COCOON
Interreg Europe

Good Practice Handbook

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SAMEN MAKEN WE MORGEN MOOIER OVAM
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sadeco
WASTESERV CREATING RESOURCES FROM WASTE

Abstract

Landfills are an essential part of the economy. Typically associated with the end of a product's lifecycle in a linear economy, landfills are proven to be an essential asset for the circular economy as well. As such, landfills are here to stay for the foreseeable future.
Due to the often hazardous nature of waste, good management of landfills (both old and new) is essential to guaranteeing safe and sustainable landfilling. This handbook, a product of the Interreg Europe COCOON project, provides good practices learned through realized projects for the safe and effective management of waste. The practices cover a broad range of topics, including but not limited to waste reduction, landfill design, policy, economics, and aftercare.

Disclaimer:
This report was developed in the framework of the Interreg Europe project COCOON. COCOON receives 1.4 Mio. euro from the ERDF. This report only reflects the author's view, the programme authorities are not liable for any use that may be made of the information contained herein.

About this handbook

Since the 1950's, Europe has been disposing vast levels of waste in landfills. Estimates from the EURELCO consortium have revealed that 90% of Europe's 500,000+ landfills are "non-sanitary" landfills, which predate the EU Landfill Directive and have limited environmental protection technologies. The Landfill Directive provides a standardisation for all EU member States to operate their landfills, following procedures aimed to prevent or reduce possible negative effects on the environment and human health. The afore mentioned negative effects include both local (surface water, groundwater, soil, air) and global (greenhouse gas emissions) forms of pollution. As a result the Directive does have some implications on waste handling and waste disposal, yet it does not fully cover landfill management in a targeted or specific way.

The lack of an adequate European landfill management legislation or framework allows for some flexibility on how to cope with environmental, economic, social, and technical challenges faced when landfilling waste. Many EU regions are already implementing landfill management in the absence of a specific landfill management legislation, leading to a divergence of applied methodologies.

This handbook is comprised of Good Practices encountered during the COCOON project. COCOON is an Interreg Europe project with the aim to improve the policy on landfill management in the participating regions. During the first phase the partners extensively exchanged experience on different aspects of landfill management, also by describing good practices related to landfill management.

This handbook serves not only to form a compendium of the encountered good practices, but also to disseminate these findings outside the project. The handbook itself is aimed to reach a broad audience of both technical, managerial and policy minded individuals in the hopes of providing demonstrated alternatives and inspiration when tackling the complexities of landfill management.

Each featured good practice is based on projects executed by the member States. The description of each practice has purposefully been kept as simple as possible. Should the reader have a particular interest in a practice, they can find contact details of the author/organisation in question listed with each practice.
Aside from pure landfill management practices, innovative ways are also addressed to:

- Stimulate waste reduction
  Taxation, sorting, etc.
- Create economically viable resources through landfill mining
  Using computational based assessments, temporary storage, implementation of policy tools, etc.
- Integrate landfills into a circular economy
  Landfill gas reclamation, resource mining, application of inert waste materials as construction material, etc.
- Integrate closed landfills into the urban landscape
  Rehabilitation with residential, recreational, educational or ecological purpose.
- Consider alternative financing and economic options within the sphere of waste management
  Citizen led cooperatives, mandatory provisions of aftercare funds, etc.

The categorisation of the individual practices is complicated due to the broad range of topics and situations covered. The authors have thus resolved to consider three categories with associated keywords for further differentiation.

The categories have been identified as:

1. **Old landfills**
   This category encompasses those practices applied to landfills predating the 1999 European Landfill Directive.
2. **New landfills**
   This category covers those practices applicable to landfills which are compliant with the 1999 landfill directive.
3. **Future landfills**
   This category refers to practices applicable to either future landfills, or innovative solutions which go beyond legislative requirements.

The keywords used for further differentiation are listed below for readers interested in a particular topic, irrespective of which type of landfills they can be applied to.

- Waste pretreatment
- Land use
- Waste separations
- Sealing
- Landfill leachate
- Groundwater
- Gas
- Rehabilitation
- Policy
- Sustainability
- Energy
- Landfill mining
- Monitoring
- Design
- Management
- Aftercare
- Tool
- Circular economy
- Finance
- Interim use
- Storage
- Waste
- Legislation
- Economics
- Awareness
- Communication

This handbook is a snapshot of the Good Practices collected up until November 2019. Good Practices, by their nature, keep evolving. For the interested reader we therefore also recommend to consult the online repository for landfill management good practices.

All good practices were divided into the three categories. The x in the following table marks if the good practice applied on, new and/or future landfills:

	Old	New	Future
BioZon: Cooperative energy production from landfill gas extraction	x		
Brownfield covenants as an instrument to revitalize former landfill sites	x		
Zaventem: turning an old landfill into a buffer basin to prevent flooding	x		
Cedalion and Orion, a decision support tool for dynamic landfill management	x		
CHARM: Airborne Detection of Methane emissions of landfills	x		
COllective REgeneration of former Landfills, COREL	x		
Complex remediation of a closed landfill below groundwater level	x		
'De Blankaart' landfill mining project: an economic viable case	x		
Extended landfill gas treatment by CHP with reservoir – case Lübben	x		
Industrial use of a closed landfill in Antequera	x		
Klaverenboer ward: landfill remediation and tackling land pressure	x		
Landfill mining to develop the area in housing area in Veenendaal	x		
Landfill remediation by excavation – Case Treuenbrietzen	x		
Marsascala Family Park: Rehabilitation of a Landfill into a Park	x		
NAVOS: Remediation strategies for former landfills in the Netherlands	x		
Possibilities of using a closed landfill area for production of renewable energy	x		
Rehabilitation of the Qortin Landfill in Gozo	x		
Rehabilitation of "La Pitilla" landfill	x		
Remediation of a landfill with low risk potential in a rural environment	x		
Remediation of a large-scale landfill by installing a surface sealing system	x		

Remediation of two landfill sites by landfill excavation in Amersfoort	x		
	Old	**New**	**Future**
The Natural Cap – Sustainable solution for landfills	x		
Using a landfill area after closure, for a Waste management facility	x		
From Landfill to Energy Campus – Case Leeuwarden	x	x	
Project :metabolon - Innovative interim use of the Leppe landfill	x	x	
Flemish ELFM Consortium	x	x	x
Methane oxidation systems for the biological treatment of weak gas	x	x	x
Aerobic fermentation of municipal waste inside the landfill in Cordoba		x	
Bird Rock, Den Helder		x	
Gozo Waste Transfer Station and Material Recovery Facility		x	
Quality control of technical elements of landfills by an independent third-party		x	
Remediation of a landfill by a surface sealing system with an electronic leak control system		x	
Requirements for the design of a sanitary landfill: The Dutch practice and legislation.		x	
Surface capping: Constructing top soil by incorporation of compost		x	
Use of slag for the construction of the drainage layer at the landfill Schwanebeck		x	
Finance of Aftercare of landfills in the Netherlands		x	x
Flemish raise awareness campaigns on waste sorting		x	x
Geophysical Prospection for the detection of leachate in a Municipal Solid Waste landfill		x	x
Temporary storage on landfills policy in Flanders		x	x
Waste deposit and landfill tax system of Flanders		x	x
Green Deal: “Sustainable Landfill Management” (SLM)			x

BioZon: Cooperative energy production from landfill gas extraction

A former landfill of municipal waste leads to resistance from the local community. Now they make a profit from renewable electricity out of landfill gas.

A former landfill (24 ha) of municipal waste was in use from 1960 until 1990. The former landfill has been covered with trisoplast and a two meters thick soil layer. Before covering a landfill gas extraction system was realised.
The extracted landfill gas is used to produce renewable electricity. Since 1994 a commercial enterprise exploited the landfill gas installation. The engine had to be replaced by a smaller one that fits to the actual gas volume. This resulted in a business model that was no longer positive for the commercial enterprise. At that moment, a new business model idea was born.
AGEM, a collaboration of municipalities and citizens from the Achterhoek-region, supports the ambition of an energy neutral region in 2030. AGEM set up the local cooperative BioZon to replace the old motor and exploit the landfill gas installation.
Now BioZon runs the 80 kW gas installation. Members of the BioZon cooperative profit from a national tax regulation for renewable energy according to their certificates of participation. Above ground the landfill was transformed into an attractive green hill full of nature, which is an open area for hikers and other recreational activities like a donkey stable, where tourists can walk along with a donkey. After 6 years even the cooperative gas turbine will be too large for the remaining gas availability. At that point the cooperative saved enough budget to purchase an PV-installation to continue renewable energy production.

BioZon: Cooperative energy production from landfill gas extraction

Resources needed

The BioZon cooperation exploits the installation. It is financed by a subsidy from the province and selling certificates to the local community. Total estimated costs of exploitation are € 205,000 for the next 6 years.

Evidence of success

BioZon is unique in its kind since it is the first landfill gas project completely financed by the local community. The initiative came from AGEM, a cooperation of municipalities, citizens and business life out of the region Achterhoek, that has the ambition to become an energy neutral region in 2030.

The municipality, participant in AGEM, is owner of the landfill. They are responsible for monitoring around and maintaining the top layer of the landfill.

Difficulties encountered

Biggest challenge for AGEM was to get a positive business case, by selling shares for BioZon to the local community. This succeeded by information provided by local media (newspapers and social media).

Potential for learning/ transfer

Members of the energy cooperation profit from a national tax regulation, which gives them exemption of energy taxes based on the amount of electricity they produce (in kWh) according to their certificates of participation. The landfill gas installation, that is now called 'the Green Engine' by the energy cooperation, is running continually on 80 kW of power. The energy cooperation is selling the electricity that is produced to AGEM, which is an official reseller of local renewable energy. Members of the cooperation can become customer of AGEM and purchase the own produced local green electricity. Both the energy cooperation and AGEM strive to maximal involvement of local businesses. Since the region Achterhoek has to deal with a population decline, this is a very desirable effect. The lesson learned is that by involving the local community a former landfill can be given a new function and especially generates income for a shrinking community.

Keywords

Gas, Energy, Design, Management, Finance, Economics, Communication

Period

January 2019 – Ongoing

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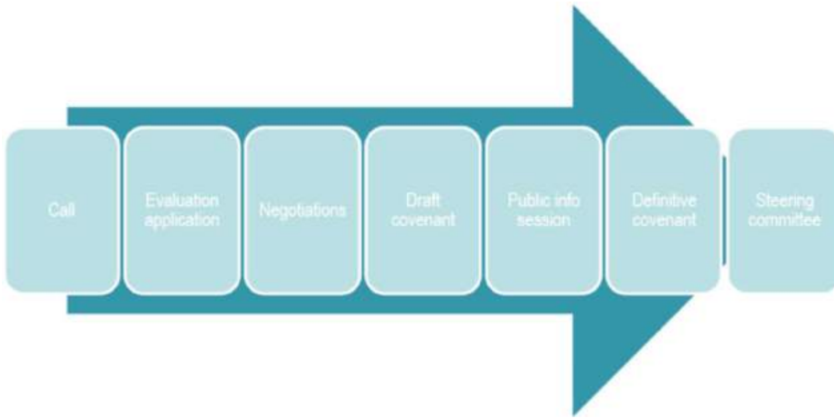
Brownfield covenants as an instrument to revitalize former landfill sites



Landfill sites can be seen as specific kind of brownfields, therefore those redevelopment processes and instruments were customized for landfills in Flanders.

Reallocation of industrial activities sometimes resulted in abandoned or under used sites, also known as brownfields. The Brownfield Covenant Act (March 22, 2007) offers developers the opportunity to sign a contract with the Government of Flanders and other private and public stakeholders, describing mutual commitments for the realization of a brownfield project. This contract is the result of a process for gaining the (public) support and the cooperation of all the stakeholders involved.

Quite often, brownfields include former landfills and even stand-alone landfills could be regarded as brownfields. OVAM identified about 3.300 former landfills. Since 2017, specific calls for the brownfield redevelopment of former landfills were launched. This procedure facilitates land owners and developers to revitalize such landfill sites.

A negotiator is appointed by the Flemish government in order to streamline this process. He/she sets up a platform where actors and stakeholders could meet and discuss the plans. This multi-actor governance is not limited to public actors at several levels (local, regional, federal) but also civil society is involved. After approval, a covenant is signed and a steering committee installed (chaired by the negotiator) in order to follow up the progress and tackle the problems. The overarching programme is coordinated by the Brownfield Board, consisting of the CEOs of the involved governmental agencies and representatives of the ministers.

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Brownfield covenants as an instrument to revitalize former landfill sites

Resources needed

5 part-time negotiators (3 Full Time Equivalent) are active in the field and supported by people of VLAIO-agency (3 FTE). Their specific time use and management costs on this process of landfill revitalization is yearly about 0.5 FTE and € 30.000 (the costs of the realisation of the projects are not included).

Difficulties encountered

The Brownfield policy involves aspects such as economics, spatial planning, mobility and environmental issues.
Communication on this innovative concept of landfill revitalization is crucial because the current vision is aiming at a static situation, often implying no activities on those sites.

Evidence of success

During the first 2 calls, 8 projects on landfills were introduced (about 1/3 of proposals). Still new proposals are in preparation for the next calls.

Potential for learning/ transfer

This integrated approach of brownfield covenants leads to a better understanding of the redevelopment issues. A successful redevelopment process is not only triggered by finding the best available soil remediation technique or the highest real estate value. The first steps focus on creating a common ground on the revitalization plans. The Brownfield covenant programme points out how those goals are achieved by bringing the stakeholders together.
Also see:
www.ovam.be/brownfields (only in dutch)
www.ovamenglish.be/dlm-explained
(broader concept of Dynamic Landfill Management)

Keywords

Land use, Policy, Aftercare, Finance, Waste

Period

March 2017 – Ongoing

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Zaventem: turning an old landfill into a buffer basin to prevent flooding

A ward in the municipality of Zaventem suffered from flooding. The problem was solved by turning a local landfill into a buffer basin.

From a historical point of view, many landfills in Flanders are in fact local depressions of rivers and streams that were levelled to make them suitable for agricultural or domestic purposes. This was okay, since surface waters had enough alternatives and land to infiltrate to not become a problem.
However, since the urban sprawl started after the last World War, the amount of open land that got sealed by concrete and buildings has gone through the roof. This causes floods, since water can't infiltrate anymore, runs off and collects at the local lowest point. One of these local low points was a residential area in the municipality of Zaventem, close to the Hector Henneaulaan. Several houses were damaged multiple times due to floods after intense rains. It was decided to create a buffer basin to store the excess water when flooding risk was high. As earlier mentioned, the historical context of landfills in Flanders proved to be the key of this case. A landfill of about one hectare, which levelled one part of the Woluwebeek valley, proved to be perfect for the buffer basin: close by, good topographical properties and free of buildings. One metre of mixed waste was partially recycled: the waste was sieved and the soil was redeposited on site and used to mould the edge of the basin. A HPDE layer was added and on top of this concrete porous blocks were placed to create a semi-natural dike.

Zaventem: turning an old landfill into a buffer basin to prevent flooding

Resources needed

This redevelopment was done by the municipality of Zaventem. We don't have any figures on the total redevelopment cost.

Difficulties encountered

None in this project.

Evidence of success

Since the buffer basin is finished, not a single flooding was registered in the affected neighbourhood.

Potential for learning/ transfer

The case of Zaventem shows that a quickly changing context may overrule the content of the landfill as a decisive factor. Although the value of the content nor the price of the land changed significantly, the insurance value of the affected houses did. Subsequently this was the last piece of the puzzle to initiate the whole process of dynamic landfill management. Managers of landfills should be aware that these type of cases will be much more common than landfills that are interesting solely for their content.

Keywords

Land use, Landfill mining, Waste

Period

January 2017 – January 2018

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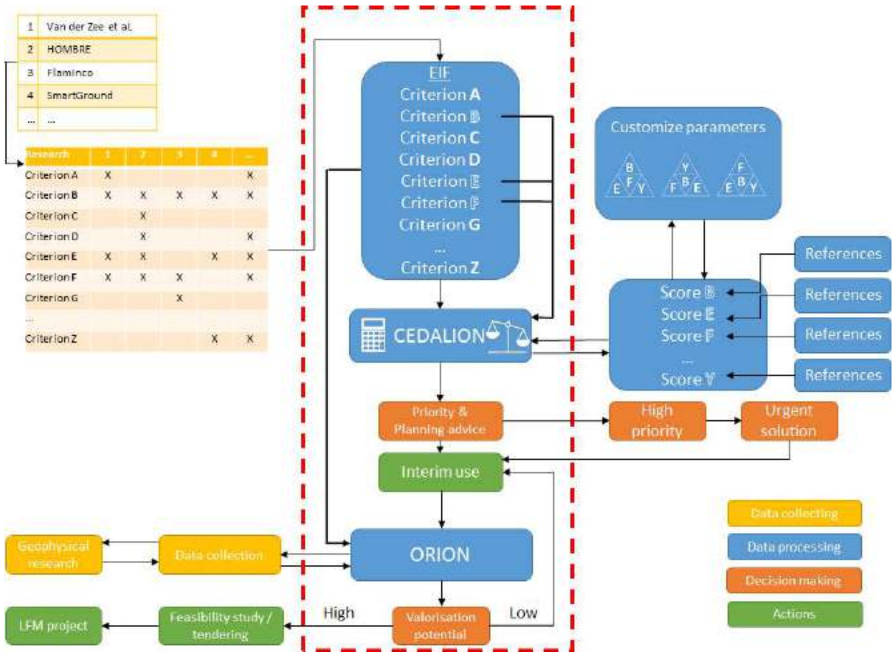
Cedalion and Orion, a decision support tool for dynamic landfill management



The Cedalion and Orion tool ranks a region's landfills to their potential and afterwards calculates a business case for the most promising landfills.

Every country in Europe has buried waste from the past, and quite some of it. What to do with all this lost space? Which landfill need to be tackled first? The dual tool tries to support the decisions that policy makers need to take when dealing with these landfills. Originally created in the Interreg project RAWFILL, the dual tool builds on existing tools and platforms from other European projects, rather than constructing another one.

The Cedalion tool is based on a Flemish decision support tool (Flaminco), that is modified to meet current knowledge and standards. It consists of a desktop programme where the main database is located and the calculations are done. An application makes it possible to collect up-to-date information and send it to the calculation sheet.

The Orion tool is a platform consisting out of existing tools, each with its strengths and weaknesses. It will help the user with estimations about the profitability of a business case, simulating certain scenario's or finding interim solutions.

The latter, interim use, is the novelty in this dual tool. It is a time loop in the programme. The landfill will be given a function that is beneficial for nature and/or society while buying time until a certain point in the future where a full valorisation point might be profitable. Interim use can go from one year up to several decades.

Cedalion and Orion, a decision support tool for dynamic landfill management

Resources needed

All together at least 10 FTE have contributed to this tool from July 2017 onwards and are continuing to do so. Specific costs (excl. wages) are estimated to be € 60,000 up to now.

Difficulties encountered

The initial versions of both tools will undergo a trial period. The goal for Cedalion is a tool that is so user friendly that it can be used by someone with no experience in landfill management (LfM). Before the trial period two parties familiar with LfM indicated the tool was still too complex.

Evidence of success

The Flaminco tool, the framework for Cedalion is a proof-of-concept of a decision support tool being used to help with enhanced landfill mining projects i.e. the allotment in the Speelkaarten quarter of Turnhout. The completed dual tool will be put to the test in the RAWFILL project on a number of landfills and results will be published according to the project agreement.

Potential for learning/ transfer

After delivery, both the desktop programme and app will be freeware. It lowers the threshold for municipalities, regions and companies to actively do something with the estimated half a million landfills that are spread across Europe.

By offering a standardized way of collecting data, it might get easier in the future to exchange data and information between regions or EU countries, a current problem that was detected in the COCOON Report on mapping.

Keywords

Land use, Groundwater, Energy, Landfill mining, Management, Tool, Finance, Interim use, Waste, Economics

Period

July 2017 – Ongoing

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CHARM: Airborne Detection of Methane emissions of landfills

Detection of methane emission hot spots and measurement of the total methane emission of a landfill by using the helicopter-based CHARM-technology.

In order to identify traces of methane, CHARM® uses the property of chemical compounds to absorb light of certain wavelengths. The system sends out two laser pulses of different wavelengths. The first wavelength is specifically absorbed by methane, while the second is not absorbed. Both light impulses hit the ground and are scattered in all directions. A very small part of the light returns to the system and is detected by a sensor.

The Ministry of the Environment, Climate Protection and the Energy Sector Baden-Württemberg contracted ADLARES GmbH to apply the helicopter-borne methane detection system CHARM® to survey the landfill Hohberg (Pforzheim, area: 14 ha) for two purposes:

- Detection of methane emission hot spots
- Determination of the total methane emission of the landfill

In order to detect methane emission hot spots, a helicopter flew over the landfill along predetermined tracks. The CHARM® automatic tracking and scanning system distributed 100 measurement spots per second along the tracks finally covering the whole landfill (in total several hundred thousand spots). The dense and complete coverage of the landfill with georeferenced measurements enabled to pinpoint emission hotspots.

For the determination of the total methane emission of the landfill the system measured the methane concentration along a track surrounding the complete landfill. In addition the wind was measured. The total methane net flux was determined numerically according to the Gauss theorem.

CHARM: Airborne Detection of Methane emissions of landfills

Resources needed

The costs of CHARM® services varies with the necessary transfer flight duration of the helicopter. Commonly helicopters cost about € 3000 per hour of flight. In the case of the total emission determination additional staff for the wind measurement is needed.

Difficulties encountered

The CHARM® measurements require stable wind conditions. The wind conditions have a major influence on the quality of the results. Very low wind conditions (< 1,5 m/s) are difficult (stability problems), and strong wind (> 6 m/s) will prohibit the detection of very small emission sources.

Evidence of success

The advantage of this practice compared to other established methods ~~are~~ is the dense and complete coverage with measurement spots even in areas which are hard to access. The dense coverage yields a very small likelihood to miss an emission hot spot.
This practice enables to directly measure the total methane emission instead of numerical modelling

Potential for learning/ transfer

The application of this good practice allows the landfill operator to detect emission hot spots even on hardly accessible areas, which is one requirement to reduce the methane emission of a landfill. The determination of the total methane emission helps to determine the importance of further methane emission reduction measures.
The Public Waste Agency of Flanders is investigating if this technology can be used in Flanders to determine emission from the landfills in close vicinity of gas pipelines, where the CHARM® technique is applied frequently for leak detection. About 33% of all landfills in Flanders are close to such gas pipelines.

Keywords

Gas, Monitoring, Aftercare, Tool

Period

April 2016 – Ongoing

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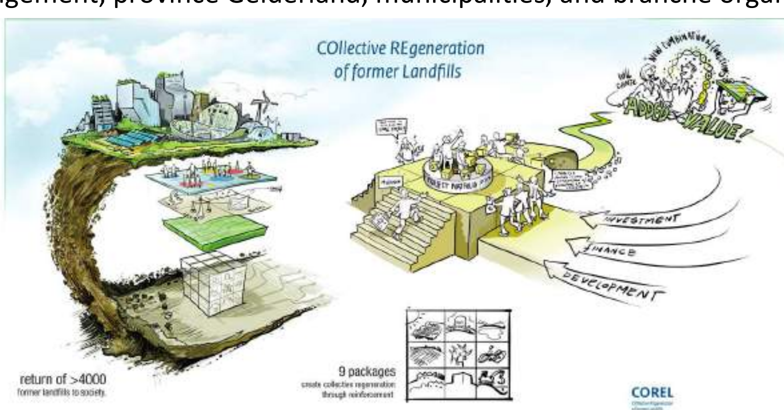
COllective REgeneration of former Landfills, COREL

COREL: A method for governments and financiers to take responsibility for the multifunctional regeneration of former landfills.

COREL is in its first stage of implementation. Developing clean energy, a park, agriculture, housing, industry and more functions is a way to regenerate a former landfill with a sound business case. This business case increases when these various functions share costs, and enhance one another, for instance when agriculture takes place under solar panels, and these panels deliver directly to the housing, making energy cheaper. Yields from this business case enable to manage the landfill. Both government and financiers have difficulties to take responsibility for these kind of multifunctional business cases. A way to overcome these difficulties is to create larger portfolios of landfills, collectives. For instance for a portfolio of 20 landfills financiers will finance as a whole the clean energy projects, as a whole the housing projects, as a whole the agriculture projects.
Governments can't take responsibility for the whole portfolio. A portfolio manager who will make a comprehensive plan for each individual landfill, wherein for instance energy, housing and park share costs and enhance one another. Next he will create packages of energy projects, housing projects and will present those to governments and investors. Once in the stage of development this portfolio manager will guard that on each landfill the projects will be realized in a comprehensive way. The stakeholders are the Ministry of Infrastructure and Watermangement, province Gelderland, municipalities, and branche organsiations.



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COllective REgeneration of former Landfills, COREL

Resources needed

To start up portfolio management in a way that it can recoup itself within three years we will need approx. € 2 Mio., cooperation of owners of 20 landfills, and cooperation of governments and financiers.

Difficulties encountered

Governments and financiers hesitate to go along with multifunctional projects, although they subscribe to their importance. Our thesis is that it will work to unbundle multifunctional projects. Than governments and financiers will take responsibility, and combine the projects again.

Evidence of success

The process is ongoing to have the various involved municipalities accept the COREL method. The nine municipalities cooperate within the so called Cleantech Region, and the board of this cooperative has accepted COREL already. The largest and main municipality, Apeldoorn, organizes the process to get all others on board, and the province. Important to mention is that Apeldoorn is currently looking at two former landfills in view of redeveloping those with the COREL method.

Potential for learning/ transfer

With 4000 landfills, old and in use, the Netherlands will have problems comparable to many other countries and their landfills. Examples of multifunctional development of landfills in other countries prove that further steps in this direction in the Netherlands will be welcomed in these and other countries. Also a more comprehensive way of spatial development is in order all over the board. These kinds of experiments can provide lessons that can be useful in many countries. Finally rehabilitation is not only something to consider in regards to landfills, but also climate change or agriculture and it's use of the soil, and urban neighbourhoods. Rehabilitation as such will be an important item in the years to come, and landfills present excellent cases to learn about that.

Keywords

Land use, Rehabilitation, Landfill mining, Management, Circular Economy, Finance, Interim use, Economics

Period

February 2019 – Ongoing

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Complex remediation of a closed landfill below groundwater level

A closed landfill in an old clay pit with ascending ground water was remediated by enclosure of the landfill body by a sealing wall and a surface sealing system.

The landfill (LF) Hennickendorf has an area of 13.8 h, and a volume of 2 Mio. m³ of waste, which was disposed between 1976 and 2001.
The LF is located in a former clay pit so a semi-impermeable barrier exists beneath, while a base liner system was not installed. The speciality of the site is the emergence of a high groundwater level. During operational phase a sump-drainage kept the water level constantly low, however, parts of the LF body was beneath water level.
After closure, the LF body was enclosed by a diaphragm wall in a single-mass method. The sealing wall around the LF merged the semi-impermeable barrier, so lateral water flow from the adjacent groundwater body into the LF was stopped.
In a second step a surface sealing system was applied, with a geomembrane impeding water infiltration into the LF. The surface sealing system was completely structurally interconnected with the sealing wall. In a third step groundwater management in the area around the LF was introduced and drainage facilities were installed to keep the overall groundwater level low.
After the encapsulation of the LF the only way water can enter the LF body is from beneath since water slowly penetrates the semi-impermeable barrier. The crucial point is that groundwater level within the LF body has to be kept below the outer groundwater level, so the groundwater flow direction is always into the LF body and pollutants do not leach into the outer zone. Therefore, sump drainage is temporarily necessary.

Complex remediation of a closed landfill below groundwater level

Resources needed

The financial resource needed for all described remediation measures was € 20,755,892. The measure was funded by ERDF with € 15,566,918 (75%).
Step 1: € 6,056,610
Step 2: € 13,315,252
Step 3: € 1,384,030

Difficulties encountered

An impermeable layer beneath the LF is needed to guarantee the sealing wall effect. Contaminated water in the LF body has to be continuously discharged and treated to maintain the gradient between inner and outer groundwater zone.
Significant knowledge of construction of sealing walls is needed.

Evidence of success

The encapsulation of the landfill body by the sealing wall and a surface sealing system interrupt the contact of the landfill body with the groundwater and prevents the penetration of rain water. The groundwater protection is guaranteed.

Potential for learning/ transfer

On the territories of the EU member states exist about 500,000 landfills (LF). For the LF in the scope of the EU landfill directive only non-obligatory recommendations for remediation of all types of closed LF exist. For more than 90% of the LF that predate the EU LF directive, no guideline or handbook on the remediation of these LF exist on a European level.
This practice is applicable for cases where an effective protection of the environment from a LF caused groundwater-pollution is necessary, in particular, from those LF where the LF body is partly located within the groundwater table. Those landfills can only predate the EU LF directive because LF in the scope of the EU LF directive must have a proper geological barrier.

Keywords

Sealing, Groundwater, Rehabilitation, Design

Period

March 2006 – October 2013

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‘De Blankaart’ landfill mining project: an economic viable case


©De Watergroep

Thanks to years of qualitative landfill management, the ‘De Blankaart’ landfill now contains a product valuable enough to mine and re-use the site afterwards.

De Blankaart is a large pond in the province of West Flanders. It is the main source of drinking water for this area and is managed by ‘De Watergroep’.
During the process of purifying water, lime is added to the mixture to precipitate the iron chloride that is present in the water. For years and years, this end product was very hard to sell, because the only interested sector was the cement industry and they would ask compensations. Therefore, management chose to store the product and create a 5 metres high buffer wall around the pond, to camouflage it from the surrounding natural environment. About 49,000 m³ of waste is stored on site. Meanwhile, the economic situation changed dramatically. The lime caught the interest of the agricultural sector as a way to neutralize the soil pH. Due to the high iron content, higher than some ores, the sludge is sold also to processing companies. The latest economic advantage (since 2014), is using the waste in bio digesters in Northern France. Demand for this type of material is very high in France, to that extent that a resource recognition procedure is pending at the government to speed up the transport.
De Watergroep not only has a financial benefit in mining its landfill. The current drinking water treatment installation became too small and they are not allowed to expand because of the nature area surrounding the pond. The space that can be won by removing the landfill is enough to be able to proceed with the project.

'De Blankaart' landfill mining project: an economic viable case

Resources needed

This project will generate nett income for De Watergroep.

Difficulties encountered

In general, the macro-economic indicators are in favour of this project, but this can change (conjuncture, geopolitical tensions,…).

Evidence of success

Due to changing economic factors and years of good management, for the first time a landfill contains a product which is so valuable that a landfill mining project with a positive net present value can be established. 49.000 m³ of waste will be treated.

Thanks to a policy change (dating 1/10/2019) in the environmental permits of Flanders, this type of projects can be categorized under a specific code.

Potential for learning/ transfer

When the iron sludge wasn't worth much, the Watergroep consequently chose for a qualitative management of the landfill. Today this has led to a ditto product which is highly sought after in several sectors (agricultural, industrial and energy). This understanding fits perfectly in a circular economy, since the landfill never was considered to be the terminus of an industrial process. Instead, storing of the waste for esthetical reasons was an example of interim use, contributing to the larger surrounding area and preparing it for that moment in the future where conditions would be favourable to proceed with the next step. That future moment is today.

See also the COCOON good practice on temporary storage policy for landfills in Flanders.

Keywords

Land use, Energy, Landfill mining, Circular economy, Waste, Economics

Period

January 2019 – Ongoing

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COCOON
Interreg Europe

Extended landfill gas treatment by CHP with reservoir – case Lübben

The practice extends the applicability of the Combined Heat and Power plant (CHP)-system to process landfill gas, avoiding greenhouse gas emissions while gaining energy and generating income.

Anaerobic fermentation of municipal waste produces methane. Concentration of CH_4 can reach more than 10,000 ppm at the surface of the landfill. CH_4 emissions can be avoided by gas collection and treatment systems. Dependent on the methane concentration different systems can be applied to convert CH_4 into CO_2. Hereby, released energy can be used to produce electricity. The landfill in Lübben is an operating landfill, parts are already closed and remediated and a gas collection system was installed. The currently used gas treatment facility (cogeneration CHP) was reaching its technical limits as the CHP is just capable to operate with CH_4 concentration higher than 40 Vol% and a flow rate of approx. 70 m^3/h, while in practice methane concentration / flow rate was predicted to be less soon. Thus, the gas flow rate has to be reduced and adjusted to gain a CH_4 concentration of > 40 Vol%. As gas flow rate was too low now, an additional storage facility to retain the gas (storage vessel with inflatable film cover) had to be installed. The CHP operates when (i) stored gas volume is sufficient to run the CHP adequately and (ii) demand for energy is high (during daytime).
This practice extends the applicability of the CHP-system to process landfill gases and avoids greenhouse gas emissions while gaining energy and generating income.

Extended landfill gas treatment by CHP with reservoir – case Lübben

Resources needed

The system works automatically and is controlled by IT-Systems. The human resources needed to run the system is equal to the one needed, when conventional flares / CHP are applied.
Financial resources needed to install the gas reservoir is about € 100,000. The installation of the gas reservoir facility was co-financed by the ERDF fund.

Difficulties encountered

This practice requires a significant knowledge and experience of gas generating potential of the landfill and the adjustment of the needed gas quality by rate of gas volume extracted from the landfill.

Evidence of success

This practice extends the applicability of the CHP-system to process landfill gases and reduces greenhouse gas emissions. The systems works with landfill gas which contains much less than 35 Vol% methane. It is quite independent from the amount of gas volume as gas from the landfill is captured intermediately.
The landfill operator benefits financially of the system, as gas to power can be conducted for a longer time span than a CHP without reservoir.

Potential for learning/ transfer

In the EU are 500.000 landfills. These landfills develop CH_4 and CO_2, which are greenhouse gases. They reinforce the natural greenhouse effect of our atmosphere. In order to avoid these effects it is necessary to build a degassing system. The mentioned practice could be replicated for landfills where municipal waste has been disposed and the gas potential is too low to run a conventional CHP. There has to be a connection to the power supply system, thus produced energy can be transported to the consumers. The practice contributes to Article 16 (greenhouse gas emissions) in the EU Directive 31/1999 on the landfill of waste, of applicability to landfills throughout the EU.

Keywords

Gas, Energy

Period

March 2019 – Ongoing

Contact

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Industrial use of a closed landfill in Antequera

Temporary use of a closed cell of a municipal solid waste landfill to compost waste water treatment sludge.

The area of some cells of the Valsequillo municipal solid waste landfill, located in Antequera cannot be used for purposes such as residential, commercial or agricultural use. The objective of this practice is to use the area for further purposes, in this case for waste management.

The municipal solid waste landfill in Antequera is currently an operational landfill, designed to be exploited in different cells. Since 2010, once cell number 3 of the landfill was filled and a surface capping was installed, this land has been partially destined to receive heavy metal-free sludge, which comes from a water treatment plant nearby. The average amount of treated sludge is between 2.000 and 5.500 ton/year, depending on needs, and the surface used is about 10.000 m^2 .

Infrastructures already built in the landfill for leachate collection and treatment such as drainage systems, pools and treatment plant were preserved and used in this new manner. The use of the land as a composting area does not negatively impact the sealing or the gas collection system.

To avoid a high generation of leachate, sludge must contain less than 30% of water to be accepted in the installation. Water treatment sludge are mixed with wood chips and agricultural waste to build piles that are weekly turned over for 10-12 weeks. Then newly produced compost is screened to remove non-degraded wood chips and is ready to use.

Industrial use of a closed landfill in Antequera

Resources needed

The resources needed to change landfill into a composting area are related to rent composting machinery and one worker to make the treatment.

Difficulties encountered

In order to obtain the authorities' approval, it was necessary to make a proposal to the authorities and guarantee to fulfil environmental requirement of the installation

Evidence of success

This is a good example of a new use given to the landfill site. The realization has demanded a coordination between the waste operator, water waste treatment plant and the competent authorities.

The use of part of Valsequillo landfill as composting plant has given not only a cost-effective solution to sludge produced in closer municipalities but also a supply of compost for farmer

Potential for learning/ transfer

This good practice demonstrates that it is possible to partially use an operational landfill for industrial purposes related to local community needs. This concept can be applied to other sites and thus gives more value to society.

Keywords

Period

July 2010 – Ongoing

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Klaverenboer ward: landfill remediation and tackling land pressure

An old landfill was completely excavated, processed and replaced by a ward.

This terrain originally was mined for its sandy clay. Afterwards the created pit was filled with waste to level it again with the surrounding landscape, covering an area of almost 28,000 m². The site received 48,000 tonnes of Municipal Solid Waste during 20 years. Afterwards the terrain was abandoned for 50 years. The whole site is located in a residential area at a short distance from the city centre of Turnhout with a good road connection. Research revealed that the historical pollution does neither pose a potential human health risk nor a potential proliferation risk. Still, the main purpose of this project was the recovery of the land for an allotment by removing and processing the waste first. The company Aertssen saw a profitable business case in this site and purchased the contaminated site. The landfill mining project was first drafted in a voluntary Soil Remediation Project, which was approved by OVAM in 2016. The remediation mainly consisted of a selective excavation and valorisation of the waste, off-site treatment and redisposal and on-site reuse of remediated soil.

The success of this project was calculated in advance by using the net present value (NPV).

Cost included the purchase of the site, planning and permits, excavation, valorisation, transport and site development for housing. Revenues included selling the land at a price of about € 250/m², reuse of uncontaminated soil and certain inert materials on site.

Klaverenboer ward: landfill remediation and tackling land pressure

Resources needed

The net present value of the project was € 392,000. Aertssen bought the land for its value, which is around € 225/m² in that area, minus the costs of the remediation.

Difficulties encountered

There's a chance on the nimby effect which actually occurred in this project. Some locals thought it was better to let the landfill be as it is now instead of digging up the waste again. Others would also lose their view on a green scenery and were not happy with this prospect.

Evidence of success

Flanders is a densely populated area, comparable with other regions or urban areas in Europe. Additionally, there's been a long time lack of a proper policy on spatial development, leading to fragmentation. By filling the gaps that landfills pose in residential areas, the suburban sprawl is slowed down or – in the future – could be reversed. In this specific case, the area will accommodate a total of 62 families and will provide over 6,300 m² of open space for water to infiltrate naturally.

Potential for learning/ transfer

Regions with a challenging situation in their available land could find a solution in reusing old landfills in or very close to existing residential areas. Optimizing these residential areas to the benefit of safeguarding the countryside contributes to a more efficient public transport system, less mobility problems and lower governmental costs for infrastructure and utilities.

Concerning the implementation of the project, different partner roles were combined by one party only, the owner of the site, which was an experienced contractor and was familiar with the working of an estate agency.

Keywords

Land use, Landfill mining, Waste, Economics

Period

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Landfill mining to develop the area in housing area in Veenendaal

Two former landfills in Veenendaal where mined to be able to develop the area into a housing area. The waste and the excavated soil was largely reused.

Options to expand the town Veenendaal was mainly possible on the south-eastern side. Unfortunately, two landfills, Benedeneind and Engelage, were located in the middle of the housing development area and thus created a major obstacle for this housing development.
A remediation study concluded that complete removal of 54,000 m³ of waste along with separation of material into partly reusable fractions was the preferred and the most economic option. The increase in the price of land, together with a subsidy from the province of Utrecht, made the complete removal economically viable. A vertical cut off wall of High Density Poly Ethylene (HDPE) was installed. The groundwater level was lowered. Extracted groundwater was slightly contaminated with mineral oil. This groundwater was treated on-site (aerated lagoons) and then pumped into the nearby sewer system. In total, 80% of the excavated waste was treated in a separation process resulting in reusable fractions within the city development project (soil, sand and rubble). The remainder (20%) was transported to a sanitary landfill where landfill tax was paid. This remainder consisted mainly of plastic, car tyres and asbestos. Polluted underground was removed and transported to an off-site soil cleaning facility. The stakeholders are the municipality of Veenendaal, Province of Utrecht (subsidy for the project), Regional water board, and Roseboom (contractor).

COCOON
Interreg Europe

Landfill mining to develop the area in housing area in Veenendaal

Resources needed

Total project fee amounts € 4,500,000 (including landfill tax).
The increase in land value together with a provincial subsidy funded the project. Three person staff from Grontmij were involved in project preparation and remediation supervision. From the contractor > 20 people were involved.

Difficulties encountered

The following challenges where encountered:

- High natural groundwater table
- Presence of asbestos in the waste hindered working conditions and the reuse potential of the different fractions.
- New legislation during the remediation lead to a negative impact on the overall reuse of the waste

Evidence of success

- In total 80% of the excavated waste was extracted for reuse
- Certain hot spots in the underlying soil were remediated completely
- Future land development (land value increase) paid for the remediation

Potential for learning/ transfer

This practice is very suitable in regions where there is high land pressure and the land value can potentially be high. As the landfill mining project also allows reuse of materials, it also generates some revenues and reduces the costs for primary materials. It contributes to a circular economy and reduces CO_2 emissions.

Keywords

Land use, Waste separations, Rehabilitation, Sustainability, Landfill mining, Design, Economics

Period

January 1999 – February 2019

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Landfill remediation by excavation – Case Treuenbrietzen

A closed landfill, Treuenbrietzen was remediated by excavation of the landfill body and transfer of the waste to other landfills.

The landfill Treuenbrietzen was operational from 1973 until 1998. The landfill has an area of 3.8 ha and a volume of 200,000 m³. Municipal and construction waste, household-type commercial waste, soil excavation and industrial waste were disposed. A geological barrier or a bottom sealing system did not exist. The leachate of the landfill caused groundwater pollution, thus remediation measures were necessary. The municipality as well as the landfill owner evaluated the possible remediation methods: surface sealing system vs. excavation. The advantage of excavation is that aftercare costs disappear. The excavation included the general elimination of the pollutant source, so the municipality decided for excavation in spite of higher investment costs in comparison to the sealing system. The excavation measures included:

- Installation of an access road
- Construction site equipment
- On-site analysis of waste
- Excavation and loading of waste
- Transport to the landfills Vorketzin and Schöneiche
- Special waste treatment for barrels of hazardous waste, found in the landfill
- Final sampling and analysis of soil beneath the landfill.

Totally, 299,677 tonne of waste was excavated and transported to other landfills. These landfills have a bottom sealing system pursuant to the German Landfill Ordinance, protecting the hydrosphere. The effect of the measure was proven by groundwater observation: the pollution, namely volatile chlorinated hydrocarbons, decreased quickly.

Landfill remediation by excavation – Case Treuenbrietzen

Resources needed

The financial resource needed for the remediation measures was € 8,300,779. The measure was funded by ERDF with € 4,150,390.

Difficulties encountered

Representative sampling and classifying the waste was difficult as disposed waste was quite heterogeneous. Although the area is free of waste now, it is still a fallow land, since a useful land use is not found. Some areas are used for motorcycle racing; at others natural succession occurs.

Evidence of success

The excavated waste is deposited on a landfill with a bottom sealing system in order to prevent contamination of the groundwater and soil. The risk for the environment of the landfill Treuenbrietzen was eliminated. Groundwater quality improved after the measure.

Potential for learning/ transfer

In the EU member states about 500,000 landfills exist. The EU landfill directive gives only a non-obligatory, very general recommendation for remediation measures, with no information about remediation on landfills which predate the directive (> 90% of the landfills). This good practice shows an alternative to the installation of a sealing system. It may be applicable particularly for landfills containing valuable resources or high-calorific wastes or in areas where land is scarce. Reloading and depositing the waste on another landfill is appropriate when the other landfill has higher technical standards of pollution control. In the case of Treuenbrietzen the focus was on the prevention of groundwater pollution and regaining land.

Keywords

Landfill mining

Period

April 2003 – December 2003

Contact

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Marsascala Family Park: Rehabilitation of a Landfill into a Park

The rehabilitation of a closed landfill into a leisure area and the adjacent valley restoration and storm water control.

The site is located in the outskirts of the village of Marsascala in the south of Malta and covers an area of circa 85,000 m². The site was used as landfill during the 1970s and following a number of studies it resulted that it no longer presents risks of gas and leachate dispersion. The major benefits of this project include the:

- Remediation for the eyesore associated with the previously unrestored site
- Rehabilitation of the adjacent valley and afforestation in order to create new habitats for birds and other fauna
- Creation of an open area in the south of Malta

The main activities implemented involved: earthworks, including capping and geocells; construction of retaining walls; surface water drainage; placing subsoil and topsoil; the installation of an irrigation system and landscape planting. The recreational facilities in the park include a picnic area, a recreation/leisure area on the former waste mound, a dog park, an equestrian area, and a visitors' centre. The park also has various play areas for different age groups, car parking facilities and the restoration of the Sant' Antnin chapel.

This project has benefited the Maltese population in general, especially the residents in the area surrounding the Marsascala landfill (~ 10,000 people). These are now benefiting from a close-by park with recreational amenities.

Marsascala Family Park: Rehabilitation of a Landfill into a Park

Resources needed

This project was co-funded through EU programmes for the period 2007-2013 as follows:

- Cohesion Fund (€ 3.1 mil) for landfill capping
- EAFRD - Measure 313 (€ 2.8 mil) for the creation of a leisure area
- EAFRD - Measure 323 (€ 0.9 mil) for valley restoration and storm water control.

Difficulties encountered

Good mitigation planning should be in place, in particular for the rehabilitation of a historic landfill site for which limited information is available. This would reduce the occurrence of delays during project implementation.

Evidence of success

This project converted a derelict area into an open space offering a unique recreational facility in the south of Malta where recreational spaces are limited. It also conserved, restored and upgraded the adjacent rural heritage thus promoting economic growth. The park has become an important attraction on the Island and is visited annually by a large number of people. This project has created a number of jobs related to park and operations management, administration, security and cleaning.

Potential for learning/ transfer

This project is the first of its sort in the Maltese Islands and can be replicated for the rest of the closed landfills once the risks associated with emissions and stability have been controlled.

Such a rehabilitation project may be replicated in old landfill sites in all regions, especially in regions having land scarcity where all land should be valorised.

Keywords

Land use, Sealing, Landfill leachate, Groundwater, Gas, Rehabilitation, Monitoring, Aftercare

Period

January 2010 – December 2014

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NAVOS: Remediation strategies for former landfills in the Netherlands

NAVOS: survey remediation of former landfills in the Netherlands. Four scenarios were formulated for the factors effectiveness, cost, and cost distribution.

The goal of NAVOS (remediation of former landfills) is to formulate realistic proposals with regard to the content, organization, and financing of remediation efforts for former landfills (4000). The first cost estimates were € 15 billion, based on minimizing further contamination of the soil. This was a major obstacle for further constructive discussion.

The NAVOS programme has led to greater insight into the scale of the issues raised by the former landfills in the Netherlands. This resulted in only 6% of the former-landfill sites the groundwater is (heavily) contaminated. The estimated cost has been reduced from € 15 billion to € 1 billion. This reduction can be attributed to the fact that the groundwater outside the actual landfills turns out to be less contaminated than was previously assumed. In addition, the topsoil issues turn out to be more serious, from a financial perspective, than the groundwater problems. The Soil Protection Act is based on risk reduction. For immobile pollutions, a top layer of clean soil is seen as a cost effective remediation option. These costs are part of the total estimated remediation costs.

It is concluded for NAVOS that landfills mining does not improve soil quality and will not significant reduce costs for monitoring and aftercare. The stakeholders are municipalities, provinces, Ministry of Infrastructure and Water Management, and landfill owners/operators

NAVOS: Remediation strategies for former landfills in the Netherlands

Resources needed

The NAVOS programme (from 1998 until 2004) was funded with Soil remediation budget and an extra € 0.90/tonne landfill taxes and executed by the 12 provinces.
The programme resulted in estimated costs for remediation of soil and groundwater and aftercare of € 1,000 Mio for a period of 40 year (2003-2043).

Difficulties encountered

The lack of practical data with regard to the scale of the issues involved made it difficult to estimate the costs. As a result, it was not possible at the time to formulate 'hard' financial claims toward remediation.

Evidence of success

The project gave insight in the real environmental risks and costs for closed landfills. The Dutch Soil protection act is based on risk reduction. For immobile pollutions a top layer of clean soil is seen as a cost effective remediation option (used widely in the Netherlands). Landfills covered with clean soil meet the legal requirements. The project gave local authorities (provinces) the possibility to make local policies on how to deal with former landfills.

Potential for learning/ transfer

It is concluded that the NAVOS study has led to greater insight into the scale of the issues raised by the former landfills in the Netherlands. In just over 10 years, the estimated cost has been reduced from € 15 billion to € 1 billion. This reduction can be attributed to the fact that the groundwater outside the actual landfills turns out to be less contaminated than was previously assumed. Local authorities (provinces) where able to implement this cost for an effective remediation option. Former landfills can be given a new (interim) function, for example solar park.
For other countries it can be useful to start a risk based approach, this might lead to a significant reduction in remediation costs.

Keywords

Sealing, Groundwater, Policy, Monitoring, Aftercare, Waste, Legislation

Period

January 1999 – December 2004

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Possibilities of using a closed landfill area for production of renewable energy


A landfill is an ideal site for a photovoltaic plant. However, the special technical conditions linked with the sealing system have to be considered.

The objective of the practice is to use the area of the landfill which cannot be used for other purposes such as residential or commercial use or agriculture. Further, an objective is the production of sustainable energy by photovoltaics (PV). The landfill Luckenwalde is an example of further use of a landfill area after the ending of waste disposal. The landfill for municipal waste (17 ha, 2.1 Mio. m^3) was closed in 2005. In 2012 a surface sealing system was installed. Afterwards, a PV plant with a capacity of 1.7 MWp was installed on the area of the landfill heading to the south (2.7 ha). Before construction of the PV, several tests had to be conducted considering the impact of the PV on the sealing system. The tests included measurements of the required engineering properties for foundation as well as the overall stability of the sealing system in interaction with the PV. The functionality of the sealing system and the gas collection system might not be negatively influenced by the construction of the PV. PV was installed with following technical requirements:

- A distance of 0.5 m between foundation and drainage layer,
- Appropriate distance between surface and panel and between each panel in order to sustain vegetation growth and allow maintenance work,
- Measures against erosion caused by run-off from pv panels.

The main beneficiaries of the practise are the financial income for the landfill operator as well as the sustainable energy production, thereby avoiding 950 Mg CO_2/a.

Possibilities of using a closed landfill area for production of renewable energy

Resources needed

The financial investments for the PV are about € 1.5 Mio./MWp. Human resources are needed during construction and afterwards for maintenance of the PV.

Difficulties encountered

There might be restrictions for the implementations when the structural stability of the landfill (e.g. at slopes) is not given. The liner may not be damaged by the installation of the PV. Also the precipitation in humid regions has to be considered to minimize impact of PV panels on soil erosion.

Evidence of success

Factors of success of the installation of photovoltaics on landfills are the reduction of greenhouse gas emission and the generation of financial income for the landfill operator. Areas are used which cannot be used for other purposes such as residential, commercial or agriculture use. Photovoltaics can also be installed when the landfill is equipped with a surface sealing system when special measures to protect the surface sealing system are applied.

Potential for learning/ transfer

On the territories of the EU member states exist about 500.000 landfills. These landfills represent an enormous potential area for energy production. Particularly, in the southern parts of Europe, with a lot of sunshine duration, the construction may be successfully implemented.

Keywords

Land use, Energy, Interim use

Period

January 2019 – Ongoing

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Rehabilitation of the Qortin Landfill in Gozo

Permanent closure and rehabilitation of a non-engineered landfill on the Island of Gozo.

Qortin landfill with an area of 4.9 ha was operational from 1968 to 2004 and took 0.6 Mio. tonnes of waste (33% municipal/commercial, 39% construction and development, and 28% industrial waste). In addition to concerns over potential impacts on human health and the environment through landfill fires, landfill gas production and emissions of leachate, the Qortin landfill was not compliant with (nor could be made complaint with) the engineering requirements of the landfill Directive 1999/31/EC. A strategy for the closure and rehabilitation of this landfill site formed part of the Solid Waste Management Strategy for the Maltese Islands. Rehabilitation and restoration of the Qortin landfill was achieved by the:

- Installation of engineered capping to improve control of gas emissions and reduce rainfall infiltration (and thus leachate production)
- Control of surface water run-off using a drainage system with attenuation ponds
- Placement of subsoil and topsoil
- Restoration planting
- Ongoing maintenance and irrigation

Future beneficial use at the Qortin landfill can only be achieved once the combustion process (and associated waste settlement) and landfill gas production are reduced to acceptable levels. The population in the area surrounding Qortin landfill is of over 12,000 and includes a tourism resort and the capital of Gozo. These will benefit from reduced visual disamenity, improved air quality and the future potential to use the site for recreational use.

Rehabilitation of the Qortin Landfill in Gozo

Resources needed

The capital cost of this project was of € 3.25 mil from the Cohesion Fund. This project has generated a number of jobs on the Island of Gozo. The landfill is monitored regularly; soil is topped up whenever necessary; landscaping is regularly watered, trimmed and maintained as necessary.

Difficulties encountered

Good mitigation planning should be in place, in particular for the rehabilitation of a historic landfill site for which limited information is available. This would reduce the occurrence of delays.

Evidence of success

This project involved the permanent closure of a non-engineered landfill and has achieved the following results:

- An improvement in the control of gas emissions
- A reduction in rainfall infiltration and leachate production
- Control of surface water run-off using a drainage system with attenuation ponds
- Restoration planting using indigenous Maltese species
- Improved visual impact
- Reduced odour generation

Potential for learning/ transfer

This project can be replicated for the rest of the closed landfills. This kind of rehabilitation project can be done with old landfill sites in all regions, most importantly in regions where the pressure on land is high and where all land should be valorised.

Keywords

Land use, Sealing, Landfill leachate, Groundwater, Gas, Rehabilitation, Monitoring, Aftercare, Waste

Period

January 2008 – December 2015

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Rehabilitation of “La Pitilla” landfill

Rehabilitation of “La Pitilla” landfill, which is located in a sensitive area, to guarantee stability, to protect the environment and to further develop a recreational area.

The landfill site “La Pitilla” is located in an urban area, in the south-eastern outskirts of the village of Puente Genil, in south Córdoba and covers an area of circa 87,000 m².
At the bottom of the landfill, a water stream was eroding the base of its slope, thereby endangering landfill stability. Moreover, leachate leaks and waste swept along by run-off were polluting the environment. The major benefits of this project include:

- Remediation of environmental problems on the previously unrestored site.
- Stability of landfill and prevention of water pollution
- Creation of a recreational area close to the village of Puente Genil.

Before starting the landfill remediation the landfill content was identified and the lack of methane was verified. This was achieved by dispersed bulky waste collection on the landfill surface, bend river cleaning and making trial excavations.
The main implemented activities related to rehabilitation of the landfill were earthworks, including capping with a 0,40 m mineral layer (clay from a close quarry) and 0,6 m top cover; surface water drainage; placing organic an erosion control blanket and wood fences, building 21 biogas pipes and placing soil with landscape planting.
This project protects the environment and the residents in the area surrounding “la pitilla” landfill. The residents will benefit from a reduced visual disamenity as well as a potential new use land (recreational purposes).

Rehabilitation of "La Pitilla" landfill

Resources needed

This cost of the execution of this rehabilitation project was 905.529,22 € and was funded for 80% by means of EU funds and for 20% by Andalusia Government funds.

Difficulties encountered

Finding cost-effective materials for proper sealing of the landfill; vandalism problems when the area is used for illegal motocross racing; and cooperating with different entities and organisations responsible for water in order to obtain legal permission were the main difficulties encountered.

Evidence of success

This project avoided continuous water pollution and converted a dangerous and useless area into an open space that can be recovered for citizens and can potentially be used for recreational purposes.

Potential for learning/ transfer

This project can be replicated for other closed landfills that are affected by water streams and risks associated with emissions and stability.

Keywords

Rehabilitation, Waste

Period

February 2015 – October 2015

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Remediation of a landfill with low risk potential in a rural environment

A closed landfill with low risk potential in a rural environment was remediated by profiling the landfill body and covering the landfill with a soil layer.

The landfill Klausdorf has an area of 4.5 ha and a volume of 420,000 m³. It was operational from the 60's until 1991. Household and construction waste, scrap, ashes and excavated soil were disposed. The Brandenburg guideline for remediation of landfills with low risk potential was applied to remediate the site. Following this guideline a landfill with a volume less than 500,000 m³ has to be remediated by installing a surface capping. A risk assessment showed that the level of groundwater pollution was very low. The main aquifer is protected by an aquiclude. There was no landfill gas emergence. The disposed waste mainly consisted of mineral material with low contamination. So the risk potential from the landfill was not relevant. In accordance with the guideline the following measures were carried out:

- Removing bulky waste from the landfill surface
- Profiling the landfill body in order for the surface water can run off the landfill
- Installation of a drainage trench around the landfill
- Covering the surface with a 50 cm soil layer
- Establishing grass vegetation.

The evapotranspiration in connection with the water holding capacity of the soil and the surface slope minimises infiltration and groundwater recharge rate. For the profiling of the landfill body 160,000 m³ of inert mineral waste was needed and 25,000 m³ of soil for the capping layer. Further, two groundwater observation wells were installed.

Remediation of a landfill with low risk potential in a rural environment

Resources needed

To shape the contour of the landfill, uncontaminated building rubble, excavated soil and road construction waste was used. The producer of waste payed for its disposal on the former landfill although used for the recultivation measure. This resulted in a financial zero- balance for the remediation measure.

Evidence of success

The landfill was remediated by measures which are adjusted to the risk potential of the landfill. The applied measures lead to a reduction of rain water infiltration into the landfill body and elution of contaminants into the groundwater. The landfill body is recultivated and integrated into the landscape.

Difficulties encountered

Considering the Brandenburg guideline, a risk assessment with different analyseswas made for the decision-making. As the composition of the deposited waste was not known, a long-term groundwater, soil and air analysis was carried out, with additional costs.

Potential for learning/ transfer

This good practice can be replicated on landfills with a small volume (< 500,000 m³), containing waste with a low pollution level. Brandenburg has created a guideline for these landfills. Many of the existing landfills in the EU member states are small-sized landfills in rural areas; therefor this practice can be widely applicable. The practice is relevant for cases with recultivation, integration into the landscape, and prevention of illegal waste disposals is the main objective, while groundwater pollution plays a minor role due to a low pollution level of the disposed waste. This good practice is currently adopted by an Andalusian COCOON stakeholder for the remediation of a construction and demolition waste landfill in the municipality of Baena.

Keywords

Sealing, Rehabilitation, Design

Period

January 1996 – January 1998

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Remediation of a large-scale landfill by installing a surface sealing system

The landfill was remediated by capping the landfill body with a surface sealing system and a landfill gas capturing facility.

The old section of the landfill Lübben (5.4 ha) was in operation from 1978 until 2005. Overall, a volume of 920.000 m³ waste was deposited, containing construction (57%), municipal, and household-type commercial waste. A geological barrier or a base liner does not exist. At the site the groundwater level is high and vulnerable for pollution. After the closure of the landfill, the remediation of the site was obligatory. As the volume of the landfill body exceeds 500,000 m³ the technical design of the remediation had to be in line with the requirements for the landfill class II of the German landfill ordinance. The landfill body was covered by a surface sealing system with two sealing elements. The surface sealing system consists of:

- Adjustment/bearing layer of 0.5 m (works as gas collection layer)
- Geosynthetic clay liner (natrium bentonite mat, weight 5000g/m²)
- Geomembrane of 2.5 mm, hdpe
- Polymer drainage element
- Cushion layer (sand, 15 cm),
- Recultivation layer of 1.00 m
- Vegetation

Furthermore the remediation measures include:

- A landfill gas capture facility, consisting of a landfill gas capturing layer under the sealing system, consisting of 15 gas wells and a flare
- A surface drainage system
- Traffic infrastructure around and on the landfill
- Facilities to measure settlement of the landfill body
- Groundwater observation wells. In the design of the capping the bentonite mat can be substituted by a mineral liner > 0.5 m, the polymer drainage element by a mineral drainage layer > 0.3 m

Remediation of a large-scale landfill by installing a surface sealing system

Resources needed

The financial resource needed for the remediation measures was € 1,937,838. The measure was funded by ERDF with € 750,800. The remaining part was paid by the landfill operator.

Difficulties encountered

This practice requires a significant knowledge and experience of planning and construction of landfill sealing systems. A quality management had to be implemented. Afterwards, maintenance works have to assure that no deep-rooting trees grow, harming the impermeable liners.

Evidence of success

The capping of the landfill restricts water infiltration into the contaminated landfill body and reduces the potential for contaminants to leach from the site into the groundwater. This is crucial as a base liner does not exist. The combination of two different sealing elements gives redundancy in the case of technical defect of one sealing element. The two liners installed have a 100-year warranty.

Potential for learning/ transfer

About 500,000 landfills exist in the EU. The EU landfill directive is decisive for the minority of the landfills (< 10%). Despite of the huge number of landfills, no information of remediation is given in the directive and there is no technical guideline or handbook on European level. This good practice can be replicated on large-scale landfills, where disposed waste may have harmful effects on groundwater. The design of the capping with a bentonite mate and geomembrane is advantageous in areas, where no natural resources such as clay for mineral liner are available. The design of the capping is appropriate particularly for older landfills without a base liner and where an effective protection of the environment from landfill caused contaminants is necessary.

Keywords

Sealing, Rehabilitation, Design

Period

April 2006 – February 2009

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Remediation of two landfill sites by landfill excavation in Amersfoort

Two former landfill sites, containing 461,000 m^3 of waste, where completely excavated in order to develop the Vathorst area in Amersfoort.

The two former landfills comprised of household waste, industrial waste and sludge. The sites were covered with soil and used for agricultural purposes. With city plans to build a new district called Vathorst in the region, the presence of the two landfills posed challenges for the development. It was decided to completely remove the two landfill sites. The majority of the waste was transported to a sanitary landfill nearby of Smink company in Hoogland (distance < 5 km). In total, 620,000 m^3 material, consisting of 461,000 m^3 waste and 160,000 m^2 soil was excavated. Smink company landfilled 94% of the waste. The excavated soil (mainly top cover) could be reused almost completely.
Grontmij conducted soil research, and prepared the remediation plan and technical specifications. During the excavation, groundwater was lowered by means of pump drainage. The groundwater was pumped into a sedimentation reservoir after which it was discharged to the municipal sewer system. The groundwater beneath the landfills was slightly contaminated. Furthermore, the soil at the bottom of the excavation pit was extensively sampled. After concluding the site was free of any contaminants, the pit was infilled with clean soil, and suitable for further development. The stakeholders are the municipality of Amersfoort, Province of Utrecht, Smink Afvalverwerking BV (contractor, now part of Renewi), and Development company Vathorst C.V.(customer).

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Remediation of two landfill sites by landfill excavation in Amersfoort

Resources needed

Total project fee was € 18,000,000 (including landfill tax). Development company Vathorst C.V. (a public-private partnership) funded the project. Three person staff from Grontmij were involved in project preparation and remediation supervision. From the contractor over 30 people were involved.

Difficulties encountered

The following challenges were encountered:

- The amount of (contaminated) groundwater to be discharged to the sewer system
- The presence of unexpected waste types such as asbestos and series of barrels containing unknown liquids (280 tons in total).

Evidence of success

In summary, the following successes where achieved:

- In total 100% of the waste was excavated
- The soil top cover was reused almost completely
- The excavation pit was drained successfully, by which the groundwater contamination was minimized
- Smart solutions to challenges resulted in remaining within budget.

Potential for learning/ transfer

A landfill excavation needs extensive on field supervision to be able to react immediately when unexpected problems (such as unexpected types of waste) arise. This way it is certain that all waste is being treated adequately, and large costs are avoided.

This practice indicates that it is possible to excavate a landfill in order to regain land that can be used as residential area. This is especially helpful in regions with a high land pressure.

Keywords

Land use, Waste separations, Rehabilitation, Sustainability, Landfill mining, Design, Economics

Period

December 2005 – February 2007

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The Natural Cap – Sustainable solution for landfills

The remediation of the 100 ha Volgermeer landfill is a key example of the transition of what was once a heavily polluted waste site into a natural park.

The Volgermeer (105 ha) was a landfill for domestic and industrial waste. Large amounts of chemical waste have been dumped during the 60’s and 70’s.

Monitoring over 30 years showed that the natural occurring peat at the sideways and bottom contained the contaminations: an important feature preventing migration of contaminations. Because of demonstrated safe containment of toxic waste in peat, it will be used to “install” a natural impermeable peat cap to ensure a much longer lifespan of the capping than in the case that the impermeable capping was only based on the application of a HDPE layer. The living peat works like a sponge and will prevent large quantities of water to penetrate the landfill. As long as the peat layer is intact the isolation of waste is secured and the cap will act as a net carbon sink. The Volgermeer has become an attractive location for science students and naturalists studying the peat formation. Together with the Centre of Wetland Ecology research programs were initiated to study the growth of peat and to assess the effects on the quality of the capping (isolation) of the waste. The Volgermeer stands out as an example of turning a heavily polluted landfill into a (scientific) natural park open for public and education by making use of the capacity of nature itself to solve environmental problems.

Main stakeholders are the municipality of Amsterdam; Ministry of Infrastructure and Watermanagement and local residents (Burgercomité).

The Natural Cap – Sustainable solution for landfills

Resources needed

The municipality of Amsterdam is responsible for monitoring and maintaining the natural capping. It is funded from their soil remediation budget.

Difficulties encountered

Intensive large-scale research needed to be performed to ensure the correct working of the peat.

Evidence of success

This practice is good in regions were peat is naturally occurring.

After four years of large-scale scientific research, the recipe for peat formation on the mineral soil has been defined. The Natural Cap starts to form slowly. Special natural values have developed.

The site is open for public and can be visited for pleasure and educational purposes. The monitoring results to date show no spread of contaminants.

Potential for learning/ transfer

This is an example of building with nature. Peat is a natural resource that can be used for groundwater remediation and to isolate contaminated sites. Peat present around and underneath the location is intact for 99% and isolates the contaminations. The high contaminant concentrations in the landfill, even after 30 years, do not spread towards the surrounding area . The peat allows for small quantities of water to penetrate while absorbing contaminants. This gives a new view compared to the conventional approach of using foil and sheet piling to isolate a landfill site. Water pressure in the landfill site can decrease gradually because the water can flow through the peat filter without the contamination leaving the area. Additionally, it is assumed that the presence of bacteria in the peat contributed to the filtrating capacities of the peat.

Keywords

Sealing, Rehabilitation, Sustainability, Monitoring, Design, Communication

Period

March 2000 – Ongoing

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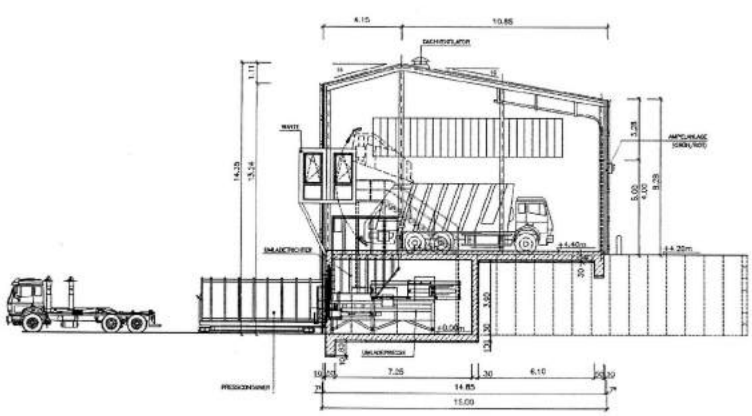
Using a landfill area after closure, for a Waste management facility

A compaction and reloading station for waste, using the infrastructure of a former landfill, helps to reduce waste volume and optimizes transport logistics.

The objective of the practice is to use existing infrastructure of the former landfill for further purpose, in this case for waste management.
The landfill in Luckenwalde for domestic waste was closed in 2005. While on the landfill a surface capping was installed, the infrastructure was of such as scale that social and administrative buildings, parking lots and others asphalted areas remained and were preserved.
In order to use the existing facilities as a waste management facility, reloading and compaction station, additionally a waste tipple and a waste press (350 kN) were constructed. The technical facility allowed containerizing the waste and thus decreasing the waste in volume. The capacity is 10,000 Mg/a or 40 Mg/d.
The domestic waste reloaded and compacted originates from the city of Luckenwalde and the surrounding rural area. The next incineration plant is at far distance; the reloading is part of transport logistics and optimizes the effectivity of the transport. All transports are conducted by trucks.
The public waste disposal authorities benefit from the practice as transport cost are reduced. Also the emission of greenhouse gas decreased.



Using a landfill area after closure, for a waste management facility

Resources needed

The financial resources to build the facilities and the waste tipple and waste press were about € 1 Mio. Human resources are steadily needed during operation of the reloading and compaction station. In return for the investments, financial cost for transport of waste is reduced.

Difficulties encountered

The capacity is limited to 40 Mg/d. The volume of waste which can be stored intermediately is limited. A technical breakdown of the facility may interrupt the garbage collection management.

Evidence of success

The practice is considered as good because it shows the use of buildings and other infrastructure in the former entrance area after closure of the landfill. Further, landfills are commonly in remote areas, thus no conflicts arise with residents due to emissions (noise or smell). Resources can be conserved as remaining technical facilities are further used.

Potential for learning/ transfer

The practice is considered as good because

- Infrastructure related to landfill management activities are reused after closure of the landfill
- Financial resources needed for waste transport decreases
- The ecological footprint of waste transport decreases

The practice may be implemented in remote rural areas, where the construction of an incineration plant or MBT-plant is not financially reasonable. It may also be reasonable in areas where waste is still deposited on landfills in order to transport the waste to the next incineration plant or waste treatment facility. In case of connection to the railway system, the reloading and transport may even be more sustainable.

Keywords

Land use, Management, Interim use, Waste

Period

January 2005 – Ongoing

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From Landfill to Energy Campus – Case Leeuwarden

Energy Campus is a campus site in Leeuwarden that supplies green energy and is integrated into the landscape. This includes the integration of an existing landfill site.

The Energy Campus is an initiative of Royal Oosterhof Holman. It is a triple helix partnership of education, business and government to stimulate innovations and economics in the region. The Campus is built on a landfill and architecturally integrated into the landscape. The new function of the landfill and the spin off developments in the brownfields surrounding gives a boom to the economics in the region.
Green energy for the Campus is provided by bio-digesters and a nearby ice skating track is provided with green energy form landfill gas .
Cooperation with the educational institutions is the important spearhead within the Campus. A special part of the Campus is the integration of the existing closed landfill site in the plan by making experiments, offices and energy generation and storage possible and constructing it at the landfill site. All constructions on the landfill have to be designed in such a way that no damage is done to aftercare measures. For example stock piling through the landfill is forbidden, as it will damage layers. Therefore the first building on the closed landfill site stands on 108 different legs, each with its own concrete slab. This construction ensures that the building can absorb the settlements of the landfill site without having a negative impact on the aftercare requirements of the province. Despite all the technical challenges, the architect has succeeded in making a design that fits in with the landscape, in which circularity is leading.

From Landfill to Energy Campus – Case Leeuwarden

Resources needed

Funding and knowledge from Triple Helix Partners:
Educational institutes (NHL-Stenden, ROC Fryslân, University Campus Fryslân (UCF), Wetsus and University of Melbourne);
Business (Royale Oosterhof Holman and Ekwadraat); Government (Province and Municipality Leeuwarden)

Difficulties encountered

In order to meet the province's aftercare requirements, the project team initially imposed strict terms on the conditions for construction. Initiators decided to be on the safe side when determining the requirements. In retrospect some provisions might have been more flexible on second thought.

Evidence of success

This is a good example of a triple helix partnership where innovations are stimulated and incorporated due to a partnership between science, business and local government, where new functions are given to the landfill site. The realization has demanded a great deal of coordination between the province of Friesland, designers, developers and the competent authorities. In which everyone's interests had to be safeguarded, of which the aftercare requirements are an important part.

Potential for learning/ transfer

This good practice demonstrates that it is possible to build on a landfill site with respect to aftercare requirements. Thorough preliminary research into the structure of the landfill site was therefore required for a successful project. This concept can be applied to other European closed landfill sites and thus give more value to society. However, this requires commitment from the landfill site owners and the competent authorities. Outside the box thinking without compromising safety and aftercare requirements is essential. Most important the Energy Campus has given a boost to area developments and economics in the region.

Keywords

Land use, Sustainability, Design, Aftercare, Interim use, Economics

Period

January 2007 – Ongoing

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COCOON
Interreg Europe

Project :metabolon - Innovative interim use of the Leppe landfill


The conversion of the Leppe landfill by the project :metabolon exemplifies an innovative interim use with a focus on research, education and circular economy.

Initially, the Leppe landfill with a waste disposal area of 39 ha and a waste volume of 9 Mio. m^2 had a negative image, like most municipal solid waste landfills during the 80's. The burdens associated with the disposal activity and the fear of harmful environmental effects characterized the landfill.

However, starting from 2006 the project :metabolon converted the Leppe landfill into a modern waste management centre, focusing on innovation, research and education supported by the European Regional Development Fund. On the landfill site a competence centre for resource management, environmental and landfill technologies as well as circular economy has been established with an emphasis on research, education and knowledge transfer. Moreover, the landfill has been made accessible for the public so that modern waste management can be experienced by everyone, accompanied by a viewing platform on top of the landfill and a multitude of information options and recreational activities for junior as well as senior visitors. Thus, a changed perception and an image change of the landfill location was achieved. All in all, :metabolon is by now a place to create the future together.

The main stakeholders are The Ministry for Environment, Agriculture, Conservation and Consumer Protection of the State of North Rhine-Westphalia (MULNV), municipalities of Lindlar and Engelskirchen, local authorities (OBK, RBK), TH Köln – University of Applied Sciences and local residents.

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Natur- und Verbraucherschutz
des Landes Nordrhein-Westfalen

Project :metabolon - Innovative interim use of the Leppe landfill

Resources needed

The budget of :metabolon (landscaping of the landfill, research infrastructure and projects) is € 34 Mio. This was funded by the Ministry for Environment, Agriculture, Conservation and Consumer Protection of the State of North Rhine-Westphalia and ERDF.

Difficulties encountered

In the beginning a lot of persuasion was needed to convince stakeholders and local residents to make the landfill accessible to the public and moreover to establish a competence, research and education centre for resource management and circular economy on the landfill site.

Evidence of success

The project :metabolon on the Leppe landfill is continuously evolving and leads to many interdisciplinary co-operations between experts and research institutions to create innovation in waste and resource management and to educate the current and next generation for a prospective implementation of a sustainable circular economy. More than 50.000 visitors and more than 5.000 pupil and students per year demonstrate the wide acceptance of the public for the project :metabolon on the Leppe landfill.

Potential for learning/ transfer

:Metabolon can be considered an exhibition for good practices in sustainable waste and resource management, environmental and landfill technologies, research and education, as well as leisure and recreation. It has the possibility to transfer experimental results to pilot plants on a semi-technical scale and to industrial plants on the landfill site, making it a reference site for international experts these fields. :Metabolon was officially nominated as a research centre of TH Köln. The interim use of the landfill ranging from a modern waste management centre with the use of renewable energy to a site of education is an ongoing success story. More than 50.000 visitors and more than 5.000 students per year demonstrate the interest to the project.

Keywords

Land use, Rehabilitation, Sustainability, Energy, Management, Circular economy, Interim use, awareness

Period

January 2006 – Ongoing

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COCOON
Interreg Europe

Flemish ELFM Consortium

The Flemish ELFM Consortium started to promote mining as a form of dynamic landfill management. The network grew beyond the region's border and became EURELCO.

In 2008, the Commission adopted the Raw Materials Initiative for a strategy facilitating the access to raw materials in the EU. To ensure the resource efficiency and supply of "secondary raw materials" through recycling, Enhanced Landfill Mining (ELFM) is one method to bring back the latter into the economy.

ELFM is defined as "safe exploration, excavation and integrated valorisation of landfilled waste streams as materials and energy, using innovative transformation technologies and respecting the most stringent social and ecological criteria." Thus, ELFM is part of a wider view on circular economy. The consortium was established to spread and investigate this way of dealing with a landfill. It grew into its current form: EURELCO.

Objectives and implementation are sharing information on the current state of the art and future potential of Enhanced Landfill Mining projects and programmes in the EU; initiate pilot ELFM-projects; analyses national and EU Landfill and Waste/Materials Management legislation; developing suggestions for improved legislation frameworks and economic incentives in favour of ELFM

Main stakeholders and beneficiaries of the current EURELCO network are research organisations; UK, German, Belgian and Austrian universities; landfill operators; Recycling industries and governmental agencies.

Flemish ELFM Consortium

Resources needed

There are not many resources needed. No financial resources are needed. With regards to human resources the time of relevant people to attend meetings and to increase open communication has to be counted.

Difficulties encountered

ELFM is a new concept with low dissemination. There are no overall transferable methods. For each project a specific combination of technologies must be chosen. Preliminary feasible studies have to deal with great uncertainties. There is no obligatory enforceable regulatory framework.

Evidence of success

A steadily growing network originating from the small Flemish consortium, the EURELCO network currently has 61 members in 15 European countries.
Cooperation between network partners is increasing - i.e. resulting in EU-Interreg projects and international symposia to exchange knowledge.
An example of a tangible result is how the Flemish government developed a consistent policy about sustainable old landfill management;

Potential for learning/ transfer

The most important target of the network is making non-member states aware of the benefits of dealing with old landfills properly. Information the network distributes on ELFM concerns:

- Policies
- Avoiding pollution and health risks for the people living close by and the environment
- Managing and mapping the landfill content as a future buffer for certain materials, e.g. In times of geopolitical tensions
- Harmless landfills could provide new space to build on or act as provider of ecosystem services

Keywords

Policy, Landfill mining, Management, Waste

Period

January 2010 – Ongoing

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Methane oxidation systems for the biological treatment of weak gas

Landfill methane (CH_4) is microbially oxidized to carbon dioxide. Thereby, the risk of explosion and the emissions of the greenhouse gas CH_4 are reduced.

Degradation of waste generates CH_4 and CO_2. Over time, landfill gas production decreases to a level where energy conversion and flaring are no longer viable. However, gas production continues for decades to centuries, and risks for safety and greenhouse gas emissions persist. In this phase as additional measure, landfill gas can be treated biologically in methane oxidation systems (MOS; filters, windows, entire covers). These consist of a methane oxidation layer (MOL), the top part of which is vegetated to prevent erosion, above a gas distribution layer (GDL). MOS are connected to a gas well or receive gas directly from the waste body, depending on the presence of gas extraction and/or liner systems. Landfill gas is actively (pumping) or passively (pressure difference between waste body and atmosphere) supplied via gas inlets implemented in the GDL. Oxygen reaches the MOL by diffusion from the atmosphere. Design goals focus on:

- Spatial homogeneity of CH_4 load, design parameters: MOL permeability (depending on texture & compaction) and its difference to GDL permeability; number of gas inlet points
- Dimensioning adapted to the soil's CH_4 oxidation capacity
- Soil chemical properties, required to sustain demands of methanotrophic bacteria and vegetation

Use of mineral soils is preferred, organic materials (e.g. composts) are microbially degradable, causing settlement and loss of permeability. The main stakeholders & beneficiaries are landfill operators and regulators.

Methane oxidation systems for the biological treatment of weak gas

Resources needed

MOS substitute a part of the landfill cover system. Capital costs increase marginally, mainly depending on the availability of suitable soils and the construction practice needed to reach target soil physical properties. After construction, costs are mainly determined by the monitoring activities.

Difficulties encountered

CH_4 flux has to be determined in advance for dimensioning (empirically, modelling). Spatial homogeneity of gas flux is the main design challenge. Choice of correct soil / construction practice to reach target properties is crucial. Organic materials used (not recommended) need regular replacement.

Evidence of success

This practice reduces the emissions of greenhouse gases from landfills where CH_4 formation is too low for economically viable technical gas treatment. Without this practice, landfill gas would migrate into the environment in an uncontrolled manner, endangering safety and releasing the greenhouse gas CH_4 for a long period of time. Factual evidence of success or failure can be provided by measurement of surface CH_4 and CO_2 concentrations and fluxes, soil gas composition and visual inspections.

Potential for learning/ transfer

Methane oxidation systems are an adequate tool to convert CH_4 into CO_2 when landfill gas production is too low to enable active extraction for energy conversion or flaring. They can also be implemented as additional measure to reduce gas emissions. The application potential is large as landfills are still a central component of waste management in many EU member states. This practice can hence be transferred to other EU member states, especially to those with moderate to high precipitation rates and moderate temperatures. The practice is less sustainable in regions low in precipitation, with long dry seasons, or strong winters as drought or freezing promote cracks, where gas can easily escape, and lower microbial activity.

Keywords

Waste pretreatment, Gas, Monitoring, Circular economy, Awareness

Period

January 2019 – Ongoing

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Aerobic fermentation of municipal waste inside the landfill in Cordoba

Rejects of municipal waste pre-treatment process undergo aerobic fermentation before landfilling in order to improve landfill management in long term

Organic waste is separately collected in Cordoba. However, as sorting by citizens is not perfect, a fraction of organic waste is rejected during pre-treatment process and ends up in the landfill. Therefore, an aerobic fermentation of waste is done inside the landfill before final deposit, dividing landfill surface into four areas and following an 8 week procedure:

During the 1st and 2nd week, waste deposited in the landfill is disposed building 2-3 meters high piles. From the 3rd to 7th weeks, piles must be turned over weekly, adding leachate through irrigation system in order to guarantee proper humidity and oxygen levels needed for the composting process. Finally, during week 8 after completing the composting process, waste piles are spread out and compacted using waste compactor and the process starts over.

Composting allows to take advantage of energy emitted to evaporate leachate, achieve waste stabilisation and avoid methane production. These are key factors for stability and safety regarding landfill management, they diminishes the risk of fire and reduce global greenhouse emissions out of the landfill.

Moreover, organic fraction within landfill waste is reduced by 30% in volume, average waste density increased and hence, landfill life is extended.

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Aerobic fermentation of municipal waste inside the landfill in Cordoba

Resources needed

A significant size opened landfill surface, human resources and heavy machinery – bulldozer, waste compactor, a mobile irrigation system- are required to make the fermentation process feasible

Difficulties encountered

This practice requires a significant surface where waste can be outdoors. Also, there are nuisances, odours, vectors and high leachate production. These are collected through a leachate capturing system and required treatment.

Evidence of success

Stabilisation of the organic waste before landfilling is proven to be good. Fire risk is minimised, greenhouse gas emissions is reduced and safety in the landfill is improved, due to the fact that methane is avoided. As waste becomes stable before landfilling, the landfill becomes less active and thus, aftercare costs and risks are reduced. Likewise, aerobic fermentation implies reducing waste volume, landfilled waste density is increased (around 1.3 t/m^3), thus the life of the landfill is extended.

Potential for learning/ transfer

This practice could be replicated in locations where rain is limited (geographical specificity) and where fires risk prevention is a target. This practice can be replicated in any landfill in any location taking into account the challenges described above.

The practice contributes to the following articles and annexes in the EU Directive 31/1999 on the landfill of waste, of applicability to landfills throughout the EU.

- Article 11: Waste acceptance procedures
- Article 12: Control and monitoring procedures in the operational phase
- Article 13: Closure and after care procedures.

Keywords

Waste pre-treatment, Sustainability, Management, Waste

Period

January 1990 – Ongoing

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Bird Rock, Den Helder

Bird Rock is built by cleaning and reusing of 90,000 m³ contaminated soil and nowadays the structure provides a safe breeding ground for multiple bird species.

In the industrial area next to Den Helder, contaminated soil is dumped for storage and cleaning. The neighbouring nature reserve offers a breeding ground for multiple coastal bird species. But due to the presence of foxes in this area, the breeding process of the birds is disturbed. The combination of Port of Den Helder, the municipality Den Helder, Landschap Noord-Holland, Milieupark Oost and the contractor De Vries & Van de Wiel, defined the idea to build a structure from the contaminated soil of the depot in order to create a safe breeding ground for the birds.

By cleaning 90,000 m^3 contaminated soil and the combination with 35,000 tonne immobilised concrete, a 5.0 meter high structure was built over an area of 2.3 ha. This structure is called Bird Rock. Due to its steep walls the rock is not accessible for foxes, enabling the birds to breed safely. After completion of the project in 2017, 120 pairs of common terns, 10 pairs of little terns, 3 pairs of northern terns, 3 pairs of little ringed plovers, 28 pairs of pied avocets and 4 pairs of oystercatchers were breeding. More than 100 pairs of martins have been observed in the walls in 2017. Bird Rock is functioning as a mega incubator.

In addition, 90,000 m^3 of contaminated soil is being cleaned and reused. A lot of emissions are saved due to the nearby solution for the contaminated soils. This concept also shows that applying (immobilized) ground flows in such large-scale applications makes high-quality reuse possible

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Bird Rock, Den Helder

Resources needed

The project is a cooperation both financial and technical between the natural organisation Landschap Noord-Holland and Milieupark Oost the landfill operator. The Bird rock is partly financed with revenues from the landfilled sludge.

Difficulties encountered

Environmental requirements are often in conflict with wishes for a natural design. This needed extra attention for the aftercare permit.
Technical the cap of the bird rock needed to be both, soft enough to create the right environment for the birds and hard enough to be weatherproof.

Evidence of success

Milieupark Oost completed the project in 2017. That year, 120 pairs of common terns, 10 pairs of little terns, 3 pairs of northern terns, 3 pairs of little ringed plovers, 28 pairs of pied avocets and 4 pairs of oystercatchers were breeding. More than 100 pairs of and martins have been observed in the walls in 2017. In addition, 90,000 m^3 of contaminated soil is being reused.

Potential for learning/ transfer

This is a good example of changing a landfill of polluted sludge in a natural bird protection area. The chosen technology of cleaning and immobilisation of the sludge has led to a product where contamination can no longer leaches into the environment and therefore there is a maximum risk control and the aftercare costs are reduced to a minimum. The former landfill is now maintained by an environmental organization, Landschap Noord Holland

Keywords

Rehabilitation, Sustainability, Design, Interim use, Awareness

Period

January 2015 – October 2017

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Gozo Waste Transfer Station and Material Recovery Facility

A controlled facility for the reception, sorting, processing, interim storage and transfer of waste.

The overall objective of this project was to improve the waste management system in Gozo by developing a controlled facility for the processing of waste to replace the only landfill site on the island. The Material Recovery Facility sorts waste received from Bring-In Sites and the door-to-door collection of separated waste into three fractions: plastics, paper and cardboard, and metals through a semi-automated mechanical process. The Municipal Solid Waste is collected at the Transfer Station where it is compacted in hermetically sealed containers and transferred to Malta for further treatment. The project thus contributes to minimise the landfilling of waste by primarily segregating the waste, which is directed for treatment. Also, efficient compaction results in more efficient transportation from Gozo to Malta thus reducing both the operational costs and the carbon footprint.

This project was intended to achieve three main objectives:

- To reduce transportation between the Islands thus applying the proximity principle
- To reduce the disamenities of waste management for Gozo residents by closing down the Qortin landfill and providing a controlled facility for the proper processing of waste
- To contribute in the development of Gozo into an ecological destination

The main beneficiaries of this project are the residents of Gozo, who are now benefiting from a cleaner environment.

Gozo Waste Transfer Station and Material Recovery Facility

Resources needed

The cost of this project was of € 10.3 mil and was co-financed from the Cohesion Fund 2007-2013.
This project has generated 28 fulltime jobs in the Material Recovery Facility on the Island of Gozo.

Difficulties encountered

The need for variations in the works contract during the course of project implementation has caused an extension in the project's completion date.

Evidence of success

All recyclable waste generated in Gozo is being collected at the Waste Transfer Station and sorted through the Material Recovery Facility in line with the proximity principle. Waste received in the transfer station is being compacted in hermetically sealed containers and delivered to Malta for further processing. The compaction of waste has reduced the number of trips between the two Islands. The landfill volume saved on an annual basis through this project is estimated at 15,100 m^3.

Potential for learning/ transfer

This project is considered to be an environmental success for Gozo. Today, all waste generated in Gozo is being collected in a controlled and safe environment for further processing. The organisation of waste sorting and recovery contributes to the circular economy and deviates waste from the landfill. This practice can be adopted by all regions where the sorting and recovery of waste is not yet optimal. Indirectly, this practice also contributes to landfill management as it prevents the loss of valuable resources by reducing the amount of waste diverted to landfill.

Keywords

Waste seperations, Policy, Sustainability, Management, Tool, Circular economy, Waste

Period

January 2009 – December 2016

Contact

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Quality control of technical elements of landfills by an independent third-party

Surface cappings and basal liners of landfills have to meet defined technical requirements. The installed quality is monitored by an independent third party.

In order to control the quality of basal or surface liner / capping systems a Quality Management Plan (QMP) has to be established. The QMP includes requirements (according to the German Landfill Ordinance / Quality Standards) for materials and construction as well as for the extent and performance of control. The quality, which is defined in the QMP, has to be monitored by an independent Third Party Control (TPC). Only the authority is authorised to give instructions to the TPC. The costs of TPC have to be paid by the landfill operator.
The TPC and the laboratory have to be accredited pursuant to DIN EN ISO/IEC 17020 and 17025, respectively. The TPC must have experience in the supervision of landfill construction works. Testing polymer and mineral elements requires special accreditations. The TPC may fulfil both requirements of accreditation and monitor the quality of these elements.
The construction company supervises the quality by its own and submits the results to the TPC to be controlled. Besides, the TPC does additional, independent quality control of material and construction, including sampling, analysis, and evaluation of results.
The TPC works independently and reports the results of quality control regularly to the authority. The TPC approves the construction works when quality is in line with the QMP. In case the quality is not in line, the TPC is authorised to stop the construction works until quality is achieved.

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Quality control of technical elements of landfills by an independent third-party

Resources needed

The cost for the supervision of the quality of surface and basic sealing is about € 30,000 per hectare

Difficulties encountered

Consultants offering accredited third party control are scarce and highly demanded. This has to be considered and the request for proposal should be at an early stage of planning the construction works.

Evidence of success

The independent evaluation of quality of material and construction of polymer and mineral sealing elements is an important tool to assure the quality of the protection measures of landfills. Only when quality of the sealing elements is approved, the landfill gets the permission for operation or closure. The independent control by a third party assures quality, since analysis, conducted by the party who construct or owns the landfill, might lead to fraud.

Potential for learning/ transfer

Only by an adequate supervision the quality of the technical sealing and capping elements of the landfill can be guaranteed. This minimizes the threat for the environment and human health, resulting from the deposition of waste on a landfill.

A defined supervision of the quality of sealing elements should be applied for all types of landfills. It is especially important for hazardous-waste landfills.

It is crucial that the third party control is independent from the construction work company. Only the authority should be allowed to give instructions to the TPC.

Regular reports from the third party control during the construction works to the authority keeps the authorised person in the authority always up to date regarding the quality of applied materials and the construction works and opens the possibility for immediate reaction.

Keywords

Monitoring, Management, Awareness

Period

January 1993 – Ongoing

Contact

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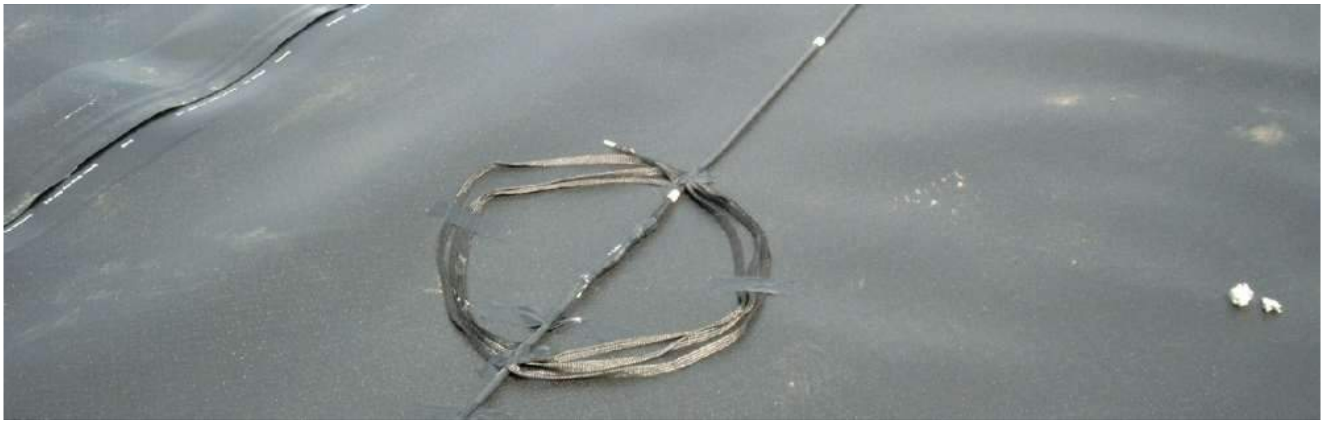
Remediation of a landfill by a surface sealing system with an electronic leak control system



A surface sealing system - a geomembrane combined with a leak control system detects damaged spots in the geomembrane and reduces the risk of hazards.

The landfill Senzig was in operation from 1968 until 2002. About 1,670,000 m³ of municipal, construction, commercial, and industrial waste was deposited on an area of 11.7 ha. A geological barrier and a base liner do not exist, while the groundwater level is high. Thus, after closure, remediation measures were obligatory. As the volume of the landfill body exceeds 500,000 m³ the remediation had to be executed following the requirements for the landfill class II of the German landfill ordinance. Accordingly, the landfill had to be covered by a sealing system with two sealing elements. However, in the case of Senzig the authority approved the substitution of the second sealing element by an electronic Leakage Control System (LCS). The LCS detects leaks > 5mm and the polymer liner can be repaired locally. The LCS consists of a grid of voltage sources installed above and electrode-sensors installed on both sides of the polymer liner. The voltages sources feature a grid of approximately 30 m, the sensors a grid of 10 m. The polymer liner acts as an insulator since electricity is not well conducted. In case of a leak the conductivity increases as the water percolating through the leak promotes conductivity. The electric potential changes, the differences in the potential provoked by a leak in the liner can be measured by the installed sensors. Overall, the LCS reduces the risk of hazards.

Remediation of a landfill by a surface sealing system with an electronic leak control system

Resources needed

The financial resource needed for the all remediation measures was approximately € 5,000,000. The leak control system is about € 10,000 per hectare. 25% of the installation of the sealing system was financed by ERDF funding.

Difficulties encountered

The practice requires a significant knowledge and experience in the installation of the leak control system. The used materials had to be approved by the German Federal Institute of Materials Research and Testing. The guarantee for the leakage control system is limited to 30 a.

Evidence of success

This practice guarantees the intended performance of the polymer liner. Leaks can be detected and repaired afterwards. In the case of Senzig already during the quality check a leak caused by the construction measures was found. By equipping the old landfill body with a surface sealing layer a long term groundwater protection is guaranteed, even though a basic sealing not exists and the pollution of groundwater decreases slowly caused by the special geologic relationship at the site.

Potential for learning/ transfer

About 500,000 landfills exist in the EU. The EU landfill directive is decisive for the minority of the landfills (< 10%), however lacks information of remediation. This good practice describes the design of remediation measures following a risk-based approach. It can be replicated for landfills with a larger volume, with disposed waste that can potentially pollute the groundwater. In Germany a surface sealing system with two sealing elements is obligatory for landfills for non-hazardous waste with higher pollutant level according to the German landfill ordinance. It can also been applied on older landfills without a basic sealing system. The practice is good for cases where an effective protection of the environment from landfill caused groundwater pollution is necessary.

Keywords

Sealing, Rehabilitation, Monitoring, Design

Period

March 2005 – April 2035

Contact

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Requirements for the design of a sanitary landfill: The Dutch practice and legislation.

Requirements for the design of a sanitary landfill in the Netherlands are described in the Dutch "Stortbesluit" and underlying technical directives.

The Dutch requirements for a sanitary landfill are from 1993 and thus well before the EU Directive (1999-31). In the period 1995 until 2001 some additional requirements were added to the "Stortbesluit". The following constructions are obligatory (from bottom to top):

- Groundwater monitoring system (both horizontal and vertical)
- Base liner consisting of both a mineral layer and a synthetic layer (2.0 mm HDPE geomembrane)
- Leachate drainage system consisting of a HDPE drainage system in a permeable layer
- Landfill gas extraction system consisting of vertical wells and a horizontal drainage system on top of the waste. Landfill gas is to be flared or utilised
- Top liner consisting of both a mineral layer and a synthetic layer
- Rainwater drainage system consisting of a run-off system and a drainage layer
- Topsoil and vegetation

In article 13 of the EU-directive the closure and after-care is the responsibility of the operator for at least 30 years. The Netherlands the after-care of a closed landfill is the indefinite responsibility of the provincial government. The operator has to pay an aftercare tax to the provincial aftercare fund. This fund will finance all necessary aftercare measures.
The stakeholders and their roles are :

- All constructions are to be designed and constructed on behalf of the owner of the landfill
- Contractors, engineers/designers
- All constructions are to be checked and approved by the provincial government
- Aftercare is done by the provincial government.

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Interreg Europe

Requirements for the design of a sanitary landfill: The Dutch practice and legislation.

Resources needed

The operation of a landfill is paid by the waste entering the landfill. This activity is economically viable. Major investments are:

- Base liner €0.4 to 0.6 Mio. per ha
- Top cover €0.6 to 0.8 Mio. per ha
- After-care €0.3 to 0.5 Mio. per ha
- Staff at an active landfill is around 5 to 15 persons

Evidence of success

The number of landfills receiving waste decreased significantly after the new legislation was published. Active landfills invested heavily. These investments reduced the environmental impact of the active Dutch landfills significantly.
All provinces have set up a dedicated aftercare fund for everlasting financing the aftercare of the closed sanitary landfills. The total value of all 12 landfill funds is at the moment more than € 400 Mio.

Difficulties encountered

The following challenges were encountered:

- Permitting a sanitary landfill (NIMBY)
- Building and operating a sanitary landfill needs more knowledge
- Financing all needed technical measures
- Transferring a closed landfill to a provincial government.

Potential for learning/ transfer

This practice describes the Dutch technical requirements for landfill management. It can inspire other regions to implement certain measures on sanitary landfills from site preparation until aftercare for proper management of sanitary landfills.
In the EU directive, the aftercare period for the operator continues as long as the landfill poses a hazard, with a minimum period of 30 years. The Netherlands has chosen for another position than the EU. After closure and capping of the landfill, the operator must transfer all aftercare responsibilities, including aftercare funds, to the regulatory body (province) for an indefinite period. With this position, problems during the aftercare can be solved since financial support is available.

Keywords

Sealing, Landfill leachate, Policy, Monitoring, Design, After care, Waste, Legislation

Period

January 1993 – Ongoing

Contact

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Surface capping: Constructing top soil by incorporation of compost

Plant growth on the landfill surface requires nutrients and organic matter in the topsoil. The topsoil can be emulated by adding compost to non humic subsoils.

The surface capping system of a landfill has to ensure proper plant growth. This requires special soil characteristics, such as good water holding and cation-exchange capacity, as well as an adequate nutrient supply. Commonly, these requirements are met when loamy subsoils and organic-rich topsoils are applied. In case of a lack of the topsoil, the subsoil can be ameliorated by compost in order to emulate a topsoil. The compost has to fulfil several requirements regarding the pollutant and foreign matter content (e.g. plastics). The thresholds are defined in the German Biowaste Ordinance (BioAbfV). The rotting process of the compost has to be completed. The nutrient content / availability and the nutrient demand of plants determine the mixing ratio of compost and soil since nutrient-leaching has to be eliminated. The soil has to be pollutant free as well and a proper water holding capacity needs to be ensured. Both materials have to exhibit a constant quality. When mixing ratio is defined, the construction of the topsoil can proceed. Quality control has to be conducted on the landfill, so it is just permitted to mix the two input materials onsite as quality control may fail, when mixed outside the landfill site by a third party (black box of mixing process). Vegetation has to be introduced immediately to prevent nutrient leaching. Topsoil with compost should be installed within the vegetation period.

Surface capping: Constructing top soil by incorporation of compost

Resources needed

The cost for the constructing a top soil and the installation as part of the capping system is about € 30,000 per hectare.

Difficulties encountered

Quality control is crucial and must be conducted at least once each 2000 Mg for the compost. Since input material is heterogenous quality will shift, however the quality has to be in a certain range and needs to fulfil the requirements set by the regulations and the quality management plan.

Evidence of success

The practice opens the possibility to construct an artificial topsoil by using subsoil and organic waste in the form of compost. The construction of topsoil may avoid excessive transport distances. The quality of topsoil achieved can sustain proper plant growth. The practice is also applied in Cordoba / Andalucía.

Potential for learning/ transfer

Fertile soils can be sparse in some regions of Europe. Topsoil just accumulate during construction works, linked with excavation and sealing. It is not reasonable to extract topsoil from elsewhere as the very vulnerable function of the soil system will be destroyed. The practice can be applied in regions, where the supply of topsoils is scarce but where a supply of organic wastes of high quality is present. The possibility to use organic waste such as compost may also support to establish or improve the collection system. A separated disposal spot for organic waste from greenery, e.g. at the civic amenity site, and from municipal waste is favourable.

Keywords

Rehabilitation, Sustainability, Circular Economy, Waste

Period

September 1998 – Ongoing

Contact

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Use of slag for the construction of the drainage layer at the landfill Schwanebeck

The construction of the drainage layer with slags substitutes the use of natural resources, such as gravel. The ecological footprint of the landfill is reduced.

The leachate of landfills is commonly contaminated. Hence, leachate has to be captured and further processed before being discharged into the groundwater. The material used for constructing the drainage layer is usually natural gravel (16/32 mm). However, the German regulation also allows using wastes as material for the drainage layer when the long-term chemical and mechanical stability is given. The quality has to fulfil the state of the art defined in the “Bundesqualitätsstandards”

The landfill Schwanebeck was recently expanded. As material for the drainage layer (0.5 m) slags (electric arc furnace slags, 16/32 mm) were applied. Before using the slags, several experiments had to be conducted to characterize the material and to prove long-term stability. This includes the long-term chemical behaviour regarding high and low pH, determination of minerals and to contaminants (overall content, leachate). Furthermore, long-term mechanical performance (fragmentation, performance during high pressures) and the impact of the leachate on this factors was examined. The results underlined the chemical and mechanical stability. Thus, the slag could be used for the drainage layer. Overall about 5000 Mg of natural gravel could be substituted by the use of slag. The ecological footprint is reduced and the landfill operator benefits as slags are cheaper than natural products. Both characteristics of the slag and leachate have to be considered when testing their long-term stability.

Use of slag for the construction of the drainage layer at the landfill Schwanebeck

Resources needed

The overall benefit is that fewer natural resources are need (0.3 m^3/m^2). In terms of human resources (work input for construction there is no difference. The financial resource needed for the material is about € 5/m^2, about € 20 less than for natural minerals. Proper analysis is about € 7000 .

Difficulties encountered

The characteristics of slag differ and depend on the metallurgic plant. The chemical performance is depending on the leachate characteristics. Application of slags required examinations and experiments. Herein, a lot of information could be gained about the characteristics of this type of slags.

Evidence of success

This practise reduces extraction of natural resources and reduces the ecological footprint of the construction of the landfill. Wastes can be used, thereby the volume of landfill needed for the deposit of such waste is reduced.

Potential for learning/ transfer

This practice can be replicated for landfills where metallurgic industry is located in the vicinity. However, as already mentioned above, a proper characterisation of the slag is necessary in order to guarantee long-term stability and functionality of the slag-based drainage layer.
The practice contributes to the following articles and annexes in the EU Directive 31/1999 on the landfill of waste, of applicability to landfills throughout the EU.

– Article 3: prevention, recycling and recovery of waste

Keywords

Sustainability, Design, Circular economy, Waste

Period

January 2019 – March 2019

Contact

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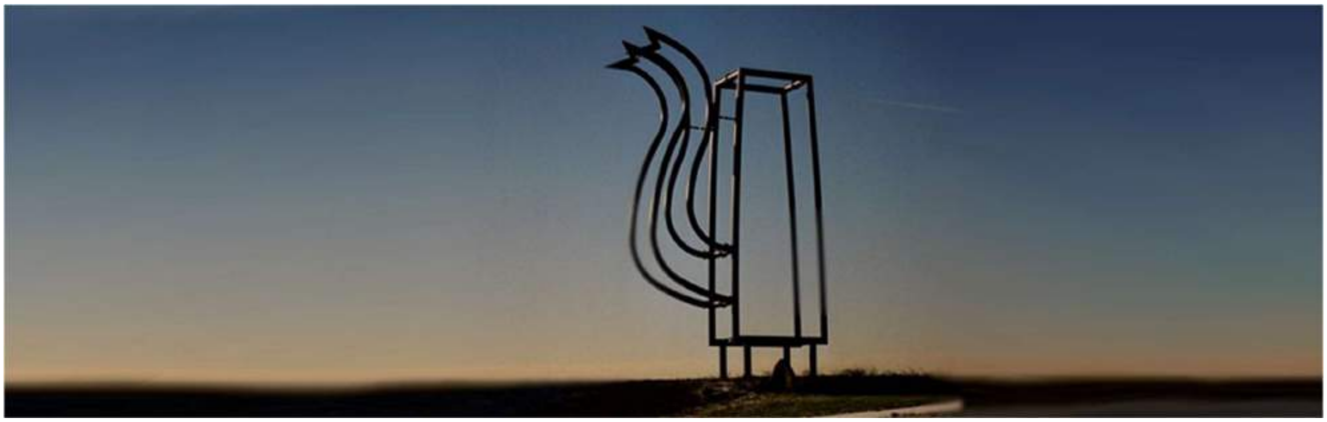
Finance of Aftercare of landfills in the Netherlands



The aftercare funds is to guarantee enough funding for the aftercare of closed landfills. This is to control and reduce risks for society and the environment.

Aftercare for a closed landfill, article 13 Council directive 1999/31/EC on the landfill of waste, is to ensure that environmental and human risks are limited and controlled. In paragraph (c) the operator is held responsible for the aftercare and its costs. But what if the operator goes bankrupt? The aftercare fund, which is a legal obligation for all Dutch landfills after 1996, is where Dutch legislation goes further than the EC Directive.

Aftercare is laid down in the Environmental Management Act chapter 8, technical measures and chapter 15, financial measures. After closure, a final inspection has been carried out by the competent authority showing that all the requirements associated with the environmental permit for the establishment have been met and that no other measures pursuant to the Soil Protection Act must be taken by the operator in the case of contamination or degradation of the soil under the landfill.

Art. 8.49 describes the measures to be taken and the obligation for an aftercare plan with Decision of the Authority and (Art. 8.50) the Provincial Executive is the authority for aftercare. The Provincial Executive sets a fee for aftercare. This includes interest and investments in a provincial owned fund. After closure, a check is complied with license obligations if the special purpose assets are reached. A settlement by additional Provincial levy Decision on aftercare plan can be put down. Unforeseen circumstances after the decision are to be paid by the province.

Finance of Aftercare of landfills in the Netherlands

Resources needed

This good practice describes the juridical framework within the Dutch Environmental Management Act for financial funding (Chapter 15) including technical measures (Chapter 8) for aftercare of a closed landfill.

Difficulties encountered

The aftercare fund is a continuous process of negotiations between provinces and operators. As the province is the competent authority there are differences per province. Operators plea for uniformity, leading to an even playing field and reducing financial risks for landfill operators.

Evidence of success

The aftercare fund is built during the time the landfill is in operation. The fund is managed and controlled by the competent authority (province). After closure of the landfill the competent authority takes a decision about both the technical measures and the financing of them. From this moment on the province is responsible for the aftercare, with no limitation in number of years.

The aftercare fund protects society for environmental and financial risks in case of a bankruptcy of the operator.

Potential for learning/ transfer

Aftercare for a closed landfill, article 13 Council directive 1999/31/EC is to ensure that environmental and human risks are limited and controlled. In paragraph (c) the operator is held responsible for the aftercare and its costs. In the Netherlands, the competent authority takes a decision about both the technical measures and the financing after closure of the landfill. The aftercare fund is managed and controlled by the competent authority (province). The aftercare fund protects society for environmental and financial risks in case of a bankruptcy of the landfill operator. COCOON partners from Flanders and Brandenburg acknowledge that this would also be a good concept in their region, however bringing it into legislation will not be evident.

Keywords

Policy, Management, Tool, Finance, Legislation, Economics

Period

April 1998– Ongoing

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Flemish raise awareness campaigns on waste sorting

Apart from taxation, sensitization of citizens to sort their waste is an important measure in reducing unwanted waste streams.

Throughout the history of Flemish waste management, OVAM and other waste related agencies did several campaigns to raise awareness. The purpose was not always to make people aware of the fact they need to sort, but also which article needs to go into which bin, and to put their waste into a bin in the first place and not into the environment.

This good practice is meant to give fellow organisations inspiration on how such a campaign can look like. Most campaigns in Flanders are done via posters, on places which are known to generate a lot of waste (shopping streets, bus stops, alongside highways,…). Also radio and TV commercials exist.

A recent project which is a major success is the ‘Mooimakers’ project: citizens can actively make a claim on a terrain or parts of their street to clean up litter. The tools to clean up (gloves, pincers, safety jacket and garbage bags) can be borrowed for free at the local municipalities. Also schools and (sport)clubs can join. They report a target, afterwards report the result and get a financial reward for this, depending on the amount of waste that was collected.

Flemish raise awareness campaigns on waste sorting

Resources needed

Campaigns can be as cheap or as expensive as you want. Poster campaigns are the most used medium because they are the cheapest to make. Radio and certainly TV commercials can become very expensive very rapidly. OVAM creates a lot of its content in house (3 Full Time Equivalent, FTE).

Difficulties encountered

Keep in mind that there can be copyright on pictures you use for your campaign. Tricking out money with this is an increasingly popular thing and lawyer companies specialised in this type of shady cases exist, happy to make your budget a lot smaller.

Evidence of success

The amount of MSW has declined in Flanders, on average with 10% per inhabitant since 2013. On a longer timeframe the decline is most distinct for residual waste: 56% between 1995 and 2015. The more recent 'Mooimakers' campaign, described above, to clean up litter and actively involves citizens is a major success.

Potential for learning/ transfer

Below a list of links to some campaigns and related information:
https://www.fostplus.be/fr/fr-fost-plus/fr-de-campagnes-van-fost-plus/fr-zwerfvuilcampagnes
https://ovam.be/iksorteer
https://mooimakers.be/

Keywords

Policy, Landfill mining, Management, Waste

Period

January 2010 – Ongoing

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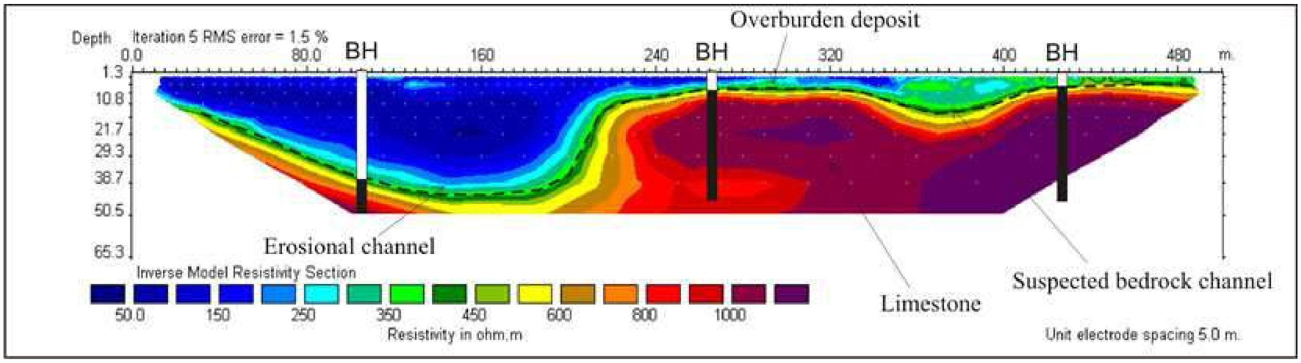
Geophysical Prospection for the detection of leachate in a Municipal Solid Waste landfill



Evaluate landfill stability according to the leachate accumulation in the waste mass in landfills, using electrical Resistivity Tomography (ERT)

Electrical resistivity tomography (ERT) is a geophysical technique for imaging sub-surface structures using electrical resistivity measurements made at the surface of landfill. The execution of this method creates a continuous current into the ground by two electrodes connected to an energy source of a known intensity. The difference in power is measured by two other electrodes. With these two measurements (intensity and power difference) the apparent resistance, which is related to greater leachate saturation, is obtained dependent on the affected material.

The plans for exploiting, the installation, available reports, and annual controls were revised prior to starting the field campaign. Using this information set of profiles has been designed and planned, allowing all of these areas to be covered in in order for ground penetration to reach sufficient depth to determine leachate levels. ERT profiles were prepared in such a way that the centre, profile section that penetrates the ground most, is situated above the areas which are expected to be the thickest.

In order to acquire a greater resolution and reliability level, both in implementation and later data reading, it has been charted following three main directions, thereby trying to achieve the straightest line possible at all times, following the existing berms

Geophysical Prospection for the detection of leachate in a Municipal Solid Waste landfill

Resources needed

A budget of approximately 15,000 € for 5,500 linear metres of electrical resistivity imaging (one week of work and another for data interpretation, conclusions, plans, profiles, and writing the report).

Difficulties encountered

This technique is only useful before landfill sealing because top cover materials distorte the results. It is convenient to apply this technique during exploitation phase every five years to analyse landfill behaviour and evolution.

Evidence of success

ERT, as a decision making tool in LfM (landfill management), allows to identify and partially characterize materials inside the waste mass; locate leachate accumulations and control landfill evolution and stability. Therefore this technique provides information to manage landfill in operational phase and to optimise sealing design in order to guarantee landfill stability.

Potential for learning/ transfer

Electrical Resistivity Tomography is a decision-tool cost-effective decision making tool in LfM (landfill management) that allow to identify and partially characterize materials inside the waste mass, locate leachate accumulations and control and fill evolution and stability. This technique could be applied in any landfill (not only municipal solid waste but also industrial waste landfill) to provide more information about landfill state of art.

Keywords

Management, Waste

Period

April 2014 – Ongoing

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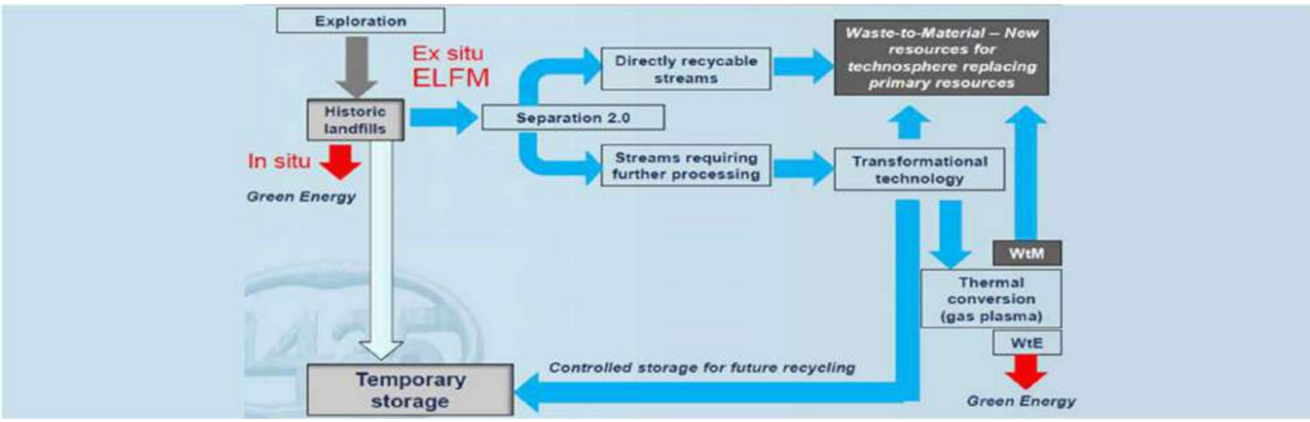
Temporary storage on landfills policy in Flanders



Flemish temporary storage policy is part of the mind shift that landfills are not the terminus of a linear economy. Instead, they are part of the circular economy.

In Flanders, new waste is either landfilled or incinerated. The reason for this is the current absence of suitable techniques to valorise this waste. Hence, this can lead to a sub-optimal use of this waste. Therefore, an objective of the government is to save up the waste and do resource management. Thus, the waste is not really landfilled, but is stored temporarily with a view on its future valorisation, when suitable techniques are available. In short, a landfill site becomes a mine for tomorrow's raw materials.

Temporary storage can take place in two different ways. Firstly, the waste can be distributed into different compartments, based on the type of waste stream, at a specific landfill site. This landfill site is built in accordance with the current regulations (foil, leachate collection, drainage layers, etc.) and can receive other waste streams from outside. Another principle involves the creation of mono-landfills with one type of waste stream (cf. current metal business). This principle simplifies the valorisation process of this specific waste stream in the future. Both ways of storing are done since the first act on waste in 1981, so Flanders was quite early in doing this. The official aftercare in Flanders is 20 years.

Temporary storage on landfills policy in Flanders

Resources needed

A team of five people worked together on the content of the concept note.

Difficulties encountered

For the actual implementation of temporary storage, the current legislative framework needed to be adapted and specific stimuli needed to be provided by the authorities. Furthermore, research by private market players was required for the prevention of the dispersion of contaminated substances.

Evidence of success

The Flemish concept note on sustainable storage policy was granted by the Flemish parliament on 16 October 2015.
Also, because of the early policy on mono-landfilling, today Flanders has landfills with a qualitative content which effectively leads to landfill mining projects. See for instance the good practice 'De Blankaart' landfill mining project: an economic viable case '

Potential for learning/ transfer

Temporary storage with a view on valorisation prevents the use of current expensive, energy-intensive separation processes for waste streams, which can be exploited again in the future, possibly with cheaper techniques, as raw materials. The principles of this good practices can be used anywhere, and can be implemented according to your national or regional waste legislative framework

Keywords

Waste pretreatment, Sealing, Policiy, Monitoring, Design, Management, Aftercare, Interuse, Storage, Waste, Legislation

Period

October 2015 – Ongoing

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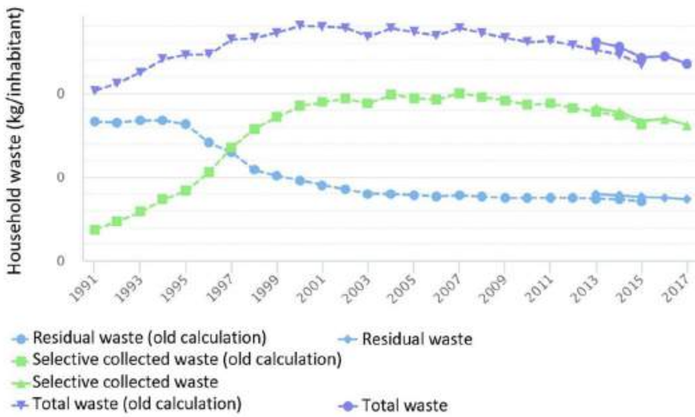
Waste deposit and landfill tax system of Flanders



The Flemish waste tax system is based on the pay-as-you-throw principle. It is made up out of two taxes: tax on landfilling waste and a tax on combusting waste.

The waste tax system counters the waste production and is based on the pay-as-you-throw principle. Taxes are paid by the waste producer to the waste collector (municipality or intercommunal organisation). The remarkable feature of the policy is the differentiated tariff for every waste stream, making it possible to steer consumers in their waste management (i.e. encouraging them to produce less waste but also encourage to recycle more so less waste needs to be deposited). The policy is made up out of two taxes: a landfill tax and a combusting tax. Both increase year over year. Currently, the tax for incineration of municipal solid waste (MSW) is an average of € 101/tonne, but in reality is can be as low as € 55/tonne and as high as € 130/tonne. This depends on the composition of the waste. For the incineration of industrial waste, Flanders uses five categories: low-caloric waste, high-caloric waste, solid no-risk medical waste, sludge and recycling residues. Each category has its own tariff based on the caloric value. Taxes on landfilling are paid by the waste collectors to OVAM. The tariff is different per landfill category and is the sum of a standard environment fee and a variable tax per ton. The three categories are:

- Hazardous waste: tariff based on composition via sampling (about € 125/tonne)
- Non-hazardous, inorganic waste: difference between MSW and non-combustible waste (about € 126-129/tonne)
- Inert materials: also including asbestos cement (€ 76/tonne)

For waste material that is released from mining activities there is an exemption of landfill tax.

Waste deposit and landfill tax system of Flanders

Resources needed

A total of seven people work on the publications and statistics of the tariffs as well as the management of the landfill taxes. The taxes only contribute partly, although significantly, to the total cost of the waste management.

Difficulties encountered

Illegal dumping is a major problem. Until recently, some municipal sorting streets didn't have balances to weigh the waste, instead employees estimated the weight, leading to randomness. This is solved. Current dumping practices are done by locals who think the tariffs are too high.

Evidence of success

See chart. The amount of municipal solid waste has declined in Flanders, with ±10% per inhabitant since 2013. The decline is most distinct for residual waste: 56% between 1995 and 2015. This is a result of the campaigns to raise awareness on avoiding waste and education of people to sort and recycle . But of course pay-as-you-throw principle and the increase in price to discard the waste is an additional stimulus for people to sort and recycle and to avoid waste being landfilled or combusted.

Potential for learning/ transfer

The pay-as-you-throw, also called diftar (differentiated tariff) principle is a very efficient system to work with. The experience is that citizens will sort there waste better, leading to less residual waste and lower costs related to that residual waste. It can be applied in all regions where no such system exists yet and could provide a source of income for the organisations that are in charge of waste collection and treatment to allow them to choose for the best waste treatment procedure. However, policy makers should take into consideration that these benefits also have a negative side, i.e. the rate of illegal dumping by citizens could increase to some extent, primarily in impoverished areas. In case of Flanders, the benefits strongly overpower the negative side-effects.

Keywords

Waste pretreatment, Waste separations, Policy, Management, Circular economy, Finance, Waste, Legislation

Period

January 1985 – Ongoing

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Green Deal: "Sustainable Landfill Management" (SLM)




Sustainable Landfill Management (SLM) aims to determine a method to reduce the emission potential of landfills which lead to a cost-effective approach .

The aftercare of landfills is costly and imposes due care on future generations. The usual method for landfills in the Netherlands is that the operator of the landfill first ensures a good under seal, followed by sealing with a top layer. The deposited waste is then completely isolated. This means that the waste materials are always retained and that the soil protection provisions must in principle be managed and controlled perpetually. An effective but expensive solution, that requires everlasting aftercare.

The SLM investigates the possibilities for speeding up the processes of degrading, stabilizing or otherwise rendering the contaminants in a landfill harmless. It is a strictly supervised research programme by the Dutch Government. It focuses on creating more sustainable landfills with a less complex (and less expensive) system of final sealing and aftercare activities.

By adding water and air to a landfill, the biodegradation processes in the landfill are stimulated. To eliminate the risks for the environment, the quality of the remaining stable waste must meet the normal environmental standards.

The final goal of SLM is to reduce aftercare costs and environmental risks for future generations. The area of the landfill can be reused for other valuable purposes. The main stakeholders are the Dutch waste management industry; Universities and research institutes; and National and regional (Provinces) governments.

Green Deal: "Sustainable Landfill Management" (SLM)

Resources needed

The exploitation will be funded by the landfill branch organisation. During the project (10 years) they will fund € 1 Mio. for research and monitoring every year. The National government will coordinate the project.

Difficulties encountered

If SML is a success, it means that it can be applied for other landfills in the EU. The consequence is that a top layer is no longer necessary on a landfill. This means that the Dutch and EU Directive need an amendment.

Evidence of success

By performing the principles of processing the landfills according to SML (aeration and moistening), the aftercare, which is considered as everlasting, very expensive and limits the potentials for area development, will be considerably reduced or ended. The pilots started from 1 July 2017, so currently results are premature. The first results are expected within 5 years.

Potential for learning/ transfer

This practice can be replicated in any landfill at any location. Performing the principles of processing landfills will increase the possibilities for area development and reduce costs for aftercare. Other regions can take advantage of the pilots in the Netherlands. If the Green Deal SLM will be a success, the Netherlands expects financial savings of at least € 66 Mio. for the 15 allocated SLM landfills (In the Regulation implementing landfill decision soil protection (17 mei 2016, no. IENM/BSK-2016/93326) is a saving on aftercare costs of ~ €20/m²). The practice contributes to the following articles in the EU Directive 31/1999:

- Article 12: Control and monitoring procedures in the operational phase;
- Article 13: Closure and after care procedures.

Keywords

Waste pretreatment, Landfill leachate, Groundwater, Monitoring, Aftercare, Legislation

Period

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