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Biogas digestate management: Evaluating the attitudes and perceptions of German gardeners towards digestate-based soil amendments

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ABSTRACT

Managing the excessive nutrient surplus in the vicinity of many biogas plants presents an ever-increasing challenge. By opening additional markets for digestate products, plant operators can create alternative routes for their digestate streams and so lessen the economic burdens arising from digestate disposal. A relatively new and promising market is the private garden sector where small quantities of digestate-based products have already been sold with little marketing effort. This niche sector has the potential to develop into something much larger, but to do so, marketers must understand the consumer base. Guided by the consumer decision process model, we found through interviews with private gardeners from southern Germany that consumers' perceptions of value and risk in purchasing soil amendments often rely on credence attributes, making packaging and trust factors paramount in successful marketing of these products. A joint effort from key stakeholders based on these insights could lead to successful integration of digestate-based products into the mass marketplace, thereby helping both to preserve finite resources and to foster the long-term viability of biogas as a renewable energy source.

1. Introduction

For more than two decades, environmental scientists as well as many policy analysts have reasoned that effectively addressing climate change requires a transition away from fossil fuels to renewable energy sources. While many of these sources, such as wind and solar power, depend on volatile weather conditions, biogas does not. Produced through the anaerobic fermentation of organic material such as maize silage, manure and food waste (Blengini et al., 2011; Velazquez Abad et al., 2015), biogas not only provides for the recovery of energy from domestic, commercial and industrial waste streams, but it also has an advantage over other renewable energy sources in that it can be stored, meaning its availability can accommodate variable demand patterns. This makes it an essential component in the renewable energy mix (Hahn et al., 2014; Wall et al., 2016).

Biogas production has grown in recent years, which can mainly be ascribed to political forces (Appel et al., 2016). In Germany, the Federal Renewable Energy Act (Erneuerbares Energien Gesetz, EEG) provides subsidies to the biogas sector through feed-in tariffs, which has encouraged a rapid expansion in the number of biogas plants (Granoszewski et al., 2013). Today, 10,786 biogas facilities operate in Germany, accounting for the majority of the 17,240 biogas plants in Europe (EBA, 2015). Other countries also have ambitious growth plans for the biogas sector. The French government, for example, has requested the tender of 1,500 plants over the next three years (Ministère de l'Environnement, 2014; Schaller, 2015).

Associated with this growth in biogas production are the ever-larger quantities of digestate that accrue from the anaerobic digestion process. For example, a typical German biogas plant with a capacity of 500 kW, generating well over 4,000 MWh annually, produces over a 12-month period a volume of digestate equal to 7,600 m^3 (FNR, 2010). The digestate volume and characteristics mainly depend on the substrates used and may vary widely.

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Dry matter (DM) and organic matter (OM) values for digestate may range from 1.5–45.7% and 38.6–75.4% DM respectively (Nkoa, 2014).

Storage, disposal and management of this digestate represent challenges for an industry striving to establish biogas as a sustainable alternative energy source.

Promising applications for digestate have been found in the agricultural sector, where it is used both as a soil conditioner and as a fertilizer. As a conditioner, digestate is valued for its ability to improve the structure of the soil (Saveyn and Eder, 2014), although its soil amending properties vary greatly depending on the biogas substrate. Nevertheless, digestate has the potential to partially reduce the widespread use of peat in the horticultural sector. Peat has properties especially important for large-scale horticulturalist businesses that use it as a major component in their growing media (Schmilewski, 2008). However, the sustainable management of peatlands has long been controversial (O'Riordan et al., 2014), as has the status of peat as a slowly renewable or finite resource (Quintero et al., 2016). Peat bogs and mires are important carbon stores and their exploitation involves the removal of the surface vegetation (Alexander et al., 2008; Bullock et al., 2012). Declining peat resources and negative environmental effects from peat cutting have prompted environmentalists to advocate the use of peat-free soils (Alexander et al., 2008). One such peat alternative is biogas digestate.

As a slow-release fertilizer, digestate provides nitrogen, phosphorous and potassium (NPK), and so can, to some degree, replace mineral fertilizers by supplying those essential plant macronutrients needed to sustain the food supply for a constantly growing population (Coppens et al., 2016; Dawson and Hilton, 2011; Wellmer and Scholz, 2015). The nutrient concentrations of N, P and K may vary from 3.1–14.0% DM, 0.2–3.5% DM and 1.9–4.3% DM for untreated digestate (Nkoa, 2014). This benefit has particular value in phosphorus applications. Phosphorus is a limited resource whose mining incurs steep energy costs and poses serious health risks. Moreover, one country (Morocco) controls almost 77% of the global reserves (Cooper et al., 2011; Walan et al., 2014). Such strong dependence on a single source represents a point of agricultural and economic vulnerability, one that could be mitigated by increased use of renewable and locally produced organic fertilizers, such as biogas digestate-based products (Schröder, 2005; Möller and Schultheiß, 2014; Möller, 2015).

But biogas production does not get a free pass in terms of environmental impact. In some regions of Germany, development of the biogas sector has led to negative externalities (Reise et al., 2012; Granoszewski et al., 2013).

Several studies have assessed the environmental impacts of biogas production with varying outcomes (Bacenetti et al., 2016b). Impacts are among others strongly influenced by feedstock source as well as the storage and application of the resulting digestate (Poeschl et al., 2012a, 2012b; Whiting and Azapagic, 2014). Both organic wastes and energy crops may serve as a feedstock for biogas plants and account for different transportation distances due to distinct methane yields and transport vehicle options (Bacenetti et al., 2015a, 2015b). Substrate cultivation impacts the availability of arable farmland, and local application of digestate is not desirable in many regions where high nutrient excesses already exist. This applies especially for areas with intensive livestock farming were phosphorous as well as nitrogen surpluses in soils can be encountered (Bacenetti et al., 2016b; Hashemi et al., 2016). According to Nayal et al. (2016) N_2O emissions from digestate application account for the largest global warming contribution in the anaerobic digestion process. This however also depends on the upgrading and application techniques for digestate applied (Bacenetti et al., 2016a; Vázquez-Rowe et al., 2015).

Where digestate cannot be applied locally, biogas production costs skyrocket through the double digit per ton disposal prices added for the transport and marketing of the product into areas with a nutrient demand (Dahlin et al., 2015).

There are several technologies available to lessen these impacts. These technologies may start from very simple technologies such as a separator. The solid-liquid separation enables the separation of phosphorous, which remains mainly in the solid phase, and nitrogen, which is predominantly found in the liquid phase (Fuchs and Drosg, 2013). More refined technologies include for example belt and drum dryers, which enable the treatment and upgrading of digestate to a solid or concentrated product (Egle et al., 2015; Rehl and Müller, 2011; Schießl et al., 2015; Vázquez-Rowe et al., 2015). Furthermore, very sophisticated technologies such as ammonia stripping, membrane process and vacuum evaporation exist. These technologies produce several product streams with distinct characteristics and account for treatment costs of over 10 € per cubic meter of raw digestate (Fuchs and Drosg, 2013; Golkowska et al., 2014; Sheets et al., 2015; Vaneeckhaute et al., 2016). Several of these technologies are indirectly subsidized through the heat incentive bonus under the German law concerning the use of exhaust heat of biogas-fueled CHP units for e.g. digestate drying (Delzeit and Kellner, 2013).

Some fertilizer manufacturers have started to mix solid digestate products with mineral or organic nitrogen fertilizers (e.g. horn meal) in order to achieve desired NPK levels (Burnett et al., 2016; Dahlin et al., 2015; Kröger et al., 2016; Riding et al., 2015). Such treatment technologies generally facilitate the transportation of digestate by reducing volume and so increasing value per ton. Solid digestate products, such as pellets may even be used in non-agricultural markets as a heating fuel, providing another distribution channel for managing digestate.

A number of innovative biogas producers have recently turned to the private gardening sector, introducing digestate-based potting soil and organic fertilizers for the home market (Dahlin et al., 2015; Egle et al., 2015). Fig. 1 illustrates one such example.

The emergence of this sector represents a new and promising market for distribution and commercialization of biogas digestate. Broadening this market would contribute both to a sustainable solution for managing nutrient surpluses from biogas production and to the use of digestate to replace non-renewable resources such as peat and phosphorous in soil amendment products.

Fig. 1. Digestate fertilizer for private gardeners.
Source: own picture