like the sleeping sickness began to break out in neighbouring states, King Leopold II instructed scientists to come up with a treatment. This was not done out of humanitarian reasons but with economic interests in mind. The research work was the basis for the foundation of the Institute of Tropical Medicine in Antwerp, which is tied to Johnson&Johnson, the company that developed a COVID-19 vaccine in 2020/2021 (Harris 2021).

These accounts illustrate what Heather Houser (2020; 2021) calls "entangled epistemology". It describes knowledge production and representation that is linked with colonialism and Enlightenment traditions that "have helped instrumentalize and dominate nature and have suppressed and supplanted bodies of knowledge cultivated by storytellers, women, indigenous peoples, and long-term inhabitants of places". We as artists and designers have to consider this epistemological dominance. When we are working within these fields, there has to be constant negotiation and reflection between what we are researching and through what environment we are doing it. A kind of attunement to the landscapes of the laboratory so to speak. Otherwise, as Houser (2020) points out, we would make ourselves "complicit in this paradigm of knowledge making when repurposing scientific information".

However, I acknowledge the ability of the lab aesthetic in terms of mediation. In a showroom or workshop, laboratory materials can provide an aesthetics experience and may contribute to knowledge production. It is bringing what is usually behind closed doors to the public and lets them experience it. Here, aesthetic experiences act as vehicles of mediation and knowledge production. They bring the viewers and participants closer to science, reducing the gap (compare Kester 2004; Zheng 2016).



F84 *Remote Sensing,* Suzanne Anker, 2013–ongoing

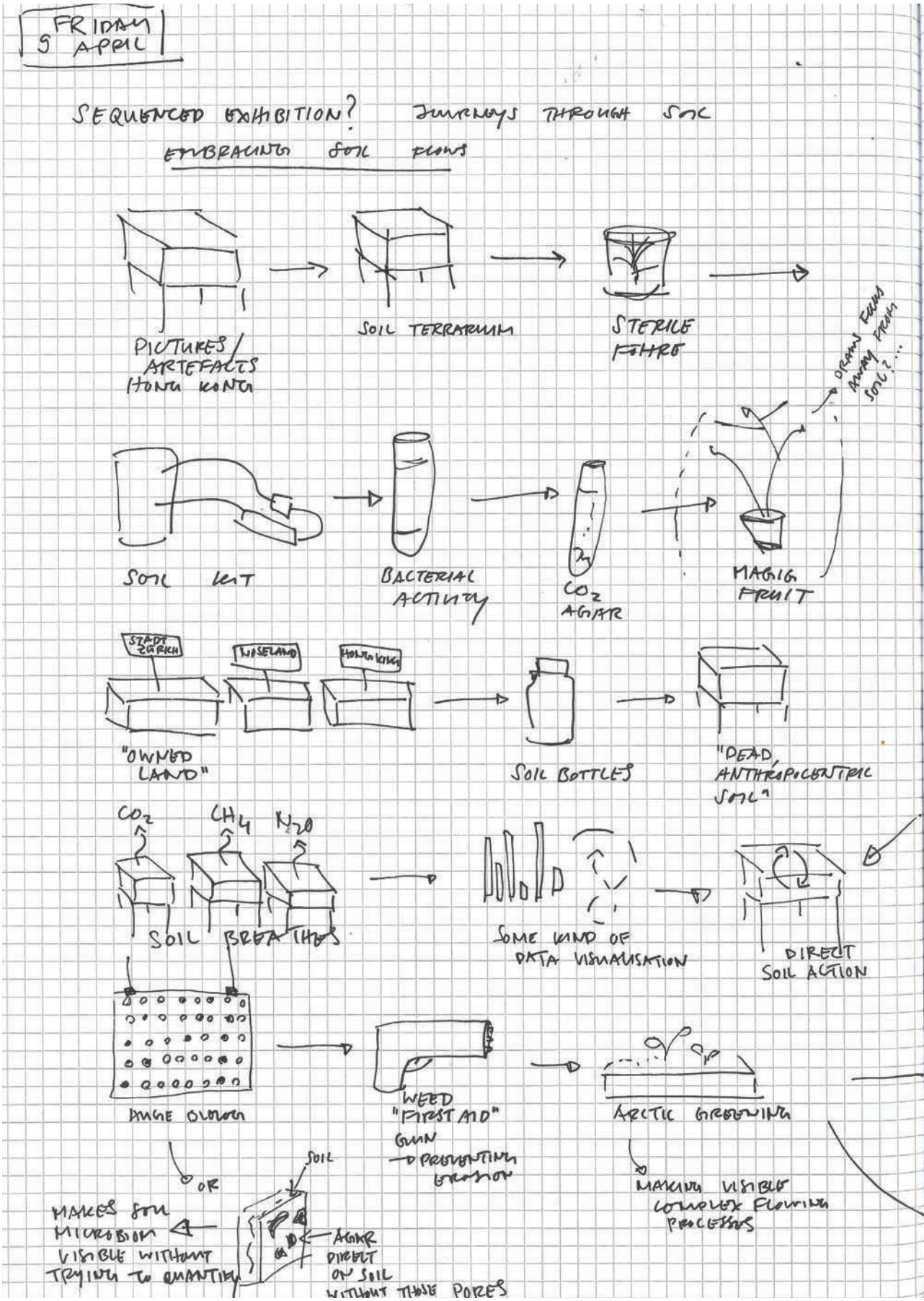
III

Exhibition Concept

How do you bring such bodily experiences in Cambodia, Hong Kong and also in Switzerland into an exhibition room? How do you distill an ongoing process that was inherently based on dialogue and collaboration? A work that is and will continue to be durational? The most ideal would be to bring the viewers to the sites. An exhibition in a room or gallery can merely be an incomplete representation (see Zheng 2021). Nevertheless, an exhibition can confront the viewers with disorder or randomness and lets them distill their own meanings with tools provided (Willats 2000). In the exhibition, I want to show the flow of soil and demonstrate why I call it flowing. As one observes the installation, this too will be a snapshot, a *Momentaufnahme*, as it flows and continues to flow beyond the timeframe of the exhibition. Initially, I planned to show a sequenced process and exhibit 3-5 "stations", each revolving around a different detail from the process. This would work for the things I have learned at WSL where I could demonstrate for example the soilKit or the indicator material. However, I was reluctant to make exhibits about Cambodia or Hong Kong. I felt that bringing those very durational and processual approaches into the showroom would devalue the contributions made. Still, the process there has been essential to the work and it has to be represented in some way.

Thinking beyond podiums and acrylic glass, I decided to use soil itself as a vessel for soil — in the form of clay. My research initially revolved around 3D printed clay vessels informed with data from each country and displaying different artefacts on the soil of each vessel. Through embodying the data, the vessels would pose as a morphing, acting material representation. Ideally, this would be clay made from soil from the sites. Those vessels would stay wet. They would change and transform over the course of the two weeks of the exhibition: they would flow. In discussion with Louisa Goldman I came to the conclusion that 3D printed vessels would distract too much from the soil and the artefacts on it. Those vessels would add more layers of meaning that are quite distinct and may overburden the installation.

The next iteration of the exhibition concept (before ac-



F85 Early thoughts on the exhibition concept

ASK ROSE, CARL, HARRISON TO SEND ME SEEDS OF THEIR FAVOURITE PLANT

↳ BUT WOULD PROBABLY FOLLOW AWAY FROM SOIL..

FIELD STUDY

↓ PUBLIC SOIL ACTION?

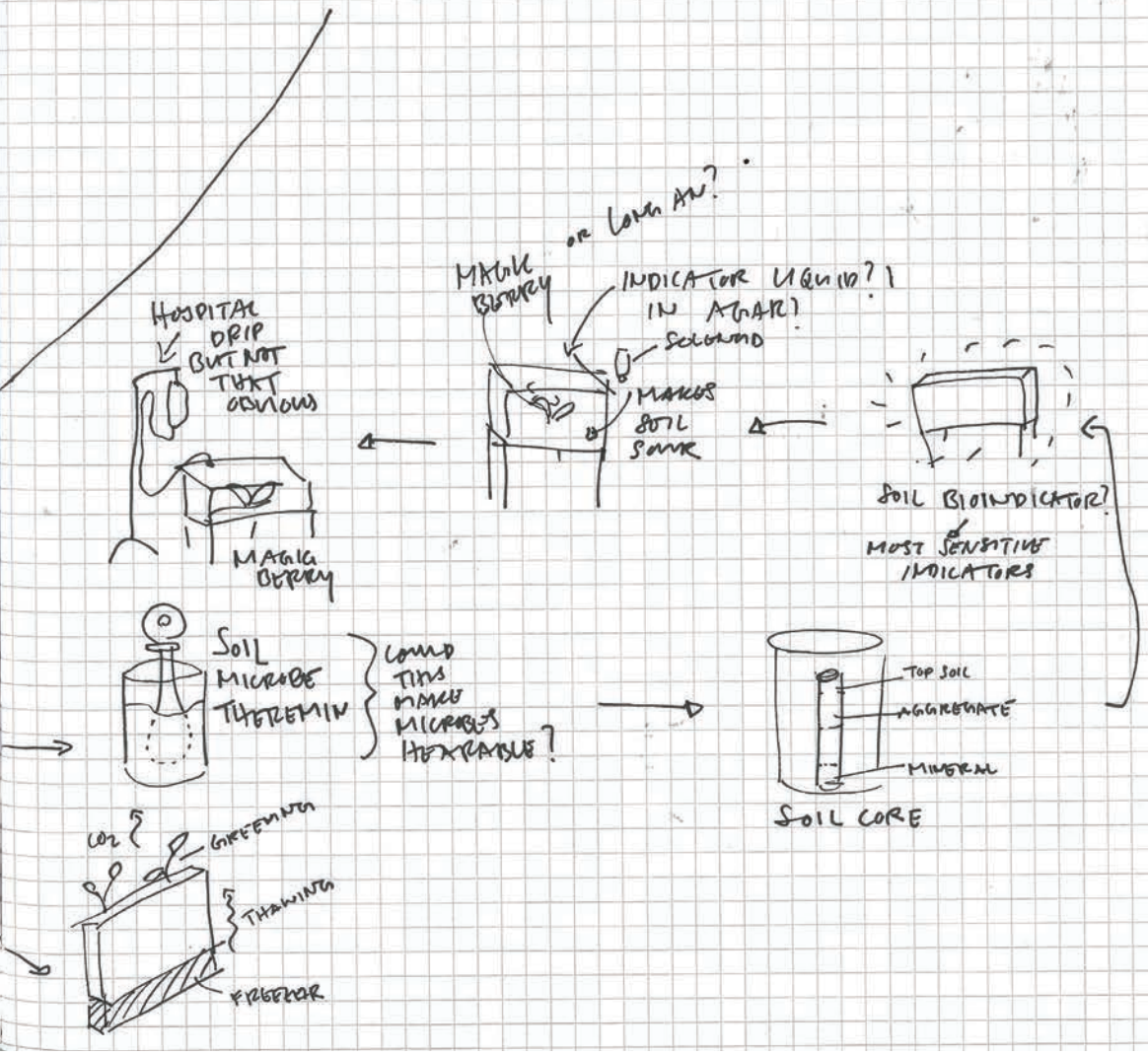
↓ MAKES PEOPLE AWARE OF SOIL?

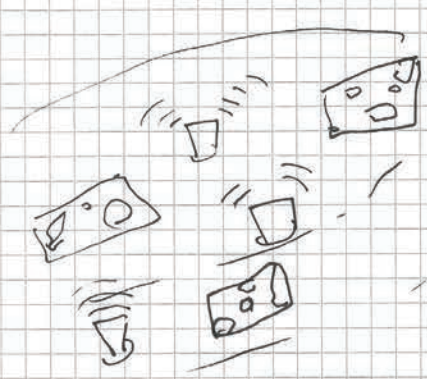
↓ DO I EVEN CARE ABOUT PEOPLE?....

DIRECT ACTION

↳ NOT AMBIENCE, BUT SOIL!

→ DISPLAY HOW SOIL ACTS DURING EXHIBITION





ALWAYS CHANGING
MICROBIAL LANDSCAPE,
MAKE VISIBLE THROUGH
MATERIAL AND SOUND

EARTH
PROCESS
ACCELERATOR
→ SUGAR,
MAKING SOIL
PROCESSES FASTER AND
EXPERIENCABLE
→ ALMOST LIKE A
BIOREACTOR

27 APRIL

SOIL RESP DATA

→ FROM EACH PLACE

↓

TRANSLATE INTO 3D,
AS EXHIBITION VESSELS!

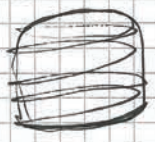
CAMBODIA

HK

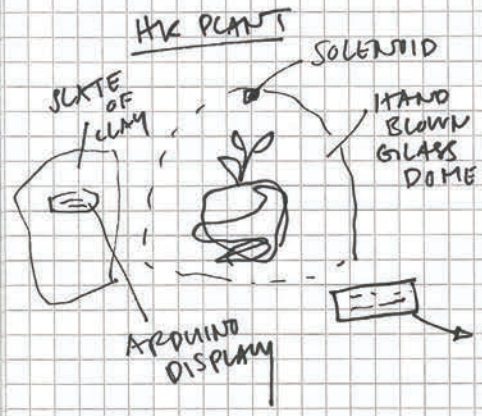
VIETNAM

SWITZERLAND

ZAD?



HK PLANTS



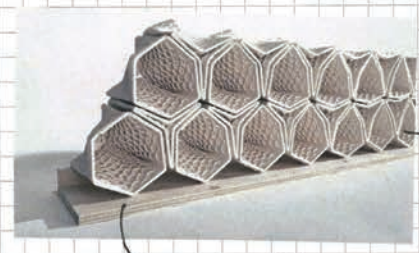
" LAND COURTESY
OF HKSAR GOV,
0,4m², 24'000USD"
TREE 2,50USD

F85.1 Research on exhibition aesthetics

TVS

EXHIBITS

OVER HEAD?



MODULAR CLAY UNITS

MAYBE STILL TOO DESIGNY / EVERY UNIT SHOULD LOOK DIFFERENTLY

INSIDE FILLING/ STRUCTURE

COMBINATION CLAY WITH DIFFERENT OBJECTS/MATERIAL

HAND MADE / BLOWN GLASS AS DOME IF NEEDED

ANYA GALLACCIO

PRINT DIRECTLY ON THE GROUND?

(GRAMAZIO/KOHLER)

STICKING CLAY BITS TOGETHER

tually receiving the soil) was a soil “cube”. Soil would be formed into a 1.5 × 1 × 1 m block. It is still up for consideration if layers of the soil should be reproduced: bedrock, parent material, mineral soil, organic matter (see Schoonover and Crim 2015; Walser et al 2018). The representational quality of the cube has to be evaluated in a small test model to determine if reproducing layers add value to the overall work. The cube will be kept moist everyday by me and will transform and move on its own over the course of the exhibition. On the soil, a synsepalum dulcificum germling from Hong Kong will grow in a chamber that will provide it with the necessary conditions such as low PH water, warmth and humidity. Ideally, a soilKit would be sent to Hong Kong from where it would transmit live data to inform the climate chamber in Switzerland. The reason I focused now only on the s. dulcificum on the soil is to not exhaust the exhibition with too many aspects of the research. Having too much going on and trying to display the whole process poses a chance to fail to do so.

The last iteration was developed upon receiving the soil from Bodmer Ton AG. The two soil types I selected are similar (I avoid the terms "representative" or "symbolic") to the ones in Cambodia (light soil) and Hong Kong (excavated soil), however they are extremely hard to process. After experimenting with "casting" those soils into form, I decided to arrange them as they are. To avoid a "thrown into the room" impression and to meet a certain formal aesthetic, I will arrange the more "sandy" and easier to process soil into a cube, flattened and pressed in form like on a construction site, while the bigger chunks of the other soil will be arranged without processing either on top (though this could convey a wrong message) or next to the soil cube.

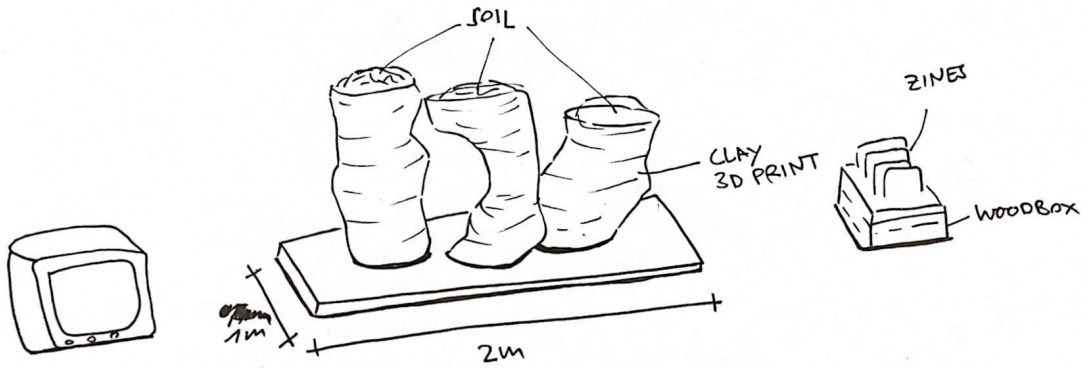
Additionally, the rights of ownership of the work, the soil and the plant should be granted from the ZHdK to me, rendering those notions of ownership to absurdity.

Further sketches in the lab journal in the appendix.

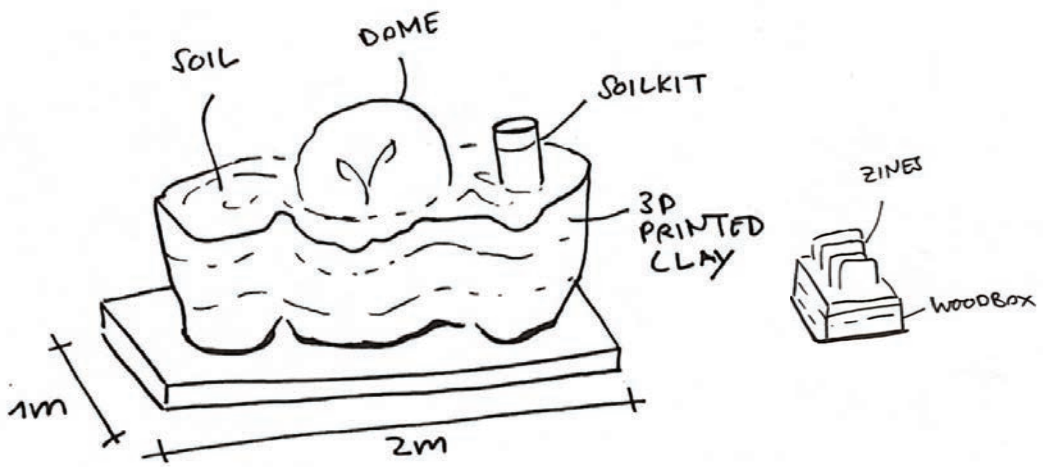
F86 Clay factory tour and soil "scouting"

F87 Soil type 1 poured into shape, considerably changed in its materiality

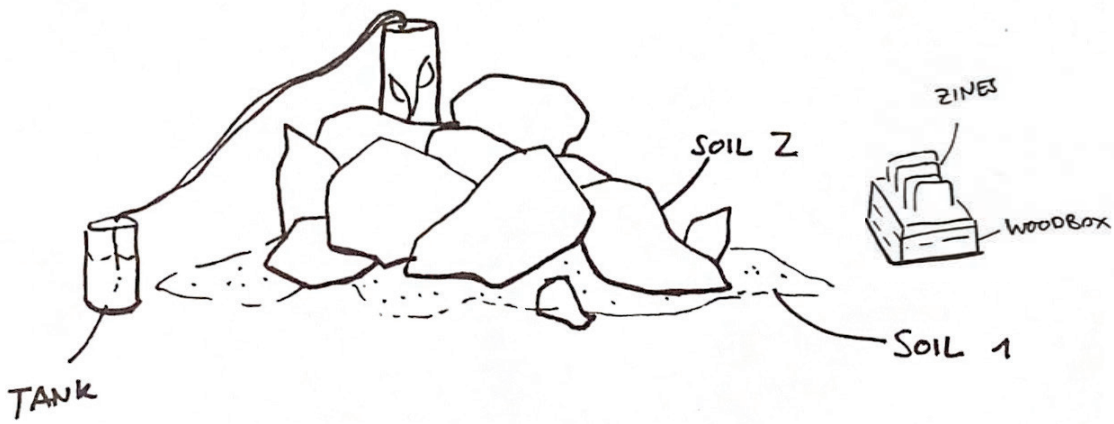
F88 The two soil types in the exhibition space before setting up, prevented from drying out with a damp cloth



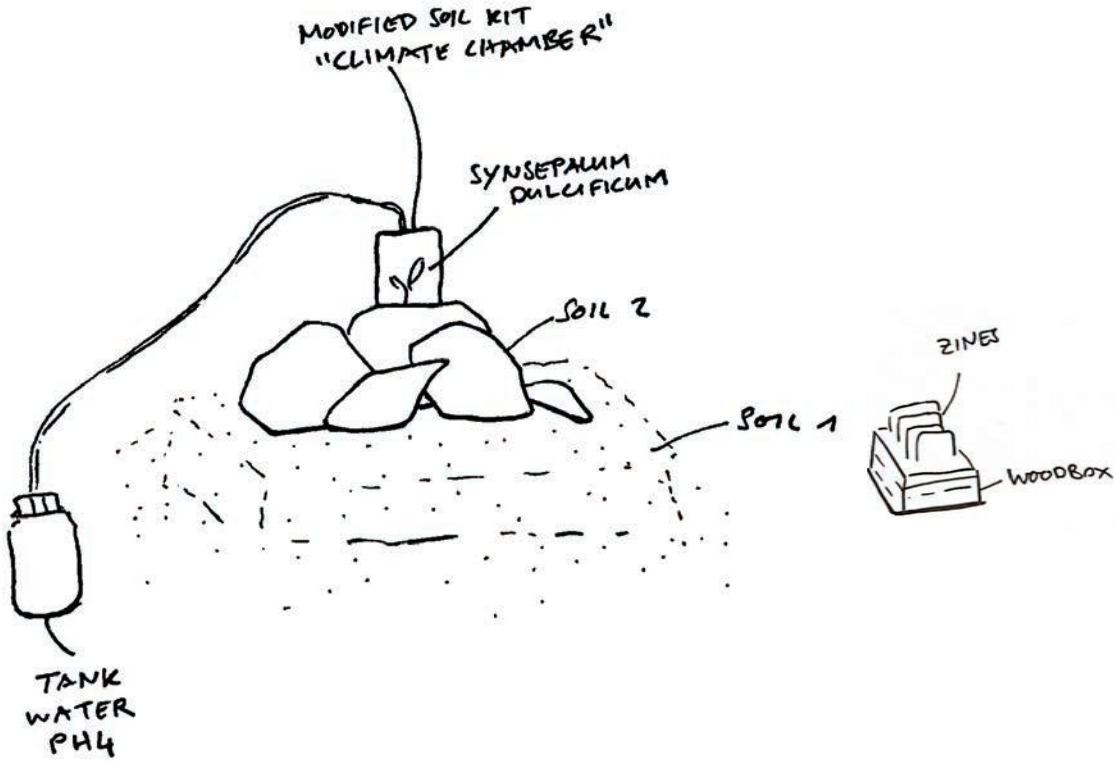
F89 Soil "towers" with TV and zines



F90 Soil "block" with s. dulcificum under a dome



F91 Iteration on the exhibition concept upon receiving the two soil types



F92 Final iteration before setting up

The world is your true body,
say the stars, seen and unseen.

— Li-Young Lee

Conclusion

Design and art are not neutral devices. With our choices and actions we practice politics. Attuning to landscape structures has been an important process in Cambodia and Hong Kong. Through an attunement to our surroundings, we regain our lost habit of "noticing through our own observations of the world in addition to conversations with human interlocutors" (Tsing et al. 2019). History and politics reveal themselves in those landscape structures; structures that are also flowing, not static but always coming into being; they attract our attention and reveal the disturbances capitalism, colonialism and extractivism have caused.

In Wang Chau, visiting, listening and being-with people was essential to the process. Staying there overnight was important to feel embedded in the village (see Miner 2018). Survival exists in many small areas such as Wang Chau and it dares us to imagine otherwise, to discover the logics beyond capitalism. This is "central to most anti-systemic movements and a precondition for resistance to exploitation" (Federici 2019). The creative resistances surrounding the eviction of Wang Chau demonstrated a rich commoning and cultivation of shared responsibility and knowledge. Through these activities collective memories are made and we are taught a sensibility towards our place in this world and the webs of entanglements we find ourselves in. This rearrangement of ourselves afforded a radical disruption of accustomed images and was a forceful demonstration and reminder of the politicality of art and design (see Leung 2016).

WSL and the soilKit

The collaboration with WSL established first connec-

tions between the WSL and the subject area Interaction Design at the ZHdK. It bridged two very different yet similar fields and opened spaces between institutions, which may provide the basis for future collaborations. However, as different as these fields are, the goals of artistic and scientific research overlap regarding the pursuit of inquiry, understanding and making sense of the world around us.

I further developed my work through learning from scientific epistemology and approach to the environment. With scientific methods, applications and field work, I developed the necessary literacy in observing environmental processes (see Tsing et al. 2019). Scientific epistemology might be expanded by dissolving the binary of nature and human culture and understanding the processes of soil through the arts. It is making visible political and cultural aspects in scientific research and showcases that research can be scientific as well as artistic (see Rillig et al. 2021). Through my work at the WSL I contributed to a working mode based on fabulation and demonstrated the validity of artistic research.

The soilKit is sharing knowledge to the masses, democratising scientific tools and enabling citizen the access to low-cost science (DIY and Maker Culture). Bringing tools to the mainstream and bringing science and the arts together fosters a reach and mobilisation at an effective performative and experienceable level.

Regarding Soil

With the ongoing research into soil, I learned about its entanglements with history, politics, human and nonhuman webs. Through this understanding soil too is "inseparable from political protest" (Tsing et al. 2019). The stories of soil teach us about the past but also about how we might continue to live life on this planet. They inspire us to search for other ways to learn about our world and to notice and imagine possibilities of life in those small patches around us (compare Lear 2006; Tsing 2015; Haraway 2018; Tsing et al. 2019). Through attuning to the flows of soil, we investigate the stories that matter and learn from the Other and from other beings without imposing.

Regarding Design

Noticing and attuning to structures are important strategies for design. To attune to structural synchronicity and global biogeochemical processes informs our design process and expands it to the more-than-human (compare Tsing et al. 2019; Franinović and Kirschner 2021). A step I see as an essential addition to a human-centred design approach. Methodology of visiting, listening and being-with (Miner 2018) are complemented with what Donna Haraway (2018) calls knowing-with and knowing-otherwise. This again underpins the importance of opening up to the environment, to fabulise and bring in interaction design's strength of storytelling. Finally, the material's quality of mediation was once again exhibited. Material performativity demonstrates its agency and highlights its role in interactions.

Learnings

Important learnings have been among others not to lose a lightness in the design approach. Not to take things too seriously but to leave space for curiosity and fabulation. Every so often it is favourable not to know every scientific detail, as it leaves open the space to imagine about what could be. Another essential learning has been to be aware of social and ecological interactions and entanglements and to be informed by them. It is important to always reflect and inquire about your actions and the environment you are acting in. Knowledge and models should not be taken for granted but always questioned. Ideas and new knowledge should be tested and discussed immediately to validate and develop them further. Through working at WSL, I learned methods of scientific research and rigour. I learned how to work through (peer-reviewed) papers, how to read, organise and compare them. Finally, I incorporated and expanded all these learnings into my practice within the field of interaction design.

Future Steps

The work is not completed and I will continue to study and embrace different landscapes and how they shape and are shaped by human and more-than-human structures. I hope to be able to work in very different parts of the world and to continue collaborations with science and other disciplines.

ZAD

I planned a trip to the ZAD in France to learn from the communities there and how they produce and live alternatives. After working a month at WSL, I felt the need to engage with activists and artists again. Unfortunately, the pandemic situation and time pressure did not allow a visit. Therefore, I will travel there once circumstances allow.

Pfynwald

The Pfynwald is a WSL research site. It is essentially an old plantation of pines that is dying due to global warming. The WSL is conducting intensive research in this forest, essentially dissecting it to study the ongoing process. As the forest is dying, the pines will probably be supplanted by oak trees as those are more resilient. However, the public does not seem to want an oak tree forest, as this type of forest would be a "scrub" (personal communication with Dr. Ivano Brunner, March 22, 2021). There are different dynamics at play in this forest: the unwillingness to let the forest die and the scientific rigour in dissecting and putting a forest into numbers. Unfortunately, I could not visit the forest and study the processes due to time constraints. Therefore, I hope to visit the Pfynwald in the future.

soilKit

The soilKit combines different qualities that make it novel: low-cost sensors applied for soil respiration, in-device data storage and transmission over Wi-Fi or LoRaWan, ease of transport and production. There are many applications for a device that combines these qualities. Nowadays, soil respiration measurements require expensive devices that are portable yet quite

heavy. These devices do not transmit data wirelessly and cannot be left on-site. The soilKit would allow for a wide and numerous application and could be deployed continuously if a solution is found to aerate the chamber at regular intervals. This is a major advantage, as the soilKit could provide a high-resolution map of soil respiration and microbial activity. Therefore, it would be valuable to develop the soilKit further.

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The title *on souls and soil* references the exhibition *Soil and Stones, Souls and Songs,* shown at Para Site 2017, Hong Kong.

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Cảm ơn.

Safe travels, and may our paths cross again.

duy bui
Zurich, June 2021

My son,
even tomorrow
you will have today. Don't you know?

— Ocean Vuong

IV

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V

Laborjournal Day Bui 2021

31 MARCH

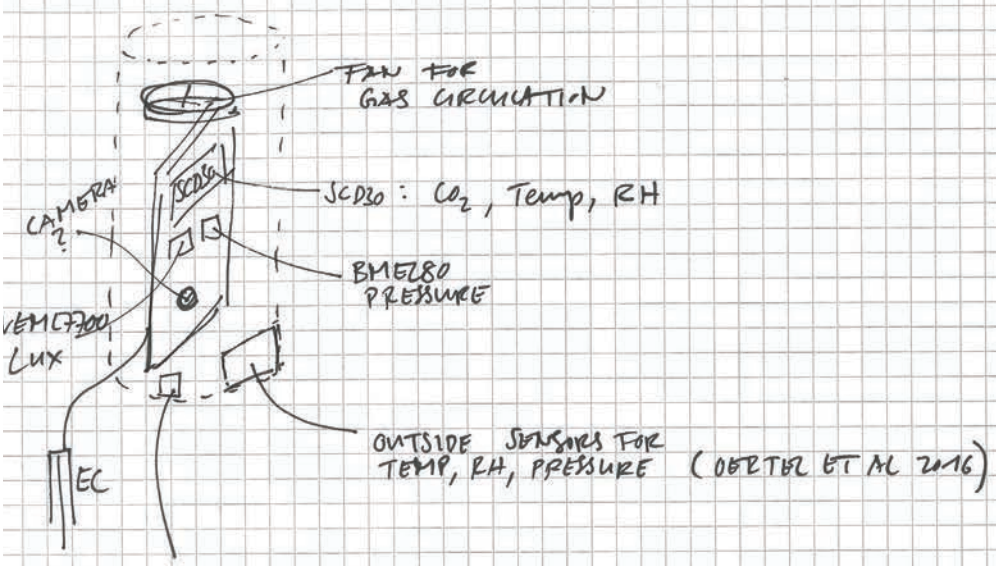
UNDISTURBED SOIL
- LOWER PH
- STRONG MUSTY SMELL

DISTURBED SOIL:
LOWER PH
ALMOST NO SMELL
MORE AND BIGGER CLUMPS

→ SHOULD TRY OUT FROM STH WHERE THERE USED TO BE A TREE (HEAVILY DISTURBED) AND UNDISTURBED SOIL RIGHT NEXT TO IT

CO_2 DATA

DESIGN SKETCHES, SOIL KIT IMPROVEMENT 5 APRIL

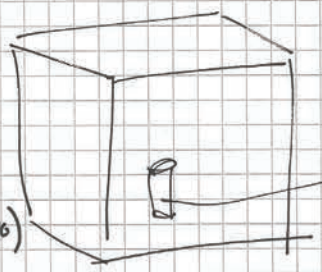


ACCORDING TO OERTEL ET AL, THEY SUGGEST AN ADDITIONAL PAR SENSOR (PHOTOSYNTHETIC ACTIVE RADIATION)
↳ IMPORTANT FOR NET ECOSYSTEM EXCHANGE (NEE)

- CO_2 NEEDS 2-4min FOR ACCUMULATION,
N_2O ~ 30-90min

→ OPEN CHAMBERS FOR CONTINUOUS MEASUREMENT WOULDN'T NEED ACCUMULATION TIME

CLIMATE CHAMBER



SOIL CORE

ALLOWS FOR MEASUREMENT UNDER SEMI-NAT. CONDITIONS (SCHAEFFER ET AL 2016)

→ USED FOR STUDYING EFFECTS OF SINGLE PARAMETERS (TEMP, LIGHT, RH)

→ EXHIBITION: DISTURB SOIL TO THE MAX? SHOWING IRONY OF OVERMEASURING IN SCIENCE

→ PLANT DECAYING OVER COURSE OF EXHIBITION?

SOIL BREATHES

IR MEASUREMENTS OF GHG FROM SPACE

CO_2 flux: $$fCO_2 = \frac{P_0 V_c}{R T_0 A} \cdot \frac{\Delta C}{\Delta t}$$

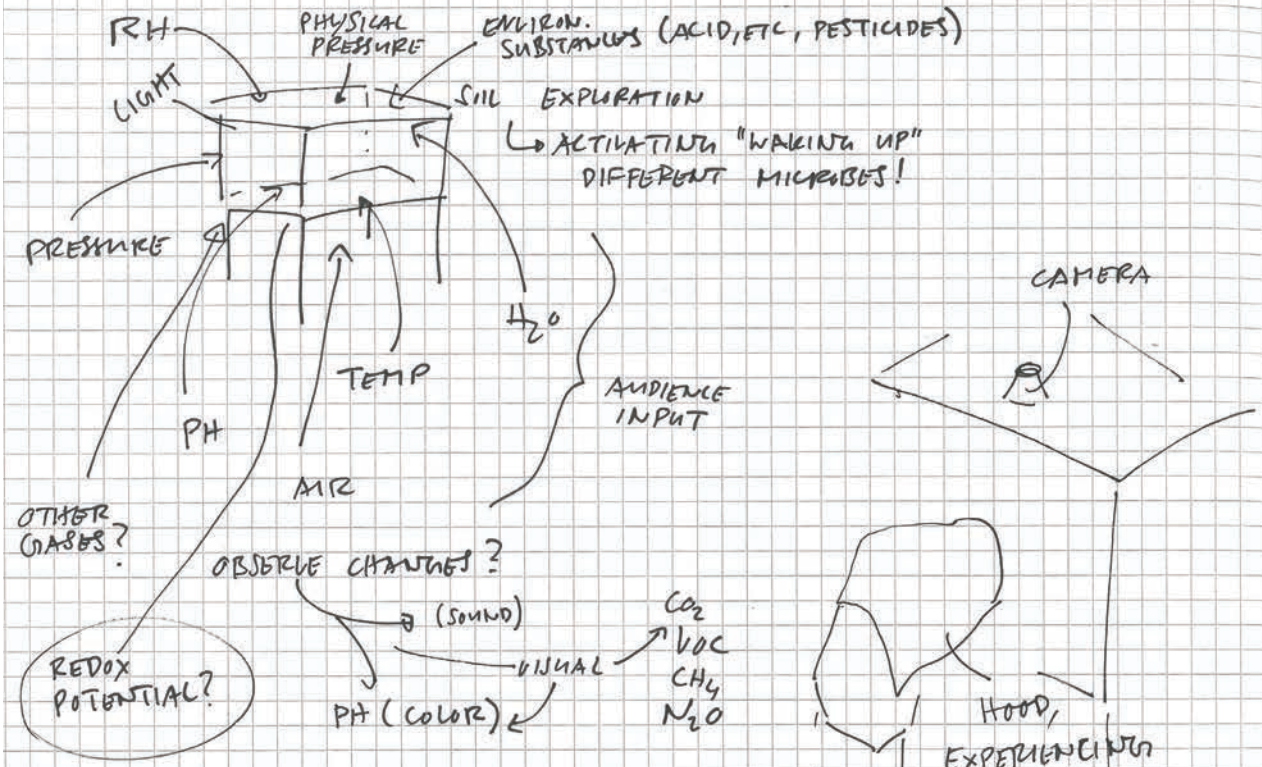
P_0: PRESSURE IN CHAMBER.
V_c: Volume of chamber + tubes, ...)
R: IDEAL GAS LAW CONSTANT $8.314462618153\,24$ $JK^{-1}mol^{-1}$
T_0: AIR TEMP
A: AREA OF EXPOSED SOIL
$\frac{\Delta C}{\Delta t}$: CHANGE OF CO_2 CONCENTRATION ON MOLAR BASIS PER CHANGE IN TIME

OPEN/FLUSH CHAMBER
↳ FURTHER DEVELOPMENT

– CONTINUOUS LOGGING MAY PROVIDE NEW INSIGHTS (JOSHI ET AL 2019)

(FIERER 2017) :- >95% OF MICROBES ARE DORMANT

- IDENTIFY WHICH (ENVIRON.) FACTORS ACTIVATE THOSE IS LIMITED TO CURRENT TOOLS



OBSERVE CHANGES?

(SOUND)

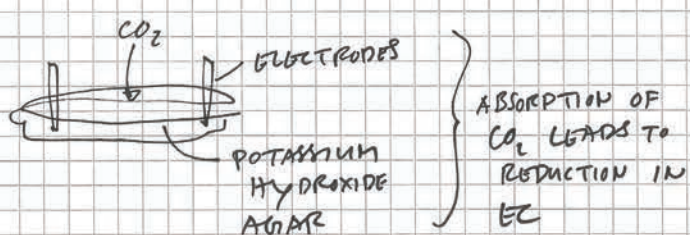
VISUAL → CO_2, VOC, CH_4, N_2O

PH (COLOR)

→ REAL-TIME MONITORING OF MICROBIAL PROCESSES SUCH AS GROWTH, DEATH, NUTRIENT ABSORPTION → METABOLIC ACTIVITY

→ OBSERVING TRUE MICROBIAL RESPONSE

(REICHART ET AL 2007)



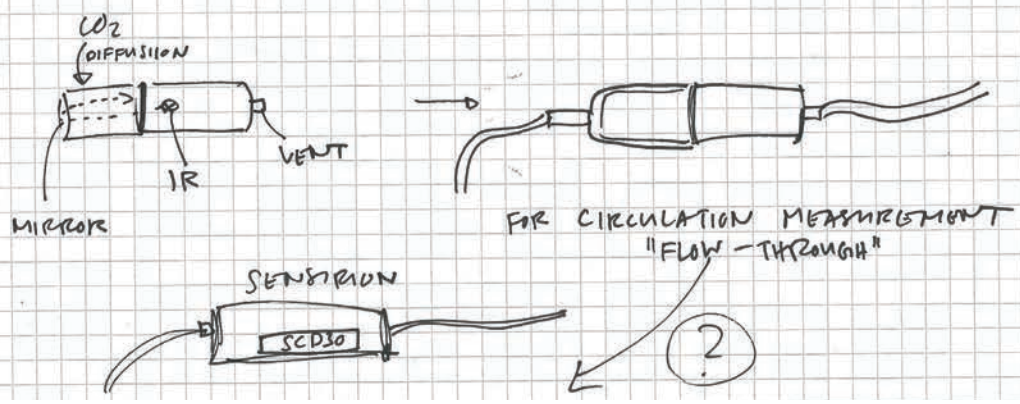
EXPERIMENTS WEEK 2, 5 APRIL

- INFLUENCE OF SUBSTANCES ON SOIL MICROBIAL ACTIVITY
  - → PESTICIDES
  - → WATER (SUBMERGED SOIL, DEIONISED WATER → OSMOTICAL STRESS?
  - → COMPRESSION
  - → GLUCOSE
  - → FERTILIZER
  - → WASTE (BEER, TEA,
  - → SALTS
- STERILISED SOIL / + H_2O / + GLUCOSE (RECOLONISATION)

ZOOM ROMAN 6 APRIL

- WEED — PLANT — HUMAN RELATIONSHIP
  - → NOTION OF JUDGEMENT AND MANAGEMENT
  - FIRST AID
- LINDE — CITY → CITY AS FERTILISER
  - CO_2, N
  - → ROOTS THROUGH ASPHALT INTO CANALISATION

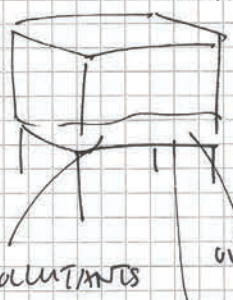
VAISALA (GMP343)



17 APRIL

"TERRARIUM" → DURATIONAL EXHIBITION, SOIL ~~FUNGI~~ CHANGES THROUGH "MISTREATMENT"

INDUCING + OBSERVING EFFECTS OF SOIL MALTREATMENT



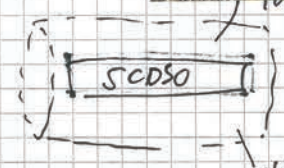
POLLUTANTS

OVERNOURISHMENT

BREAKING DOWN POM

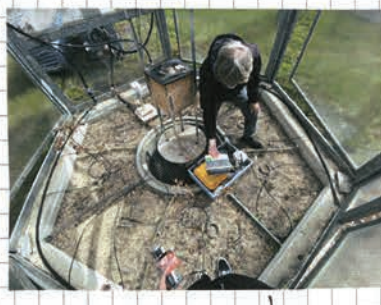
DECENTLAB SOIL MOISTURE

BUILT YOUR OWN?



SILICA TUBE?

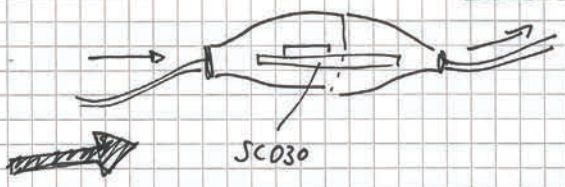
LORAWAN

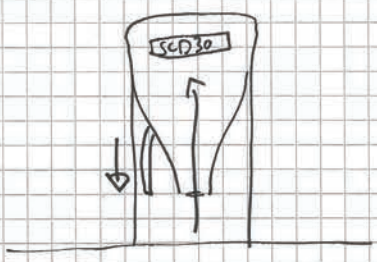


CLIMATE CHAMBER: WARMTH + DROUGHT

CHAMBER (PET)

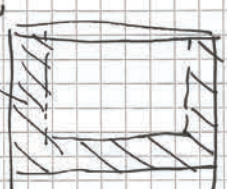
2× PET

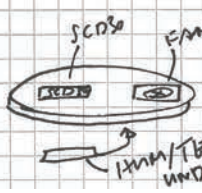




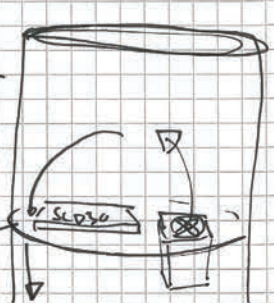
PREVENT HARSH TEMP SHIFTS

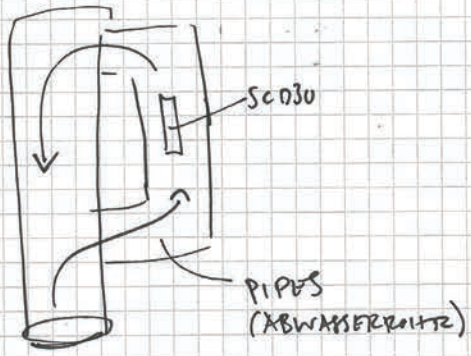
TEMP INSULATION FOR SCD30



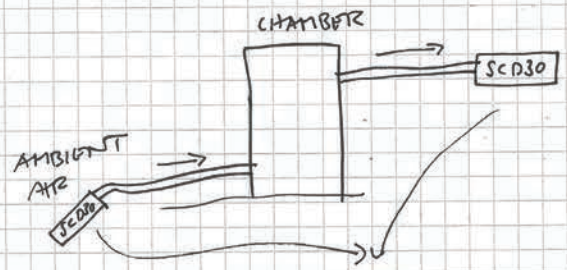


LIGHT/TEMP UNDER-NEATH





OPEN CHAMBER DESIGN



COMPARING CHANGES BETWEEN INTAKE AND OUTTAKE

→ ADVANTAGE
- INEXPENSIVE
- SIMPLE

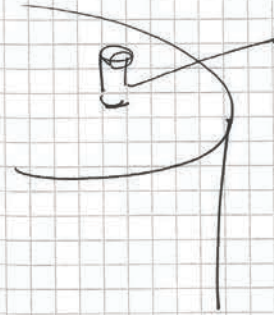
→ DISADVANTAGE
- 2x SCD30 ∴ (IN SYNC)
- DIFFICULT NOT TO CREATE PRESSURE DIFFERENTIAL
- FLOW METER REQUIRED

CLOSED CHAMBER DESIGN

→ DISADVANTAGE
- TRACK CHAMBER/ATM. PRESSURE
  → BUILTS UP OVER TIME

REQUIREMENTS
- GOOD GAS MIXING
- NO DISTURBANCE SOIL MOISTURE OR TEMP
- PRESSURE CHAMBER/ATM. IN EQUILIBRIUM

USE
- PUT CHAMBER DOWN SLOWLY TO NOT DISTURB GASES OR PRESSURE

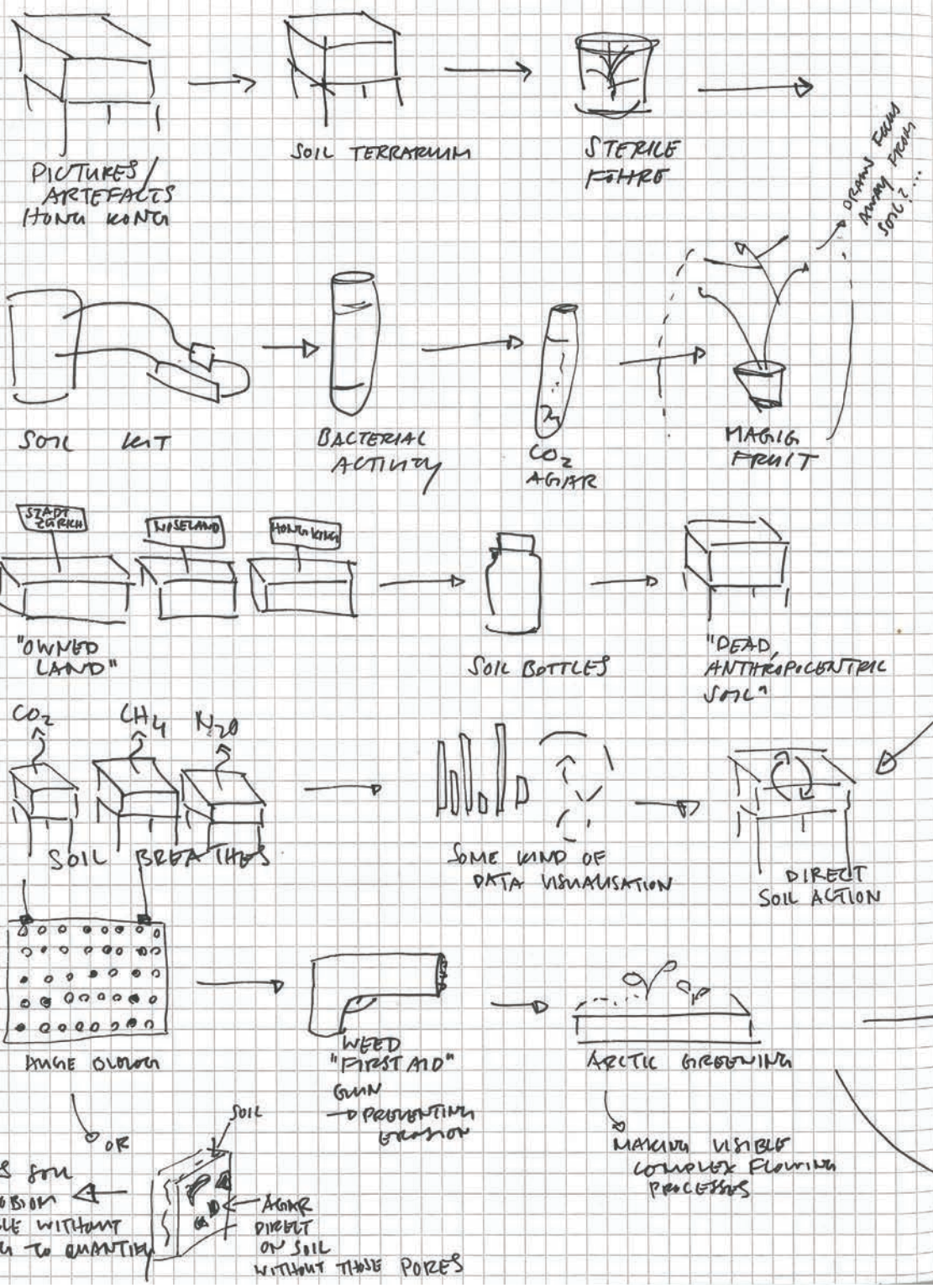


LICOR: BERNOULLI EFFEKT

FRIDAY 5 APRIL

SEQUENCED EXHIBITION? JOURNEYS THROUGH SOIL

EMBRACING SOIL FLOWS



ASK ROSE, CAIS, HARRISON TO SEND ME SEEDS OF THEIR FAVOURITE PLANT

↳ BUT WOULD PRAM FALLS AWAY FROM SOIL..

FIELD STUDY

PUBLIC SOIL ACTION?

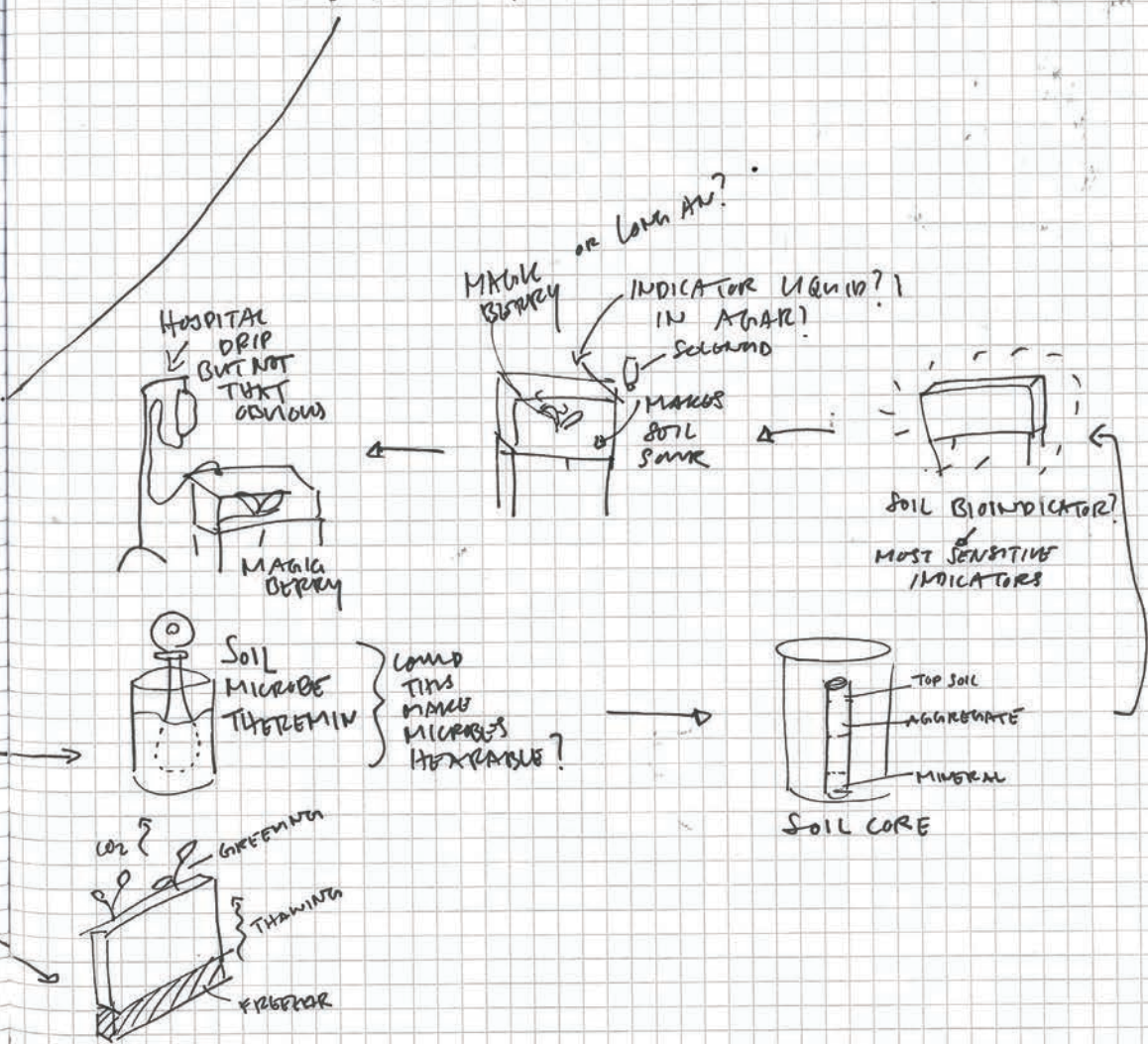
MAKE PEOPLE AWARES OF SOIL?

↳ DO I EVEN CARE ABOUT PEOPLE?.....

DIRECT ACTION

↳ NOT AMIDINES, BUT SOIL!

→ DISPLAY HOW SOIL ACTS DURING EXHIBITION



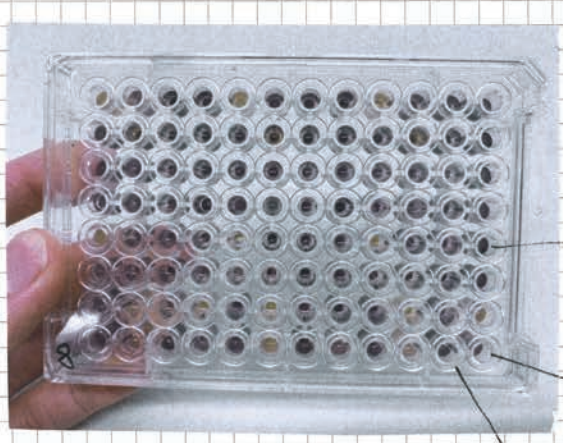
MATHIAS MAYER'S
CO_2 CHAMBER
FOR NET ECOSYSTEM
EXCHANGE MEASUREMENT
→ CO_2 SINKS (PHOTOSYNTHESIS)
— LICOR

FAN

INTAKE TUBE

STERILE BABY TREE

(SINCE WINTER 2020)



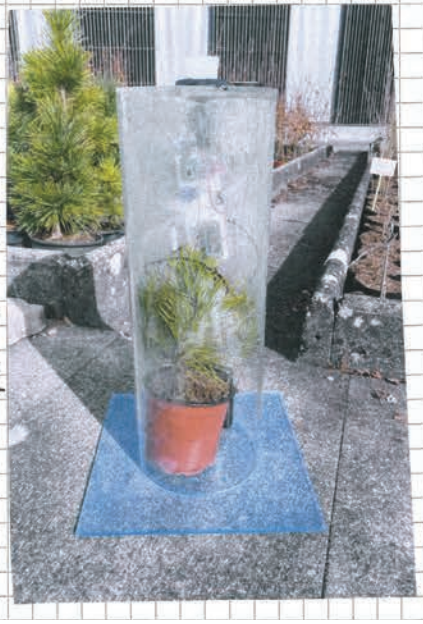
— ISOLATED BACTERIA
IN SUSPENSION

— SOLUTIONS
(GLUCOSE, ETC)

BIOLOG MICROTITER SYSTEM

COLOURING
INDICATES BACTERIAL
ACTIVITY

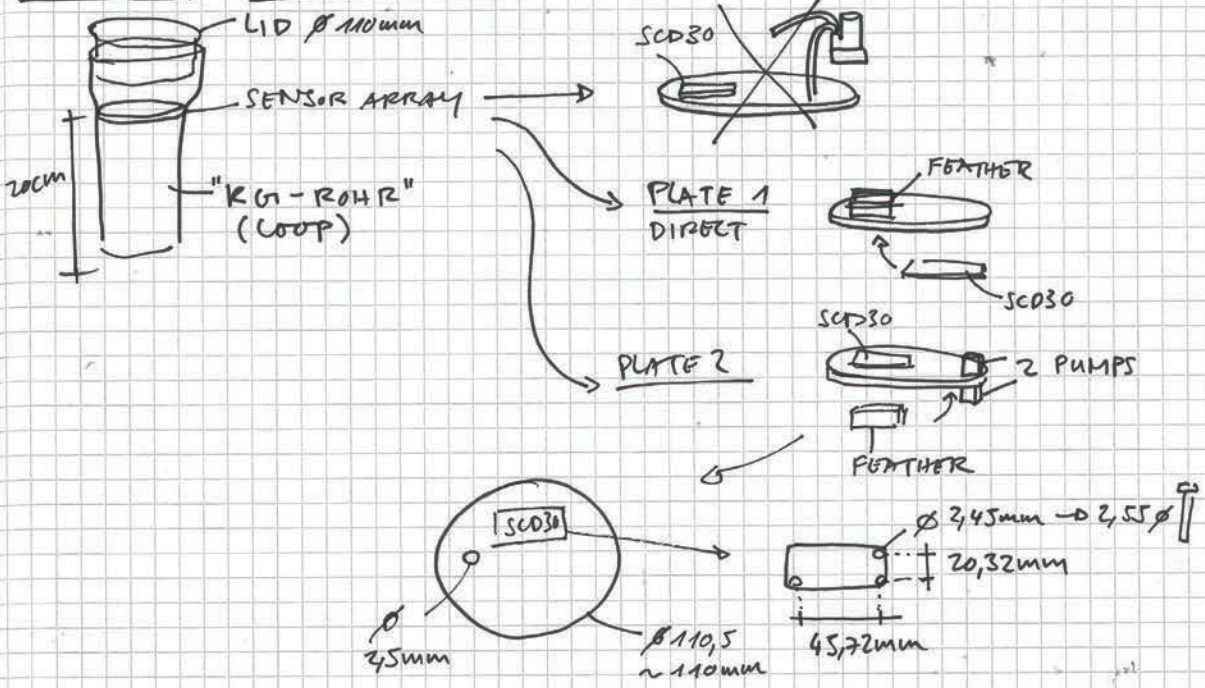
→ CO_2 IS RESPIRED
(NO PHOTOSYNTHESIS)



QUICK
TRYOUT
(23 MARCH)

→ HUMIDITY
AND DIRECT
SUN ARE
COMPROMISING
SENSOR FUN-
CTION

12 APRIL : DESIGN CHAMBER #2



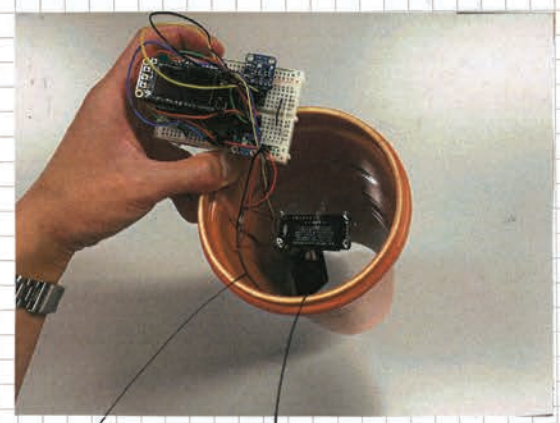
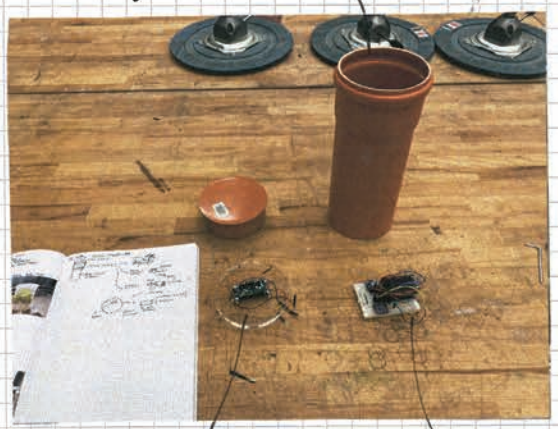


PLATE COULD BE REVERSIBLE → QUICKLY DE-COUPLE SENSOR FROM CHAMBER

FAN



MACHE FRUIT, SYNSEPALUM DULCIFICUM

→ OFTEN FOUND IN WAMPU CHAM

13 APRIL

LIQUID INDICATOR

EXPOSED TO CO_2

MICROTITER

TUBES

AGAR CHUNKS

PLATES

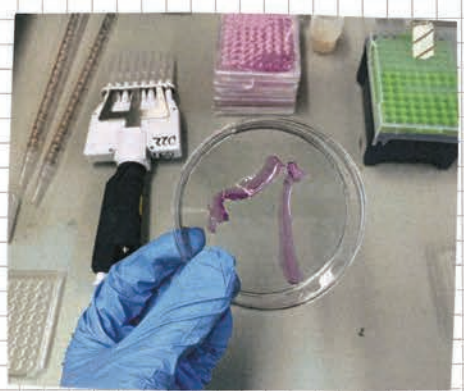
FOR 1000 ml :

- 18,75 mg CRESOL RED → USE OTHER INDICATOR? PHENOLROT?
- 16,77 g KCl
- 0,315 g $NaHCO_3$

→ IN 3% AGAR → ADD GLUCOSE TO KEEP MOIST AND INHIBIT BACTERIA GROWTH

1:2 (AGAR/INDICATOR)

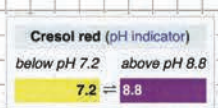
RETURNS TO INITIAL STATE



BREATHING

DROP OF BASE (INCREASE PH)

→ ESSENTIALLY ABSORPTION / EMISSION OF CO_2 CHANGES PH



SCALABLE:
REACTS TO HUMAN BREATH AS WELL AS MICROBE BREATH!

15 APRIL

12 APRIL

3h

48h

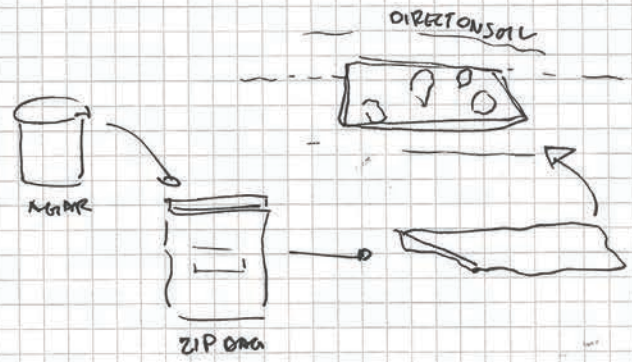
↳ INDICATOR GEL RETURNING BACK TO PINK AFTER OPENING THE SYSTEM

19 APRIL

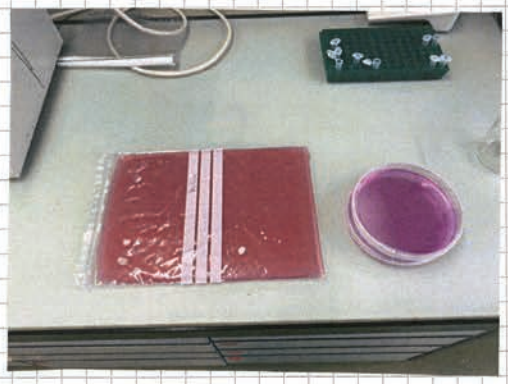
6h

→ SAME SOIL (BENEATH GRASS)

HERE NOT VISIBLE, BUT SLIGHT GRADIENT VISIBLE



20 APRIL

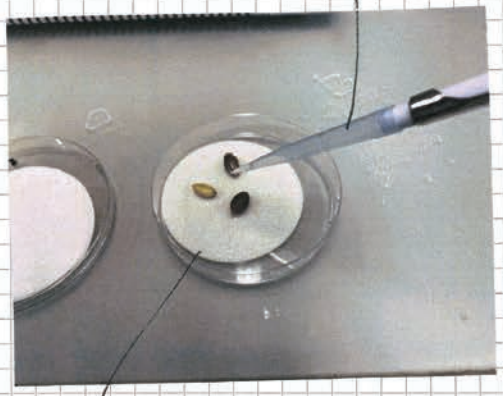


150ml AGAR
300ml INDICATOR

AGAR FLAP WITH SPOTS WITH GLUCOSE

2 PLATES
→ 1 CONTROL
1 WITH GLUCOSE

PH 4 SOLUTION



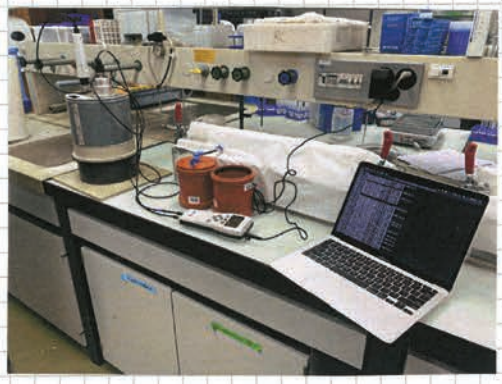
FILTER PAPER

PH 2 (23 APRIL)

BRINGING PH OF dH_2O DOWN TO 4 WITH KOMBUCHA

SYNSEPALUM DULCIFICUM

CARE PACKAGE



→ COMPARING CURVES WITH VANJALA

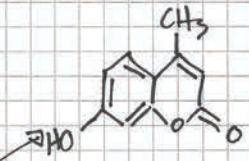
INITIAL INSIGHT: SURPRISINGLY CLOSE VALUES AND CURVES!

EMPAIR REACTING TOO SLOWLY

TO DO 22 APRIL

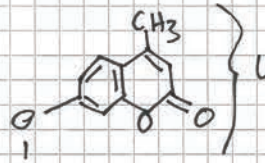
- [x] PLANTING NEW MAGIC BERRIES
- [x] SONIA → GLOWING SOIL!
- [ ] BUILDING MINIATURE EXHIBITS
- [x] RED CABBAGE → TAKE HOME dH_2O, COFFEE FILTER

1kg RED CABBAGE
1l dH_2O
→ COOK FOR 30 MIN,
STRAIN + SIMMER TO REDUCE
TO 100 ml

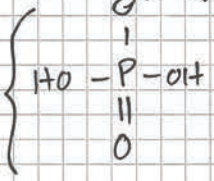


4-METHYLUMBELLIFERONE (GLOWING COMPOUND)

→ SONIA USES 4-METHYLUMBELLIFERYL PHOSPHAT



LUMINESCENT GROUP



PHOSPHAT GROUP, ENZYME CUTS THIS AWAY

→ MANY MORE CHEMICALS WITH GLOWING AND ENZYME GROUP

23 APRIL RED CABBAGE PH TRYS

1000µl dH_2O
20µl Anthocyanine (pure)

(COLOUR EFFECT COULD BE MORE PRONOUNCED WITH 40µl)

→ 4 COLOUR STAGES ACHIEVED THROUGH ADDING KOH (1 molar)

VIOLET → BLUE → GREEN → YELLOW

PH 6/7 8 10 12+

→ EVERY COLOUR ACHIEVED THROUG ADDING EITHER KOH (BASE) OR HCl (ACID)

KCl + $NaHCO_3$ SOLUTION WITH 6% ANTHOCYANIN

CONTROL

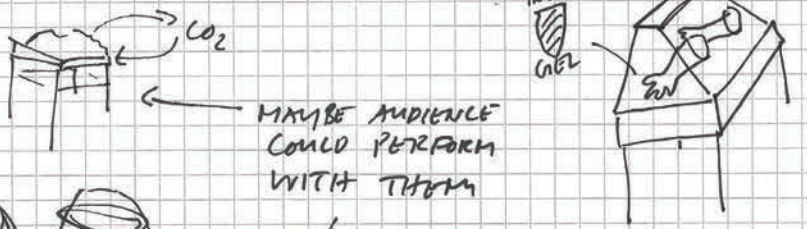
WITH CO_2

→ SPECTRUM IS TOO BROAD, THUS NO SUDDEN COLOR CHANGE BUT MORE A VERY SOFT GRADIENT..

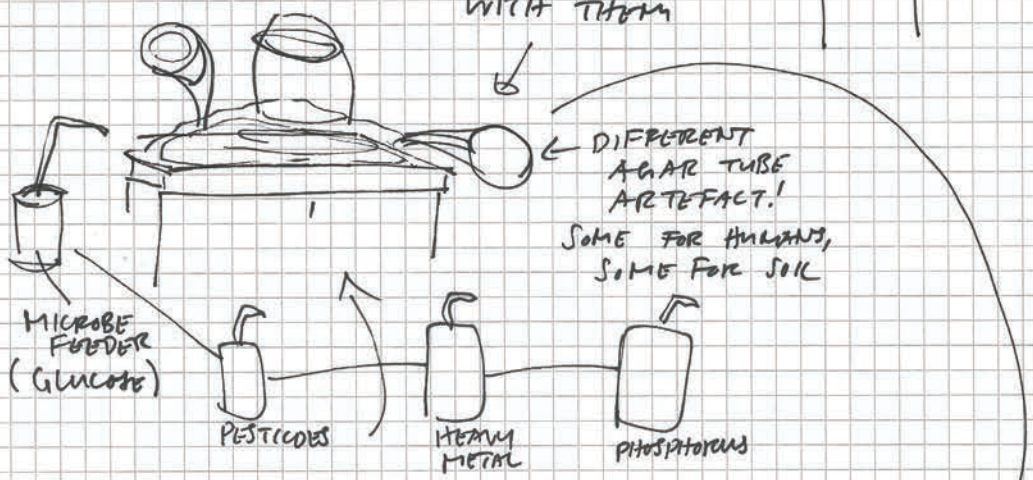
→ BUFFERING WITH HCl/KOH IS NOT HARMLESS EITHER

THOUGHTS ON EXHIBITION 26 APRIL

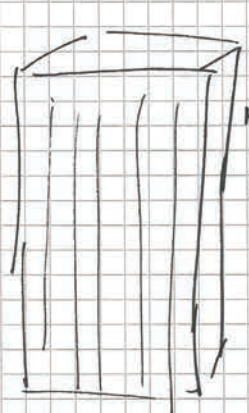
- MICROBES OFTEN PUT BEHIND GLASS FOR SAFETY
  → DESIGN OPEN SYSTEMS



MAYBE AUDIENCE COULD PERFORM WITH THEM



HOW CAN AUDIENCE LEVERAGE SOIL?
EXPERIENCE THEIR IMMERSION INTO ECOSYSTEMS?
PROBING THE CONSEQUENCE ~~THE~~ OF THEIR INTERVENTION
HOW CAN THEY INTERACT WITH MICROBES



MAYBE COULD BE CABIN TO MAKE AUDIENCE IMMERSE TOTALLY

CREATE OBJECTS AND USE THEM IN FOREST
↳ EXHIBITION IS JUST A SMALL REPRESENTATION

RADICALLY RETHINK CATEGORIES!

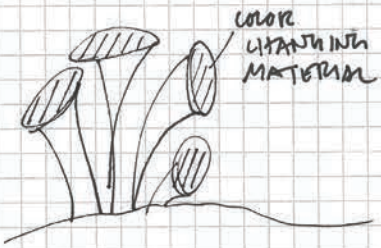
VISITING PFYNWALD

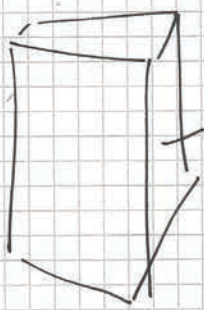
ARCTIC GREENING, ERUPTION OF METABOLIC PROCESSES

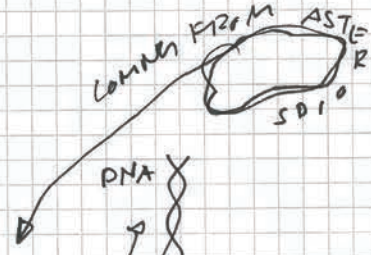
FABULIZE MIRE, MAYBE WRITE A SCI FI NOVEL?

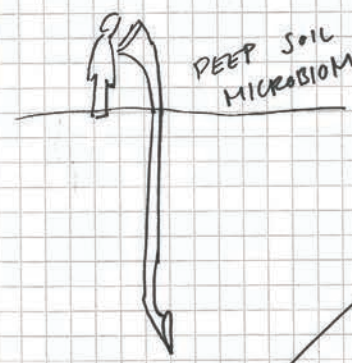
WAS MY WORK ACTUALLY FACILITATING DIALOGUE WITH SCIENTISTS?

SOLICIT / MATERIAL AS CONVERSATION DEVICES

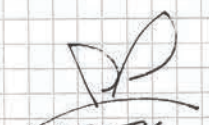








Slowest cycles on EARTH

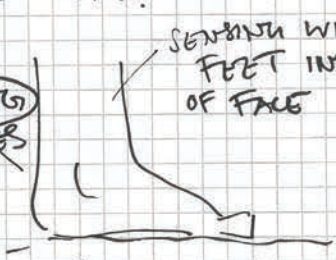


PUBLIC ACTION → STICK IT EVERYWHERE

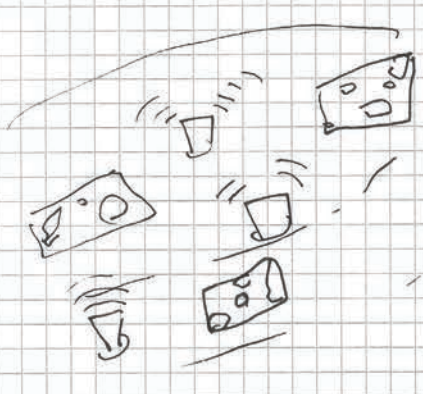
PFYLLWALD
- FEEL PROCESS OF DECAY
- IS IT ULTIMATELY A BAD THING

OR GROWING PROCESSES

SOIL THEREMIN



FEELING THEM UNDER YOUR FEET, DIFFERENT BACTERIA DIFFERENT SOUNDSCAPE



ALWAYS CHANGING MICROBIAL LANDSCAPE, MAKE VISIBLE THROUGH MATERIAL AND SOUND

EARTH PROCESS ACCELERATOR → SUGAR, MAKING SOIL PROCESSES FASTER AND EXPERIENCABLE → ALMOST LIKE A BIOREACTOR

27 APRIL

SOIL RESP DATA → FROM EACH PLACE ↓ TRANSLATE INTO 3D, AS EXHIBITION VESSELS!

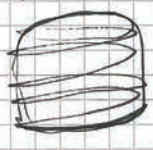
CAMBODIA

HK

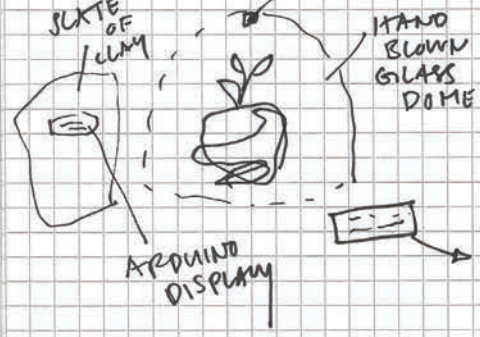
VIETNAM

SWITZERLAND

ZAD?



HK PLANT



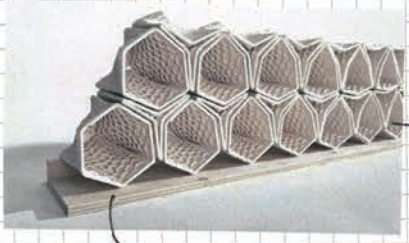
" LAND COURTESY OF HKSAR GOV, 0,4m², 24'000USD"

TREE 2,50USD

TV'S

EXHIBITS

OVER HEAD?



MODULAR CLAY UNITS

MAYBE STILL TOO DESIGNY / EVERY UNIT SHOULD LOOK DIFFERENTLY

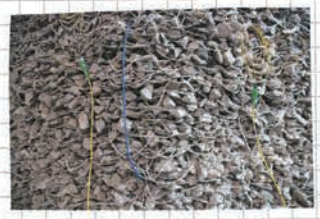
INSIDE FILLING/ STRUCTURE

COMBINATION CLAY WITH DIFFERENT OBJECTS/MATERIAL

ANYA GALLACCIO

PRINT DIRECTLY ON THE GROUND?

HAND MADE / BLOWN GLASS AS DOME IF NEEDED



(GRAMAZIO/KOHLER)

→ STICKING CLAY BITS TOGETHER

(GI/K)

POURING CLAY?

GRAMAZIO/KOHLER,
SHAPING CLAY BLOCK

→ MAKE OWN CLAY
FROM SOIL FROM
CAMBODIA / VIETNAM / HONG KONG / CH / ZAD

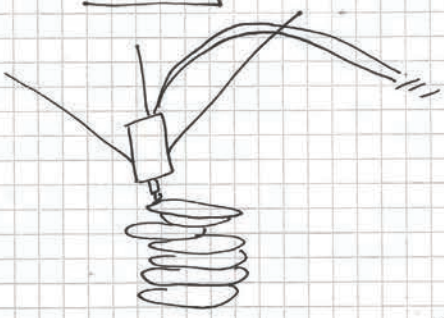
RobotSculptor: Artist-Directed Robotic Sculpting of Clay

(ZHAO MA, GRAMAZIO KOHLER)

28 APRIL

- CLAY AS REPRESENTATION OF ABSENCE
  - linked to destruction / absence of object,
    only coming into existence through demolition of spaces
    (RACHEL WHITEREAD ARTIST)
  - PLANT SEED | AS REPRESENTATION OF ABSENT MOTHER TREE!
  - RADICALLY RETHINKING ALL CATEGORIES ... AND SOIL!

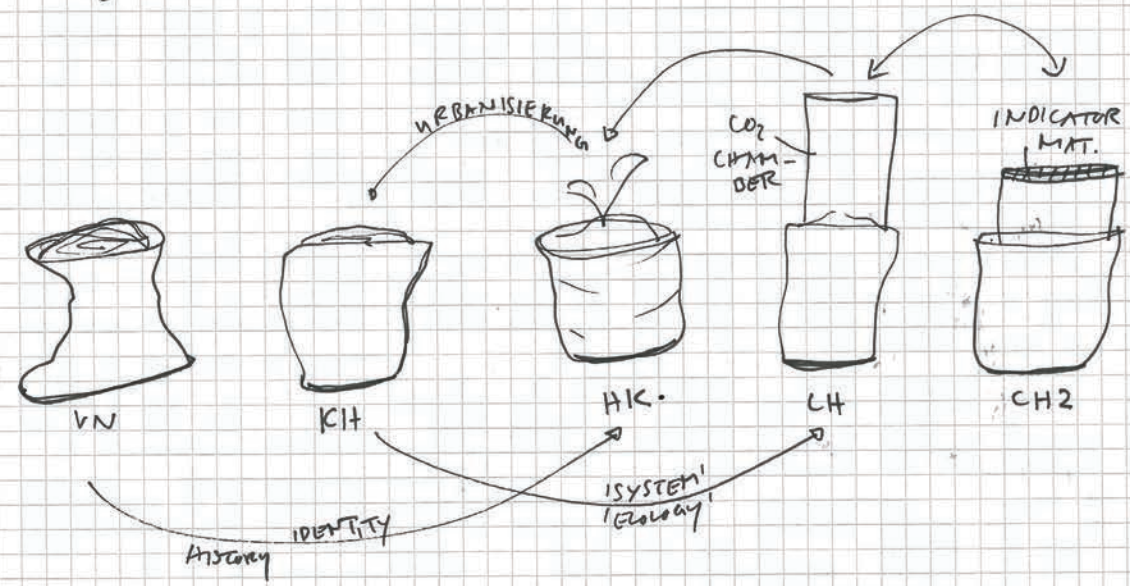
3D ARYL



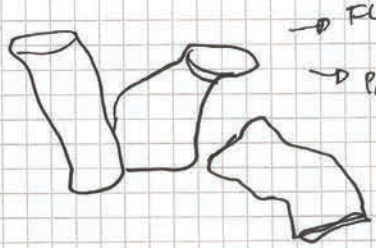
LIVE PRINTING ACCORDING TO CO_2 DATA?

OR PLANT DATA?

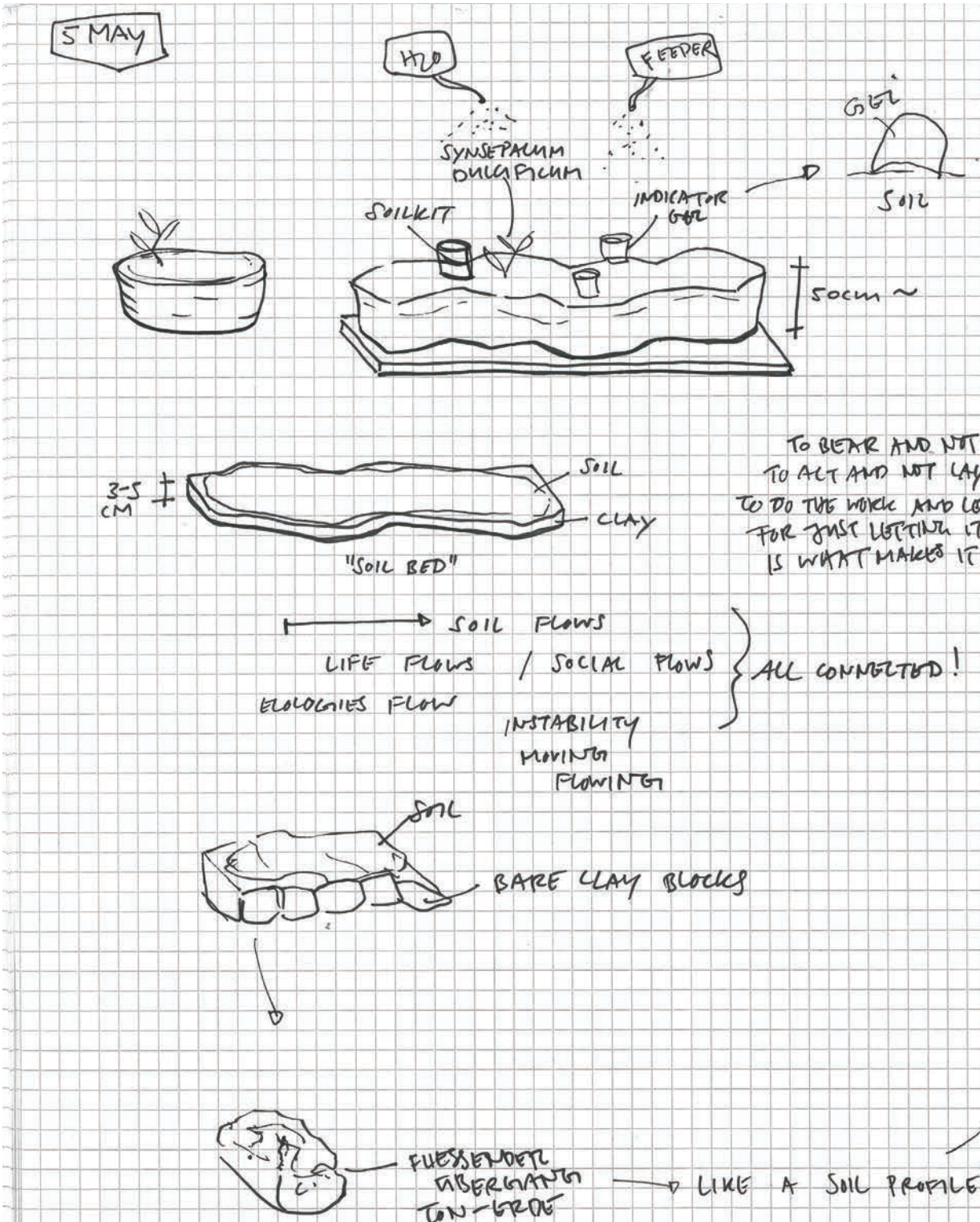
INSTRUMENTALISING?

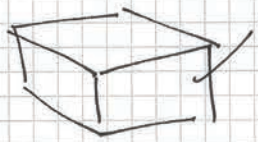


- HOW TO INTERCONNECT THEM
- HOW TO INTERACT WITH THEM? SHOULD you?

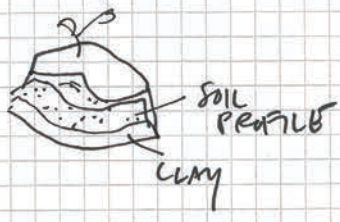


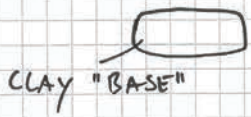
- FLOWING!
- PROGRAMMED/ PLANNED DESTRUCTION


5 MAY
H2O
FEEDER
SYNSEPALUM DULCIFICUM
SOILKIT
INDICATOR GEL
GEL
SOIL
50cm ~
3-5 CM
SOIL
CLAY
"SOIL BED"
TO BEAR AND NOT TO OW
TO ACT AND NOT LAY CLAI
TO DO THE WORK AND LET IT
FOR JUST LETTING IT GO
IS WHAT MAKES IT STA
SOIL FLOWS
LIFE FLOWS / SOCIAL FLOWS
ECOLOGIES FLOW
ALL CONNECTED!
INSTABILITY
MOVING
FLOWING
SOIL
BARE CLAY BLOCKS
FLUSSENDE
ÜBERGANG
TON-ERDE
LIKE A SOIL PROFILE!



LIFT

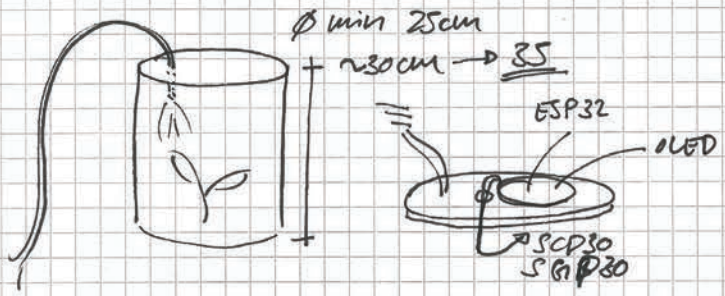


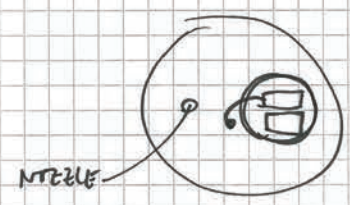


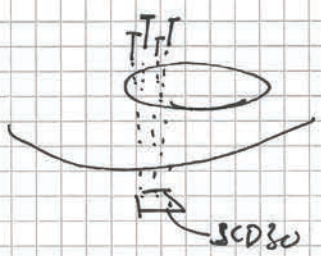
silk screen layer (solder mask)
copper layer
↳ do not cover to expose footprint

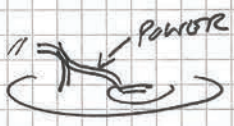
18 MAY

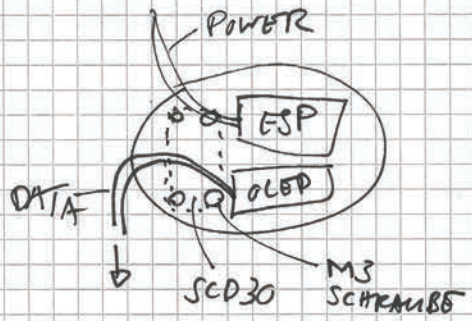
S. DULCIFICUM LIFE SUPPORT





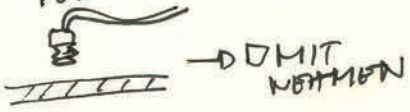




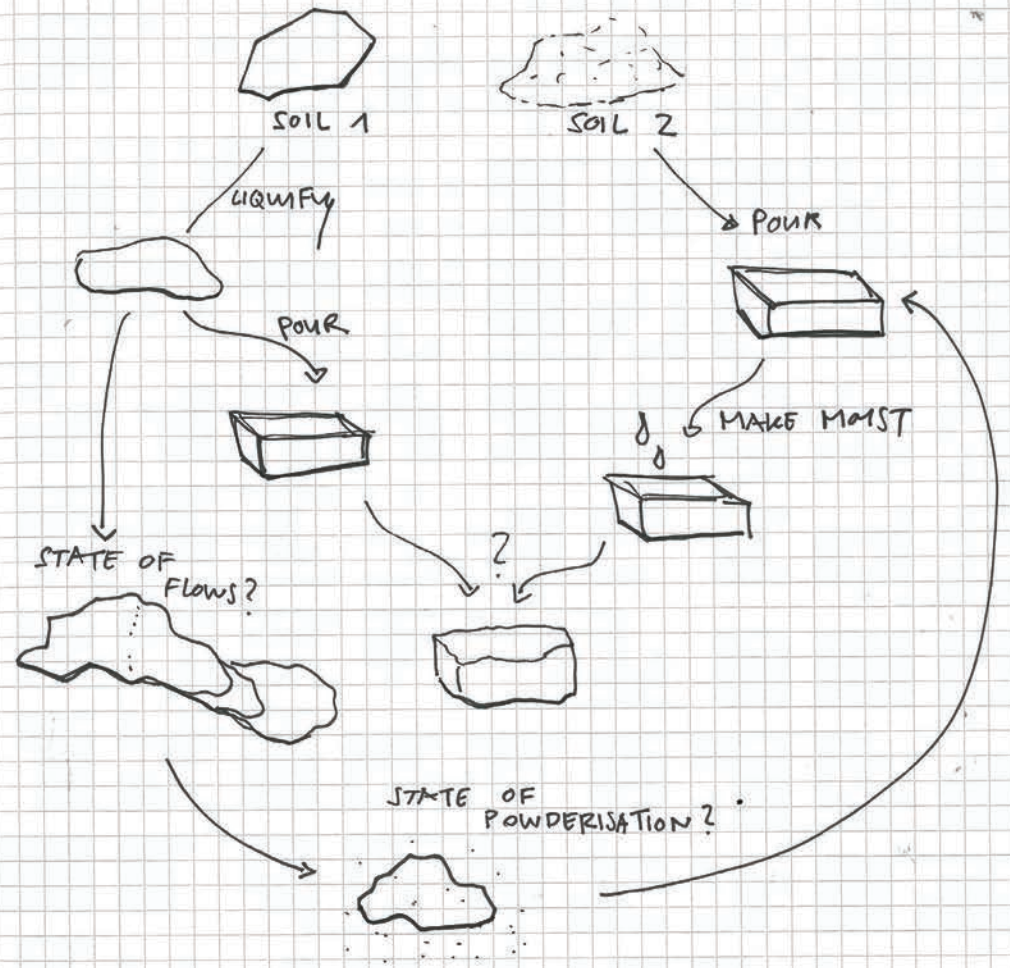


- MATERIAL INTERVIEW:
  - ☐ IND. GIEL
  - ☐ SOILKIT

- WIE IST DÜSE IN DECKEL VERSCHRAUBT?



22 MAY | SOIL EXPERIMENTS



→ USE TO DETERMINE WATER AMOUNT

CAMBODIA HONG KONG SWITZERLAND

WSL Diary

2021-03-12

At half past one in the morning, I wrote Ivano Brunner, head of research unit forest soils and biogeochemistry, an email. I asked him if I could get an insight into the labs and research activities of the Swiss Federal Institute for Forest, Snow and Landscape Research WSL, one of the four federal research institutes in Switzerland. A few hours later, at 8 in the morning, he invited me to visit the institute, with detailed descriptions on how to get there.

At WSL, Ivano invited me into his office and we had an exchange for about two hours. In the beginning, he was extremely sceptical, which he not only mentioned but which one could see in his closed body language. He didn't know to what extend design is concerning the WSL or himself, as design is "giving form to cars". I introduced him quickly to the field of interaction design and gave him concrete examples (the ones I always give, websites and apps...), but I also mentioned how interaction design is now tapping into many fields. We talked briefly about biodesign (leather from fungi, baumaterial, material of renewable sustainable biological sources).

Then I explained him the backstory of my research. I told him about my travels in Cambodia, Hong Kong and my engagement in Wang Chau. From these experiences, I started to connect the struggle for land with many other topics, such as colonialism, extractivism, capitalism and identity. I mentioned that I recently learned about the strain of aedes aegypti mosquito, that evolved in America through the combination of the Mediterranean (preference of living in human made waters) and the African strain (carrying yellow fever). Together with the destruction of landscapes through imported herdes and the exposure of swamps, this new mosquito strain caused a massive endemic. Ivano seemed less impressed by this, as it is "simply evolution" for him. I was surprised that he wasn't as fascinated as I was by those strings of events, the emergence of human cultivated organisms and botanical and zoological imperialism. For him, it seemed like inevitable courses of nature.

We discussed the term ‘multispecies’ and how I looked into how humans could collaborate and learn more from the species that they share Earth with. Through these mutual understandings, new forms of cultivation could emerge, where we collective build habitats where every species thrive. This was especially interesting for the field of design and the question what it means if design drifts away from a human-centred appraoch to a multispecies approach. Ivano responded that it is always about humans in the end, also what they do. When they try to preserve landscapes and the forests, it is for the human. The second priority might be the preservation of biodiversity and the ecosystem, but the main motivation is always to serve humans through those actions. As humans are cruel and will destroy everything, the only thing to counter this are laws and policies. But they could protect and research all they want, if everyone else continues to burn fossile fuel, it will be in vain. I was surprised by how sharply and to some extend passionately he describes those issues, but at the same time to tolerate them stoically and wait for a top-down approach through governments. (And to fail to see that animal farming is the biggest source climate change through greenhouse gases and land destruction).

Our discussion quickly revolved about zoos and botanical gardens. How cruel and useless zoos are except for one point: education. And how interesting it might be, if the plants in those botanical gardens could oppose their captivity and displacement. One term that caught his interest was ‘preferable/speculative futures’. I explained to him that it is not about the near or far future, but more about imagining alternatives that may unfold in present time, perhaps in a different world. And that this may stimulate and broaden people’s thinking about an issue, leading to a bottom-up approach to tackle those issues.

Ivano was critical towards ZHdK, as we are not a institution of science (Wissenschaftsstätte), as we are not or only a little publishing peer-reviewed articles, and that artists are not scientists anyway. At that time, I did not know how to respond, but now thinking about it I may argue that artistic research is as valid as scientific reseasrch in creating knowledge. And during the course of my stay at WSL, I should discover that the research

is not all that different, as both scientists and artists try to make sense of the worlds we find ourselves in.

So for my research, I was interested to see how they work, what research they are currently conducting and to see their labs. He immediately offered that I could accompany Oliver Schramm on one of his probe collecting tours in one of their research sites LWF (Langfristige Waldökosystemforschung). I could see how they collect probes like rain water, leafs, soil water, ..., to monitor all nutrient cycles and compare them with each other. All those probes then go to the lab, where PH and conductivity is measured. The central lab does measurements of calcium, nitrogen, magnesium to see the cycle of every substance. The leafs and branches that are collected (through falling into baskets or collecting fresh leafs from treetops) are sorted, dried, measured and drawn.

All this data goes into a database and eventually to the government. He wasn't so clear about what exactly is done with the data except future models and early warning systems (drought for example). "Es wird so viel Schrott gemacht (mit den Daten) ..." The forest research originated in times of forest declines when there was a need to understand nutrient cycles and the workings of forests in general more.

There are over 100 types of soil in Switzerland. Soil is a reservoir of nutrients and plant take roots. In Switzerland it is one of the biggest carbon reservoirs and we have to keep this carbon in the soil. With climate change, this carbon will mineralise (?) and will go into atmosphere as CO2. So the trees should bind CO2 and store carbon long time in forest soil. Therefor, we have to build up the humus but they don't know all the factors so well. Will the humus build up or are we losing it? 1gr soil has the biggest biodiversity of all of Switzerland. Forest soil in Switzerland is over 20'000 years old and developed since the last ice age. When the ice age ended and glaciers withdrew, slowly the vegetation came back and then the first forests and so the soil has begun to develop. Soil organisms convert organic materials for thousand of years and formed the soil. The weather eroded the rocks, and those minerals mixed with the soil, forming what we have today. So it is truly a process of thousands of years. Agricultural soil however is heavily contaminated with pesticides and

heavy metals. All this will eventually go into the groundwater. He told me about the term ecosystem services or cultural ecosystem services, which is again human centred. He said that those are the services one imagines upon the forest (dem Wald andichten). Again surprising how clearly he dissects his own research.

He was quite shocked when I told him about bringing soil from Hong Kong to Zurich. Soil is a blackbox, he told me, and in that black box could be pathogens that destroy whole ecosystems. It is one of the greatest dangers. But if I do it, I should dry it before (and best case cool it), as you can preserve the current state of the soil for days. If soil is wet, fungi may grow and the microbe composition changes. One microbe may dominate over others, so soil dramatically changes when it is removed from its original place. Two examples he brought where the Asian long-horned beetle, that threatened Swiss forests. The other one was quite surprising for me. Along railroads, you'll find Mediterranean flora, as the train brings those seeds into Switzerland.

Last I told him about my idea of developing a soilKit. I brought this up last, as I wanted to focus on the cultural connections of soil before showing him concrete objects or devices. Of course this was what really sparked his interested, as soil .

2021-03-22

Today I visited 3 LWF areas with Oliver Schramm: Lägeren, Vordemwald, Othmarsingen.

Othmarsingen (first area, level 3, least measurements taken)

Introduction into probing: - rain water - rain wip device - soil activity - humidity - temperature - CO2 - Methane and Nitrous Oxide (Lachgas) > very important - ozone through passive, material based ozone collectors that accumulate ozone - Zeigerbäume: trees that change leaf color to red if there is too much ozone (japanese cherry?) - soil pot hole > see different soil layers: thin humus, soil underneath mixed with mineral soil - bark water collector: collecting water running down bark. This water could be on leafs before and running down the tree, it accumulates and exchanges nutrients with the tree - together with rain water and soil water, you can see how nutrients change and how they are

absorbed at different stages by different organisms

60% forest in Mittelland is private property: for conservation, making money, hunting, etc...

Föhrenwald in Wallis are all practically dead as there is even less rainfall now due to climate change. Föhren are getting replaced by oak trees, which cope better with climate change and need less water

Ivano: Föhrenwald: Touristenattraktion. Niemand will Eichenwald, sondern schöner lichter Föhrenwald > Naherholungsgebiet, die Leute verlangen schöne Wälder > Eichenwald > dickicht, mit vielen Zecken > ==Der Mensch will keine Natur, er will gezielte gepflegte Natur==

Oliver is expert in phenologie

Inka/Maya: cultivating pumpkin, corn and bean together > beans can grow along corn, pumpkin gives shade to soil so it stays humid

Vordemwald (level 2, more measurements taken)

collector for things that fall to the ground (leafs, small branches, etc)

Tensiometer: creates vaccuum and sucks water out of soil. Old method

New method: creating vaccuum 0.6bar, that continuously sucks soil water into bottle

1x1m area that is completely left alone to study long term effects

tree sensors: growth/girth, baum fluss (tree liquids), special more sensitive sensor measuring and sending realtime expansion/contraction

CO2 “hubs”: putting cover over it, sucking in air with needle and transferring it into tube > done periodically over certain time, sample is analysed in gas chromatography

Lägeren (Supersite)

measurement tower: CO2 circulation forest soil and atmosphere and many more

WSL

Discussion with Zürcher, Alois

Comparing Sensirion CO2 sensor with Licor

around 500ppm, sensirion and lab device are +/- 10ppm

Alois blew one time into tube > confused sensirion way more, at around 1500-2000ppm, the differences to lab device are even greater - later found out that the humidity in his breath might have fogged internal optics, thus giving a consistently high reading

lab device could be unprecise too > high effort to calibrate and evaluate CO2 readings

have to consider pressure, temperature and humidity in CO2 measurements, as all three influence CO2 molecule behaviour - >> write alghorithm that somewhat includes those measurements - we did it with CO2 / 1013 / hPA (current pressure), which gave fairly accurate readings

interesting:

As a scientist he is more interested in getting measurement results than really knowing indepth about the device

he has no idea about electronic

EMPA and Decentlab are currently researching low cost sensor application

>> sometimes, many not so accurate measurements are better than a few very precise ones

should talk with Frank about sensors > he would be interested

looked at PH and conductivity sensors > in lab: mixing 20gr soil with distilled water or kalziumchlorid

Discussion Brunner, Ivano

more casual chat

felt welcomed by him > got to officially register as guest. He gave me an office space and will probably get a batch

looked and discussed casually about fungi > told him about Affenkopf Pilz (Hericium erinaceus) - he offered me to help me isolate the spores and grow this fungi after I've done the other learnings at WSL

will let me work with different scientists at all stages of probing: today collecting with Oli, tomorrow analysing in the lab with Noureddine

water and air are already researched "popular" among people, people are sensibilised, now soil is coming more and more

Marcus Maeder's Sounding Soil > doesn't make sense ac-

cording to him, it is not measuring anything

Ivano regards erosion as most severe process right now, not forest death - Erosion destroys habitat and destroys humus and fertile soil - Sahara and Gobi are expanding, destroying more habitat - China is investing in reforestation to conserve soil

2021-03-23

Helped Noureddine in the lab to analyse the conductivity of the rain probes Oliver and me collected yesterday. The sensor is placed in demineralised (deionised?) water between every measurement. The recent probes show the least conductivity Noureddine has ever measured, apparently because of the lowered traffic during the pandemic. Interesting note: he described the 'saurer Regen' acid rain as a polemic. As well as forest deaths, that are also a polemic brought to the table by a former Swiss Federal Council. In general, I don't have the impression that the scientists at WSL are all too concerned, as many issues seem to be politicised and turn out as not that severe in the end.

Ivano wrote Frank Hagedorn to meet me today and we had a quick chat about my soilKit. I was told that he would be quite interested, as the he is the CO2 guy of WSL. He did mention his interest, but I never really felt this curiosity I felt with Alois for example. We had a quickl walk outside and he showed me those mini greenhouses, where they simulate different climate scenarios. For example in one greenhouse they plant different tree species and simulate a high CO2 content. The result is quite hilarious, as the plants actually like and benefit a higher CO2 concentration. It helps them grow. The thing they cannot tolerate is a rise in temperature. So in the end it is (of course) not desirable to have a higher CO2 concentration in the atmosphere, as 1. the temperature rises and 2. disturbed soil cannot store all this carbon.

2021-03-25

Sat down for a few hours with Ivano today. We discussed how we should frame my stay at WSL and how our collaboration should look like. With silent consent (I guess) Ivano became my external mentor, and with that he demanded a written concept with the research questions and goal of my work until next Mon-

day. He has to know my step by step planning and my deadlines, so he can evaluate what makes sense in this short time and what not. During our discussion, I grew more and more frustrated, as I felt pushed into a certain direction. I was surprised to find pressure coming from science. Of course this seems to be how scientific research works, to have a strong research question / hypothesis and an expected outcome. Everything is to be laid out and noted down in a lab journal. It is the way knowledge generation has worked there for decades. In that moment, I felt torn between my initial intentions of a non-western, more fluid approach to knowledge and this new setting I find myself in. I was afraid to lose my approach in the process of further developing the soilKit. Another reason why I am afraid to sink too deep into a scentific approach is that I am quite comfortable with it. Natural sciences were my best subjects in school and I would feel very comfortable staying in them as I would be in design. So between those two extremes, I would have to carve out something I can call my own.

I chatted quickly with Helene and Sonia who share the office space with me, the two founders of Digit Soil. They are developing a soilKit (for farmers) to determine soil health through enzyme activity. As far as I can remember, they transfer enzymes to an agar strip. Those enzymes somehow produce a light pattern that can be captured by a camera. In our discussion, Sonia asked quite some critical questions, such as "what is the most challenge I have right now in building the sensor? Did you think about the placement (height/position) where you put your sensor? How is the sensor protected?" First I thought that maybe my role is science communication. But I quickly dismissed this thought. My role is not to communicate their research nor is it to impose design methods on their work. My role is whatever I carve out of this intersection of science and design.

2021-03-30

I sent Ivano my concept last evening. In the morning he wrote me that he unfortunately won't have time to read it before our meeting at 1300. When I went to his office, my concept and timeframe were printed and laid out on the table in addition to one copy of my concept translated to German and every sen-

tence separated and reorganised... If that how it looks like when he doesn't have time to read it, I don't know what he will do when he actually has had the time to read it... After my long discussion with Ivano, I took the chance to walk around at the WSL. I met Mathias on my way back as he was measuring CO2 in his self built chamber. It looked quite similar to mine and essentially works the same way (just bigger and presumably more precise). He built a small fan into the tube to help circulate the heavier CO2, something I have to add in my design as well. In his experiments, he is interested in the CO2 respiration of forest soils with trees and without trees (with grass only). He measures CO2 while the pots are exposed to sunlight (CO2 sinks as plants do photosynthesis) and covered (CO2 rises as photosynthesis stops and soil respiration overtakes CO2 absorption). Frank came along and we had a quick talk about how room plants actually produce more CO2 than they absorb, as they are mostly not directly exposed to sun and thus soil respiration takes over. Also green roofs produce net more CO2, because often very humus rich soil with high microbial activity is used. He once did some measurements at a roof, but the client just wanted some of the numbers to just show that green roofs are beneficial...

2021-03-31

In the morning I accompanied Ivano to meet Mathias again. We chatted a bit and went back to work (and soon for lunch already).

It seems you will truly get to know scientists during lunch and after work beers. Went to lunch today with Ivano and Beat (the technician). We were sitting outside and it seemed like we were the odd white men table (+me, points for diversity..). We were discussing the role of art again. I told them that artistic research is not that differently from scientific research. That both inquire and follow their curiosity, both wanting to understand the world they live in. And on the practical side, that artistic work process looks quite similar to scientific one: elaborating a concept, wiriting and obtaining grants.

Ivano seems to like to challenge me on thoughts of art and design. After initial confusion about this sudden confronta-

tion, I really began to enjoy his challenges, as nobody has challenged me like that before and it forces me to think deeply and lay out my arguments why design and art matter and are not just activites of unemployed people with too much to spent. That's when I also *really* realised that we designers are also (of course) in a bubble. That we have not been challenged in our thinking and acting in *this way*. That ZHdK is a safe space just like WSL is

Met Beat Frey and a Chinese guest scientists during coffee break. She felt clearly uncomfortable in a room with 5 men (Ivano, Beat, Beat Frey, Oliver, me) as they were also challenging her about China... Anyway, went to visit Dr. Aline Frossard in the afternoon, who has bought a Kuppel for CO2 measurements. It is essentially just a metal hood with a few connections for the licor and data and a fan that circulates the air inside. And it's 12'000CHF. And she realised that Frank already had one of these so now they have two... Ivano, Beat Frey, Aline and me all hilariously agreed that this thing was way overpriced. But as Aline put it she "has budget". I showed her quickly my soilKit prototype and she shared some pictures of a friend of hers who also built a CO2 chamber. Though it is a DIY chamber, it's also huge and far from portable. It also uses tubes to suck out the air and introduce new air into the chamber. I asked her why the sensor is always outside the chamber and never put inside. She was surprised by this question, as she never questioned it herself.

2021-04-06

Today was quite a busy day at WSL, as I had a lot of exchanges with various people. (And my office space being at the same time used for coffee break gatherings really brings a lot of people to me - in a good way!) Throughout the day I had a lot of exchanges with Ivano. In the morning we were quickly discussing the papers he sent me last week and that I've read for today (Joshi Gyawali et al. 2019; Nazarious et al. 2020). The first paper centers more about the building and testing of an actual low-cost CO2 sensor, though the prototype is quite rudimentary, as it neglects temperature, pressure and relative humidity, which are important parameters for working with soil respiration. Went also quickly into the seed collection/vault of WSL. The most interest-

ing thing about the seed collection is the surprising and extremely fragrant smell inside!

During lunch, chatted quickly with a Chinese guest scientists (bioinformatics) , who does sequencing of genomes of all micribiome of (artic) soil. She observes how soil microbiome responds to higher temperature. With global warming, microbial activity changes, some dormant microbes wake up, others go "back to sleep". I asked her if she finds undiscovered bacteria in the soil. I'm not sure if she understood my question but she said there are (in a manner that was very "easy going" about the discovery of new microbes). She uploads all genomes to a database, which either already has information about microbes or stores them as new (?) species.

Noureddine asked for my help in the evening, actually to help Alois to debug the command terminal (of Windows) to run the Vaisala CO2 probe (that was hooked to a carbattery-like thing, super ancient tech). Funny note: What do a scientist and a designer do when the computer does not work? Just press the keys as hard and determinate as possible... Afterwards I went with Alois to the mini greenhouses to test Licor measurements. They installed 80 mini PVC rings into the soil to take long time measurements. When I asked Alois during start up of the Licor what the 'Deadband' setting is, he didn't really know and he said that probably nobody here really knows. You just ignore it as long as the device does what it should. This sounds quite similar how we designers sometimes engage with things we don't really understand... We moved the Licor on a cart to the greenhouses and went really offroad with that thing. It was quite a hilarious moment to push 20k+ worth of devices through the dirt.

The whole measurement taking made me realise how much of an effort everything is. It is tedious and inconvenient. If he had 80 of my low-cost sensors, he could do it much more efficiently. He was really open in sharing his thoughts about this experiment series (I think initiated by Mathias). In his opinion, the initial experiments already failed and he doesn't see the purpose of measuring the CO2 in the greenhouse soils (that are artificially put under stress, for example extreme drought or heat). So there would be not much to measure. This made me think about

how scientists also sometimes just do seemingly random things or just do things because they can. At WSL in general, a lot of random stuff is made and a lot of research fail. Of course this can lead to unexpected insights and taking a detour might actually lead you to the actual research.

Had a quick chat with Helen and asked her when I could finally see her Digit Soil (apparently Sonia does the engineering part). The Digit Soil works with the principle of fluorometry. If enzymes are active and come in contact with their (agar?)membrane, they will emit light visible to the naked eye. A camera captures then this light. They can determine if enzymes are active but not if they are actually "converting" something right now.

Towards the end, I talked briefly with Ivano again about the different requirements of artistic and scientific work. He seemed to slowly understand what artistic reseasrch is about, as I told him the aims of both research is about generating new knowledge and mediating this knowledge. With the arts, it is just on a different level with different requirements than with science. We seemed both stuck at how to bring those two fields together, how to grow where they intersect... What to do for the BA?

I couldn't get anything done today as I was getting involved and distracted by a lot of people having an exchange with me. Getting "distracted" is actually very valuable and in my case desirable, as there is always an exchange of thoughts going on with so many diverse people working on their own project. Other advantage is that stuff that I read can be immediately discussed, dissected, put in context and sometimes even tried on the spot, so knowledge finds its way very quickly into discussion and from there into the field.

Funny observation of the day: Ivano never new anything about the Vaisala, and always say that Frank and Alois have things that they never mention and then they suddenly appear someday (Ivano is the head of the research unit, so it is quite funny that he just never got wind from those things) Ivano (who always preaches to only consume peer-reviewed papers) to Alois (veteran CO2 measurement specialist) about CO2 chamber measurements with the Vaisala: "you're doing it wrong. I saw it in a YouTube video"

Further (furiously) discussing the Vaisala chamber, Ivano: See there is a vent, those chambers need a vent! Me: No Ivano, it's just some velcro tape! He examines the chamber upside down: Oh, yes you're right it's just tape!

2021-04-07

Today was a quiet day at WSL, as Ivano and a lot of people were doing home office today. Being at WSL really is only worth it for exchange with people or using the infrastructure. I went to ZHdK in the evening and build a quick extension to my CO2 chamber, which now circulates the air to the Sensor. The construction became undesirably big, but I am curious to see if this way of chamber design (used by LI-COR, but curiously not by Vaisala) improves the CO2 readings.

Side note: Got my WSL mail address today and wrote Empa again with this address. The answer came an hour later, and another hour later I received an invitation, meeting room booked and all...

2021-04-08

Today was a very busy day again. Ivano came by in the morning and found my chamber extension quite cool. The first time seeing him delighted with the soilKit. Sonia Meller was also there and brought a UV chamber and parts of the Digit-Soil device she's developing. Bacterial enzymes (or in fact, whole soil), can be put on this plate with a chemical mixture (I forgot the exact composition, but it is readily available and not propietary). According to enzyme activity, the mixture will begin to glow (only under UV light?). Met Aline during lunch and quickly showed her the chamber expansion. In the coffee break, always happening after lunch and always with Beat Frey joining, we had quite a rich chat about the soil microbiome.s Beat outlined the microbes resistance to temperature changes, as for example in Switzerland air temperature may rise and fall up to 20 degree celsius on a single day. So the microbes in Swiss soil are quite flexible regarding temperature but also regarding humidity. Soil can dry out for months and the soil microbes go into a dormant state. Other stressors as pesticides, herbicides and heavy metals

can disturb communities from which they cannot recover. What Beat researchers is how soil microbiome changes in permafrost, which is 15 to 20 thousand years frozen and now suddenly thaws. He researches how this shows in the soil microbiome and in carbon cycling, as carbon trapped for thousands of years suddenly is released. These are vast amounts of carbon that are being released in a short time. With thawing, plants populate the arctic area and also populate higher areas. As the plants then bring easily available carbon through the roots into the soil, the system almost explodes. The quickly thriving organism profit, as they exude a lot of enzymes and decompose the newly availabe carbon and organic matter as well as the old, trapped carbon. It triggers a chain reaction and releases massive amounts of carbon. Plants act almost as primer, as they 'prime' the soil or 'prepare' the basis for this reaction to happen. This arctic greening is not yet considered in climate models, what happens when the plant biomass increases and moves into the arctic and into higher altitudes. It is unclear (contradicting studies) if with new vegetation more CO2 is bound and stored in soil or will more CO2 respired through the rhizosphere priming. The tendency is that more CO2 is released into the atmosphere. Following the chat, Beat Frey showed me the MicroResp system they have upstairs (and never used). I was quite excited to find this material sensor for CO2 and to start doing experiments with it.

Through this chat I realised that scientists never have time, except you're already in! Then you have a wealth of access and resources. Everybody is open to share their insights, knowledge, discuss, showing you new material or things they are working on or with. During coffeebreakes the most interesting discussion take place. The conversations are most vivid and casual. Thats why we do three coffeebreaks a day. I make sure I am part of every one of those breaks, where researcher openly and flowingly tell the most vivid tales of their research

Went to Alois in the afternoon to test my new chamber construction and to compare my data with his, but unfortunately the sensor delivered unsatisfactory data. My hypothesis is that the direct sunlight or sudden temperature change together with the insufficient performance of the air pump resulted in incom-

prehensible data. Thus I decided to improve the chamber and postpone the simultaneous measurement to another day. s

2021-04-09

Met Beat first thing in the morning and he brought me to the green house, where he showed me some peculiar sterile baby trees, surviving for years on agar. This was one of the most interesting things I've seen this week. There are so many questions coming up like how can a tree survive in sterile conditions? How can it grow only in agar? Why hasn't it become bigger than the mini container? Showed Ivano the MicroResp kit this morning and we went together to the chemical cellar to see if there is enough cresol red for mixing the material sensor. All dyes in the cellar are decades old (and unused), as well as the substance cabinet with ingredients for bioindicators. The research group around bioindicators was suspended, as all members went into retirement... Had a quick chat with Maomao. It is incredible with what vast data sets she is working just to try to understand ongoing soil processes (and subsequently to predict the future). This made me realise that so many people at WSL work on so many highly complex topics and entanglements

In the afternoon, the conversations with Ivano shifted to common curiosities like tempeh and the erenicium fungus. It seemed like we were all just mutually having fun and exploring things and interests, like looking if the mycel in the erenicium is already growing and talking about bits and things.

Now already at the end of this week, I noticed an opening up and gradual understanding towards my workings there, and I felt an exchange building up that now flows in both directions (instead only from them as "professors" to me as "student"), a mutual learning was establishing, concretely in the example of Kombucha, Kimchi and Tempeh (which all have never been heard at WSL...)

2021-04-13

Asked Beat Stierli today if we could experiment with the MicroResp method. He was very welcoming and interested and took the whole afternoon to prepare the indicator material with

me. The indicator material is quite simple and straightforward, yet elegant method to measure soil respiration. The indicator solution is a mixture of potassium chloride, sodium bicarbonate (baking soda!) and cresol red, a PH indicator, in deionised water. This mixture alone is already capable to indicate CO2 concentrations by converting the atmospheric CO2 to carbonic acid. The higher the CO2 concentration, the more carbonic acid is made, thus lowering the PH of the solution. The pinkish colour will thus turn to yellow. This can be already achieved by simply breathing into a container with the liquid and closing it, making the solution to change colour within seconds. (Later tested an agar plate on soil, which will probably take at least 12 hours to see a noticable colour change).

At lunch, I asked Beat about their current research into PET decomposing materials. I was particularly interested in how they 'insert' a gene into bacteria, so that they translate this gene and produce proteins/enzymes which decompose the plastic. They induce the vector resistance gene through a heat shock: First they freeze the bacteria and let them thaw. During the thawing, they induce the vector DNA and put the bacteria into the oven to induce a heat shock. Through this shock, the bacteria take in this new gene. The bacteria are then cultivated on an agar plate that is mixed with antibiotics. Those bacteria that have successfully incorporated the new gene will have an antibiotic resistance and survive while those who do not have the new gene will die.

Beat Frey and Margharita were present in the lab while we mixed our solution. As Beat Stierli demonstrated the colour change, we all were mesmerised by this simple reaction. This reaffirmed to me the power of material performance in mediation. In the weeks before when I was developing the soilKit, no scientist was ever fascinated by the number it showed or the curve the sensor drew. But the material through its agency and performance was able to reach them on a different level. We chatted quite a bit about how we could exchange cresol red with other indicators, for example red cabbage juice, which has one of the widest spectrums. It was exciting to see Beat Stierli fully turning into a curious experimentation and discovery mode, a level of excitement that is sometimes rarely seen at WSL, perhaps be-

cause you're surrounded by people who have seen and done it all. I continued to pour agar plates in different sizes, vials and micro titration plates.

2021-04-14

I was shortly at WSL in the morning and to my surprise, Beat Stierli continued already with indicator experiments. He used a different chemical, that changes from a bright red to strong yellow (Chrysoidine G). Marcus Maeder wrote spontaneously and we met for a coffee. In the afternoon I met Lukas Emmenegger (Head of Air Pollution / Environmental Technology) and Simone Baffelli, who takes care of the CarboSense network. The two were incredibly welcoming and spontaneously took time to discuss the soilKit with me. I hoped to gain insights into the design and programming of the sensor and I was glad to talk with them about the details. After weeks only talking to biologists, it was relieving to find two scientists who actually understand the technology and could give valuable insights into their work at CarboSense and the design of such low-cost environmental sensors. And to be quite frank here, to finally talk with people who actually understand the technology and not just give 'some' advice just for the sake of it. The discussion turned into a relaxed and free flowing brainstorming. Key points from the brainstorming:

There is no need for an alghorithm to correct irregular data. CarboSense is designed to measure continously over long periods of time (years), so high humidity (mostly during nights) of over 80% that disrupt proper sensor functioning and fluctuation and aging of the infrared light source have to be compensated. With soil respiration, the measurement only takes a couple of minutes before the chamber is opened and ventilated. With these kinds of measurement, no alghorithm is needed. - These kind of low-cost sensors are thus actually better suited for soil respiration than for atmospheric CO2 measurements like CarboSense - Sensor is good enough and perfect application for this sensor - No need to separate the sensor from the chamber - fan and diffusive open sensor is quite an ideal system

As the chamber relative humidity rarely reaches 80%, there is also no need to compensate for high humidity.

As only the delta is needed, the absolute accuracy of the sensor does not matter. It does not matter if the measurement starts at 400 or 430ppm, as we only need the difference - thus this kind of sensor is ideal

They regard compensation for pressure build up in the chamber as unnecessary as the measurement interval is short enough. A vent for overpressure is also unnecessary, as it does not change in that short time

Biggest challenge: building the ventilation mechanism, but could be an interersting challenge as interaction designer, the combination of electronic and mechanic. And to make it durable in the forest against plants and animals. - while the chamber is open, the environment/soil shouldn't be disturbed, so ventilating on max maybe isn't the best idea - measurement should take only a couple of minutes to not disturb the soil system, and with measurements every few minutes where the chamber closes, this would be ideal

Pipe is a good idea, they would propose a bigger diameter one

Reaction: with high changes, the sensor can take up to 10min to adjust, but with incremental changes in concentration, the reaction time is fast enough

data must be plausible but not reproducible

besides the mechanic, everything else is Fleissarbeit: data collection, transmission, database, etc

breadbord could have loose contacts and this could lead to corrupt data

2021-04-17

First agar plate > soil experiment. My hypothesis is that if some microbe communities in the soil are more active (thus respire more CO2), this must be visible as a pattern in the agar plate. I prepared three plates with soil from the field outside. One soil is left as is, one is fully soaked with a glucose solution (10g/100ml) and one plate is only half soaked. After 6 hours, the one fully soaked with glucose turned pale yellow / peach and the half soaked plate was in between the other two with a very slight gradient visible. So it is possible to observe microbial activity

through patterns in the plate. For next time, the plate should be in closer contact with the soil to avoid dispersion of CO2 before coming in contact with the indicator gel. Also prepared while waiting for the

2021-04-19

Quick first measurement test with two Sensirion and one Empair. Although the absolute value is not the same with all of them, the increase in CO2 concentration is plausible. Met Beat Frey, Basil and Margherita while having a coffee break in my space. Beat was more curious than usual and asked me a lot of questions about my exhibition and about the work I'm doing. It felt good to share my resesarch again in depth with those three. Had an interesting discussion with Margharita about her upcoming research on plastic (PET?) decomposing bacteria. We talked about the systemic problems surrounding plastic waste, that for example customers demand vegetables to be packaged in a certain way that is appealing to them or 'recycable' packaging often containing little bits of plastic. To change the way we're using plastic, it is really about changing behaviour and attitude rather than just covering the symptoms. One point that came to my mind was the promotion to use cotton bags instead of plastic bags (or similar the promotion of using metal water bottles). It seems to be a logical and green alternative to plastic bags, but if you consider the cycle of cotton that involves intense land and water use, deforestation, forced labour, even slavery, pesticides and other chemicals to treat the cotton it is not a very green alternative either. It was nice to discuss those systemic issues with her and to show her what design research involves. She didn't realise that design could also be about that and that it involves this very broad knowledge that we acquire.

2021-04-20

Quick catch up with Ivano in the morning and my plan for today: pouring big agar plates and doing a few measurements with the soilKit, ideally one in the morning, midday and in the afternoon. For the plate I used 300ml indicator solution and 150ml agar. After it cooled down, I put it outside straight on the ground,

with a few spots sprinkled with sugar water. Next to it I put two large petri dishes, with one I soaked the ground with sugar water. I did one measurement before lunch and on in the afternoon. After lunch I visited Alois and we spontaneously compared the Sensirion with the Vaisala. We put them both in the same chamber and measured the difference and then the increase (curve) while gently breathing into the chamber. The Sensirion and Vaisala are surprisingly close, sometimes just a few ppm apart. The increase/curve was also very close. We then pumped special air without any CO2 into the chamber and observed the decline. Just until around 400ppm the decline with both is very close. I think since the Sensirion is only calibrated from 400ppm onward, it reacts incoherently below 400ppm. The EmpAir was overall very slow in reacting and ppm was around 100 apart. After that I went with Oliver to the storage and picked some bigger rings to use the Vaisala simultaneously with the others. Fabian came to me as he was curious what I was doing. He was the guy sharing the office with Alois and overheard me talking about soil respiration, so he just passed by to chat. I was very glad that someone was interested in my project and that I could share what I was working on.

2021-04-22

Chat with Jasmine Fetzer

I met Jasmine before lunch and asked her about the details of her research on the phosphorus cycle in forests. Phosphorus is essential for life, involved in genetic (DNA), energy metabolism (ATP, here footnote or footnote for all) and structural systems (bones and membranes) (Ruttenberg 2003) and the only source of phosphorus in forests is through erosions of rocks thousands of years ago which eventually formed forest soils. Plants absorb it through their roots and animals through feeding on them. When they die, their organic matter is decomposed by soil microbes and phosphorus returns to the soil. Through deforestation and intensive agriculture, the phosphorus cycle is interrupted and the phosphorus in soil is not regenerating. In agriculture phosphorus has to be constantly replenished in soil through fertilisation, but phosphorus is not available indefinitely and overfertilisation results in phosphorus deposition in the ground water. Further-

more it will eventually end up in the ocean, where it causes major disruption and also end up in the sediment, where it is harder to make it available for plants and microbes again. And you cannot just fertilise whole forests, as this would pose a severe intervention into forest ecosystems. Technically, we would have to recycle human waste to win the phosphorus back. There are some projects trying to tackle this, but it requires the right infrastructure and money.

I was not aware of the phosphor cycle and the complexity that comes with it. How tiny changes and interferences ripple through entire ecosystems. And how dystopic every research at WSL that I learn about is. Everyday I learn about the latest research and how they uncover the effects human activity has on the dynamics of the ecosystem, the ripples we are causing. It seems like the ecosystem is breaking down while we're watching. In a surprising moment of reflection Jasmine asked why we even do the research. I am reminded of Anna Tsing, that what we need at the moment is truly the art of living on a damaged planet. Or John Lear (2006), acknowledging our life on this damaged planet, acknowledging catastrophe (Tsing et al. 2019), while still imagine possibilites of life, collaborative survival, that happens in many small areas around the world. "Hope rests on staying with the trouble: the troubled pleasures of co-species collaboration and cross- disciplinary learning." (Tsing et al. 2019)

Chat with Margherita and Basil

Spontaneous lunch with Margherita, a trainee and master student, and Basil, civil service employee. Both are also new at WSL. Margharita told me before how she was adjusting to the new, relaxed atmosphere at WSL and we talked again about this very 'flowing' way of working there. I found it amusing that we thought Beat Frey would be their supervisor, as Ivano is somehwat 'my' supervisor, but apparently Beat Frey is not 'supervising' them in the traditional sense and lets them have more freedom. Margharita is mainly working with Joel Rüthi and assisting him in his research into plastic decomposing bacteria. I suggested that she could shape her own role at WSL and be free to do whatever she wants, like I have. She pointed out that while I am working on my own research, she is basically helping Joel and thus has to

follow a certain research agenda. We went on to discuss scientific research and how it compares to artistic research. I was surprised to learn that Basil's master thesis was 'designed' for him by his supervisor so that it will contribute to his own research. Basil mentioned that he was basically just executing what has been asked of him. This way of doing theses seems to be common practice, as Margharita told me. Lab equipment, use and material are expensive and limited, so the student's research has to fit the professors field of research to gain access to the infrastructure. They are very dependent on the supervisors and have to accept their terms. I realised that all the equipment I am using is super expensive as well and that I easily fill a a trash bin on my own when I am extensively workin in the lab. And of course that all the materials I am using are non recycable single use plastics. Margharita added that in order to have the best results and trustable data, you have to use new, sterile single-use equipment.

I was curious to see their view on scientific research versus artistic research, as I had the impression that they are not that different after all. We both pursue with great curiosity a topic and try to approach it with experimentation and research. Margharita again pointed out that she thinks they are not that alike, as scientific research often revolves around a very nice topic that in the end nobody cares about unless it is truly groundbreaking and does not involve any thinking about systemic relations and evironmental dynamics. The research is usually not aimed at really improving something. She remarked that she really likes the openness and different way of thinking in my field of studies, as I can explore and research freely. Overall, I was quite surprised about their very clear and sharp critique on the way scientific research works.

I was curious to bring in some rather wild questions and ask them if it is possible that the bacteria they are cultivating can mutate out of control and spread out of the lab. Margharita denied that they can mutate that quickly and pose serious threats, especially not E. Coli. Regarding the plastic decomposing bacteria they are working on, she relativised their ability and pointed out that if they could manage to cultivate them, it will still requrie optimal conditions for them to decompose the plastic and that it

will still be a slow process. And you have to consider the fact that bacteria are always in competition with other microbes and that there is rarely a case where one species is overpowering all of the rest. According to Margharita a much bigger gamble are GMO plants, as they are inherently more resistant and thus will 'push out' non GMO plants.

Basil will do his PhD on bacterias found on leafs. There is not much research in this area yet. Plants found with certain bacterias on their leafs are more resistant to pests and diseases than those without. Almost like the bacterial barrier on our skin! I asked him what applications he imagines this could have and of course it would probably be agriculture...

Chat with Sonia Meller

Sonia was today in our shared office space and I asked her how her research is going. I was particularly interested in the details of soil fluorescence and was keen to know the details. She showed me the newest prototype, a tube that you stick in the ground with the carrier plate in the middle. Small compartments on the carrier plate will react with the soil and emit light, that is registered by a camera above. A display will show that data is available, but not what the data is saying about the soil health. Interpreting the data is another huge obstacle they have to master. I asked her a provocative question if it is not better for the farmers to learn about their soil and to apply methods like permaculture instead of relying on a device to tell them which fertiliser to use. She pointed out that every soil is different and so is the crop that is cultivated. There are just so many factors that play a role, not only environmental but also different agricultural practices. An example she brought up is tilling, which is commonly regarded as an outdated practice as it disrupts the soil. However, without tilling there is considerable build up of pesticides in the top soil, that gets distributed and decomposed much quicker when soil is tilled. I am again made aware of the complexity of the systems, which is always moving and always changing. When trying to observe it, you merely take a momentary snapshot of it. Personally, I am not convinced by her response, as it is solving issues that technology caused with more technology, that in itself carries another string of entanglements with it, like the resources that go

into making this tech.

Sonia explained in detail the chemicals she is using to detect enzyme activity in soil. For example one chemical she is using (4-Methylumbelliferyl Phosphate) has a phosphorus group and another group that is responsible for the fluorescence. If there are phosphorus decomposing enzymes in the soil (meaning there is enough organic matter available for the microbes to decompose), these enzymes will also cut off the phosphorus group in the chemical, releasing the fluorescent group. Under UV light, this fluroescent group will be charged with energy and emit visible light. This fluorometric detection of enzyme activity in soil is possible with a range of chemicals.

As I was curious to experiment with fluorescence for determining soil microbe activity, I asked her if I could borrow a few (micro)grams of the chemical. She generously offered me a gram of 4-Methylumbelliferone (the fluorescent group without phosphorus group), as the other chemical needs to be stored at -20C.

2021-04-23

Brought the red cabbage juice containing anthocyanidine to the lab and discussed with Beat Stierli how to handle and store this pigment. Beat Frey quickly visited the lab and we discussed the characteristics of the pigment and why certain plants have this pigment while others do not. It seems to be not completely clear and there are many hypothesis like for attracting animals to eat and distribute the plant's seeds. It is really nice to talk to Beat Frey, as he always brings unexpected *systemic* questions. Beat Frey suggested to experiment with the dilution of the pigment and to experiment with the different colours it produces under different PH values. We set up the experiments for the day, the dilution and determining of colour changes, conserving the pigment either pure or diluted with glycerine, in the fridge or freezer and to experiment with the KCl + NaHCO3 solution to see if the carbon reaction would trigger a colour change with anthocyanine.

During lunch, I asked Beat to tell me about some ongoing research he's working on. It was surprising to learn that he does all the lab work and experiments and the scientists basically just look at the data and write papers. Some of the research he's

working on are the PET decomposing bacteria that Joel and Margherita are working on. Another one is the research about deep soil organisms, that have not been researched yet. Recently they found out that organisms are sitll present a few meters deep into the soil, mostly archae but also fungi. It is yet unclear how those fungi produce fruiting bodies, as they are unlikely to grow their mycelium all the way to the surface.

In the afternoon I proceded with the experiments, first producing the colour spectrum of anthocyanine by adding either hydrochloric acid (HCl) or potassium hydroxide (KOH). After that I mixed up KCl and NaHCO3 to test anthocyanine with this solution. Unfortunately, the colour shift of anthocyanine is too soft and not as drastic as with cresol red, but yet visible (from violet to blue-ish violet). I measured the PH of the solution before and after breathing on it and the changes are very minimal, from 7.23 to 6.62.

As my magic fruit berries had mold, I had to dispose of all three plant pots. Beat Stierli suggested to germinate the seeds on filter paper and then put them into soil. As the plant requires a very sour soil PH of about 4-5, I prepared a solution of dH2O and added kombucha to lower the PH. It required quite some fine tuning to lower the PH to 4. The plant is an interesting organism that will not grow on Swiss soil, so I have to create conditions and transform the soil for the plant to survive.

Once again I realised that I can do whatever I want in the lab with people trusting and supporting me, which is super powerful. As a PhD student or employee, I would have to follow the agenda of the head scientists and couldn't just freely experiment around. This is a extremely valuable position I find myself in.

2021-04-27

Discussed with Margherita over lunch what would happen when I "unplug" the modified plastic decomposing bacterias she is working on and throw them into the pond? She thinks that probably nothing will happen but still would not want to be near it when I do it.