www.susan.bam.de

Sustainable and Safe Re-use of Municipal Sewage Sludge for Nutrient Recovery

Research Project within the Sixth EU Framework Programme
Duration: November 2005 – October 2008
Total Volume: approx. 1.6 Mio EUR
EU-Funding: approx. 1.2 Mio EUR

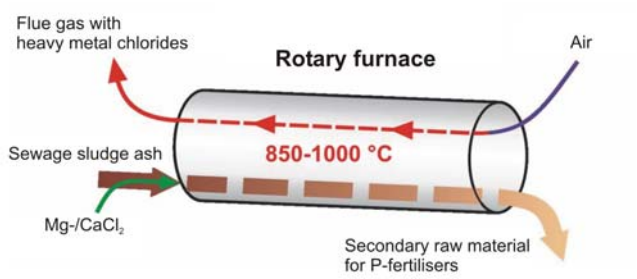
Background

Municipal sewage sludge (MSS) is a carrier of valuable nutrients – most important phosphorus (P) – but is often contaminated by pathogens, hazardous organic pollutants such as pharmaceuticals, pesticides, polyaromatic hydrocarbons (PAH), chlorobenzenes, phenols, polychlorinated biphenyls and phthalates and inorganic pollutants such as arsenic, nickel, cadmium, lead, mercury, chromium, copper and zinc. Therefore, agricultural application of municipal sewage sludge is a controversial issue. In the last couple of years, the agricultural application of sewage sludge has decreased, while the interest in alternative sludge disposal routes to protect farmland and human health has increased. However, following the disposal routes, nutrients are irreversibly lost and the need for mineral fertiliser products will increase. Concerning the scarce resource phosphorus, more than 300,000 tonnes of P could be recovered from sewage sludge in the European Union if a sound recycling strategy was developed and applied.

Objectives of the SUSAN-project

The SUSAN-project - *Sustainable and Safe Re-Use of Municipal Sewage Sludge for Nutrient Recovery* - is aimed at developing and assessing an alternative (sustainable and safe) management option for municipal sewage sludges based on thermal treatment.

Technological development. Mono-incineration of the sludges completely destroys pathogens and organic pollutants in a first step. For subsequent application of phosphorus-recovery techniques it is required to incinerate the sludges in mono-incineration facilities. The incineration residues from mono-incineration are sewage sludge ashes (SSA) with a high phosphorus content in the range 15-25% P_2O_5.



Principle of the thermo-chemical process with the two main goals: i) heavy metals removal and ii) transfer of phosphorus into mineral phases with high bio-availability

However, these ashes often contain heavy metal compounds above the limits for agricultural use (fertiliser ordinances). Furthermore, phosphorus in the ashes exhibits low bioavailability - a disadvantage in farming. Therefore, a second step is required after mono-incineration to i) reduce the heavy metal concentrations below the relevant limits and ii) to transfer phosphorus into mineral phases with high P-bioavailability. The second process step is thermo-chemical treatment - the "key-technology" developed and optimised in the SUSAN-project.

Large-scale applications. The technological development is focused on large-scale application aiming at facilities treating up to 50,000 tons of ash per year and producing marketable P-fertilisers out of it. Therefore, engineering and cost calculations for large-scale facilities are carried out in the SUSAN-project. A pre-study on economic feasibility prepared in the beginning of the project showed that margins of approx. 18 EUR/ton can be expected for facilities treating approx. 8,000 tons SSA per year.

Market analysis and product design. In addition to the technological development, the P-fertiliser market is analysed in order to identify suited markets for the envisaged newly designed products and to optimise the final product design according to the requirements of those markets. Different ash based P- and multi-nutrient fertilisers are produced using and comparing different granulation techniques.

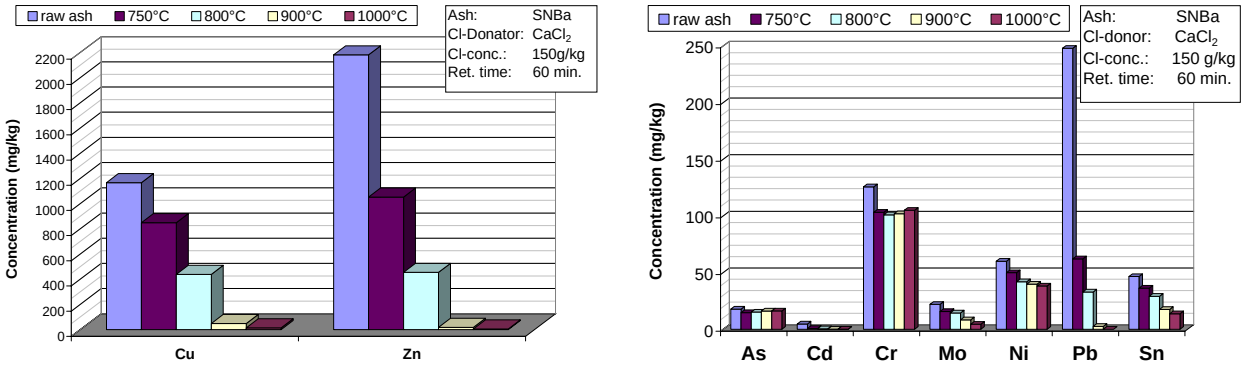
Agricultural investigations. The agrochemical quality of the ash based fertiliser products is determined in which the P-bioavailability is an important criterion. The ash based fertilisers are tested and compared to conventional fertilisers. Comparative growth tests are carried out with different crops and soils.

Assessment. The sustainability of the proposed technological solution is investigated. Advantages and disadvantages are analysed and compared to other treatment and management options. The comparison is based on energy and substance balances as well as established evaluation methods and will quantify the contribution of all options to environmental protection and resource recovery.

Status

Extensive investigations on the thermo-chemical process were carried out in lab-scale and technical-scale rotary kilns from 0.5 kg batch charges to a continuous operation with a throughput of 500 kg/h. All test runs have shown that volatile heavy metal chlorides are formed when a chlorine donor is added to the sewage sludge ashes and thermally treated at

temperatures of 850-1000°C. The volatile heavy metal chlorides are separated from the off-gas and thus removed from the main solid product – the P-rich raw material for fertiliser production. Heavy metals removal performance depends significantly on the temperature applied. Removal rates > 90% are achieved for cadmium, copper, lead and zinc (removal rates of molybdenum >80 % and tin >70 %) by treatment with $CaCl_2$ or $MgCl_2$ at 1000°C resulting in low remaining heavy metal concentrations in the final product.



Heavy metals concentrations of raw ash and thermo-chemically treated ash at temperatures between 750 and 1000°C.

At the same time, new mineral phases are built up (e.g. magnesium phosphates) resulting in P-solubility in citric acid (2% citric acid solution) of up to 100%. The thermo-chemically treated ashes were characterised and further treated at KEMIRA GrowHow. P- and PK-fertilisers were produced in a dry granulation process. First greenhouse pot experiments were carried out with different fertiliser products made of sewage sludge ashes in order to compare the plant performance (growth and development, health and yield) of these fertilisers with the performance of conventional fertilisers. First results showed that fresh matter yields produced by plants fertilised with some of the ash based products came close to the yields produced by plants fertilised with conventional fertilisers.

Fertiliser products made of sewage sludge ashes (KEMIRA GrowHow)

Pot experiments with newly designed fertilisers made of sewage sludge ashes (FAL)

Conclusion

The investigations during the first year of the SUSAN-project showed that sewage sludge ashes are suitable raw materials for the production of P-fertilisers. The P-content of up to 25 % P_2O_5 matches the requirements of P- or multi-nutrient fertilisers. Heavy metals can be effectively removed by thermo-chemical treatment e.g. in a rotary furnace. The P-solubility in citric acid, an indicator for the bioavailability, is significantly increased during thermo-chemical treatment from 30-50 % of the raw ashes to up to 100 % of the treated ashes. An economic operation of large-scale facilities treating sewage sludge ashes is expected. A pilot plant is currently under construction by the project partner ASHDEC and will start operation in 2007.

The participants of the SUSAN-consortium and their role in the project

BAM Bundesanstalt für Materialforschung und -prüfung

The Federal Institute for Materials Research and Testing (BAM) coordinates the SUSAN-consortium and carries out thermo-chemical trials in bench- and medium-scale including the required analytical investigations. Furthermore, BAM is working on materials optimisation for a thermo-chemical reactor. (www.bam.de)

Contact: Dr.-Ing. Christian Adam
Division IV.3 Waste Treatment and Remedial Engineering
Richard-Willstätter-Straße 11
12489 Berlin, Deutschland
Tel.: ++49 (030) 6392-5843 Fax:-5917
Email: Christian.Adam@bam.de

ASHDEC Umwelt AG

The ASHDEC Umwelt AG works on thermo-chemical processing of sewage sludge ashes into marketable products. Within the SUSAN-project ASHDEC carries out further investigations on the thermo-chemical process in pilot-scale, conducts a market analysis and works on the planning of commercial large-scale applications. (www.ashdec.com)

SNB NV Slibverwerking Noord-Brabant

SNB operates one of the largest sludge incineration facilities in Europe that annually incinerates 95,000 tons of sludge (DM). SNB is interested in an ecologic and economic re-use of their sewage sludge ashes and contributes to the SUSAN-project with its know-how in sludge incineration. SNB produces different qualities of ashes (e.g. with different Fe-content) for the investigation. (www.snb.nl)

BAMAG is an engineering company operating in the fields of water, wastewater, sludge treatment and sludge incineration. BAMAG installed several fluidised-bed incineration plants for sewage sludge world wide (amongst others for SNB) and contributes to the SUSAN-project with their specific experience in planning and engineering of large-scale facilities.
(www.bamag-water.de)

Kemira GrowHow is a leading European provider of fertiliser products for use in agriculture with a particular focus to customized fertilising solutions. As a producer of different types of P-fertilisers, KEMIRA GrowHow contributes to the SUSAN-project with a market research and investigations in product design and conditioning of the fertilisers.
(www.kemira-growhow.com)

The research fields of the FAL Institute of Plant Nutrition and Soil Science (FAL-PB) cover the research and consultant demand of the German Ministry of Consumer Protection, Nutrition and Agriculture with emphasis on sustainable plant nutrition and soil science. In the SUSAN-project FAL-PB will investigate the fertilisation performance of the different products in close co-operation with KEMIRA GrowHow. Comparative pot experiments with fertiliser products from ashes and conventional mineral fertilisers are conducted. Finally, accreditation of new fertiliser products from sewage sludge ashes is targeted. (www.pb.fal.de)

The main expertise of the Institute for Water Quality, Resources and Waste Management (IWA) of the TU Vienna includes waste water engineering, water quality management, waste and resource management, thermal waste treatment, and sustainable regional materials management. IWA establishes the framework that is required to evaluate different options and technologies for sewage sludge management and does comparative investigations into sustainability of the different options. This is done by applying material flow analysis (MFA), statistical entropy analysis (SEA) and established evaluation approaches from the field of Life Cycle Analysis (LCA).
(www.iwa.tuwien.ac.at)