ABSTRACT

The central heating plant of Kalmar, Sweden, produces approximately 380 tons of wood ash every year. A stabilised material for nutrient recycling on forest soils is produced by adding water and dolostone to the wood ash and agglomerating the mixture. Chemistry and mineralogy provide a basis for interpreting the transformation process and the final characteristics of the agglomerates, thus leading to refinements in the production process and the possibility to predict the environmental effects after spreading to the forest soil. The objective of this thesis is to characterise agglomerated wood ash from the heating plant of Kalmar with respect to its composition, mineralogy, treatment and leaching properties. The results from four papers, dealing with these topics, are summarised. Thirty elements were determined in the ash, of which Ca, K, Mg and S are the main constituents. Fe, Si and V contents are low and B, K and Mg are high compared to the general contents of wood ashes in Sweden and Finland. The As, Cd, Ni and B concentrations exceed the limit values for nutrient recycling in some cases. The ash has a high electric conductivity and releases K, present in easily soluble species only, very rapidly. Minerals present in untreated ash are calcite, arcanite, anhydrite, sylvite, periclase and lime. The secondary minerals calcite, portlandite and syngenite are formed during self-hardening of the wood ash. Leaching of K and Na from the self-hardened wood ash is independent of the particle size. The most problematic property of the ash is its high content of unburned matter during the winter season, leading to insufficient nutrient content for recycling. The dolostone commonly used for agglomerate manufacturing originates from Estonia. Its basic components are Ca, Mg and Si. Its composition varies stratigraphically at the quarry, and the most significant changes are in SiO_2-content. The presence of ankerite and a decrease of the inter-grain porosity downward in the rock profile are documented. The clay intercalation present in the rock contributes Si, Al, and trace metals to the composition of the final material that is used as binder at the heating plant. Dolostone from Glanshammar, Sweden and limestone from Ignaberga and Öland, Sweden, were tested as binders and compared to the Estonian dolostone. The dolostone from Glanshammar is more crystalline and less soluble than the Estonian dolostone. It contains much less Al, K and Ba and twice as much Mn as does the Estonian dolostone. The limestone from Ignaberga is low in Mg, Al, Fe and Mn and high in Si, and the limestone from Öland has a low inter-grain porosity and contains more Fe and Mn than the dolostone from Estonia. Granules and pellets, produced from equal weight amounts of ash and dolostone, consist mostly of Ca, Mg, Si, K and S. Secondary minerals, calcite, gypsum, Ca silicate hydrate, Ca silicate, magnesite, alumohydrocalcite, syngenite and bassanite occur in the granules. Magnesite is the only Mg-containing secondary mineral in the granules in the field, probably derived from dolostone weathering. Portlandite occurs only in the control granules in the field study. This suggests that hardening continues in the field and Ca hydroxide transform into calcite. The granule content of quartz, dolomite, ankerite and a Fe-K-Mg silicate originate from dolostone. The grain size is most important to leaching of K and Na from granules, but the release of S, Cl, Na and K is a rapid process in spite of the formation of components with low solubility. The ash component in the granules is the first to dissolve and leach. The dolostone component is still important, both as a slow release soil conditioner and as a creator of the framework of the granules. These results suggest that the dissolution of granulated and pelletised wood ash is slower than that of untreated or self-hardened wood ash due to the formation of less soluble compounds, such as calcite, syngenite, Ca silicate hydrate and alumohydrocalcite during the granulation process or weathering in the field. Naphthalene, acenaphtene, phenantrene and pyrene are observed in the ash and granulated materials. Carcinogenic PAHs occur at levels of 0.092 mg kg^{-1} or less. Flue gases from combustion of sawdust and natural gas were tested for drying the granules. Drying by flue gases does not affect the chemical composition of granules, but minor effects are seen in their mineralogy. The calcite content is slightly higher in granules treated with flue gas from natural gas combustion compared to the granules dried by hot air only.

Keywords: Wood ash, granules, pellets, biofuel ash, leaching, dolomite, dolostone, ash stabilisation, ash chemistry, ash recycling

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