CONTROLLED INFILTRATION OF LEACHATE CONCENTRATES INTO LANDFILL BODIES

EXPERIENCES AND SOLUTIONS

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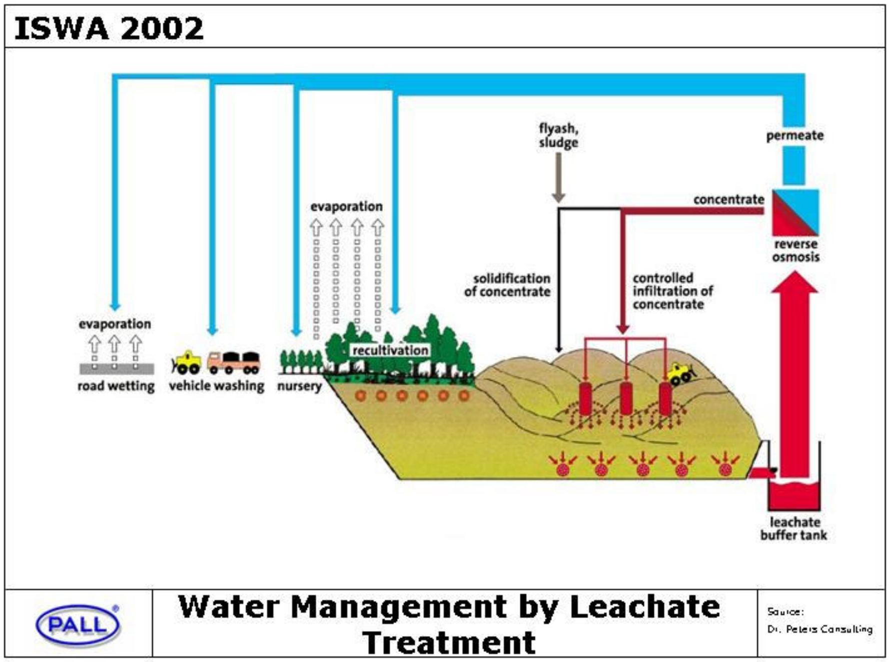
INTRODUCTION

Direct leachate circulation has been practised for a long time as a measure to get rid of leachate for which no appropriate equipment for treatment is available. However, in temperate climate regions natural evaporation is never enough to prevent the steady increase of water volumes generated in the landfill. Well-considered concepts therefore restrict recirculation to infiltration of part of the leachate in order to provide for a proper water management in the landfill. In domestic waste landfills, infiltration leads to an increased biological activity resulting in a considerably higher production of landfill gas and faster mineralisation of organic matter. This has a positive impact on the duration of the after care period after closing of the landfill. The further development of this concept leads to a combination of leachate treatment with the landfill water management: If landfill leachate is treated by Reverse Osmosis, the concentrate may be used for infiltration. The recovery rate of the permeate controls the amount of concentrate which may be adapted to the requirements of the specific landfill (fig. 1).
By the raised concentration of leachate contents in the concentrate, the biochemical and physical processes are enhanced. The main processes are:

- biochemical decomposition processes in the landfill body
- decomposition of organic and inorganic material in the form of oxides, sulphides and carbonates
- adsorption of heavy metals at different inner surfaces in the waste body
- crystallisation processes
- arising of carbonates, sulphides and sulphates by inorganic-chemical processes

Figure 1. Water Management by Leachate Treatment



REQUIREMENTS FOR INFILTRATION

For these reasons, infiltration of leachate and concentrates is common practice in many countries. However, in some countries this process is looked at critically or it is limited by approval authorities within special boundary conditions.
The main concern is the danger of ground contamination by these liquids due to channelling and local air pollution by contact with the atmosphere.
Experiences in the past have demonstrated that improper design of infiltration may lead to undesirable results. Therefore a couple of measures are usually required by approval authorities (fig. 2):

- Efficient bottom lining is to prevent penetration of liquids into the ground if channelling occurs
- An appropriate drainage system is to collect leachate and prevents accumulation of water within the landfill body
- Solidity of the landfill body itself, depending on the type of refuses, humidity and way of disposing
- Relevant amount of organic waste
  The landfill must be effective as bioreactor to make use of humidification for biochemical decomposition processes
- A degasification system is to provide for gas extraction from the landfill body
- Control of gas and water balances must be achieved by appropriate control and monitoring systems
- The landfill height must not fall below a minimum (e.g. 10m) in order to enable horizontal distribution of the liquid

Figure 2. Preconditions Required by Authorities

ISWA 2002

Efficient bottom lining	plastic liner or mineral sealing
Drainage system	
Solidity of landfill body	
Relevant amount of organic waste	domestic refuse
Degasification system	
Controlled infiltration	proper distribution design flow volume measuring
Control of gas and water balances	volume control flow limitation
Minimum height of landfill	

PALL **Preconditions Required by Authorities**

The majority of these points refers to liquid distribution and avoidance of preferential flow channelling. Fortunately a landfill is a complexly composed waste body which exhibits principally branched flow paths without direct channels down to the bottom. Figure 3 shows the liquid flow within a landfill body under conditions of equally distributed paths. Preferred directions should occur neither horizontally (overflow at slope) nor vertically (channelling and liquid accumulation at the bottom). The a.m. concerns require some basic design considerations which are compiled in figure 4:

- Avoidance of channelling and local super saturation by means of a proper liquid distribution system
- To prevent air pollution through odors and aerosols, the liquid should not be sprinkled over the landfill but percolated into the surface or under the cover
- The dimensioning of pipes and fittings should be suitable for cleaning and rinsing
- During standstills the concentrate must be replaced by clear water to prevent scaling in the pipes

Figure 3. Flow Paths in the Landfill Interior

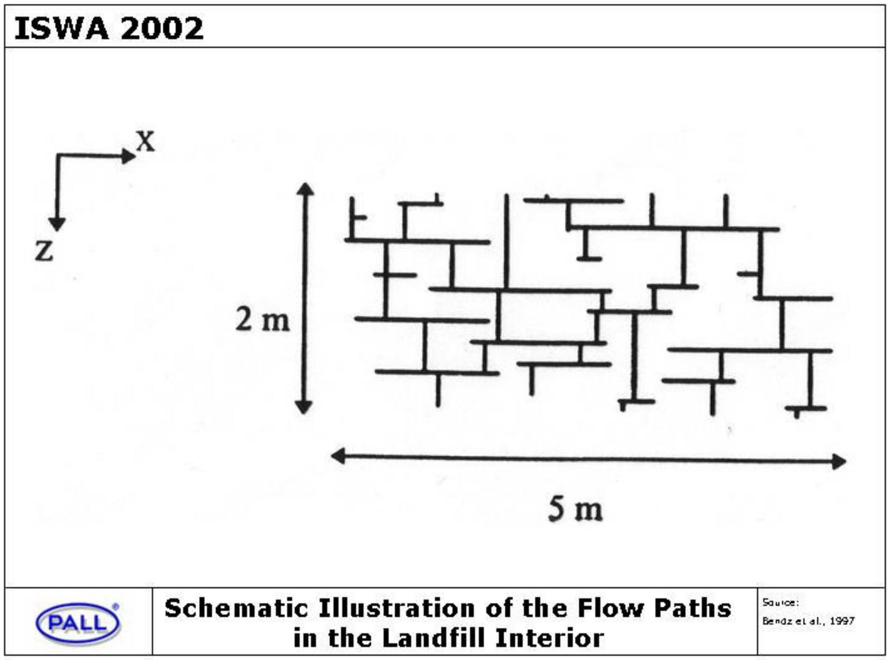


Figure 4. Basic Design Requirements

ISWA 2002

Proper distribution of concentrate in landfill body

- Avoidance of chanelling
- Avoidance of super saturation

Reduction of contact with atmosphere

- Odors
- Aerosols

Sufficient dimensioning of piping

- Cleaning and rinsing
- Filling with clean water at standstill

Basic Requirements for Design of Injection Systems

TECHNICAL SOLUTIONS FOR INFILTRATION

"Controlled infiltration" implicates technical equipment that enables the change of position of liquid feed. This flexibility must be ensured, as the optimisation of adjustment, control and monitoring of infiltration parameters may vary with long-time effects.

Figure 5. Horizontal Infiltration System

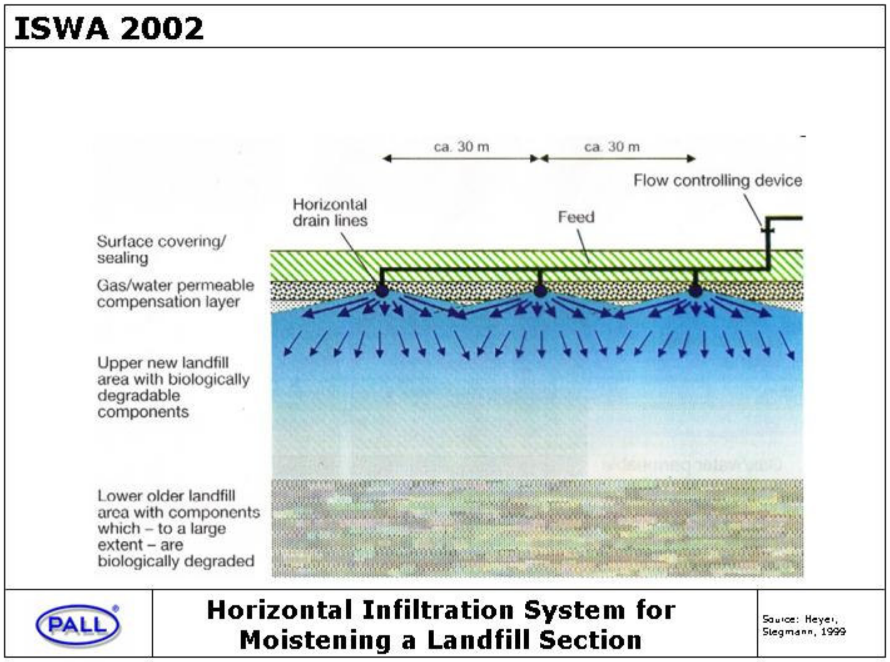
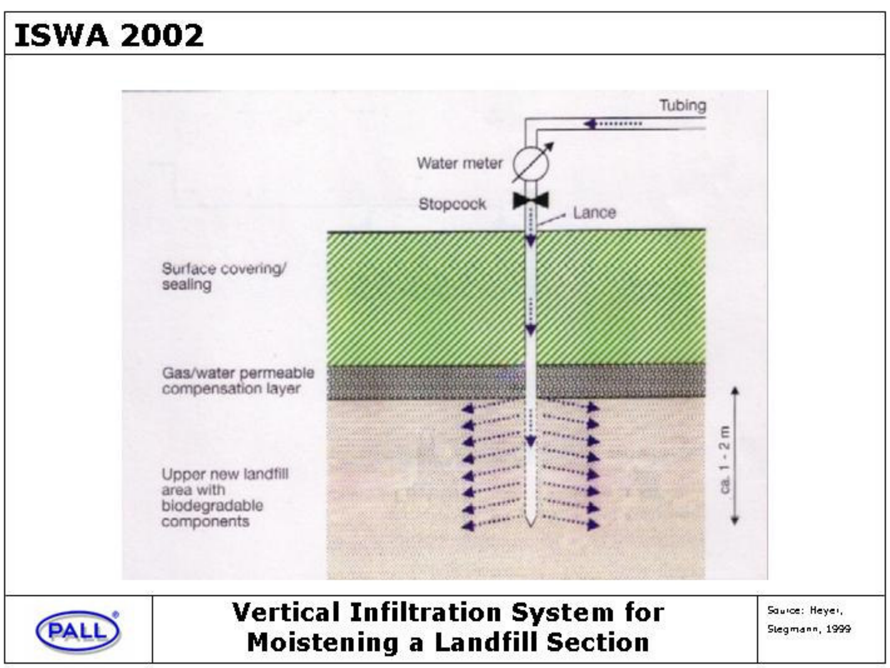


Figure 6. Vertical Infiltration System



Examples for such technical equipment are horizontal systems with several drain lines (figure 5). In cases where the arrangement of layers in the landfill body may prevent proper penetration, vertical irrigation systems with lances may be applied (figure 6).

Figure 7. Trickling Bed with Gravel Filling

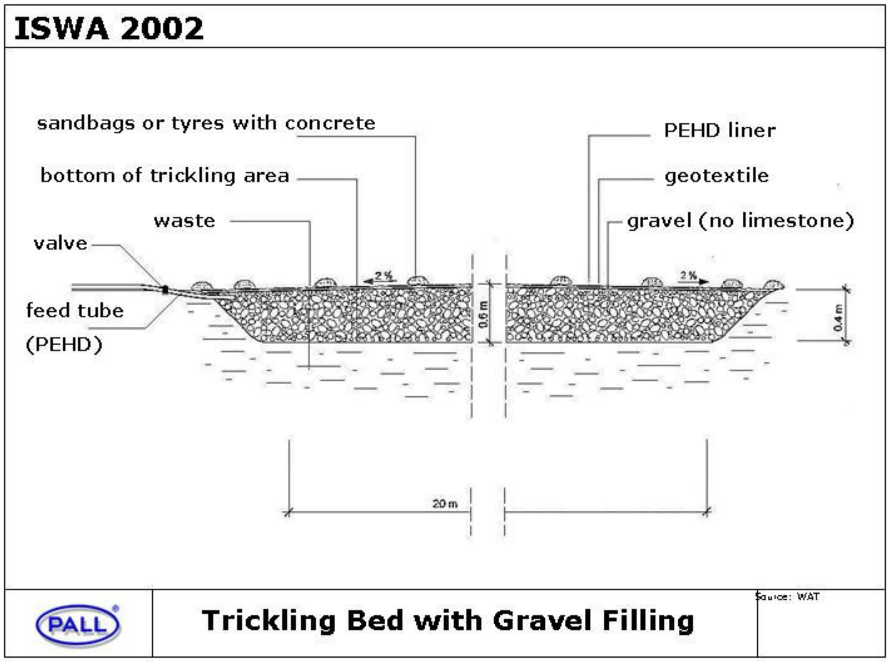
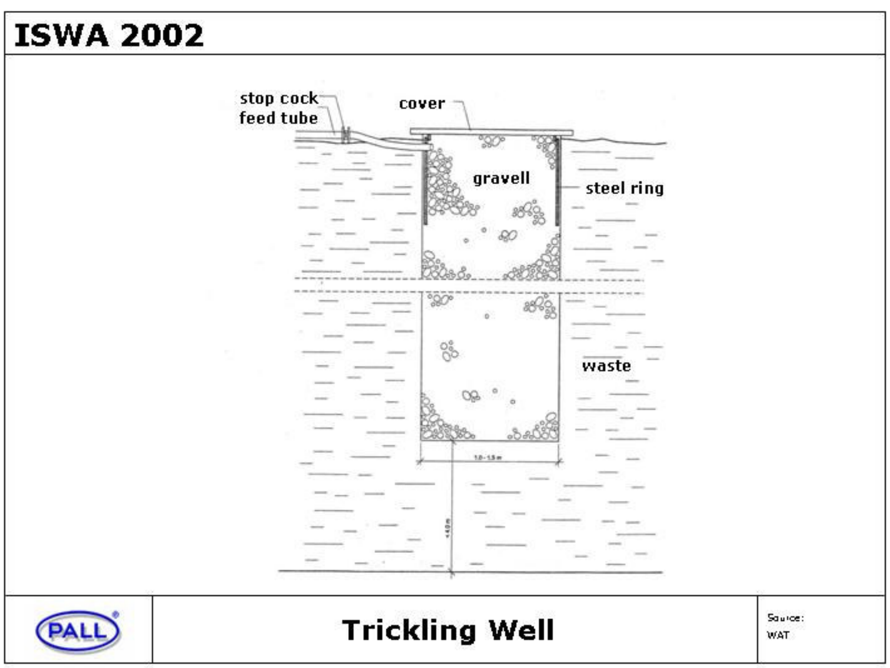


Figure 8. Trickling Well

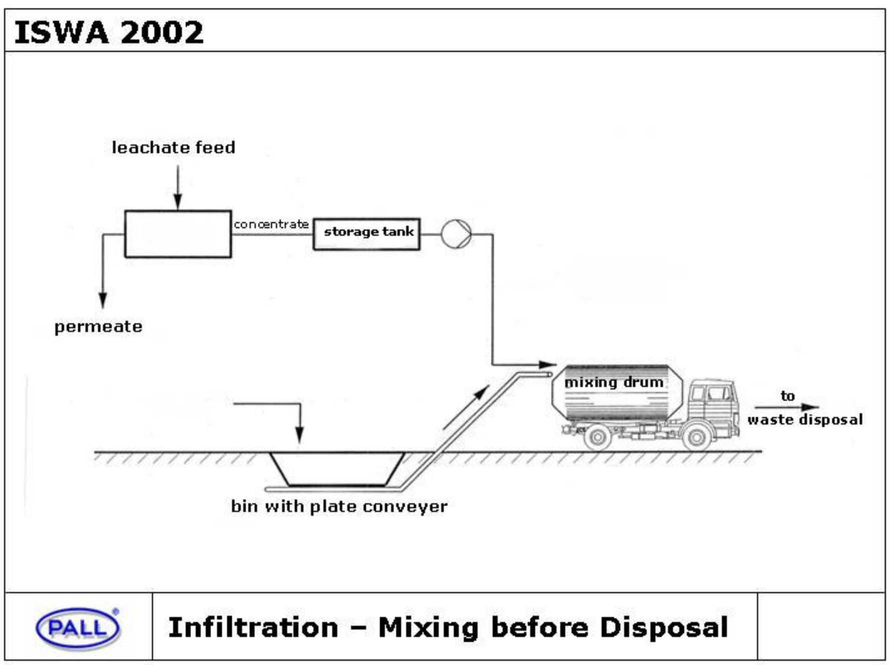


Another proposal for horizontal distribution is shown in figure 7. The gravel bed provides equal distribution of the liquid over the whole area. The gravel should not contain calcium carbonate, because the sulphate content in the liquid would lead to gypsum formation with blocking of flow paths.

A corresponding proposal for a more vertical solution is presented in figure 8. A drainage well filled with gravel is the measure for the distribution of the liquid.

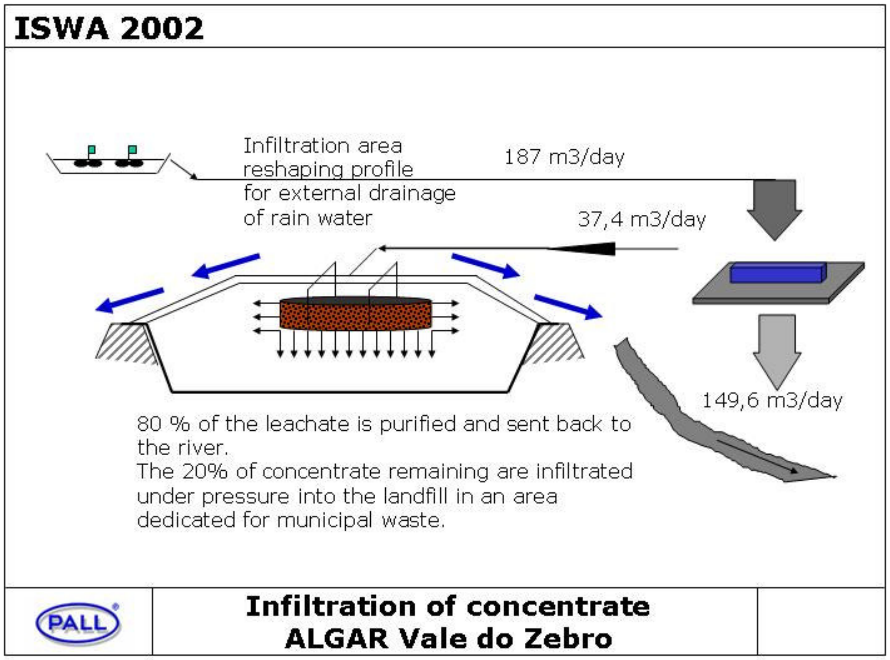
A totally different approach to the solution of the distribution process is shown in figure 9. In this case the liquid is mixed with waste before it is placed into the landfill. This distribution of liquid is perfect and channelling may be safely prevented.
However this method requires an additional step before dumping the waste. Moreover, enough waste has to be available to absorb the liquid.

Figure 9. Mixing before Disposal



A practical example for a modern infiltration system is presented in figure 10. It refers to the landfill Algar in Portugal where nearly two years ago a leachate treatment with RO and concentrate infiltration was installed.

Figure 10. Example: Infiltration Algar



Max. 37,4 m³/d are trickled onto an area of approx. 1250 m². Whether this area is sufficient will be seen in the future (fig. 11 and 12).

Figure 11. Distribution Network

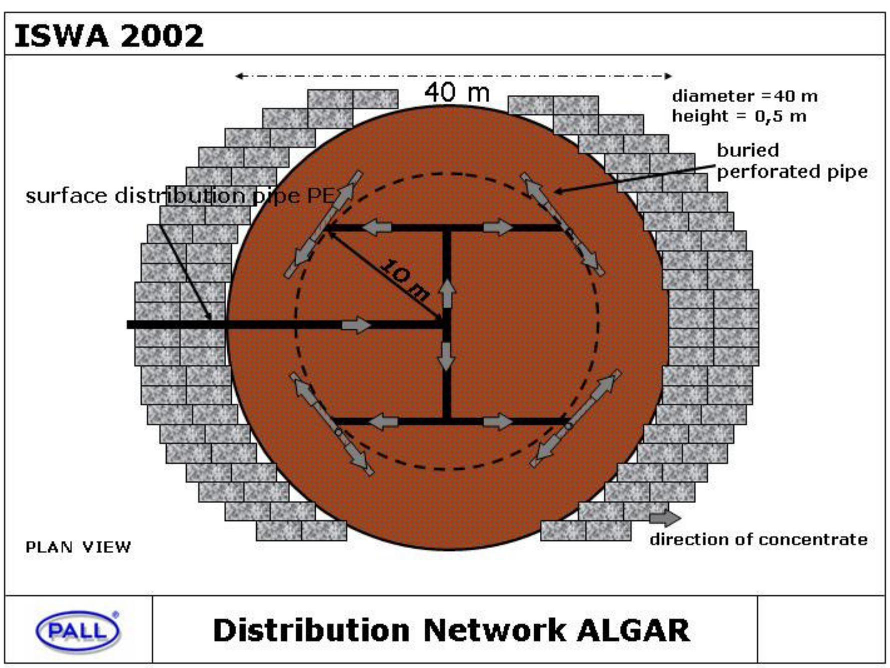
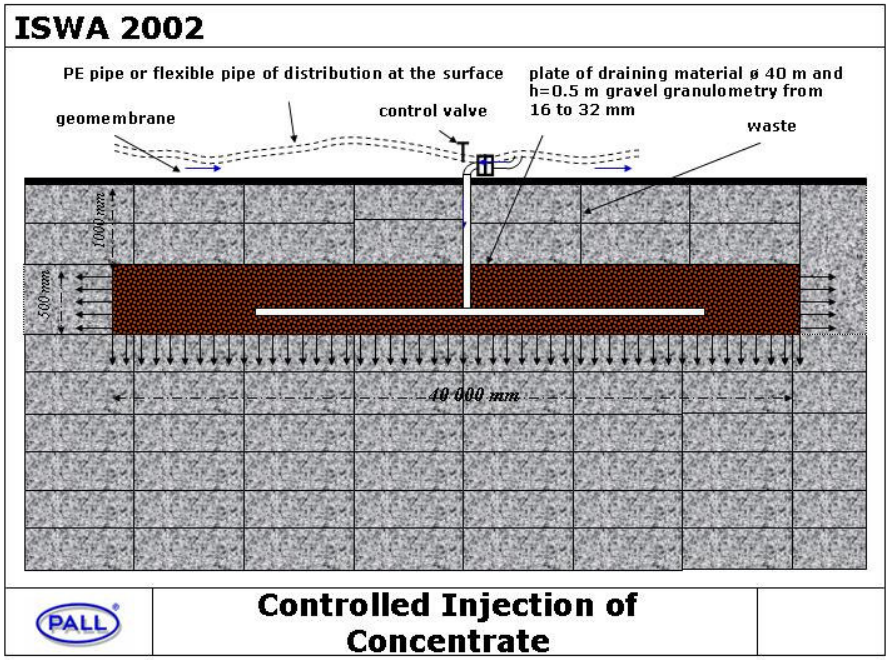


Figure 12. Controlled Reinjection of Concentrate



In the landfill Valnor in France, a by far smaller amount of concentrate is sunk by two rectangular blocks (fig.13). The design aims at a vertical infiltration (fig. 14 and 15).

Figure 13. Example: Infiltration Valnor

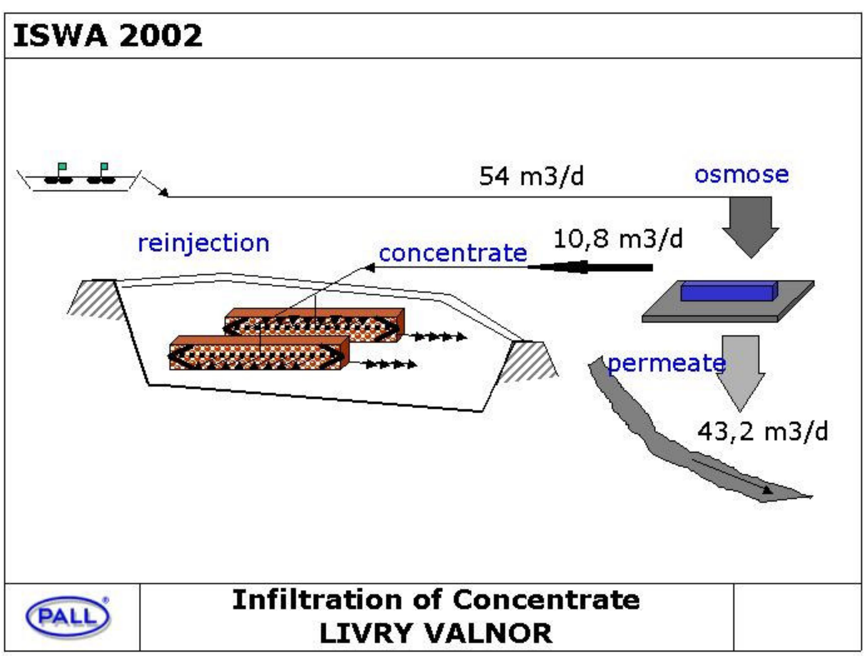


Figure 14. Trickling Body

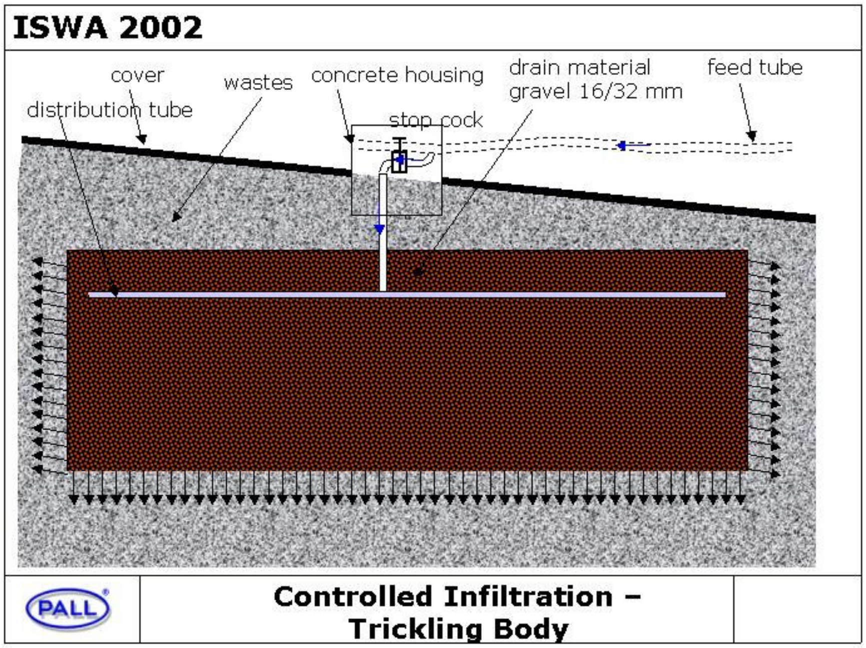
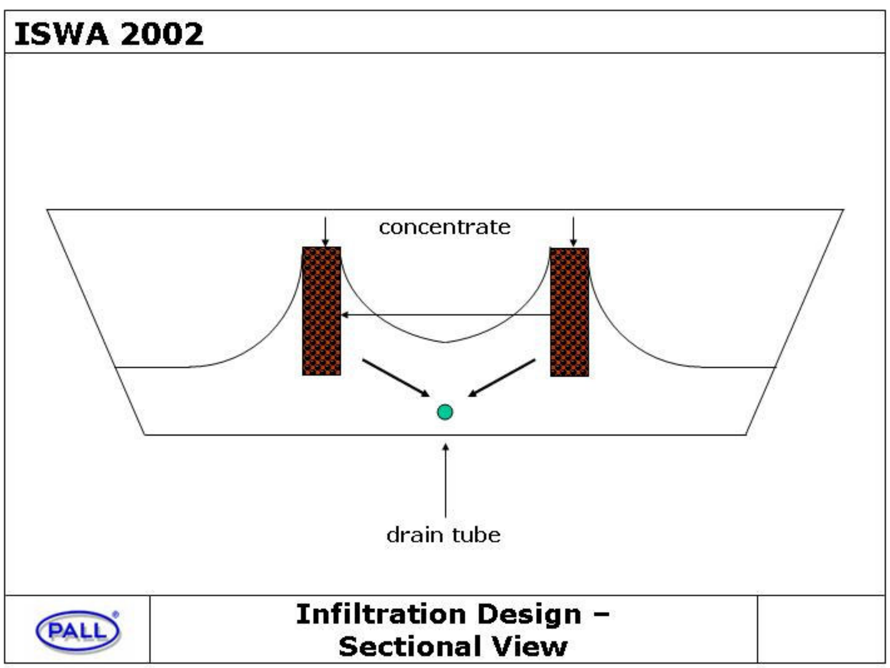


Figure 15. Sectional View



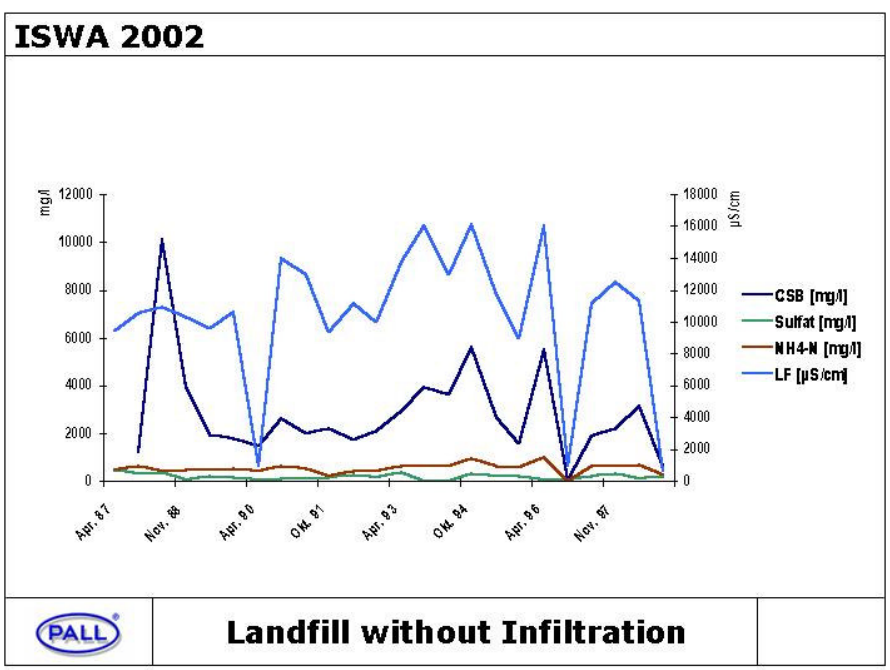
RESULTS FROM LANDFILLS WITH INFILTRATION

The two cases in Portugal and France mentioned before, are too recent to make any substantial statements on their function. However, a couple of long-term monitored experiences are available from landfills with infiltration in Germany. Furthermore two scientific publications have dealt with the behaviour of landfill waste with controlled injection on laboratory resp. small technical scale (Henigin 1999; Albrecht 2001). These investigations have shown that the gas production is enhanced. On the other hand the major parameters such as COD, ammonia and TOC remained constant during the reinjection period. Any further concentration of these or other components could not be observed. Concerning the increase of the leachate amount by concentrate injection it has been proven that an unlimited accumulation of leachate is not possible under these conditions. The maximum increase remains between 10-30% depending on the recovery rate of the reverse osmosis treatment system (Henigin 1999).
Some preliminary results referring to experiences with concentrate infiltration on a commercial scale have similarly demonstrated that the impact of concentrate recirculation on the composition of leachate is limited (Eipper, Maurer 1999).

Meanwhile more data have been collected and longer periods for assessing the impact of concentrate injection are available.

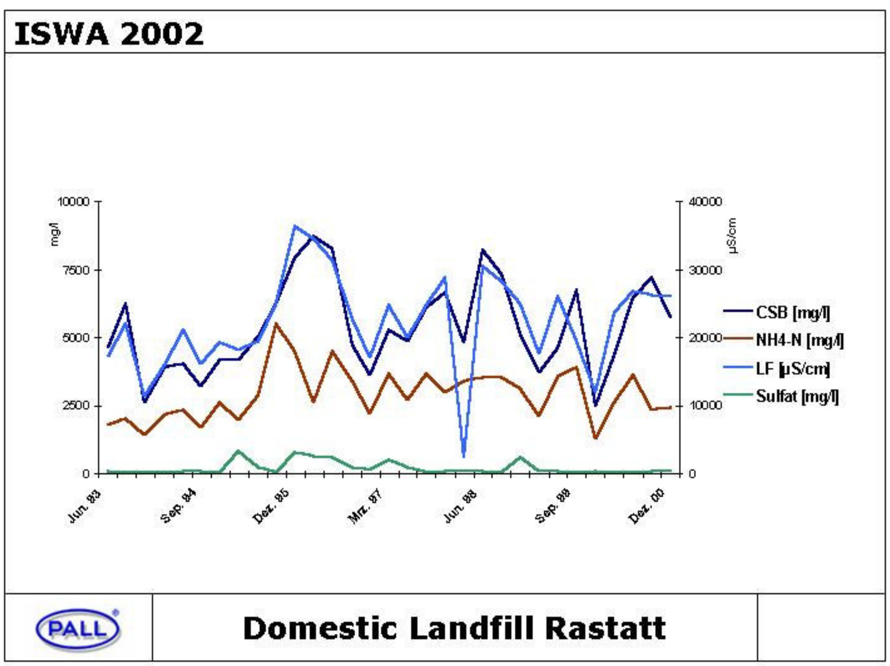
Before assessing the trends for major parameters such as e.g. conductivity, COD, ammonia, it may be interesting to look at the curves for a landfill without infiltration (fig. 16). It becomes clear that the a. m. major parameters fluctuate considerably depending on seasonal conditions and special features of landfill operation. This landfill is filled with domestic waste with a height of 25m.

Figure 16. Main Parameters without Infiltration



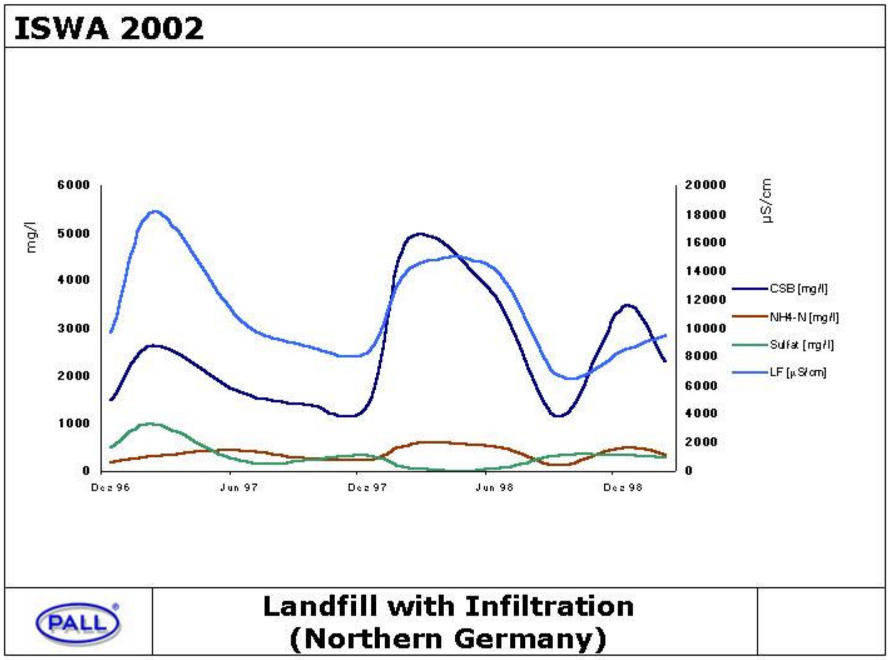
The next diagram (fig. 17) presents the same parameters for the landfill of Rastatt in Germany. On this landfill a RO-system has been installed in 1986 for the purification of leachate. It was the first one in Germany. This landfill disposes of an area of 12,4 ha with a max. height of 60m and is filled with domestic waste. The leachate production varies between 30.000-50.000 m³/d and the RO-system achieves a permeate output of approx. 70%. The concentrate is pumped through PE-pipes to 8 drainage wells, filled with gravel, which are 15-20m deep. They are fed alternately.
When looking at the diagram more closely a peak for the parameters in 1995 becomes obvious. This was due to the removal of a part of the preliminary cover. As simultaneously the leachate amount increased, it appears that a washing out process is happening in the corresponding part of the landfill body.
The presented section from 1993-2000 does not show any significant trend for the various parameters. It is remarkable that this is valid for the sulphate concentration as well, although sulphuric acid was added for pH-decrease before RO-treatment. This effect may be explained by the anaerobic condition in the landfill body by which sulphate is reduced to sulphide and then immobilized as e.g. FeS (Albrecht 2001).

Figure 17. Main Parameters Landfill Rastatt



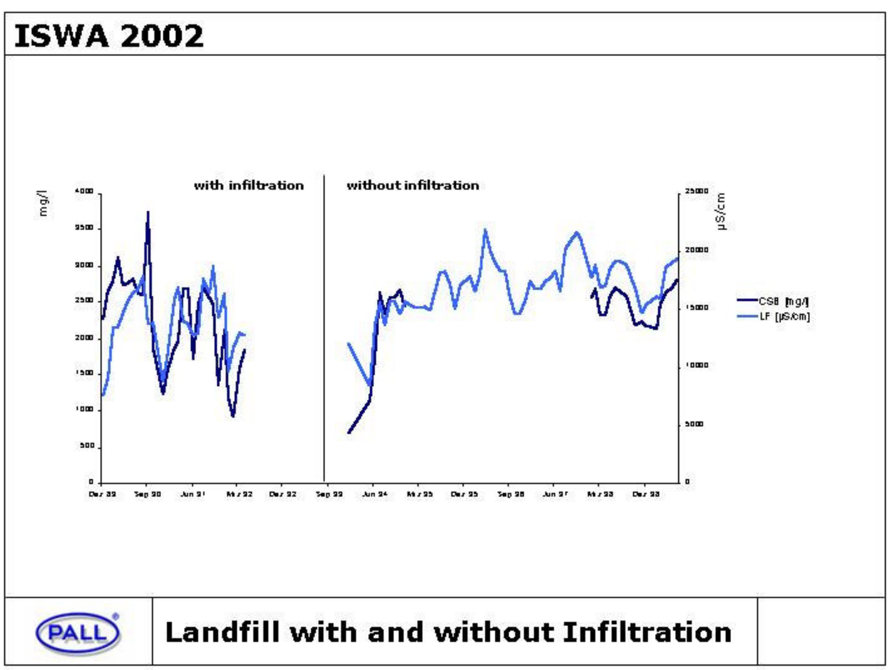
Another example (fig. 18) is presented from a landfill in Northern Germany where infiltration has been practised since 1992. A section covering the years 96-98 again shows mainly seasonal effects with strong variation in conductivity, ammonia and COD. However, no specific trend may be observed. Again the sulphate concentration remains constant.

Figure 18. Main Parameters Landfill North Germany



A direct comparison between parameter curves (fig. 19) before and after the start of concentrate infiltration is presented from a landfill near Hanover. This landfill has been in operation since 1968. The RO-Treatment started in 1992 with preceding biological treatment.
The concentrate is distributed by a trickling hose which is moved every 100 h.

Figure 19. Main Parameters Landfill with and without Infiltration



SUMMARY

The background for the feasibility of concentrate reinjection is the fact that a landfill can usually be compared with a bioreactor which produces an important amount of gas on optimised operating conditions. As the organic part of a landfill decreases with the increased gas production, the time interval for the immobilising of waste material in the landfill can be reduced. This process may be accelerated by additional humidity introduced via concentrate injection.

Scientific studies have shown that the injection of concentrates has no striking detrimental effects on the long-term behaviour of the leachate concentrations. This has been attributed to the following main reasons:

- Biochemical degradation processes take place inside the landfill
- Deposit and fixation of organic and inorganic compounds in the landfill body

To avoid problems such as channelling and odor formation, infiltration must be performed in a controlled way. The term “controlled infiltration” describes engineering solutions for the infiltration of water into the landfill body, which can be monitored, controlled and optimised.
Depending on the specific landfill conditions a variety of technical solutions is available which allow tailor-made solutions.

Many landfills with RO leachate treatment systems and infiltration of concentrate have already been in operation for a couple of years without significant problems. The development of key parameters in the course of the years demonstrates that the composite of raw leachate is not significantly influenced by concentrate reinjection.

FIGURES

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