FUTURE AVAILABILITY OF SECONDARY RAW MATERIALS FOR ALTERNATIVE CONCRETE PRODUCTION IN A CIRCULAR ECONOMY

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Background

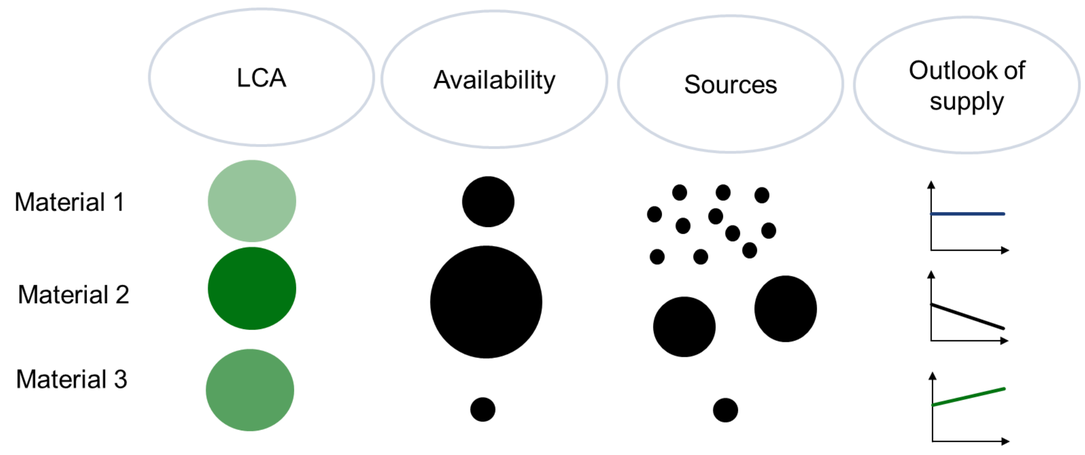
Nowadays, growing global population is associated with a higher urbanization rate and thereby with increasing demand for sustainable construction materials. Concrete is the most widely used construction material in the world, which consists of cement, water and aggregates. Today, production of cement is responsible for approximately 8% of total GHG emissions. To minimize emissions, alternative binders are being developed, including alkali-activated materials (AAMs).

The AAM technology allows utilization of industrial by-products (ground granulated blast furnace slag (GGBS), fly ash (FA), and waste materials (municipal solid waste incineration ashes, glass fiber waste, sewage sludge ashes, mineral wool waste) in concrete production, thereby contributing to circular economy principles.

Methods

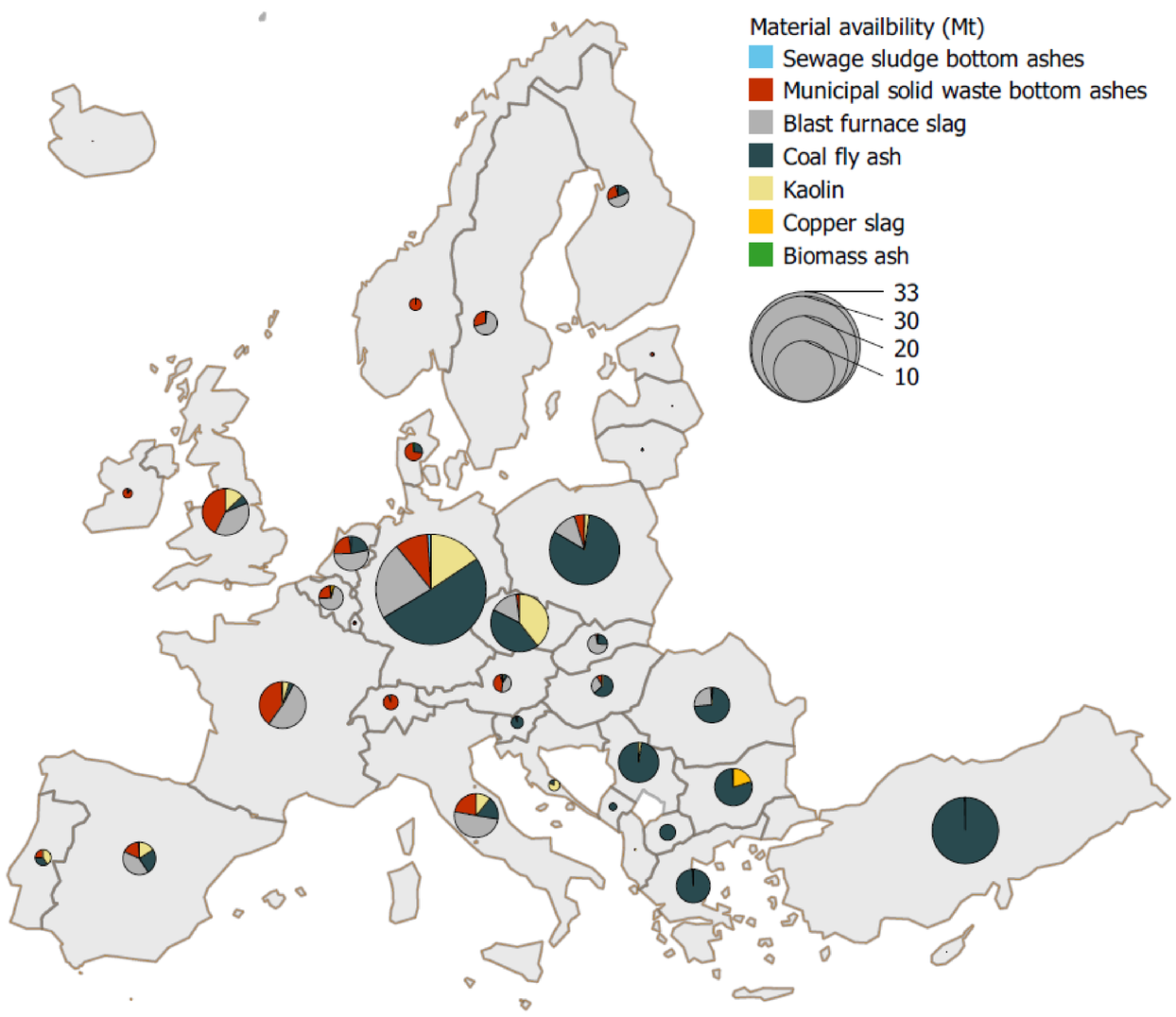
- The life cycle analysis (LCA) is usually performed to assess the sustainability of AAMs mix designs as an alternative to cement concrete.
- In this study, to assess the potential of AAMs in real-world applications, the LCA methodology is combined with the estimation of availability of resources, sourcing potential, and analysis of the stability of supply of secondary raw materials in the future.

Figure 1. Applied methodology



Results

Figure 2. Availability of secondary raw materials in Europe



- The LCA of AAMs shows that open-loop recycling of waste materials and industrial by-products in AAM concrete decreases CO_2 emissions by up to 70%, compared to cement concrete.
- The availability of traditional precursors, such as GGBS and FA is currently dominant in Europe (Fig.2), however, their supply will be decreasing in the future due to the phase-out of coal power plants and transformation of the steel industry.
- Waste materials such as municipal solid waste and sewage sludge ashes as well as mineral wool waste from construction and demolition activities have a high potential to be used as precursors. These materials currently are primarily landfilled and their stocks will continue to grow, being correlated with population growth. The decentralized nature of these material sourcing indicates opportunities for establishing industrial symbiosis and optimization of supply chains to ensure lower environmental impacts associated with transportation.

Table 1. Assessment of materials to be used as precursors in AAMs

	LCA	Availability	Sources		Outlook of supply
	kg CO_2 eq. per tonne	Mil. Tonne	Centralized	Decentralized	Trend
GGBS	178	15.54	x		→
FA	217	51.25	x		→
Calcined Kaolin*	346	11.9	x		→
Municipal solid waste ashes	6	15.5		x	↗
Sewage sludge ashes	6	0.76		x	↗
Biomass ashes	1.9	0.47		x	→
Copper slag		0.14	x		→
Mineral wool waste	3.7	2.5		x	↗
Glass fiber waste		0.07		x	↗
Cement	803	180	x		↗

Conclusions

To assess the potential of real-world application of alternative binders, the LCA methodology is combined with the material flow analysis, as well as future availability of wastes and industrial by-products is taken into account. The framework allows to select optimal materials at the regional scale and can be applied to assess the opportunities of industrial symbiosis and corresponding benefits.

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