IncLoo*sive Architecture

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"To talk about architecture without talking about toilets is to operate in denial of a whole array of sexual, psychological, and moral economies. For all the endless apparent talk about the body in architecture, architects don't really want to talk about it. Architectural discourse is a deodorizer."

Beatriz Colomina and Mark Wigley, "Toilet Architecture: An Essay About the Most Psychosexually Charged Room in a Building" (2017–18).[1]

Peeing* is political![2] Sanitary facilities are an essential infrastructural part of everyday life. They provide the opportunity to fulfill the basic sanitary needs of urinating and defecating, have an influence on the kind, quality, and radius of activities people can undertake, and constitute a precondition for participating in both private and public life. However, they are often taken for granted and their importance is only registered when they are unusable, unavailable or inaccessible. When planning and managing buildings and public spaces, sanitary facilities are rarely considered as core infrastructure to be designed for and by society.[3] For example, many local authorities not only lack the monetary and human resources, but also the knowledge about and expertise on inclusive sanitary infrastructures. However, these would be necessary, as toilets involve a range of structural social marginalizations and discriminations relating not only to the acts of urinating, defecating, and menstruating, but also to all practices regulating access to and use of toilets. "The bathroom—or the lack of a bathroom—generates all kinds of questions about safety, accessibility, gender, sexuality, class, homelessness, race and more," writes geographer and feminist urban researcher Leslie Kern in *Feminist City*.[4] Sanitary facilities and the related infrastructures, practices, and discourses (re-)produce segregation, mechanisms of exclusion, and restrictions that must be critically questioned and revised.[5] Today, the major social challenges of climate change and global access to drinking water raise another urgent question: How can current sanitary systems, which account for a massive share of water consumption and pollution, be converted in an ecologically sound and climate-neutral manner in the future.

The human right to water and sanitation

In 2010, the human right to water and sanitation was firmly enshrined in the United Nations Charter. The year 2015 saw the United Nations declare their aim to "ensure availability and sustainable management of water and sanitation for all" as one of their Sustainable Development Goals (SDGs).[6] What has become obvious, however, is that the abstract universalism of human rights does not automatically lead to the reduction of myriad forms of exclusion from urban and social infrastructures. In Germany, the supply and quality of existing public toilet facilities is constantly criticized by actors from civil society; yet, little has been done on the political, legal, and urban planning levels to provide and operate adequate public sanitation infrastructure. Indeed, this can be traced back to a lack of authority, as providing public toilets does not fall under the jurisdiction of local authorities in Germany. In other words, there is no legal obligation for municipalities and local authorities to make any public toilets available at all.

However, a number of regulations exist for bathrooms in private homes and publicly accessible businesses, regarding the number, size, equipment, and accessibility of the facilities. Private spaces are therefore also embedded in public infrastructure systems: The German industrial norm DIN 18040 became part of German building regulations in 2017 and outlines the technical requirements for accessibility in buildings. The aim is to promote inclusion by guaranteeing equal access to the built environment for people with dis_abilities. To this end, the existing barriers between the private and public spaces need to be reduced. For only if the sequence of transportation and movement—from the street to the private or public toilet—is continuously identifiable, usable, and accessible can people's radius of activity be expanded. At the same time, this approach often remains insufficient. Inclusion, in contrast to integration (i.e., assimilation), requires an expansion of the existing systems of thought and infrastructure to do justice to both personal and universal needs.

De/politicizing the private and the public

Since Classical antiquity, the division between the private and the public realms has played a key role for the de/politicization (or: de/tabooing) of entire fields of action. What is part of the public realm (agora/forum) is considered political and can be politicized, whereas what is considered private (oikos/domus) cannot. All intimate things, including fundamental bodily functions, are hidden. Once the body evacuates what it does not need, we are rid of it.

Everything else is a “private matter.” That makes it all the harder for socially marginalized and statistically disregarded groups to achieve political leverage for their concerns and to ensure their most fundamental needs are met, especially without being permanently exposed to and dependent on the good will of others, on support in everyday life, on lucky coincidences. Instead, they should be structurally considered and given a say. Regarding questions of infrastructure, the focus must be on factoring in needs in a way that facilitates a system benefitting all—not just society but the entire ecosystem. Capitalist structures of governance and logics of valorization, however, produce exclusion, i.e., socially constructed divisions of spheres established as norms and arbitrarily categorizing and ranking beings, bodies, and their properties, such as: human or animal, man or woman, local or foreign, able or unable, useful or harmful? Ultimately: us or the others? Who gets the right to exercise power; who is entitled to act politically? Who and what is/becomes visible when we plan/convert our core infrastructures to master the social and ecological challenges and secure the basis of our lives in the future?

Binarity and patriarchal design

Socio-spatial power mechanisms are expressed in terms of both bathrooms’ accessibility and their labeling, equipment, and design. One of the most obvious power mechanisms is based on the assumption that there are only two genders. This manifests itself in the spatial allocation and binary separation of toilets for *men*, on the one hand, and for *women*, on the other. Those who do not identify with either of these or are perceived by others as not belonging in a restroom ascribed to a certain gender face challenges. Due to the forced designations, those affected often feel discomfort, and repeatedly experience verbal and/or physical violence. For people who align with the binary gender norm, access to and use of public restrooms is easier and has fewer negative connotations. Cis men in particular are advantaged (“potty privilege”) by the higher number of “men’s rooms” and the presence of standing urinals in urban space. This structure hinging on gender separation goes hand in hand with a cultural coding both of behavioral roles and of design principles for the facilities. For example, body postures when urinating and defecating are historically and culturally determined. In the everyday public mindset however, they are still naturalized and justified entirely in physiognomic terms. While defecation is primarily structured as a seating activity irrespective of gender, the stance for micturition, meaning the posture when emptying the bladder, is linked to genital anatomy (man/penis/standing vs. woman/vulva/seated). In line

with this idea, men are offered both sitting toilets and urinals, while sanitary facilities for women only feature sitting toilets. Since sitting toilets, as a general rule, are planned inside cubicles, they require more space than urinals. This often translates to less toilets available to women than there are to men.[7] To counter this bias, the newly amended version of the German engineering association VDI's guidelines on restroom design recommends that in the future, gender-inclusive toilets (shared by everyone irrespective of their gender) be taken as the new standard for public buildings. This not only aims to raise the number of toilets for all genders, but also simplifies the placement of infrastructure elements such as baby changing tables. The latter, in binarily separated toilets as we encounter them to date, have been placed in women's or barrier-free restrooms, thereby reproducing the gendered division of (child)care work.

Toilets for Everyone?!

How can we reclaim (urban) space and the right to pee* by addressing flawed and discriminating infrastructure? According to cultural theorist Lauren Berlant, a possible solution lies in a repair of the commons by the excluded.[8] This would render precisely those goods and infrastructures accessible to the people who are marginalized for their deviation from a socially constructed norm, and often experience an even greater need to access them as a result.

Gender-neutral urinals, which enable all people regardless of their genitals to urinate in a non-seated position, are unfortunately still a rare, albeit simple, measure with far-reaching impacts. Alongside technological devices, we also see low-threshold practices adopted out of solidarity and resistance, such as relabeling toilets with stickers, which eliminate the binary division (men/women) of restrooms.[9] Such a form of repair results in the expanded usability of sanitary infrastructures and can be understood as an intimate, everyday political practice of appropriating identification, access, and participation. Moreover, this form of appropriation shifts our understanding of infrastructure to include the human body, which, instead of being a simple extension of the former, becomes infrastructural itself.[10]

Ableist design: barrier-free vs. low-barrier

Toilet infrastructures are highly standardized spaces based on a uniform Western body norm in regards to equipment, as well as measurements and dimensions, as becomes evident from the example of the aforementioned VDI guidelines. Most restrooms' designs are based on adults without dis_abilities and a body weight within the so-called "'normal weight'-range" of the Body Mass Index. This, however, impedes access to these bathrooms—or makes their use altogether impossible—for anyone who does not correspond to these norms.[11] Certain "deviations" from these standards, such as for wheelchair users, are increasingly being taken into account when planning accessible public buildings (as mandated by DIN 18040). These efforts usually result in separate wheelchair-accessible bathrooms, marked as exceptions both in terms of architecture and use, and colloquially referred to as "disabled bathrooms" or "barrier-free WCs." In the private realm, many people only recognize the importance of barrier-freedom once their own needs make them necessary. Additionally, the term "barrier-free" is itself controversial. For people with severe or multiple dis_abilities, barrier-free access refers to far more than just level access or the presence of ramps. In its project titled *Toiletten für alle* (Toilets for Everyone), the foundation Stiftung Leben pur (Pure Living Foundation) calls for all barrier-free toilets to include height-adjustable care stretchers as well as disposal amenities for medical products such as catheters, urine bags, or needles. If one applies this standard, "barrier-free" sanitary facilities, the way they are commonly understood today, are merely "low-barrier." Although changes surely cannot be driven by the concerns of a white baby-boomer generation alone, the contexts of an increasingly aging population and age-related incontinence have broadened the calls for restrooms that cater to a wider spectrum of needs, providing the necessary change in perspective—from physical "disability" to the inadequacies of the space itself.[12]

Colonialist and capitalist design

Alongside the social discrimination on the basis of gender and dis_ability, structural racism has strongly influenced the design of bathrooms and the acceptability of certain sanitary practices. As a result, many Western societies consider water-flushed sitting toilets and the use of toilet paper as the worldwide, normatively set and desirable standard. This assumption becomes clearest in development aid, travel guides, and travel accounts.[13] In the process, not only ecological, but also anatomical and health aspects are ignored: Many people crouch to

defecate, which makes it easier to completely evacuate the bowels, while a seated position makes excretion harder.[14] Moreover, flushing toilets and toilet paper waste invaluable resources. The same is true of sanitary products customarily used during menstruation. Disposable single-use products stand for progress and cleanliness, while alternatives, such as reusable sanitary pads, menstrual sponges, and organic materials like natural fibers or plant leaves, are considered primitive and unhygienic. A critical look at the historical development of today's western bathrooms reveals that the water-flushed private sitting toilet is not only a hygienic achievement in combating pandemics and boosting comfort, but also first and foremost a status symbol. Soon after their invention in the 19th century, ownership of private flushing toilets—or the absence thereof, or even their shared use in stairwells of apartment blocks—began to constitute a segregating infrastructure that divided different socio-economic classes. Likewise, designated sanitary practices reproduce and stabilize social power relations by not only standardizing Western practices but furthermore linking these to certain (consumer) goods. The social inequalities produced in capitalism as regards race, class, and gender reflected in the Global North do not stop at the management and maintenance of bathrooms. Cleaning, particularly of sanitary installations, is socially looked down upon, poorly paid, rendered invisible, and often externalized to racialized people, and above all women. The "throne" therefore manifests multiple, interlinked socio-spatial power mechanisms, ranging from its design, positioning, and type of equipment, to sanitary practices constituted by the West, to the labor policy aspects of its management and maintenance. A complex analysis of these mechanisms will be required to create future socio-spatial justice in the context of sanitary infrastructure.

Flushing toilets and resource consumption

Sanitation facilities as a network of flush toilets connected to a sewerage system and wastewater treatment plants are commonplace in many countries today, especially in the Global North. The system is easy to use, is considered progressive and—purportedly—hygienic or more hygienic than other systems. However, the existing system relies on "linear" exploitation, meaning one that consumes invaluable resources such as water and introduces nutrients and toxic materials into the ecological material cycle without subsequently extracting and/or recycling them. The current sanitary system, for all the ease of use it offers, therefore entails profound ecological disadvantages.

In Europe, the average person flushes about 15,000 liters of processed drinking water down the toilet every year. Given the global water crisis, flush toilets and the use of drinking water to transport human feces warrant scrutiny going forward. Furthermore, combined sewage systems blend reusable materials such as nutrients (e.g., phosphorus, nitrogen, and potassium) and carbon with harmful substances like heavy metals, microplastics, and prescription drugs, while also strongly diluting it with large volumes of water from human use and urban runoff. This dilution makes the retrieval of nutrients and exfiltration of contaminants challenging for wastewater treatment facilities. Centralized sewage systems do not have convincing purification and recycling capacities; instead, they can rightfully be regarded as "nutrient destruction plants"[15] whose emissions are a burden on ecosystems.

The circular use of nutrients is important for two reasons. First, nutrients such as nitrogen, phosphorus, and potassium are indispensable for vegetal growth. Nutrients are food for our food, which we then excrete once digested. But instead of using nutrients circularly, we have built one-way streets for resource depletion. In Germany, each year, 2.5 million tons of reactive nitrogen are extracted from the air using energy-intensive processes to manufacture nitrogen-based fertilizers.[16] The reliance on cheap energy and natural gas for this process resulted in fertilizer factories facing closure throughout Europe in 2022 due to rising operating costs.[17] Phosphorus, for its part, is obtained from open pit mines and imported to Europe. The finite reserves are spread across few locations, including the USA, China, and northwestern Africa.[18] The mining practices in the Moroccan-occupied territory of Western Sahara, which contains the world's largest reserves, are responsible for devastating ecological and health damage to the local population.[19] Moreover, despite modern *purification*, far too many nutrients from sewage plants still find their way into rivers, lakes, or coastal waters, where they lead to eutrophication: excessive algae growth, lack of oxygen, and finally the death of fish and the destruction of entire ecosystems.[20] Furthermore, microplastics and diluted residues of prescription drugs find their way into open water, damaging ecosystems. In particular regarding the global material flows of nitrogen and phosphorus, as well as new chemical substances and plastic, we have already crossed the upper limit of the "safe operating space," set by the extent to which the ecosystem can be put under pressure, and are now in a high-risk zone for the planet's habitability.[21] In short, we are poisoning our environment in a way that lastingly endangers the regenerative ability of natural material cycles. Bathrooms are part of this problem. However, they could also be part of the solution if we turn what is now effectively a straight line back into a circle. The idea being that wastewater should no longer be viewed as some dirty slurry that has to be begrudgingly

disposed of, but instead as a material flows, the careful (re-)processing of which can fundamentally contribute to maintaining the cycle of life.

A sanitation and nutrient revolution: Saving water and using nutrients

What is called for is a socio-technical transformation from the linear wastewater system to a circular sanitation management. This change will be made possible through appropriate toilet systems and circular reuse technologies, which—while upholding high hygiene and quality standards—can reclaim nutrients from digested food to be used for local agriculture. A glance at the history of architecture shows that alternative sanitation systems such as dry toilets, urine-diverting toilets, or compost toilets are not new inventions by any means. In Germany, Austria, and Switzerland, social housing estates in the 1920s involved different typologies—from workers' housing estates with peat moss toilets and self-supporting vegetable gardens (e.g., the Rosenhügel estate in Vienna) to apartment buildings with their own vegetable gardens. Since the 1980s, composting toilets and plant-based sewage treatment facilities have been devised and included in many pilot projects for ecological housing estates. Today, they are likewise used around the world after natural disasters and in places without sanitation infrastructure.[22]

In recent years, researchers and practitioners have jointly developed new technologies and systemic approaches. One important concept is that of material flow separation, which involves the technical separation of urine, feces, graywater, and rainwater at their origin (i.e., in a neighborhood, in a building, in a bathroom, or even in a single toilet). By separating the collection of material flows, circular processing solutions tailored to the location and type of material flow can be flexibly applied. These tend to take the neighborhood or block as the starting point of wastewater treatment and not, as with conventional solutions, the rear end of the sewer. Moreover, by switching to alternative toilet systems (e.g., vacuum toilets, urine-diverting flush toilets, urine-diverting dry toilets, or composting toilets) large parts—if not all—of the normally used flushing water can be avoided. The major advantage of these toilets is that they do not need to be connected to the sewage system and can thus be placed more or less anywhere. By means of special bowl design, the natural separation of urine and feces can be upheld, and subsequent processing facilitated. Urine has a higher density of nutrients and also represents a majority of excretions in terms of volume. It usually exits the body in a sterile form, meaning free of germs. Drug residues are mostly excreted in the urine, making

the elimination of toxins easier if the urine is separated. Feces, by contrast, contains fewer nutrients but a higher proportion of organic matter and intestinal bacteria, which can be eliminated and/or deactivated by targeted treatment of the sludge. While the main focus in processing urine is on nutrient recycling, volume reduction, and removal of drug residues, the treatment of feces concentrates on "sanitization," i.e., killing the germs, and the combined recycling of organic components and nutrients. The end products are high-grade forms of dry, liquid, and humus fertilizer.

Despite successful model projects aimed at implementing a circular sanitation infrastructure, a sanitary and nutrient revolution will require profound social change. The current, linear, unsustainable model is literally cemented at three different levels: physically in the infrastructure, legally in technical requirements, and mentally in our heads. In Germany, the existing legal situation puts a brake on the deployment of already developed and functional innovative wastewater treatment systems and the introduction of new, quality-controlled recycling fertilizers into the soil. The wastewater, waste, and fertilizer laws need to be amended to enable recycling to be practically implemented through circular economy legislation. Local authorities require support in authorization processes for plants designed to ensure circular utilization. And we all need more images and stories of a world with different toilets and circular nutrient hubs. Finally, architects, planners, and building cooperatives urgently require access to knowledge, plans, and detailed information.

Now what? The future role of architects

The work of architects traditionally focuses on buildings as objects. The toilet and/or the bathroom is categorized as a utilitarian feature of any building, the design of which usually is predetermined by standardized floor plans, regulatory stipulations (e.g., accessibility), and the location of utilities shafts within the building. Planning and organizing what happens once the wastewater leaves the toilet proper is not typically considered to be within an architect's purview, but rather within that of technical building equipment specialists. Rooms for maintenance and operations (technical rooms, storage areas, locker rooms, etc.) are often given exceptionally tight dimensions in line with conventional briefs by specialist planners and developers. However, changing the perception of the bathroom from that of a purely functional room to a space which translates the aforementioned social, ecological, and technical standards into an architectural solution will be the task of architects.

For that to happen, the focus will need to be expanded beyond the actual building phase to include usage and maintenance, if we want to achieve a resource-oriented overall view. Planning and building, which make up a mere two percent of a building's total life cycle costs, have the potential to decisively influence its usage costs, which weigh in at almost 80 percent of the total figure. Significant leverage lies not only in saving energy but also in reducing the building's water footprint—in Germany, 45 percent of the latter is created during use.[23] Furthermore, alongside an extensive prolongation of the service life, other key parameters to consider in planning new buildings could include the regeneration of resources beyond their sparing use, along with an increase in the ease of maintenance (robust and easily-cleaned materials, maintenance joints, large-enough rooms, etc.). The fundamental incorporation of these aspects into architectural practice will shift our notion of buildings as finished units, with the underlying object fixation this view entails, in favor of an idea of architecture as a metabolism that is embedded in ongoing/permanent metabolic processes and material cycles (water, nutrition, goods, electricity, heat, cooling, etc.), steadily (re)producing these by itself.

In contemporary Western academic discourse, increasing attention is being paid to the conversion of existing buildings. In Germany, modernization and conversion will soon replace newly built structures as the main task for planners. A sanitary revolution for existing—and new—buildings going beyond technically isolated solutions for single rooms with small collection tanks will require additional space that architects will have to factor into their plans. Here, technical and ecological issues must be structurally considered in combination with social questions of inclusion, accessibility, and widespread user-friendliness.

In recent years, systems have consistently evolved, including new components devised for existing buildings in urban settings. Now, urine-diverting standing, sitting, and squatting toilets exist—either with or without flush systems. A separate transport of collected waste matter can be facilitated by a "pipe-within-a-pipe" system, whereby a second pipe is inserted into an existing pipe.[24] Pipes leading to a decentral urine treatment plant in the neighborhood—so-called "Urinodukte" (urinoducts)—could use existing sewage pipes as their service ducts. In some cases, no new pipes are required at all: New technological developments enable (partial) treatment with simultaneous reclaiming of nutrients right at the level of the individual bathroom (see for example the project inside the German Pavilion).[25] The range of options that planners have at their disposal to implement material flow-based

solutions is expanding. However, planning solutions on their own will not suffice: we urgently require laws that allow exceptions to the mandatory connection to existing sewage systems and that enshrine innovation and experimentation clauses in building regulations to expand the possibilities for creative solutions. The sanitary revolution will need the reactivation of cultural techniques old and new regarding bathrooms, which architects need to support and mediate: How to discuss toilets with clients? What toilet systems function for which users? How is what cultural technique conveyed and nurtured? What role do daily cleaning and maintenance play in the design of these spaces?

Even if the ideas of inclusion and life-cycle analyses are gradually being incorporated into planning, we need a more systematic rethinking and appropriate action. Physical diversity is just as much a fact as is the threatened status of our planetary ecosystems. Today, we must ask ourselves how we can not only reduce (to achieve sufficiency) and repair, but also how we can reconstruct, nurture, and regenerate. With a sanitary revolution at the level of the individual building, the neighborhood, and the entire city, architecture can substantially contribute to greater social justice and the ecological regeneration of soils, the drinking water supply, and the production of food.

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[1] Beatriz Colomina and Mark Wigley, "Toilet Architecture: An Essay About the Most Psychosexually Charged Room in a Building," *PIN-UP*, no. 23 (2017–18), 231.

[2] See klo:lektiv (eds.), "Pissen* ist politisch: Feministische und kritisch-geographische Perspektiven auf Geographien der Notdurft," *Feministische Geo-Rundmail* 84 (Winter 2020), accessed February 16, 2023, ak-feministische-geographien.org/rundmail/.

[3] See Lilith Kuhn, et al., "Notdürftige Infrastrukturen: Öffentliche Toiletten zwischen Neoliberalisierung und Utopie," *Bürger & Staat: Öffentliche Infrastrukturen. Die politische Gestaltung der vernetzten Gesellschaft* 1/2 (Spring 2022), 69–75.

[4] Leslie Kern, *Feminist City: Claiming Space in a Man-made World* (London: Verso Books, 2019), 106.

[5] See Kuhn, et al., "Notdürftige Infrastrukturen" (see note 3).

[6] See United Nations, "Goal 6: Ensure availability and sustainable management of water and sanitation for all," *Sustainable Development Goals*, 2015, accessed January 30, 2023, sdgs.un.org/goals/goal6.

[7] See Kathryn Anthony and Meghan Dufresne, "Potty Parity in Perspective: Gender and Family Issues in Planning and Designing Public Restrooms," *Journal of Planning Literature* 21, no. 3 (2007), 267–94.

[8] See Lauren Berlant, "The Commons: Infrastructures for Troubling Times," *Environment and Planning D – Society and Space*, vol 34, no. 3 (2016), 393–419.

[9] See Katharina Ciax, "Flushing Down Hegemony: Public Toilet Infrastructure and the Politics of Accessibility," in *Jenaer Sozialgeographische Manuskripte*, vol. 20, ed. Simon Runkel (Jena: Friedrich-Schiller-Universität Jena, 2022).

[10] See Yaffa Truelove and Hanna A. Ruszczyk, "Bodies as Urban Infrastructure: Gender, Intimate Infrastructures and Slow Infrastructural Violence," *Political Geography* 92 (January 2022), doi.org/10.1016/j.polgeo.2021.102492.

[11] See Rob Kitchin and Robin Law, "The Socio-spatial Construction of (In)accessible Public Toilets," *Urban Studies* 38, no. 2 (2001), 287–98.

[12] See Daniela Hayder and Wilfried Schnepp, "Umgang mit Harninkontinenz: Ergebnisse einer qualitativen Studie mit Betroffenen und pflegenden Angehörigen," *Pflege* 23, no. 3 (2012), 154–62.

[13] See Alison Moore, "Colonial Visions of 'Third World' Toilets: A Nineteenth-Century Discourse That Haunts Contemporary Tourism," in *Ladies and Gents: Public Toilets and Gender*, eds. Olga Gershenson and Barbara Penner (Philadelphia: Temple University Press, 2009), 105–25.

[14] See Alexander Kira, *Das Badezimmer* (Düsseldorf: Krammer, 1987).

[15] Quote from an employee of the Berlin public water management agency BWB.

[16] See „Welche Rolle spielt reaktiver Stickstoff für die Chemieindustrie?" *Umweltbundesamt,* accessed January 30, 2023, www.umweltbundesamt.de/umweltatlas/reaktiver-stickstoff/verursacher/energiewirtschaft-industrie/welche-rolle-spielt-reaktiver-stickstoff-fuer-die.

[17] See Olaf Zinke, "Yara schließt Düngerwerke: Steht Europa bald ohne Dünger da?" *Agrarheute*, September 21, 2022, accessed January 30, 2023, www.agrarheute.com/management/betriebsfuehrung/yara-schliesst-duengerwerke-steht-europa-bald-ohne-duenger-598174.

[18] See Dana Cordell, et al., "The Story of Phosphorus: Global Food Security and Food for Thought," *Global Environmental Change* 19, no. 2 (May 2009), 292–305.

[19] See Natasha White, "Toxic Shadow: Phosphate Miners in Morocco Fear They Pay a High Price," *The Guardian*, December 16, 2015, accessed February 1, 2023, www.theguardian.com/global-development/2015/dec/16/toxic-shadow-phosphate-miners-morocco-fear-they-pay-high-price.

[20] See Cascade Tuholske, et al., "Mapping Global Inputs and Impacts from of (*sic!*) Human Sewage in Coastal Ecosystems," *PLOS ONE* 16, no. 11 (November 2021), doi.org/10.1371/journal.pone.0258898.

[21] See Linn Persson, et al., "Outside the Safe Operating Space of the Planetary Boundary for Novel Entities," *Environmental Science & Technology* 56, no. 22 (November 2022), 1510−21; See also Will Steffen, et al.,

"Planetary boundaries: Guiding human development on a changing planet," *Science* 347, no. 6223 (February 2015), 736–47.

[22] See for example the nonprofit SOIL in Haiti, which develops, tests, and deploys ecological sanitary systems worldwide, accessed February 14, 2023, www.oursoil.org.

[23] See *Umweltfußabdruck von Gebäuden in Deutschland: Kurzstudie zu sektorenübergreifenden Wirkungen des Handlungsfelds "Errichtung und Nutzung von Hochbauten" auf Klima und Umwelt*, ed. Bundesinstitut für Bau-, Stadt- und Raumforschung, (Bonn: Bundesamt für Bauwesen und Raumordnung, 2020), 15.

[24] See Susanne Veser and Jörg Londong: *EVaSENS: Einsatz von Vakuum-Inlinern im Bestand; Integration von Unterdruck-Sanitärtechnik im bestehenden Gebäude zur Etablierung von NASS-Systemen* (Stuttgart: Fraunhofer IRB Verlag, 2017), 2, accessed January 30, 2023, www.irbnet.de/daten/rswb/17079006196.pdf.

[25] See Michel E. Riechmann, et al., "On-Site Urine Treatment Combining $Ca(OH)_2$ Dissolution and Dehydration With Ambient Air," *Water research X* 13 (2021), doi.org/10.1016/j.wroa.2021.100124.

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