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Self-heating of dried wastewater sludge

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ABSTRACT

We experimentally studied the occurrence of spontaneous self-heating of sludge after drying, to understand its nature, course and remediation. The sludge originates from primary and biological treatment of both municipal and industrial wastewater, the latter largely dominant (approx. 90% total organic carbon, mainly from local tanneries). Dried sludge is collected into big–bags (approx. 1.5 m^3) and landfilled in a dedicated site. After several years of regular operation of the landfill, without any management or environmental issue, indications of local warming emerged, together with smoke and smelling emissions, and local subsidence. During a two year monitoring activity, temperatures locally as high as 80 °C have been detected, 6–10 m deep. Experiments were carried out on large quantities of dried sludge (~1 t), monitoring the temperature of the samples over long periods of time (months), aiming to reproduce the spontaneous self-heating, under different conditions, to spot enhancing and damping factors. Results demonstrate that air is a key factor to trigger and modulate the self-heating. Water, in addition to air, supports and emphasizes the heating. Unusual drying operation was found to affect dramatically the self-heating activity, up to spontaneous combustion, while ordinary drying conditions yield a sludge with a moderate self-heating inclination. Temperature values as well as heating time scales suggest that the exothermic process nature is mainly chemical and physical, while microbiological activity might be a co-factor.

1. Introduction

Wastewater treatment plants yield a large quantity of sludge in addition to purified water. Disposing of sludge may be a significant issue. Dehydrating and drying processes allow to largely reduce the sludge mass, before landfilling. Questions arise about the chemical and biological stability of dried sludge.

In the plant of our interest, quite large indeed, dried sludge is collected into PP, with waterproof PE internal layer, big–bags with a volume of approx. 1.5 m^3. Bags are subsequently landfilled in a dedicated site. After several years of regular operation of the landfill, without any management or environmental difficulty, local temperature unusually high have been measured. At the same time, landfill produced smoke and malicious odor. Locally, quite significant subsidence was measured, up to 2 m. After a systematic monitoring campaign, lasting more than two years, temperatures locally as high as 80 °C have been detected, in specific zones, typically 6–10 m deep. Local surface subsidence up to 2 m was measured, over a total depth of approx. 12–14 m.

While surprised by the significance of the process going on in the landfill, we started a systematic investigation, beginning with a literature survey on comparable scenarios. The self-heating on a large scale of different materials (carbonaceous material, MSW, municipal sewage sludge) has been reported (Riley et al., 1987; Moqbel et al., 2010; Escudey et al., 2008). Riley et al. (1987) focused on coal in barges, clearly admitting that exhotermic oxidation reactions take place, stressing the role of air. Moqbel et al. (2010) revert to laboratory to identify the auto-ignition temperature of synthetic MWS; they already observed the key role of oxygen to support chemical oxidation reactions. Escudey et al. (2008) carried out field tests on sewage sludge piles extending several meters, for 20 weeks, confirming that temperature could rise up to 90 °C, never causing self combustion, though reporting that it was observed in landfills in their region.

In the case of our dry sludge, the first hypotheses concerns the occurrence of some extraordinary biological activity. Literature reports contrasting opinions about that. Li et al. (2008) explicitly support the quantitative generation of heat by biological processes. Others (Poffet et al., 2008; Gholamifard and Eymard, 2009), claim that bacterial activity requires a longer induction time (days or weeks) and sufficient moisture degree. Finally, Yasuhara et al. (2010) like Fu et al. (2005) definitely exclude any connection between self-heating and the bacterial metabolism. The residual moisture in our case is always less than 15% (typically 10%), to prevent the onset of biological processes. However, loss of containment by a big–bag in the landfill, causes sludge to rehydrate, possibly triggering some biological activity. This activity, while

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