Drying and incineration of sludge

In a nutshell

SUMMARY
It is best practice to efficiently mechanically dewater the anaerobically stabilised sludge, e.g. by means of chamber filter presses, and then completely oxidise it in a mono-incineration plant (as detailed in the best available techniques reference documents[1] according to the Industrial Emissions Directive[2]). The phosphorus contained in the ash of the incineration residue can be recovered.
Target group
Public administrations responsible for waste water management and urban drainage.
Applicability
The technique is applicable to public administrations responsible for waste water management, both in new and existing waste water treatment plants. In the case of small plants, the mechanically dewatered sludge can be sent to a separate central mono-incineration sludge plant instead of being incinerated on site.
Environmental performance indicators
• Percentage of the sewage sludge produced in the waste water treatment plant that is mono-incinerated (%) • Percentage of phosphorus present in the incineration ashes of the waste water treatment plant that is recovered (%)
Benchmarks of excellence
N/A

[1] The Best Available Techniques (BAT) Reference Documents (BREFs) according to the Industrial Emissions Directive are available at: http://eippcb.jrc.ec.europa.eu/reference/.

[2] Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control) (Recast).

Description

Sewage sludge is a complex matrix containing (Schönberger, 1990; BUWAL, 2003, Birkett/Lester, 2003, Bayern, 2011):

- Heavy metals[1],
- Organic pollutants (thousands), such as endocrine disruptive chemicals, chlorinated and brominated aromatic compounds, polycyclic aromatic hydrocarbons, mineral oil-derived compounds, pharmaceuticals, disinfectants, washing agents, industrial chemicals, hormons etc.,

- Microbial pathogens.

At the same time, sewage sludge contains phosphorus, one of three elements critical to plant growth (along with nitrogen and potassium). Usually, it is sourced from phosphate rock which is a non-renewable resource, and it is thus an element of a list of 20 raw materials which are considered critical by the European Commission (EC, 20014a; EC, 2014b). According to some researchers, Earth's phosphorus reserves are expected to be completely depleted in 50–100 years and peak phosphorus production from mineral rock to be reached in approximately 2030 (Cordell et al., 2009) although another report estimates that global phosphate rock resources will last for several hundred years (Van Lauwenbergh, 2010). The amount of phosphorus in sewage sludge is significant; currently, the annual quantity of 11.5 million tonnes of sewage sludge (as dry matter) contains about 300,000 tonnes of phosphorus (Eurostat, 2009; Kabbe, 2013) which can be exploited. Firstly, the sludge is efficiently mechanically dewatered, preferably by means of chamber filter presses achieving a dry matter content of 25 – 35 %. Subsequently, the organic compounds and pollutants of the partially dewatered sludge are completely oxidised in a mono-incineration plant meeting best available techniques according to the Industrial Emissions Directive (EU IED, 2010), which are laid down in the best available techniques reference document on waste incineration (EC, 2006). Steam and electricity is generated from the incineration process and no additional fuel is required except for the combustion start-up. Finally, the phosphorus contained in the ash as the incineration residue can be recovered. For the recovery of phosphorus from municipal waste water treatment, specifically from the ash of mono-incinerated sewage sludge, different techniques have been developed such as the SESAL-PHOS Process, the PASCH Process and the ask development with and without separation of heavy metals (Seiler, 2014; Stemann/Kappe/Adam, 2014). The development is still ongoing, focusing specifically on improving the economics. Therefore, it is also proposed to store the incineration ash until the developed processes have been technically and economically optimised (DWA, 2010, Lehrmann, 2013).

Compared to mono-incineration, the co-incineration of sewage sludge in power plants, cement plants or solid municipal waste incineration plants does not allow phosphorus recovery.

For the mono-incineration, different technical options are available (Table 1). In most of the existing plants, the fluidised bed technology is applied (Lehrmann, 2013) which is also considered as best available technique (BAT) (EC, 2006).

Table 1: Comparison of different furnaces (Umweltbundesamt, 2012)

	Fluidised bed furnace	**Multiple hearth-furnace**	**Multiple hearth cyclone catcher**	**Cyclone furnace**
Characteristics	No mechanical moving parts and low wear	No separate pre-drying required, complex furnace design with moving parts, cooled hollow shaft	No separate pre-drying required, flexible hollow shaft, low fluidised bed volume	No mechanical moving parts and low wear, no fluidised bed material
Operating behaviour	Fast start-up and shut-down times due to short heating and cooling times, intermittent operation possible	Long heating time, continuous operation required	Medium heating and cooling times	Comparable to fluidised bed furnace, applicable to a wide range of fuels

	Fluidised bed furnace	**Multiple hearth-furnace**	**Multiple hearth cyclone catcher**	**Cyclone furnace**
Incineration	Low excess air level required, complete burnout above the fluidised bed only	Burnout difficult to control, insensitive to variations of feed quantity and coarse matters	Low excess air level required, good burnout control, incineration is largely completed in the fluidised bed, compared to fluidised bed furnaces, less insensitive to variations of sludge composition	Solids, long and gaseous fractions, short retention times, variable supply of primary and secondary air at different levels
Ash content in exhaust gas	High	Low	High	High
Ash discharge	Via exhaust gas and sand removal	Directly from lowest hearth	Via exhaust gas and sand removal	Via exhaust air, coarse dust at the bottom
Residues	Ash, fluidised bed material	Ash	Ash, fluidised bed material	Ash, if so coarse ash

Figure 2 shows the latest layout of a mono-incineration plant for sewage sludge. This plant for the incineration of the sewage sludge of all municipal wastewater treatment plants of the canton of Zurich in Switzerland will go into operation in 2015 but the illustrated technique is already successfully operated at many other sites, e.g. in Neu-Ulm/Germany since 1995 (Hiller, 2013). Considerable efforts have to be undertaken to purify the flue gases. With multi-step processes, very low emissions are achieved (see environmental benefit). However, for the time-being, the ash will be separately stored until the recovery of phosphorus from it will be more economic.

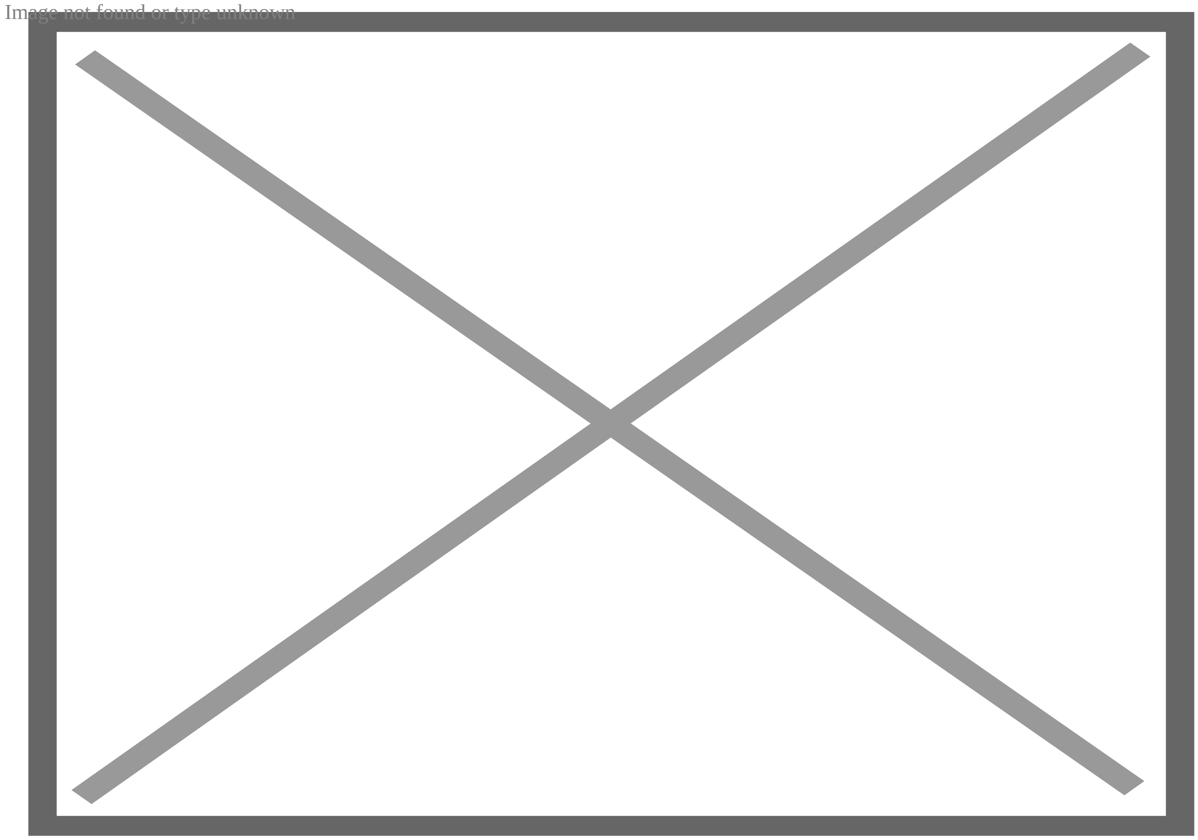

Figure 2: Sludge incineration plant of the canton Zurich which will go into operation in 2015 (Decker/Müller, 2014)

In case of phosphorus recovery from ash, the extracted ash could be used as a raw material in clinker production.

[1] Heavy metals (e.g. Hg, Cr, Ni, Cd, Pb, U) are normally available in nature and thanks to their high density are successfully used in a number of applications such as electronics, catalysts, ferstilisers. Some of them are potentially hazardous due to their toxicity in combined or elemental forms.

Environmental benefits

The countless organic pollutants present in the sludge are completely oxidised. Due to efficient flue gas purification, very low emission values for the different parameters are achieved. The different applied systems (sequences) are mentioned under operational data. Table 2 shows the achieved values of the sewage sludge mono-incineration plant of the city of Hamburg.

Table 2: Sewage sludge mono-incineration plant of the city of Hamburg - achieved average values for emission to air for the time period 2011 - 2013

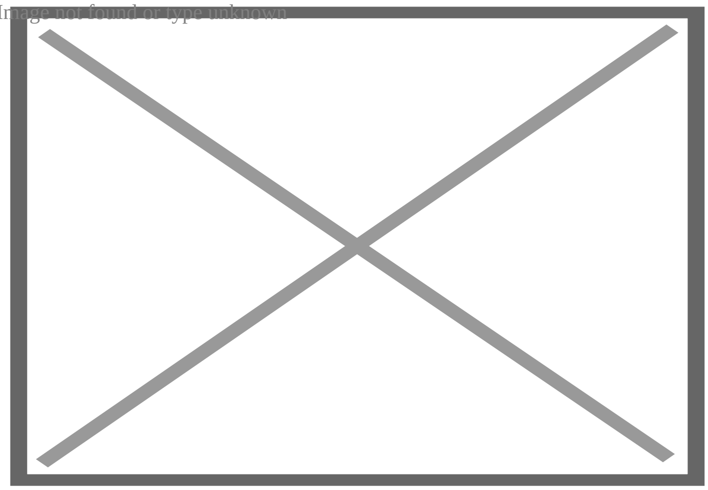

Table 3 gives the contents of nutrients and important heavy metals in the ash of sewage sludge mono-incineration plants from 252 measurements. For uranium and cadmium, the contents are much lower than in natural phosphate rock. Currently, there are no limits on the cadmium content of fertilisers on European level but there are in some European Member States, such as Germany (see Table 3). However, a limit of 60 mg Cd/kg P_2O_5 is currently discussed (Fertilizers Europe, 2013) to be introduced into the regulation of fertilisers (EU, 2003). In the ash of mono-incinerated municipal sewage sludge, the average phosphorus content is 90 g/kg.

Table 3: Heavy metal content (As, Cd, Hg, Ni, Pb, U) in ashes from mono-incineration of sewage sludge and limits according to the German Regulation on Fertilisers (values for ashes from (UBA, 2014) and limits from (DE DüMV, 2012))

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Recovered phosphorus reduces the sourcing of phosphate rock. As the latter is a non-renewable resource and is an element of a list of 20 raw materials which are considered critical by the European Commission, the recovery is a significant environmental benefit.

Side effects

Dust and other residues result from flue gas purification. These residues have to be carefully disposed of.

Applicability

The technique is applicable for existing and new waste water treatment plants. It can be retrofitted to existing plants.

Economics

The investment in a dedicated plant for the mono-incineration of sewage sludge can be significant. The investment for the plant in Zurich/Switzerland is about 45 Million EUR.

The costs for different processes for the recovery of phosphorus from ash of sewage sludge mono-incineration plants are compiled in Table 4. Currently; the costs are higher than the mining and processing of phosphate rock (Herr et al., 2013).

Table 4: Compilation of costs for different processes for the recovery of phosphorus from ash of sewage sludge mono-incineration plants (Seiler, 2014)

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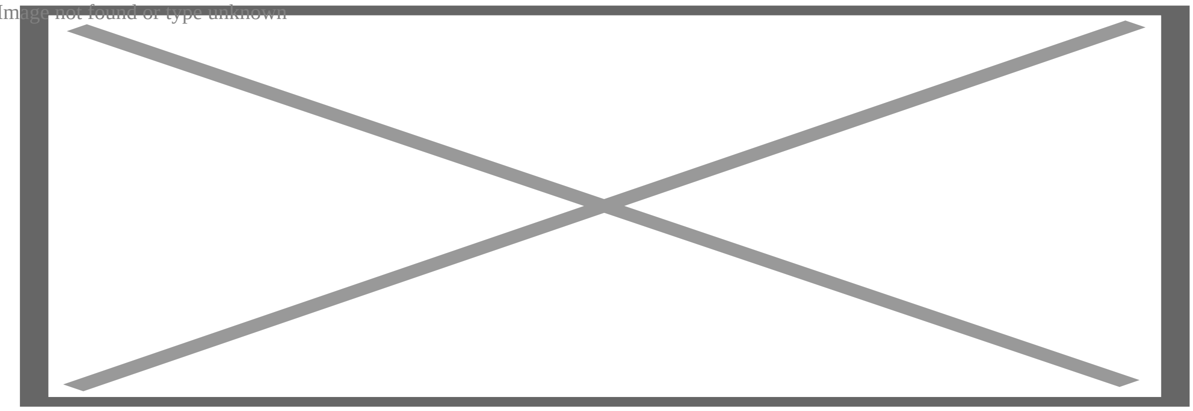

Depending on the sequence of flue gas purification, the costs for chemicals used are between 1.3 and 1.8 EUR per tonne of dewatered sewage sludge and for the disposal of residues between 1.4 and 2.4 EUR per tonne of dewatered sewage sludge (Decker/Müller, 2014). The disposal of the residues from flue gas purification can represent a significant percentage of total operating costs (Lehrmann, 2013).

Driving forces for implementation

The rising awareness of the countless organic pollutants present in sewage sludge and the conclusion that the sludge disposal on landfills is inadequate as well as the finding that phosphorus recovery is best from ash were the main driving forces to mono-incinerate sewage sludge and to recover phosphorus from the ash or to store the ash until more economic recovery processes will be developed.

Reference organisations

Hamburg/Germany, Neu-Ulm/Germany, Zurich/Switzerland, Stuttgart/Germany, Moerdijk/Neterlands, Copenhagen/Denmark, Berlin/Germany; Dordrecht/Netherlands

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