Proceedings of the 13th International Students Conference "Modern Analytical Chemistry"

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Stabilization of Solid Residues Obtained During Sewage Sludge Thermal Treatment

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Abstract
Currently wastewater treatment plants are still dealing with the problem of ecological management of sewage sludge. Nowadays, thermal utilization is considered the most eco-friendly way of processing excess sludge. However, during mentioned process, fractions of ashes and dusts are generated. Such wastes, especially dusts fraction, can be potentially harmful for the environment and wastes should be stabilized before further management. In presented work, new method of stabilization of solid residues produced during sewage sludge thermal treatment is described. Laboratory and industrial scale trails were performed. Based on the results of the conducted research it can be stated that dust and ash fraction can be stabilized together without causing threat for environment. Moreover, presented method seems to be economically justified.

1. Introduction

Nowadays the problem of sewage sludge management is becoming critical. More and more sludge is produced all over the world [1]. The main cause is rapid urbanization and vigorous development of industry [2]. Thermal utilization of excess sludge is gaining popularity, since such process leads to complete disintegration of organic pollutants. However, mentioned technique cannot be considered as a fully-complete management method, while ash and dust fractions are produced and generally landfilled [3]. Landfilling may cause threat for the environment since pollutants such as heavy metals can infiltrate to environment. There is vast variety of novel management methods, nonetheless, they do not solve the problem of incomplete waste management [4, 5]. Therefore, landfilling is becoming much more expensive, since suitable sites areas are decreasing [6].

Many researchers are seeking for new management methods. Stabilizing solid wastes with the possibility of construction material generation seems to be especially ecologically concept because raw resources availability is decrease [7]. That is why researchers are focusing on development of artificial lightweight aggregates from wastes [8]. Cementation of produced waste with construction material production seems to be very attractive in economical point of view [9].

2. Experimental

2.1 Samples

Ash and dust fractions were obtained from two sewage sludge treatment plants located in Poland: Group Wastewater Treatment Plant in Łódź (GWT) and Wastewater Treatment Plant "Wschód" in Gdańsk (WTPW).

In both cases excess sludge is pre-dried and utilized in fluidized bed furnace. Ash and dust fractions are produced and stopped on two sets of bag filters. However, mentioned wastewater treatment plants are using different sorbents for dust fraction production. WTPW uses calcium sorbent mixed active carbon. GWTP uses active carbon mixed with sodium bicarbonate. Both facilities produce around 8 t/d of ash fraction. WTPW produce 5 t/d of dusts while GWTP produces around 1 t/d of mentioned waste. Ash and dust fraction from both sewage sludge treatment plants were sampled, transported to laboratory and stored in HDPE containers.

After that, obtained material were stabilized with proposed procedure. Ashes and dust were mixed together with cementing medium: CEM III A-S, 42,5 R and plasticizer. The amounts of certain fraction used for stabilization are described in Table 1 (next page).

Also, the industrial scale trail was performed. Ash fraction and dust fraction from WTPW was stabilized in the facility. The amounts of reagents used for stabilization single stabilization process was: 145 kg of dust, 35 kg of ash, 64 kg of cement, 181 kg of technological water and 13.5 kg of plasticizer. Several stabilizations were performed. About 9 tons of the stabilized material was produced. In Fig. 1 (next page) scheme of industrial scale trail is presented.

Appropriate amounts of samples were collected and transported to laboratory to perform leaching test and heavy metals analysis. All stabilized materials were subjected to extraction procedure to determine amounts of heavy metals which can be rinsed form obtained samples. Leaching procedure which was used for extract preparation was adopted from EN 12457-2006 *Characterization of waste. Leaching. Compliance test for leaching of granular waste materials and sludges* with following changes: liquid to solid ratio was equal 0.25 time of extraction was 72 ± 1 h; mixing with 165 rpm.

2.2 Reagents and chemicals

For mineralization presented oxidizing agent were used: 10 ml of 65% nitric acid, 2 ml of 36% hydrochloric acid, 2 ml of perhydrol. All reagents were Suprapur

Table 1
The amounts of certain ingredients used for stabilization of dust and ash fractions performed on laboratory scale (WTPW - Wastewater Treatment Plant "Wschód" in Gdańsk, GWTP - Group Wastewater Treatment Plant in Łódź).

Ash and dust fractions from	Reagents added for stabilization /g				
	Cement	Ash	Dust	Water with plasticizer	Total mass
WTPW 1	10	25	15	26	76
WTPW 2	15	25	15	30	85
WTPW 3	10	25	15	28	78
WTPW 4	20	25	15	30	90
WTPW 5	15	25	15	28	83
WTPW 6	10	25	15	27	77
WTPW 7	15	25	15	26	81
WTPW 8	10	15	25	25	75
WTPW 9	15	25	15	25	80
WTPW 10	15	25	20	30	90
WTPW 11	10	30	20	30	90
WTPW 12	15	30	20	30	95
WTPW 13	5	25	15	27	72
WTPW 14	5	25	25	27	82
GWTP 1	20	30	15	27	92
GWTP 2	10	25	10	27	72
GWTP 3	15	25	15	30	85
GWTP 4	15	30	15	30	90
GWTP 5	10	30	15	30	85
GWTP 6	10	25	15	30	80
GWTP 7	15	25	15	27	82

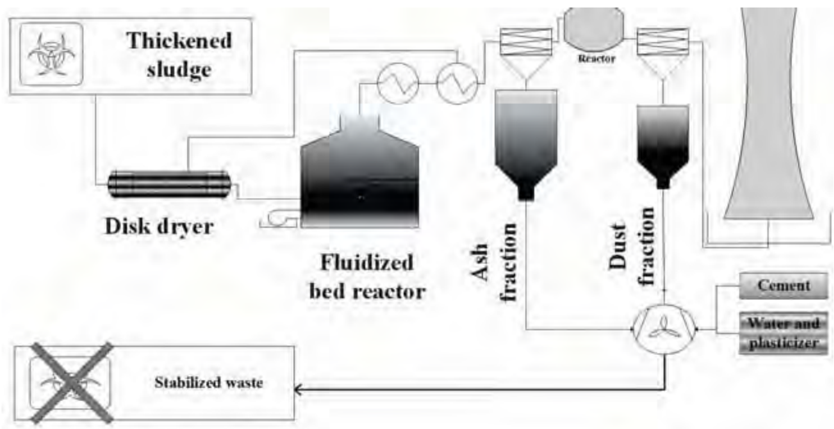

Fig. 1 The scheme of industrial scale trail.

grade and supplied by Merck. For calibration solutions preparation, extraction and leaching tests Mili-Q water was used. Calibration solutions for determination of: Cd, Co, Cu, Fe, Mn, Ni, Pb, Sb, Sn, Zn were supplied by MS-Spektrum company. All specified solutions were 1000 mg/L with varied uncertainty (from ± 4 mg/L to ± 6 mg/L), in 2% HNO_3 solution. Calibration solution for Hg determination was 100.48 ± 0.22 mg/L in 3.3% HCl, diluted in 0.001 % L-cysteine solution. Also the following modifiers for certain heavy metals determination were used: Phosphate modifier for graphite furnace AAS, $NH_4H_2PO_4$ 100 ± 2 g/L in H_2O supplied by Merck company for Sn, Ni and Cd analysis. Magnesium nitrate-palladium nitrate matrix modifier 0.2% Mg and 0.3% Pd in 1% HNO_3 supplied by MS Spektrum for Pb analysis.

2.3 Instrumentation

For mineralization Multiwave GO digestion system supplied by Anton Paar company was used. For moderate concentration heavy metals determination, Flame Atomic Absorption Spectrometer SensAA supplied by GBC Scientific Equipment (Australia) with dual beam optical system and air acetyl flame was used. Deuterium lamp for background correction and hollow-cathode lamps as radiation source were installed. For low concentration heavy metals determination, Graphite Furnace Atomic Absorption Spectrometer Savant AAZ supplied by GBC Scientific Equipment (Australia) with Zeeman background correction was used. As a carrier gas technical grade argon was supplied and hollow-cathode lamps were installed as radiation source. Mercury/MA-3000 supplied by Nippon Instruments Corporation (Japan) was used to analyse mercury by cold vapour technique and pure oxygen was used as the carrier gas. To carry out simultaneous determination of elemental species in solid samples (ashes, dust and stabilized materials) Thermo Scientific Niton Xl3t GOLDD+ XRF Analyzer was used.

3. Results and discussion

It was possible to obtain satisfying stabilization in all studied cases regardless of the ratio of reagents used. All determined heavy metals were leached from stabilized material in amount below the limit of detection in both cases, laboratory and industrial scale trails. Comparing the amount of determined heavy metals in solid stabilized material and the limit of detection in extract it can be stated that heavy metals are leached from prepared material in amounts lower than 1%. Maximum rinsing factor are presented in Table 2 (next page). All legal regulation concerning maximum allowable leaching were met.

Table 2
Maximum rinsing percentage of specified heavy metal from stabilized materials.

Element	Maximum rinsing
Cd	0.80%
Co	0.32%
Cr	0.05%
Cu	0.05%
Fe	0.00%
Hg	0.84%
Mn	0.02%
Ni	0.22%
Pb	0.20%
Sb	2.32%
Sn	0.00%
Zn	0.01%

4. Conclusions

Dust fraction obtained from WTPW and GWTP can be stabilized using commercially available cement and ash fraction produced in each of studied sewage sludge treatment plants. Such approach may lead to simplify the dust stabilization process and significant cost reductions. Since main pollutants, such as heavy metals are not rinsed form produced material, there is a possibility to produce construction materials form stabilized wastes. Proposed stabilization process can be safely implemented in both sewage sludge treatment plants while all legal standards concerning landfilling of stabilized wastes are met. However further studies have to be conducted to prove environmental safety of using stabilized wastes as construction materials.

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