

## TRAININGSMATERIAL

### Titel:

The use of **ashes and ash-based materials** as fertilizers

### Training:

#### Main features of the subcategory

Ash is the burned-out solid residue powdery product after oxidative thermo-chemical processing: oxidative combustion or semi-oxidative gasification processes.

Ashes are characterized as fly ash or bottom ash or a combination thereof formed through the incineration of bio-based materials by oxidation. Co-incineration is an economically viable and widely applied waste disposal route for many nutrient-rich wastes. For nutrient recovery the mono incineration of defined biomass stream is necessary to control the input of contaminants and for concentration of the nutrient content

Ashes obtained through incineration can be post-processed with the aim to partly remove metals and metalloids, and to increase the availability of plant nutrients in the ash complexes.

#### Input material

Organic residuals, including municipal sewage sludge, manure, green residue from urban collection, straw or wood and wood residuals.

#### How to produce?

The incineration of ashes is normally done in a central incineration plant and not on farmer's level. Substantial quantities of ashes are produced via co-incineration facilities that combine the purposes of energy production with waste disposal, especially for waste materials of low calorific value or of high moisture content. Ashes can also be obtained from incineration plants that are specifically designed for the purpose of producing ash-based materials for further fertilizer use (mono incineration) or they can be a production residue resulting from a process aimed at disposing waste or producing a different primary product (e.g. energy).

Ashes from biomass: Depending on the firing system, different ashes are produced, which are generally summarized under the term "biomass ash" and mostly in the three fractions of coarse ash (grate, boiler or furnace ash) with 60 to 90 % of the total, middle ash (cyclone ash, cyclone fly ash) and fine ash (filter ash, fine fly ash, filter dust) are separated. In wood ash the content of heavy metals (especially chromium, copper, cadmium, lead and zinc compounds) can be higher. In other biomass ashes from straw or manure the content of heavy metals is significant lower. Incomplete combustion can also produce organic pollutants such as polycyclic aromatic hydrocarbons (PAH) and polychlorinated dibenzodioxins and furans (PCDD / PCDF). For many compounds there is a clear increase in the pollutant content from coarse to medium to fine ashes. According to the German Fertilizer Ordinance (DüMV), limits for organic contaminants and heavy metals from certain contents are mandatory. The same approach is followed by the new EU legislation EU 2019/1009, in which certain ash products shall also to be included in the legal framework.

Ashes from mono incineration of sewage sludge: Municipal wastewater represents an important material flow for the recovery of phosphorus. Since around 90% of the phosphorus contained in the wastewater is transferred to the sewage sludge in the sewage treatment plant. The direct agricultural use of sewage sludge would be an option to recycle a large part of the phosphorus in terms of the circular economy. However, sewage sludge is the sink for organic and inorganic pollutants in the sewage process and is highly controversial as a fertilizer. For this reason, agricultural utilization is declining, and alternatives are being sought to recycle phosphorus from wastewater, sewage sludge or sewage sludge ash without carrying any pollutants. In the case of co-incineration, the phosphorus content of the resulting ashes is greatly reduced due to the composition of the main fuels, which limits the possibilities for subsequent phosphorus recycling or makes it impossible in some cases. Therefore incineration in mono-incineration plants is necessary for P recovery. Since sewage sludge is used as the solo fuel in mono-incineration plants, sewage sludge ash with quite concentrated higher phosphorus contents of up to 25%  $P_2O_5$  is present after incineration. In order to improve the plant availability of the P-compounds and to reduce possible levels of heavy metals, various wet-chemical and thermochemical processes have been developed with which these ashes can be subsequently effectively processed. So it is also technically possible to recover raw materials from the ash for the production of fertilizers or phosphoric acid.

### Typical nutrient content and availability for plants

#### Biomass ashes

The ashes contain several plant nutrients (calcium, magnesium, potassium, phosphorus). The calcium and magnesium content are mainly in oxidic form (25 - 45% CaO, 1 - 6% MgO) So ashes have a lime effect due to this basic character. While potassium (1 - 12%  $K_2O$ ) and sulphur (2-7 %  $SO_2$ ) is almost completely available to plants, phosphorus (1 - 10%  $P_2O_5$ ) is not in every case good plant available. Raw ashes are therefore not always suitable for direct use as fertilizer and must be processed before application. Mixing wood ash and carbonate lime fertilizer is also a suitable application form.

#### Ash-based materials from sewage sludge

Depending on the subsequent process the material can contain P as a Ca- or Ca/Na-Phosphate in a plant available form with a content up to 15-40 %  $P_2O_5$ ; 1-2 %  $K_2O$ , CaO and MgO.

### Examples for ash products available on the NUTRIMAN Farmer Platform

- [https://nutriman.net/farmer-platform/product/id\\_321](https://nutriman.net/farmer-platform/product/id_321) (France)
- [https://nutriman.net/farmer-platform/product/id\\_397](https://nutriman.net/farmer-platform/product/id_397) (Germany)
- [https://nutriman.net/farmer-platform/product/id\\_401](https://nutriman.net/farmer-platform/product/id_401) (Netherland)



Figure 1. Wood ash (ID:321)



Figure 2. AshDec product (ID:397)



Figure 3. Ash for BMC Moerdijk process (ID:401)

The Wood-Ash material from France (ID:321) is provided by Energie Bois Sud Cornouaille from France. The product arises from the incineration of wood residues. The ash collected at the outlet of the boilers can come from different fractions: sub-fireplace or flying (from dust removal and smoke filtration). The ash under the fireplace is generated in larger amounts and concentrates the non-combustible minerals of the wood (1 to 2% of the initial mass of the wood). With significant levels of lime, magnesium, potassium and phosphorus, this fraction generated up to 95% of the total ash production presents valuable agronomic advantages. The nutrient concentration is 0.4%  $P_2O_5$ ; Specify 0.9%  $K_2O$ , 0.4%  $MgO$ . The neutralization value is 45%  $CaO$ . A return to the ground allows benefits from the fertilizing and liming value of these ashes. They generally contain phosphorus around 20 to 50 g  $P_2O_5$ /kg of raw material, and potassium around 80 to 100 g  $K_2O$ /kg. Cationic nutrients Ca, K and Mg in ash are readily available to potentially available for cultivation. With a neutralizing value sometimes reaching more than 50%, they are a liming material that can increase the pH by 1 point after a cumulative application of 7 to 8 t/ha. The French wood ash is not commercially available yet. But there are already wood ash products on the EU market available.

The Calcium-Sodium-Phosphate from sewage sludge ash conversion with the "AshDec<sup>®</sup>" process (ID:397) is offered by the company Outotec in Germany. AshDec<sup>®</sup> is a thermochemical process designed to convert the low plant available phosphorus compound in the ash ( $Ca_3(PO_4)_2$ ) to the highly plant available compound  $CaNaPO_4$  while reducing the heavy metal content. The core process encompasses feeding ash to a rotary kiln where it is mixed with sodium compounds and a reducing agent, preferably sewage sludge. The material is treated at around 900 °C for 15-20 min. Sodium ions replace calcium ions in the phosphates and form the AshDec<sup>®</sup>- product: Citrate-soluble  $CaNaPO_4$  compounds. The nutrient concentration is given as 15-25%  $P_2O_5$ , depending on the P content of the input material streams used, and approx. 1%  $K_2O$ . Many comparative studies showed the good plant availability of P for this product (Fertilizer performance comparable to Triple-Superphosphate). The P-content highly soluble in neutral ammonium citrate > 80 % as a Calcium-Sodium-Phosphate, but not soluble in water, so a reduced risk of runoff, leaching and fixation is given. A low content of contaminants, e.g. heavy metals (Cd, U, As, Pb), no organic compounds and free of pathogens is given. The AshDec product is in a pilot phase of technical implementation in Germany.

The PK fertilizer from the ash of poultry manure with produced with the thermochemical process in a powerplant by BMC Moerdijk (ID:401) in the Netherland. The PK fertiliser is derived from hydrated ash of incinerated poultry manure. Poultry manure is obtained from poultry farms in the Netherlands meeting EU compliances for animal production. The material is produced from the ash of incinerated poultry manure and water. Main nutrients are phosphorus and potassium. The fertiliser has a neutralizing value due to the presence of hydrated burnt lime and the fertiliser contains secondary and micronutrients. The nutrient content is 10%  $P_2O_5$ ; 12%  $K_2O$ ; 20 %  $CaO$ ; 7 %  $SO_3$ , 5 %  $MgO$ . The product contains useful amounts of secondary nutrients and trace elements. The efficacy is tested in pot trails and field experiments and under real farming conditions. The product has a low content of contaminants, e.g. heavy metals (Cd, As, Pb), no organic compounds and is free of pathogens. The ash product from BMC Moerdijk is still available on the market in the Netherland.

**Fields of application in agriculture: crop, dosages, application method and practical recommendations.**

The ash and ash-based products are usually approved and suitable for conventional farming. There are also considerations to approve these products for organic farming since alternative effective P-fertilizers are being sought here. There are no restrictions on agricultural crops. The application rate is generally based on the P requirement of the crops, considering the soil P content. In powder form, the application is more dependent on the weather conditions (wind). If ashes are mixed in with lime fertilizer, they are spread with special lime spreaders. After granulation or pelleting, the products can be applied using conventional sprinkling technology.

**Benefits for farmers**

The ashes contain several plant nutrients (calcium, magnesium, potassium, phosphorus). Ashes have also a lime effect due to this basic character so they can be used for balancing the pH level on acidic soil.

After appropriate preparation, ash-based P-fertilizers provide highly concentrated P-fertilizers with good plant availability and low content of impurities.

Using ashes and ash-based material is closing a material and nutrient cycle. They can represent a valuable resource as a substitute for finite mineral derived P fertilizers. In particular, the ashes obtained from sewage sludge represent a great recovery potential for phosphate. In addition to direct use, these material flows could also be used for the production of fertilizers in industry.

**Bottlenecks of application. Potential risk or limitation.**

The main bottlenecks for the application of ashes are their lower nutrient concentration (biomass ash) and their fine, powdery structure. The ashes from sewage sludge subsequently require a further, complex, technical chemical or thermophysical treatment, so that the nutrients are more available and to reduce possible contaminants.

**Legal framework for using**Specific national legal conditions

ID:321 must be approved according to the French national regulation standard NF U44-051. Similar products are approved according to the German Fertilizer Ordinance.

ID:397: Approved according to the German Fertilizer Ordinance.

ID:401: National authorisation in e.g GB, Fr, B, NL, Germany.

It is planned to include ashes also by the new EU Fertilising Products Regulation 2019/1009. Then these products could be brought onto the EU market and bought under the PFC 1 (C) as inorganic fertilizers.

**Economic evaluation of the application of the products**

The prices for biomass ash can vary over a wide range, depending on the nutrient content.

The prices for processed ash-based products are currently not known, as the technologies for the production are mostly still in advanced stages of development.

**Best management practice guideline, taking into account of specific conditions of the given territory, for the use of the product to the specific applications (soil improvers, growing media, organic fertilisers etc.).**

Application doses

ID:321 (Inorganic fertilizer): It can be considered that a soil application of 2,5 t/ha every 3 years is generally enough for soil maintenance, but this dose should be estimated according to the culture system needs and the soil pH. (according to lime and nutrient requirements of the soil, season, crop uptake,...)

ID:397 (Inorganic fertilizer): The dosage depends on the nutrient level of the soil and the crop demand as well as on the nutrient content of the specific AshDec® product. It is suitable for all sort of crops production like wheat, rape or maize. For an appropriate dosage, a soil test is recommended in advance. The application should take place before sowing and the product should be worked in flat.

ID:401 (inorganic fertilizer): The dosage depends on the nutrient level of the soil and the crop demand and on the nutrient content of the product. It is suitable for all sort of arable crops production like wheat, rape, maize or similar. For an appropriate dosage, a soil test is recommended in advance. The application should take place before sowing and the product should be worked in flat.

**How to store, apply to land, machinery needs**

Ash-based material must be stored dry in silos or in big bags. In powder form they are be spread with special screw spreader for fine material or be mixed with lime material and spread with special lime spreader.

Granulated or pelletized products can also be stored in a box or in big bags. They can be spread with the fertilizer spreading technology usually used in the farm.

**For more information:**

- [https://nutriman.net/farmer-platform/product/id\\_321](https://nutriman.net/farmer-platform/product/id_321) (France)
- [https://nutriman.net/farmer-platform/product/id\\_397](https://nutriman.net/farmer-platform/product/id_397) (Germany)
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