FFG collective research project „Development of innovative processes for wood ash recycling“

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FACT-SHEET: Utilisation of wood ash as a binder for soil stabilisation e.g. in road construction

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1 What ash fractions are suitable for use as a binder?

The following ash fractions can be recommended for use as a binder:

- Dry bottom ash (only recommended if a mixture with coarse fly ash as generated in the heating plant is not possible) or a dry mixture of bottom and coarse fly ash (e.g. cyclone fly, boiler fly ash) as generated in grate furnaces (crushing/milling of the bottom ash is recommended)
- Dry fly ash from fluidized bed furnaces

Physical Properties:

- **For use as a binder, the ashes must remain dry during the entire process chain!**
- Recommended maximum particle size <1 mm (coarse ashes must be crushed/milled)

Chemical properties:

- High calcium (at least> 15 % dry mass fraction) and CaO content (> 20 % dry mass fraction)
- Low percentage of organic carbon (maximum of 5% dry mass fraction, recommended are <2% dry mass fraction)
- The heavy metal content in the ashes must be in a range which excludes a threat to groundwater caused by ash utilization → therefore, filter fly ash from grate furnaces (high concentrations of volatile heavy metals such as As, Cd, Pb and Zn) cannot be used as a binder

Recommended analyses from a professional perspective:

- Wet chemical analysis to determine the contents in the ash: TOC (total organic carbon), Ca, As, B, Cd, Cr, Cu, Fe, Hg, Mn, Na, Ni, Pb, Se, Zn (recommendations for limiting values are currently drawn up, the frequency of analysis should be defined in the course of creating a respective guideline in Austria).
- Performance of laboratory pressure resistance tests in accordance with ÖNORM B 4710-1 to determine the optimal ash admixing ratios.

Ash admixing ratios:

- 10 to 15 % mass fraction, based on dry mass of soil; to determine the exact amount of ash needed laboratory pressure resistance tests are recommended in accordance with ÖNORM B 4710-1

Ash demand:

- Depending on admixing ratio and thickness of the soil layer to be stabilized:
- Applying an ash admixing ratio of 10% by weight, based on dry soil mass: 60 to 100 kg / m² soil surface to be stabilized
- Applying an ash admixing ratio of 10% by weight, based on dry soil mass: 90 to 140 kg / m² soil surface to be stabilized

- Example: the ash demand for a road construction project of 500 m length (with a road width of 6 m) is between 180 and 420 t. Therefore, adequate storage capacities have to be provided to serve larger projects.
- The ash demand could be reduced by the addition of burnt lime (for example if burnt lime and ash are used as a mixture with 40 % dry mass fraction of burnt lime, the ash demand is reduced to about one-third). However, based on the current legal framework conditions (mixing of wastes is banned according to AWG 2002) a mixing with burnt lime is not permitted.

2 Where can wood ashes be used as a binder from a technical perspective?

Wood ash can be used in all cases where burnt lime is used for soil stabilization. These are mainly silt and clay ("cohesive") soils. Similar to the application of burnt lime the application of wood ash enhances the compressibility of soils and thereby a higher strength of the stabilized soil can be achieved.

3 What are the benefits of the utilization of wood ashes for users?

Application of wood ash with a spreader (left), mixing with the soil to be stabilized by a rotary hoe (right)

- Wood ash is much cheaper compared to burnt lime
- The processing of wood ash as a binder for soil stabilization requires more time (since wood ash contains less CaO compared to burnt lime, 2.5 to 4 times as much ash has to be applied for the same binding effect achievable with burnt lime) and thus results in higher personnel and equipment expenses compared to the application of burnt lime. However, as the costs for ash (delivery free at site) are much cheaper than for burnt lime a significant cost advantage in the binder costs is given. Thus, the total costs per m² stabilized soil with wood ash as a binder **are typically somewhat lower than with burnt lime (based on current costs for burnt lime between 80 and 100 €/t)**.

4 What are the benefits of the use of wood ash as a binder for the heating plant operator?

- No disposal costs (the ash can be delivered free at site)
- The plant operator has only to bear the following costs:

  - transport costs (depending on the distance 20-30 €/t, delivery by authorized transport companies only)
  - processing costs (crushing/milling of bottom ash if necessary)
  - storage costs if intermediate storage is necessary
- These costs are dependent on the respective local conditions. It is expected that normally the costs of utilization are below typical Austrian landfill costs.
- Due to the high ash demand per m² to be stabilized, large amounts of ash can be utilized in *one* construction project with *one* partner which makes the organization of ash recycling considerably easier. This is a big advantage compared to other utilization paths such as the application on agricultural or forest soils, where due to the lower ash demand a significantly larger area is needed to utilize the same amount of ash and therefore usually several partners are required.

5 What are the economic benefits of the use of wood ash as a binder for soil stabilization?

The economic benefits are listed below:

- saving of CO_2 emissions
  - during the production of one ton of burnt lime 200 kg of CO_2 are released (if natural gas is used as an energy source), the combustion of biomass is considered to be largely CO_2 neutral
- conservation of non-renewable resources
  - reduction of limestone mining, thus reducing dust emissions and reducing the loss of fertile surface
- conservation of landfill space
  - reduction of the amount of ashes landfilled in Austria

6 What is the current status in Austria regarding the legal basis and the implementation in practice?

Legal basis in Austria:

- Wood ashes are considered as waste within the meaning of the Austrian Waste Management Act (AWG 2002). Wood ash from the incineration of natural and chemically untreated biomass has to be categorized as a non-hazardous waste with the ID-number 31306 - wood ash, straw ash. In theory, by recycling the ashes (defined as an ecologically appropriate treatment of waste by using the properties of the waste material with the main purpose of using the waste directly for the substitution of raw materials or products obtained from primary raw materials) they are no longer considered as waste according to AWG 2002. However, since no specific Austrian ordinance or an EU ordinance legislated on the basis of the EU Waste Framework Directive regulates any end-of-waste-criteria, wood ashes are as long considered as a waste until the ashes, or the substances recovered from them, are used directly to substitute raw materials or products obtained from primary raw materials. Therefore, in

the case of the use of wood ash for soil stabilization wood ashes do not reach the end-of-waste status until they are applied to the soil as a substitution of burnt lime. For this reason, wood ashes have to be handled as wastes from the biomass plant over storage and transport to the application by the end user. The whole handling process is subject to waste legislation.

- Based on the definition of recycling according to AWG 2002 the utilization of waste can only be considered as recycling if the waste substitutes raw materials or products obtained from primary raw materials and if the utilization is environmentally safe. A utilization according to AWG 2002 is only permissible if the waste in question is used safely for the purpose intended, no protected goods (groundwater etc.) are affected by this application and no legal provisions are violated. Since the criteria of the use of the material properties and the substitution of a raw material or products obtained from primary raw materials (burnt lime) are present without any doubt, the utilization of wood ash for soil stabilization in road construction or other construction projects has to comply with the following requirements:
  - the ashes are suitable to fulfill the purpose of soil stabilization,
  - no protective goods (public interest in accordance with AWG 2002) are impaired and
  - no legal provisions are violated

  More precise binding targets, based on which the admissibility of the use of wood ash for soil stabilization in road construction or other construction projects has to be assessed (e.g. in the form of limit values for pollutant concentrations) do not exist.
- According to AWG 2002, the owner of wood ash (= owner of the biomass combustion plant) may assign the wood ashes only to natural or legal persons who are entitled by the Governor to collect and treat waste categorized with ID 31306).
- The use of wood ash as a substitution for burnt lime for soil stabilization is a waste treatment within the meaning of AWG 2002. The use of wood ash for soil stabilization may therefore only be performed by a (natural or legal) person who is authorized under AWG 2002 to treat waste categorized as waste with the ID 31306. A permit for the collection and treatment of wood ash is to be granted if
  - the kind of collection and treatment applied complies with the requirements of the AWG 2002 and does not contradict public interests according to AWG 2002;
  - the kind of collection and treatment applied is suitable for wood ashes;
  - the waste collector has a suitable intermediate storage available which is approved for the storage of wood ash;
  - the reliability of the (natural or legal) person in respect to the collection and/or treatment of wood ash is given and
  - the technical knowledge and skills are demonstrated for the collection and treatment of wood ash.
- According to the Austrian Remediation Act (AlSAG), the depositing of waste above or below the earth but also the filling of uneven terrain (including the filling of pits or trenches), the construction of ground structures (including the construction of dams or substructures of roads, railway tracks or foundations) or the filling of mines with waste

is generally subject to a remediation fee. Wood ashes are still characterized as waste according to the AWG 2002 at the time of application as a substitute for burnt lime and no exception according to § 3 para 1a AlSAG to the obligation to pay remediation fees exists. However, the use of wood ash as a substitute for burnt lime for soil stabilization is not subject to remediation fees within the meaning of the AlSAG, since the use of wood ash for soil stabilization meets the criteria for recycling according to AWG 2002. Since the results of the collaborative research project show that the criteria of substitution and environmentally sound utilization are met, the utilization of ashes as a binder has to be qualified as recycling and not as a deposition according to AlSAG. Moreover, the use of wood ashes as a substitute for lime cannot be qualified as backfilling or terrain adaptation, because wood ashes do not substitute any backfilling material and are not used for landscaping (especially the construction of any structures), since the application of wood ashes by a spreader and a rotary hoe is only carried out for the substitution of burnt lime with the purpose of water retention and to improve the bearing capacity of an existing support layer.

An obligation to pay a remediation fee according to AlSAG for the use of wood ash for the purpose of soil stabilization in road construction or other construction projects is therefore not given, since these activities are not subject to remediation fees according to AlSAG. However, a legal certainty relating to an obligation to pay a remediation fee according to AlSAG is not given, since in this respect there is no positive opinion of the Federal Ministry of Agriculture, Forestry, Environment and Water Management available.

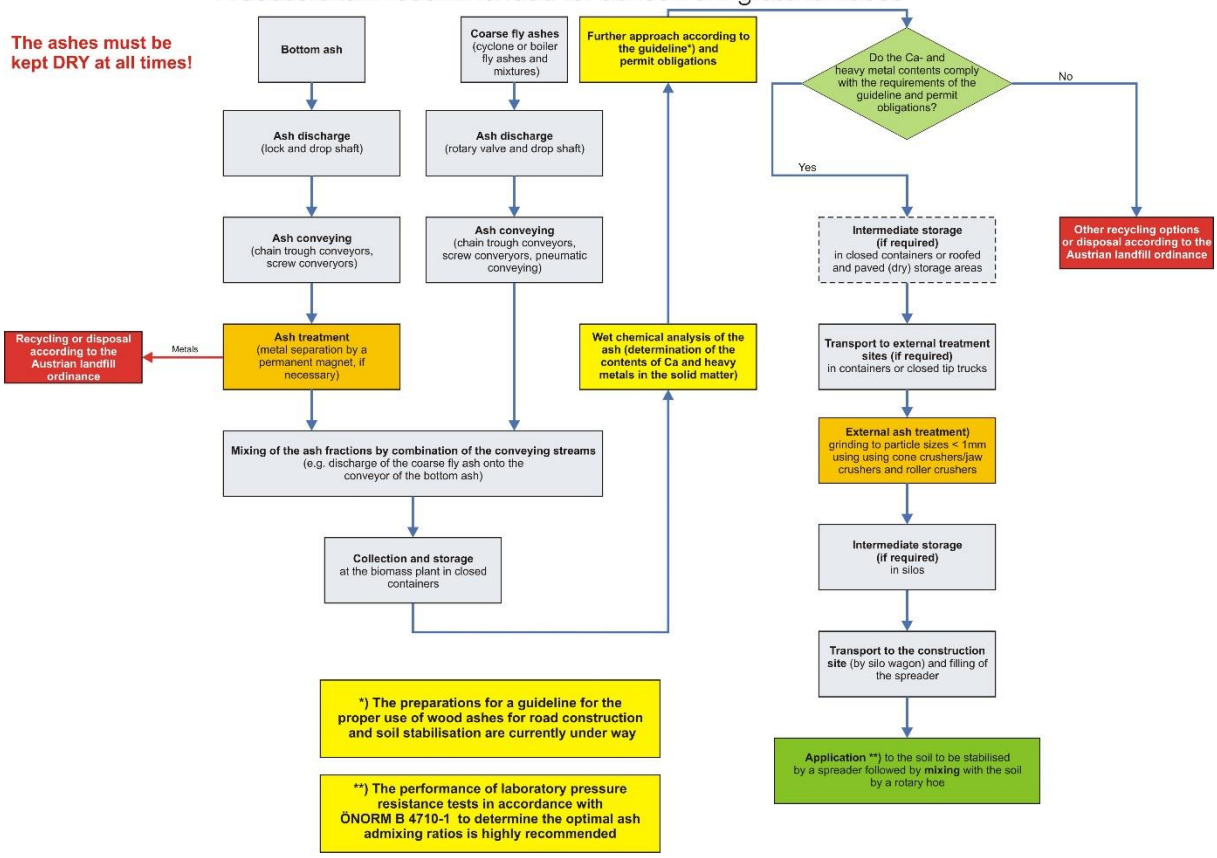
- Based on the results of the project a guideline for the proper utilization of wood ashes in forest and conventional road construction for soil stabilisation, which includes all relevant technical, economic and environmental framework conditions shall be prepared. The main goal is the definition of a standardized approach for operators of heating and combined heat and power plants as well as for users of the wood ash, which is accepted by the relevant authorities. Once such a guideline is prepared and come into force it shall be the basis for future approvals by the authorities.

Status in Austria:

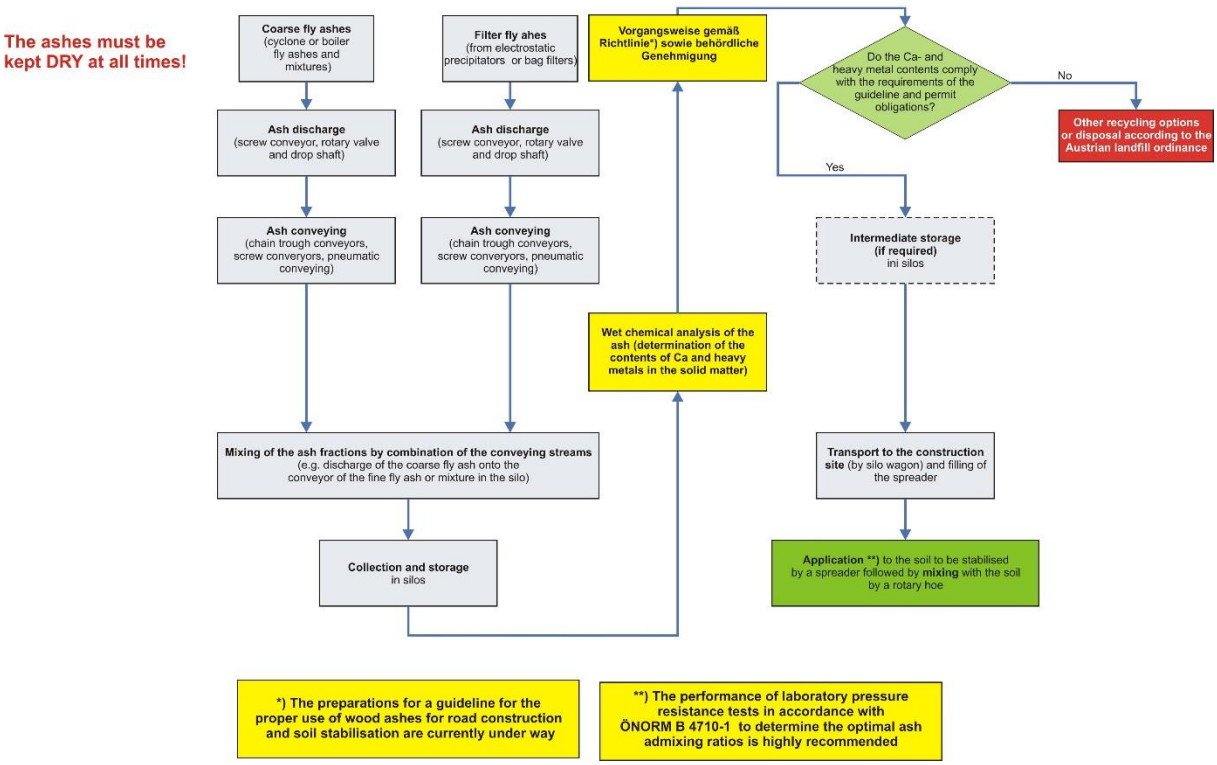
- To date no use in industrial practice. The method was successfully tested as part of the four-year collaborative research project "Development of innovative processes for wood ash utilization" on experimental road sections (located in Styria).
- **Unfortunately, due to the lack of legal framework conditions a use in industrial practice is currently not yet possible.**

7 Process chain recommended

Process chain recommended for ashes from grate furnaces



Process chain recommended for ashes from fluidized bed furnaces



Ash treatment at the biomass plant

- Grate furnaces:

  - bottom ashes: metal separation by permanent magnet, followed by a mixing with coarse fly ashes. The metal separator has to be designed in a way that a high separation efficiency can be achieved at a high throughput and that the metal separated does not block the conveyor (e.g. positioning of the metal separator above a conveyor belt). Metal separation of the ashes can be omitted if metals were separated during biomass fuel processing.
  - Coarse fly ashes: no ash treatment necessary
- Fluidised bed furnaces:
  - fly ashes: no ash treatment necessary

Ash conveying and storage at the biomass combustion plant

- Grate furnaces:
  - Bottom ashes: conveying by conveyor belts, chain trough conveyors or screw conveyors, mixing with coarse fly ashes and storage in closed containers
  - Coarse fly ashes: conveying by chain trough conveyors, screw conveyors or pneumatic conveying, mixing with bottom ash and storage in closed containers
- Fluidised bed furnaces:
  - Fly ashes: conveying by chain trough conveyors, screw conveyors or pneumatic conveying, storage in silos

Intermediate storage (if required)

Due to the large amount of ashes needed for a single construction project, appropriate storage capacities have to be provided. Dry storage is very important!

- Grate furnaces:
  - Bottom ashes and mixture of bottom and coarse fly ashes as generated in the heating plant: if untreated, storage in a container or at roofed and paved storage sites (dust emissions have to be minimised); crushed/milled ashes shall be stored in silos.
- Fluidised bed furnaces:
  - Fly ashes: storage in silos

Transport to external treatment sites (if required)

- Grate furnaces:
  - Bottom ashes and mixture of bottom and coarse fly ashes as generated in the heating plant: transport in containers or tip trucks (the cargo area has to be covered to avoid dust emissions during transport)
- Fluidised bed furnaces:
  - Fly ashes: silo wagon

External treatment

- Grate furnaces:

  - Bottom ashes and mixture of bottom and coarse fly ashes as generated in the heating plant: crushing/milling to particle sizes < 1 mm using cone crushers/jaw crushers and roller crushers → storage in silos

- Fluidised bed furnaces:
  - fly ashes: no ash treatment necessary

- Basically, a mixture of crushed/milled ashes from grate furnaces or fly ashes from fluidised bed furnaces with 30 to 50 % mass fraction (based on the dry substance of the mixture) burnt lime would be reasonable to minimize variations in ash quality and to reduce the specific amount of binder required per kg soil and thus the processing time (for application and mixing with a rotary hoe). Ideally, crushing/milling and mixing with lime should be performed at the same site to avoid additional transport costs. However, the mixing of wastes with other materials is not allowed according to AWG 2002, as long as end-of-waste-criteria are not fulfilled. To date there is no regulation into force that defines end-of-waste-criteria for wood ashes. Therefore, a mixing of ashes with burnt lime prior to the application on the soil is not permitted.

Transport to the construction site

- Transport in silo wagons (for all ash fractions), in order to allow for an immediate filling of the spreader at the construction site.

Application/processing

- Immediate filling of the spreader out of the silo wagon.
- Application to the soil by spreaders (maximum particle size 1mm).
- Mixing with the soil by a rotary hoe.