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Heavy Metal Flows in Livestock Farming - the Impact of the Stable

Heavy metals - among these copper and zinc, which act as trace nutrients, - spread from livestock facilities onto farmed land. High accumulation levels cause damaging effects. Therefore, for precautionary environmental protection, heavy metal inputs into agriculturally used soils must be minimised. Within the framework of a joint research project the metal flows from livestock husbandry were investigated and possibilities for reducing heavy metal inputs into the stable were analysed.

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Keywords

Heavy metals, trace elements, feeding stuffs, animal manure, stable balances, mitigation strategies

Trace elements, as e.g. copper and zinc, are essential for maintaining various physiological processes and need to be fed in sufficient amounts to ensure an optimal supply to the animal and to avoid animal health disorders. Trace elements which are not retained in the body tissue or in the products are disposed of in excrement. Livestock manures contain nutrients as well as trace elements and heavy metals. Besides feed stuffs and feed additives, potential sources of heavy metals in livestock manure are disinfectants, bedding materials, corrosion and wear and tear of stable equipment or storage containers as well as building materials and paints [1]. The spreading of manures, which are contaminated with heavy metals, can lead to an accumulation of these elements in agricultural soils.

This was why the German Federal Environmental Agency (UBA) promoted a research project to record the flows of heavy metals in animal production systems (stable balances) and to develop a strategy for reducing heavy metal inputs into livestock manures [3]. The project was coordinated by the Association for Technology and Structures in Agriculture (KTBL), Darmstadt.

On-farm investigations

Twenty farms, which practice animal husbandry in various regions of Germany, were selected for investigations including dairy, beef cattle, pig rearing and pig fattening and poultry production, and took into account different husbandry systems and farm sizes. Stable balances were calculated for different livestock farms. By quantifying the input of heavy metals from different sources, their proportion of the total import was determined. For the calculation of these stable balances, the inputs of trace elements/heavy metals (copper and zinc as well as lead, cadmium, chromium and nickel) from feed stuffs and other farm sources (e.g. bedding, hoof disinfectants, medication, water) were contrasted to the outputs with the manure and animal products (meat, milk, eggs).

Input of heavy metals into the stable

Feed stuffs

The investigation showed that apart from copper-containing hoof disinfectants in dairy husbandry, feed stuffs and feed additives are the main input sources of heavy metals at stable level (*Fig. 1*). Despite their usually low heavy metal content, home-grown feed stuffs are the main source of heavy metals on dairy farms (40 to 75 %) due to their widespread use. Purchased complete and supplementary protein and energy rich feeds often show higher trace element/heavy metal contents compared to home-grown feeds. This is because these feed stuffs are commonly supplemented with trace elements, so that only a small part of copper and zinc inputs in dairy farming originates from (pure) mineral premixes (20 %; Fig. 1).

Four of the five investigated farms with pig husbandry used only purchased feeds - generally compound feeds. The results from the farm, which uses both home-grown and purchased feeds, illustrate that a major proportion of the copper and zinc imports in pig husbandry originated from mineral supplementary feeds, which were also an important source of import of chromium and, to a lower extent, nickel (*Fig. 1*). For cadmium and lead, however, sources other than feed stuffs, as bedding material and drinking water, mainly contributed to the input of these elements.

Hoof disinfectants

Copper- or zinc-based disinfectants for use in foot baths are important inputs of these

Table 1: Heavy metal concentrations in different concrete samples [3, 4]

Material	Cd	Cr	Cu	Ni	Pb	Zn
			mg kg^{-1}			
Concrete slatted floor	0.04	15.1	10.0	17.7	7.8	16.7
Screed manure channel	0.11	13.5	12.2	12.5	6.5	5.8
Plaster samples pig houses	0.08-0.56	11-20	8-36	13-17	3-22	18-112

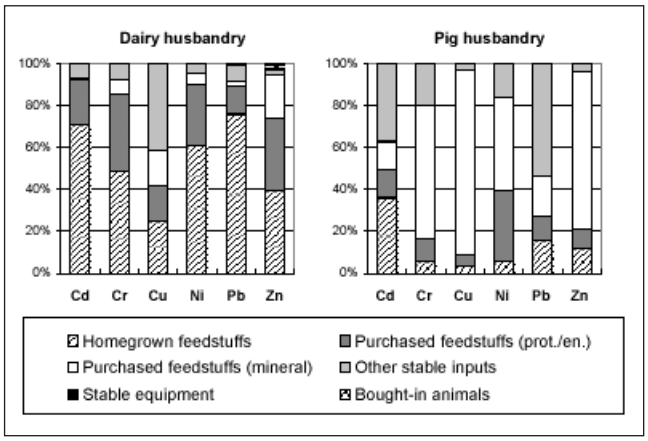

Fig. 1: Relative importance of the different sources of heavy metals on stable level; mean values for dairy (n=8) and pig husbandry (n=1)

metals in cattle farming and also for some sheep systems. The input may account for up to 40 % of the total copper input into the manure (copper vitriol used on five farms; see other stable inputs, *Fig. 1*; [3]).

Stable equipment
The measurements of corrosion rates of stable equipment show inputs of 2 to 13 % of the total zinc input into the stable [3]; there were no considerable inputs for cadmium und lead.

For (slatted) floors, manure passages and partition pens, usually concrete parts with a high concrete and surface quality are used. Single samples of screed and concrete parts show contents of chromium and nickel (*Table 1*) which are similar to the concentrations of plaster from pig houses [4]. No information is available till now about the corrosion rates and thus the heavy metal input from slatted floors and partition pens into the stable. Important element inputs are however not to be expected as these are firmly bound in the concrete matrix and can be dissolved only to a small extent.

Mineral bedding, slurry additives, lime
Mineral beddings, which are common in pig production, may contain higher element contents compared to other stable inputs. In particular the copper inputs are as high as those by feed stuffs [4].

Additives and lime, which are utilised as slurry additives and bedding materials show highly variable contents for chromium, nickel and also for zinc [4]. No information is available on the heavy metal inputs by these materials.

Output of heavy metals

The output of heavy metals occurs mainly via the manure. Livestock manure from pig production, and partly those from poultry production, show higher concentrations of copper and zinc than manure from cattle production (*Table 2*). The highest concentrations of copper, zinc and nickel were determined in slurries from weaners/growers compared to other manure.

Stable balances

The stable balances for different livestock farms with cattle and pig production showed that the output levels of chromium, lead and zinc with animal products and manure frequently exceeded their input levels. This was also the case for nickel and copper in pig production. The cause for this could not always be determined. Newer research shows that by the use of mineral bedding, slurry additives or carrier substances for medicine, additional element inputs enter the stable and then the manure, which can reach levels comparable to those originating from feed stuffs [4].

Outlook

When discussing heavy metal contents in livestock manure it should be taken into account that a heavy metal cycle within the farm from home-grown feeds, straw for bedding and manure exists. The turnover within the farm is difficult to control and this is especially relevant to farms with a high level of home-grown feeds. Mitigation strategies need to tackle purchased feed stuffs, which are already supplemented with trace elements and other element rich inputs, e. g. Cu-containing hoof disinfectants, mineral bedding, carrier substances for medicine. In general, livestock feeding is considered to be of great importance to the reduction of heavy metal concentrations in livestock manure. In this context, above all the reduction in the supplementary levels of copper and zinc in feed stuffs is being discussed [2].

In dairy husbandry however, the use of mineral-rich supplementary energy and protein rich feed stuffs and the lack of methods for farm-individual site and performance determination of the trace element requirements, limits the potential of feeding to reduce heavy metal contents in livestock manure. Whereas in pig husbandry mineral premixes are responsible for the bigger part of the copper and zinc inputs; here the reduction of trace element supplementation would lead to decreased inputs at least of these elements into livestock manure.

In cattle production, hoof disinfectants are a strong candidate for mitigation strategies which should focus on the concentration and frequency of their use and the development of alternative substances. Furthermore prophylactic measures in hoof care would minimise the need for using hoof baths.

The corrosion of the zinc coating of steel depends largely on the microclimatic conditions in the stable. The areas of the steel structures especially susceptible to corrosion are where they are fixed in the concrete floor, due to the direct contact with excrements, cleaning agents and disinfectants. Coating these parts of the steel structures using protective coatings or plastic tubes should significantly reduce corrosion. For a better understanding of corrosion rates more systematic measurements are necessary

Animal manure	n	Cd	Cr	Cu	Ni	Pb	Zn
		mg kg^{-1} TM / mg kg^{-1} dm					
Cattle slurry	127	0.4	6.1	48	7.7	8.9	305
Cattle manure	74	0.3	6.1	25	4.1	5.2	122
Pig slurry (mixed)	65	0.4	10.3	531	11.5	5.7	1508
Slurry weaners	7	0.4	7.1	1165	16.0	3.4	1884
Pig manure	69	0.4	13.7	206	4.9	1.9	465
Turkey manure	34	0.5	22.1	150	6.5	2.6	395
Laying hen manure	9	0.2	9.8	45	8.2	2.4	430

Table 2: Heavy metal concentrations in animal manure [3]

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