Cyanamide as potential candidate for substitution

What cyanamide does and what it is used for:
Cyanamide is used to treat liquid manure in pigsties in order to control *Brachyspira hyodysenteriae* (PT3) and to control larvae of house flies (Musca domestica) (PT 18). Due to this double effect, it has been used in Germany for more than 40 years already. In recent years, this use of cyanamide has become established in other European countries also as for example Austria, Switzerland, Spain and Poland. As cyanamide controls both, the causative pathogen B. hyodysenteriae as well as its vector, the house flies, it has proven itself as a very effective tool to prevent swine dysentery and in this way to reduce the need for antibiotic treatments. Reducing antimicrobial consumption in animal husbandry is one of the key objectives of the EUROPEAN COMMISSION action plan (2017) against antimicrobial resistance (AMR). Thus, treatment of infectious liquid manure with cyanamide helps to prevent antimicrobial resistance.

Cyanamide use in PT3 is distinctly different from surface disinfectants
Typical disinfectants used in pigsties are strong oxidants, acids or alkalis. These biocides are generally applied to disinfect the surface of pigsties like floors, walls and pen partitions. All these active ingredients tend to react with organic compounds immediately. Thus, users should apply them on thoroughly cleaned surfaces only in order to achieve the required degree of disinfection. However, as soon as these disinfectants drip down from the slatted floor into the manure pit, they lose their efficacy. This is due to the heavy dilution of the biocides in the large volume of slurry and due to their reactions with the high organic load. To achieve a bactericidal effect in liquid manure these chemicals would have to be applied in such high dose rates, that the treatment no longer would be economically feasible.

In contrast to those surface disinfectants, cyanamide breaks down in liquid manure only gradually and exhibits its full activity in the liquid manure. It is therefore used to eradicate Brachyspira and fly larvae in the residual slurry beneath the slatted floor of modern pigpens. As cyanamide is a multi-site inhibitor which – among others – inhibits enzymes like catalase (DeMaster, 1986) and aldehyde dehydrogenase (Deitrich et al. 1976), it is very unlikely that Brachyspira hyodysenteriae will be able to develop any resistance to this biocide. Even when the cyanamide concentration gradually goes down due to chemical breakdown and progressive dilution through fresh faeces, according to practical experience it still controls fly larvae and also seems to control Brachyspira for a certain period of time due to a prolonged exposure time. This is supported by the observation that cyanamide is quite stable in liquid manure under anaerobic conditions. Eight days after the application of cyanamide to liquid manure still 89.3 % of the original concentration of cyanamide have been detected in liquid manure (Voelkel, 2007)

Another property of cyanamide has to be considered in this context. As cyanamide is a naturally occurring substance, which is synthesised by several plant species (KAMO et al., 2008), the soil's microflora is capable of breaking down this compound rapidly. Thus, although cyanamide only breaks down gradually in the anaerobic milieu of the pig slurry, it quickly breaks down in the soil into urea as soon as the manure is applied to the field. According to the study "Aerobic Soil Metabolism of 14C-Cyanamide" (Schmidt, J., 1990), a half-life of 1.26 days was calculated for 14C-cyanamide under aerobic soil conditions. Thus, cyanamide does not leave any unacceptable residues in the soil.

Is there a feasible substitute for cyanamide?

To our knowledge, there is no other active ingredient offering the combined effect against Brachyspira and larvae of houseflies when used as a treatment of liquid manure.

According to STRAUCH (1991), following chemicals can be used to disinfect liquid manure within four days reaction time:

Chemical	**Application rate**
Formaldehyde	9–15 kg/cbm
40 % Calcium Hydroxide suspension	25–40 kg/cbm
Sodium Hydroxide (NaOH)	8–12 kg/cbm
Peracetic acid 15 %	40 kg/cbm

However, none of these chemicals is a feasible substitute for cyanamide for the following reasons:

- High application rates: These are 3 to 13 fold higher than those of cyanamide. This would not only cause very high costs for the chemicals but would also require much more labour for transport, preparation of dilutions and application. For the same reason these chemicals would leave more package for proper disposal.

- Formaldehyde is classified as carcinogen category 1 B and thus itself a potential candidate for substitution (ECHA, 2015).

- Calcium hydroxide and sodium hydroxide are strong alkalis and expel the ammonia of liquid manure. Thus, they cannot be used for manure treatment in pigsties as this would dramatically affect the climate of the stable by significantly increasing ammonia emissions. Ammonia emissions are already a major environmental concern of pig husbandry, because ammonia in the atmosphere serves as precursor gas for the formation of particulate matter (PM). According to the European Environmental Agency the agricultural sector is the main source of ammonia emissions with an estimated 391 000 premature deaths attributed to $PM_{2.5}$ within the EU 28 (EEA, 2018). Last, not least, nitrogen deposition in natural habitats resulting from agricultural ammonia emissions negatively affects plant biodiversity and contributes to soil acidification (GUTHRIE et al., 2018). For this reason, adding strong alkalis to liquid manure is economically as well as environmentally not a feasible alternative.

- Risk for human safety: Solutions containing sodium hydroxide can cause chemical burns, permanent injuries, scarring and blindness, immediately upon contact.

- All these disinfectants neither claim nor are recommended for the control of fly larvae and therefore an additional application of a larvicide would be required.

- None of these chemicals – to our knowledge - has an approval for the treatment of liquid manure in pigsties. Regardless the fact, that the use would not be practicable and economically, it would be illegal, too.

Conclusion

There is definitely no substitute or alternative to cyanamide for controlling Brachyspira hyodysenteriae and simultaneously the larvae of Musca domestica in liquid manure under the slatted floor of pigsties, which could serve similar effects, would be economically and technically feasible, and would not pose unacceptable risks to human health or the environment.

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