Flooding Risks At Old Landfill Sites. Linear Economy Meets Climate Change.

Eddy Wille, OVAM - Department Soil Management

ISWA Conference 2018, Kuala Lumpur

Contact

Eddy Wille, senior advisor, OVAM (Public Waste Agency of Flanders), Stationsstraat, 110, 2800 Belgium, , eddy.wille@ovam.be

Executive summary

Estimates have revealed moreover 500.000 landfills in the EU and the majority is no longer operational. According to limited mapping results, tens of thousands of historic landfills are situated in coastal and alluvial areas (in Flanders 55%). The content of these historic landfills could pose a significant environmental threat if they are flooded and erode. The impact of climate change on landfills is barely investigated. The main risks come from higher rainfall intensity in short intervals causing erosion and flooding. If flooding or demographic pressure remain an increasing factor, the stand-still principle is far more a contradictio in terminus than a sustainable solution. This paper gives an overview on the general aspects of flooding of landfills, the risks and the potential contribution of the ELFM-concept as a solution. The development of the specific approach by the governmental agencies in Flanders will be shown.

Introduction

On the 4th of September 2017, CNN spread the following news: "Toxic waste sites flooded: at least 13 toxic waste sites in Texas were flooded or damaged by Hurricane Harvey, according to the Environmental Protection Agency. ". This was possibly the first announcement of extreme weather conditions causing large environmental damage at landfill sites, mostly denominated as 'final waste disposal facilities'. Suddenly, due to this meteorological impact, eternity seems to last only several decades. These eternal storages of waste were commonly regarded as sources of methane and as such causing higher greenhouse gas concentrations and contributing to climate change.

Landfills and flooding risks

Since the 1950s Europe has been disposing vast levels of waste in landfills. Estimates have revealed 350.000 to 500.000 landfills in the EU (Hogland et.al, 2010[1]) whereof the majority is no longer operational and monitored. According to estimations based on limited mapping results, tens of thousands of historic landfills are situated in coastal and alluvial areas. The content of these historic landfills could pose a significant environmental threat if they are flooded and erode.

Already in 2009, D. Laner et.al.[2] investigated the risk of flooding of MSW landfills in Austria. Out of 1064 landfills, 312 sites or about 30% are located in or next to areas flooded on average once in 200 years. Around 5% of these landfills are equipped with flood protection facilities. Material inventories of 147 landfill sites endangered by flooding are established, and potential emissions during a flood event are estimated by assuming the worst case of complete landfill leaching and erosion. More recently, J. Brand[3] (2017) did research on UK's 21.027 historic landfills and assessed their individual vulnerability to flooding and coastal erosion. Nearly 3.000 of them located in flood plains – and a further 1.264 in low-lying coastal areas, often by the sea – many waste sites risk being flooded from heavy rain, storm surges and coastal erosion.

The Alaska Department of Environmental Conservation conducted a four-year $1.4 million project to inventory and rank vulnerable sites, and generate detailed action plans for the sites of highest concern. Its Final Report[4] in May 2015 includes the preliminary reports for each community visited, which provides a brief narrative of the community's sites and photos of each site. It also contains the detailed action plans for the 20 sites of highest concern, risking flooding within the next 50 years. In order to reduce damage of flooding, siting of hazardous facilities is an important element in the decision-making process. According to M. Sara[5] (2003), the 100-year floodplain is normally an exclusion zone for the disposal of solid waste. As a part of the National Flood Insurance Program, Flood Hazard Boundary Maps (FHBM) have been prepared for virtually all communities that have been identified as "flood prone". The regulations of Harris County[6] (cfr. supra CNN) stipulate that construction of critical facilities (e.g. waste disposal/storage) shall be, to the extent possible, located outside the limits of the 0.2% floodplain or 500-year floodplain (Shaded Zone X) and any "A" Zone. Despite these restrictions, 13 waste facilities were damaged and flooded during the Harvey hurricane (US EPA, 2017[7]).

At EU-level, the Directive 2007/60/EC[8] on the assessment and management of flood risks entered into force on 26 November 2007. This Directive requires Member States to assess if all water courses and coast lines are at risk from flooding, to map the flood extent and assets and humans at risk in these areas and to take adequate and coordinated measures to reduce this flood risk. Member States should carry out a preliminary assessment by 2011 to identify the river basins and associated coastal areas at risk of flooding. For such zones they would then need to draw up flood risk maps by 2013 and establish flood risk management plans focused on prevention, protection and preparedness by 2015. Regarding landfills, flood risk maps shall show the potential adverse consequences associated with installations as referred to in Annex I to Council Directive 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control which might cause accidental pollution in case of flooding and potentially affected protected areas. Guidances or best management practices on this specific issue are lacking to date.

Climate change and landfills

Landfills produce landfill gases (methane) and contribute as such to the greenhouse effect and climate change. This concept is not at stake but recent landfilling practices reveal a minor impact due to the fact that organic waste is no longer allowed to be landfilled. Table 2 pointed out that the drastic decline of landfilled organic waste resulted in much lower methane emissions from landfills. This implies a lower impact of landfills on climate change.

Those actions on the waste composition are one element in the discussion and also the surface of landfills should be considered as a potential contributor to sustainable development. According to the EU-project Sufalnet[9] (Sustainable Use of Former or Abandoned Landfills Network), former landfills occupy a considerable amount of space in all EU-Member States. Many sites are located at the edges of cities, towns and villages. However, with careful consideration, they have the potential to provide new facilities for local communities such as for recreation, as parks or nature reserves, for companies or offices, business and even for housing. The first SufalNet project (2005-2007) identified this problem of former and abandoned landfills at European level and developed a new approach for having these sites redeveloped. Moreover, specific initiatives on greening landfills and installing solar energy panels on top, result in a positive effect in view of climate change.

The impact of climate change on landfills is barely investigated. As mentioned above, the main risks come from higher rainfall intensity in short intervals causing erosion and flooding. Especially landfills in lower areas are vulnerable to these changes. The environmental consequences due to higher flooding patterns were seldom taken into account in the commonly used risk models. The external impact on landfills might be of larger importance than the internal adverse effects of the landfilled waste. The traditional management concepts aim at a continuation of the static feature, although the boundary conditions of the complex system are substantially changing. If flooding becomes an increasing factor, the stand-still principle is far more a contradictio in terminis than a sustainable solution.

Situation in Flanders (Belgium)

Since the end of the 18th century general regulations on waste management came into force. The decree of 16-24 August 1790[10] emphasized on the quick evacuation of waste out of the (medieval) city centre. Those cities were often situated along rivers and waste was initially transported to the adjacent lowlands. It can be regarded as a kind of land reclamation. Later on, shipment to larger landfills close to the water network became a common practice. Based on the OVAM inventory of landfills, VITO detected 965 landfill sites vulnerable to flooding on a total of 1735 sites, i.e. 55 %.

Table 1: Landfills and flooding risks in Flanders

Province	flooding risk		no flooding risk	
	number	ha	number	ha
Antwerp	260	1898.7	283	1368.8
Limburg	124	278.5	145	917.1
Eastern Flanders	132	930.7	75	930.7
Flemish Brabant	193	690.5	81	195.8
Western Flanders	256	1020.3	186	560.1
Total	965	4818.7	770	3972.4

Further research pointed out that more than 10 % of the vulnerable landfills areas were effectively flooded in the period 1988-2016. However, no serious damages were reported and landfilled waste was not eroded to date. In the next phase, OVAM conducted more detailed investigations to detect frequently flooded areas and anticipate more effectively to potential damages of sealing and protection systems at landfills.

The vast majority of the landfill facilities were closed before 1984 and currently only 28 landfills are operational. Only 7 landfill zones have public access and since the last decade less than 2% of the Municipal Solid Waste is landfilled. Landfill bans on both unsorted waste and on separately collected waste materials since 1998 and a landfill ban on combustible residual wastes since 2000, resulted in a decreasing content of biodegradable waste. The recovery rate of landfill gas is diminishing over the last decade: 13 installations produced 865 TJ in 2004 and 12 installations recovered 415 TJ (VITO[11]). A similar decreasing tendency was pointed out in the Environmental Status Report MIRA-T[12].

Table 2. Methane emissions in Flanders

Emission methane (kton CO2-eq)					
1990	1995	2000	2005	2006	2007
1 641	1 519	1 193	632	544	479

This positive effect of lower methane production is jeopardized by the increasing risk of flooding. Beside the erosion of waste, intrusion of water in old landfills can initiate renewed biogas production. Recently, OVAM discussed the issue with the responsible agencies on Flooding risk control (Sigma plan[13]). The presence of landfills is now integrated in the planning process in order to avoid supplementary risks.

The possibility of eliminating/mining landfills in alluvial areas is tested in 2 pilots. By introducing the concept of ELFM, the reduction of the landfilled material offers more options to create a safer environment to flooding. The reuse of the recycled material in new infrastructure is considered and was already proven in an earlier project at Zaventem. The surface take by the old landfill was reduced to less than 50% and the reclaimed space was reshaped as a buffer basin. The construction and demolition material was processed and partly reused on site. This action resulted in a remediated landfill site and better flood control; no dwellings were flooded since its installation in 1996. Landfills are no longer a threat but also an opportunity regarding to Climate change. Besides the recycling of materials, landfills may contribute to a multi-layer flooding safety management and be part of measures on climate adaptation[14].

Static features and dynamic systems

Operational standards for landfilling became more severe since the 1980s and waste dumps were phased out (1999/31/EC, Landfill Directive). Sanitary landfills are preferably sited at locations with a natural low vulnerable environment and precautionary measures are taken to prevent leakages. This involves protective liners and drainage infrastructure but also operational restrictions on the types of landfilled waste. After closure of the landfilling activities, a final cover is installed and if landfill gas is produced, an extraction unit evacuates these gases and is mostly combined with an energy-producing facility.

Sanitary landfills are operated under such conditions that they result in final waste disposal sites, thus creating a steady state landfill within a dynamic environment. All measures are (should be) put in place to avoid adverse impact and interaction with the environment. The dynamics of the adjacent media are not only limited to physical-chemical processes but also triggered by economic and social drivers. From that perspective, setting up a final disposal facility requires severe boundary conditions which are mostly attained by introducing containment measures resulting in an isolated volume of waste. This approach is in line with the conceptual site models and risk assessments in order to eliminate the exposure pathways and potential hazards for human health and the environment.

The impact between landfills and its environment is mutual and the traditional concept of isolating closed landfills from their surroundings is under pressure. The dynamics of the environment (ecological, economic and social) become a threat for static features such as landfills. The main purpose of ELFM is to recover resources (in the broadest sense as defined by the UNEP International Resource Panel: materials, energy, water and land) from landfill sites and to reuse them. The ultimate objective is to turn the threat of landfills into opportunities. The first results indicate that ELFM is a feasible option for obtaining added value in a broader perspective.

Overall mining of 2.000 landfills in Flanders is neither feasible nor advisable in the short term. A decision support system (Flaminco) was developed to set up a ranking of landfills based on the environmental risks and the redevelopment opportunities. An interim use was also considered which resulted in projects such as solar energy parks, methane extraction units (including introduction of nutrients to obtain a better-performing landfill bioreactor), resource extraction by leaching and interim use of land and waste.
ELFM² contributes to the transition to a circular economy in a healthy environment by the conditioning and transformation of landfills as stocks of resources. To develop and implement this ELFM² policy, OVAM has joined networks and shares good practices EU-wide. RAWFILL[15] is an INTERREG EU-funded landfill mining research project, gathering partners and associated partners of North-West Europe regions and supported by EURELCO. RAWFILL was launched in March 2017 and will end in March 2020.

RAWFILL develops a cost-effective standard framework for creating enhanced landfill inventories (ELIF) based on existing experiences, an innovative landfill characterization methodology by geophysical imaging and guided sampling and an associated Decision Support Tool (DST) to allow smart ELFM project prioritization. The DST is a ranking tool that will allow ELFM projects prioritization based on a set of suitable physical, chemical, environmental, technical and social information. It will integrate the multiple aspects involved in ELFM projects, i.e. economic, technical, environmental and social factors in order to compare and classify landfills regarding their ELFM interest. Figure gives an overview of the relevant parameters taken into account with DSTs.

RAWFILL's DST will operate at 2 levels:

- “Selection”: a first level of quick screening to identify landfills with a priori interesting potential/risk but which need further historical investigations and geophysical survey.
- “Ranking”: a prioritisation tool to rank pre-selected and fully investigated landfills of economic interest for resource recovery purposes. This 2nd level of the DST is a more dynamic model integrating the landfill in its physical, economic and social environment, including safety aspects of the operations.

By using these DSTs, long term landfill management plans could be developed also providing interim use at landfills sites which require no remedial actions or redevelopment/mining activities in the short time.

Conclusion

The waste management policies of the EU resulted in a significant decrease of landfilled waste and its biodegradable content. These actions imply an ongoing reduction of methane production and release of this greenhouse gas is also limited due to its energetic valorisation. This positive tendency is under pressure because of increasing flooding risks. A vulnerability index for historic landfill sites is needed to determine where resources and attention might best be focused. The concept of Enhanced Landfill Mining could become an appropriate option if (partly) relocation or remodelling of landfills is required.

References

1. W. Hogland, M. Hogland, M. Marques, “Enhanced Landfill Mining: Material recovery, energy utilization and economics in the EU (Directive) perspective.”, in Proceedings of the International Academic Symposium on Enhanced Landfill Mining. 4-6 October 2010, Houthalen-Helchteren, Belgium, p. 233-245, 2010.
2. D. Laner, J. Fellner, P. H. Brunner, “Flooding of municipal solid waste landfills — An environmental hazard?”, *Science of the Total Environment*, 2009.
3. J.H. Brand, “Assessing the risk of pollution from historic coastal landfills.”, PhD dissertation, Queen Mary University of London, 2017.
4. Department of Environmental Conservation. State of Alaska, “Waste erosion assessment and review. Final report.”, May 2015.
5. M. Sara, “Site Assessment and Remediation Handbook.”, Lewis Publishers, 2003.
6. Harris County, Regulations of Harris County-Texas for Flood plain management, revision 2011.
7. US Environmental Protection Agency, website Hurricane Harvey, 2017, https://response.epa.gov/site/site_profile.aspx?site_id=12353.
8. EU. “Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks”.
9. Interreg IIIc Sufalnet, www.interreg4c.eu/uploads/media/pdf/SUFALNET_4W0151N.pdf
10. J. Van Eeckhout, “Van mestrapers tot beerruimers: over afval en afvalverwerking in Aalst (1800-1901), master dissertation, University Ghent, 2009.
11. VITO, “Inventaris hernieuwbare energiebronnen Vlaanderen 2005-2013”, 2015.
12. Vlaamse Overheid. “MIRA-T Milieurapport Vlaanderen 2008. Indicatorrapport.”, 2008.
13. De Vlaamse Waterweg, Agentschap Natuur en Bos, “The Sigma plan.”, 2017.
14. N. Bal, E. Luyten, W. Tempst, A. Van Pelt, J. Wante, E. Wille, “ De circulariteit als strategie voor een klimaatbestendige economie.”, in Adapt for life, InPlanning, 2017.
15. RAWFILL, www.nweurope.eu/rawfill