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# Horse Manure

## Problem-Solving through Mechanical Processing, Composting and Thermal Utilisation

*With more than 750,000 leisure and sport horses in Germany, mostly in areas lacking in land for manure application, a serious waste problem has developed (9 tons of fresh manure produced per horse and year). Due to the high litter fraction, horse manure is no longer considered an attractive organic fertiliser. Because up to € 430 per horse and year have to be paid for horse manure disposal, three process engineering techniques for mechanical comminution and treatment have been investigated in trials on practical farms, which reduce disposal costs and ameliorate composting. For final disposal through thermal utilisation the heating values of manure substrates were ascertained. Currently experiments with pyrolysing substrates are being carried out.*

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### Keywords

Horse manure, litter substrate, shovel processor, manure shredder, composting, incineration, heating value, pyrolysis

### Literatur

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The economic impact of horse keeping in Germany is characterised by an estimated annual turnover of € 3.6 billion and by the impressive number of 1.5 Million riders [2]. In the past, when mainly working horses were kept, their dung still was a worthy farmyard manure. But along with the increase of the national stock up to a number of more than 750.000 horses a dramatic change in the purpose of horse keeping was observed from working animals to leisure and sports animals. Subsequently not only the housing systems and the littering practice changed, but also the amount of fresh manure being produced annually per horse grew to about 9 t. In riding clubs, larger pension horse farms and with private owners this led to considerable waste disposal problems. This is especially the case in the the outskirts of metropolitan areas, where the housing of leisure horses is concentrated. Additionally the requirements of riders increased, e.g. for larger boxes being continuously provided with clean bedding. This is the reason why horse manure is no longer attractive for plant production and therefore shortages in dung storage capacity (in volume and retention time) occur. Due to this development, storage volumes of up to 6 $m^3$ per large horse are today required, but are frequently not available. Due to the storage of horse manure in the fields, it came to some criminal cases for environmental pollution. To take out the sting of this problem, solutions had to be developed on behalf of the Ministry of Nutrition and Rural Areas Baden-Württemberg.

#### Material and Methods

To at least reduce the extent of the problems, different techniques to comminute horse manure were investigated. One target among others was to reduce the dung volume and subsequently the costs for commercial disposal (account for container volume). Moreover composting should be accelerated by enlarging the surface and mixing. First, moisture content, C:N-ratio and homogeneity were adjusted with help of a manure spreader with extended volume (system Tebbe HKS 180). For crushing a shovel processor (*Fig. 1*, system Allu, Standard SM 3-17 connected to a wheel loader - Liebherr L 524), a bale processor (*Fig. 2*, system Lucas, Abeille +12, with 12 $m^3$ volume, scraping floor and cutting rotors with knife blades), and a special manure shredder (*Fig. 3*, system Wüller, WS-01 AMS with dosage unit) had been put to use on three larger horse farms (between 50 and 75 horses) for comparison. The horse manure of every single farm was processed with these techniques and composted on a common location in 10 experimental windrows. The windrows were covered with compost fleece (system Polyvelt) and were weekly processed by a windrow agitator.

Animal excrements are in many corners of

*Fig. 1: Shovel processor (system Allu) at a wheel loader for picking up, transport, chopping and forming of windrow heaps*

*Fig. 2: Bale processor (system Lucas) at a tractor for variable chopping of horse manure and forming of windrows*

*Fig. 3: Special horse manure shredder (system Wüller) powered by electric motors with dosage unit (left) and shredder (right)*

the world, with a lack of fuel material, an important and sometimes the only utilisable energy source. As the heating values of horse manure had up till now only been estimated, they got determined in systematic laboratory investigations with the help of bomb calorimetry [5]. Because the composition of horse manure is strongly fluctuating (depending on race, feeding, housing system, daily amount and type of litter), its components faeces, urine and litter material (4 straw substrates, 5 wooden substrates, 3 hemp- /flax substrates) got burnt with pure oxygen in a calorimetric bomb. At the time of publishing, these substrates get investigated in the pyrolysis lab unit at the Institut für Siedlungswasserbau und Abfallwirtschaft, at Stuttgart University.

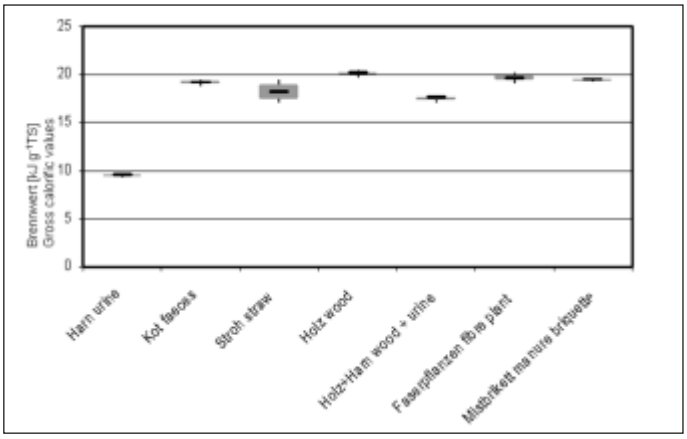


*Fig. 4: Comparing mean gross calorific ($H_o$) between litter, faeces and urine as well as manure briquettes (different letters characterise significantly different substrates)*

## Results

The most frequently used bedding materials for horses in south-western Germany are long straw (with a share of 42 %), saw dust (34 %) and wood shavings (15 %). The remaining horse farms used either chopped straw, milled straw or hemp stems. The horse keepers spend annually for the purchase of bedding material € 290 in average per horse for straw and € 510 for wooden substrates. The selection of the type of bedding determines not only the litter costs, but also the costs for the later, mostly commercial waste disposal of horse manure. The horse keepers have to pay annually up to € 427 per horse for manure on a wooden base, € 381for mixed manures of straw and wooden litter and € 195 for straw manure [3].

This is based on the fact that horse manure is only a strongly diluted carrier for plant nutrients. Solid manures based on wooden litter are even less attractive for crop production, because lignified fibres are resistant to bacterial decomposition, bind available nitrogen (due to wide C:N-ratio) and lower soil pH. Therefore this manure has to be stored or be composted before application. When stored intermediately along fields, this resulted in environmental investigations and severe punishments, in cases of storage in protected areas.

## Comminution of horse manure

The comminution of horse manure is a technical process, in which the bulky solid manures get chopped, crushed or shredded and simultaneously homogenised, thus ameliorating microbial availability and decomposition rates. It is decisive for commercial waste treatment that the process is able to reduce storage volumes significantly and to contribute to cost reduction, because the containers are accounted for per $m^3$ of volume. Mechanical processing increased bulk density from originally 97 to 122 $kgm^{-3}$ with the manure shredder, 133 after the shovel processor and even 156 kg $m^{-3}$ with the bale processor. The best comminution (loosely spliced) and the strongest increase in water retention capacity (+65%) were obtained with the stationary manure shredder, whereas shovel processor and bale processor had the best throughput performance with 4.2 resp. 9.2 t $h^{-1}$ [4].

## Biological decomposition

Biological decomposition of organic substance by soil microbes is the usual way to utilise horse manure as fertiliser in crop production. An accelerated decomposition is either achieved by aerobic (composting) or anaerobic (biogas fermentation) treatment [1]. Biogas fermentation has to be regarded critical, because lignified fibres in the wooden substrates cannot be fermented in a biogas process. The solid fermentation cannot yet be recommended as an alternative to the classic liquid fermentation systems.

Therefore up to now only composting under safe aerobic conditions is a reasonable biological treatment. Because horse manure is a rather dry substrate with a wide C:N - ratio, water and nitrogen (e.g. N mineral fertilisers, liquid manure or other sources) should be mixed in order to obtain a C/N-ratio of 25:1 to 35:1 and a moisture content of 60 - 70% for an optimal composting process. As an alternative horse manure can be composted with other biowaste in commercial units.

The substrates being crushed by the different machines got composted in windrows being covered by compost fleece and they were turned weekly. In the centre of all 10 windrows, temperatures reached values above 60 °C; partially more than 70 °C were measured for more than 24 h, resulting in good sanitation effects. The composts never exceeded the threshold values of the biowaste ordinance (Bioabfall-Verordnung, BioAbfV, 2002) for heavy metals.

## Energetic Utilisation

The gross energy contents resp. heating values showed that the substrates could be interesting fuels. Horse manures could either be dried, briquetted and stored for later incineration or be directly burnt. The substrate specific gross energy contents $H_o$ (*Fig. 4*) varied between 17.2 and 20.4 MJ $kg^{-1}$. The highest energy concentrations were determined with the wooden litter substrates (20.1 - 20.4 MJ $kg^{-1}$). To dimension an incineration plant the heating values $H_u$ are relevant, being calculated from the correction of the gross energy values by the water/hydrogen content. They varied between 16.7 to 19.7 MJ $kg^{-1}$ for the litter substrates, between 17.7 and 18.8 MJ $kg^{-1}$ for horse faeces, and between 18.8 and 19.1 MJ $kg^{-1}$ for horse manure. The daily output of 13.5 kg DM horse manure including urine adds up to an annual gross energy per large horse of $H_o$ = 95 840 MJ $a^{-1}$. Perhaps in the future horse manure will no longer be a waste problem, but an interesting source of regenerative energy to be utilised by incineration, pyrolysis or gasification.

## Outlook

It can be taken for sure that the problems with horse manure will aggravate. Volume and mass of manure depend on numerous factors, esp. on the individual requirements of the riders. Mechanical processing reduces manure volume and subsequently the costs for commercial disposal, and accelerates microbial decomposition during composting. A far-reaching solution can be the thermal utilisation by incineration, pyrolysis or gasification, thus exploiting a new source of regenerative energy.