Universiteit Utrecht

History and Philosophy of Science

MSc Thesis

A Soil Story

The Coming of Age of a Scientific Concept Through the Eyes of D. J. Hissink

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Preface

A week before my thesis deadline I visited the pre-premiere of the documentary *Onder het Maaiveld* at a local Utrecht cinema, fifteen minutes walking from my home. The documentary was brought to my attention by a friend of mine and as soon as I learned it was about the soil, the farmers, and their relationship with each other I knew I had to go. I hoped it might give me some fresh perspective on my thesis subject. At times I was so caught up in the details that I texted that same friend that "ik door de *bodem* het bos niet meer kon zien," pun unintended. Apparently, I had been reading, writing, and thinking so much 'bodem' that either my typing muscle memory or my subconsciousness accidentally inserted it into Dutch proverb.

The documentary ended up being mostly about, what they called 'the living soil', meaning soil organisms. It started with a giant white translucent tardigrade walking across the screen against a black background. Then, the screen was taken over by growing and blossoming fungi hyphae. More and more larger organisms were displayed: a nematode, a springtail, mites, ants, woodlice. And eventually an enormous earthworm joined the bunch, slithering around the soil and the screen. Unfortunately, this is not really what my thesis is about. My thesis is about what a chemist looked at when he researched the soil, and my chemist did not look at the living organisms in the soil. At the same time, though, I also would not say my chemist researched the *dead* soil. The soil, to him, had many life-like qualities. Saying there is a living soil, would almost be a pleonasm.

And so, what really interested me about the documentary and the discussions that followed, were just how different (and how similar) the ideas of the soil were in the documentary as well as in the audience from the soil that I had just been reading about for the past year-and-a-half. This difference in thinking of the soil relates closely to why I wrote this thesis: to document a change in thinking about the soil, though in a specifically scientific context.

In the documentary, someone says: "We used to think we had to feed the plants, now we know we have to feed the soil, who will then feed the plants for us." It is a widely shared sentiment within organic farming that it all revolves around soil improvement; around caring for the soil, who will repay you in food. Then, I wondered, is this really so different from what my chemist was trying to do? Was he also not just trying to find out how to improve and care for the soil. Perhaps the goal of caring has always been similar, just the thing that has changed was our idea of what it means for a soil to be 'good' or 'healthy'. For my chemist, a high crop yield meant a good and healthy soil. Now, our idea of a healthy soil is different. One of the audience members even said: "A poor soil actually does not exist." He meant that the minerals, which are the 'start' of a soil, are always there. They just need the right organisms to be present to convert it into food for the next organism in line.

There exist and have existed so many different ideas on what a soil is and when it is as it should be. Currently, the idea is that many soils are not as they should be: monoculture, pesticides, heavy machinery, tillage, and overfertilization have transformed the soils for the worse. So much so that in 2020 the Dutch Council for the Environment and Infrastructure published a report titled "De bodem bereikt?!" indicating that Dutch soils are seriously deteriorating.[1] It called for a move towards more sustainable agricultural systems.

After the documentary two organic farmers talked about how they practiced their farming. An audience member asked what had been the hardest for one of the farmers since she had started the organic farming adventure twenty-five years ago. We had already discussed the financial struggle a farmer has to go through to switch to organic farming, and it clearly was not an easy process. The farmer, Josephine, had her answer ready, but let out a deep sigh first. "Policy," she said. "The government." In her view the current policies were not going to accomplish the change in approach to the soil that she thinks we so desperately need. The plans under discussion of getting rid of animal agriculture and buying out farmers from their businesses would only lead to more intensification, according to her. She argued we need policy to change the system. We need a new idea of how to do agriculture. A new idea of what the soil should be.

1. Raad voor de leefomgeving en infrastructuur, *De Bodem Bereikt?!* (Digital publication, 2020).

Contents

1 Introduction

The Netherlands, like any other place, has its own unique relationship and history with the soil. It is one strongly revolving around the concept of creation and re-creation of the soil and landscape to fit the needs and visions of society—a practice going back centuries. The adage "God created the world, and the Dutch created the Netherlands" is often brought up to show how manufacturability (*maakbaarheid*) is infused in the Dutch approach to the soil and landscape.[2] Though the Dutch engagement with the soil has a long history, the scientific discourse is rather recent and was for a long time remarkably divergent. Winand Staring described the soil in his foundational text *The Soil of the Netherlands* as an expression of geology.[3] His soil map classified the different types of soil in terms of geological time periods, meaning there were, for example, diluvial and alluvial soils corresponding to the Diluvium and Alluvium.[4] Gerrit Jan Mulder, on the other hand, spoke about the soil in terms of its fertility, the chemical components it consisted of, the desires it had for certain nutrients, or how it related to the atmosphere.[5]

While Staring and Mulder were referring to the same physical object (the soil), they spoke about it differently. They spoke as if they were referring to different objects with different characteristics and different identities. Since these scientists were all in the business of truth-finding, does it mean that one of them had a better understanding of the soil than the other? Was for one the soil in their mind closest to the physical soil? According to scientific realism, the answer ought to be 'yes' to these questions. There is one real physical soil, and one of these two had the best idea of what that is. As we progress through history, the different

2. The origin of this adage is sometimes ascribed to Voltaire or Descartes, but this is not supported by any evidence. The origin is not entirely clear, but can likely be found somewhere in the seventeenth century. See Frits Niemeijer, "'God schiep de Aarde, maar de Nederlanders maakten hun eigen land' - Een zoektocht naar de oorsprong van het gezegde," *Vitruvius*, 2021, http://vakbladvitruvius.nl/images/essay/GodSchiep-Frits_Niemijer_Mei2021_DEF-dd27mei.pdf.

3. Winand C. H. Staring, *De bodem van Nederland*, vol. 1 (Kruseman, 1856).

4. The Diluvium and Alluvium were subclasses of the 'fourth time period' in geology. Diluvium in the 19th century generally refered to deposits resulting from Noah's flood, whereas the alluvium related to deposits coming after. See, for example, Bradley A. Miller and Jérôme Juilleret, "The colluvium and alluvium problem: Historical review and current state of definitions," *Earth-Science Reviews* 209 (2020): 103316.

5. Mulder's book *The Chemistry of the Cultivable Earth* contained sections like "Needs of the soil for useful plant nutrients" or "Maintaining the fertility of the soil". See Gerrit J Mulder, *De scheikunde der bouwbare aarde*, vol. 3 (Kramers, 1860).

ideas of the soil should slowly converge towards one singular truth.

Scholars in Science and Technology Studies (STS), however, put the scientific endeavor in different terms. They argue that scientists are not in the business of truth-finding but in the business of knowledge-making, and that this knowledge-making is a messy and social process. Scientific knowledge about nature evolves, not disembodied from, but in interaction with society: it is shaped by the person, place, practice, and purpose of its production. In STS, science does not surpass culture but is an intricate part of it.

Scientific objects

Along these lines, Lorraine Daston has described in the book *Biographies of Scientific Objects* how scientific objects are created through the observations and descriptions of scientists and that these objects have a history of their own. As a scientist describes their object, they shape the reality and perception of it. But how scientists perform these descriptions changes throughout history and so does the object itself. Even though an object like the soil possesses an undeniable reality before it becomes a scientific object "scientific scrutiny nonetheless alters [it] in significant ways."[6] Similarly, Bruno Latour has drawn attention to how a scientific method places a certain lens on its object, which shapes the research's outcome.[7] Specific scientific practices mold the knowledge flowing from them.

Pey-Yi Chu has applied these ideas in her book *The Life of Permafrost: A History of Frozen Earth in Russian and Soviet Science*. She has researched how the scientific object of permafrost, which is a very specific kind of soil,[8] has been understood in different ways throughout its history. She poses the framework as follows: "Scientific objects emerge as people apply questions, theories, and investigative tools and techniques. Their essence and significance change over time as they become embedded in social and scientific practices in different ways."[9] So the questions, theories and techniques help shape the scientific objects

6. Lorraine Daston, "Introduction: The Coming into Being of Scientific Objects," in *Biographies of scientific objects*, ed. Lorraine Daston (University of Chicago Press, 2000), p. 6.

7. Bruno Latour, "Circulating Reference: Sampling the Soil in the Amazong Forest," in *Pandora's hope: Essays on the reality of science studies* (Harvard university press, 1999), 24–79.

8. But, not really. Chu explains how permafrost is still understood in multiple ways, for example as frozen ground, but also as frozen water in the ground, or not even as a physical object, but as a state of cold in which the ground can be.

9. Pey-Yi Chu, *Life of Permafrost: A History of Frozen Earth in Russian and Soviet Science* (University

they research.

In the case of the soil, this means that to understand what the soil *is* to these various scientists, we must look at how the soil is *investigated* by them: "To understand ontology, (...) we must understand epistemology."[10] In other words, we need to look at how soil scientists performed their science. Interestingly, even though Staring and Mulder were speaking about the soil in a scientific context, they did so in a time when soil science as an independent discipline had not yet formalized.[11] Instead, science of the soil was performed in other disciplines, primarily chemistry and geology, and their approach to the soil was fundamentally different from each other.[12]

Two soil traditions

These two historical roots of soil science were at the time called agricultural chemistry and agrogeology. Agricultural chemical analyses of the soil were primarily focused on the soil's ability to support and nurture plant life (mostly crops). The agrogeologists, on the other hand, focused on the characterization and mapping of different soil types and their origin. When these two groups of scientists described, measured, analyzed, and named the soil in significantly different ways, so were their scientific objects, though in reference to the same physical object, not the same. Therefore, the scientific object 'soil' was in fact multiple. It was not one object, but a superposition of multiple perspectives and ideas originating from various origins. Studying the different epistemologies and terminologies from these different scientific backgrounds allows us to learn how the soil, as an historicized scientific object, changed over time.

Moreover, the places where the chemists and geologists performed their research differed substantially. And place, as David Livingstone has described in his book *Putting Science in*

of Toronto Press, 2021), p. 8.

10. Chu, *Life of Permafrost: A History of Frozen Earth in Russian and Soviet Science*, p. 8.

11. The finalized institutionalization of soil science is quite recent. Only in 1957 did Dutch soil scientists Ferdinand van Baren (1905-1975) give a talk titled "The Development of Soil Science into an Independent Science," which Van Baren identified as a development completed at that moment in time. See Ferdinand A. van Baren, "De Ontwikkeling van Bodemkunde tot Zelfstandige Wetenschap" (J.B. Wolters, Groningen, 1957).

12. There were also other disciplines that took an interest in the soil, though to a lesser extent and not so much relating to the origin of soil science. Soil physics and soil microbiology are examples of this. These fields gained importance towards the end of the period I discuss in this thesis.

its Place, greatly affects the scientific process.[13] In his 'geography of science' Livingstone explained how the conduct and content of science are influenced by location on multiple scales. Locally the exact venue of science (laboratories, museums, expeditions, etc.), regionally the cultures of science, and, finally, the exchange and movements of science all press their mark on the creation of scientific knowledge. As such scientific knowledge does not only have a universal aspect to its character, but also a local and particular one.

Locally, the agricultural chemists were at home in the laboratory, where they used experiments as the basis of knowledge production, while the agrogeologists were more prone to produce their knowledge in the field, based upon empirical observatory strategies, like mapping, surveying, and collecting. Regionally, soil scientists Van Baren, Hartemink and Tinker have described in a historical overview of the International Society of Soil Science that there was a specific geographical distribution of agricultural chemists and agrogeologists.[14] In areas that were long-settled and with a high population density, like nineteenth century Western Europe, most available areas were already used for farming. So, the emphasis was on improving the soil conditions for the already existing fields, which is why in Western Europe, agricultural chemistry developed as the primary school of thought. The USA and Russia, on the other hand, were extremely vast countries, with many areas still available for agricultural expansion. So, the question was not so much "How do we improve existing agricultural soils?" but rather "How do we know if this unused piece of land is suitable for agriculture?" And this required a rather different approach that focused more on soil genesis, characterization, mapping, and classification themes, which belonged to the agrogeological school of thought.

So, on multiple scales the chemists and geologists occupied different spaces, which led to a different approach to the soil. Not only did these different places have different effects on how chemists and geologists might have viewed the soil, but there was also an epistemic hierarchy between them. In relation to the circulation and movements of science it is important to consider what knowledge was more readily accepted and in the case of soil science the 'field' and the 'lab' as places of knowledge production played a crucial role in this. The epistemic

13. David N. Livingstone, *Putting science in its place* (University of Chicago press, 2010).

14. Hans Van Baren, Alfred E. Hartemink, and Philip B. Tinker, "75 years the international society of soil science," *Geoderma* 96, nos. 1-2 (2000): 1–18.

valuing of both places is best explained by looking at the history of the lab and the field as places of science.

The lab and the field

Initially, the laboratory was a place for chemical operations exclusively, where the focus usually lay more with commercial production and regulation than scientific research, Catherine Jackson has described in a historiographical overview in *A Companion to the History of Science*, and around 1800 it was simply one of the many places where scientific activities could occur.[15] However, between the 1840s and 1880s there was a laboratory revolution. Chemistry as a discipline had moved into the polite, scholarly world, and the associated laboratories became grander, purpose-built, and associated with all academia; first in Germany and then spreading towards other countries. As such, by 1900 the major scientific disciplines had all taken up institutional laboratories as a defining feature. It would even play a crucial part in the legitimization of scientific knowledge production, "functioning as an essential badge of intellectual—and especially academic—credibility."[16]

The field, then, as a term for a distinct place of knowledge production, came into use around the same time that the laboratory became the standard place for knowledge production, Kohler and Vetter have described in the same *Companion*.[17] It became the categorical other: the not-lab. The badge of academic credibility that the laboratory had obtained originated in its placelessness and associated objectiveness. Placelessness as an epistemic value is extremely dominant in modern science and culture because the knowledge stemming from it must be universal, as the argument goes. With its view from nowhere, the high-status, modern laboratory could remove any outside world chaos, and all experiments could be performed under stringent controls.

The field, on the other hand, was the messy and complex outside world and, obviously, not placeless. It became epistemically inferior to the laboratory as it was not "properly

15. Catherine M. Jackson, "The Laboratory," in *A Companion to the History of Science*, ed. Bernard Lightman (John Wiley & Sons, Ltd., 2016), 296–309.
16. Ibid., p. 301.
17. Robert E. Kohler and Jeremy Vetter, "The field," in *A Companion to the History of Science*, ed. Bernard Lightman (John Wiley & Sons, Ltd., 2016), 282–295.

quantitative, experimental, hypothetico-deductive, and analytically rigorous."[18] In the field, particular knowledge was created, which was connected to notions like observation, non-quantitativeness, subjectivity, and most importantly the past. Field research could serve a post-lab function—testing the universal knowledge produced in the lab in a particular outside-world setting—but it could no longer produce standalone knowledge of equal epistemic value to the laboratory. The physical, epistemic, and institutional border between laboratory science and field science is one of the most important borders in modern science, Kohler has argued in his book *Landscapes and Labscapes.*[19]

But, as Kohler and others have stressed, borders are permeable.[20] Field scientists will often still perform analyses in the laboratory and lab scientists might go out in the field. The field can also be a place of experiment and exact measurement, even though these are research methods associated with the laboratory. The importance of the border, according to Kohler, lies not in the fact that no exchange can happen between the two worlds of lab and field, but that the traffic between them can be properly regulated. These borders are a place of control, rather than a non-crossable line.

There are a few regularities about what constitute laboratory and field spaces, however. Firstly, Kohler and Vetter argue that the meaning of field in science is found in the combination of the characteristic of use and the characteristic of place. Fields are always multipurpose and shared with other users like farmers, hunter, travelers, indigenous people, or landowners, meaning it can be a place of complicated politics. The laboratory, on the other hand, very strictly keeps the 'other' people outside. A consequence of the multiple users in the field is that there is more opportunity for vernacular practices and knowledge to influence the scientific process.[21]

A second characteristic that Kohler and Vetter assign to the field is that "phenomena are studied in the situations in which they normally play out." In the laboratory phenomena are isolated and can be analyzed one variable at a time, whereas in the field phenomena cannot

18. Kohler and Vetter, "The field," p. 282.

19. Robert E. Kohler, *Landscapes and labscapes: Exploring the lab-field border in biology* (University of Chicago Press, 2002).

20. Kohler, *Landscapes and labscapes: Exploring the lab-field border in biology*; Peter Galison, "Buildings and the Subject of Science," in *The Architecture of Science* (London: MIT Press), 1–21; Graeme Gooday, "Placing or Replacing the Laboratory in the History of Science?," *Isis* 99, no. 4 (2008): 783–795.

21. Jeremy Vetter, "The History of Fieldwork," *Histories* 2, no. 4 (2022): 457–465.

be isolated and must be studied in their complete and complex but meaningful situation. But what does it mean to play out *normally*, I wonder. Does it mean without human intervention? Does it mean without scientist intervention? What if, as we find plenty in the history of soil science, farmers are asked to execute an experiment where they test the effects of different fertilizers on crop growth. Is it then a laboratory because agriculture is inherently people intervening in nature? Or is it a laboratory because the scientist told the farmer to perform the experiment? Or is it actually a field, simply because the farmer (a non-scientist user of the space) is there?

Borderlands

Luckily, Kohler has entered some nuance into the discussion by referring to similar situations in the history of biology as hybrid lab-field spaces. These spaces are regions between the cultural spheres of the field and the laboratory, where hybrid phenomena can occur.[22] An example from the history of biology of such a hybrid phenomenon is a natural experiment in the field, where laboratory practices are imported and adapted to field conditions, and as such becomes an equally built and natural environment. An institution where such natural experiments occurred were biological field stations.

Raf de Bont has studied field stations in zoology around the turn of the twentieth century and has explained that, even though this period was signified by a large increase in "urban research institutes that housed industrial-looking laboratories,"[23] there were also zoologists who practiced place-based research and studied nature in field stations. Though their knowledge was in first instance place-based, they tried to develop this to universal knowledge (a laboratory ideal) through a detailed understanding of one place in particular by way of natural experiments ('experiment' being another laboratory ideal). These stations existed on a border space between laboratory and field, between experimental and observation science, between universal and local knowledge.[24] Vetter has similarly described how place-based knowledge from botanical field stations in the US was extended to a larger

22. See Kohler, *Landscapes and labscapes: Exploring the lab-field border in biology*, p. 11-22 or Robert E. Kohler, "Labscapes: Naturalizing the lab," *History of Science* 40, no. 4 (2002): 473–501.
23. Raf De Bont, *Stations in the field: A history of place-based animal research, 1870-1930* (University of Chicago Press, 2015), p. 1.
24. Ibid., p. 207.

scale.[25] Or, rather, how cosmopolitan goals had moved field scientists to reconfigure their local knowledge into a larger global framework, because, again, universal knowledge was deemed more valuable than local knowledge. There was a consistent intention to move the relevance beyond the local.

Several historians of science have applied these theories of a lab-field hierarchy and specifically the borderlands in between to the history of biology, but I would like to extend them to the history of soil science as well. Chemical laboratories and geological fieldwork play an important role in the history of soil science and practices from both come together in places like agricultural testing fields and farms. It will therefore be interesting to look at how these epistemic hierarchies are expressed throughout the history. Therefore, we need to understand how the practices and soil-ideas from both these disciplinary flavors of soil science developed.

Agricultural chemistry

In the early nineteenth century, there was a strong conviction among chemists of what historian Christopher Hamlin has called 'chemico-theology'.[26] This essentially meant that everything was chemistry. Matter was indestructible and therefore all processes were essentially unlimited circulations of the same basic chemical compounds. As such, chemistry could also be applied to everything and one of those things was agriculture. One person who did this very well and influenced the field internationally was the German chemist Justus von Liebig (1803-1873).

Liebig had proposed a 'mineral theory' of the soil, which claimed that plants did not receive their nourishment from the organic part of the soil, which was called 'humus', as was the commonly accepted idea until then, but that plants were fed by water, carbon dioxide, and ammonia, which were all taken up from the air.[27] Other nutrients, like potassium and phosphorus, could be found in the inorganic mineral part of the soil. Since everything re-

25. Jeremy Vetter, "Field stations and the problem of scale: Local, regional, and global at the desert lab," in *Spatializing the History of Ecology* (Routledge, 2017), 79–98.

26. Christopher Hamlin, "Robert Warington and the moral economy of the aquarium," *Journal of the History of Biology*, 1986, 131–153.

27. "Book Reviews," *Annals of Science* 56, no. 1 (1999): 99–109, https://doi.org/10.1080/000337999296562; Richard P. Aulie, "The mineral theory," *Agricultural History* 48, no. 3 (1974): 369–382.

volved around circulation, it was important that the nutrients that were taken from the soil through agriculture were also returned to it. However, because of the increased separation between places of food production and places of consumption due to urbanization, the nutrients were not returned to the soil. This is what Liebig called *Raubbau* and it led to a tradition of agricultural chemists who advocated for creating a connection between urban sewage systems and rural fertilization, as historian Erland Mårald has explained.[28]

Several chemists were influenced by Liebig to counteract this mismanagement of nutrients through proposing recycling systems between sewage and agriculture, including Alexander Müller (1823-1906) in Sweden, James F. W. Johnston (1796-1855) in England, and Charles T. Liernur (1828-1893) in the Netherlands. Liernur had, for example, proposed a pneumatic sewage system, as historian Maarten Meijer has described.[29] In the second half of the nineteenth century, however, artificial fertilizers entered the stage, which was one of the reasons that the recycling between city and farm eventually was abandoned. It was no longer necessary to 'close the loop', as it were, and on the farm "for the first time in history, the problem of the constant shortage of nutrients seemed to have been solved."[30] The ideas of a chemistry-based nutrient management of soils remained however, and it helped manifest the idea behind it that plant growth could be expressed in measurable chemical relationships.

This idea is what human geographer Greta Marchesi has called the 'NPK-mentality'.[31] This NPK-mentality essentially meant that a model of soil fertility existed which allowed for the reduction of complex processes to a handful of clear-cut chemical relationships that could be easily applied in any geographical context, meaning a simple extension into unfamiliar soils such as those of the colonized areas was possible. Marchesi argued that the embedding of the NPK-mentality into the consciousness of the industrial agricultural system led to a

28. Erland Marald, "Everything circulates: agricultural chemistry and recycling theories in the second half of the nineteenth century," *Environment and history* 8, no. 1 (2002): 65–84.

29. Maarten Meijer, "Charles Liernurs pneumatische riool en het besturen van bodems," *De Moderne Tijd* 5, nos. 3/4 (2021): 311–327.

30. Marald, "Everything circulates: agricultural chemistry and recycling theories in the second half of the nineteenth century," p. 80.

31. The NPK-mentality refers to the reduction of the entire soil-plant nourishment system to three compounds: nitrogen (N), phosphorus (P), and potassium (K). See Greta Marchesi, "Justus von Liebig makes the world: Soil properties and social change in the nineteenth century," *Environmental Humanities* 12, no. 1 (2020): 205–226.

"reorganization of capitalist agricultural production" in the mid-nineteenth century.[32]

Moreover, moving the questions around soil nutrient management into the domain of the chemist helped position laboratory-produced knowledge on an epistemological pedestal when compared to other forms of knowledge, including field- and farmer-produced knowledge.[33] Both Meijer and Marchesi attest to this view. Liebig explicitly rejected the "habitual wisdom of farmers"[34] and though there were voices protesting such a callous disregard, like the Dutch chemist Gerrit Jan Mulder (1802-1880), the farmer would lose authority in this field. Meijer explained that the 'modern' science that Liebig contributed to should be understood as an 'epistemological seizure of power', which meant that producers of 'modern' knowledge would be placed in an elevated position. These producers no longer had to consider practical experience or knowledge from rivaling disciplines if these were in conflict with Liebig's 'view from nowhere'.[35] As such the farmer's land slowly became captured by the laboratory's disciplinary tools: standardization, efficiency, and a conceptual disassembly of complex systems.[36]

These were the ideas on the soil that remained prevalent in Western-Europe until the first decades of the twentieth century. Through the organization of international conferences, however, Western-European scientist became familiar with other ideas on the soil, that were more geologically focused and primarily came from Russia.

Agrogeology

In Russia, the soil had long been considered as just an extension of geology, as rocks in a somewhat different form. At the end of the nineteenth century, however, the idea arose that the soil was actually something quite different, with particular characteristics that were different from stone and therefore deserved to be researched as its own entity. One of the

32. Marchesi, "Justus von Liebig makes the world: Soil properties and social change in the nineteenth century," p. 206.
33. Marchesi, "Justus von Liebig makes the world: Soil properties and social change in the nineteenth century"; Meijer, "Charles Liernurs pneumatische riool en het besturen van bodems."
34. "Gewoonte wijsheid van boeren." In Meijer, "Charles Liernurs pneumatische riool en het besturen van bodems."
35. Ibid.
36. Marchesi, "Justus von Liebig makes the world: Soil properties and social change in the nineteenth century."

Russian geologists who performed groundbreaking work in this area was Vasily Dokuchaev (1846-1903). His systems thinking, which regarded phenomena in nature as complex totalities rather than reducible to components, led to new concepts surrounding soil genesis and classification. They were based around the interconnectivity of all the environment's components (including humans), which was a perspective resulting from the immense influence of Alexander von Humboldt's (1769-1859) work and resembled the emerging discipline of ecology.

Historians Catherine Evtuhov and David Moon have provided thorough descriptions on Dokuchaev in relation to his scientific work in soil science, his concept of soil, and the environmental history of the Russian steppes.[37] Moon has shown that in response to several droughts in major agricultural regions of Russia in the 1880s, the Free Economic Society, which was committed to the improvement of agriculture, had commissioned Dokuchaev and a team of Russian scientists to research the Russian steppe soil, called *chernozem* ('black earth'). These soils were extremely fertile, and it was their goal to get an overview of the available natural resources.

Soil maps had become an established way to determine the distribution of natural resources in the nineteenth century. Evtuhov explained, however, that Dokuchaev was critical of the soil maps that had been created thus far. The absence of a system of soil classification, of an understanding of different soil types, and of the associated physical and chemical analyses were three points of criticism that Dokuchaev had expressed towards the Chaslavsky soil map from 1878.[38] Dokuchaev's approach for creating his soil map was localized and place-specific. He and his team performed a cadastral soil analysis, where they took samples of each plot in the region at several feet deep, made detailed notes about their surroundings (relating to relief, meteorological conditions, flora and fauna, and geology), and chemically

37. Catherine Evtuhov, "The Roots of Dokuchaev's Scientific Contributions: Cadastral Soil Mapping and Agro-Environmental Issues," in *Footprints in the soil: People and ideas in soil history*, ed. Benno P. Warkentin (Elsevier, 2006), 125–148; David Moon, "The Environmental History of the Russian Steppes: Vasilii Dokuchaev and the Harvest Failure of 1891," *Transactions of the Royal Historical Society* 15 (2005): 149–174; David Moon, "The Steppe as Fertile Ground for Innovation in Conceptualizing Human-Nature Relationships," *Slavonic & East European Review* 93, no. 1 (2015): 16–38.

38. This was the first soil map of European Russia. A figure of this map can be found in Elena Rusakova, Elena Sukhacheva, and Alfred E. Hartemink, "Vasiliy Dokuchaev–A biographical sketch on the occasion of his 175th birthday," *Geoderma* 412 (2022): 1–19.

analyzed the samples in a St. Petersburg laboratory.

It led to his influential work called *Russkii chernozem* ('the Russian black earth'), which contained one of the most detailed soil maps of the time and received immediate recognition in Russia.[39] It contained his revolutionary ideas relating to the genesis of soils, where different soil types were the result of a process that could be affected by five factors: subsoils, climate, flora and fauna, geological age, and relief of the locality. Dokuchaev now conceptualized the soil as an independent natural and historical body that was something entirely different from the parent material (or bedrock) and had to be researched in its own right, not simply as a part of geology. The soil was no longer static; it had a history that had decided its evolution up to that point and explained its qualities.

An important feature that Evtuhov has identified in the creation of Dokuchaev's work is the intellectual environment that Dokuchaev found himself in at the time. Namely, while he was working at the Free Economic Society, other prominent scientists were working there as well, not the least of which was Mendeleev who was studying the effects of chemical fertilizers on the soil. With meteorologist Voieikov Dokuchaev could discuss the influences of climatic conditions on soil formation, and with his opponent Kostychev he could discuss the relative importance of the organic and inorganic components of the soil. "Dokuchaev's own views developed in a constant exchange with other investigators interested in similar issues,"[40] and these other investigators had a range of different backgrounds from chemistry to geology to ecology.

The soil knowledge that was produced in Russia spread very slowly to the West and it took a long time for Dokuchaev's methods of classification and ideas about soil genesis to reach it. Dokuchaev and his pupils' ideas did reach the Hungarian soil scientists in the first decade of the twentieth century, who then organized the first International Conference of Agrogeology in Budapest.[41] Through this and the following conferences Western-European soil scientists would become familiar with Dokuchaev's ideas. Until that time, however, these

39. A figure of Dokuchaev's soil map from Russkii chernozem can be found in David Moon, *The plough that broke the steppes: agriculture and environment on Russia's grasslands, 1700-1914* (OUP Oxford, 2013).

40. Evtuhov, "The Roots of Dokuchaev's Scientific Contributions: Cadastral Soil Mapping and Agro-Environmental Issues," p. 130.

41. István Szabolcs, "The 1st International Conference of Agrogeology, April 14-24, 1909, Budapest, Hungary.," *Advances in GeoEcology*, no. 29 (1997): 67–78.

Western Europeans were mainly influenced by the ideas of agricultural chemistry, and this was no different for the Dutch protagonist of my thesis.

David Jacobus Hissink

The focus of my thesis lies on the works of Dutch chemist David Jacobus Hissink (1874-1956). Hissink was a prominent figure in both national and international soil science. He was a chemist by education and would become the director of several State Agricultural Experiment Stations (*Rijkslandbouwproefstations*) in the Netherlands throughout his life. His final place of employment was as the director of the Soil Institute in Groningen from 1926 until 1939, which was at the time the central place for physical and chemical research of the soil.

Internationally, Hissink played a big role in the foundation of the International Society of Soil Science (ISSS), which was an important step in bringing the two communities of chemists and geologists (and others) together. After its foundation, Hissink continued to be of great importance to the society, functioning as its Secretary-General until 1950. In the year of his retirement as Secretary-General, the fourth international congress was held in the Netherlands (the first one after the Second World War) as a token of gratitude towards Hissink.[42] Being the strong networker that he was, Hissink was in close contact with both the national and international soil scientific community.

Different places, different players

Throughout Hissink's life, he worked at a variety of institutions, both in the lab and in the field. He therefore experienced various scientific cultures when researching the soil, according to Livingstone's assessment of the role of 'venue' in scientific knowledge production. By being employed at different localities, we can assess the effect of these different places on Hissink's soil conceptualization.

Moreover, this was a period of institutionalization, internationalization, and standardization, meaning that his interactions with the soil itself and other players in the field were changing, leaving a mark on his soil concept. These other players were agricultural chemists

42. S. Tovborg Jensen, "Dr. D. J. Hissink, In Memoriam," *Plant and Soil* 8, no. 1 (1956): 1–3.

from other countries, scientists from other fields like agrogeology, or people from outside the sciences like farmers. Hissink, as an active member of national and international communities, provides us with an interesting point of entry into the history of the scientific object soil.

The central question of my thesis then is: "How did Hissink's understanding of the soil develop throughout this period of internationalization, institutionalization, and standardization, while under the influence of an epistemic hierarchy between the lab and the field?" This will allow us to further understand how scientific knowledge is situated in a cultural, historical, and environmental context rather than being disembodied from society.

Structure of this thesis

I have applied the ideas from STS, Daston, and Chu to Hissink's understanding of soil. As Chu said, by focusing on Hissink's epistemological approach to the soil I have tried to derive his soil ontologies. I have researched the development of Hissink's soil concept by focusing on his terminology when referring to the soil as well as the methodology with which he researched the soil in his own published works. These works were mainly published in Dutch scholarly and trade journals like *Chemisch Weekblad*, *De Indische Mercuur*, *Landbouwkundig Tijdschrift*, and private publications. My thesis is divided into three chapters that refer to the three different kinds of institutions he worked at.

Hissink's first experience with the soil was at the Botanical Garden in Buitenzorg, Java (1899-1904). In Chapter 2, I will discuss that he landed in a fully set up system of agricultural experiment field research through fertilization experiments. The field-nature of the research meant that the knowledge produced was too local to Hissink's liking, however, and he tried to produce larger-scale knowledge through chemical analyses in the laboratory. Though these analyses had more epistemic potential to Hissink, the methodological developments were not where he wanted them to be. I will show how both kinds of research contributed to a view of the soil as nutrient infrastructure, shuttling nutrients from fertilizer to plant, and complied to what Marchesi described as the NPK-mentality. Finally, Hissink's yearning for larger-scale knowledge also led him to search for regional regularities among soil types.

He then returned to the Netherlands to work at State Agricultural Experiment Stations

Goes (1904-1907) and Wageningen (1907-1916). During most of this period he was the director of these Stations, but to his own dismay he had to focus a lot of his time on monitorization and quality control, which was the primary task of the Stations. Much of his soil research was therefore related to methodological developments. But I will show that Hissink's soil was also influenced by the Dutch environment, by international exchanges, and by interdisciplinary exchanges. All of these factors eventually led him to consider the structural buildup of the soil and approach it reductionistically by trying to find the soil component that represented its fertility or absorbing essence. Moreover, it also created the 'Soil Story', where the soil had become an entity with a beginning and conclusion to its life.

After a reorganization of the Experiment Stations' tasks in 1915, Hissink moved to Groningen, where now the scientific soil research was centralized. Hissink would be employed here until 1939 (also founding his world-renowned Soil Institute in 1926), but Chapter 4 will end in 1924 with the foundation of the International Society of Soil Science. In this period, the internationalization of soil science was continued, further pushing the soil's move from local to global. Nationally, Hissink also moved away from local knowledge and practices as his ties with the farming community weakened. I will show how both factors meant that there was much less room held for local knowledge in the scientific process or for local characteristics in Hissink's soil. Finally, the geologically influenced ideas on the soil's transformation became recontextualized in the specific context of the Dutch environment in combination with Hissink's agricultural chemistry.

2 Buitenzorg (1899-1904)

To understand the origins of Hissink's concept of soil, we must look at the places where he first researched it. I will begin with a description of Hissink's chemical education, which set him up with a laboratory centered view of knowledge production. He started his career as a chemist at the Botanical Garden in the Dutch Indies, which was an important and influential center of knowledge production. The Garden performed a lot of agricultural research, and Hissink himself focused on the development of Deli-based tobacco cultivation. Through his work at the Garden, I will argue that a view of the soil as nutrient infrastructure started to form in Hissink's mind. Namely, the primary way he approached the soil was through in-the-field fertilization experiments, which regarded the soil as a medium for nutrients from fertilizer to plant.

Though the fertilization experiments had classical laboratory features, their field-nature meant that the knowledge derived from them was more local than Hissink liked. They could only tell him which fertilizers one specific plantation needed and did not even go into the question why. I will show that he was frustrated with the fact that these field experiments did not produce knowledge of sufficient scientific value. To obtain knowledge that was of a larger scale, and therefore epistemically more valuable to Hissink, he moved back to the laboratory. Here, he researched the chemical and physical 'nature' (*geaardheid*) of the soils on which the fertilization experiments were run. The methods available to him had their own issues in regards of accuracy, but the general idea was to obtain knowledge about the connection between fertility and the chemical nature of the soil. He assessed whether a low occurrence of a plant nutrient in the soil also meant that the soil was 'in need of' (*behoefte hebben*) that same nutrient in the form of fertilization. The answer generally seemed to be 'yes' and the rhetoric was in line with the prevalent NPK-mentality and Hissink's view of the soil as nutrient infrastructure.

But still the knowledge was very local, and I will show that Hissink started to think about whether it was possible to extend soil knowledge towards a larger region. Namely, the soils in Deli were classified into regional types. Hissink worked on finding chemical and physical regularities within a specific soil type, though he found that between soils of the same type considerable differences could occur. The upscaling from the local character of soils did not come about easily. Hissink's final remarks before moving back to the Netherlands was that much more scientific research into these soils was necessary.

2.1 Introducing David Jacobus Hissink

'Pure' chemical education

David Jacobus Hissink was born in 1874 in Kampen, the son of a municipal secretary, and started his education in 1893 at the University of Amsterdam, where he studied chemistry.[43] Hissink mostly learned the ways of the laboratory during his study and did not engage with science of the soil. However, his dissertation supervisor did have some connections to the world of agricultural chemistry.

Namely, Hissink became a pupil of H. W. Bakhuis Roozeboom (1854-1907), who had become professor of chemistry in Amsterdam in 1896. Before Bakhuis Roozeboom became a professor of chemistry, he worked for J. M. van Bemmelen (1830-1911) in Leiden by helping him with the analysis of soil samples from the recently drained IJpolder in 1873 and later became a student of his. Van Bemmelen was a chemist that made important contributions to agricultural chemistry through his research on colloid chemistry and is one of the most cited sources of Hissink in his later soil-related work. It is possible that Hissink became aware of Van Bemmelen's work and his association with agricultural chemistry through Bakhuis Roozeboom. Van Bemmelen had played a big part in the success of Bakhuis Roozeboom's career.[44]

Besides this possible connection to science of the soil, when Hissink promoted under the supervision of Bakhuis Roozeboom, the latter was primarily working on mixed crystals.[45] Bakhuis Roozeboom expected that his work on phase theory and mixed crystals would

43. W. Reinders, "Dr. D. J. Hissink," *Chemisch Weekblad* 26, no. 48 (1929): 582–586.

44. W. P. Jorissen and W. E. Ringer, "H. W. Bakhuis Roozeboom," in *Mannen en Vrouwen van Beteekenis in onze dagen* (Haarlem: H.D. Tjeenk Willink & Zoon, 1907), 155–219; Harry A. M. Snelders, "Bakhuys Roozeboom, Hendrik Willem (1854-1907)," in *Biografisch Woordenboek van Nederland* (Amsterdam: Huygens ING, 2013), accessed February 13, 2023, http://resources.huygens.knaw.nl/bwn1880-2000/lemmata/bwn1/bakhuys.

45. Mixed crystals were at the time defined as "homogenous crystals, consisting of two components, that together act as one phase." See *Mengkristallen*, in *Oosthoek's geïllustreerde encyclopaedie*, 1st ed., vol. 8 (Utrecht: A. Oosthoek, 1922), 157.

be of great importance to the fields of technical chemistry and geology, and historian Harry Snelders states that it did.[46] Hissink's dissertation topic, moreover, had potential connections to mineralogy.[47]

Regardless, in a memorial publication of *Chemisch Weekblad*, one hundred years after Bakhuis Roozeboom was born (and forty-seven after he died), Hissink did not indicate any connection between his education with Bakhuis Roozeboom in Amsterdam and his later work on the soil.[48] Hissink's friend from his time in Amsterdam, Willem Reinders (1874-1951), similarly described Hissink's time in Amsterdam as being based around 'pure' chemistry, which was, according to Reinders, left behind as Hissink moved to Buitenzorg to focus on science of the soil.[49] What Hissink at least did take with him from his Amsterdam research was a highly fundamental, laboratory state of mind.

The Botanical Garden

After working as a teacher for a few months, Hissink was appointed as a chemist at the Botanical Garden (*'s Lands Plantentuin*) in October 1899 in Buitenzorg (now Bogor, Indonesia).[50] Even though it was called a botanical garden, historians like Harro Maat and Robert-Jan Wille have shown that it was much more than that.[51] The Garden was a center

46. Snelders, "Bakhuys Roozeboom, Hendrik Willem (1854-1907)"; Harry A. M. Snelders, *De geschiedenis van de scheikunde in Nederland: Deel 1: Van alchemie tot chemie en chemische industrie rond 1900* (Delftse Universitaire Pers, 1993), 155.

47. Reinders, "Dr. D. J. Hissink."

48. D. J. Hissink, "Enige herinneringen uit de jaren 1896 tot januari 1900 aan mijn leermeester prof. dr. H. W. Bakhuis Roozeboom," *Chemisch Weekblad* 50, no. 44 (1954): 756–757.

49. Reinders, "Dr. D. J. Hissink."

50. "Wetten, besluiten, benoemingen, enz.," *Nederlandsche staatscourant*, August 1899, accessed March 6, 2023, https://resolver.kb.nl/resolve?urn=MMKB08:000172462:mpeg21:p001; "Wetten, besluiten, benoemingen, enz.," *Nederlandsche staatscourant*, November 1899, accessed March 6, 2023, https://resolver.kb.nl/resolve?urn=MMKB08:000172352:mpeg21:p002; "Academie- en schoolnieuws," *Provinciale Overijsselsche en Zwolsche courant*, October 1899, accessed March 6, 2023, https://resolver.kb.nl/resolve?urn=MMHCO01:000074528:mpeg21:p007.

51. Harro Maat, *Science cultivating practice: A history of agricultural science in The Netherlands and its colonies 1863–1986* (Wageningen University and Research, 2001); Robert-Jan Wille, "The Coproduction of Station Morphology and Agricultural Management in the Tropics: Transformations in Botany at the Botanical Garden at Buitenzorg, Java 1880–1904," *New perspectives on the history of life sciences and agriculture*, 2015, 253–275; Robert-Jan Wille, "From Laboratory Lichens to Colonial Symbiosis. Melchior Treub Bringing German Evolutionary Plant Embryology to Dutch Indonesia, 1880–1909," *Studium: Tijdschrift voor Wetenschaps-en Universiteitsgeschiedenis* 11, no. 3 (2018): 191–205. See also Andrew Goss, "Treub's Beautiful Science," in *The floracrats: State-sponsored science and the failure of the enlightenment in Indonesia* (The University of Wisconsin Press, 2011), 59–76; Robert-Jan Wille, *Mannen van de microscoop: De laboratoriumbiologie op veldtocht in Nederland en Indië, 1840-1910* (Vantilt, 2019).

of knowledge and scientific research entrusted with the task to research, develop, and improve agriculture in the Dutch Indies. Under the directorship of Melchior Treub (1851-1910) the Garden had developed into an imperial and global force, becoming the biggest scientific institute of the entire Dutch empire in 1900. Rather than simply being a garden, it had become a laboratory complex, where scientific research and application to societally relevant fields like agriculture and forestry went hand in hand.

Namely, the evolutionary principles of Charles Darwin had become accepted by a first generation of biology students, of which Treub was part, and this had led to "a new perception of the relation between biology and agriculture. Agriculture was viewed as an area where natural processes developed in artificial conditions."[52] The idea allowed for the perception that it could be a field for biological research and formed the basis of the philosophy behind agricultural experiment fields. Influencing growth conditions through, for example, fertilization experiments was "considered a cultural mirror image of the process of evolution".[53] Moreover, during the 1880s an agricultural crisis had given incentive to the plantation owners to invest in agricultural research and provide land for experiment fields to the Garden.

So, when Hissink arrived at Buitenzorg in 1899 to work at the eight department for laboratory research related to Deli-cultivated tobacco, a network of cooperation between plantation owners and a far-reaching, influential scientific community at the Botanical Garden had long been set up. Moreover, a whole range of agricultural experiment field plans were already laid out by his predecessor, A. van Bijlert (1864-1925), for Hissink to execute. It meant that Hissink's first scientific encounter with the soil was through fertilization experiments at an institution with a tradition of borderland field experimentation.

2.2 Fertilization Experiments

The fertilization experiments that Hissink performed in Buitenzorg were highly structured, quantitative, one-variable-at-a-time experiments that were executed in-field and in-farm, and were influenced by local users, local knowledge, and local environments. These experiments

52. Maat, *Science cultivating practice: A history of agricultural science in The Netherlands and its colonies 1863–1986*, p. 67–68.
53. Ibid., p. 181.

found themselves on the borderlands between laboratory and field science, but what was notably different from Kohler's field biologists entering such a space, is that Hissink was a laboratory chemist. In other words, he approached the borderland from the other side and therefore had a substantially different experience. Whereas Kohler's biologists essentially tried to find legitimization for their field research by creating hybrid structures, for Hissink the local character of the hybrid structure he had entered was a fundamental problem.

As was pointed out, Hissink did not start or design these experiments himself: his predecessor Van Bijlert had published a detailed plan on how the fertilization research should be executed in Deli in 1899.[54] When Hissink started his rounds of fertilization experiments in 1900, his execution only swayed in small details from Van Bijlert's proposal and would remain the same throughout his employment (Figure 1). Fertilizers that Hissink would use on the testing fields included green manure, guano, and various combinations of nitrogen, phosphorus, and potassium sources. One of the fields would always remain unfertilized to serve as the control group, a technique associated with the laboratory.

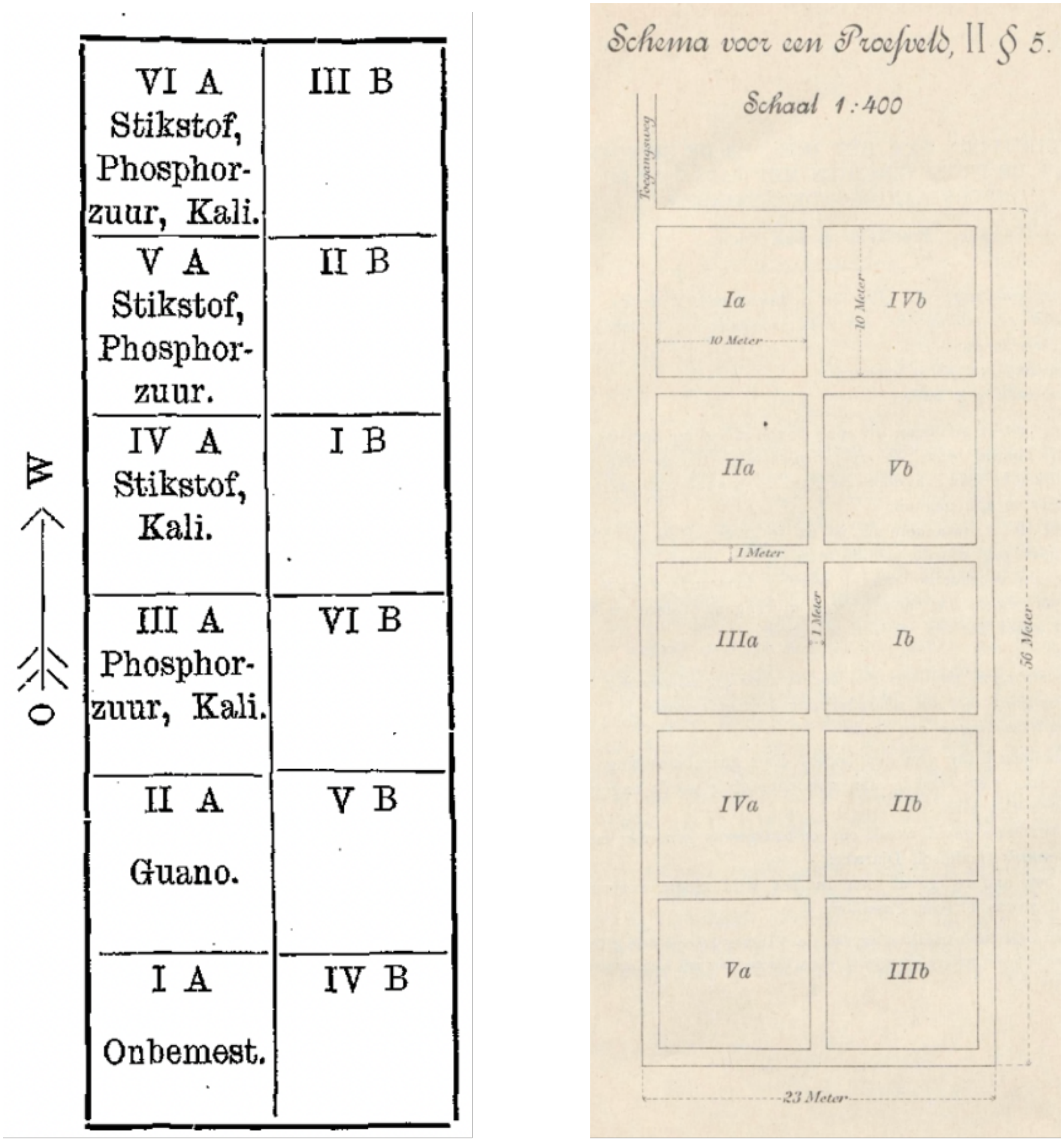
Nutrient infrastructure

Fertilization experiments essentially compared the effect of different fertilizers on the amount and quality of tobacco cultivated in a specific place. Their philosophy was largely based on Liebig's law of the minimum, which Van Bijlert described as meaning that the harvest size will depend on the 'plant-feeding component' of which the least amount is available to the plant.[55] For example, if the soil did not contain enough phosphorus, then it did not matter how much nitrogen you added through fertilizers, the harvest would not increase. The rhetoric strongly revolved around what Marchesi called Liebig's NPK-mentality (Chapter 1), though sometimes the number of plant-nutrients that mattered was fourfold and also contained lime (Ca) next to the usual nitrogen (N), phosphorus (P), and potassium (K). Either way, the experimental setup revolved around the assumption that plant growth was reducible to the availability of a few chemical components in the soil.

When these nutrients were not available to plants, it could lead to a soil that was 'ex-

54. A. van Bijlert, *Plan van eenige proefvelden in Deli gedurende 1899 betreffende de tabakscultuur* (Batavia: G. Kolff & Co., 1899).

55. Ibid., p. 40.



(a) (b)

Figure 1: a) The layout of a typical fertilization experiment setup from Hissink. I A, I B: unfertilized. II A, II B: fertilized with guano. III A, III B: fertilized with phosphoric acid and potassium carbonate. IV A, IV B: fertilized with ammonium nitrate and potassium carbonate. V A, V B: fertilized with ammonium nitrate and phosphoric acid. VI A, VI B: fertilized with ammonium nitrate, phosphoric acid, and potassium carbonate. From: D. J. Hissink, "Verslag van de op Deli met betrekking tot de tabakscultuur genomen bemestingsproeven op proefvelden in het jaar 1901," *Mededeelingen uit 's Lands Plantentuin* 60 (1902): p. 40.
b) Van Bijlert's example setup for a fertilization experiment. The different Roman numerals indicate different fertilizers. The 'a' and 'b' refer to the two rows that are created to account for local fluctuations. From: A. van Bijlert, *Plan van eenige proefvelden in Deli gedurende 1899 betreffende de tabakscultuur* (Batavia: G. Kolff & Co., 1899), p. 15.

hausted' (*uitgeput*) and is also in line with Liebig's concept of *Raubbau*: agricultural activities lead to a kind of soil decay that essentially meant a decrease in plant-nutrients. Notably, this kind of decay was very different from the soil decay that we will learn of in Chapter 3, where soil decayed (died) into not-soil. In this case, however, an exhausted soil simply needed fertilizers. What the shortage in the soil was exactly, was essentially the question of fertilization experiments.

These fertilization experiments led to a view of the soil that I call 'nutrient infrastructure'. Namely, a good soil, according to Hissink was characterized by the fact that it was adept at absorbing dissolved nutrients from fertilizers, "such that the fertilizer-solution that runs through the soil comes out much poorer in these nutrients."[56] Permeability and absorbability were two soil characteristics involved in its nutrient transport-abilities. A good soil did not necessarily already have all necessary plant-nutrients, but it did have good permeability, such that the plant-nutrients could reach the appropriate soil layers.[57] It also had good absorbance such that the nutrients were actually held onto by the soil and not flushed out. But, also not held onto too tightly, that they were not available for the plant. There was a perfect balance in the soil between holding onto nutrients and releasing them such that it acted as a medium guiding the nutrients from fertilizer to plant.

Local soils, local knowledge

However, there was more soil knowledge involved in the experiment's design than simply its functioning as nutrient infrastructure. As the experiment was situated in the field, a lot of vernacular knowledge came into play. But, more than that, the experiment actually *required* it. Namely, these fertilization experiments were not executed by the Garden's chemists themselves. According to Hissink, the Garden's chemists should merely be involved in the research through assisting the planters or administrators in designing the experiment. The responsibility of the execution was put entirely with the planters, and therefore both Van Bijlert's proposal and Hissink's own *Plan for the Fertilization Experiments* were full of

56. "Zoodat de doorfiltreerende oplossing veel armer aan deze stoffen weer uit de bodem tevoorschijn komt" in D. J. Hissink, "Over het gehalte aan zwavelzuur (SO3) in de op Deli gebruikelijke meststoffen," *Teysmannia* 12 (1901): 569–581.
57. Ibid.

regulations and advice to the planters.[58]

Before the start of the experiments in 1901, Hissink had travelled to Deli in January to discuss with the planters which terrain would be appropriate for the experiments. It was important that the space which would be allocated as the testing field was homogenous in its top- and subsoil across the field, to minimize the effects of local fluctuations on the experiment's results. Moreover, the soil should also not be too fertile, because then the effects of the fertilizers might be minimal and not measurable. Whether there had been enough rainfall was also a judgment that was left with the planters: some experiments started later than others, because the necessary rain still had to come. Afterwards they decided together with the scientist, based on whether the tobacco had developed 'normally', whether the experiment was sufficiently successful that scientific conclusions could be drawn from them.[59]

These are all points where the planter's local knowledge was required in the experimental setup and even considered more important by Hissink than any scientific knowledge:

> "It would be ideal to acquire a piece of soil, that is completely homogenous everywhere. More than to any chemical and physical research of the soil, we should depend on the instructions from the practical farmer. He sees every year the state of his crops and can derive from that, which parts are more, and which are less homogenous."[60]

The soil had an inherently local character, which necessitated the use of local knowledge.

It was not just the planters who influenced the scientific process. Hissink always directed his messaging at the 'gentlemen administrators and assistants,' who performed the land management and administrative record keeping. However, the actual ploughing, sowing,

58. D. J. Hissink, "Verslag van de op Deli met betrekking tot de tabakscultuur genomen bemestingsproeven op proefvelden in het jaar 1900," *Mededeelingen uit 's Lands Plantentuin* 55 (1902); D. J. Hissink, *Plan voor de Bemestingsproeven op Deli gedurende 1902* (Buitenzorg, 1902); Bijlert, *Plan van eenige proefvelden in Deli gedurende 1899 betreffende de tabakscultuur.*

59. D. J. Hissink, "Verslag van de op Deli met betrekking tot de tabakscultuur genomen bemestingsproeven op proefvelden in het jaar 1901," *Mededeelingen uit 's Lands Plantentuin* 60 (1902).

60. "Het ideale geval is wel een stuk grond te verkrijgen, dat overal volkomen homogeen is. Meer dan aan een scheikundig en natuurkundig onderzoek van den bodem dient hierbij gehecht te worden aan de aanwijzingen van den practischen landbouwer. Die ziet telken jare den stand zijner gewassen en kan daaruit afleiden, welke gedeelten wel, welke minder gelijksoortig zijn." In ibid., p. 12.

fertilizing, and harvesting—the actual execution of the experiment—was done by plantation workers, who were mostly Javanese women.[61] Hissink was aware of the fact that so many different people were working on the experiment and noted that it was important that the execution on all fields should be precise and equal, for which reliable (European) supervision was crucial.[62]

The local character of the soil did not just mean local knowledge was necessary as input, it also meant it was the output of the experiment. Hissink would regularly stress that the results of the fertilization experiments were mainly useful for the administrator of the location of that particular experiment. They could not be applied to other locations, because they reflected the specific circumstances of *that* climate, *that* soil, and *that* crop. This was frustrating to him and an unattractive aspect of the research he was doing. On the fertilization experiments from 1900 he noted that, though they might be helpful to point in the right direction, the results could absolutely not be used to draw any universal conclusions from.[63] Hissink was unimpressed with the scientific value of these experiments, which was entirely because of their local character.

So, while these fertilization experiments were laboratory-like in structure and analysis (all fields had to be roughly the same, the tobacco growth and quality could be quantitatively measured, there were control groups, the one variable tested was fertilizer), the local quality that was associated with field research meant that Hissink felt he was not doing science in the proper sense. As Kohler and Vetter pointed out, what gave the laboratory such epistemic superiority was placelessness. Therefore, the localness of fertilization experiments led to a devaluation of the knowledge produced as far as Hissink was concerned. However, Hissink did attempt to produce universal knowledge of some sort through laboratory analyses of soil samples. Though these came with issues of their own.

61. Hissink, *Plan voor de Bemestingsproeven op Deli gedurende 1902*; R. T. M. Guleij, "Inventaris van de kaarten en tekeningen behorend tot het archief van de Deli Maatschappijen en de Waterleiding Maatschappij Ajer Beresih NV," Nationaal Archief, last modified February 21, 2022, https://www.nationaalarchief.nl/onderzoeken/archief/4.DELI.

62. Hissink, "Verslag van de op Deli met betrekking tot de tabakscultuur genomen bemestingsproeven op proefvelden in het jaar 1901," p. 4–9.

63. Hissink, "Verslag van de op Deli met betrekking tot de tabakscultuur genomen bemestingsproeven op proefvelden in het jaar 1900"; Hissink, "Over het gehalte aan zwavelzuur (SO3) in de op Deli gebruikelijke meststoffen"; D. J. Hissink, "Over het chloorgehalte van op Deli voor de tabakscultuur gebruikelijke meststoffen," *Teysmannia* 9 (1901): 478–486.

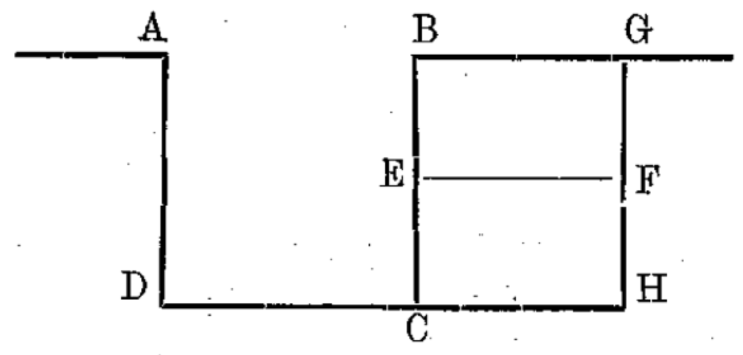


Figure 2: The instructions on how to take the soil samples for the soil analysis. First a hole had to be dug of 50 centimeters deep and 0.5 meters wide (ABCD). Then at 25 centimeters deep (BE) a chunk of soil needed to be taken out (BEFG); this was the topsoil sample. The remaining chunk of soil (CEFH) was the subsoil sample. From: D. J. Hissink, "Verslag van de op Deli met betrekking tot de tabakscultuur genomen bemestingsproeven op proefvelden in het jaar 1900," *Mededeelingen uit 's Lands Plantentuin* 55 (1902): p. 55.

2.3 Chemical Characterization

In all three rounds of fertilization experiments (1900, 1901, and 1902), the experiments were accompanied by an analysis of the physical and chemical nature of the soil on which the fertilization experiments were run. This research was conducted in Buitenzorg, at the laboratory of the eigth department, but the sampling was of course done on the plantations themselves. The samples for this research were taken by someone from the Garden, but in 1902 Hissink noted that in the future the planters will have to sample these themselves. He provides instructions on how to do so, because "a unanimous procedure is highly desirable" (Figure 2).[64]

Laboratory characterization

The goal of the chemical characterization was essentially to find connections between the chemical characteristics of the soil and its fertilization needs.[65] Fertilization experiments did not only take a long time (an entire harvest) to find out the needs of the soil, but they were also very empirical. The expectation (or desire) of the chemical characterization was to

64. Hissink, "Verslag van de op Deli met betrekking tot de tabakscultuur genomen bemestingsproeven op proefvelden in het jaar 1900," p. 55.

65. Soil characteristics that were analyzed included water content and capacity, humus, total nitrogen, phosphoric acid (P_2O_5), potassium (K_2O), and in some years also lime, sulphuric acid, and magnesia.

achieve better theoretical understanding of when and why the soil desired a specific fertilizer.

Unfortunately, soil chemistry was not in a great place, according to Hissink. On multiple occasions, he commented on the fact that he was unimpressed with the state of the field. There was no agreement on sample preparation, on methodology of the experiment, or even on the purpose of the experiment. Chemical extractions were, for example, one method of soil analysis through which the chemist would determine the quantitative presence of certain plant nutrients in the soil. But there was a wide variety of methods used to measure the presence of the same compound that, when compared, gave varying results. The chemists were still assessing and building on each other's methods, adding their own personal adaptations to some and commenting on the inaccuracies of others. It meant that methodological unity was hard to find.

Moreover, there was disagreement on the goal of extractions: should they aim to produce a solution comparable to plant root excretions (and in that way extract from the soil what the plant would extract), or should they aim to extract the total amount of a certain plant nutrient (even if that might be more than was in reality available for a plant)? The problem with the former, according to Hissink, was that chemists would use one solution of comparable strength to a certain plant root acid. However, he pointed out that plants differ from each other and that some plants might extract different nutrients from the soil than others. Hissink said it will never be possible to create a solution that corresponds to *all* plants in *any* climatic circumstance. He therefore favored the extraction of all nutrients from the soil with very strong acids: even though this method did not represent the nutrients available for the plant, it also did not pretend that it did.

In 1903, when Hissink had just returned to the Netherlands, he noted that at that point there was such a large variety of soil research methods that they were "far from obtaining a scientific method" and chemistry was unable to provide a complete understanding of the soil.[66] However, the purpose of the chemical soil analysis points us towards Hissink's desire for upscaling his knowledge. He wanted to study and understand the character of an entire soil type: "When through previous studies the character of a soil type is established, other

66. D. J. Hissink, "Onderzoek van Deligronden," *Landbouwkundig Tijdschrift*, 1903, 405–416, 439–443.

soils of the same type, in the same region, and serving the same crop, can be compared."[67] These soil types form the final piece of Hissink's understanding at this point.

Soil types

Soils were divided up into different categories. And, though at this point I do not believe we can speak of a sophisticated classification system, there was a certain descriptive set of words in use. These descriptive words include phrases like "black, humus-like, weathered ground", "red-brown weathered ash layer", or "red hill ground." The classes that were used, seem to be derived from local practices. In 1901, Hissink constructed a soil type map, which was based on sketches from the Deli plantation administrators of their own land broadly indicating the main soil types, that the administrators were asked to send to the Garden. The map (Figure **??**) shows five different soil types: 1) paja ground; 2) clay, sand, and mixed ground; 3) black ground; 4) chocolate colored ground; 5) red hill ground. I have not been able to indicate the origin of these names for the different soil types, but it does not seem to be the case that they were based on a chemical or physical understanding of the soil; the only somewhat geological knowledge that was involved in their classification was related to possible volcanic origins.

Rather, the soil types were already established as fact, and now Hissink is researching how they chemically or physically differentiate from each other. It led to statements like "black grounds contain a high amount of nitrogen and are little grateful for a nitrogen fertilization,"[68] but also "the black ground in Padang Boelan contains a low amount of potassium when compared to other black ground."[69] So, not all soils from the same type were necessarily equal. Hissink concluded more scientific research ought to be done to achieve proper understanding of these different soil types. It does show that Hissink understands soils to have regional identities that differ chemically and physically from each other.

67. "Indien door breede voorafgatnde studies het karakter van een grondsoort is vastgesteld, kunnen andere gronden van hetzelfde typus, gelegen in dezelfde streek en dienende voor dezelfde cultuur, hiermede en verder onderling vergeleken worden." In Hissink, "Onderzoek van Deligronden," p. 442.

68. "De zwarte gronden wijzen een hoog stikstofgehalte aan en zijn weinig dankbaar voor eene stikstofbemesting." In Hissink, "Verslag van de op Deli met betrekking tot de tabakscultuur genomen bemestingsproeven op proefvelden in het jaar 1900," p. 61

69. "De zwarte Padang Boelan-grond bevat, in vergelijking met de andere zwarte gronden, een zeer laag gehalte aan kali; uit de bemestingsproef bleek eene kalibemesting allernoodzakelijkst te zijn." In ibid.

2.4 Conclusion

Hissink met the soil in a scientific context through the fertilization experiments that he would perform for the Botanical Garden in Buitenzorg. These field experiments are interesting borderlands. On the one hand their design speaks of a kind of labscape, where we find a high degree of control. As much as possible, everything was kept the same, and the only variable that was changed and tested was the fertilizer applied to the land, allowing for cause-and-effect kind of statements between fertilizer application and crop growth. On the other hand, the place-based side of the field research meant that local knowledge was both involved in the experiment design as well as the product of the experiment.

This local character of the research was something that Hissink wanted to move away from. One side of this was trying to answer the same question the fertilization experiments did, but through pure laboratory research. He was trying to find a connection between the chemical composition of the soil and its fertilization needs as indicated by the fertilization experiments. If such a connection could be clearly defined, harvest-long in-field experiments could be replaced by a single soil sample analysis. Unfortunately, the state of chemical methodology development was at this time not 'scientific' enough that Hissink deemed it reliable. Another move away from the local was the upscaling of the soil knowledge towards the regional. A regional classification system was in place and Hissink was looking for chemical and physical regularities within a soil type. This endeavor did not seem to be so straight-forward, and the local variations of the soil were hard to shake.

Finally, all of Hissink's approaches to the soil underlined an understanding of it as nutrient infrastructure, which is closely related to Liebig's NPK-mentality. The questions all revolved around how the soil moves nutrients around, picking it up from the fertilizers and eventually offering it up to the plant. How to approach the question of what the soil 'desired' was still under development.

3 Goes and Wageningen (1904-1916)

After Hissink moved back to the Netherlands, he came to work in a different research environment, had to deal with a different natural environment, and, through international exchanges, became aware of different research directions related to the soil. His soil-concept, consequently, made a considerable transformation. While the agricultural relevance of the soil remains throughout, the soil itself transforms from a *function* as nutrient infrastructure to an *entity* with a story.

First, I will explain how the State Agricultural Experiment Stations that Hissink comes to work at are mainly focused on monitorization tasks for agricultural products. I will argue that the station's existence as a service for agriculture coincided with a view of the soil as in service of plants. The focus that Station scientist had to put on fertilizer research perpetuated the 'nutrient infrastructure'-view of the soil. A new area of research entered the scene when a massive storm in 1906 flooded large areas of Zeeland. I will show that this led Hissink down the path of researching soil absorbability and its relation to fertility. It meant Hissink started to move closer to the structural build-up of the soil, but as he was doing so, struggled with how complex the soil was. This complexity of the soil necessitated a reductionistic approach to it and I will show how this was expressed in Hissink's laboratory research of the soil, where the soil became completely abstracted to single characteristics, such that single variables could be investigated.

Then, from 1908 onward, Hissink became more engaged with the international community. He went on a study trip through Germany, he went to an International Agrogeology Conference, and he became active in various soil commissions and an international soil journal. He started to regard the soil more in terms of its 'character' and its 'needs' and furthered his research on the absorbability quality of the soil. In line with the reductionistic approach, he discussed ideas from other scientist on the specific part of the soil that carries this quality of absorbance. It led him towards an appreciation of the colloidal particles in the soil, which were considered to be the active, life-giving parts of the soil and carried a certain vitalism as they did in the field of biochemistry. Another big item on the international agenda was standardization. While it was certainly not achieved in this period, I will show that both the localness of methods and of soils became more and more problematic. There was a desire to move to universal methods and a universal understanding of the soil.

Finally, I will show how all of these developments culminated in the Soil Story. The soil became an entity, for Hissink, that had an origin and a conclusion. I will argue that these ideas about the story of the soil came from the geological soil community, though Hissink reconfigured it in a specifically chemically and agriculturally focused context, which revolved around absorbance. The absorbing character of the soil colloids was what distinguished soil from rock, and the death of a soil then meant it could no longer absorb the nutrients necessary for agriculture. By virtue of the humid Dutch climate, Hissink had learned that large amounts of precipitation caused a leaching out of nutrients. The eventual emptying of the soil by rainwater together with the notion that soil colloids eventually had to return to their crystalline state, and become rock again, meant that the soil could not exist forever.

3.1 Monitorization and Quality Control

In the Netherlands, the first steps towards structural agricultural research were taken in 1877 by establishing a State Agricultural Experiment Station (*Rijkslandbouwproefstation*) in Wageningen.[70] The primary purpose of this station was the monitorization and quality control of fertilizers, animal feed, and crop seeds, and to advise farmers on their use.[71] It was a period where new agricultural products flooded the market from every corner and farmers needed protection from scams and counterfeits. In addition, an agricultural crisis arose in the 1880s because of an increased global trade network that brought all sorts of agricultural products (mainly American grains) to European ports at lower prices than European farmers could market them. As a response to this crisis another four State Agricultural Experiment Stations were established during the following years. In 1904, when Hissink returned, there were Stations in Hoorn, Goes, Groningen, Maastricht, and Wageningen; all with their own

70. Simon van den Bergh, "Agrarische en rurale ontwikkelingen tussen 1850-1990," *Historia Agriculturae* 35 (2004): 25–35.

71. Harm Zwarts, "Van Rijkslandbouwproefstation tot Wageningen Research. De historische ontwikkeling van het landbouwkundig onderzoek in Wageningen sinds 1877," *Bijdragen en Mededelingen Gelre. Historisch Jaarboek voor Gelderland* 109 (2018): 111–134.

area of responsibility (Figure 3).[72]

The Experiment Stations were given three tasks that they had to execute for their specific region in the Netherlands:

1. Examining soil types, fertilizers, agricultural products, animal feed, crop seeds, and any other materials used for the purpose of agriculture.

2. Performing agriculture experiments (cultuurproeven) and fertilization experiments on agricultural experiment fields (proefvelden) that had been made available by either the government or private persons and institutions.

3. Performing scientific research of a general agricultural nature.

Despite three tasks being listed, the Stations' time and energy could not be divided equally among them. The number of fertilizers and feed that had to be analyzed increased exponentially in the decades following the Stations' installation (Figure 4) and was taking up more and more of their available resources. So, importantly, these circumstances left very little space for research and experimentation.

Hissink started his journey with the Experiment Stations in Goes, where he was appointed as a chemist in April 1904 and promoted to director in December that same year.[73] In 1907, Hissink moved to the Experiment Station in Wageningen, where he remained director until 1916.[74] Though Hissink's new working place at the Experiment Station was a laboratory just like it had been at the Garden, it was a different kind of laboratory at that. Therefore, it was also a different venue of science leaving different marks on the knowledge stemming

72. In 1889 the three experiment stations that were established were in Groningen, Hoorn, and Breda. The one in Breda moved to Goes in 1893. See Zwarts, "Van Rijkslandbouwproefstation tot Wageningen Research. De historische ontwikkeling van het landbouwkundig onderzoek in Wageningen sinds 1877"; H. A. J. van Schie, "Inventaris van het archief van de Staatscommissie tot onderzoek naar de toestand van de Landbouw (Landbouwcommissie), 1886-1891," Nationaal Archief, last modified June 10, 2019, https://www.nationaalarchief.nl/onderzoeken/archief/2.11.25.

73. "Ministerie van waterstaat, handel en nijverheid," *Nederlandsche staatscourant* ('s-Gravenhage), March 1904, accessed March 6, 2023, https://resolver.kb.nl/resolve?urn=MMKB08:000174088:mpeg21:p005; "Wetten, besluiten, benoemingen, enz.," *Nederlandsche staatscourant* ('s-Gravenhage), November 1904, accessed March 6, 2023, https://resolver.kb.nl/resolve?urn=MMKB08:000173836:mpeg21:p001.

74. "Wetten, besluiten, benoemingen, enz.," *Nederlandsche staatscourant* ('s-Gravenhage), March 1907, accessed March 6, 2023, https://resolver.kb.nl/resolve?urn=MMKB08:000170155:mpeg21:p001; "Benoemingen, pensioenen, enz.," *Nederlandsche staatscourant* ('s-Gravenhage), May 1916, accessed March 6, 2023, https://resolver.kb.nl/resolve?urn=MMKB08:000176450:mpeg21:p003.

Figure 3: An overview of the five State Agricultural Experiment Stations at the beginning of the twentieth century and their area of responsibility. From: Directie van den Landbouw, *Staatszorg voor den Landbouw* ('s-Gravenhage: Gebrs. J. & H. van Langenhuysen, 1913), p. 88.

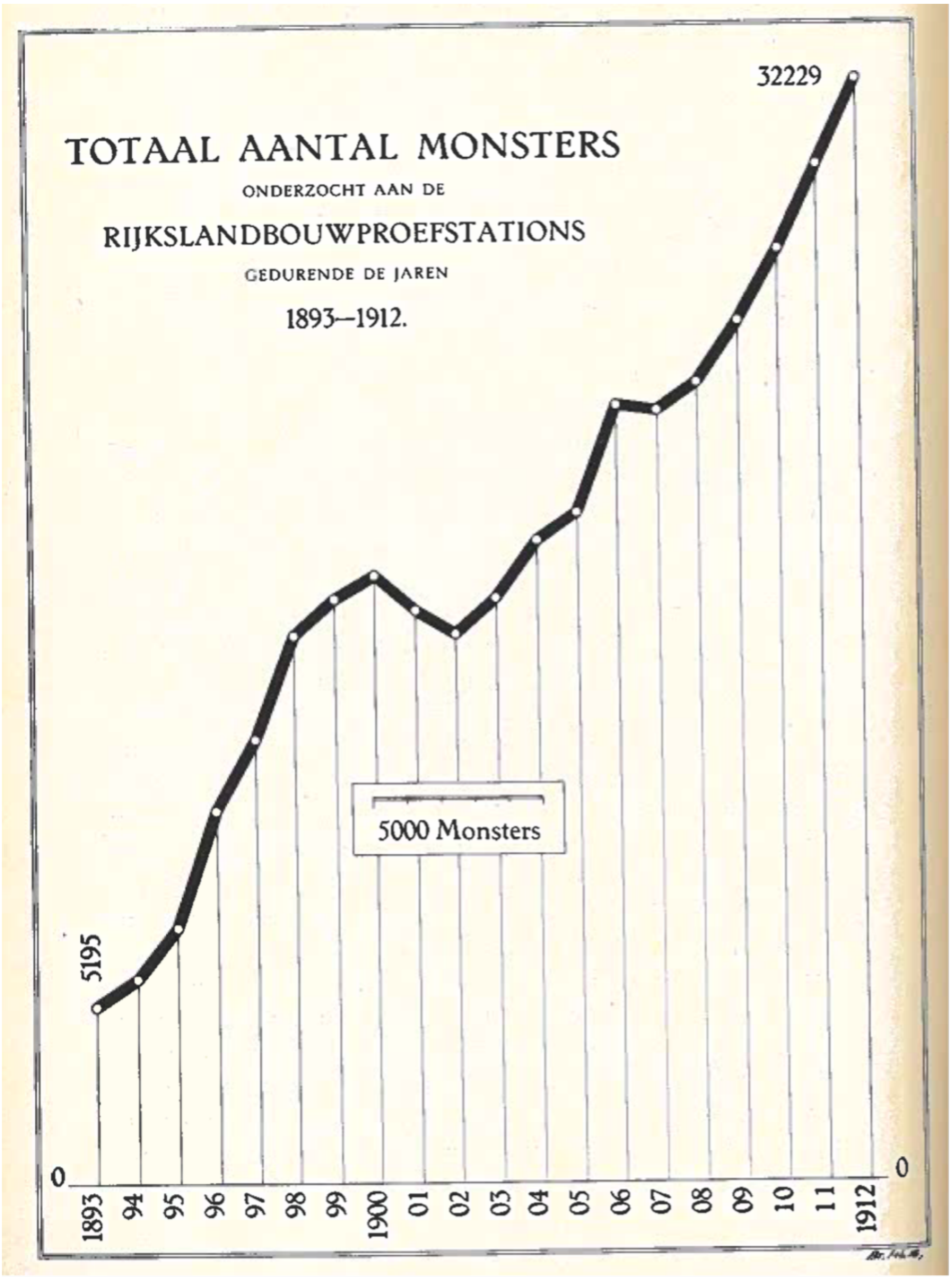


Figure 4: Total number of samples researched at the State Agricultural Experiment Stations between 1893-1912. From: Directie van den Landbouw, *Staatszorg voor den Landbouw* ('s-Gravenhage: Gebrs. J. & H. van Langenhuysen, 1913), p. 92.

from it, as Livingstone would say. Arjan van Rooij has discussed how many different kinds of laboratory have existed and still exist, even though the academic university laboratory is often seen as the basic type.[75] Van Rooij argued that knowledge production has essentially been the goal of laboratories, but identified three different kinds of knowledge that can be produced: research, development, and testing. Moreover, orientation and ownership are also bases for the distinguishing of different kinds of lab.

The Experiment Stations, though they have general research in their goal set as well, focused mainly on the testing of products for agriculture and were government institutions. Van Rooij distinguished between internal, regulative, and normative government laboratories, where the latter had the purpose of improving the competitiveness of the industry. He categorized the Dutch Experiment Stations within this normative group, and I agree that their goal generally was to improve the place of Dutch agriculture in the international market. However, though Van Rooij indicates that the stations performed a lot of agricultural product testing, I think he slightly understates the regulative character of these institutions. Namely, merchants were obligated to have any batch worth more than 25 gilders to be approved by an Experiment Station.[76] Moreover, part of the reasons that the Stations' personnel was so over-occupied with monitorization and control, was because, from 1908 onwards, it included tracking down manufacturers of counterfeits such that they could be warned, exposed, or fined.[77] Moreover, The Experiment Station from Chapter 4, I think, leans much more towards a mostly normative, research kind of laboratory, but the ones in Goes and Wageningen revolved strongly, though not exclusively, around regulation.

Consequentially, during the entire period of this chapter, Hissink was subject to the abovementioned overflowing of sample monitorization and his publications from this time show that the situation had an impact on the kind of research Hissink did. Many of his publications were related to method development for the analysis of fertilizer composition

75. Arjan Van Rooij, "Knowledge, money and data: an integrated account of the evolution of eight types of laboratory," *The British Journal for the History of Science* 44, no. 3 (2011): 427–448; Arjan Van Rooij et al., "Modellen van onderzoek. De oprichting van TNO, 1920-1940," *TSEG-The Low Countries Journal of Social and Economic History* 4, no. 4 (2007): 136–160.

76. Directie van den Landbouw, *Staatszorg voor den Landbouw* ('s-Gravenhage: Gebrs. J. & H. van Langenhuysen, 1913), p. 93.

77. Ibid., p. 98.

and the associated discussions within the agro-chemical community.[78] Since the Stations had to repeat the same analyses hundreds of times, they wanted to develop methods of analysis that were faster, cheaper, and, above all, more accurate. These developments were surrounded by much discussion within agricultural chemistry, which ranged from questions related to methodological refinement (for example, what the effects of other components in the fertilizers may be on the analysis results) to questions surrounding the processes underlying fertilization (like what happened to fertilizers when they 'enter' the soil and mostly how they ended up in the plant).[79]

However, Hissink was still dissatisfied with the state of his field. There were at the time essentially three ways to answer the central question "What fertilization do I need?", which were for the most part a perpetuation of the NPK-mentality. Firstly, there were the fertilization experiments, which Hissink called time consuming, cumbersome, and of questioning value.[80] Then, there were chemical extractions, where methodological unity was hard to find. Hissink even pointed out that finding an extraction solution representing all soil-crop combinations (which was the goal for many agricultural chemists) "is and will remain a fantasy, that one will keep pursuing in vain."[81] Finally, there were ash experiments, that argued the nutrient content in plants reflected the nutrient content in soils and could indicate the soil's fertilization needs. Hissink regarded this vision as too simplistic, however. Though he thought that 'soil wealth' (*bodem rijkdom*) had the strongest influence on the nutrient content in plants, it was also affected by soil moisture content, weather, and climate. The applicability of the results from ash experiments on fertilization advice was therefore, according to Hissink, contestable.[82] Here, we see an ever-so-slight deviation from the NPK-

78. See for example D. J. Hissink and H. van der Waerden, "De methode Pemberton ter bepaling van het phosphorzuur," *Chemisch Weekblad* 2, no. 11 (1905): 179–184; D. J. Hissink, "Phosphorzuurbepaling," *Chemisch Weekblad* 2, no. 7 (1905): 115–126.

79. See for example D. J. Hissink, "De methode voor het meststoffenonderzoek volgens Mitscherlich," *Cultura* 25 (1913): 226–232; D. J. Hissink, "De bepaling van het phosphorzuur in meststoffen volgens de gewijzigde methode Pemberton en volgens de methode van Lorenz," *Chemisch Weekblad* 6, no. 12 (1909): 181–191.

80. D. J. Hissink, "Scheikundig bodemonderzoek," *Verslagen van landbouwkundige onderzoekingen* 6 (1909): 17–38.

81. Hissink half-cites his colleague Masschaupt. The full quote from Hissink's work reads: ""eine allgemein gültige Düngemittelanalyse" in de zin van Mitscherlich is en blijft "een droombeeld, dat men tevergeefs zal najagen."" See Hissink, "De methode voor het meststoffenonderzoek volgens Mitscherlich," p. 3

82. D. J. Hissink, *Een studie over Deli-Tabak naar aanleiding van de in 1900 en 1901 genomen bemestingsproeven op de onderneming Padang Boelan (Deli)* (Batavia: G. Kolff & Co., 1905).

mentality, pointing towards a developing understanding, or dread really, of the complexity of the soil.

So, while there was a persisting discussion within the field on how to properly perform their own science, most of all, this research maintained the plant-central perspective that Hissink had picked up in Buitenzorg. His work was very intimately related to the needs of 'the practice' (*de praktijk*) and his role at the Experiment Stations was essentially one in service of agriculture and agricultural problems. In that same vein, the scientific object soil was also one in service of agricultural crops. By focusing so much of the research on the analysis and effect of fertilizers, the Experiment Station as a workplace almost forced the scientist to view the soil through fertilization.

3.2 Storm Surge of 1906

The storm

One area of research, which was not fertilization-focused (but still in service of agriculture), was brought into Hissink's life in response to a storm surge in March 1906. The province of Zeeland has a long history of 'give and take' with the sea, where the thing that is given and taken is usually land. People 'reclaim' land from the sea through polder-projects (*inpolderen*), and the sea 're-claims' it during storms and floods. On March 12th, 1906, an extreme storm surge flooded a large part Zeeland and Vlaanderen, that in the end did not lead to any land-loss.[83] However, newspaper articles from the time show that this does not mean keeping the land was easy. The storm had led to a breaching of the dikes, and until these were repaired the land could not yet be 'dried' (*droogleggen*). On March 24th, a Friesland newspaper reports: "We've already forgotten the storm, but Zeeland has not yet lost the flood,"[84] meaning that large areas of land were still under water.

83. Or land-gain, from the sea's point of view. The storm surge did not lead to many human casualties either, because it happened during the daytime and people therefore had enough time to respond and bring themselves to safety. In Vlissingen, a water level was measured of 3.92 m above NAP. Only during the North Sea flood (*Watersnoodramp*) of 1953 a higher water level was measured. See Judith Siegel, "De overstromingsramp van 12/13 maart 1906 in het waterschap Oud-Vossemeer," *Tijdschrift voor Waterstaatsgeschiedenis* 24, no. 1 (2015): 38–46.

84. "We zijn den storm alweer vergeten, maar Zeeland is zijn overstrooming nog niet kwijt." In "De overstrooming in Zeeland," *Nieuwsblad van Friesland : Hepkema's courant* (Heerenveen), March 1906, accessed March 6, 2023, https://resolver.kb.nl/resolve?urn=ddd:010736130:mpeg21:p009.

Figure 5: The State Agricultural Experiment Station in Goes in 1907. From Zeeuws Archief, Verzameling Beeld en Geluid, nr 220-1.

Figure 6: The laboratory at the State Agricultural Experiment Station in Goes in 1907. From Zeeuws Archief, Verzameling Beeld en Geluid, nr 220-4.

Moreover, once the sea water could be removed, it would have left a soil that had become infertile. In April, the newspaper *Land en Volk* reports: "When you see new life sprouting everywhere, you must involuntarily feel deep pity for the people in Zeeland, who see their farmland and pastures become barren for a long time due to salt water. (...) The clever agriculturists, that our country possesses, will find a rewarding and wide field of work here."[85] And so Hissink, as the director of the Experiment Station that was responsible for Zeeland, started researching the effects of salt water on the soil in two distinct ways. First, he researched the salt content of the flooded areas themselves at two different moments in time, and, second, he performed a laboratory experiment assessing the effects of different salts on the permeability of soil.[86]

85. "Als je zoo overal het nieuwe leven ziet uitbotten, moet je onwillekeurig diep meelij hebben met de menschen in Zeeland, die hun bouw- en weiland door zout water voor langen tijd onvruchtbaar zien worden. (...) De knappe landbouwkundigen, die ons land bezit, vinden hier een dankbaar en ruim arbeidsveld." In "In Bosch en Duin," *Land en Volk* (Den Haag), April 1906, accessed March 6, 2023, https://resolver.kb.nl/resolve?urn=MMKB12:000185012:mpeg21:p00001.

86. D. J. Hissink, *Het zoutgehalte der in maart 1906 ondergeloopen Zeeuwsche polders* (Goes, 1906); D. J. Hissink, *Het zoutgehalte van de op 12 Maart 1906 ondergeloopen Zeeuwsche polders* ('s-Gravenhage: Van

Figure 7: The State Agricultural Experiment Station in Wageningen in 1907. From Karl Harmsen, *Het Instituut voor Bodemvruchtbaarheid 1890-1990* (Instituut voor Bodemvruchtbaarheid, 1990).

Field sampling and laboratory abstractions

Hissink needed a large collection of soil samples from the flooded area to research their amount and change in salt content. To collect these samples, he communicated a specific set of sampling instructions to local agri- and horticulture teachers, mayors, and farmers (Figure 8): they had to be taken at specific depths, mixed extensively, and used to fill up a box that was sent to them by the Station to be returned. Where the soil sample had come from, however, was left with the sample taker. Consequently, the collection of soil samples that Hissink received included samples from either the lowest or highest point in the *polder*, samples taken close or far away from the water, or samples from any arbitrary spot in the

Langenhuysen, 1907); D. J. Hissink, *De invloed van verschillende zoutoplossingen op het doorlatingsvermogen van den bodem* (Wageningen, 1907).

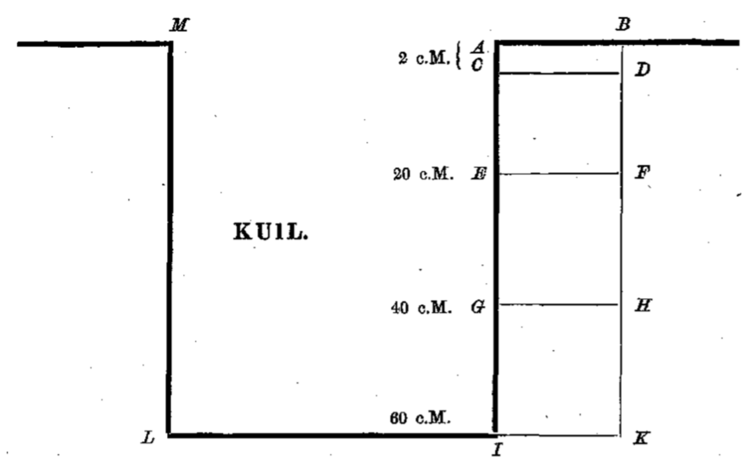


Figure 8: The instructions for local sample takers on which parts of the soil needed to be sampled. Hissink wanted a sample from four sections of the soil: 0 - 2 centimeters, 2 - 20 centimeters, 20 - 40 centimeters, and 40 - 60 centimeters. From: D. J. Hissink, *Het zoutgehalte van de op 12 Maart 1906 ondergeloopen Zeeuwsche polders* ('s-Gravenhage: Van Langenhuysen, 1907), p. 4.

field. Hissink asked for soil and received whatever the local sample taker considered to be the most relevant piece or simply had not considered it at all.

From these samples, Hissink measured the amount of kitchen salt (NaCl) in each layer. He also calculated what the total amount of kitchen salt was in the upper 20 centimeters of soil, which is the layer used for agriculture (called the '*bouwkruin*'), as well as the grand total across the entire 60 centimeters of depth. The variety of sample origins, and the fact that Hissink had asked the sample takers to inform him about a variety of soil characteristics, meant that Hissink could conclude that clay soils absorbed more salt than *zavel* and sandy soils, that drained soils absorbed more kitchen salt than undrained soils, and that low places in the *polder* absorbed more salt than high places.[87] So, even though this was a place-based field research, he did draw universal conclusions from them, and I believe this was possible because in this instance the soil itself was the variable.

In his second research, however, the soil is no longer the variable under investigation and therefore the soil's diversity is abstracted to a single characteristic. This research is a laboratory experiment, where *the soil* is now represented by 200 grams of lime-rich, but further unspecified soil that lies on top of a small layer of 50 grams of 'pure sand' (Figure 9).

87. The characteristics that Hissink was informed about included sample location, the amount of time under water, fertilization, pre-crop (*voorvrucht*), and drainage system.

So, whereas the soil in his first experiment could be clay, loam, drained, undrained, have a history of potato farming, have recently been fertilized with sheep manure, or combinations thereof. Now, the soil was extremely unidentified: 'lime-rich' is all we know. A blank soil to represent all soils. The fact that such an abstraction is allowed, accepted, and even necessary is, I think, strongly related to the laboratory-nature of this experiment, whereas the impossibility to do so follows from the field-nature of the first one. In the laboratory sample characteristics are controllable, and, as it seems, excludable. The soil Hissink used in his experiment must have come from somewhere, but as Kohler describes of the policeable border, the laboratory scientist gets to decide which parts of nature they leave outside.

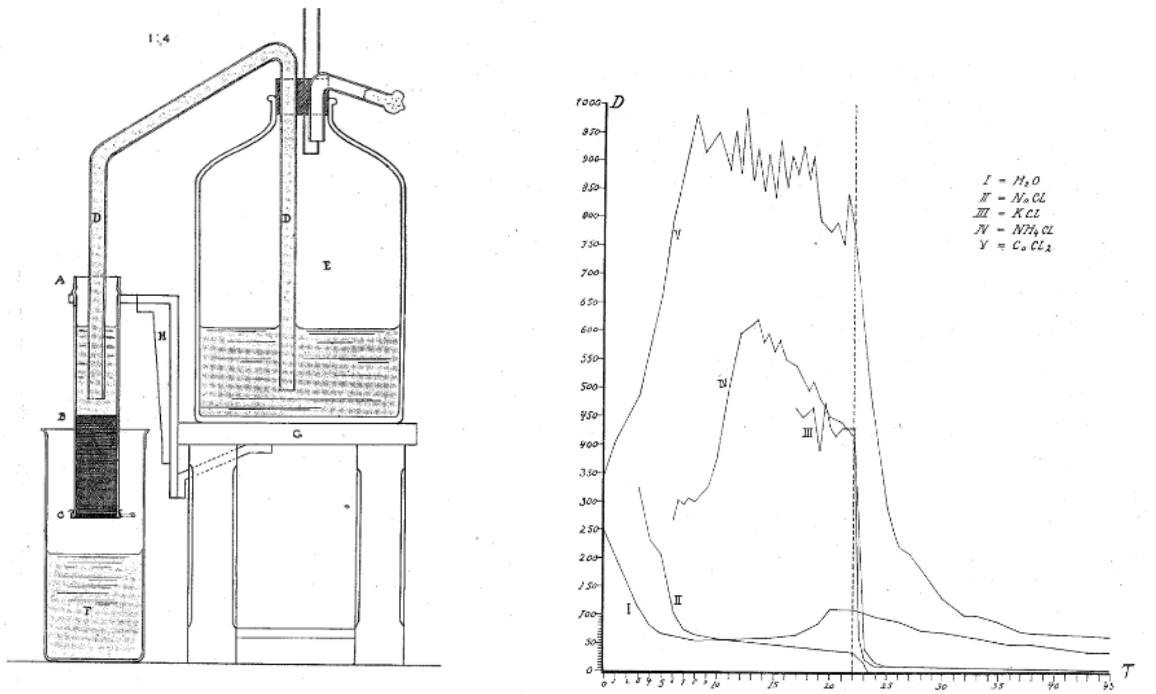
This is not to say that Hissink completely disregarded the complexity of the soil. In this laboratory research paper, he bemoaned that "in such a composite medium as the soil, further research will be met with many difficulties."[88] He found the situation uncomfortably complicated. But, while he recognized the soil as being complex, he still allowed the simplification. Even more, the complexity of the situation was exactly what warranted this simplification, I think. Such a complex problem as the soil called for a scientific approach that included "reducing it to its simplest factors."[89] The impossibility of such a reduction might have meant that the field-soils had more intricacy, it also meant that they were less meaningful and could not lead to real understanding. Reduction was to Hissink an essential part of the scientific method. And the fact that the laboratory allowed him to approach the soil in a strictly 'rational' way, gave it much more epistemic potential.

Absorbability and Soil Part(icle)s

Hissink's conclusion from his saltwater research was that salt affected the soils in two different ways. First, saltwater caused a leaching out of plant nutrients through absorbability processes and, second, saltwater negatively affected the soil structure. Both ideas led to new realizations on the functioning of soil fertility.

Absorbability is a recurring theme in Hissink's work and with this research he started

88. "Bij een zoo samengesteld medium, als de bodem is, zal het verdere onderzoek zeer vele moeilijkheden ondervinden." In Hissink, *De invloed van verschillende zoutoplossingen op het doorlatingsvermogen van den bodem*, p. 9.
89. D. J. Hissink, *Specialiseering in landbouwwetenschap* (Wageningen, 1908).



(a) (b)

Figure 9: a) This figure shows the experimental set-up of Hissink's permeability experiment. Glass ABC is closed off on the bottom with a piece of linen. On top of this a layer of pure sand (Z) is put (50 grams) and on top of that 200 grams of soil (BC). Different salty solutions are run through the soil from the big flask and captured in the beaker below the soil sample.
b) This figure shows the permeability graphs that Hissink produced as the result of his experiment. It shows how quickly the different solutions ran through the soil over time.
From D. J. Hissink, *De invloed van verschillende zoutoplossingen op het doorlatingsvermogen van den bodem* (Wageningen, 1907), p.11-12.

to consider the soil's absorbing qualities as the underlying function that provided fertility. Namely, he realized that the infertility consequences of saltwater floodings are related to the soil's absorbing and releasing character. Hissink described that the salts from the sea water essentially replace the absorbed plant nutrients in the soil, bringing the nutrients in solution and leaving the salts absorbed to the soil. Momentarily, this is good news for the plants! For the plant to 'eat' the nutrients, they have to be in solution. However, if all nutrients are released from the soil at once, this is much more than plants can eat and most of the nutrients will be flushed out of the soil with the groundwater.[90] This is a process that Hissink called leaching (*uitloogen*) and it resulted in the situation that nearly all plant nutrients will have been removed from the topsoil (*bouwkruin*). The research led to a refining of his ideas on how the soil-infrastructure functioned.

The other side of the story is that Hissink had to look at the actual particles, the grains, that the soil consists of, and how they relate to soil fertility. He discussed how the soil can consist of a 'single grain structure' or a 'crumb structure,' two concepts coined by American pedologist Eugene Hilgard.[91] When a soil is in a single grain structure, it is very compressed, which makes it difficult for the plant roots to grow, but when it is in a crumb structure, it is much looser and the plant roots have much more freedom of movement. Salty water, Hissink learned, destroys the crumb structure of the soil and brings it into a single grain structure, which will lead to the soil closing up (*dichtslibben*).[92] It was the first time that Hissink actually considered the physical grains that the soil consisted of outside of the vernacular practices of referring to soils as sandy and clayey.

Both the ideas about the soil's absorbing function and the soil structure were not Hissink's own, but he learned of them because of the 1906 Storm Surge. Moreover, now that the soil-infrastructure has been identified as a result of soil absorbability, it led him to ask next which part of the soil was responsible for it. This question would further occupy him during his upcoming engagement with the international community.

3.3 International Exchanges

The study trip

In the Summer of 1908, Hissink went on a month-long study trip across various soil and agricultural experiment stations in Germany.[93] In the early twentieth century, the German

90. This is essentially the same thing that happens when soils are overfertilized, leading to harmful algal blooms in nearby streams and lakes.
91. 'Enkelkorrelstructuur' and 'Krummelstructuur'. In D. J. Hissink, "De chemische en physische inwerking van zout water op den bodem," *Chemisch Weekblad* 3, no. 25 (1906): 395–403.
92. Ibid.
93. D. J. Hissink, "Verslag eener in den zomer van 1908 gemaakte studiereis naar Duitschland," *Verslagen van landbouwkundige onderzoekingen* 6 (1909): 1–16.

chemical laboratories were the place for cutting-edge research.[94] A big part of the reason for Hissink's visit was to inquire how the German experiment stations managed their resources between monitorization tasks and scientific research (Chapter 4). But Hissink also explored the different kinds of soil research that was being performed at the stations. He met with R. Gans in Berlin and Mitscherlich in Königsberg, who were, respectively, working on what Hissink called 'character' and 'needs' of the soil.

This separation of the soil in characters and needs reflects the different kinds of research that were associated with it. The needs of the soil were essentially what had preoccupied Hissink up to this point and were related to fertilization research. The character of the soil, however, was related to research into the structural composition of the soil. It related to finding how the soil could absorb and release plant nutrients, and which chemical compounds were responsible for this. According to Gans, the absorbing fraction of the soil was the 'zeolitic material', which existed in crystalline, ordered form in rocks, and in non-crystalline, disordered form in soils. Though no one had been able to isolate the zeolitic material from the soils, it was thought to contain the soil's absorbing powers. This power would also be attributed to the 'gelatinous silicate,' or to the 'weathering complex', or to the 'amorphic silicate humate complex'—it was a matter of discussion which part of the soil was actually responsible for its absorbability—but they all represented the same function.

This is the crux of the reductionistic approach to the soil. The soil became subdivided in multiple parts that all carried their own function and one of the most important functions, for which the associated soil-part was tracked down, was (of course) fertility. They even tried to recreate just the absorbing part of the soil in the laboratory to research its functioning.[95] Since absorbability was at the heart of soil fertility, the discussion on which part of the soil absorbed the plant nutrients was ongoing throughout this period. Hissink joined the international discussion at the Second International Conference of Agrogeology.

94. Van Rooij, "Knowledge, money and data: an integrated account of the evolution of eight types of laboratory."

95. D. J. Hissink, *De binding van de ammoniakstikstof door permutiet en door kleigrond en de opneembaarheid van de permutietstikstof voor de plant* ('s-Gravenhage: Gebrs. J. & H. van Langenhuyzen, 1913).

The agrogeology conference

During the first six years of Hissink's work at the Experiment Stations, the fertilizer monitorization from Section 3.1 and the salt effects on soil absorbability from Section 3.2 were his main focus. In 1910, however, Hissink attended an international conference for agrogeology in Stockholm and this brought about a big shift in his soil conceptualization.

The conference in 1910 was actually a sequel to a conference a year prior: the First International Conference of Agrogeology in Budapest, which was attended by ninety soil workers from nine different countries (mostly geologists). As I mentioned in the introduction, Russian agrogeologist Dokuchaev's ideas about soil genesis and types based on soil forming factors did not immediately reach the West, but it did reach the Hungarians. Soil scientist István Szabolcs describes that at the turn of the century, Hungarian soil scientists went on study tours through Russia from time to time, where they became acquainted with Dokuchaev's and his pupils' ideas. According to Szabolcs, the idea to organize an international conference in part revolved around communicating Russian ideas on soil genetics to the West.[96] In the invitation letter for the conference, however, the most important reason for the organization was given to be standardization.

Two kinds of standardization were deemed necessary: firstly, for soil mapping and classification, and, secondly, for field and laboratory research methods. Hungarian soil scientist B. Inkey (1847-1921) commented on the needs for standardization in the foreword of the conference report:

> "It is not the multitude of living languages that hinders mutual understanding. This difficulty exists for any other science but has proven surmountable everywhere. The main objection to agreeing to the terms and methods in soil science rather stems from the multitude of points of departure, and this confusion is further increased by the lack of close contact between the branches of the sciences dealing with the questions of soil."[97]

96. Szabolcs, "The 1st International Conference of Agrogeology, April 14-24, 1909, Budapest, Hungary."

97. "Ce n'est pas la diversité des langues vivantes, qui empeche I'entendement: cette difflculté se rencontre dans la pratique de chaque science, mais partout on a su la surmonter. L'obstacle a I'uniflcation de la terminologie et des methodes consiste chez nous plutot dans la diversité des points de depart, et la confusion n'a été créé que par le manque de contact entre les diverses sciences, qui ont approché la question du sol."

So, Inkey identifies that the multiple origins of science of the soil, both in scientific discipline and in physical location, has led to such a variety in methodology that he calls it a "scientific Babel."[98]

At the end of this conference, a second one was immediately planned for a year later to be organized in Stockholm following the International Geological Congress. For this conference, a list of experts was put forward that ought to receive an invitation for the next edition of the conference, though this list "did not claim to be complete."[99] For the Netherlands, the two names that were put forward were I. van Baren, Wageningen, and J.F. van Bemmelen, Delft.[100] However, the only Dutch scientist that came to the Second Conference was Hissink and he would give a talk that was titled "The colloidal substances in the soil and their purpose."[101]

Hissink's talk

The Second International Conference for Agrogeology was organized in Stockholm, Sweden, from August 17th until August 25th, 1910, and was attended by almost 120 soil workers (again, mostly geologists) with twenty-one different nationalities. At the opening of the conference, the prime minister of Sweden, Arvid Lindman, gave a short speech on the importance of soil science and the growing of an international community. He described soil science as the research of how to best help nature with her resource production and stated that proper development and international unification of methodology was the most important step in progressing towards this goal.

During the conference various chemical and geological soil topics were discussed related

From "Comptes Rendus de la Première Conférence Internationale Agrogéologique" (Budapest: Armand Fritz, Nap-Utca 13, 1909), p. 3. Translation from Szabolcs, "The 1st International Conference of Agrogeology, April 14-24, 1909, Budapest, Hungary."

98. "Comptes Rendus de la Première Conférence Internationale Agrogéologique," p. 1.

99. "Natürlich erhebt diese Liste keinen Anspruch auf Vollständigkeit, denn es werden außer den Angeführten auch andere Mitarbeiter teilnehmen." In ibid., p. 57.

100. I. van Baren, I think, refers to the agrogeologist Johan van Baren (1875-1933), who would become a professor of mineralogy, geology, and agrogeology in 1918 in Wageningen. J. F. van Bemmelen was the son of J. M. van Bemmelen and worked in Delft as professor extraordinarius of historical geology and paleontology. See ibid., p. 57–60.

101. "Die kolloidale Stoffe im Boden und ihre Bestimmung." In G. Andersson and H Hesselman, "Verhandlungen der Zweiten Internationalen Agrogeologenkonferenz" (Stockholm: Nordiska Bokhandeln, 1911), p. 25–42. One Dutch forester student (Rodolphe de Constant Rebecque) also attended the Second Conference.

to an inherent understanding of the soil or to methodological development, and often to both. When Hissink presented his talk on the second day of the conference, August 18th, at the Business School in Stockholm, the topic of the session was "The Colloids of the Soil."[102] Colloids were understood as a state where very small particles were in solution in some other medium. Colloidal substances were called sols or gels (depending on the kind of medium in which the colloidal particles are dissolved).[103] Notably, these small colloidal particles were not as small as molecules—so it was not a true solution—, but they were so small that they had some characteristics that molecules in solution also have.

Colloids were often taken as an opposite of crystalloids, where crystalloids were static, energy-keeping, stable, and dead, and colloids were considered dynamic, energy-giving, labile, and living. Thomas Graham, called the founder of colloid chemistry, described colloids in 1861 as "the probably primary source of the force appearing in the phenomena of vitality."[104] Robert Kohler similarly described that, in early twentieth century biochemistry, colloids were employed as appealing to both reductionist and vitalist sentiments through their particulate nature but more-than-particulate properties; an attempt to "explain life in terms of entities that were more than "molecular" and less than morphological."[105]

In the case of the soil, colloidal particles referred to small clay or humus particles, that were capable of absorbing water and salts from soil solutions, "capturing them and offering them to the root hairs of the plants."[106] But, there were clear parallels with biochemistry. Swedish soil scientist A. Atterberg (1846-1916) commented on soil colloids that "just like the organic and physiological chemists try to reduce the complex tissues of organisms into specific chemical compounds, so must the soil chemist eventually be able to reduce the tissues of soils, the colloid aggregates, into specific chemical compounds."[107] The colloidal particles

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102. "Die Kolloide des Bodens." In Andersson and Hesselman, "Verhandlungen der Zweiten Internationalen Agrogeologenkonferenz," p. 17–68.

103. Examples of colloidal substances include aero*sols* (or aethero*sols*) and gelatine, but also milk or foam. See *Colloïd*, in *Oosthoek's geïllustreerde encyclopaedie*, 2nd ed., vol. 4 (Utrecht: A. Oosthoek, 1926), 130–131.

104. A. J. J. van de Velde, *Verslagen en mededelingen van de Koninklijke Vlaamse Academie voor Taal- en Letterkunde*, accessed through DBNL (KB, nationale bibliotheek) (Gent: N. V. v/h Vanderpoorten % Co., January 1934), p. 1175.

105. Robert E. Kohler, "The history of biochemistry: a survey," *Journal of the History of Biology*, 1975, p. 291.

106. "Ze vastleggen en aan de haarwortels der planten aanbieden." In J. E. Enklaar, "De colloïdaaltoestand der stof," *Album der natuur* 53, no. 1 (1904): 289–320.

107. "Wie die organischen und physiologischen Chemiker die komplicierten Gewebe der Organismen im-

were considered to be the most active part of the soil, and, in line with colloids being the 'primary source of vitality,' it is exactly where Dutch soil chemist Van Bemmelen looked for the soil's fertility.

How Van Bemmelen did this was the topic of Hissink's contribution to the Second Conference.[108] Hissink used his time to review the work of other soil scientists he deemed important for the international community, supplemented by some of his own thoughts on the matter. There are two interesting points from Hissink's talk that I would like to discuss. The first one relates to Hissink's discussion of Mitscherlich's and Hilgard's understanding of a bipartite soil, and the second relates to the discussion following Hissink's argument for the relevance of Van Bemmelen's colloid work.

Two sides of the soil

Hissink started his talk by presenting the ideas of two contemporary scientists: the German chemist A. Mitscherlich (1836-1918) and the American pedologist E.W. Hilgard (1833-1916). These ideas further developed Hissink's understanding of approaching the soil in terms of its character and its needs. On the one hand, we have what Hissink called the fertilization state of the soil, which was tied to the question "What plant nutrients are available for the plant right now?" and "What fertilization does the soil need?" Mitscherlich referred to this as the soil's *Betriebskapital* and Hilgard called it the soil's temporary production capacity. It is described as a changeable state of the soil, as something that can be purposely affected through fertilization. Essentially, it seems to me that the soil's *Betriebskapital* is what has occupied Hissink in his fertilization research (be it through extraction analyses, fertilization experiments, or ash experiments) in the preceding years. Only then, this was, for all intents and purposes, the whole picture.

Now, a second layer had been added: Mitscherlich's *Grundkapital* or Hilgard's permanent production capacity. This is what Hissink explained to be what the "practical farmer" meant

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mer mehr in bestimmte chemische Verbindungen zerlegen, so müssen wohl ebenfalls die Bodenchemiker die Gewebe des Bodens, die Kolloid-Aggregate, schliesslich in besondere chemische Verbindungen zerteilen können." In Andersson and Hesselman, "Verhandlungen der Zweiten Internationalen Agrogeologenkonferenz," p. 46.

108. There were two other talks in the session on soil colloids, but both presenters (one of them a colleague of Hissink from Wageningen) were unable to attend the conference. Their written contributions were read aloud.

when he categorized his soil into sand, loam, and clay. It referred to the soil's inherent potential for production: the soil's natural strengths and limits—its core functioning. Hissink explained that this *Grundkapital* can be found in what Van Bemmelen called the "amorphic silicate humate complex," which were the colloidal soil elements. This complex formed the foundation of a soil type's character, and therefore was much less (or perhaps even not at all) changeable than the *Betriebskapital*. It reflected a reinforcement of the reductionistic approach where the soil is subdivided into manageable qualities. Hissink continued to present Van Bemmelen's approach to examining and isolating the colloidal part of the soil. His message was met with resistance, however.

Local soils, local methods

To assess the soil's character (or *Betriebskapital*), Hissink described in his talk, it was necessary to determine which colloidal elements were present and in which amounts. During the first international conference several methods had already been mentioned, but Hissink was not impressed by any of them. To Hissink's big surprise, Van Bemmelen's methods to determine the colloidal soil elements were not even mentioned during the First Conference, despite Van Bemmelen having published in many German scientific journals. So, to educate the international community, Hissink went on to explain in detail what Van Bemmelen's vision on the soil colloids was. Hissink ended his talk with the note that it would be prudent for each soil scientist to "properly study the work of this 80-year-old Dutch scholar."[109]

However, in the discussion that followed, nearly all participants indicated that Van Bemmelen's work and methods were known to them and their fellow countrymen, but that they were simply not suitable for their soils.[110] Van Bemmelen's methods were based on dissolution principles and for the Dutch soils only the colloidal substances dissolved. However, soils from other countries apparently contained non-colloidal substances that would *also* dissolve into the solution that Van Bemmelen used in his method. In other words, while Van Bemmelen's method promised to isolate soil colloids, this was not the case everywhere.

109. Andersson and Hesselman, "Verhandlungen der Zweiten Internationalen Agrogeologenkonferenz," p. 41.
110. In the discussion that followed Hissink's talk the following scientists participated: H. Stremme (Berlin), K. Glinka (Novo-Alexandria, Russian Empire), P. Treitz (Budapest), A. Atterberg (Kalmar, Sweden), P. Kossowitsch (St. Petersburg), A. Vesterberg (Uppsala), A. Rindell (Helsinki), R. van der Leeden (Berlin), G. Murgoci (Bukarest), P. Vageler (Königsberg), J. E. Hibsch (Tetschen), and of course Hissink himself.

Hissink responded to the criticism by saying that, naturally, any chemical analysis of the soil should be preceded by a mineralogical one to know if the chemical analysis is going to be accurate. But clearly it meant that Van Bemmelen's analysis was not going to be accurate for many soils. This dispute shows that the local characters of the soil could also lead to local methods; to methods that have been specifically attuned to the local soils. Unfortunately, this meant that comparison between regions was difficult. Moreover, in a time where laboratory research was supposed to produce 'view from nowhere'-knowledge, having the success of a method depend on location was problematic and put significant question marks behind its theoretical basis.

Getting involved

Though Hissink was not put on the list of experts to be invited after the First Conference and his talk at the Second Conference was met with fierce discussion, he was actively involved during the entire conference proceedings. He chaired several sessions of the conference, participated in discussions, and even provided the closing words on the final day, thanking the organizational committee for an exceptional preparation and declaring the conference to be concluded.[111]

At the end of the conference, a total of three committees were established for 1) the classification of soil grains in mechanical soil analysis, 2) the preparation of soil extracts in chemical soil analysis, and 3) the nomenclature of soil types in the Moraine Region of Western Europe.[112] Hissink became a member of the first two committees and met with them a few times between 1910 and 1914. It was the intention of the conference in Stockholm to organize a third International Agrogeology Conference in 1914 in St. Petersburg, but this did not happen because of the outbreak of the First World War. The next international conference would be organized some years after the War in 1922 in Prague at the initiative of Hissink and two other scientists (Chapter 4).

Hissink later also joined the editorial team of the international soil science journal *Internationale Mitteilungen für Bodenkunde* and was generally described by his contemporaries

111. Andersson and Hesselman, "Verhandlungen der Zweiten Internationalen Agrogeologenkonferenz," p. 118.
112. Ibid., p. 359–360.

as an active member in the international soil community.[113] Furthermore, this international community also left a mark on him. This entire period of international exchanges led to a re-conceptualization of what the soil was. As I will describe in the next section, it led to the construction of the 'Soil Story'.

3.4 A Soil Story

During the years following the conference Hissink published a handful of papers on the monitorization of animal feed, seeds, and fertilizers, as he had done before.[114] Remarkably, now he started to also communicate research from the areas of soil research that he had become acquainted with at the conference. These topics included on the one hand classical agrogeological questions surrounding soil mapping, typing, and genesis, and on the other hand the vaguely familiar field of mechanical soil research. Hissink's view of the soil remained plant-central: the soil is the residence of plants—that much is clear. Moreover, that the goal of soil science must also remain in service of agricultural problems is a sentiment that Hissink repeated time and again. What changed because of the international exchanges and the new research directions that Hissink consequentially became familiar with is that the soil eventually got a story with a beginning, middle, and an end. The end of the story being also shaped by the specific Dutch climate and its influence on soil decay.

The beginning: geological formation and transformation

Through the agrogeological influences Hissink experienced during the Second Conference, the soil story got a beginning. It had a formative process, a genesis tale, that had been influenced by various factors. These were the ideas that had originated with Dokuchaev in Russia. Hissink's thinking was influenced by this as he published his thoughts on the matter in, for example, two papers on the possible genetic processes of the red soils from the Veluwe.

113. Jensen, "Dr. D. J. Hissink, In Memoriam"; Reinders, "Dr. D. J. Hissink"; A. Zuur, "David Jacobus Hissink: 1874–1956," *Soil Science* 82, no. 1 (1956): 1–2; Jac. van der Spek, "David Jacobus Hissink: Zijn werk als bodemkundige," *Chemisch Weekblad* 36, no. 44 (1939): 732–736.

114. D. J. Hissink, *Thomasphosphaatmeel* (Wageningen: Rijkslandbouwproefstation, 1910); D. J. Hissink, "Rijstvoedermeel," *Verslagen van landbouwkundige onderzoekingen* 9 (1911): 56–69; D. J. Hissink and G. B. van Kampen, "Thomasphosphaatmeel," *Cultura* 23 (1911): 493–501; Hissink, "De methode voor het meststoffenonderzoek volgens Mitscherlich."

But it also influenced how he spoke about the soil.

How much Hissink's conceptualization of the soil had changed becomes clear from a chapter called *The Soil* that Hissink wrote in K. W. van Gorkom's book *Oost-Indische Cultures* in 1913.[115] The chapter provided a summary of Hissink's conceptualization of the soil, which was clearly influenced by the international exchanges described above. In the introduction of the chapter, Hissink defined the soil and soil science as follows:

> "From an agricultural point of view the soil can be regarded as the residence of plants. In accordance with this view, we define the soil as the total of water, air and solid particles of different sizes, which, if supplied with the necessary plant nutrients, can serve as a carrier for plant vegetation. The soil science or pedology is the study of the formation, the transformation, and the features of the soil."[116]

So, interestingly, next to the familiar plant-central focus, the study of soil formation and transformation were also included, which were traditionally agrogeological topics. He explained the processes of physical and chemical weathering that led to soil formation and clarified how the weathering processes that birthed the soil continue to operate and transform it, where this transformation of the soil could also be affected by plants, animals, and humans. The soil got a story, a life, for Hissink. It was not only born, but it also lives, and grows, and transforms.

The middle: international classification and mechanical soil analysis

The middle of the story was related to the soil's character. It related to questions surrounding soil type classification systems and Hissink communicated the principles of soil surveying as based on research from English chemists A.D. Hall (1864-1942), the director of the experiment station in Rothamsted from 1902 until 1912, and E.J. Russell (1972-1965), who succeeded Hall as director in 1912.[117] The experiment station in Rothamsted is one of the

115. D. J. Hissink, "De Bodem," in *Oost-Indische Cultures*, 1st ed., ed. K. W. van Gorkum (Amsterdam: J. H. de Bussy, 1913), 33–116.
116. "Uit een landbouwkundig oogpunt beschouwd is de bodem op te vatten als de woonplaats der planten. Overeenkomstig deze opvatting definieeren wij de bodem als een geheel van water, lucht en vaste deeltjes van verschillende grootte, hetwelk, voorzien van het noodige plantenvoedsel, als drager van eene plantenvegetatie dienen kan. De bodemkunde of pedologie is de leer van de vorming, de vervorming en de eigenschappen van den bodem." In ibid., p. 37.
117. D. J. Hissink, "Bodemkarteering en bodemonderzoek," *Cultura* 24 (1912): 158–163.

oldest agricultural research institutes, founded in 1843, and was famous for its agricultural field experiments.[118] Furthermore, Hall and Hissink were both members of the Second Committee for the preparation of soil extracts in chemical soil analysis created at the Second Conference, which connected them.

In this science communication paper, Hissink stated that the main goal of soil surveying was to 1) classify, and 2) describe. Surveying consisted of providing an overview of the most common soil types, indicating their value for agriculture, and describing their features. Hall proposed the basis of such soil typing to be mechanical soil research. Since chemical soil research was not able to discern the full molecular build-up of the soil (it could only tell you which compounds were extracted by a specific acid, but never give the full picture at once), Hall turned to mechanical soil research as it "referred to the soil as a whole."[119]

Mechanical soil research approached the *Grundkapital* of the soil, its character. It referred to what the 'practical farmer' meant when they categorized their soils into sand, loam, and clay. It was about particle sizes, and it needed a classificatory system. Hissink presented the system that Hall proposed (Table 1) but mentioned in a footnote the problematic reality that there was no internationally unified system yet. The idea of mechanical soil research was that for any soil sample the percentage occurrence of certain grain classes could be calculated, see for example the London clay soil in Table 1. Then, for this grain size distribution, which became appointed the 'London clay'-soil type, the chemical properties were established. Thus, you would know for any similar grain size distribution, what the properties should be.[120]

Such a classificatory system as Hall proposed here is much more refined than what Hissink's approach to the soil's grain sizes was before this. I called it a vaguely familiar

118. See Giuditta Parolini, "The emergence of modern statistics in agricultural science: analysis of variance, experimental design and the reshaping of research at Rothamsted Experimental Station, 1919–1933," *Journal of the History of Biology* 48 (2015): 301–335; H. L. Walster, "Rothamsted Experimental Station," *Bimonthly Bulletin* 18, no. 6 (1956): 200–206.

119. "Omdat, zooals wij reeds zagen, volgens de opvattingen van Hall het mechanisch bodemonderzoek betrekking heeft op de bodem in zijn geheel, in tegenstelling tot het scheikundig bodemonderzoek." In Hissink, "Bodemkarteering en bodemonderzoek."

120. Hissink noted that this system could only be used for mineral soils, because the presence of other substances like organic matter and carbonated lime could skew the properties. For example, organic matter could reduce the characteristic differences, up to completely removing them, between light (sandy) and heavy (clayey) soils.

Grain size	**Grain class**	**Example: London clay**
>1 mM	Fine gravel	0.4 %
1 – 0.2 mM	Coarse sand	12.8 %
0.2 – 0.04 mM	Fine sand	25.5 %
0.04 – 0.01 mM	Dust	11.3 %
0.01 – 0.002 mM	Fine dust	11.1 %
<0.002 mM	Clay	23.7 %

Table 1: A grain size classification system with a London clay example from D. J. Hissink, "Bodemkarteering en bodemonderzoek," *Cultura* 24 (1912): 158–163.

field because it is so closely related to the vernacular practices of farmers in naming their soils. So, Hissink certainly was familiar with the concept that soils consisted of grains, that these grains could have various sizes, and even that soils with different grain sizes could have different properties. But, whereas before the reference to soil grain sizes used to always be in the context of how farmers spoke about their soils, now it became the scientist who decided how the soils ought to be classified.[121] It will become a testament to the fact that knowledge about the soil moves from the farm to the laboratory (Chapter 4).

The end: rethinking soil death

The end of the soil-story did not materialize immediately after the Second Conference. In Hissink's 1913 chapter *The Soil*, the introduction states that "geology comprises the dead part of the earth, soil science the eternally living envelope, which is constantly transformed by the sun's energy, atmospheric water, and organisms."[122] An *eternally* living envelope clearly does not have an end it its story. In 1916, however, Hissink rewrote this introduction for a second edition of the book, and, crucially, left out the word 'eternally'. In that introduction, Hissink continued to say:

> "while the geologist sees the weathering of the rocks as a process of death, to the

121. All reference by Hissink to grain size before this was along the lines of "the soil consists of small particles, of different sizes. Depending on the ratio between small and less small particles the [practical farmer] speaks of sand or clay soils." Original: "De bodem bestaat uit kleine deeltjes, van verschillende grootte. Naar gelang van de verhouding tusschen kleine en minder kleine deeltjes spreekt de praktikus van zand- en kleigrond." In Hissink, "De chemische en physische inwerking van zout water op den bodem."

122. "De geologie omvat het doode gedeelte der aarde, de bodemkunde het eeuweig levende omhulsel, dat door de zonne-energie, door het atmosferische water en door organismen voortdurend veranderd wordt." In Hissink, "De Bodem."

soil scientist this phenomenon is the birth of a new individual. The soil scientist sees the soil live and grow and take other forms: he gets to know it in his youth, full of wealth and strength; he sees the soil changing more and more and growing old, to die at last like every life that harbors the germ of death and return to its origin. (...) from a state of rest arises a state of constant change, which, however - obeying the laws of nature - seeks less and less metastable equilibria, finally ending again in the stable crystalline state."[123]

So, these are two incredibly different ideas about the life of the soil. In 1913, the soil could be born, since Hissink does talk about soil formation (and transformation), but it would *eternally* continue to exist, whereas in 1916 there was clear conclusion to the soil's story.

What I think played a crucial role in the concluding of the Soil Story was Hissink's work on soil absorbability from 1913 onwards in combination with the humid Dutch climate as well as Hissink's familiarity with the concept of soil colloids.[124] Namely, one process of soil deformation that Hissink identified revolved around the leaching out of plant nutrients as a consequence of rain. And in the Netherlands, it rains a lot. He explained, for example, that the soil lime capital (*bodemkalk-kapitaal*) becomes quickly depleted in Dutch soils because, firstly, lime is one of the more weakly absorbed nutrients in the soil, and, secondly, "every year large amounts of lime are removed from the soil, partly because of the harvesting of crops, but mainly because in our humid climate the soil is leached by the rainwater."[125] This is a process that Hissink could identify because he recognized the plant nutrients to be

123. "Terwijl de geoloog in het verweeren van de gesteenten een afstervingsproces ziet, is dit verschijnsel voor den bodemkundige de geboorte van een nieuw individu. De bodemkundige ziet den bodem leven en groeien en andere gestalten aannemen: hij leert hem kennen in zijn jeugd, vol rijkdom en kracht; hij ziet den bodem meer en meer veranderen en ouder worden, om eindelijk als elk leven, dat in zich bergt de kiem van den dood, af te sterven en tot zijn oorsprong te keren. (...) uit een toestand van rust onstaat een toestand van voortdurende verandering, die echter – gehoorzamend aan de natuurwetten – steeds minder metastabiele evenwichten opzoekt, om ten slotte weer te eindigen in den stabielen kristallijnen toestand." In D. J. Hissink, "De Bodem," in *Oost-Indische Cultures*, 2nd ed., ed. K. W. van Gorkum (Amsterdam: J. H. de Bussy, 1917), p. 41.

124. See, for example, Hissink, *De binding van de ammoniakstikstof door permutiet en door kleigrond en de opneembaarheid van de permutietstikstof voor de plant*; D. J. Hissink, "Het bodemkalkvraagstuk," *Jaarverslag van het Natuurwetenschappelijk Gezelschap te Wageningen*, 1915, 9–12; D. J. Hissink, "Het Bodemkalk-vraagstuk," *Cultura* 27, no. 324 (1915): 273–291; D. J. Hissink, "Bijdrage tot de kennis van het bodemadsorptievraagstuk," *Chemisch Weekblad* 15, no. 17 (1918): 517–524.

125. "Jaarlijks worden groote hoeveelheden kalk aan den bodem onttrokken, gedeeltelijk in den oogst van de gewassen, maar vooral omdat in ons humied klimaat de bodem door het regenwater wordt uitgeloogd." In Hissink, "Het Bodemkalk-vraagstuk," p. 275.

absorbed, or exchangeable, to the soil structure, and therefore removable.

Moreover, I think that the fact that Hissink refers to the 'death' of the soil being a return to the stable crystalline state, points towards the vitality ideas surrounding the colloidal substances in the soil in their opposition towards crystalloids (Section 3.3). The colloidal parts were the labile, but life-giving, part of the soil. Their presence, and their absorbing functions, were essentially what distinguished soil from rock, but eventually they had to deteriorate back into the stable crystalloids. These three aspects—the geological ideas of soil genesis, the rainwater leaching out exchangeable nutrients, and the stabilizing vitality of the soil colloids—together meant that Hissink arrived at a view of the soil as an entity that was temporary.

3.5 Conclusion

Hissink's work at the Experiment Stations meant that an agricultural focus remained throughout this period. But, whereas at first the monitorization activities confined him to a fertilization-view of the soil, changing research and natural environments meant that new perspectives were added to this. A salt-tormented Zeeland meant Hissink started his research on the absorbability function of the soil. The laboratory-reductionistic approach that was distinctive of this time furthermore meant that soil scientists, Hissink included, started to look for which part of the soil carried this specific function. It was a crucial function, as it strongly related to soil fertility, which was considered to originate in the active, energetic soil colloidal particles. The fact the colloidal soil particles eventually had to return to their crystalline, dead state together with Hissink's research on the Dutch rain-induced soil depletion and the geological approach to the soil of formation and transformation, led to a full picture of the soil's life, from beginning to end. Hissink's view of the soil changed from a 'nutrient infrastructure'-*function* to a created, changing, and dying *entity*. However, the beginning and end of this *entity* were defined by whether it could perform absorbency, which still relates to carrying around nutrients.

Another consequence of the internationalization of soil science was the desire to move away from a local appreciation of the soil and local soil research methods to universal ones. As the soil was moved into the laboratory it became stripped of many of its local characteristics, such that research could be performed one variable at a time. Moreover, methods like Van Bemmelen's that were only suitable for local soils indicated a methodological and theoretical shortcoming in a time where laboratories were supposed to produce 'view from nowhere'-knowledge. The pressure for universal methods and a universal idea of the soil was intensified.

4 Groningen (1916-1924)

In the previous chapter, a process of internationalization had been set in motion, which continued and intensified in the upcoming chapter and functioned in a general move from the local to the universal. First, I will discuss how this pressure towards universality was expressed in a national context. Namely, a large reorganization of the Experiment Stations took place, which meant that Hissink could focus on general soil science alone and leave the monitorization of agricultural products for what it was. I will argue that it also meant he was now in a space which held less room for vernacular influences and that the distance between him and the practical farmer became larger.

At the same time, the internationalization continued. Hissink regrouped the soil scientist after the First World War, which would eventually lead to the foundation of the International Society of Soil Science (ISSS). Throughout all discussions leading up to this foundation, the point of standardization of methods and universalization of theory remained one of the most important ambitions of the international community.

Together, these two processes meant that not only scientific theories about the soil and scientific methods for soil analysis had become universal, but also Hissink's soil had become a more universal object, where local nuances were not of interest. I will show that this was expressed in the way Hissink approached the problem of soil classification for the Dutch soils. This practice had a long vernacular tradition but became replaced by a laboratory-created scientific system. At the same time, I will mention how Hissink could not escape the local character of the soil entirely. The specific Dutch context of soil reclamation projects led to a new chemically and environmentally influenced expression of the geological ideas on soil genesis and death.

4.1 Reorganization of the Experiment Stations

Taking notes from Germany

As was mentioned in the previous chapter, the State Agricultural Experiment Stations were overloaded with analytical control activities to test the quality of cattle feed, fertilizers, and seeds as well as tracking down counterfeits. The effect of this was that little room was left for the scientists employed at the Stations to focus on 'pure' scientific research. In 1904, when Hissink had just started working at the Station in Goes, he had already published an article expressing his dismay on the situation, but the problems persisted.[126] In 1907, new regulations were established for the Experiment Stations that stated each Station should have separate departments for quality control activities and for scientific research. However, because of the continuing increase in quality control demand, these new regulations had little to no effect and both the Experiment Station personnel and the Directorate of Agriculture agreed that more drastic measurements were necessary.[127]

In 1908, Hissink had been commissioned by the Dutch government to investigate how German experiment stations addressed this same problem during his study trip there. He judged that in Halle the best system was employed. Namely, in Halle the agricultural-chemical research on the one hand and the quality control and monitorization activities on the other were divided across entirely separate institutions. As such the institute responsible for the agricultural-chemical research could focus completely on the science. Hissink reported these findings to the Dutch Director-General of Agriculture and recommended the system of Halle to be adopted nationwide in the Netherlands.[128]

The reorganization of the Experiment Stations started in 1913 and was finalized and made official with a royal decree on September 6th, 1915. From now on, Groningen and Hoorn would focus their efforts on pure scientific research, where Groningen became responsible for agricultural research relating to crop and grazing fields, and Hoorn, on the other hand, for dairy agriculture and animal feed.[129] Wageningen, Maastricht, and Goes would solely focus on monitorization and quality control of different kinds of materials for agriculture.[130]

After the reorganization was finalized, Hissink was made director of the third depart-

126. D. J. Hissink, "Het personeel aan de Rijkslandbouwproefstations," *Chemisch Weekblad* 1, no. 61 (1904): 934–937.

127. Directie van den Landbouw, *Staatszorg voor den Landbouw*, p. 98–102.

128. D. J. Hissink, *De Reorganisatie van het Proefstationwezen in Nederland* (Wageningen: R. C. Kniphorst, 1916).

129. Ibid.

130. E. Pelzers, "Inventaris van de archieven van de Commissie van Toezicht op de Rijkslandbouwproefstations; Commissie van Advies voor de Rijkslandbouwproefstations, 1889-1957 (1958)," Nationaal Archief, last modified November 21, 2019, https://www.nationaalarchief.nl/onderzoeken/archief/2.11.37.16/download/pdf.

ment of the Experiment Station in Groningen in May 1916.[131] The Station in Groningen was subdivided into five different departments: I) Department for agriculture on clay and *zavel* soils, II) Department for agriculture on sand and peat soils, III) Department for general soil research, IV) Department for bacteriological research, and V) Department for botanical research.[132] All departments were assigned their own director and could independently decide their own scientific program.[133] As director of the third department, Hissink became responsible for a field that was much broader than simply agro-chemical monitorization research as he was in Wageningen and Goes.

So, while Hissink was still working at a State Agricultural Experiment Station as he had been in Goes and Wageningen, the purpose of research was entirely different. The kind of laboratory that he came to work at functioned more through research than through testing and was therefore a new venue of scientific activity in Hissink's life. Whereas the Stations in Goes and Wageningen had a strong regulative character, the focus was now much more on normative purposes. The goal was to improve the state of agriculture in the Netherlands, but though, wat Hissink called, 'pure' scientific research.

So, let us then finally look at what Hissink actually meant with 'pure' when he said pure scientific research, as it will further show how different the research practices were in Groningen. In a 1994 issue of *Gewina*, which was focused around exactly this question, Bert Theunissen explained in an introductory essay that where we might understand 'pure' scientific research to not necessarily invite any societal relevance (and surely not right away), this was not always the case around 1900 in the Netherlands.[134] Through several examples, the issue showed that what was exactly pure scientific research was not so clear-cut and it meant different things for different Dutch scientists.[135] Generally, however, and perhaps

131. "Benoemingen, pensioenen, enz."
132. "Instituut voor Bodemvruchtbaarheid en taakvoorgangers, 1889-1993," Regionaal Historisch Centrum Groninger Archieven, lat modified June 6, 2019, https://www.archieven.nl/nl/zoeken?mivast=0&mizig=210&miadt=5&miaet=1&micode=726&minr=924159&miview=inv2.
133. Hissink, *De Reorganisatie van het Proefstationwezen in Nederland.*
134. Bert Theunissen, "Inleiding: Zuivere wetenschap en praktisch nut. Visies op de maatschappelijke betekenis van wetenschappelijk onderzoek rond 1900.," *Gewina* 17, no. 3 (2012): 141–144.
135. For example F. A. F. C. Went's ideas on pure and applied biology in relation to agriculture in the Dutch Indies in Wim van der Schoor, "Biologie en landbouw. F.A.F.C. Went en de Indische proefstations," *Gewina* 17, no. 3 (2012): 145–161, or Kruyt's ideas on the societal relevance of pure and applied chemistry in Geert Somsen, "Hooge school en maatschappij. H.R. Kruyt en het ideaal van wetenschap voor de samenleving," *Gewina* 17, no. 3 (2012): 162–176. See also Bert Theunissen, *'Nut en nog eens nut': wetenschapsbeelden van*

different to our current understanding, a relevant societal application was part and parcel of pure scientific research, and without societal relevance the research hardly had legitimacy.

For Hissink, societal relevance was definitely a very important part of his work. Improving agriculture was eventually the goal of the scientific research at the Experiment Stations and of soil science in general. At the same time, however, Hissink also advocated to let go of the immediate practical results in order to achieve pure scientific research. Even more, he argued that the poor state of the field of soil research was precisely because in the past there had been such a large focus on practical applicability. So, I think that to Hissink pure scientific research consisted of reaching a higher form of understanding through the rational, laboratory-based scientific method, which "*for the time being* does not focus on practical results" and instead approached the problem through breaking it down into its components, assessing them through the primary sciences.[136] Naturally, that would lead to valuable knowledge for the practice.

Losing touch

However, there were also critiques of the reorganization of control and agricultural research.[137] Namely, according to the critics, the quality control and monitorization activities provided the scientist with a certain connection to the practical agricultural worlds. Such a connection would get lost if the agricultural experiment stations were focused on 'pure' scientific research alone. Would the scientist not get out of touch with what is actually of value to the farmer? Hissink's response to these criticisms was that the reorganization was not a division between scientific research and control *activities*, but between agricultural research and control *research*, meaning that research to improve analytical control techniques kept taking place (though at other institutes) and therefore the link between the scientist and farmer would remain intact. However, reading between the lines of Hissink's texts, it

Nederlandse natuuronderzoekers, 1800-1900 (Uitgeverij Verloren, 2000).

136. The full quote reads: "Hoe dit echter ook zij, in alle geval lijkt het mij wenschelijk, dat men bij het bodemonderzoek thans ook eens een anderen weg inslaat en dat men tracht door fundamenteelen arbeid, die voorloopig niet op practische resultaten let, een dieper inzicht in het zoo ingewikkelde samenstel van den bodem te krijgen." In D. J. Hissink, "De methode van het mechanisch bodemonderzoek," *Handelingen - Nederlands Natuur- en Geneeskundig Congres* 15: 450–468. See also Hissink, *Specialiseering in landbouwwetenschap.*

137. Hissink, *De Reorganisatie van het Proefstationwezen in Nederland*, p. 20–21.

looks like the relations between the scientist and the farmer did sour throughout Hissink's directorship in Groningen.

The sentiment that the scientist should never forget about the practical applications of their research was continuously reiterated by Hissink and other soil scientists. In the end, it was always the farmer for whom the research was done, and their needs always had to be kept in mind. Nevertheless, Hissink became aware of certain complaints from the farming community relating to the importance of the scientific research performed at the Experiment Station. The issue was that the knowledge that came out of the station was often not *new* knowledge to the farmer. The research simply confirmed what the farmers already knew through experience and therefore their general attitude seems to have been something along the lines of "tell us something we don't know."

Hissink responded to this by saying that the research was nonetheless valuable because it explained scientifically "facts that are known in the practice (. . .) and therefore make practically acquired experience into knowledge."[138] In other words, what science did would always be valuable because it was the body that created knowledge. What farmers had of the soil was specifically not referred to as knowledge, but as experience, which clearly found itself in a lower epistemic category. Though farmers' experience could guide the scientist into the right direction, it could only become knowledge once the scientist had taken a proper look with their scientific method. Through explaining farmers' experience, the scientist would eventually be able to provide the practice with new insights. The farmers simply had to be patient, but they were not.

In 1916, Hissink had already complained that farmers ought to show more interest in scientific output than they did and the appreciation from farmers for scientific research did not improve during the period after.[139] In 1919, the chairman for the Dutch Association of Agricultural Science put out a cry for help because there was not enough enthusiasm, and the meetings became increasingly less visited. Hissink argued that such an Association was

138. "Maar zelfs indien onderzoekingen, als thans door Dr. Mohr verricht zijn, voorlopig tot geen andere resultaten leiden, dan dat ze in de praktijk bekende feiten wetenschappelijk verklaren, de in de praktijk verworven ervaring dus tot kennis maken, dan nog zijn dergelijke onderzoekingen zeer toe te juichen en zullen zij in de toekomst ongetwijfeld vruchten afwerpen." In D. J. Hissink, "Physisch Bodemonderzoek," *De Indische Mercuur* 39, no. 22 (1916): 469–470.

139. Hissink, *De Reorganisatie van het Proefstationwezen in Nederland.*

an important place where the farmer and scientist could come together to exchange views and friendships, but he also conceded that there was not much interest.[140] Furthermore, in 1921 Hissink admitted that the central question coming from the practice was still not readily answerable by the scientists: they had not yet been able to put a number on fertility, which was eventually what the farmers wanted.[141]

Experiment farms

There was, however, one space where Hissink thought the scientist and farmer might rekindle their relationship. This was on so-called 'experiment farms' (*proefboerderijen*), which were farms completely dedicated to scientific agricultural research. During this period the establishing of an experiment farm, tied to the Experiment Station in Groningen, did not yet materialize, but there was a lot of talk. In 1918 a Groningen organization was founded for the creation and regulation of experiment farms called the *Association for the exploitation of experiment farms in the province of Groningen*.[142] The Association was not connected to the Experiment Station, and discussions were ongoing as to who should be allowed to perform research on the farms. In 1920, nothing yet had come of their ambitions, and therefore Hissink implied that the issue was with the way the association was going about setting up the research structure.[143] Therefore, Hissink decided to share how he thought it should be done.

Firstly, he addressed a farmers' proposal that the Association and the Experiment Station should part ways entirely, which was extremely undesirable according to Hissink:

> "If anything is necessary, then it is that the practice and the science should meet each other on the experiment farms. (...) But the conditio sine qua non for this is that both remain together and do not go their separate ways."[144]

140. D. J. Hissink, "Eenige losse opmerkingen naar aanleiding van het artikel „Waar zit de fout" van den Voorzitter van het Genootschap voor Landbouwwetenschap," *Cultura* 31 (1919): 197–200.
141. D. J. Hissink, "De beteekenis van het physisch-chemisch grondonderzoek," *Chemisch Weekblad* 18, no. 32 (1921): 447–450.
142. Original: Vereeniging tot exploitatie van proefboerderijen in de provincie Groningen.
143. D. J. Hissink, "Proefboerderijen in de provincie Groningen," *Groninger landbouwblad* 2, no. 5 (1920): 1–7.
144. "Indien er iets nodig is, dan is het dit, dat praktijk en wetenschap elkander op de proefboerderijen ontmoeten. (...) Doch de conditio sine qua non hiervoor is, dat beide bijeen blijven en niet ieder huns weegs gaan." In ibid., p. 3

Then, Hissink proposed that any person or organization should be able to propose a problem or question needing of research. The Experiment Station could then approve or reject the question and hand in a research proposal with the Association. The Association then had the final say on which research proposals would be executed. With this setup, the Experiment Station decided whether a certain question needed research of a more fundamental nature before it could be tested in practice, and the Association could turn down a proposal when it was "very nicely thought out in the laboratory but will lead to practical concerns on the experiment farm."[145] I think this firstly shows how the field character of the farm, meant that it had to become a post-lab place of research; only to test previously gathered knowledge in a real-world situation.

Besides that, the farm also became more laboratory-like than, for example, the agricultural experiment fields from Chapter 2 had been. On the research execution, Hissink said that this should be left entirely with the experimenters from the Experiment Station, while the day-to-day management could be *entrusted* with a farmer with sufficient scientific education.[146] To say that the farmer could be *entrusted* with this, is interesting phrasing as it clearly shows that it was the scientist who had the authority within the realm of knowledge production and therefore the power to choose who was allowed to enter and in what way. The scientists were able to perform an epistemic gatekeeping: a farmer was allowed to engage with scientific work as long as they did it in their specifically designed way and were not completely unfamiliar with the scientific method. This was different from earlier situations, where Deli farmers performed the fertilization experiments themselves, or Zeeland farmers could decide for themselves which soil sample to send in for analysis. Now, sure a farmer was allowed on the premises, but only for the day-to-day management, acting as a kind of laboratory assistant to the specific labscape that was the experiment farm:

> "[The farmer] must be guided in all his actions by this principle, that the experimenters are not there for him, but the other way around, he is there for the

145. Full quote: "Wanneer ten slotte een proefnemer een plan indient, dat wel heel mooi in het laboratorium is uitgedacht, doch waarvan de uitvoering op de proefboerderij practische bezwaren oplevert, dan bezit de Vereeniging de macht den betrokken proefnemer hierop te wijzen." In Hissink, "Proefboerderijen in de provincie Groningen," p. 5

146. Hissink, *De Reorganisatie van het Proefstationwezen in Nederland.*

experimenters."[147]

Less and less room existed for vernacular knowledge in Hissink's soil and I believe this is tied to the processes of internationalization and standardization, creating a universal soil, as well as Hissink's 'liberation' from the practice through the Experiment Station reorganization. At his Department for general soil research, Hissink was allowed to alleviate his focus on immediate practical results, and therefore was put in a space where the practical farmer had less claim to a voice. The universalizing of the methodologies and ideas of soil through the ongoing internationalization furthermore meant that local aspects, local ideas, and local knowledge of soils were neither needed nor wanted. "We've got it from here," the scientist said.

4.2 Unification of Soil Scientists and Soil Science

While the relationship with the farming community was souring, Hissink was trying to revive the international community that had taken a big blow after the First World War. The strengthening of the international relationships and the weakening of the local ones, seem to almost go hand in hand. A major concern that remained for Hissink was the fact that so many methods within his field of research were still 'unscientific', the solution for which, firstly, was found in the international unification of methodologies in all aspects of research: field research, laboratory research, and classification systems. The internationalization of soil science was consummated by the founding of an International Society of Soil Science (ISSS) in 1924.

Prague

It had initially been the intention to host the third International Conference in St. Petersburg in 1914. Because of the First World War, however, this was not realized. Only in November 1921, three years after the War, Hissink sent out a letter to the international soil scientific community together with geologist F. Schucht (1870-1941) from Berlin and agropedologist J.

147. "Hij moet bij al zijn handelingen zich laten leiden door dit principe, dat de proefnemers er niet voor hem zijn, maar omgekeerd, hij voor de proefnemers." In Hissink, "Proefboerderijen in de provincie Groningen," p. 6.

Kopecký (1865-1935) from Prague. This letter was an invitation for a preparatory meeting that should lead to the organization of the next international conference. All participants had to let Hissink know through a letter whether they would be present. Soon the registrations came rolling in and Hissink, Schucht and Kopecký decided that enough registrations from enough different countries had arrived that it would be legitimate to turn the meeting into an official conference: the Third International Conference of Agropedology in Prague, held from April 19th until April 24th, 1922.[148]

After the First World War tensions remained between European countries and while Hissink, Schucht and Kopecký decided that enough nationalities were present, the internationality of this conference was a lot lower than that of the second one.[149] Two soil scientists from the Netherlands were present, which were, naturally, Hissink as the director of the department for general soil research at the Agricultural Experiment Station in Groningen, and F. C. Gerretsen (1889-1966) as the director of the department for bacteriological research. Regardless of the slightly lesser internationality of this meeting, in the opening speeches Hissink said that, in the spirit of the League of Nations, the goal of the conference was to revive the international relationships within the soil scientific community after the War. Moreover, it remained absolutely crucial that an internationally unified system was created for research methods and procedures as well as scientific nomenclature and definitions.[150] Plans were furthermore made to organize a fourth conference only two years later in Rome (The Fourth International Conference of Pedology), which was of much greater grandeur.

Rome

In December 1923 another round of invitations were sent out to soil scientists and soil scientific institutions all over the world. To this invitation a registration sheet (*feuille d'adhésion*)

148. J. Kopecký, "Comptes Rendus de la Conférence Extraordinaire (IIIème Internationale) Agropédologique à Prague 1922" (Prague: Politika, 1924). The name for the third International Conference had changed to "agropedology", and for the fourth conference it would change to just "pedology."
149. Approximately 50 soil scientists were present, representing several nationalities. Soil scientists from, amongst others, France and England had sent their regrets for not being available to attend; only Belgium decided to abstain. "Les nations invitees, qui ne sont pas representees a cette conférence, nous ont envoyé leur témoignage de sympathie. Seulement la Belgique a decide de s'abstenir. Permettez-moi, Messieurs, sans porter aucun jugément, de regrétter cette decision."
150. Kopecký, "Comptes Rendus de la Conférence Extraordinaire (IIIème Internationale) Agropédologique à Prague 1922," p. 16–19.

was attached which had to be returned to the Italian team of conference organizers.[151] Eventually over 300 persons attended the conference, representing a large variety of nationalities.[152] The Dutch delegation had also expanded considerably. Interestingly, most of the Dutch participants still came from the State Agricultural Experiment Station in Groningen.[153]

One of the most important outcomes of the Fourth Conference was of course that the International Society of Soil Science was founded with explicitly as its purpose the coordination and encouragement of soil science all over the world. Hissink was named as its Secretary-General and would remain so until 1950. Besides that, it planned to standardize methods for soil analysis, standardize methods for soil microbiological research, decide on definitive nomenclature and a classificatory system for soils, develop an international agrogeological map of Europe on a 1/500.000 and a 1/2.500.000 scale, organize soil research in countries where it did not exist yet, introduce soil science in middle and higher education, and to organize the first International Congress of Soil Science in the United States, which would in fact take place in 1927 in Washington DC.[154]

The founding of the ISSS was the culmination of the process of internationalization from the First Conference onward. Hissink played a very important role in the foundation of the Society as well as in its functioning afterwards. In 1950, the Fourth International

151. These were interesting times in Italy. Mussolini had just come to power in October 1922 and the fourth conference was held under his patronage. There are strong links in fascist ideology between the national population and the national soil. See, for example, Tiago Saraiva, "Fascist modernist landscapes: Wheat, dams, forests, and the making of the Portuguese New State," *Environmental History*, 2016, The conference's opening and closing texts from the Italian organizational committee echo such sentiments.

152. Several sources claim the conference had 463 participants (for example Van Baren, Hartemink, and Tinker, "75 years the international society of soil science"). This number is derived from the total of (official and unofficial) government delegations (24), 'members' (303), scientific institutions (120), and economic or industrial institutions (16) that were represented at the conference. Hissink, for example, appears as the Dutch government delegation and as a member. So the number of 463 does not represent physical persons being present, but it represents both people, and institutions or governments represented by those people.

153. The Dutch delegation consisted of: Ivan van Baren, professor of Geology at the Agricultural University in Wageningen (I think this should actually be Johan van Baren); R.M. Barnette, department for general soil research at Experiment Station Groningen; I.G. Bijl, engineer *Haarlemmermeerpolder*; F.C. Gerretsen, director department for bacteriological soil research Experiment Station Groningen; D.J. Hissink, director department for general soil research Experiment Station Groningen; J. D. Hissink-Massee, Hissink's wife; J. G. Ligtenberg, engineer Zuiderzeewerken; E. W. van Panhuys, director of the reclamation service The Hague; Jac. van der Spek, department for general soil research Experiment Station Groningen; K. Zijlstra, director department for botanical research Experiment Station Groningen.

154. R. Perotti, "Actes de la IVéme Conférence Internationale de Pédologie, Vol I" (Rome: Imprimerie de l'Institute International d'Agriculture, 1926).

Conference of Soil Science was held in Amsterdam in his honor.[155] Throughout all the proceedings of the conferences leading up to the ISSS's foundation, internationalization and unification of methods took center stage. It led to a universalizing of the idea of soil, which had consequences for the place that local and vernacular knowledge could have in Hissink's soil-concept.

4.3 A Universal Soil?

Now that Hissink did not have to focus so much on monitorization, he published no more research on the development of fertilizer analysis techniques. This did not mean that his focus on agricultural relevance also left. As I mentioned before, agriculture was eventually what they were doing it all for. But it essentially meant that he had free reign on how to approach the problems. The research focuses of this period were soil absorption, in relation to both new and aged soils, soil acidity, and its relation to fertility, and mechanical soil classification. The focus on agriculture was still there, but the plant-central narrative of the soil diminishes. The soil was approached more liberally. Moreover, the internationalization of soil science and universalization of the soil eventually meant that local, vernacular knowledge lost its right to a voice.

Classifying the Dutch soils

One area where important developments were taking place, especially in relation to the farmer-scientist interactions, was mechanical soil classification. We already know that in this area there were clear vernacular practices of classification in play and that scientists had started to create their own systems. Hissink now presented his own classification of the Dutch soils to the international community, which was neither based on vernacular practices, nor suited to agrogeological standards of classification. It was however a systematic, quantifiable, and laboratory-based way to categorize soils.

As was mentioned in the previous chapter, mechanical soil research considered the grain size distribution of the soil and was, among others, proposed as a classification system by

155. They started to count again from one after the foundation of the ISSS.

Hall and Russell. From 1916 onward, Hissink further developed the system and applied it specifically to the Dutch mineral soils.[156] Whereas Hall and Russel's system had subdivided the soil into six fractions, Hissink now used Atterberg's system as his basis, which subdivided the soil into four fractions: clay (<0.002 mm), fine (0.002 – 0.02 mm), water-retaining sand (0.02 – 0.2 mm), and water-permeable sand (>0.2 mm). He presented the results of this classification as applied to the Dutch soils in an international collection of soil classification systems of various European soils.[157]

This collection was an initiative following the third International Conference and was led by a group of agrogeologists. Classification was, traditionally, a more agrogeological subject and could be based on many things like parent material, climatic alteration journey, soil profile, agronomy, chemical, and mechanical analyses and discussions were still ongoing at the end of our period relating to which attributes were most informative. According to the agrogeologists, a classification that was solely based on mechanical soil research was not a proper one, however, because it did not in the slightest consider the formative processes of the soil and did not look at soil profiles. In the collection, then, the classifications which were not based on soil profiles were presented separately from the rest, Hissink's classification including. The allure of mechanical soil classification, I believe, for Hissink (and other chemists that presented a non-profile classification in this collection) was that it was a precise, laboratory-based method. And though deciding which soil classes to use was somewhat conventional, they were at least quantitative. Moreover, though it was not simple, there was a clear route to standardization. Two years after the international collection, Hissink had asked six different institutes to perform their version of mechanical soil research on soil samples that he had sent to them in order to see what influence different chemical sample preparations might have on the outcome of the research. Different results did indeed appear, and the conclusion was that—next to an agreement on what the soil 'classes' should be—it was also necessary that "identical methods of analysis should be agreed upon."[158] In the

156. Again, for soils with a high humus content, like the peat soils in the Netherlands, a classification based on grain size distribution was meaningless.

157. B. Frosterus, *Quatrième Commission - Commission pour la Nomenclature et la Classification des Sols - Commission pour l'Europe* (Prague: Politika, 1922).

158. R. Perotti, "Actes de la IVéme Conférence Internationale de Pédologie, Vol II" (Rome: Imprimerie de l'Institute International d'Agriculture, 1926), p. 38.

agrogeological classification discussions, on the other hand, the route to standardization was much less clear because there was such a strong local aspect to these systems.

The ease of universalizing the looking at the soil with the mechanical classification system moreover meant an ease of erasing vernacular practices. There were long standing vernacular practices relating to the grain size distribution of the soil, because it related both to its fertility and 'tillability' (*ploegbaarheid*), both important factors for farmers.[159] With a universal methodology it meant that local practices were no longer necessary. Farmer's classification became associated with an 'in the field', subjective description of the soil rather than true analytic understanding. On how farmers classify their soils, Hissink commented that their division "when they are performed by the practical farmer in the field, will always be extremely subjective. In a region with heavy grounds, a slightly less heavy clay ground will quickly be classified as a lighter ground, while the possibility exists that this same ground type, when found in a region of sandy grounds, will be classified as a heavy clay ground."[160] Hissink's laboratory mechanical soil analysis, on the other hand, would produce a much more consistent and reliable basis for soil classification.

New soils, old soils

The universalization of the soil did not mean, however, that Hissink's soil concept was immune to the local environment. The ideas on soil formation, transformation, and death that he had formed during his time in Wageningen got a specific expression in the Dutch context. Namely, Hissink revisited the concept of soil birth in this period through the many land reclamation projects that were going on in the Netherlands. Especially with the Zuyderzee Project being set in motion around this time, it became paramount to learn how previously sea soils could be turned into soils fit for agriculture. As we learned from the

159. Traditionally the farmer divided soils into light (sandy) soils, which were more easily plowed but needed more fertilization, and heavy (clayey) soils, which were harder to till but were generally rich in soil particles that naturally consist of many plant feeding nutrients and can easily absorb new plant feeding nutrients as well as water.

160. "Men kan daartegen dan weer de opmerking maken, dat de praktijk toch slechts op zeer ruwe wijze eene verdeeling kan maken in lichte en zware gronden en aan deze opmerking, toevoegen, dat deze verdeeling, wanneer, zij door den practischen landbouwer op het veld plaats vindt, altijd van zeer subjectieven aard moet zijn. In een streek van zware gronden zal een minder zware kleigrond al reeds tot de lichtere gerekend worden, terwijl de kans bestaat, dat dezelfde grondsoort, gelegen temidden van zandgronden, als zware kleigrond zal worden gekwalificeerd." In Hissink, "Physisch Bodemonderzoek," p. 1.

flood following the Storm of 1906, saltwater is not good for agriculture. So, when a piece of land was reclaimed, how would they know when the soils were ready for cultivation? We saw in the previous chapter that it was mostly a waiting game: the fresh rainwater had to leach out the salts that had been added to the soil by seawater.

In Groningen, this had relevant applications, because much new land was created there on soils that were previously in the sea (called *kwelders*) and therefore entrenched with salts. Hissink gave, for example, a lecture to alumni of the national agricultural winter school, where he told them that one year of precipitation should be enough to remove all the kitchen salt from the soils and they should be ready for cultivation (though at the same time not all soils in Zeeland had yet recovered from the storm in 1906).[161] Hissink, furthermore, published an in-depth explanation of the development that *kwelder*-soils go through from the moment they are exposed to the air.[162]

Hissink really envisioned a certain aging process for the *kwelder*-soils, where the rain which had allowed their birth would eventually also lead to deterioration. However, it was the task of the farmer to prevent this from happening with the help of the proper fertilization:

> "Finally, the poor soil recalls the image of an old man. Fortunately, this comparison is not an identity. Where man, in the words of our great poet Da Costa, may not bear his spring a second time, for the soil it is different. It is the farmer's task to keep the soil in good condition by good and judicious cultivation and (. . .) by timely fertilization with lime to restore it to its lost strength."[163]

Whereas the rain initially led to a 'birth' of soils by removing the salts, it eventually also meant that plant nutrients (lime as first, because it was the most loosely bound nutrient) would eventually be depleted, leading to soil decay.

161. D. J. Hissink, "De nadeelige gevolgen van eene overstrooming van zout water op kleigronden," *Provinciale Groninger Courant*, October 1918, D. J. Hissink, "Het verouderingsproces van de zeekleiafzettingen in Nederland," in *Demeter-Eugeïa almanak voor het jaar 1922* (1922), 79–88.

162. D. J. Hissink, "De natuurkundige en scheikundige veranderingen, die kweldergronden nà de indijking ondergaan," *Verslagen van landbouwkundige onderzoekingen* 29 (1924): 170–184.

163. "Tenslotte biedt de knikkige grond ons het beeld van den grijsaard. Gelukkig is deze vergelijking geen identiteit. Mag de mensch, naar het woord van onzen grooten dichter Da Costa, zijn lente geen tweede maal dragen, met den grond is dit anders. Het is de taak van den landbouwer, om door goede en oordeelkundige bewerking en (. . .) door tijdige bemesting met kalk den grond in goeden toestand te houden en hem de verloren kracht terug te geven." In Hissink, "Het verouderingsproces van de zeekleiafzettingen in Nederland," p. 8.

And this, then, sounds incredibly similar to both the geological ideas of a transforming soil and agrochemical *Raubbau* sentiments. Only where *Raubbau* was a problem that was manmade and reflected a disturbance in the natural balance of nutrient cycling, Hissink's nutrient depletion was actually an expression of nature. It was the normal way of things that the rain removed nutrients from the soil and the farmer had a natural place in the system in trying to counteract this process. It shows how geological ideas of a natural progression of the soil's life become reconfigured in the context of the Dutch environment combined with Hissink's absorbance agro-chemistry.

4.4 Conclusion

Throughout this period there has been a moving away from the local and refocus from local nuances towards a unified system of larger-scale regularities. The ongoing internationalization led to a universalizing of the idea of soil as well as the approaches on researching it. Moreover, Hissink's own relocation to Groningen meant that he could let go of the control and monitorization tasks and focus on general soil science. It also led to more distance between him and the farmer, as his new place of research was less welcoming to farmer's influence and their local knowledge on the soil. Specifically in the case of mechanical soil classification this led to the creation of a universal system for soil typing, which had similarities with vernacular practices but did not consider their perspective. However, the specific environmental context of soils still left their mark on Hissink's conceptualization. The Dutch sea soil reclamation projects meant that Hissink's ideas on soil genesis and death were shed in the new light of ageing through rain-induced nutrient depletion.

5 Conclusion

Hissink's soil concept has made a considerable transformation as a consequence of his different places of employment, a changing relationship with the international community, a changing relationship with the farming community, and the specific environmental conditions of the Netherlands. In Deli, Hissink met the soil through fertilization experiments and chemical extractions of plant nutrients in the soil. Both methodologies created a view of the soil as nutrient infrastructure: it was the soil's purpose to hold onto nutrients from fertilizers and offer them up to the plants when they needed them. The rhetoric of these experiments furthermore confirmed Marchesi's idea of a persisting NPK-mentality. Namely, they revolved around expressing plant growth in clear-cut statements like "if I add X amount of nitrogen, phosphorus, or potassium to the soil, then plant growth will be increased by X." The local character of the fertilization experiments did not suit Hissink however and he longed for larger-scale knowledge as well as methodological refinement.

After Hissink moved back to the Netherlands, he came to work for the State Agricultural Experiment Stations which revolved around monitorization and quality control of agricultural products. It meant that Hissink continued in his fertilization-central view of the soil. However, two important things happened during this period that influenced the direction of Hissink's soil conceptualization: a storm surge of Zeeland and increased international engagement. From the chemical side, it led Hissink to consider the structural buildup of the soil and investigate its absorbability qualities. Namely, a necessary reductionist approach to the soil meant it became subdivided in different parts holding different functions. Naturally, one of the most important soil functions was fertility and it was thought to lie with the absorbing soil colloids. Together with new geological ideas, it created the concept for Hissink that the soil was born, lived, and eventually died. The colloidal particles of the soil would naturally, eventually decay into the original crystalloids they came from. With that, the absorbing function that distinguished the soil from stone disappeared with it.

Finally, Hissink relocated to the Experiment Station in Groningen after a large reorganization meant that he no longer had to perform monitorization tasks but could instead focus on 'pure' scientific research and leave the immediate practical applicability for what it was.

As a consequence, however, Hissink's relations with the farming community soured. The further ongoing internationalization in which Hissink played a considerable part also pushed the soil concept towards the universal. Both factors attributed to the situation that there was no longer a need nor a want for local knowledge into the science of the soil. This was expressed in Hissink's classification system for the Dutch soils that disregarded local knowledge and practices entirely. However, the local uniqueness of the Dutch environment still left its mark on Hissink's soil conceptualization. The practices of soil reclamation together with high precipitation characteristic of the Dutch climate led to a reconfiguration of the geological ideas of soil transformation into a context revolving around Hissink's chemical absorbency research.

Throughout this period, Hissink attempted to move the soil from a local to a universal object. This was expressed in the drives towards standardization of methods, the unification of theories, as well as the increasingly unwelcome local, vernacular soil knowledge. Soil science was born out of agriculture and as such the ties with agriculture were incredibly strong in the beginning. It is not for nothing that the foundational disciplines are called *agricultural* chemistry and *agro*geology. Therefore, initially the ties with the local farming communities were strong, the importance of local knowledge high, and space for vernacular influences large. In Deli, a system of cooperation between farmers and scientists was set up to together improve agriculture.

However, when Hissink entered these borderlands, he did so as a laboratory chemist. This is where this story differs considerably from Kohler's field biologists in *Landscapes and Labscapes*. These field biologists created lab-field hybrid spaces in a struggle for legitimacy and as such reconfigured laboratory methods in a field situation in order to extrapolate local knowledge to universal regularities. Hissink, however, entered the 'agricultural experiment field'-borderland and thought "this is not right." And it was precisely the local character of the research that devalued it for him—exactly what Kohler's field biologists had been struggling against. Hissink did not want a detailed understanding of one place to arrive at universal regularities. He wanted universal knowledge from the get-go.

He is however shackled to the local by, in Buitenzorg, the inherent local nature of the fertilization experiments, and in Goes and Wageningen, the service to local agriculture by the institutions he was working at. In Groningen, he found some release as the only local research he might engage in related to the agricultural experiment farms (that had not yet been created), which in his vision would be completely reconfigured as outside-laboratories, where the only other user may be a scientifically trained farmer functioning as laboratory assistant, and with the farm's only function as testing previously laboratory produced knowledge. And, though in Groningen he has released himself both from having to focus on the immediate practical concerns of the farming community as well as from experimentation that necessitated a local consideration of the soil, still the unique, local environment, landscape and soil of the Netherlands shaped his soil conceptualization.

Hissink's soil conceptualization started out at as nutrient infrastructure. As a function, essentially. It had to shuttle nutrients from fertilizer to plants and Hissink did not really consider how that happened. The rhetoric of the fertilization, extraction, and ash experiments almost bypass the soil entirely. Then, through an increased engagement with the agricultural chemistry community, Hissink started to reconceptualize the soil into 'characters' and 'needs', into Betriebskapital and Grundkapital, into temporary and permanent production capacities, and he moved his focus away from the soil's needs to the soil's character. He started to consider the part of the soil that was responsible for soil absorbency and therefore for fertility which led him to learn of soil colloids. These colloids were a sort of vitalistic structure of the soil that provided it with an energetic, living character but would eventually deteriorate back into stable crystalloids. His engagement with the geological community meant he learned about soil genesis and transformation; how different factors acting upon rocks could create and continue to re-create the soil throughout its life.

Importantly, the unique Dutch environment further developed these ideas. The Storm Surge in Zeeland, the reclamation projects in Groningen, the upcoming Zuyderzee project. They all led to new ideas of soil 'birth' which related to the functioning of rain on leaching out of salts bound to the soil. But this same rain also caused the soil to age by leaching out plant nutrients, eventually leading to soil decay. Whereas for nineteenth century agricultural chemists soil decay had been an expression of a disbalance with nature, for Hissink soil decay was a normal natural process. Just another part of the Dutch struggle with the water.

In this thesis, I have tried to show how a scientist's conceptualization of their own subject can change considerably through the institutions they work at, through the scale with which they look at it, through their network with other scientists and the practice. The epistemic hierarchy between the lab and the field has furthermore greatly influenced Hissink's approach in researching the soil as well as his decision on which kinds of soil knowledge to allow into his realm. This was the case for the laboratories that he worked at as well as the lab-field hybrid spaces where he performed experimentation. However, even though Hissink has tried to move away from localness of the soil to universal ideas, theories, and methods, those same unique, inherently local features of the Dutch landscape have kept influencing his Soil Story.

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A Appendix: List of Soils

A list of the soil types that I have mentioned in my thesis with an explanation of what is meant by them. This is not an official classification system, but these are definitions that were used at the time from Oosthoeks geïllustreerde Encyclopaedie.

Dutch name: Klei

English name: Clay

Explanation: "The fine sediment of rivers, lakes or the sea, which contains as a characteristic component an amount of amorphous hydrous aluminum silicates in addition to the never-missing fine powder of unweathered or incompletely weathered minerals from the original rock. (...) It is precisely to the amorphous colloidal state that the clay owes many of its most important properties, in particular its high absorption capacity for water and numerous bases, including those which man adds as plant nutrients. (...) If a soil contains more than 30% clay, it is called a clay soil."[164]

Dutch name: Kwelder

English name: no translation

Explanation: "The vegetated part of the land outside the dike along the seacoast or along the great estuaries. (...) Outside the dike, accretions arise against the dike, which either slope towards the sea (fertile! clayey) or landward (barren! sandy)."[165]

Dutch name: Leem

English name: Loam

Explanation: "The loamy soils contain at least 20% siltable parts (= lutum; clay) and sometimes much more. However, in contrast to a clay soil, the silting part of lutum usually consists largely of very fine sand. This very fine sand gives loam more or less the physical properties of clay, although its chemical composition is closer to that of a sandy soil. Nev-

164. *Klei*, in *Oosthoek's geïllustreerde encyclopaedie*, 1st ed., vol. 7 (Utrecht: A. Oosthoek, 1921), 381–382.
165. *Kwelder*, in *Oosthoek's geïllustreerde encyclopaedie*, 1st ed., vol. 7 (Utrecht: A. Oosthoek, 1921), 548.

ertheless, the potash and sometimes also the lime and humus content is important, so that the natural fertility of the loamy soil is generally greater than that of sandy soil."[166]

Dutch name: Veen

English name: Peat

Explanation: "A sediment formed by dead and fallen plant parts, the layers of which consist of an accumulation of carbon-rich plant matter formed by partial decomposition."[167] "Is relatively widely used for the cultivation of vegetables. The advantage of the peat as a warm-house soil lies in its high water-holding capacity (vegetables need a lot of moisture!), in its dark color, which means that it absorbs a lot of sunlight and therefore heats up easily, and in the high content of plant food. However, the water capacity can sometimes be too large and therefore make heating more difficult. For this reason, vegetable growers prefer peat soil mixed with sand."[168]

Dutch name: Zand

English name: Sand

Explanation: "Consists of those decomposition products of rocks, which are finer than gravel and coarser than clay. It can contain all minerals in granular form, which occur as components in the original rocks."[169]

Dutch name: Zavel

English name: no translation

Explanation: "A clayey sandy soil or a sandy clay soil. Belongs to the most fertile and also the easiest to cultivate soil types. Provides reliable harvests of the most diverse crops."[170]

166. *Leem*, in *Oosthoek's geïllustreerde encyclopaedie*, 1st ed., vol. 7 (Utrecht: A. Oosthoek, 1921), 641.
167. *Veen*, in *Oosthoek's geïllustreerde encyclopaedie*, 1st ed., vol. 10 (Utrecht: A. Oosthoek, 1923), 456.
168. *Veengrond*, in *Oosthoek's geïllustreerde encyclopaedie*, 1st ed., vol. 10 (Utrecht: A. Oosthoek, 1923), 458.
169. *Zand*, in *Oosthoek's geïllustreerde encyclopaedie*, 1st ed., vol. 11 (Utrecht: A. Oosthoek, 1923), 95.
170. *Zavel*, in *Oosthoek's geïllustreerde encyclopaedie*, 1st ed., vol. 11 (Utrecht: A. Oosthoek, 1923), 99.