HEAVY METAL FLUXES IN LIVESTOCK FARMING AND INPUT REDUCTION STRATEGIES

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ABSTRACT

The overall objectives of the project were to assess heavy metal flows on livestock farms and to develop, based on the results, a strategy to reduce heavy metal inputs into livestock manures. For the investigations 20 farms with animal husbandry in Germany were selected and heavy metal inputs and outputs were balanced at the stable level. It was shown, that the main input pathways for heavy metals into livestock manures are, apart from copper disinfectants in dairy production, feeding stuffs and feed supplements. Due to the internal recycling of heavy metals in home-grown feeds and animal manure, effective strategies to reduce metal levels in livestock manures have to be targeted at the inputs, e. g. the purchased feed stuffs. A main option to reduce the heavy metal input is to lower the trace element concentrations in supplementary feed stuffs. In addition, an optimal absorption of copper and zinc by the animals can be ensured using highly absorbable trace element compounds and, in grain-based pig and poultry diets, phytase. In cattle production, the use of copper and zinc containing claw disinfectants should be minimised.
Keywords: *heavy metals, trace elements, livestock manure, stable balances, mitigation strategies*

INTRODUCTION

Livestock manures contain nutrients as well as trace elements and heavy metals. 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. 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 (Wilcke and Döhler, 1995, Schenkel and Breuer, 2002). 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 prod uction systems (stable balances) and to develop a strategy for reducing heavy metal inputs into livestock manures (UBA, 2004). The project was coordinated by the Association for Technology and Structures in Agriculture (KTBL), Darmstadt.

MATERIALS AND METHODS

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. The aim was to gain insight into the heavy metal fluxes of a broad variety of conventional production farms.

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 from feed stuffs and other farm sources (e. g. bedding, hoof disinfectants, medication, water) were contrasted to

the outputs with the manures and animal products (meat, milk, eggs). In this context, the trace elements copper (Cu) and zinc (Zn) are important because they are used in animal nutrition. The elements lead (Pb), cadmium (Cd), chromium (Cr) and nickel (Ni) are discussed here because they are subject to legal regulations concerning the recycling of organic residues (e.g. sewage sludge, compost) as well as soil protection in Germany and other European countries.

RESULTS AND DISCUSSION

Input of heavy metals

The investigation showed that apart from Cu-containing hoof disinfectants in dairy husbandry, feed stuffs and feed additives are the main input sources of heavy metals at stable level (figure 1).

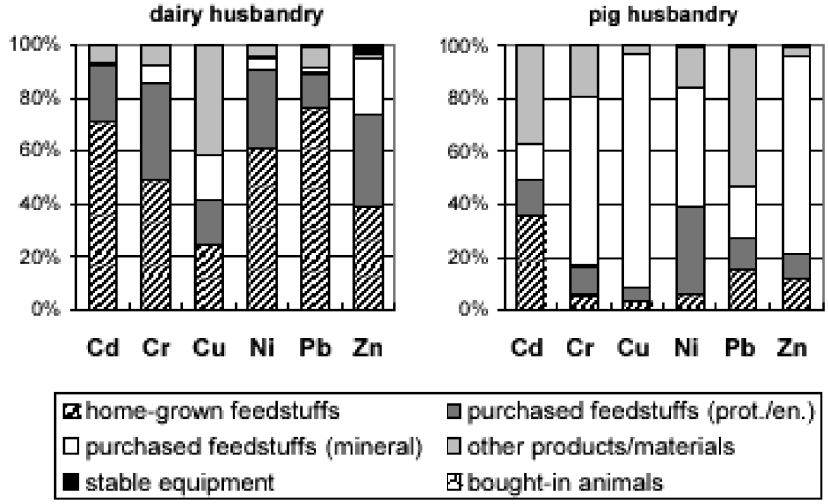

Figure 1. *Relative importance of heavy metal inputs at stable level in dairy (n=8) and pig husbandry (n=1)*

Despite their usually low heavy metal content, home-grown feed stuffs are the main source of heavy metals on dairy farms due to their widespread use. Purchased complete and supplementary protein and energy rich feeds often show elevated trace element/heavy metal contents in comparison 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.

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 feeds, which were also an important source of import of chromium and, to a lower extent, nickel. For cadmium and lead, however, sources other than feed stuffs, as bedding material and drinking water, mainly contributed to the input of these elements.

Output of heavy metals

The output of heavy metals occurs mainly via the manure. Livestock manures from pig production, and also partly from poultry production, show higher concentrations of copper and zinc than manures from cattle production (table 1). The highest concentrations of copper, zinc and nickel were determined in slurries from weaners/growers compared to other manures.

***Table 1**. Heavy metal contents in livestock manures (UBA, 2004)*

Livestock manure	n	Cd	Cr	Cu	Ni	Pb	Zn
				mg kg^{-1} dm			
Cattle slurry	127	0.4	6.1	48	7.7	8.9	305
Cattle farmyard manure	74	0.3	6.1	25	4.1	5.2	122
Pig slurry (mixed)	65	0.4	10	531	12	5.7	1508
Slurry weaners/growers	7	0.4	7.1	1165	16	3.4	1884
Pig farmyard manure	69	0.4	14	206	4.9	1.9	465
Turkey manure	34	0.5	22	150	6.5	2.6	395
Layer manure	9	0.2	9.8	45	8.2	2.4	430

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 be determined. Newer research shows that by the use of mineral bedding, slurry additives or carrier substances for medicine, element inputs enter the stable and then the manure; these inputs can reach levels comparable to those which originate from feed stuffs.

Options for reduction

In general, livestock feeding is considered to be of great importance to the reduction of heavy metal concentrations in livestock manures. In this context, above all the reduction in the supplementary levels of copper and zinc in feed stuffs is being discussed (KTBL, 2002). There are, however, clear differences in the feeding situation depending on animal species (see figure 1) or the farm structure (e.g. varying importance of home-grown feeds). These factors should be considered when evaluating the options for reduction discussed below.

The investigation showed that trace element concentrations in pig diets are in line with the permitted maximum levels (MPL) for single fed compound feeds (in the daily ration) as stated in the German feed stuffs regulation (= Directive 70/524/EEC; EC, 1970). These include in some cases, especially in pig rearing, trace elements levels which exceed the nutritional recommendations in order to take advantage of ergotropic effects. By approaching the copper and zinc dosages to the recommendations of scientific societies (Society for nutritional physiology; National Research Council, NRC) clear reductions of the contents of these elements in livestock manure would be possible. This circumstance was at least partly acknowledged by the European Commission when reductions to MPLs of some trace elements including copper and zinc in certain livestock feeds have been agreed in July 2003 (EC, 2003). Model calculations by KTBL have confirmed the reduction potential of decreasing the supplementation of the trace elements copper and zinc in pig production (UBA, 2004).

Other measures focus on the bioavailability of trace elements, e.g. the kind of trace element compounds used (inorganic, organic) or the addition of phytase dependent on the feeding situation (especially in grain-based phytate-rich pig and poultry diets), can complement the reduction or even make a further reduction possible. In addition to animal nutrition, further options to reduce heavy metal imports into livestock manures are offered by other element rich inputs. In cattle production, hoof disinfectants are a strong candidate for mitigation strategies which should focus on the concentration and frequency of their use, the proper disposal of any residues and the development of alternative substances.

CONCLUSIONS

Within the discussion of heavy metal content in livestock manure it should be taken into account that heavy metals cycle within the farm because of home-grown feeds, straw for bedding and manure. The turnover within the farm is difficult to control and this is especially relevant to farms with a high level of home-grown feeds. By using high quality roughage and grain-based feed stuffs, the import of heavy metals via purchases of energy and protein rich feeds can be reduced. 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.

The results and consequently the conclusions from the presented project are based on a one-off screening of selected farms and should be confirmed by further systematic investigations. For a comprehensive yield and transfer of information the implementation of a monitoring of all heavy metal flows in farms and agricultural enterprises is recommended.

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