Hermann J. Heege, Kiel

On Segregation of Mineral Fertilisers

Particle Size Standard for Blended Fertiliser Components

Multi-nutrient fertilisers are increasingly being purchased from local farm dealers, because shorter transport distances make them cheaper per nutrient unit than industrially made complex fertilisers and any desired nutrient-ratio, including micro-nutrients, can specifically be blended. However, nutrient segregation can occur. This paper shows how that can be avoided.

It is well known, that segregation of nutrients can occur when blended fertilisers are not handled in a proper way. The main reason for this are differences in particle-size- distributions of the components [1, 2]. When fertilisers containing particles of different sizes are loaded, the small granules tend to sift downwards through voids between the larger particles. The segregation occurring thus can be important, if during handling a cone is formed, and the fertiliser is moving downwards along the slopes of the cone. The result is that small particles accumulate increasingly in the central part of the cone. On the other hand, the larger granules tend to roll farther downwards along the slopes and thus accumulate in lower and more peripheral parts of the cone. The corresponding arrangement of particle sizes in stores is shown in *Figure 1*, left.

Alternatives for the Prevention in Stores

The segregation can be avoided in two ways:
- by uniform particle-sizes,
- by preventing the formation of cones during loading.

The formation of cones can be prevented or reduced by moving the conveyor-spout during loading or by subdividing the store using partitioning walls and thus reducing the length of the slopes along the cones. Both alternatives are used with small vertical storages; however, they can hardly be employed in large horizontal storages with shovel loaders. The latter storage system is very common nowadays.

Furthermore, the segregation of particle sizes during loading can be reversed again completely or partly by remixing during unloading of the store. There can be substantial remixing especially with cylindrical storages as a result of the unloading in a vertical direction (Fig. 1, top). In case the fertiliser is well free flowing, all parts within the silo move uniformly downwards. The unloading takes place in a so-called mass-flow pattern. Segregated fertiliser is remixed at the outlet-opening.

However, the vertical flow can be partly restrained because of bridging within the fertiliser. In this case the unloading starts in the centre in a so-called core-flow pattern. Remixing therefore hardly occurs.

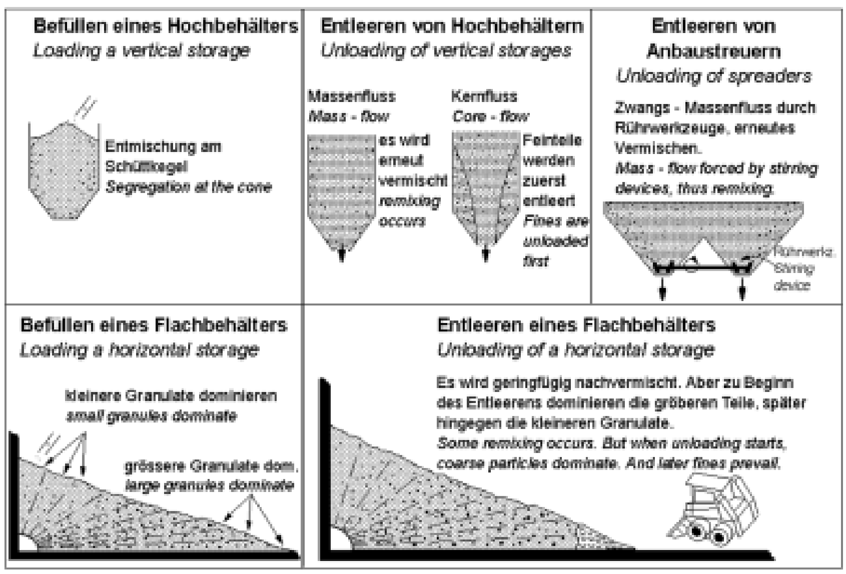

Fig. 1: Segregation during loading and remixing during unloading

Prof. em. Dr. Hermann J. Heege, Department of Agricultural Systems Engineering, University of Kiel, Olshausenstr. 40, 24098 Kiel. The author is chairman of the European Fertilizer Blenders Association; e-mail: *hheege@ilv.uni-kiel.de*

Keywords

Fertilizer-blends, segregation, particle-sizes, standard

Literature

Books are identified by •

[1] *Heege, H. J.*: Hofnahes Mischen von Düngemitteln und der teilflächenspezifische Landbau. Berichte über Landwirtschaft 79 (2001), H.1, S. 94 ff
[2] • European Blenders Association: Handbook of Solid Fertilizer Blending. European Blenders Association, Montviron, 1997
[3] • *Hofstee, J.W.*: Physical Properties of Fertilizer in Relation to Handling and Spreading. PhD thesis, Wageningen, 1993

Yet remixing during discharge in a mass-flow pattern can be mechanically induced by using stirring-devices at the bottom of storages. This method very often is used in containers of spreaders (Fig. 1, upper right).

Thus concluding the situation is that for stores, which are unloaded in a vertical direction, several methods are available for preventing negative consequences of segregation by particle-sizes in the handling system.

For large horizontal storages - which are widely used in industry as well as by retailers - the situation is quite different. Neither a simple method for preventing the segregation during loading is at hand, nor can it be assumed that sufficient remixing takes place during unloading (Fig. 1, lower right). Therefore essentially the problem is, how can the segregation be avoided in these widely used horizontal storages. The use of fertilisers with uniform particle-size-distributions is the obvious alternative.

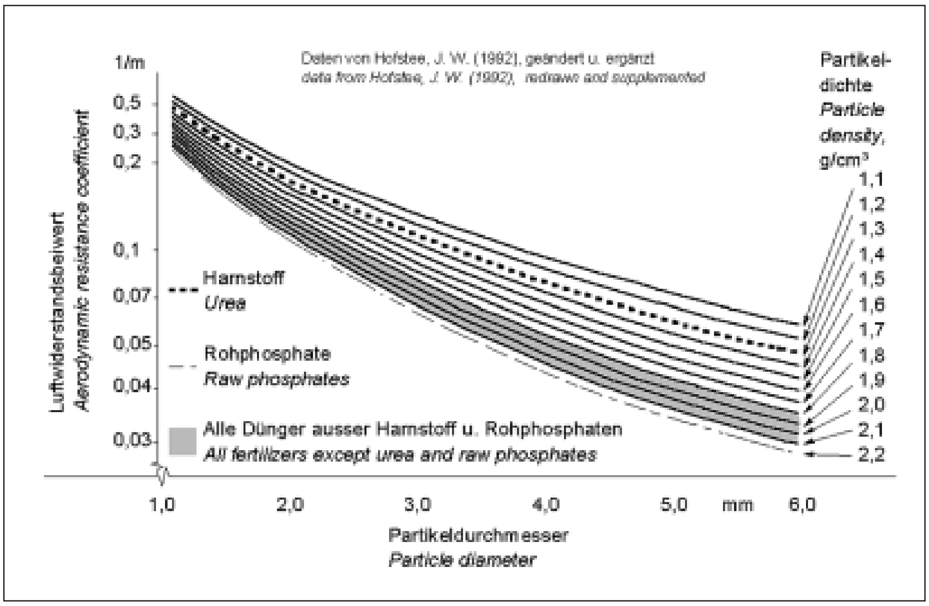

Fig. 1: Aerodynamic resistance, particle-diameter, and particle- density

The situation when spreading

In most cases the fertiliser is spread in the field by centrifugal acceleration on rotating discs. This too induces a segregation of particle sizes: the larger and thus heavier the granules are, the wider they are thrown. However, this segregation of particle sizes during spreading is reduced by the usual overlapping of adjacent spreading-swaths. Heavy overlapping of adjacent spreading-swaths even can eliminate the segregation completely.

Yet increasing the overlapping reduces the acreage treated per hour, if the throwing-width is constant. Therefore, generally farmers overlap only so much, until a uniform transverse distribution of the total fertiliser-mass is attained. For this, the maximum overlapping is such that the whole area is spread twice. In this respect it must be taken into account that with small cereals the overlapping depends on the tramline-distance, too. In short, it probably cannot be assumed generally, that the segregation-problem with centrifugal-spreading is eliminated completely by the overlapping.

Fundamentally the segregation during spreading is induced by differences in the aerodynamic resistance of the particles [3]. It is often mentioned that in addition to the diameter also the density of the granules defines the aerodynamic-resistance-coefficient and thus the segregation during spreading.

But the aerodynamic-resistance-coefficient depends very much more on the diameter than on the density of the particles. The present day fertilisers used as blending-components, leaving out urea and raw-phosphates, have particle-densities within the range of 1,8 to 2,1 g/cm^3. These small differences have rather low effects on the aerodynamic-resistance-coefficient when compared to the particle-diameters (*Fig. 2*). Only urea has a markedly lower particle-density. Therefore this fertiliser should be made with larger particle-diameters to compensate for this.

Tab.1: Granulation of raw-materials: targets and tolerances of the European Blenders Association

Criteria		Target	Tolerance
Verbal notation	**Physical dimension**[1]		
Mean particle size	d_{50} in mm	3,25 mm	± 0,25 mm
Fine particles	< 1 mm, % of mass	0 %	0,25 %
Coarse particles	> 5 mm, % of mass	0 %	1,00 %
Main range	2,5 - 4,0 mm, % of mass	90 %	± 5 %
Granulometric spread index[2]	$GSI = ((d_{84} - d_{16}) / 2d_{50}) \bullet 100$	<18	

[1]) It is assumed, that the sieve analysis occurs according to European standard EN 1235.
[2]) Former notation was „Average size range variation“.

Defining Standards in Particle-Sizes

Summarising the results, the situation is that the segregation within the whole system by and large is overcome, if the particle-size-distributions of the components used for blending match. This fact is already paid attention to by the operators of blending-installations. Principally, every farm-dealer alone for himself could define his individual needs concerning the particle-sizes of the components and can order accordingly. Yet the logistics for matching the particle-sizes on an individual basis is not easy to organise. This background induced the European Blenders Association to present a proposal for a standard of particle-sizes (*Table 1*).

The most important part of this proposal is the mean particle-size of 3.25 mm with tolerances of ± 0.25 mm. However, standardising the mean particle-size alone is not sufficient. Large deviations from a principally matching mean, can still result in segregations of particle-sizes. Therefore also the maximum granulometric spread was defined in such a way, that any segregation of particle-sizes is prevented. Further details are in *Table 1*.