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The material politics of slurry: Mobilisations and transformations along the waste–fertiliser continuum

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ABSTRACT

Agriculture is a major source of excess nitrogen inputs into the environment. In Germany's Weser Ems region, the extreme concentration of intensive livestock farming translates recent improvements in nitrogen regulation into a 'slurry problem' that makes manure disposal services increasingly vital for the beneficiaries of an agroeconomic production system based on ongoing intensification and externalisation. The paper uses ethnographic research to focus on the material politics of different sociomaterial assemblages of slurry. It shows how manure export and new technologies to materially transform slurry both facilitate a further integration of livestock farming by intermediaries such as nutrient brokers and feedstuff producers. As slurry is mobilised and transformed, the material politics of slurry hinges upon shifting material properties and ontological struggles that position slurry along a continuum between nutritious natural fertiliser and abject organic waste. While slurry export to arable regions is problematically framed as a circular economy approach, the aim to transform slurry instead of transforming the unsustainable agroeconomic structure is embodied in hopes set upon 'full processing' of slurry into products akin to mineral fertilisers. The disposal of excess slurry eventually depends on both material and ontological transformations. Emerging protest against central manure processing facilities shows that slurry and its odour make intensive livestock farming a material and 'sensible' presence that can be acted upon politically. Embodied reactions and abjections related to this material agency of slurry can potentially bridge everyday practice and structural questions of socioecological wellbeing and justice in a more-than-human world.

1. Introduction: The 'slurry problem': Understanding slurry as a naturalcultural material and political matter

Worldwide, increasing amounts of reactive nitrogen emissions from fertiliser use, combustion processes, energy production and human sanitation circulate in the biosphere, with detrimental effects on water, air, soil and human health (Galloway & Cowling, 2002; Sutton et al., 2011, 2013). Excessive inputs of reactive nitrogen have been identified as 'one of the biggest environmental problems of our time' by the Advisory Council on the Environment in Germany (Sachverständigenrat für Umweltfragen (SRU), 2015; cf. Rockström et al., 2009; Steffen et al., 2015), where the main source of nitrogen pollution are agricultural losses from nitrogen fertilisers, manure application and livestock (Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit, 2017). Intensive livestock farming depends on constant influxes of nitrogen into local agricultural systems via externally produced foodstuffs (Jarvis, 2011). While manures can theoretically be used to fertilise crops or pastureland, the farmland available in agro-industrial livestock clusters is often not sufficient to apply all nutrients locally. Therefore, manure can easily become, in the words of cultural anthropologist Mary Douglas (1991), 'matter out of place'.

The article takes the public controversies related to increasing amounts of slurry resulting from intensive livestock farming concentrated in north-western Germany as a starting point. It argues that through political conflicts and everyday practices, slurry itself emerges as a political matter. The political character of slurry depends on its social and material relations – the shifting 'sociomaterial assemblages' (Barry, 2013, p. 19) of slurry. Not only has slurry a history as the *object* of environmental regulation (Conrad & Teherani-Krönner, 1989), it also has a more active part in the sense that its physical properties and changing material character play a significant role in its becoming political (Bennett, 2010; Barry, 2013). The very materiality of slurry complicates the ongoing attempts of powerful agroindustrial actors to maintain the livestock sector in its current form by intensifying externalisation practices. The article focuses on the material politics of two major approaches to handling excess slurry from Lower Saxony's livestock hotspot region Weser Ems. The first is to accelerate the export of slurry (and other manures) to arable farming areas and biogas

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operations located in other parts of Lower Saxony and beyond state borders, a business practice that has drastically intensified in quantity and radius due to changes in the German Fertiliser Law in recent years (Bundesministerium für Ernährung und Landwirtschaft, 2017). The second is the material transformation of slurry with processing technologies ranging from on-site centrifugal drying (to lower transportation costs) to central full processing plants (that could potentially allow for the recollection of nutrients in a mineral form).

Liquid manure or slurry is a novel material that is generated in increasing quantities due to the intensification of meat production worldwide. It can be understood as a modern form of waste (MacBride, 2012), an anthropogenic matter that problematises simple distinctions between nature and culture, human and non-human. While it is an organic material based on excretions from animal bodies, it comes into being only within technologically mediated forms of intensive livestock farming. Slurry is coproduced by the breeding strategies, feeding protocols and housing infrastructures that characterise intensive livestock farming, such as the slatted floors and slurry cellars that mix solid and liquid excreta. The widespread introduction of slurry practices in the second half of the 20th century has changed livestock farming drastically, reduced the human labour required and allowed for much larger numbers of animals per farm (Lowe, Clark, Seymour, & Ward, 1997).

From a more-than-human perspective (Whatmore, 2006), slurry could therefore be conceptualised as a 'naturalcultural' (Haraway, 2008) material that embodies intensified agroeconomic structures. In the case study area in north-western Germany, slurry management has become a crucial factor determining the fate of current forms of intensive livestock farming vis-a-vis environmental concerns, mainly over local groundwater pollution. In the light of ongoing legal action from the European Commission, the German government has been struggling to eventually implement a long awaited and deeply controversial overhaul of its national fertiliser ordinance. For the incumbent meat industry players, these developments now translate into vital attempts to solve the regional 'slurry problem' (Hummel, 2021).

Struggles over the material qualities of slurry and its derivates vitally affect how this problem and corresponding solutions are discussed in a climate of increasing political and public concerns over the environmental impacts of the intensive livestock industry. The article demonstrates that the changing material properties *and* representations of slurry are part and parcel of its politicisation as a 'matter of concern' (Latour, 2004; cf. Braun & Whatmore, 2010). The ethnographic evidence shows that the practice of slurry transport, which currently forms the backbone of intensive animal farming in the case study area, depends not only on a complex and sometimes fragile sociotechnical network of slurry banks and contractors, specialised vehicles and the resolution of conflicts over exact nutrient contents. Importantly, the ongoing struggles over what slurry actually *is* for differently positioned actors, e.g. nutritious natural fertiliser or abject organic waste – the 'ontological politics', in Annemarie Mol's (2002) terms, of slurry – also play an important role. In order to be applied to agricultural fields elsewhere, excess slurry first has to be successfully framed or reframed as a valuable organic fertiliser.

To entangle the sociomaterial networks and categorisation practices related to the 'slurry problem', the paper employs a more-than-human political ecology approach (Whatmore, 2013) that is attentive to how the material properties of slurry – its water content, heterogeneity, chemical composition as well as the potential transformation of liquid into solids – do matter for how slurry is handled both practically and politically. Methodologically, the paper builds upon a broad empirical basis of ethnographic material collected between November 2017 and July 2020 in relation to slurry management in the German state of Lower Saxony, which, in its Weser Ems subregion, houses the country's largest and most dense stocks of pig and poultry. Forty-five qualitative, partially structured in-depth interviews were conducted with differently positioned actors involved and engaged in the slurry trade, such as pig farmers (breeding and fattening) providing slurry, arable farmers and biogas operators receiving slurry, nutrient bank operators, logistics and agricultural contractors organising slurry transport and application, feedstuff retailers, agricultural extension officers, representatives of the Agricultural Chamber and the Farmers' Association, as well as local government, water authorities and water suppliers in both slurry providing and slurry receiving regions. In relation to pending proposals to establish central slurry processing plants in the Weser Ems region, interview partners further included engineers and investors, political representatives and citizens' action groups. Interview partners were selected according to the theoretical sampling criteria developed for Grounded Theory (Glaser & Strauss, 1967). Interviews were conducted in German and partly translated into English for the purpose of this article; all interviewee names given are pseudonyms.

Apart from the interviews, participant observation was conducted at conferences, workshops, training courses and round-table events on slurry management (cf. Schulte-Römer & Gesing, 2022). Here, local stakeholders discussed how slurry transport could be enhanced to reduce the nutrient load in specific counties, as reported by the annual Lower Saxony nutrient report (LWK Niedersachsen, 2021). These events provided insights into how local actors negotiated apparently irreconcilable objectives, such as maintaining intensive agricultural industries while enhancing environmental governance, especially regarding water quality. The way some solutions were put forward by central stakeholders, such as the idea of a 'nutrient circular economy' (see section 2) and the material transformation of slurry (see section 3), while others – such as reducing stock numbers or a spatial reorganization of agricultural production – were not discussed openly made it possible to also gain insights into how the respective 'slurry problem' at hand was defined by powerful agroeconomic actors interested in maintaining the current production system. In this respect, the analysis has built on the observation that suggested solutions always correspond with specific problem framings put forward.

Stakeholder meetings also helped to establish further contacts with possible interview partners. A visit paid early on to long-standing local 'slurry broker' Hein Hellmann proved especially fruitful as he provided access to invitation-only events and facilitated contact to members of his close-knit network of business partners. These contacts further allowed insight into the importance of long-term, personal relations for how business is typically done in this region. A research project on manure transport and processing carried out, amongst others, by the Lower Saxony Agricultural Chamber with the goal to connect animal farmers, logistics companies and arable farmers located in regions beyond the Weser Ems livestock hotspot was another source of valuable contacts. Field research was complemented by compiling a large collection of reports and documents, policies and regulations, as well as media items referring to slurry management, related problems and conflicts, targeted at both agricultural and general audiences. This body of materials has been ordered and structured with the assistance of MAXQDA software and coded with a focus on the practices, sociotechnical networks and social relations of regional slurry management, the discursive framing of problem definitions and solutions, such as the idea of establishing a transregional circular nutrient industry, and the role of materialities, transformations and practices of categorising slurry. The research on which this article is built is itself part of a larger and ongoing project on the emergence of integrated nitrogen management within global science and policy arenas (cf. INMS, n.d.).

2. Governing slurry in Weser Ems: Framing solutions and problems

The ambiguous character of slurry as both (potential) fertiliser and abject organic waste (cf. Kristeva, 1982), as both nutrient and pollutant, is reflected in the fact that the earliest piece of fertiliser regulation introduced in the study area, the 1983 Lower Saxony Slurry Decree, was part of the waste law (Conrad & Teherani-Krönner, 1989, p. 241; Teherani-Krönner, 1988). Writing about the then first nitrate policies in

Western Germany, Conrad (1990, p. 556, trans. FG) observes that, '[i]n contrast to mineral fertilisation, the application of liquid manure, especially by farms with a slurry surplus, is primarily waste disposal, the costs of which they will endeavour to externalise as far as possible', an observation also made by Lowe et al. (1997, p. 19) in the UK. The UK dairy farmers studied by Lowe et al. around the same time, however, insisted that farm waste and its smell was something 'natural' that should be categorically distinguished from pollution caused by industrial activities. A UK Royal Commission set up to investigate the issue of farm-based pollution eventually proposed a redefinition of intensive livestock farming as an 'industrial' (as opposed to agricultural) activity: 'Agricultural pollution was thus not only an aberrant act but also an anomalous category', Lowe et al. (1997, p. 59) conclude. The intensive agricultural production concentrated in the Weser Ems region of Lower Saxony is an excellent example of this relatively new category of 'industrial' livestock farming and, in this sense, slurry is indeed truly 'modern' waste (MacBride, 2012).

The county of Vechta – also known as the 'Oldenburg Münsterland' together with the neighbouring Cloppenburg district – features the highest stock density in the whole of Germany (see Fig. 1). The livestock industry has provided an enormous economic prosperity in an area once dubbed the 'poorhouse' of northern Germany (Klohn, 2012). Because of its distinct industries comprising not only feedstuff producers and slaughterhouses but also internationally leading companies, producing for example stable equipment and manure processing technologies, the area has achieved a reputation not only as a conservative stronghold, but also as Germany's 'Silicon Valley of agrotechnology' (Windhorst, 2004).

As a result of decades of excess manure application on mostly sandy soils, the area has also become a hotspot of nitrate pollution. When the local water supplier first encountered immense problems with nitrate pollution in the 1980s, deeper wells were drilled to dilute the drinking water sourced from higher layers (Aue, 2017). Some of the near-surface water monitoring stations in the area today still document disconcertingly high nitrate concentrations of more than four times the legal threshold (NLWKN Cloppenburg, 2019). Since water moves about the soil very slowly, the effects of past, less-regulated slurry application practices are expected to register in the deepest groundwater wells (at about 120 m depth) only in the coming decades (local water works Managing Director, interview, 17 July 2020).

Already in 1985, a special report by the Advisory Council on the Environment provided a systematic overview of the environmental problems caused by intensive agriculture in German, pointing at excess slurry application in livestock hotspots as a growing concern (SRU, 1985, p. 19). Regardless of the concern over water quality, however, the livestock industry in Weser Ems has not been subject to much public controversy locally, and the strong connection between the conservative party (CDU) and the agricultural lobby on both State and National levels has for many years impeded stricter environmental regulations on agricultural activities. Only when the EU Commission took legal action against Germany and threatened to impose penalties of up to 850,000 euros per day for the failure to fully implement the 1991 EU Nitrates Directive (91/676/EEC), a major reform of the national regulatory framework was eventually realized in 2017, with repercussions and re-tightening of some aspects still ongoing. The refined fertiliser ordinance which imposed strict limitations on organic nitrogen application including biogas digestates and longer retention periods had immediate and profound effects on the Weser Ems region, namely on farms with high stock numbers and limited land available for slurry disposal. Furthermore, the amount of slurry theoretically increased 'overnight', as a young pig farmer puts it, because standard calculations for nitrogen (N) and phosphorus (P) content were adapted to higher values (J. Rehder, interview, 22 March 2019). In effect, less slurry could be legally spread on the fields.

From the perspective of local livestock farmers, this long debated and contested policy change therefore translated the 'slurry problem' into increasing costs for slurry management and disposal. More than 3.5 Mio tons of manure are currently transported from Weser Ems to other parts of Lower Saxony or beyond state borders annually (LWK Niedersachsen, 2021, pp. 15f.). Prices for removing slurry from a pig farm in Weser Ems have risen to about 12–15 euros per cubic metre. With costs for slurry disposal rising, its has become a major production factor, and many of the farmers interviewed argued this new economic pressure was exploited by political actors to foster a structural and spatial reorganization of Germany's intensive agricultural production system through the backdoor.

From the point of view of the agricultural chamber, the new fertiliser ordinance has aggravated an existing imbalance between animal numbers and agricultural area, leading to an overall 'recovery problem [*Verwertungsproblem*]' for slurry (Schepers, 2018). Actors with a stake in intensive livestock farming tend to frame the problem as a spatial mismatch. The German Agricultural Society (DLG) for example asked, 'Where to put the slurry?' on the title of its member journal in January 2019 (DLG, 2019), while a pig production trade journal drew attention to the missing 'slurry area' (Schnippe, 2017). Another widely used framing locates a 'nutrient surplus' (LWK Niedersachsen, 2021) at livestock hotspots, pointing to the significant spatial differentiation between areas of concentrated livestock farming in Weser Ems in the west, and arable farming in the eastern part of Lower Saxony (Schepers, 2018). Defining the slurry problem as a matter of spatial distribution is closely linked to the envisaged solution: to transport slurry towards areas with low animal numbers, such as the eastern Lower Saxony wheat belt, and to market it as an economic fertiliser with the potential to substitute mineral inputs to a certain extent.[1]

Consequently, interested parties from the Weser Ems region refer to this practice as to 'close the nutrient cycle' (Arden, Rohlmann, & Bröker, 2019, p. 1) between west an east, or livestock and crop farming operations. A flyer of one of the many companies in Weser Ems that combine slurry transport with other agricultural contracting services reads: 'Closing nutrient cycles hand in hand. We help to close the nutrient cycle between farms.' (Dettmer Agrarservice, 2019). This framing turns the role of middlemen – the actors directly benefitting economically from slurry transport – into 'nutrient mediators' and crop farmers into partners waiting. At the same time, it neglects the substantive effects of nutrient-rich feedstuff imports such as grain or soy on the local and regional material flows.[2] Thereby it also rhetorically severs the connection between the Weser Ems agribusiness cluster and the global production networks it is embedded in (cf. Franz, Schlitz, & Schumacher, 2018). Drawing on a 'cycle of nature' image reminiscent of organic and small-scale agriculture, the massive environmental destruction and socio-ecological injustices caused, e.g., by soy plantations in Latin America are moved out of sight – and thereby also the longstanding political struggles against the externalisation inherent in globalized agroeconomic networks. The question if the often quoted 'slurry problem' is a problem of the material properties, quantity or spatial distribution of slurry or rather a symptom of an unsustainable agroeconomic production structure is central for the solutions that are discussed in more detail in the following, namely the mobilisation of slurry and its transformation into fertiliser in material, social and symbolic terms.

3. Mobilising slurry: Transport from west to east

In Vechta county, the amount of slurry to be managed has long been recognised, also officially, as too large to be applied on local fields alone.

[1] This potential corresponds with the synthetic fertiliser and energy markets, which have become even more volatile due to the economic effects of the war in Ukraine and sanctions against Russia.

[2] Åkerman et al. (2020, p. 78) have observed a similar framing in relation to the (failed) attempt to 'close the disrupted local loop of pig farming' via biogas and fertiliser production in Finland.

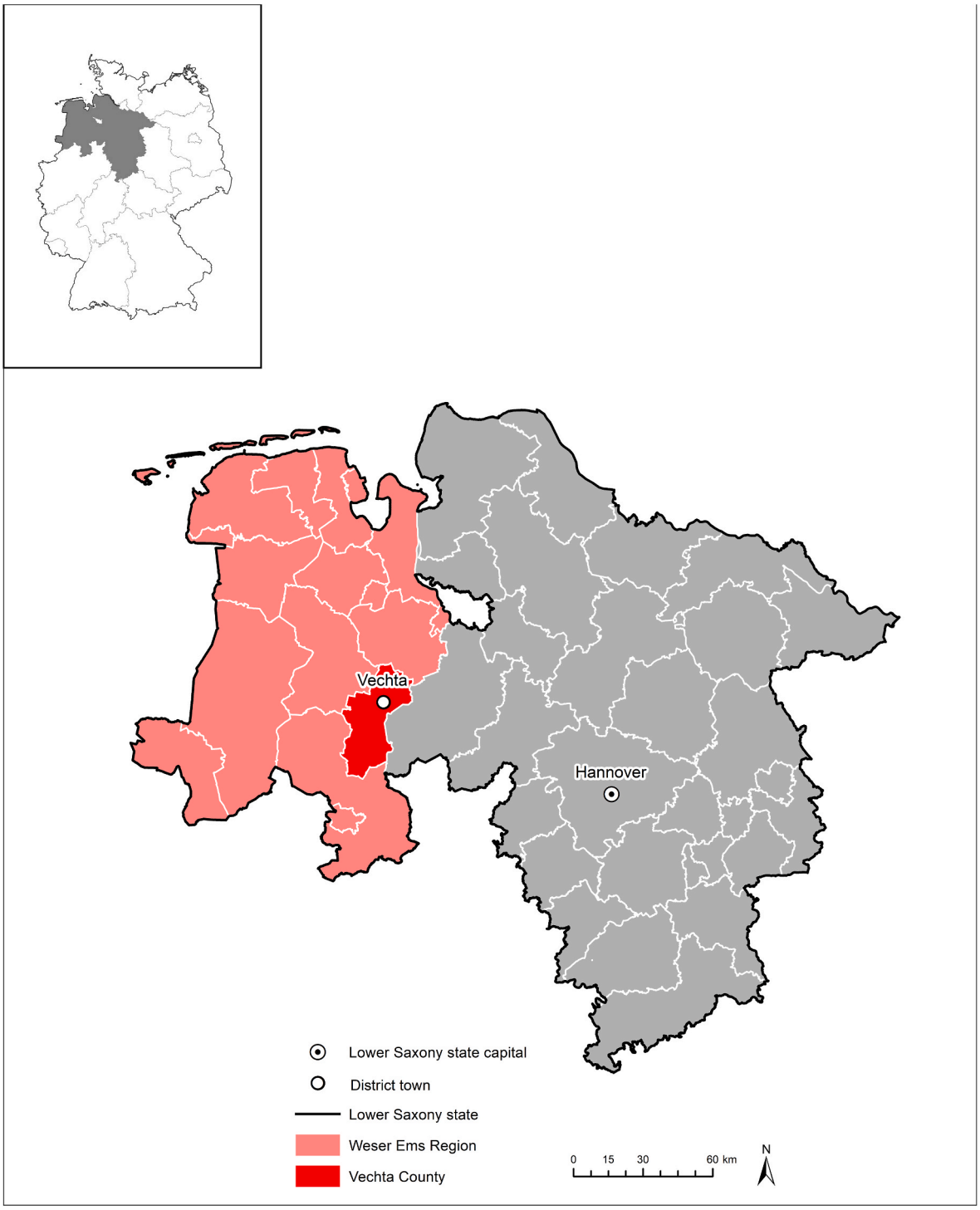

Fig. 1. Study area: Location of Vechta county in the Weser Ems region, Lower Saxony. Graphic: Lisa Feuchter.

Already before the 2017 fertiliser reform, building permits for stable constructions and reconstructions had been subject to farmers documenting both their available land and a 'recovery concept' for additional amounts of slurry – in the form of acquisition agreements, usually a contract with one of the many slurry brokers in the area. A conglomerate of actors has developed over decades to dispose of excess slurry. Initially, the slurry was collected in simple slurry tanks and redistributed to the neighbouring counties. This practice, which still coexists with novel and extended networks, relies on the traditionally tight and long-term personal business relations common in the area, such as between local slurry broker Hein Hellmann and agricultural contractors who collect, transport and apply slurry. Under the 2017 regulations, this practice has intensified and, consequently, larger distances now must be covered 'to get the slurry away from here', as a local sow farmer describes it (F. Breide, interview, 26 March 2019). From the perspective of a representative of the Lower Saxony Fertiliser Agency, this meant that '1 to 1.2 million tons have to get out of here [Vechta county]' (Round Table Vechta, field notes, 10 August 2018).

Initially, the situation developed into a local 'transport crisis' (Round Table Vechta, field notes, 10 August 2018). The crisis materialised during the first winter season after the reformed fertiliser ordinance had become active in June 2017. The 2017/2018 winter was characterised

by extremely wet weather conditions in northern Germany. Because this limited field application even before the newly enforced retention period began, slurry storage facilities reached full capacity, bringing the slurry issue also to public attention (Sprockhoff, 2018). While emergency permits for temporary storage were granted by the Lower Saxony Fertiliser Agency, others saw a business opportunity to offer unused storage space, however small: 'They called us saying, if you are in need, you can bring the shit here, but you have to bring 10 euro extra per cubic metre and then you have to pick it up again on April 1st', a slurry broker reports (R. Ahrens, interview, 27 February 2019).

The transport crisis, however, turned out to be only temporary (H. Hellman, interview, 8 October 2019). Lasting effects of it were that the radius of transport generally enlarged, and that biogas plants became more central players in the network of slurry disposal. A local nutrient broker and logistics company estimates that about 80% of the excess slurry is still distributed with tankers to adjacent counties up to approximately 50 km towards the northeast (J, Laakmann, interview, 14 January 2020). While the 'final destination [of slurry] is always the field', as another nutrient broker puts it (M. Teuscher, interview, 17 February 2020), only 20–30% of the material is applied directly to the soil as fertiliser. The rest is first digested in biogas plants and the residues are then applied in the vicinity. However, because there is no longer enough 'space' for the slurry in surrounding counties, which are now mostly 'full' (J. Rehder, interview, 22 March 2019), the distances covered have overall increased. Standard slurry destinations can now also be found further along the A27 and A7 motorways (see Fig. 2).

Actors describe these distances in relation to large cities in northwestern Germany – slurry is transported 'until Bremen', 'up to Hannover' or left 'behind Braunschweig'. Until Bremen is described as 'close by', until Hannover is medium-range and everything else is far in 'the east'. Obviously, the slurry is not distributed *within* these cities, but the slurry transporters use the well-developed traffic infrastructure connecting Vechta to motorways and large federal roads (see Figs. 2 and 3) that are highly frequented by agricultural traffic, such as transporters filled with animals, feed, slurry or food. Distance is relevant here mostly in relation to cost. 'Close enough' is what is economical from the point of view of the livestock farmer and the logistics company for transporting slurry with a given weight and nutrient content.

3.1. The 'Combi-Liner' approach: Sociomaterial assemblage and economic integration

Another factor affecting the distances that can be covered are specific technological innovations for slurry transport. Richard Ahrens, the CEO of the large nutrient distribution company NutriBank, has developed the so-called 'combi-liner', a truck with two separate compartments: one for liquid slurry and one for dry bulk material. Combi-liners are used to transport slurry to 'the east' and then take a return freight back to the Weser Ems region. The return cargo is primarily feed wheat loaded on behalf of a local feedstuff producer, and sometimes other materials such as gravel for the building industry. The combi-liner approach sets NutriBank apart from other local players. Consequently, NutriBank defines itself as a specialist for transregional nutrient export. For them, the main business area begins where the range of standard slurry transportation ends:

> A lot is already taken to the local area – for us, the local area is actually as far as Hannover, although it's 140 km from here. That is a local area, which is served by normal slurry vehicles. And we [NutriBank] start again, from Hannover to Braunschweig, Helmstedt – that's our area […]. (R. Ahrens, interview, 27 February 2020).

Because of the reduced transportation costs, the combi-liners are used up to a distance of about 300 km one way (Fig. 3). Max Teuscher, who works for a competitor who also uses combi-liner vehicles, explains that this limit is due to a 'technical relation between driver, working shifts and the combi-liner' (M. Teuscher, interview, 17 February 2020). His company operates a two-shift system, and 300 km return plus loading and unloading time is the maximum distance that can be managed by a single driver within one shift.

For NutriBank CEO Richard Ahrens, the larger radius covered with combi-liners equals a solution to the existing 'nutrient surplus' in Weser Ems as such. He is convinced that the approach could be scaled up to address the issue for the region as a whole:

> There should be maybe 20 NutriBanks, then this would be settled for Weser Ems. Then the nutrient surplus would be absolutely reasonable and properly distributed. (R. Ahrens, interview, 27 February 2020)

The quote demonstrates Ahrens's understanding that the slurry problem is a matter of distribution, and not of amount – he sees no need for the production system itself to be changed or spatially reorganized. His solution, however, not only deals with the difficulties of organising an economically viable transport of slurry – a liquid and heavy material – via technological means. It also depends on the willingness of social actors, namely the crop farmers, to take part in this system as both slurry recipients and crop sellers. Part of NutriBank's success lies in promising crop farmers access to the feed wheat market in exchange for slurry receival. The wheat market is volatile and very competitive, and feedstuff producers in Weser Ems have such strong market power that their purchases define maximum achievable prices for wheat in all northern Germany (H. Walters, interview, 21 March 2019). Farmers from the wheat belt therefore might decide to market some of their grain as feed wheat to minimize risk and compensate possible losses from fluctuations in achievable prices or grain quality. With the assistance of the combi-liner, NutriBank succeeds in connecting livestock farmers, crop farmers and feedstuff producers across contrasting interests and achieves an economically feasible extension of the slurry trade. NutriBank uses the combi-liner as a tool to integrate feedstuff producers, logistics companies, nutrient brokers, livestock and crop farmers, biogas plants and the construction industry into their business network. Such integration efforts and power concentrations are characteristic for intensive farming production systems in general (Hinchliffe, 2015). In this sociomaterial assemblage (Barry, 2013) the combi-liner is not only a technical innovation; it is a sociotechnical object whose material agency assembles a whole network of actors, objects and objectives.

Using slurry as fertiliser elsewhere also requires the integration of further infrastructural elements, especially storage capacities, that cater for the material properties, regulatory requirements and complexities of the sociotechnical network of handling slurry. In this sense, the successful mobilisation of slurry also hinges upon the controlled demobilisation of this heterogenous material. For practical and legal reasons, organic fertilisers can be applied only during a small window of time in spring, weather permitting. The availability of drivers, vehicles and the traffic jams often occurring on the over frequented roads are further limiting factors. The availability of storage room also influences transportation costs, because if slurry can be delivered outside of agricultural peak times, such as in winter, more drivers are available, and costs are lower. Plans to construct new slurry tanks in crop farming areas are, however, faced with resistance. Legally, the construction of slurry storage on farm sites is only permissible if directly related to the agricultural activities, a relation disputed by some local authorities in the case of crop farms. Arguably, local authorities are generally reluctant to facilitate access for the slurry trade in counties where residents are not accustomed to livestock farming, organic fertiliser application is more controversial and complaints because of smells more common (A. Schmidt, City of Salzgitter, interview, 26 February 2020). While some farmers in the east have envisioned shared facilities to split investment costs, there is also an unwillingness to financially engage in solving a problem caused by livestock farmers elsewhere 'for them' (E. Mohn, interview, 12 June 2020; M. Tiedemann, Wolfenbuettel county, interview, 24 February 2020). Here, the circular economy framing, allegedly reweaving connections between livestock and arable farming, clearly

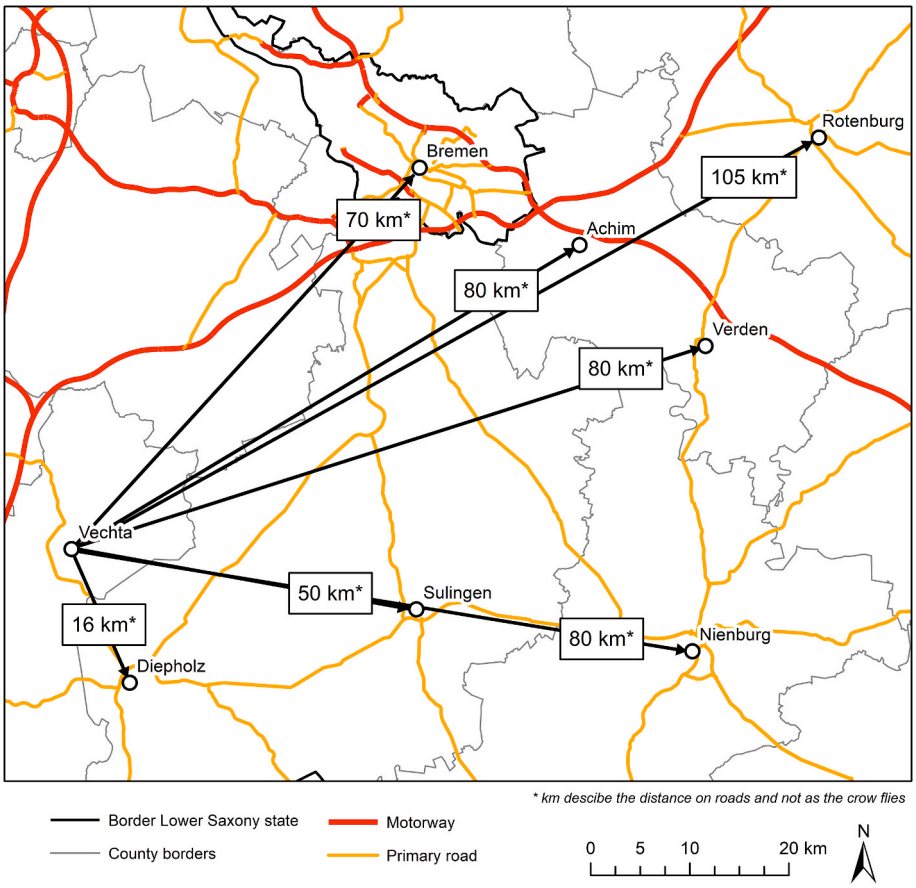

Fig. 2. The 'close by' slurry destinations: Adjacent counties towards the east of Vechta. Graphic: Lisa Feuchter.

reaches its limits. Besides, the dynamic development of slurry processing operations makes farmers hesitant to invest. What if full processing is successful and the cheap nutrients promised by slurry brokers will arrive in a mineral fertiliser pack in the near future? These visions, related to transforming the material properties of slurry, will be discussed in the following section.

4. Transforming slurry

4.1. Material transformation

To facilitate transport, there are, on the one hand, 'separation' technologies used such as mobile centrifuges that extract humidity from liquid manure. These technologies, however, address the 'slurry problem' – here understood as the unfavourable relationship between weight, water content and transportation costs – again mainly from the point of view of the slurry producer or 'provider'. The drier substances resulting from separation can theoretically be applied elsewhere on the fields with a conventional dry manure spreader, while the liquid phase remains at the livestock farm. However, in practice, the separated materials do not allow for exact application on the fields. Slurry broker Hein Hellmann envisions crop farmers responding to the prospect of receiving separated slurry, telling him that 'we're spooning up our [grain]stock and you come in here with this crap!' (Round Table Vechta, field notes, 1 July 2019). Separated material has to be worked into the soil and cannot be used on growing stock. Therefore, Klaus Rebmann from the eastern Lower Saxony Agricultural Chamber explains, only 'raw' slurry can be used in spring: 'We could only work with liquid manure then. There we know it works [laughs]. Otherwise, we'll get into trouble with our pilot farms, which won't work either' (K. Rebmann, interview, 25 October 2018).[3]

To be successfully transformed and then mobilised, the material first has to become enrolled into a wider network. Once again, an intermediate actor plays a key role, in this case an agricultural cooperative that has developed a nutrient disposal service based on separation technology. Their 'all-inclusive solution' (H–P. Wichmann, interview, 10 June 2020) successfully enrols slurry separation into a larger sociomaterial assemblage, similar to the combi-liner transport network described above. This assemblage is centred around a mobile centrifuge placed in a container and driven directly to the pig farms. The separated phosphorus-rich dry material is then transported to biogas plants in eastern Lower Saxony at a cost of about 10 euros per cubic metre. A nitrogen-rich fluid is left at the farm and applied locally. This slurry disposal service is yet another example of the increasing market integration in livestock farming, especially since the cooperative is also a major player in the feedstuff market. It also recently started to build a digital platform integrating various services, such as the provision of localized weather data for site-specific herbicide and fertiliser management. Such smart farming applications rely on small-grid data from farmers. Manure management services again serve as a means to an end, in this case as the cooperative's investment in future markets in the hope of extending their local value chain into the agricultural data business so far mostly dominated by multinational companies.

[3] A follow-up project currently focuses on the use of processed organic fertilisers in arable farming.

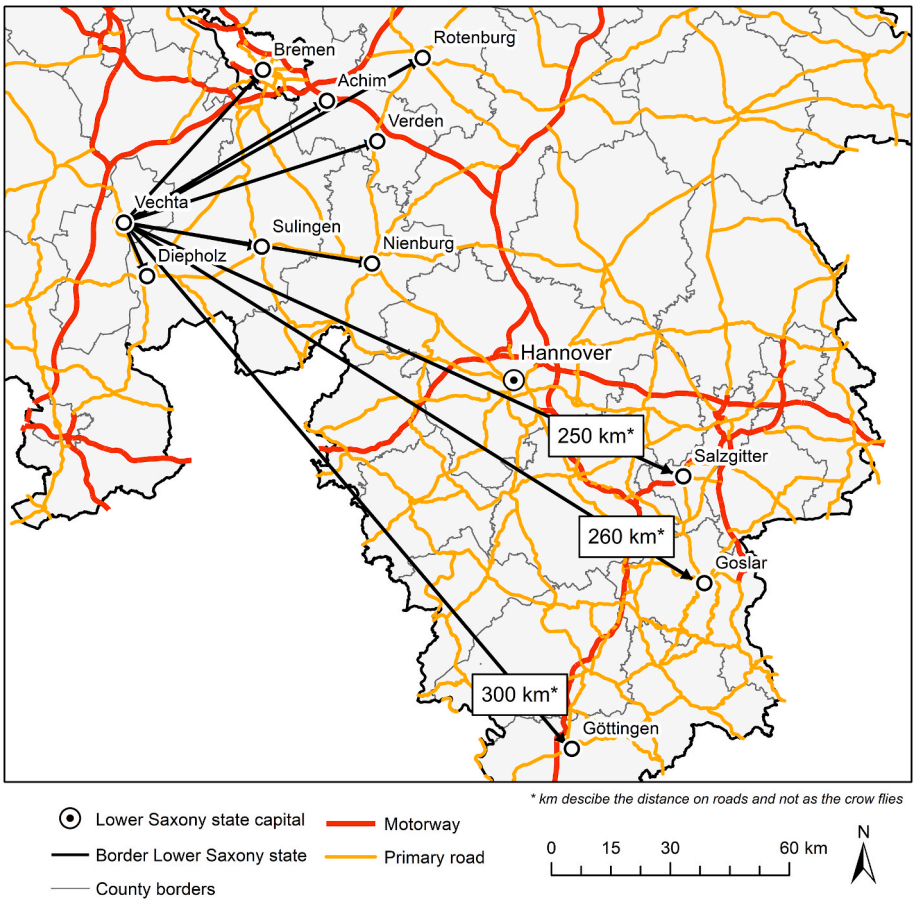

Fig. 3. Longer distances are covered with combi-liner vehicles. Graphic: Lisa Feuchter.

4.2. *'Full processing': The promise of moving beyond the nutrient cycle …*

In contrast to the relatively simple separation technologies that are embedded into more complex socio-economic networks, 'full processing' is itself technically more advanced and provides a more thorough material transformation of slurry into dry matter and water deemed clean enough to enter on-site pre-flooders. Such technologies can operate on different scales, as on-site units located next to very large pig farms, or in the form of central processing plants where slurry is transported to. Plans to establish full processing plants in the Weser Ems region can be understood as yet another symptom of the ongoing integration and intensification of agrarian production. For the agro-economic livestock cluster, part of the – in Weser Ems yet unfulfilled – promise of full processing lies in slurry-turned-fertiliser products that resemble mineral fertiliser more closely, and which would presumably be of more interest to conventional crop farmers.[4] In this sense, full processing would add another layer of intensification – the disposal of manure replaced by its complete commodification. This vision mirrors the 'valorisation of waste through dynamics of intensification' already observed by Schlitz (2020, p. 161ff.) in the context of methane production from manure.

Since 2019, plans for several such facilities have been developed, including one by local entrepreneur Eberhard Koerner who emphasises that the ultimate goal of slurry processing is to sustain intensive livestock farming and related industries in the region.[5] Their loss, he argues, would be 'non-compensable' (E. Koerner, interview, 24 July 2018). Again, local feedstuff producers play a role, investing heavily into centralised full processing projects, motivated by their market interest to keep local livestock production in its current shape (farmer and politician B. Fischer, interview, 14 January 2020). Centralised processing could also provide alternative options in case of epizootic disease outbreaks such as African Swine Fever (ASF), when '[slurry] export would be gone overnight' (agricultural lobbyist N. Müller, interview, 2 August 2018). However, those in the slurry export business consider this only a partial solution, a 'Plan B that will relieve the strain' in a situation where potential slurry recipients are said to 'take us to the cleaners' by expecting an increasing payment in return (Round Table Vechta, field notes, 1 July 2019). Full processing entrepreneur Koerner also states that 'full processing' does not equal a 'full solution' to the Weser Ems slurry problem in his view – even with his goal to process half a million cubic metres of slurry per year, the future plant 'cannot take the surplus out [completely]', he argues (E. Koerner, interview, 24 July 2018).

At the same time, the vision he puts forward transgresses the dominant – and deeply problematic – narrative of the current manure export business as closing the nutrient cycle between livestock and crop farming which he argues 'is still a mindset in agriculture, especially among agricultural functionaries and also in agricultural policy. […] They always think in terms of these cycles; everything that is produced in agriculture must also end up in agriculture. That is the so-called circular economy' (E. Koerner, interview, 24 July 2018). Contrary to this

[4] There is a separate market for certified organic manures that has also been subject to the research but is beyond the scope of this article.

[5] Centralised slurry processing is not a novel idea. Already in the 1980s, a project was announced in the area with a 30 million Deutschmark investment volume.

framing of a circular economy to be established *within* agriculture, Koerner defines his goal to 'completely remove/take out an amount X from this region and add it to other cycles. And these cycles do not necessarily have to be linked to agriculture' (E. Koerner, interview, 24 July 2018). He thinks also of other material flows, such as the chemical industry. As a result, he claims, 'we will have no waste': 'We are not building a waste disposal plant but creating a technical solution for the nutrient surplus of the region' c-Port Zweckverband, n.d.). He consequently calls his planned facility a 'transformation plant for slurry', arguing that it will 'not [be] a profit centre in the classic sense, but an infrastructure project for the region' (c-Port Zweckverband, n.d.): an externalisation of waste turned into economic development. This mirrors popular media discourse, where slurry transformation is evoking appraisals such as 'technology turns slurry into black gold'[6] or 'where slurry is gilded' (Mlodoch, 2020).

4.3. … but no symbolic transformation of slurry

The world-making effects of such onto-political statements have also been noticed by local residents who became vocal opponents of another full processing project. Siegfried Staaken recalls that he first learned about the plans to build a facility in his village from a public notification in the newspaper:

> It said […]: Processing plant. That's what it said. There was nothing about slurry. A treatment plant […]. So, and then we met at a neighbourhood barbecue in the summer [and] talked about it. And then one of the neighbours said, don't you know what that is? I say, no. What is this? - A slurry processing plant. At first everything was quiet. What do you mean, slurry processing plant? And then it was discussed. […] And between obituaries and crossword puzzles. That's where it was at [in the newspaper]. (S. Staaken, interview, 6 February 2020)

This proposal by a local technology company was – after initial support – eventually rejected by the local council citing the strain it would have put on the road infrastructure. Staaken and other residents of a neighbourhood of scattered houses surrounding the proposed site had managed to mobilize the larger community, and hundreds of written submissions were filed in opposition to the project. The action group collected information on slurry management and eventually brought forward a whole series of counterarguments reaching from increased traffic to the threat of spreading multi-resistant bacteria to water pollution and, importantly, smell. Reporting from a site visit undertaken to a similar plant operating in the Netherlands, Staaken recalls: '2 km away you could still smell it, where the wind comes from. […] You cannot imagine that' (S. Staaken, interview, 6 February 2020). The proximity of houses to the proposed site also provided the opportunity for the owners to question the results of a mandatory 'odour assessment' commissioned to assess the effects on properties located within a 600 m 'odour radius' (see also Åkerman, Humalisto, & Pitzen, 2020, p. 77).

The local Green Party also campaigned against the construction but took a different vantage point, arguing that this approach equalled a consolidation – literally a 'cementation' – of factory farming (Bündnis 90/Die Grünen, 2020). They argued the initial land sale on part of the council was 'a fundamental, structural policy decision that paves the way for continued factory farming' and 'consolidates the current system for the future', repudiating the framing that it was simply 'a normal land deal' (Bündnis 90/Die Grünen, 2020). Instead, the party related the siting discussion to the demand for a fundamental structural change to 'another kind of agriculture' (Bündnis 90/Die Grünen, 2020).

Two points seem important here: firstly, the question of slurry processing makes environmental problems related to intensive livestock farming *sensible* – perceptible, and something to act on. And secondly, while they followed different agendas – defending local amenity values against increasing traffic and smell on the one hand and working towards a new agrarian structure on the other, both sets of actors – the local resident activists and the Green Party – shared a common frame of reference by referring to full processing plants as 'slurry factories'. The industrial scale of these operations then seems able to mobilize resistance against pollution in a way that intensive agriculture itself often does not – as if agricultural pollution still remained a somewhat 'anomalous category' (Lowe et al., 1997, p. 59).

It should also be noted that while large-scale slurry processing is certainly a '"technical fix" approach that subscribes to a productivist view of agriculture' (Ward, Clark, Lowe, & Seymour, 1998, p. 1170; cf. Iles, Graddy-Lovelace, Montenegro, & Galt, 2016), not all technical fixes addressing nutrient surpluses are necessarily such 'end of pipe' strategies (Ward et al., 1998, p. 1076). Technical fixes can also aim at transforming the very corporeality of slurry-producing livestock: to this end, the feedstuff industry offers nitrogen and phosphorus (N/P) reduced feeding regimes, complemented with various food supplements, that directly influence the metabolism and thereby excretion of farm animals. Focusing on their bodily functions – their digestion, growing tissue and excreting surplus nutrients as central parts of the agro-industrial network, this approach enrols animals' bodies into new sociomaterial assemblages of feeding, slurry transport and processing.

In sum, while full processing might be a promising approach from the point of view of both the livestock industry and potential customers because it would allow for a material transformation of slurry into a raw material and resource for either synthetic fertiliser production or the chemical industry, the symbolic transformation of slurry into 'gold' – something valuable removed from its context of production – remains incomplete and contested. It does not convince other critical actors such as local residents and environmentally concerned politicians. This points to the crucial importance of the ontological multiplicity of slurry, an argument that will be developed in more detail in the following section.

5. Ontological struggles and material conflicts

5.1. The waste–fertiliser continuum

Shifting the focus back to the current practice of slurry transport from Weser Ems towards the east, it becomes evident that this also builds on slurry being considered as a useful fertiliser in the first place. In other words, the practice depends on slurry physically and symbolically covering increasing distances, and successfully becoming organic fertiliser elsewhere. The initial motivation for arable farmers to use slurry as fertiliser is usually cost efficiency: 'In any case, it's a cheap fertiliser [which] is delivered […] postage free field edge, at zero price', a farmer representative from eastern Lower Saxony sums up (M. Wibeke, interview, 15 August 2018). Transport and application costs are covered by the livestock farmers in Weser Ems. Jens Rehder, a young pig farmer describes the increasing difficulties he encountered when organising slurry export within his extended network of crop farmers following the 2017 reform:

> In principle, one had to go further and further. And even then, it sometimes becomes already more difficult to get rid of it. Or – expensive, let's put it this way […]. Now when I saw this inner circle was full, I had to take the next, bigger distance. Then the people in the inner circle here said, oh, if you can pay to go over there anyway, then you can leave it with us. But the extra money you'll have to give us, too. […] They just saw the business in it. And then – [he inhales] – [they] turned the whole product from a good nutrient to a waste product. And that was one thing I didn't really like. (J. Rehder, interview, 22 March 2019)

In Jens' experience, slurry recipients try to reframe slurry into waste

[6] Field notes, Conference 'Mist! Zu viel Gülle, Nährstoffe und Keime … (Gewässer-) Belastungen und Schutzmaβnahmen', 23–24 October 2018, Loccum.

in order to negotiate a better deal. This becomes possible because of the ambiguous ontological status of slurry oscillating between potential fertiliser and waste. The distinction between slurry as a valuable nutrient and slurry as disposable waste is not a stable one – rather, it has to be enacted in practice (cf. Mol, 2002). Livestock farmers and their representatives point out the naturalness of slurry, for example by comparing it to an organic diet for humans, arguing that slurry is 'wholefood for our fields – there is nothing better because it contains everything that our soil and our plants need […]' (Bischoff, 2019). This framing of slurry as a 'complete fertiliser' (Bischoff, 2019) points to the fact that it contains both a combination of nutrients and organic matter with the potential to enhance soil quality by increasing soil organic matter, water retention capacity and heat stress resilience (K. Schröder, interview; Round Table Göttingen, field notes, 1 July 2019). The context of production (non-organic) and possibly unwanted organic material that could also be contained in the manure, such as bacteria, are not addressed.

These categorial shifts along what could be termed a 'waste–fertiliser continuum' go to the heart of the onto-political struggle over slurry. Ironically, those actors who face a slurry surplus which forces them to invest a considerable share of their profits into costly disposal services are also those who are at pains to stress that slurry is a nutritious fertiliser, even almost a gift. They argue that 'crop farmers demand money while getting nutrients' (Round Table Vechta, field notes, 10 August 2018). Seen in this light, full slurry processing is anticipated as a transformation of nitrogen 'in a way that crop farmers take it with greatest pleasure [*mit Kusshand*] and come to pick it up themselves' (Round Table Vechta, field notes, 10 August 2018). In other words, livestock farmers hope that the materially different products resulting from full processing will also have less potential for ontological shifts along the waste–fertiliser continuum.

5.2. Conflicts over content

Those engaged in the current slurry transport practice hope to enact slurry as a natural substance and hence valuable fertiliser. From the perspective of a conventional crop farmer considering the use of manure, however, it is vital to know the exact nutrient content and the ratio of elements contained in the substance. In this sense, the variability of an organic substance such as slurry makes it somewhat unreliable and unruly. Consequently, the ontological transformation of slurry into fertiliser is further complicated by conflicts over the exact nutrient content. Nitrogen and phosphorus contents of organic fertilisers have to be reported to the Fertiliser Agency by both slurry provider and recipient. However, standard practice means that the samples used to measure nutrient contents are taken by the providing livestock farmer before the slurry is loaded and shipped. The material is then received and applied by crop farmers before they have had the opportunity to commission their own testing.

Here, on the one hand, the materiality of slurry comes into play. Since slurry is a heterogeneous liquid substance containing various solids, the nutrient content of a sample depends on how and where this sample is taken. The thicker the material, the more nutrients it contains. Therefore, when the slurry is stirred before sampling from the tank, nutrient contents are much higher compared to a sample taken from the upper layers of a settled substance. On the other hand, the contrasting interests of the actors involved emerge in the process. For livestock farmers, it is favourable to *document* the highest possible nutrient content in order to have the lowest possible transportation costs for the maximum removal of excess nutrients accounted in their farm balance. Crop farmer, however, want as many nutrients as possible in the material sense – to have the highest fertilising effect. But, at the same time, the documented nutrient content should be as low as possible, because the nutrient import adds to the overall fertiliser input that is strictly limited and monitored also for the crop farm. In other words, they want the lowest possible figures on paper but as many nutrients as possible on the field.

Conflict resolution often falls upon the intermediate slurry brokers who address the issue by both technical and social means. Big logistics companies who distribute large quantities of slurry to a spatially distributed client base have invested in costly near infrared spectroscopy (NIRS) sensors that measure nutrient content while slurry is pumped into or out of trucks. Smaller players such as local slurry banks, on the other hand, rely on a culture of trust, maintaining personal business relationships sometimes over several generations of farmer families. They build on the strong local culture of doing business with people one knows. This approach, however, is not easily expandable beyond the region and to new actors with contrasting interests.

6. Towards material and sensory politics of care

The material properties of slurry and the ontological politics of what it *is* or may become – waste or nutrient, fertiliser or pollutant, resource or public nuisance – have been shown to be a matter of conflict and concern for differently positioned actors: pig and crop farmers, intermediaries such as slurry brokers and feedstuff retailers, local residents and regulators. The arena of onto-political conflicts over slurry, however, also includes the wider public. Therefore, the pig farming trade journal mentioned above distributes large stickers reading '100% natural fertiliser – for the sake of our environment'. According to the journal, 'with this simple slogan on the slurry barrel, the feeder, the field container or directly on the slurry storage it should be made clear that slurry is a natural product and is needed!' (SUS, 2021) This comment addresses members of the general public, such as the residents of the small town of Achim, a municipality close to the city of Bremen that can be considered a classic destination for 'slurry tourism' (Purschke, 2018) from Weser Ems. Some local residents worded a petition in protest of the slurry trade, demanding the local council 'to search for and investigate ways to prohibit carting toxic hazardous waste (slurry) from distant regions to the fields of the town of Achim under the pretext that it is harmless, natural fertiliser' (Mix, 2018). These statements again locate slurry firmly at the waste end of the waste–fertiliser continuum.

Public controversies about slurry often focus on the matter of smell. The extension of slurry transport beyond the centres of intensive animal farming has been met with resistance from those who are not familiar with this form of production and the odours related to it. Smell can also be understood as a matter of material – and sensory – politics. As Lowe et al. (1997, p. 196; see also Chan (2020) observe, before agricultural pollution became recognised and eventually governed, only smell was seen as a political issue – as a 'public problem' – whereas other aspects of farm pollution were framed as merely technical issues. Already in the 1980s, an award-winning documentary put the 'eternal stink of the fields' on the public agenda (Kleinschmidt & Eimler, 1984). This smell of slurry marks a material presence that remains invisible most of the time – even to livestock farmers – as slurry is stored in channels and cellars below slatted floors, or closed tanks emptied only by specialised contractors. Nonetheless, volatile ammonia molecules enter and irritate human noses and let them experience the materiality of slurry in the sensation of smell – an odour that can provoke strong, visceral reactions. Bodily waste triggers abjection (Grosz, 1994). Stemming from the early preoccupation with the boundaries of the body and thereby the self (Kristeva, 1982), abjection remains an ambiguous sensation throughout life that mixes repulsion and recognition (Arya, 2017). Drawing on Kolnai (2004), Arya (2017, p. 54) underlines the 'significance of the organic' in defining what is considered disgusting and dirty. She points to the 'presence of the organic and its location' (Arya, 2017, p. 54) as that which provokes reactions of stark disgust in encountering faeces and other substances that are of the body. Smell threatens the corporeal boundaries in a very literal sense when minuscule molecules physically enter the sensing body (Neubert, 2020).

While water pollution is the major concern for the political regulation of slurry through instruments such as the EU Nitrates Directive and

the German fertiliser ordinance, smell remains an immediate sensation that can be felt directly by sensing human bodies – other than, for example, nitrate contamination of groundwater. When smells enter the body, they make pollution *sensible*. The regulation of abject, 'beastly' smells caused by practices such as inner-city animal husbandry, manure storage or slaughtering has been a main driver of what Atkins (2012, p. 2) describes as the 'great separation' of spaces for humans and spaces for animals in the changing urban economies of 19th-century European cities. This historical example shows that the nuisance of smelly organic material is, besides its immediate, visceral quality, always linked to specific multispecies relations and production systems (see Doron, 2021, p. 26).

As Neubert (2020) observes in his (auto)ethnographic work in Iowa, manure smells different to different people. For some, it is the 'smell of money' (Neubert, 2020, p. 742) – an effect of habituation but also an indication that the connection to economic value may indeed change individual interpretations of sensual experiences and that 'abjection, like odour itself, is fundamentally social, cultural and political' (Neubert, 2020). Also, as has been discussed above in relation to protests against full processing, there is not per se a contradiction between an embodied politics of the everyday related to smell and political arguments against the power laden and deeply unsustainable structural concentration and integration of intensive livestock farming. Abjection and disgust can remind us that we are animals too (Arya, 2017, p. 55) and can possibly provide an inroad for people to care about the more-than-human environment (Puig de la Bellacasa, 2011, 2015). Understanding the permanence and pervasiveness of smell connected to intensive animal farming as a 'slow disaster' can motivate acts of caring or 'slow activism' (Liboiron, Tironi, & Calvillo, 2018): everyday but nonetheless political practices of 'doing and intervening' (Puig de la Bellacasa, 2011, p. 89) that take responsibility for the well-being of the more-than-human worlds surrounding and connecting our sensing bodies.

7. Conclusion: Material agency and agroeconomic structures

To conclude, the case study has demonstrated the ontological multiplicity of slurry. Shifting along the waste–fertiliser continuum, slurry can be different things as it is enrolled into different socioeconomic networks and sociomaterial practices. Slurry may become fertiliser by transgressing simple binaries of nutrient–pollutant, organic–artificial or nature–culture. This potential for slurry to become fertiliser is realised in relational practices of producing, transporting and transforming slurry materially and ontologically. Ontological struggles over what slurry is and may become therefore play a vital part in any technical solution to the 'slurry problem'. There are in fact multiple slurry problems and solutions – as there is 'more than one' slurry (cf. Mol, 2002). It is a production factor that allows powerful intermediate players to integrate various agricultural actors into ever more complex production networks and to maximalise capitalization, but it is also a public nuisance that triggers citizens' action groups. It can be a means to increase soil organic matter that comes delivered to the field for free, and, in the future, it might serve as a raw material to extract mineral nutriments from. In all of these cases, slurry emerges as a complex material-symbolic matter. Its material properties effect and are affected by the larger sociomaterial assemblages (Barry, 2013) it is embedded into, such as the transport infrastructures and economic networks centred around the use of combi-liners, 'all-inclusive' disposal services for separated slurry or the transformation into the potentially materially and ontologically more stable products of so-called full processing.

The focus on material politics highlights that the more-than-human agency of slurry actively affects structural processes, such as the ongoing market integration along the chain of production from animal feeding to slurry management. Emerging and enlarging networks of manure transport reproduce existing agricultural structures and forge new connections between actors who share common interests in maintaining intensive livestock farming in its current shape. Players such as NutriBank, while claiming to 'close the nutrient cycle' between livestock production hotspots and farming areas, knit the chain of production ever closer. Crop farmers may be more reluctant to join but the market power of intermediaries, especially the feedstock market, are certainly a strong incentive to do so. The sociotechnical infrastructures of slurry transport thereby help to maintain highly intensive livestock farming and the associated industries upstream and downstream, such as stable construction companies and feedstuff producers based in the Weser Ems region. For the latter, the nutrient surplus even provides new market opportunities to develop nitrogen and phosphorus reduced feeding regimes that directly target animals' metabolisms and excretion.

The mobilisation of slurry hinges upon its potential for material transformations, since some its physical properties are major obstacles for the slurry trade. The hope to transform slurry instead of transforming the unsustainable agroeconomic structure is embodied in the promise of a future 'full processing' of slurry into marketable products akin to mineral fertiliser. So far, the complex sociomaterial assemblage of slurry from Weser Ems has not been translated into the construction of a centralised processing facility, and the very materiality of slurry – especially the smell associated with it – might ultimately prove to be a limit to this latest attempt to further intensify the production chain to fully incorporate the valorisation of waste (cf. Schlitz, 2020).

In fact, slurry becomes eventually more visible in the context of public controversies over industrial-scale 'slurry factories' (cf. Moore, 2009, p. 435). The successful protest organised against such a building proposal shows once again that the envisaged material transformation alone is not sufficient for slurry processing to change its ontological status from a source of sensory nuisance to a neutral recovery infrastructure. The fact that immediate, embodied reactions to the smell of slurry can trigger such determined public protest further demonstrates its material agency. Slurry and its odour can make intensive livestock farming – happening mostly behind closed bars – a material, visceral presence that is felt most immediately in the sensation of abjection. Sensual and embodied experiences such as disgust and abjection can then become a vital part of a practical politics of care for a more-than-human world (Martin, Myers, & Viseu, 2015) and help address structural questions of socioecological wellbeing and hence justice (Yaka, 2019).

Declaration of competing interest

The author declares that she has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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