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# The hidden impacts of incineration residues

*Case Study*

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Waste incinerators in the Netherlands create a large amount of toxic residues (bottom and fly ash) which are increasingly used in so called useful applications under the Green Deal agreement. The evidence shows that the current standards for safety of this practice are outdated posing a significant threat to human health and the environment.

## Introduction

The Waste-to-Energy (WtE) incineration industry in the Netherlands started its operations in the 1970s as a state-of-the-art solution for waste disposal. After several disastrous accidents and calamities in the past, but also more recently, the public is increasingly aware of the toxic potency of burning waste. Still, most media coverage of incineration and the growing public awareness of its health concerns, is focused on atmospheric and local air emissions. Yet, the toxic potency of contamination from ashes and incinerations 'green' applications are being largely underestimated. In contrast to the abundance of data on flue gas emissions, recent analytical data on hazardous substances in bottom and fly ashes which result from incineration are not available.

Industry promotes burning waste as a solution to waste management challenges and a way to generate clean energy. Industry also claims that residues from the incineration process can be used in road and civil construction as a green and circular solution. This paper looks to prove otherwise. Focusing on the types of residues generated by waste incinerators, the methods of their disposal or supposedly "useful" application, as well as pollution occurring as a result of these practices.

*Figure 1. Waste handling crane in Reststoffen Energie Centrale plant, and examples of "useful" applications of bottom ash, October 2019 (photos: K. Bouman), mountain of bottom ash in Joure 2019 (photo Jaring Rispens)*

# About ToxicoWatch

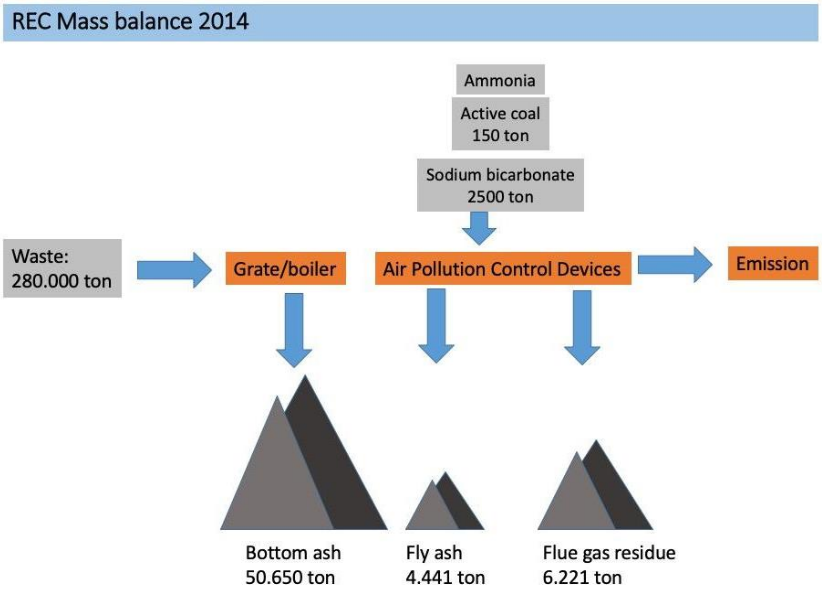
In 2013, ToxicoWatch[1] found high levels of dioxins in backyard chicken eggs in the area surrounding the Restafvalstoffen Energie *Centrale* (REC) waste-to-energy (WtE) incinerator in Harlingen. In cooperation with local and provincial governments, ToxicoWatch initiated extended research projects on Persistent Organic Pollutant (POPs) emissions were carried out in response to the 2013 findings, and measurements in both the physical environment and local air were undertaken. The findings from these research projects, combined with the ToxicoWatch results, were then presented in scientific congress. The results were reinforced by articles such as: Hidden Emissions (published in 2018[2]) which underlined the added value of long-term sampling of air pollutants with AMESA methodology, and the need for short term measurements in Other Than Normal Operating Conditions (OTNOC) to effectively reduce the emissions of dioxins.

Although data on air pollution related to incineration exists and is relatively well-established, what is seriously lacking is an understanding of toxicity from bottom and fly ash residues in the Netherlands and Europe as a whole. If these "useful" applications are to be classified as green and circular, then the toxic consequences of bottom and ash need to be fully explored.

# Types of residue that originate from waste incineration

In general, waste incineration residue (ash) can be classified in three categories: bottom ash, fly ash, and flue gas cleaning residues (with both bottom ash and fly ash being recyclable). Figure 2 shows the quantities of ash residue produced by the Restafvalstoffen Energie Centrale (REC) in 2014.

*Figure 2. Mass balance of the incinerator REC*




1 http://toxicowatch.wixsite.com/toxicowatch/media
2 https://zerowasteeurope.eu/2019/06/the-story-of-rec/

# Bottom ash

After waste is incinerated around 20% remains as bottom ash. In the Netherlands, with 13 incinerators operating, this means that incineration generates around 2 million tonnes of bottom ash per year[3].

In 2012, the Dutch Waste-to-Energy industry[4] reached an agreement with the Ministry of Infrastructure and Water Management to improve the quality of bottom ash generated during incineration, so that it is suitable for "useful" applications without the need for isolation measures[5]. This agreement should be taken in light of the Dutch WtE industry's Green Deal[6] with the Dutch government on 'incinerator bottom ash recycling' which currently lasts until 2020.

Despite this, data on dioxins (PCDD/F), PAK's (PAH), and fluorinated compounds (PFAS) is lacking. That means that the standards set for the "useful" application of bottom ash residue are based on outdated regulations on toxicity[7]. This could indicate that the agreement does not properly account for environmental consequences, and may result in disastrous impacts. Notably, Weber et.al show in their publication, that animals foraging on soil which has been contaminated with bottom ash residues, can have highly toxic impacts across the food chain.

Dutch regulations set a persistent organic pollutants (POP) limit of 55 pg TEQ/g ds for soil. Yet, the lack of scientific consensus on the potentially hazardous impacts of bottom ash residues clearly stress the need to re-evaluate current POP limits. The Basel convention has recently made amendments for lowering the levels to 15 or 1 pg TEQ/g.[8] A real Green Deal would therefore imply as a minimum, an adaption to 1 pg TEQ/g. However, even this limit value underestimates the risk of contamination of the environment because other TEQ-related substances such as dl-PCBs and brominated dioxins are not included under any regulation.

Regulation on bottom ash residues also includes a government requirement that bottom ash should be packaged in an insulating plastic, like HDPE material. Regulation also obliges that project owners manage and monitor the use of bottom ash to avoid any leakages and leaching into the environment.

Before the application of bottom ash in so called "useful" applications (construction and road materials) it will be treated in a treatment plant such as Heros Sluiskil in the South of the Netherlands.

Bottom ash is then transported by cargo ships for further treatment, such as for the extraction of metals with magnetic instruments, and the removing of coarse particles. Once treated, bottom ash is then labelled as "suitable" for "useful" applications such as in concrete or for use in soil, road, and water based construction works.

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[3] https://www.afvalcirculair.nl/onderwerpen/helpdesk-afvalbeheer/publicaties/downloads/downloads-0/afvalverwerking-8/

[4] https://www.wastematters.eu/

[5] The bottom ash programme aims to improve the quality of bottom ash so that this secondary raw material is suitable for "useful" applications without the need for isolation measures.

[6] https://www.greendeals.nl/english

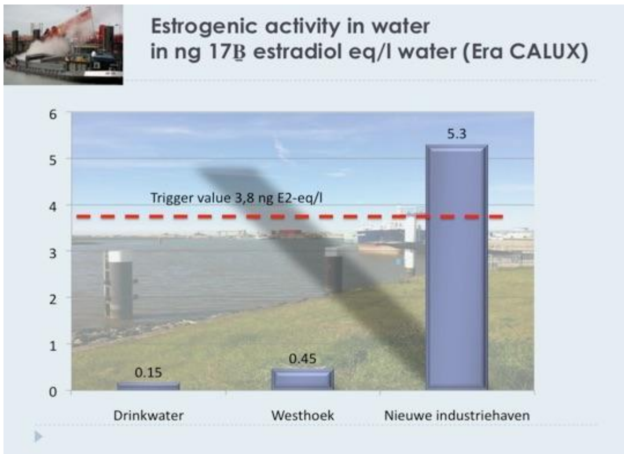
[7] Weber et all (2015), High levels of pcdd/f, pbdd/f and pcb in eggs around pollution sources demonstrates the need to review soil standards, organohalogen compounds vol. 77, 615-618

[8] Toxic ash poisons our food chain, ipen 2017
Study to support the review of waste related issues in annexes iv and v of regulation (ec) 850/2004

At this stage, where bottom ash has been treated and labelled as "suitable", a lot of documents are available, but none provide data on hazardous waste components such as dioxins, PAHs and PFAS. In addition, no PCDD/F analysis data is available at this stage in the process.

The offloading of bottom ash onto cargo ships is done in the open air, without any precautionary measurements, despite licence permits explicitly stating the necessity for taking precautions during the offloading of bottom ashes. Precautionary actions mentioned in the licence permits include: water spraying, cover-protection to avoid dust, and mouth protection for personnel. As a result, lots of dust spills into the surrounding water, which in the Netherlands is the UNESCO classified Wadden Sea. Figure 3 shows the transhipping of bottom ash into cargo ships from regular trucks.

*Figure 3. Transshipping bottom ash in cargo ships Harlingen (2011) and the results Era-CALUX of water spoiled with bottom ash (2014).*


To investigate the effects of this practice ToxicoWatch set up a pilot research project in 2014[9]. Samples of water were taken from near the loading locations as well as reference samples from the middle of the Wadden Sea (kilometres away from the loading station). The results (Figure 3) showed elevated oestrogenic activity (stimulated changes in female reproductive organs during the oestrous cycle), expressed as estradiol equivalent in the Era CALUX[10], of water near the transhipping place. This research therefore demonstrates a significant threat not only to the (UNESCO) World Heritage marine site but local fishermen too have testified abdominal growths on fish such as pouting (Trisoplerus luscus), the European flounder (Platichthys flesus) and growths on the mouths of certain species of European eel (Anguila anguila), caught in the Harbour near this bottom ash loading location.

To make matters worse, several accidents have occurred (Figure 4) from transporting bottom ash by truck, resulting in direct contamination of the ground.

9 https://www.helpdeskwater.nl/publish/pages/132819/presentatie_haven_van_harlingen_versie_150121.pdf
10 ERa (Estrogen Receptor alpha) CALUX (Chemically Activated LUciferase eXpression) bioassay

*Figure 4. Accident with bottom ash (2011), picture by Ruben Alkemaa, www.scannernet.nl*


Analysis done using the DR CALUX[11] found 35 pg TEQ/g of dioxin and dioxin such as PCB contamination in the ash, therefore complying with the Dutch regulation[12]. But if chicken were to forage on soil like this, elevated levels of dioxins would be found in eggs as research has shown[13].

Similarly, bottom ash is often stored in huge piles before its use in road construction work.

The regulation requires that these storages should be packaged (covered) to avoid any spillages into the environment[14]. However, evidence shows that simple packaging using plastic is not sufficient enough to avoid contamination of the ambient environment during rain[15].

[11] Dioxin Responsive Chemical Activated LUciferase gene eXpression (DR CALUX) is a bioassay used in the detection of dioxins in samples.

[12] https://wetten.overheid.nl/BWBR0023085/2018-11-30

[13] Arkenbout A (2014): Organohalogen Compounds 76, 1700-1703
Weber et all (2015), High levels of pcdd/f, pbdd/f and pcb in eggs around pollution sources demonstrates the need to review soil standards, Organohalogen Compounds Vol. 77, 615-618

[14] https://wetten.overheid.nl/BWBR0023085/2018-11-30

[15] https://www.lc.nl/friesland/Zorgen-over-water-in-wegfundering-knooppunt-Joure-werk-aan-de-taluds-24448013.html

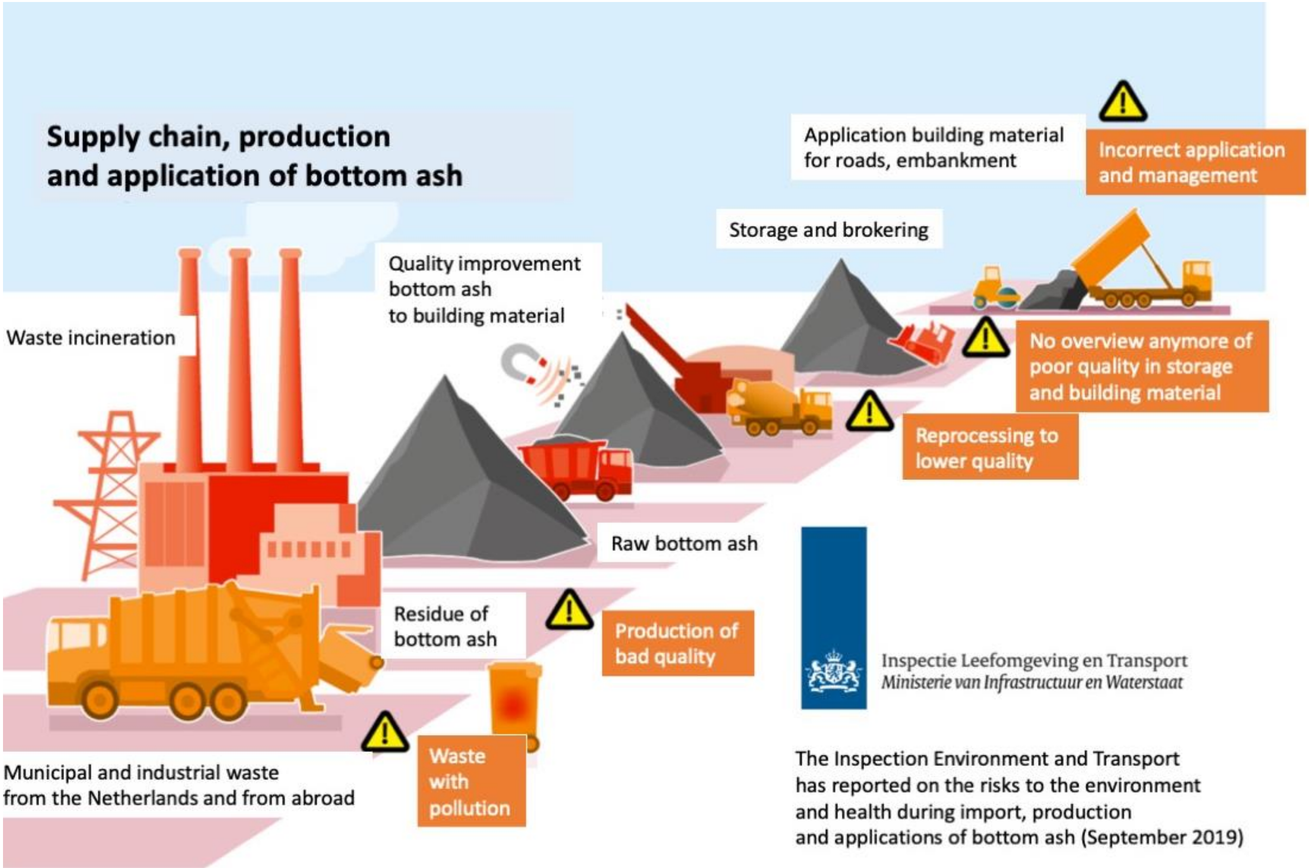
*Figure 5. Black hill of bottom ash in Joure, picture by Jaring Rispens, 2019*

Moreover, the Sluiskill treatment plant specifically raised concerns about large fluctuations in the quality of ash and a general trend of decreasing bottom ash quality[16]. The causes of this are largely unknown. Future research should consider investigating elements such as incomplete combustion, changing waste inputs, heterogeneous combustion temperatures, and mixed deliveries. However, due to a lack of commercially viable options to 'clean' the bottom ash to acceptable levels of toxins (POPs and heavy metals), it is simply not done.

The Inspectorate of Human Environment and Transport of the Dutch Ministry of Infrastructure and Water Management (Ministry of Health, Welfare and Sport) released a report in September 2019 highlighting the risks of the import, production, and application of bottom ashes to the environment and human health[17]. Figure 7 shows the level of perceived risk in relation to supply chain, production, and application of bottom ash. This research was supported by another government report by the Netherlands National Institute for Public Health and the Environment in September which also warned of the high damage that bottom ash has on soil, ground and surface water[18]. Significantly, the earlier report by the Inspectorate concluded that there was a high risk of fraud coming from industry due to the negative market value of bottom ash - indicating a clear problem with current implementation of regulations.

[16] https://www.heros.nl/nl/nieuws/214/heros-ziet-donkere-wolken-boven-green-deal-aec-bodemas.html
[17] Signaalrapportage, Analyse risico's in de keten van bodemas, September 2019, Inspectie Leefomgeving en Transport, www.ilent.nl https://www.rijksoverheid.nl/documenten/rapporten/2019/09/05/bijlage-3-analyse-risico-s-in-de-keten-van-bodemas-signaalrapportage
[18] https://www.rijksoverheid.nl/documenten/rapporten/2019/09/05/bijlage-2-risicogestuurd-toezicht-en-handhaving-ranking-ongewenste-gebeurtenissen-in-de-bodemketen

*Figure 6. Report inspectorate 'Human Environment and Transport' (ILT 2019)*




Millions of tonnes of bottom ash are used in public works, roads, and waterworks, but data on quantity and location is missing, making it unclear as to whether these locations are complying with all the regulation requirements[19].

This raises serious questions about the control of toxicity in public works. There is therefore a need to ensure that hazardous substances such as endocrine disrupting compounds are not leaking out of concrete or other building materials containing bottom ash, now or in the future.

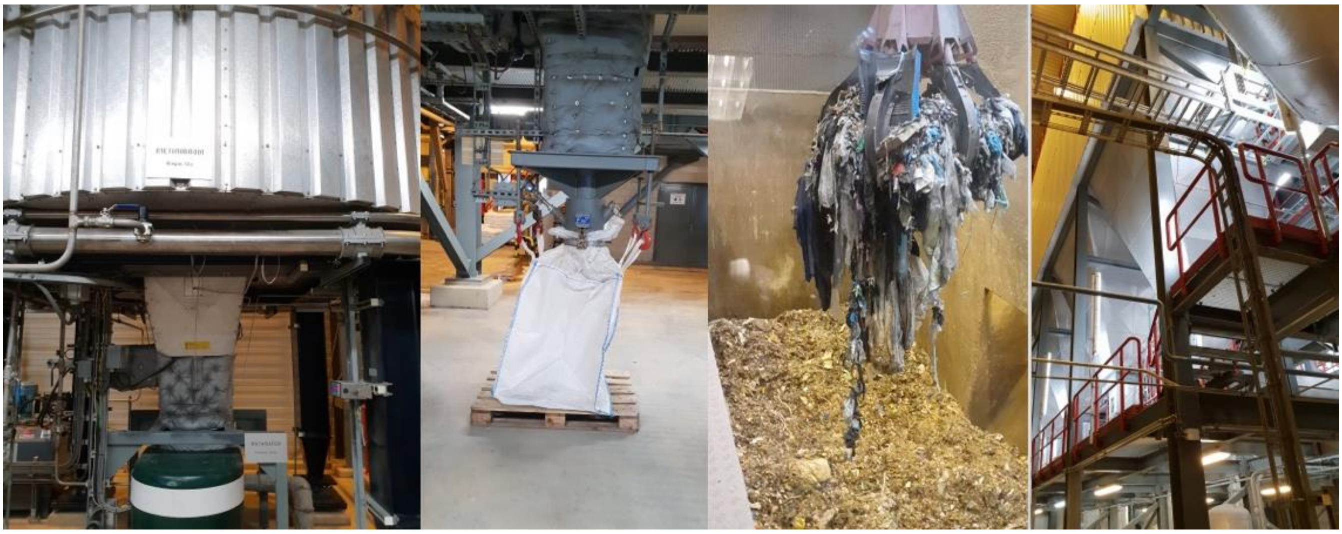
[19] https://www.sikb.nl/doc/as6900/PRJ%20283%20Informatiedocument%20IBC-bouwstoffen%20(170216).pdf

# Fly ash

In addition to bottom ash, waste incinerators also create significant amounts of fly ash and flue gas cleaning residues (which together make up to 10% of incineration residues). These residues are more contaminated with heavy metals, dioxins, and other persistent organic pollutants than bottom ash[20]. However, no analytical toxicity data is currently available.
The main disposal routes for these residues are: in the manufacture of cement, landfill, deposits in deep underground voids, or immobilisation[21]. Most flue gas ash (up to 40%) is used in cement production, the rest however, is either deposited in deep underground voids or landfilled. Again, no toxicity data is available for these applications of fly ash.

As landfilling in the Netherlands is heavily taxed, it has been more economical for WtE facilities to deposit these residues in salt mines, such as Sonderhausen in Germany[22]. However, the Dutch government initially had serious concerns about the export of hazardous waste, and eventually forbade it in 2017, instead forcing companies to landfill their toxic residues in C2 landfill for hazardous waste in *Maasvlakte*, near Rotterdam. Only after years of legal battle were the companies again allowed to deliver waste to German salt mines. The depositing of hazardous waste in deep underground voids has now been approved by the judicial court since January 2019 deeming it as a “useful” application[23].

*Figure 7. REC public day October 2019 (photos: K. Bouman)*



[20] Concentration of PCDD/F in fly ash is on average around 2.5 ng TEQ/kg, up to 10 ng TEQ/kg, for Europe there are only a few measurement data from recent years available. Study to support the review of waste related issues in annexes IV and V of regulation (EC) 850/2004. Available at https://op.europa.eu/en/publication-detail/-/publication/8ea39ec6-4479-11e9-a8ed-01aa75ed71a1/language-en/format-PDF
[21] Immobilisation is used to physically immobilize the hazardous content present in bottom ash.
[22] https://www.nrc.nl/nieuws/2004/11/04/de-bodemloze-put-van-sondershausen-7709322-a438251)
[23] https://twence.nl/twence/nieuws/2019/Uitspraak-Raad-van-State--vliegas-mag-naar-Duitse-zoutmijnen.html

## Conclusion and recommendations

Waste incinerators generate highly toxic compounds which are released as residues (e.g. heavy metals, dioxins, and other persistent organic compounds). These residues are then often used in so called "useful" applications as "green" solutions throughout the construction sector. However, the content of hazardous compounds in those solutions exceed the safety limits recommended by scientific researches and the amended Basel Convention. Specifically, Dutch regulations are based on outdated data, posing a significant threat to human health and the environment. A truly green deal means taking all efforts to minimize the impact of hazardous compounds such as dioxins, but also other persistent organic pollutants like PCBs and PFAS.

Although current research is limited, what exists indicates strong concerns for public safety and the environment. Therefore, ToxicoWatch urgently calls for further research and study which should prompt reconsideration over the impacts of using incineration ashes in a wide variety of applications. Until then, any "useful" application of bottom or fly ash from incineration should be suspended. Continuing to use these residues, could put our health and the environment at risk.

*Case study by Abel Arkenbout, NGO ToxicoWatch*

*Editors: Rossella Recupero, Eilidh Robb and Janek Vahk, Zero Waste Europe*

*Zero Waste Europe 2019*

*The ToxicoWatch foundation is a Non-Governmental Organization dedicated to creating a safer and healthier world by advancing the science of toxicology and raising awareness about toxic hazards. toxicowatch.wixsite.com/toxicowatch*

*Zero Waste Europe is the European network of communities, local leaders, businesses, experts, and change agents working towards the same vision: phasing out waste from our society. We empower communities to redesign their relationship with resources, to adopt smarter lifestyles and sustainable consumption patterns and think circular. zerowasteeurope.eu*

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