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Interdependencies Between Landfill Operation Procedures and Leachate Treatment

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Abstract: Leachate of landfills with organic waste consist a complex composition of different ingredients. Therefore it is not enough to design a leachate treatment plant only on the base of leachate analysis from a selected period. As a consequence, an examination of the expected development of landfill body over next 20 to 30 years must be an important part of the design in order to get an optimum solution of leachate treatment.

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INTRODUCTION

Leachate treatment is one of the most complex tasks in the field of wastewater treatment, and is next to the treatment of landfill gas an important parameter for economical landfill operation. Wastewater of landfills have an extremely variation of components. This has to be kept in mind while designing a new treatment plant or refitting an old one.

Different leachate treatment systems are available and cannot be used universally in the same way in every case. Depending on the contaminant loads and outlet limits, applied technologies have to be varied and adjust. Designer of leachate treatment plants need all information about landfill operation conditions as well as analysis data of leachate to select the best treatment process. In sum, the landfill body and the belonging management is a complex system with interdependencies of type of waste storage, types of waste, local precipitation, the arising leachate, type of leachate catchment, type of landfill gas catchment/treatment etc. Biological leachate treatment systems are one of the most used solutions for landfills in high activity phase with lots of biodegradable organics. Depending on experiences with SBR treatments plants for leachate, this article shows some essential notes that have to be regarded using biological treatment systems. Recently we see more and more large equalization tanks being built at leachate treatment plant inlets in order to reduce the treatment capacity to an economically justifiable extension.

Looking at the aforementioned explanation about the complexity of landfill body following aspects are mainly responsible for the content of leachate:

Precipitation or surface water

- Type of deposited waste and kind of deposition method
- Age of landfill body
- Efficiency of landfill degassing system
- Size of uncovered surface or surface covering solutions
- Recirculated leachate
- Changes in waste composition

As an example, we take a look at the landfill age. As shown in figure 2 the components of a landfill change significantly during a long-term period. Leachate components like COD and especially BOD decrease significantly, nitrogen increases. This has dramatic consequences on biological treatment processes.
Another example is the kind of landfill degassing. Landfill gases consist almost to 100 % of CH_4 and CO_2 (Ehrig, H. J, 1989). If the aerosis is more effective in the landfill, the rate of carbon atoms in the landfill gas decrease and do not get to the leachate.
If a biological treatment is designed and realized regarding common design criteria (Bishof, W. 1998) at a period with fully operation of a landfill big problems will be expected maybe 10 or 15 years later when the landfill is full and must be covered. The biological treatment needs external COD like e.g. acetic acid to reduce nitrogen.

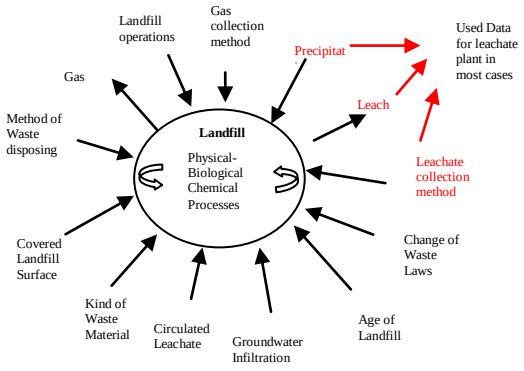

Figure 1: Complex interdependencies in a landfill (Mueller-Czygan G. 2010)

Design guidelines for efficient and sustainable leachate treatment

As shown above, it is not sufficient to use only a spot of leachate composition as sole design criteria. Waste water experts should always coordinate the selection of the appropriate treatment method and the according facility design together with landfill experts and operators. Table 1 is an excerpt of recommended design guidelines for municipal landfills and can be used as a checklist. Mainly it is used to analyze the interdependencies of a landfill and to ask important questions to the landfill operators during design. The additional costs at design doing an evaluation along the shown guidelines are only a small fraction of complete costs that can be saved if an optimum leachate treatment solution will be chosen.

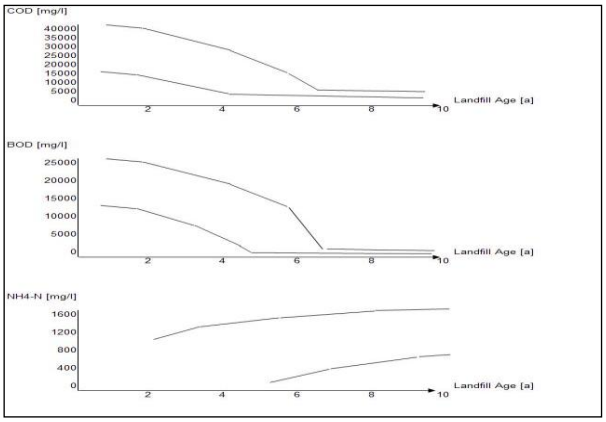

Figure 2: Leachate composition depending on landfill age (Ehrig, H. J.1989)

Available leachate treatment technology

The overview of chosen technologies for leachate treatment is shown. Table 2 is a summary of lecture material from Technical University of Dresden that is available as a download. As each landfill has its own characteristic, universal methods for leachate treatment do not exists. To get a well done solution for each single leachate, it is recommended to spend needed effort for analyzing the influence parameters from landfill body and waste management at landfill even on creating a likely scenario how the landfill body will develop in the future incl. expected influences to leachate characteristics. In lots of cases, solutions with modular systematics are preferred in order to have the possibility adapting the treatment process onto expected changes of conditions in the landfill body. Furthermore, the selection of a suitable control and automation technology like Scada V 10 or the little sister Scada.web supports a maximum flexibility in operation control.

Example SBR-plant of landfill Jakuševac (Croatia)

To improve the existing leachate treatment plant of landfill of Jakuševac (Zagreb, Croatia) the plant was ordered to change the automation system and to renew the dosage system. Several years before, the owner of the landfill built a SBR treatment plant with standard control solution based on common design criteria (see e.g. Chang, L., 1993). The plant does not hold the outlet limits about COD < 700 mg/l. The main problem was that during start of design and end of commissioning of new SBR plant, the NH_4 load inside of landfill body increased significant and COD decreased. As the original control system was not flexible to adjust the SBR cycles in a way adapting the operation steps of nitrification and denitrification onto the change of inflow conditions the performance of SBR was unsatisfying. Furthermore the possibility to add acetic acid was not foreseen that is needed if NH_4 is rising while parallel COD concentration is reducing. After refitting the old SBR plant with control and automation system Scada V10 and new dosage equipment for adding acetic acid within 6 weeks the outlet limits could be hold.

Table 1: Examples for basic conditions that should be considered during design/ redesign/ optimizing of leachate treatment plants

Topic	**What questions must be answered?**	**Possible measures**
Precipitation - surface water	Is the flow measured automatically?	It can be derived from this value if the leachate consists mainly of rain water or if other water sources like i.e. groundwater intrusion exist.
	Do prognoses exist for future rain events?	The size of a mixing and buffer tank is directly related to the amount of rain expected.
	Is information how surface water is collected and removed available?	If surface water removal is insufficient, leaks in the surface seal are likely the cause. An immediate repair of such leakages reduces the leachate flow.
	Do alternative storage options to a mixing and buffer tank for extreme rain events exist?	If a strong rain event happens only a few times a year, it might be more economical to reduce the size of the mixing and buffer tank and to truck the peak flows to the municipal WWTP. The use of prognostic models like the Virtual Rain Gauge allows planning the logistics for such measures ahead of time. Alternatively it should be checked if sufficient storage volume might be available inside the landfill. This could provide several days of storage. Further alternatives like add. retention basins, unused but already sealed areas are to be checked. Leachate recirculation might be another useful alternative.
Type of waste and method of installation	Is the composition of the waste going to remain similar for a longtime?	Leachate data at the beginning of the design phase is data of the past. The chosen process technology based on this data is usually suitable only for limited contaminant compositions. Changes in composition often mean process adjustments with significant costs.
	If not, when and how does the composition change?	If it is known from the beginning that significant types of waste are left out in a few years, this can be considered in phased or modular concept. Is for example the entire green waste within 2-3 years excluded, can the biological process split in multiple units that can be used as buffer tanks after the exclusion. Respective flexibility in piping should be added in design.
	Are open installation areas minimized during operation?	Mainly good communications between treatment plant and landfill operator is important here. When the treatment plant runs at or over capacity, should the operator ensure that as little area as possible is uncovered (maybe interim storage of waste necessary)
Age of landfill	In which process phase is the landfill?	At the beginning of a landfill the BOD is relatively high. Later the amount of hard to treat carbons (COD) increases. It can be wise to install a first phase biological plant and to remove the rest COD with mobile activated carbon units. Is the easy to treat carbon content to low should a chemical-oxidative unit (ozone, H_2O or UV) added. The construction of a chemical-oxidative unit at the beginning is usually uneconomical. A high degree of flexibility can be achieved through respective piping design, if all tanks are connected in a way that their function can be modified. It can be economical for smaller landfills to choose some technical components as mobile container solutions. That way new or alternative process phases can be realized by simply exchanging the container unit.
Landfill degassing	How efficient is the current landfill degassing system?	Efficient landfill degassing reduces the biologically easy to treat carbons. This can cause problems when choosing the bio-reactor, if not considered. With sufficient amounts of CH_4 energetic use is desired which can cover part of the energy demand of the leachate plant.
	Is landfill gas routed through leachate pipes?	It has to be checked, if and in what amount landfill gas leaks through the leachate piping system. Respective measures should be taken if this is the case.

Table 2: Overview of the common methods for leachate treatment

Process	Comments	Limits
Physical Methods		
Sedimentation	low cost	suitable only for un-dissolved components
Concentration	concentration of ingredients	costly, corrosion, only partial solution (COD is removed but not destroyed).
Physical-chemical Methods		
Adsorption on activated carbon	suitable for hydrophobic waste water contents	only partial solution, thermal regeneration of carbon necessary
Adsorption on adsorption resins	for chloride hydro-carbons, hydro-carbons, condiments usable	only partial solution, costly
Membrane technology/ reversed osmosis	reversed osmosis, good retention	concentrate might have to be disposed of, coagulation of colloids on the membrane („Fouling“) possible.
Ion exchange	suitable only for special problems (Ions)	Organic matter and colloids interfere
Flocculation and coagulation (with $Ca(OH)_2$ + Fe-salts or $Al_2(SO_4)_3$)	is used often, partial COD elimination, is considered as outdated	disposal of sludge and salts necessary (35 kg/m³ leachate!)
Chemical Methods		
Wet oxidation w/ H_2O_2	No accumulation, elimination of rest COD and AOX contents	not always suitable for direct dischargers (too much salt), high energy requirements
Wet oxidation w/ Ozone/ UV radiation	No accumulation, elimination of rest COD and AOX contents	not always suitable for direct dischargers (too much salt), high energy requirements
Wet oxidation w/ Ozone /packed bed catalyst	high reaction speed	high energy requirement
Bio-chemical Methods		
Anaerobic treatment	no energy required for aeration, no excess sludge	retention of biomass, sensitive, no extensive treatment
Anoxic treatment	Denitrification	prior Nitrification necessary
Aerobic treatment (COD/BOD5-Elimination)	the most common, cheapest method	not efficient for biological hard to treat matter, therefore local effluent requirements not always reachable (more suitable for indirect dischargers)
Nitrification	Oxidation of ammoniac nitrogen via nitrite to nitrate	sensitive method (Inhibition)

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Summary/Sažetak

Procjedne vode deponija sa organskim otpadom sadrže različite komponente složenog sastava. Kako je tijelo deponije biološki reaktor, to se sastav procjednih voda kao i sastav razvijenog plina mijenja sa promjenom pokrova deponije. Stoga nije dovoljno osmisliti postrojenje za tretman otpadnih voda samo na osnovu analize procjednih voda za odabrani period. Pa izrada studije vjerovatnog razvoja deponije za period od 20 do 30 godina treba biti važan dio dizajna za izbor optimalnog rješenja tretmana procjednih voda.