

Scent of Soil

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Abstract

Microorganisms living in soil have been producing volatile substances responsible for a distinctive earthy scent for millions of years. Life forms across the soil ecosystem including springtails, humans and flies are able to detect these compounds. This essay engages with the scientific literature addressing the function of these microbially induced substances and leverages these discussions to advance novel possibilities for engaging with more than human lives linked to the senses. Through an olfactory exploration of the scent of soil, it is possible to reconnect with invisible microbes, neglected soils and wider ecosystems residing underground. Breathing soil and breathing microbes can initiate a critical reorientation in human demeanours towards more attentive embodied perceptions and relations with other lives.

Keywords: soil, scent, microbes, embodied relations

Introduction

The current emergence of soil from public inattention and the growing scientific interest in its molecular and genomic relevance have been noticed and attentively documented in recent years (Puig de la Bellacasa, 2014; 2015; 2017; Granjou and Phillips, 2018). Scholars across disciplines are recognising an undergoing “microbiome revolution” or “microbial turn” (Craig, et al., 2016: 3; Paxson and Helmreich, 2014: 166), where microbial life becomes seen as useful to think with and consider renewed configurations of human relations with other lives. The microbe is increasingly conceptualised as a future promise across diverse social spaces, beside and beyond merely harmful characterisations. There is a growing sense that microbes represent the most critical life forms on Earth, involved as they are in many biogeochemical processes. Microbial soils specifically are coming to matter in scientific laboratories, agricultural fields and policy corridors, navigating outside their original place of inception, to circulate and shape other epistemological fields (Author, 2022). This increased attention to the microbial world seems to point to an occurring shift in biological perspectives of life as ecologically interconnected. If biophilia is humans’ “innate need for affiliation with other forms of life” (Craig, et al., 2016: 5), these connections seem to increasingly focus on invisible organisms.

This essay proposes an exploration of the scientific knowledge around volatile compounds produced by microbial communities living in soil and detected by diverse

life forms, including humans. This field of study examines the microbial origin of the scent and the diverse functions the compounds perform for the entire soil ecosystem. Alongside attracting arthropods who feed on the very microbial colonies producing the scent, thus spreading their spores, these compounds have an effect on human health. When individuals are exposed to the typical aroma of forest soil, their wellbeing is found to improve on a physiological, psychological and spiritual level.

This area of research becomes particularly relevant at a time when urgent action is called to reduce destructive economic activities responsible for the obliteration of ecosystems and for global warming (Rosales, 2008). This essay argues that engaging with the scent of soil can entail a reconnection with wider communities living above and underground, a relation reawakened through the knowledge that the life forms generating the aroma are responsible for connecting different species with each other. Drawing on calls from disciplines across the social sciences and humanities for more careful consideration of sensory perceptions, breathing the fragrance of soil can become a meaningful, embodied and shared experience able to facilitate novel bonds involving diverse and often neglected organisms. In exploring the possibilities of relations that olfaction can offer, it is possible for new ways of knowing the world to emerge. The sense of smell, with its powerful connection to emotion and memory, can turn into a form of enquiry that does not obliterate its perceiver and instead allows for a relational embodied encounter with other organisms. Microbial lives are not disconnected from human experience, but inextricably entangled through myriad involvements and associations materialising at the corporeal level. Rather than maintaining an abstracted relation with soil and its ecosystem, it is possible to descend to muddy, meaningful encounters between visible and invisible bodies that share spaces and histories.

Olfaction and human wellbeing

In what have been defined “visual and textual biases of the Western episteme” (Howes, 1991: 4) and the “hegemony of vision” (Low, 2012: 273), a hierarchy has given the sense of sight a primary position compared to the other senses across disciplines including science, linguistics, philosophy and psychology. The sense of smell in particular, with “its boundary-transgressing propensities” threatening comforting ideas of set confines, has been largely neglected (Classen, Howes and Synnott, 1994: 5). Because of a focus on order and objectivity, the sense of smell has been considered too subjective to be trusted as reliable or rational compared to vision (Press and Minta, 2000). While olfaction elicits memories and images that are complicated to communicate linguistically, it is not the result of imprecise guess. Unlike sight, olfaction remains strong, stable and trustworthy over time in the retention of memory and emotion (Press and Minta, 2000). European languages may not be particularly articulated in conveying the sense of smell, but this is not because

olfaction cannot be described; rather, these languages reflect a culture that has neglected the sense of smell (Classen, Howes and Synnott, 1994).

As a type of perception connected to the limbic system, the olfactory sense is the least rational and the most somatic, embodied and ancestral. With a strong “odor-memory-emotion triad” (Press and Minta, 2000: 177), the sense of smell is able to evoke memories and emotions (Licon, et al., 2018). The olfactory function is connected to cerebral areas that also process emotions, hence the strong “affective dimension of smells” (2018: 46). The perception of scent involves the elicitation of pleasant or unpleasant emotions and has intense influence on mood, emotions and behaviour, as well as on changes in functions such as heart rate. The affective states, positive and negative, induced by certain scents are strongly entrenched in memory (Licon, et al., 2018). Anosomia, the loss of the ability to smell, has recently received renewed attention due to the recurrence of this symptom in some of the patients affected by the respiratory disease COVID-19 caused by the SARS-CoV-2 virus (Mathis, et al., 2021). Olfactory deficiencies are also increasingly being linked to a range of psychiatric disorders (Atanasova, et al., 2008). Brain studies have established a particularly significant association between olfactory impairment and depression (Rochet, et al., 2018), findings that highlight the strong interconnection between the sense of smell and emotional wellbeing (Licon, et al., 2018).

A growing area of study concerns specifically the ways in which the scent of soil affects human health. The volatile chemicals present in forests have been linked to a decrease in blood glucose levels in diabetic patients, in a study that specifically emphasises the olfactory element involved in the now popular Japanese practice of forest bathing (Ohtsuka, et al., 1998). Shinrin-yoku, initially defined as “forest-air bathing and walking” and aromatherapy (Ohtsuka, et al., 1998: 125), or “bathing in the forest atmosphere” (Li, 2018: 12), entails “walking aimlessly and slowly” in a forest and become aware of the surroundings through the five senses (Li, 2018: 118). The sense of smell involved in experiencing the aroma of soil and trees is believed to deliver the most beneficial and lasting effects of forest bathing (Li, 2018). Heart rate decrease has been found in human participants when stimulated with the aroma of soil in a study conducted in Japan (Morisawa, et al., 2017). The “healing effect” is thought to be due to the memories of childhood and of forests that the scent of soil elicits (2017: 236). This is because, as mentioned, “the sense of smell enters the limbic system which is responsible for processing memory and creating emotion” (2017: 242). This influences the autonomic nervous system that regulates the heart rate. By breathing soil, the parasympathetic nervous system becomes more active while the sympathetic nervous system subsides (Morisawa, et al., 2017). Beyond the physiological benefits for human health, shinrin-yoku has been shown to improve mental wellbeing, including anxiety, depression, stress and anger (Kotera, et al.,

2022) as well as enhance human spirituality (Hansen and Jones, 2020). The spiritual effect may be connected with the religious and spiritual connotation characterising the historically strong relationship the Japanese people have with their forests and green spaces (Oe and Yamao, 2021). Shinto religion for instance places various spirits within natural environments such as forests, that often turn into worshipping sites (Li, 2018). The following section explores how volatile compounds found in soil have been fashioned as ‘public goods’ for their effect on human health and crop pathogens.

Microbial volatile compounds in soil

The field studying volatile compounds present in soil has long analysed the origin of various mineral odour (McCartney, 1968). More specifically “argillaceous odour”, later named “petrichor” by scientists Isabel Bear and Richard Thomas is the characteristic, tenuous scent coming from a variety of source material and generally associated with the essence of rain (Bear and Thomas, 1964; 1966). *Geosmin* is one of the compounds that creates the evocative fragrance of forest soil, although there may be over a hundred further volatile chemicals involved (Insam, 2014). Geosmin is an odorous terpene, a large class of natural products responsible for conveying information to a wide variety of animals and plants (Gershenson and Dudareva, 2007). Geosmin is produced by the bacteria *Streptomyces* as well as other bacteria and soil moulds (Chater, 2015). *Streptomyces* have produced geosmin for millions of years, and they are the descendants of an ancestor who produced the earthy odour already two billion years ago. The scent both attracts and repels different living entities. Organisms as diverse as flies and humans possess geosmin receptors and are therefore able to sense the compound. *Streptomyces* multiply in a fungal fashion, through spores (Chater, 2015). A recent study proposes that they use volatile compounds to multiply through soil arthropods (Becher, et al., 2020). Attracted by geosmin, springtails consume *Streptomyces*, thus spreading their spores. The production of this compound may therefore have an advantage for the dissemination of the microbes responsible for the scent (Becher, et al., 2020).

The study of organic volatile compounds present in soil, or soil volatilomics, has been employed as an alternative to other methods such as metagenomics to understand soil microbial composition, although the diverse conditions and susceptibility of these compounds make it complicated to draw specific conclusions on microbial activity or soil characteristics (Insam, 2014). Some volatile compounds may cause soil disease suppression, a function considered important especially in relation to plant resistance to pathogens and as an alternative to the employment of chemical products in agriculture. This potential has been investigated in crops such as tomato and watermelon (Insam, 2014). Microbial volatile compounds are

therefore currently proposed as possible solutions towards sustainable agriculture for their ability to provide pathogen control without the use of pesticides (Kaddes, et al., 2019; de Boer, et al., 2019). Alongside their effect on crops, the influence of microbial volatile compounds on human health is opening new areas of research where the chemicals are envisioned as tools for the suppression of diverse infectious diseases and antimicrobial resistance (Weisskopf, et al., 2021).

In this context, microbial volatile compounds are increasingly considered ‘public goods’ that can be manipulated to benefit sectors such as agriculture as well as human health (Weisskopf, et al., 2021: 402). This focus on the functions of volatile compounds produced by microbial communities in soil and their effect on crops and human wellbeing is rendering unseen and often neglected microorganisms scientifically important and deserving of attention. While the coming to matter of microbial life is a welcomed turn in its potential to reorient the anthropocentric conceptualisation of humans as clearly bounded, rational individuals, it is also critical to interrogate the kinds of questions asked in the microbial sciences. This is particularly essential when microbial life is examined through a mere ecosystem services approach, narrowly defined in terms of human wellbeing and economic value (Millennium Ecosystem Assessment, 2005). This is because current debates around soil are entangled with a technoscientific and anthropocentric narrative focused on production and the exploitation of resources (Puig de la Bellacasa, 2015). When microbial communities of soil are studied for their mere potential to improve human wellbeing or to ensure an uninterrupted and more sustainable agricultural supply, it is important to notice and make visible the instrumental aims characterising the field, so that other ways of engaging with microbial life can emerge.

Breathing *with* microbes

The scientific interest in the microbially produced scent of soil, alongside a “sensual revolution” ongoing across the social sciences and humanities envisioning an increased focus on the “sociality of sensation” (Bull, et al., 2006: 5), prompt a proposal for imaginative olfactory and embodied relations with soil microbial organisms. The idea of sensing as a way to experience the world through corporeal engagement is recently undergoing a turn towards less anthropocentric approaches that include more than human lives (Gabrys, 2019). “Sensing practices” entail multiple experiences cutting across scientific approaches, activism, theory and practice (Gabrys, 2019: 724). These diverse conceptualisations include the experience of different entities and relations. Drawing on this perspective, embodied sensing of microbial soils emerges as a form of knowing both grounded in corporeal affinity and informed by scientific discussions around volatile compounds and their effect on human wellbeing.

Different modes of enquiry alongside science can embrace responsibility while rejecting the utilitarian aims pursued by the scientific project, as well as its management and hierarchical approach (Myers, 2017). Reconnecting with the olfactory perception of microbial soils needs to be contextualised in the awareness of the human exploitation of soil, people and microbial life itself. Breathing soil cannot become yet another scientific gaze generating a totalising and generalisable data, but it can be practiced as an attentive refusal of the commodification of invisible lives through microbial products such as bioinoculants used in agriculture. Beyond calls for technofixes aimed at continuing business as usual, 'we' - the 'we' that includes others seen and unseen - must remember that "we are not alone" and have never been (Myers, 2018b: 54). 'We' need novel ways to overcome the disconnection from a microbial fragrance that is political and not simplistic, an aroma that calls for entanglements beyond economic growth and towards the extension of our sensorium. This is a recognition of widespread, multiple "affective ecologies" taking place all around us, beyond the "economization of life that grounds conventional ecology" (Myers, 2018b: 58-59). A sensorial reconnection with microbes and soil can thus only take place in the context of a wider project of decommodification of ecologies, where scent is taken seriously and explored for its potential to create meaningful and decentred relations with different soils, territories and lives. Recognising the validity of olfactory data as a way of knowing encourages an expansion of the anthropocentric horizon, to embrace qualities beyond objectivity and intellectual abstraction. An emphasis on rationality only risks reinforcing human exceptionalism, allowing for the narcissistic control and exploitation of a separately constituted sphere of 'nature' (Haraway, 2008). Rather than humans being identified as the only agents able to examine their subjects, in the encounter between humans and microbes, microorganisms become actors capable of influencing.

These decentred relations across taxonomic domains can be imagined alongside and beyond the scientific knowledge confirming positive health outcomes of the microbial scent of soil such as lower glucose levels and heart rate. As the heart slows down, breathing deeply the microbial volatile compounds, humans become connected with the surrounding ecosystem, in a corporeal becoming that brings forth a sense of the earth below and a returning to the ground. But the sense of smell contains also cultural and social dimensions infused with symbolism (Classen, Howes and Synnott, 1994), so that reconnecting with microbial soils assumes meanings beyond the profiling of useful strains and their effect on human physiology and psychology. When allowed to be guided by sensory perceptions, the symbolism of sensing soil can widen the imagination to experience and imagine relations beyond the visible. When not bounded by scientific criteria and the constraints of ecologies based on deterministic descriptions of nature and colonial logics (Myers, 2018a), it is possible to ask questions about the lives of microbes that can lead to an expansion of the

sensorial range. Becoming sensor entails learning to develop a sensitivity and attunement that enable new modes of relating beyond the quantification and commodification of resources (Myers, 2018a). These kinds of sensorial relations allow for an articulation that intentionally makes space, and time, for somatic awareness. It is then possible to invert the question of who is influencing whom when humans attune to soil microbes. These new imaginations need to be open to a logic of “not knowing”, an ethic that resists preconceived assumptions about what is worth paying attention to (Myers, 2018a: 75). In this sense, olfaction epitomises a starting point to build modesty and empathy in human relations with the environment, as well as to embrace different, non abstract ways of knowing (Press and Minta, 2000). Only then can humans meet microbes in their field, beyond approved methodologies and objectivity and embracing multiple possibilities including sentience and spirituality.

As the body sensing soil becomes oxygenated with new microbial breath, it can be profoundly affected and altered. Breathing soil while breathing microbes, in conjunction with a multitude of other organisms who also sense the same scent, can contribute to a much needed reorientation in humans’ approach to other life forms and ecological systems. This shift entails a stronger awareness of the interconnected nature of all life, where *anthropos* is located within and not above the ‘natural’ sphere. Engaging with olfactory perceptions of soil can become a transformative practice where microbially produced scents can take humans back - down, underground - to the lower realms of mud, a space rich to experience through different modes of enquiry. These slow and attentive olfactory explorations of microbial soils may enable humans to recognise and corporeally sense the intrinsic value of other life forms and the entire soil community, so that they “*become with many*” (Haraway, 2008: 4). The microbial aroma can then reconnect humans to ancestral relationships, and take them back to the present moment. Through this convergence, soils, forests, microbes, insects and humans become affected in new modalities.

Conclusion

While the coming to matter of microbial communities living in soil is a welcomed turn in scientific enquiry that increasingly pays attention to previously neglected life forms, this essay has suggested the importance of noticing when scientific questions carry an instrumental tinge. Considering the field exploring microbial volatile compounds’ capacity for disease suppression in plants and their role in human wellbeing, it is critical to notice the manipulative and exploitative approach taken in this area of research, where microbial compounds become envisioned as public goods. Only by examining the formation of this scientific field it is possible to

propose a shift that entails different ways of knowing, beyond a regulatory view of life and towards a decommodification of ecologies and methodologies. This turn can redirect the scientific gaze to embodied and muddy experiences occurring underground. The sense of smell, as opposed to other sensorial experiences like sight, has the ability to activate ancestral emotions and memories. Through an awareness of the role microbial compounds can play in human wellbeing, as well as the recognition that this olfactory experience is shared across species and soil communities, breathing microbes can offer a way to reconnect with unseen lives and become corporeally aware of the ecological systems living in soil. By detecting and engaging with the microbial scent of soil, it is possible for imaginative forms of relations grounded in the body to emerge, beyond anthropocentric and exploitative practices. Rather than considering olfaction through the lenses of biotechnology, this shift can serve as a prompt to seek direct somatic experiences that are not mediated by science. These olfactory perceptions involve a turn towards proximate, personal and authentic modes of relating with invisible histories and neglected beings.

References

- Atanasova, Borianna, Graux, Jérôme, El Hage, Wissam, Hommet, Caroline, Camus, Vincent and Belzung, Catherine (2008) Olfaction: a potential cognitive marker of psychiatric disorders, *Neuroscience & Biobehavioral Reviews*, 32(7): 1315-1325
- Bear, Isabel Joy and Thomas, Richard Grenfell (1964) Nature of argillaceous odour, *Nature*, 201(4923): 993-995
- Bear, Isabel Joy and Thomas, Richard Grenfell (1966) Genesis of petrichor, *Geochimica et Cosmochimica Acta*, 30: 889-879
- Becher, Paul, Verschut, Vasiliki, Bibb, Maureen, Bush, Matthew, Molnár, Béla, Barane, Elisabeth, Al-Bassam, Mahmoud, Chandra, Govind, Song, Lijiang, Challis, Gregory, Buttner Mark and Flärdh, Klas (2020) Developmentally regulated volatiles geosmin and 2-methylisoborneol attract a soil arthropod to *Streptomyces* bacteria promoting spore dispersal, *Nature Microbiology*, 5: 821-829
- Bull, Michael, Gilroy, Paul, Howes, David and Kahn, Douglas (2006) Introducing sensory studies, *The Senses and Society*, 1(1): 5-7
- Chater, Keith (2015) The smell of the soil, *Microbiology today*, 42(2): 66-69
- Classen, Constance, Howes, David and Synnott, Anthony (1994) *Aroma: The cultural history of smell*, London: Routledge
- Craig, Jeffrey, Logan, Alan and Prescott, Susan (2016) Natural environments, nature relatedness and the ecological theater: connecting satellites and sequencing to shinrin-yoku, *Journal of Physiological Anthropology*, 35(1): 1-10
- de Boer, Wietse, Li, Xiaogang, Meisner, Annelein and Garbeva, Paolina (2019) Pathogen suppression by

microbial volatile organic compounds in soils, *FEMS Microbiology Ecology*, 95(8): fiz105

Gabrys, Jennifer (2019) Sensors and sensing practices: Reworking experience across entities, environments, and technologies. *Science, Technology, & Human Values* 44(5): 723-736

Gershenzon, Jonathan, Dudareva, Natalia (2007) The function of terpene natural products in the natural world. *Nature Chemical Biology*, 3: 408-414

Granjou, Céline and Phillips, Catherine (2018) Living and labouring soils: metagenomic ecology and a new agricultural revolution?, *BioSocieties*, 14: 393-415

Hansen, Margaret Mary and Jones, Reo (2020) The interrelationship of Shinrin-Yoku and spirituality: A scoping review, *The Journal of Alternative and Complementary Medicine*, 26(12): 1093-1104

Haraway, Donna (2008) *When species meet*, Minneapolis: University of Minnesota Press

Insam, Heribert (2014) Soil volatile organic compounds as tracers for microbial activities in soils, In: Nannipieri, Paolo, Pietramellara, Giacomo and Renella, Giancarlo (eds.) *Omicis in soil science*, Norfolk: Caister Academic Press

Kaddes, Amine, Fauconnier, Marie-Laure, Sassi, Khaled, Nasraoui, Bouzid and Jijakli, Mohamed-Haïssam (2019) Endophytic fungal volatile compounds as solution for sustainable agriculture, *Molecules*, 24(6): 1065

Kotera, Yasuhiro, Richardson, Miles and Sheffield, David (2022) Effects of Shinrin-Yoku (Forest Bathing) and nature therapy on mental health: a systematic review and meta-analysis, *International Journal of Mental Health and Addiction*, 20: 337-361

Li, Qing (2018) *Shinrin-Yoku: The art and science of forest-bathing*, Penguin UK

Licon, Carmen, Manesse, Cédric, Rouby, Catherine and Bensafi, Moustafa (2018) The sense of smell in relation to our affective states and wellbeing, In: Murphy, Philip N. (ed.) *The Routledge International Handbook of Psychobiology*, London: Routledge

Low, Kelvin E.Y. (2012) The social life of the senses: Charting directions, *Sociology Compass*, 6(3): 271-282

Mathis, Stéphane, Le Masson, Gwendal, Soulages, Antoine, Duval, Fanny, Carla, Louis, Vallat, Jean-Michel and Solé, Guilhem (2021) Olfaction and anosmia: from ancient times to COVID-19, *Journal of the Neurological Sciences*, 425: 117433

McCartney, William (1968) *Olfaction and odour: An osphrésiological essay*, Berlin, Heidelberg: Springer
Millennium Ecosystem Assessment (2005) *Overview of the Millennium Ecosystem Assessment*. Accessed on 22 October 2021 from <https://www.millenniumassessment.org/en/About.html>

Morisawa, Tateyuki, Hanyu, Kazuyo, Mori, Hidetoshi and Tamura, Kenji (2017) Physiological and psychological effects of scent of soil on human beings, *Open Journal of Soil Science*, 7(9): 235-244

Myers, Natasha (2017) Ungrid-able ecologies: decolonizing the ecological sensorium in a 10,000 year-old natural-cultural happening, *Catalyst: Feminism, Theory, Technoscience*, 3(2): 1-24

Myers, Natasha (2018a) Becoming sensor in sentient worlds: A more-than-natural history of a black oak savannah. In: Bakke, Gretchen Anna and Peterson, Marina (eds.) *Between Matter and Method: Encounters in Anthropology and Art*. London: Routledge.

Myers, Natasha (2018b) How to grow livable worlds: ten not-so-easy steps, In: Oliver-Smith, Kerry (ed.) *The world to come: art in the age of the Anthropocene*, Samuel P. Harn Museum of Art: Gainesville

Oe, Hiroko and Yamao, Yasuyuki (2021) An exploratory discussion of the forest bathing effect in a disruptive environment: inbound tourism and Japanese nature, *Japanese Society of Travel Medicine Annual Conference*, 10-11 April 2021, Tokyo

Ohtsuka, Yoshinori, Yabunaka, Noriyuki and Takayama, Shigeru (1998) Shinrin-yoku (forest-air bathing and walking) effectively decreases blood glucose levels in diabetic patients, *International Journal of Biometeorology*, 41(3): 125–127

Paxson, Heather and Helmreich, Stefan (2014) The perils and promises of microbial abundance: novel natures and model ecosystems, from artisanal cheese to alien seas, *Social studies of science*, 44(2): 165-193
Press, Daniel and Minta, Steven C. (2000) The smell of nature: olfaction, knowledge and the environment, *Ethics, Place and Environment*, 3(2): 173-186

Puig de la Bellacasa, Maria (2014) Encountering bioinfrastructure: ecological struggles and the sciences of soil, *Social epistemology*, 28(1): 26-40

Puig de la Bellacasa, Maria (2015) Making time for soil: technoscientific futurity and the pace of care, *Social studies of science*, 45(5): 691–716

Puig de la Bellacasa, Maria (2017) *Matters of care: speculative ethics in more than human worlds*, Minnesota: University of Minnesota Press

Rochet, Marion, El-Hage, Wissam, Richa, Sami, Kazour, François and Atanasova, Borianna (2018) Depression, olfaction, and quality of life: a mutual relationship, *Brain Sciences*, 8(5): 80

Rosales, Jon (2008) Economic growth, climate change, biodiversity loss: distributive justice for the global north and south, *Conservation Biology*, 22(6): 1409-1417

Weisskopf, Laure, Schulz, Stefan and Garbeva, Paolina (2021) Microbial volatile organic compounds in intra-kingdom and inter-kingdom interactions, *Nature Reviews Microbiology*, 19: 391–404

Zanzu, S. (2022) The microbiopolitics of pots and compost making, *Anthropocenes – Human, Inhuman, Posthuman*, 3(1): 1-8

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