The Role Of Sustainable Landfill In Future Waste Management Systems

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EXECUTIVE SUMMARY: Prevention, re-use and recycling should be promoted over disposal. Materials should not be landfilled if an alternative option is available that is practically, economically and environmentally more sensible. Members of the Sustainable Landfill Foundation support the aim of the European Landfill Directive, which is to reduce the environmental impact of landfill. Members of the Foundation also support financial instruments to promote prevention, re-use and recycling. But no matter how much prevention, re-use and recycling a society realises, there will always be a role for landfill in a waste management system, namely to dispose of wastes that for some reason cannot be prevented, re-used or recycled. There are some types of waste for which landfill is the best waste management option. Moreover, treatment of waste results in residues for which there is very often no option other than landfill available. Landfill is also a 'safety net' for other waste management operations experiencing a (temporary) lack of capacity. Landfill will continue to play a role in future waste management systems. This means that landfill is a valuable and essential element of any integrated waste management system, and should be recognised as such. A society striving for sustainable development needs sustainable methods of landfilling. As well as environmental considerations, sustainability has many other facets, including economic and social. One could imagine development that is considered sustainable from an environmental perspective but is too expensive for a society. It is clear that this society could not sustain such development in the long run. In general there is agreement that … sustainable development …meets the needs of the present without compromising the ability of future generations to meet their own needs (definition of the UN Bruntland Committee). It follows from this definition that every generation should solve its own problems. Very often a maximum period of 30 years is assumed. Recently enormous progress has been made in understanding and predicting landfill processes. This enables risk and impact assessment as promoted by EU regulation. It should be noted that it is not landfill in itself that is undesired, but its environmental impact. Sustainable landfill will tackle that. The research has indicated that for many types of waste with suitable process optimisation sustainable landfill is feasible. It offers solutions for different types of waste: organic, inorganic and hazardous waste suitable for immobilisation. If we are really serious about protecting human health and the environment, we should also be prepared to consider that landfill in some cases is not the least desired option of the waste management hierarchy.

SUSTAINABLE DEVELOPMENT

Europe aims at moving up in the waste hierarchy, away from landfill and more and more towards a recycling and recovery society. With the title 'Taking sustainable use of resources forward' the European Commission in 2005 proposed the thematic strategy on the prevention and recycling of waste (CEC, 2005). Since 1999 the Landfill Directive (CEC, 1999) contains requirements to reduce the amount of waste to be landfilled. In 2016 member states are not allowed to landfill more than 35% of the biodegradable municipal waste they landfilled in 1995. Some countries are allowed to reach this target four years later. As in Europe, the key objective of the waste policy in the

Netherlands is to prevent the generation of waste. If prevention is not possible, waste should be re-used or recycled. If that is not possible either, it should be incinerated with energy production. Only if other waste treatment options are not suited, the waste should be landfilled.

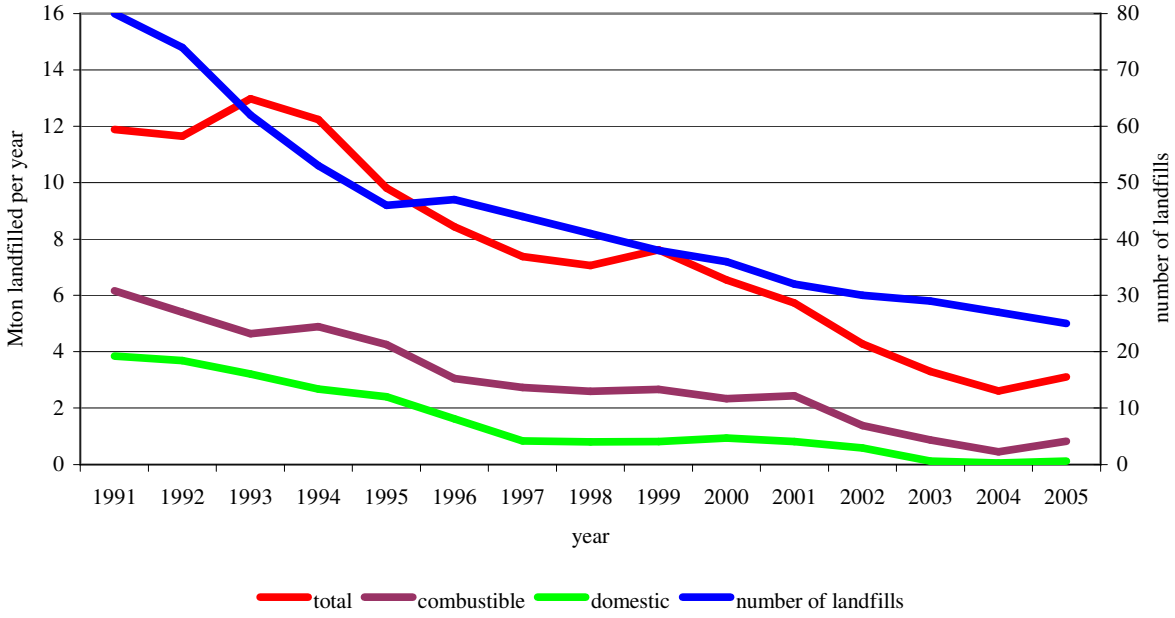

Figure 1. Development of landfill in The Netherlands (Werkgroep Afvalregistratie, 2006).

By legislation the Dutch government banned landfilling of 35 categories of waste. This included waste such as recyclable materials -like used glass, waste paper and VFG-waste (vegetable, fruit and garden), household and comparable wastes and construction and demolition waste. The first bans became effective in January 1996. This policy has lead to a decrease in the amount of waste to landfill. In 1993 about 13 million tonnes of waste were landfilled. In 2005 only 3 million tonnes were landfilled. In the same period the number of operational landfills reduced from around 80 to less than 30.

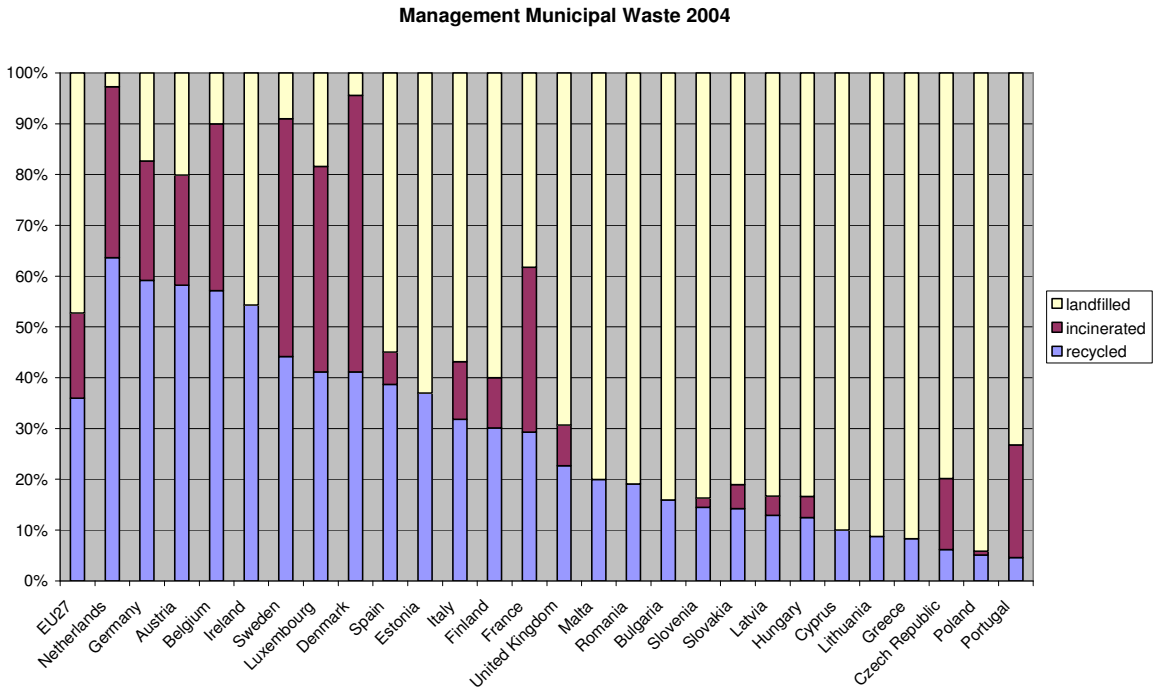

Figure 2. Management of municipal waste in the EU27 in 2004 (Eurostat, 2006)

During the last decade the Dutch waste management policy has been very successful. It has resulted in high recycling rates. The Dutch recycling rate of municipal waste is among the highest in Europe (Fig. 2). Landfill of municipal solid waste is very low. Plans for extra incineration capacity are proposed and the regulation on the reuse of soil and other stony wastes is being revised. The total amount of waste to be landfilled will reduce further.

THE NEED FOR SUSTAINABLE LANDFILLS

No matter how much prevention, re-use and recycling a society manages to realise, there will always be a role for landfill in a waste management system. It will not be economically sound to have enough capacity to recycle or recover all waste under all conditions. While aiming for more prevention it is economically unsound to invest in recycling and recovery of waste that is bound to disappear. Furhtermore, the amounts of waste fluctuate over the year. Sometimes the amount of waste exceeds the capacity for recycling, recovery or incineration. Not all wastes can be recycled, recovered or incinerated. For some wastes landfill is the best option. And in case a recovery or incineration plant is out of operation because of maintenance, repair or an accident, the waste should not remain in the streets. This means that even in a recycling and recovery society some wastes need to be landfilled. The landfill sites are the 'safety net' in a good waste management system. Landfill should be carried out in a way such that future generations do not have to worry about it. It should be done in a sustainable way.

Figure 3. Construction of an impermeable hdpe top liner.

Isolation of landfills by means of impermeable liners (Figure 3) seems to become the standard in Europe. Isolation stops all processes in the landfill. Liners may hold for fifty years. They may even hold for five hundred years. But they will inevitably fail at some point in time. When the liners fail the processes, as driving force for emission, will start up again. Therefore potential emissions are postponed to future generations. Aftercare is a requirement of many national regulations. Aftercare generally has to be carried out for at least thirty to sixty years after the closure of a landfill. Some countries require it 'as long as the competent authority considers it necessary'. Aftercare cannot be considered sustainable, given the UN Bruntland Committee's interpretation of sustainability. Clearly aftercare is always required for longer than one generation. We can question whether it is acceptable to impose the threat of imminent emissions on our children's children's children. An

intrinsically safe solution would be more sustainable. A society striving for sustainable development consequently needs sustainable landfills.

WHAT IS A SUSTAINABLE LANDFILL

There is no internationally accepted definition of sustainable landfill. With respect to landfills very often terms as stability, completion, end-point and threat to the environment are used together in discussions about sustainability. A selection of definitions is:

- SWANA Stability Subcommittee (Barlaz, 2005): A landfill is 'functionally stable' when the waste mass, post-closure, does not pose a threat to human health and the environment. This condition must be assessed in consideration of leachate quality and quantity; gas composition and production; cover, side-slope and liner design; site geology and hydrogeology; climate; potential receiving bodies, ecosystems and human exposure; and other factors deemed relevant on a site-specific basis.
- Anglo-Welsh Environment Agency (Environment Agency, 2005): Completion is defined as that point at which a landfill has stabilised physically, chemically and biologically to such a degree that the undisturbed contents of the site are unlikely to pose a pollution risk in the landfill's environmental setting. At completion, active aftercare pollution controls (e.g. leachate management and gas management) and monitoring systems are no longer required.
- DHI (Hjelmar, 2005): Waste at final storage quality provides a situation where active environmental protection measures at the landfill are no longer necessary and the leachate is acceptable in the surrounding environment.
- Technical University of Hamburg (Stegmann, 2003): The aftercare phase may end when the emission potential is that low that the actual emissions do not harm the environment.

Although the different definitions use slightly different wording, there seems to be a general consent that a sustainable landfill or a landfill for which it is considered safe to end aftercare is a landfill that within a limited period of time reaches a state where the undisturbed contents no longer pose a threat to human health and the environment. At that point, often called completion, aftercare can be ended. It is important to note that this is in accordance with the intention of European waste legislation. The Annex II of the Landfill Directive requires neither isolation nor aftercare for landfills for inert waste (CEC, 2003a). And it defines inert waste in similar terms. That is: not posing any threat to human health and the environment.

FEASIBILITY OF SUSTAINABLE LANDFILL

Throughout the world various methods are proposed to stimulate landfill processes in order to accelerate achievement of a stabilised landfill. In the end the goal is the same: to achieve completion of the landfill. Most of the proposed methods relate to pre-treatment or bioreactor type of operation for biodegradable organic waste. When most of the organic carbon has been degraded the behaviour of the landfill body converges to the behaviour of an inorganic waste landfill (Mathlener et al., 2006). The same applies to (suitable types of) hazardous waste after immobilisation or cement stabilisation. In other words: for all types of waste on the road to completion it seems inevitable to 'pass through' a stage that is comparable to an inorganic waste landfill (Figure 4). An inorganic waste landfill is not necessarily a stabilised landfill. There are components that can not be biologically stabilised or immobilised with cement-like additives. Such components either need to be flushed out or 'caught' in 'precipitates'. When that state is achieved the behaviour of the landfill is very much like the behaviour of a landfill for inert waste.

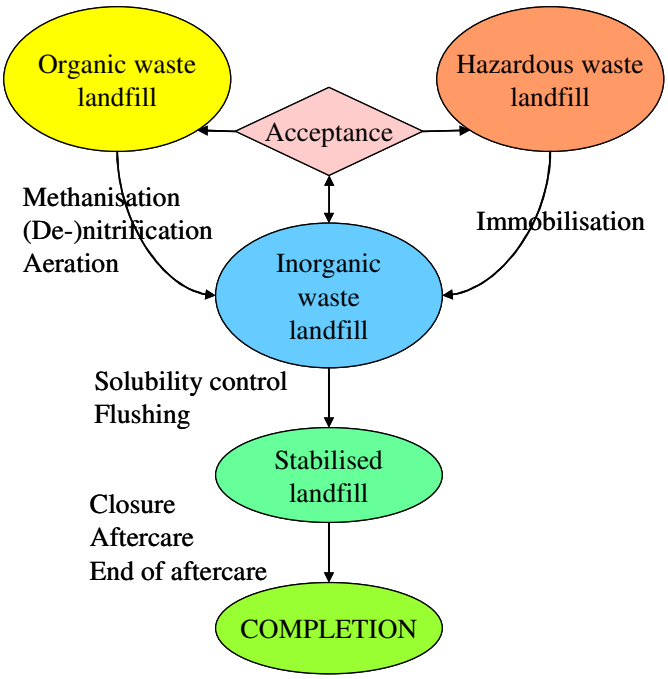

Figure 4. Waste types and processes to achieve a stabilised sustainable landfill.

Between 1999 and 2005 a comprehensive research program has been carried out in The Netherlands. With sustainable landfill better results are achieved than current practices and it can be used for many different types of waste (Mathlener et al., 2006). By careful selection of solid waste input and suitable control measures (Table 1) it is possible to obtain a landfill that performs in compliance with the standards of the EU Landfill Directive of a landfill for inert solid waste. Compliance with the proposed European Groundwater Directive (CEC, 2003b) is uncertain with regard to chloride, sulphate and ammonia.

Table 1. Combination of processes and types of emission components

Process / Component	Waste Selection	Solidification / stabilisation	Biodegradation	Solubility control	Flushing
Org. matter properties	X	-	X	x	x
Organic contamination	X**	X	x	X##	X#
Metals	X	X	X	X	x
Oxyanions	X	X	x	X	X
Salts	X	X	-	-	X

Legend:

**	Evaluation by leaching is lacking as yet.
#	Only for water soluble organic contaminants.
##	Relevant for poorly water soluble constituents.
X	Strong influence, can be applied to minimise or to control the release.
x	Some effect, possibly a side-effect of the main effect for other components.

Figure 5. Landfill enjoyed by people.

In landfills, containing organic material, biodegradation is the most important process. It produces, removes, mobilises and immobilises key pollutants. Biodegradation can be enhanced by leachate recirculation and leads to reduced emissions. The flushing of contaminants from the landfill appears to be the limiting factor. Emissions of contaminants from inorganic waste can meet the criteria for inert waste, except for chloride and sulphate. Clever combinations of waste enable us to create beneficial conditions for the leaching behaviour of contaminants. Oxyanions and salts seem to be critical parameters in the judgment of stabilised waste with respect to the criteria for hazardous waste. Although not all questions have been solved in detail, it can be stated that most proceses are known and applicable. It estimated that applying the processes would results in a cost increase of 10 to 20% compared to the costs of an EU Landfill Directive compliant landfill.

CONCLUSIONS

The project shows that a sustainable landfill:

- has final emissions that are lower than ordinary landfills;
- has an emission release that occurs within a shorter period of time;
- enables active control and prediction of emissions and;
- is technically and economically feasible.

Pollutants are transported through the environment when there are differences in their concentration. If there is no significant difference, there is no transport. As soon as the internal environment of a landfill is stabilised and comparable to the conditions in the surrounding soil there are no natural gradients between the two. There will then be no transfer of pollution from the landfill into the surrounding environment. When waste is landfilled in a sustainable way, pollutants are either broken down into harmless substances and/or flushed out (and therefore rendered harmless) or immobilised in the landfill and so remain there for ever. Enormous progress has been made in understanding and predicting landfill processes. This enables risk and impact assessment as promoted by EU regulation. It should be noted that it is not landfill in itself that is undesired, but its environmental impact. Sustainable landfill will tackle that. It offers solutions for different types of waste: organic, inorganic and hazardous waste suitable for immobilisation. If we are really serious about protecting human health and the environment, we should also be prepared to consider that

landfill in some cases is not the least desired option of the waste management hierarchy. Sustainable landfill sites no longer pose a threat to human health or the environment and can be used for much wider applications (Figure 6) after the operational period than previously believed possible.

Figure 6. Office building under construction on top of a landfill.

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