HTC of sewage sludge: feasibility study for fertilizer production and process water treatment

Project duration 2021 - 2022

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Abstract

In order to achieve a circular economy, nutrient-rich waste streams such as sewage sludge must be used as a resource instead of being disposed of in a landfill or incinerated unused. In order to achieve this goal, a new regulation came into force in Switzerland in 2016 with the Ordinance on the Avoidance and Disposal of Waste (VVEA), which requires phosphorus recovery (VVEA, Article 15) from phosphorus-rich waste such as sewage sludge, as well as animal and bone meal by 2026. In recent years, there have been promising developments in phosphorus recovery directly from sewage sludge or from sewage sludge ash after incineration. In the field of wet sewage sludge recycling, the process of hydrothermal carbonization (HTC) enables multiple use of the sewage sludge resource. On the one hand, HTC increases the dewaterability of the digested sludge, which leads to savings in thermal energy during incineration, and in addition to the nutrient phosphorus, some of the nitrogen can also be recovered.

This study investigated the production of a heavy metal-free fertilizer from digested, carbonized sewage sludge and the improvement of process water treatment. In a first step, the sewage sludge was converted into a char like product under high pressure and high temperature in order to subsequently extract the bound phosphorus from the HTC-char using acid and transfer it to the liquid phase. After dewatering and drying, the coal could thus be retained as a fuel, while the nutrients were removed beforehand. More than 50% of the nitrogen contained in the digested sludge was transferred to the liquid phase, which was later used for fertilizer production, and also led to an upgrading of the HTC-char as a fuel. During the acidic phosphorus extraction of the coal, other metals that were bound to the phosphorus were also dissolved. The largest proportion comes from precipitants such as iron and aluminum salts, over 97% of which were recovered from the acid extract during purification with ion exchange resins and are available for later reuse in the wastewater treatment plant. The purified acid extract was later used as a source of phosphorus for struvite precipitation, which can be reused as a fertilizer in agriculture.

Another product of the HTC process is the process water, which contains large amounts of organic compounds that require energy to be decomposed and removed during aerobic treatment in wastewater treatment plants. In order to remove a large part of the dissolved organic compounds in advance, freeze concentration was investigated as a promising alternative to evaporation and membrane separation. Compared to evaporation, this has seven times lower energy consumption and is more resistant to corrosive wastewater. Separation tests showed a recovery of over 90% of the dissolved compounds in the concentrate. This can be reused for the recovery of valuable compounds or fed directly back into the HTC process as a carbon source to further increase the carbon efficiency of the process. In the present

study, the concentrate was used as an ammonium source for struvite precipitation in order to utilize the contained nitrogen for fertilizer production.

Following project goals were achieved:

- Total phosphorus recovery of over 64% from sewage sludge to fertilizer.
- With the help of an ion exchange resin, over 97% of the iron and aluminum contained in the acid extract could be recovered.
- Production of a low heavy metal containing struvite fertilizer (heavy metal contents for Ni, Cu, Zn, Cd and Pb below the MinRec threshold vlaues (ChemRRV)).
- Part of the dissolved nitrogen served as a source of nitrogen for the production of the struvite fertilizer and could thus be made available again as a plant nutrient.
- Over 90% of the organic carbon and other dissolved substances were removed from the process water by means of freeze concentration.
- Aerobic treatment of the process water purified by means of freeze concentration leads to a COD reduction of 85%.

Final report

The full report was published in the journal Energies and is available for free under following link: Hydrothermal Carbonization of Sewage Sludge: New Improvements in Phosphatic Fertilizer Production and Process Water Treatment Using Freeze Concentration (https://doi.org/10.3390/en16207027)