MEASURING RESULTS ON THE LANDFILL SURFACE LINER SYSTEM "ASBACH"

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ABSTRACT: The landfill Asbach is located in the south-east of Bavaria and represents a municipal solid waste landfill. The first part of the landfill liner system was installed in 1996 and combines a capping system of a mineral sealing and a CBR-C (Clay Geosynthetic Barrier [1]). This first part represents an area of about 22,000 m². The area is divided in 16 parts, which have different inclinations. Some of them have a very steep slope and others have a very flat slope. Some parts are exposed directly to the solar radiation and other parts of the area are capped by the shadows of a nearby forest. During the installation of the sealing system, intercepting reservoirs were integrated in each of the 16 fields. These reservoirs allowed the recording of the leakage rate through the CBR-C by manual measurements. Therefore only temporary recordings were possible, which implies, that the exact leakage rate and the behaviour of the CBR-C on the precipitation could not be obeyed. In fall 2002 an automatic measuring system was installed. This system works with double-pan balances (100 ml each buckling), which were installed in the interception reservoirs. To understand the leakage rate, it was necessary to install a weather station, too. This station records the rain rate, the humidity, the solar radiation, the temperature, the wind run and the wind direction. Because of the large area of the measuring field the station was installed in the centre of the field. First measuring results show very different leakage rates of the CBR-C in the 16 different fields.

1 INTRODUCTION

The Bavarian landfill near the town of Asbach, located in the middle-east of Bavaria, was capped in 1995 in the first cell, called RA I. The area includes ca. 22,000 m². It is a municipal solid waste landfill only. During the setting up for the cover, an indicator measuring system was installed, which makes manageable one part (the CBR-C) of the capping system.

Since 1995 the permeability of the capping system (only the CBR-C) is manually and temporary controlled with the aid of reservoirs.

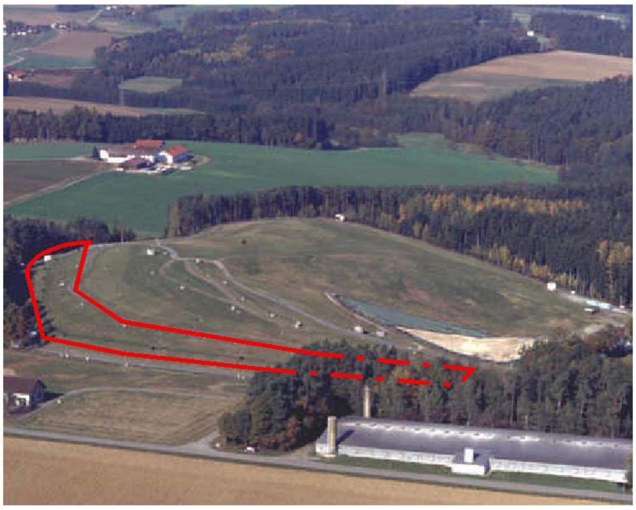

Figure 1: The landfill in Asbach, the red-lines illustrate the capped area "RA I"

In 2002/2003 the Institute for Soil Mechanics and Foundation Engineering of the University of the Federal Armed Forces, Munich, has been assigned by the Bavarian State Ministry for Regional Development and Environmental Affairs to install an automatic measuring system, which allows a continuous monitoring of the possible leakage of the Clay Geosynthetic Barrier (CBR-C) [1].

2 THE LANDFILL

The municipal waste landfill "Asbach" is located in the middle east of bavaria [Figure 2].

Figure 2: The map of Bavaria, the landfill "Asbach" [3]

The altitude of the landfill is about 450 m MSL and the northern lattitude is 48° 32'. Longtime climatic records for this area are according to Table 1. The climatic is more dry than the rest of the bavarian region and in cause of the seating of the landfill, especially the RA I, the global radiation is within normal values. The nearness of a forrest with very large trees makes parts of RA I very shady.

Table 1 Longtime climatic records:

Temperatur	
January	-2.5
April	7.5
July	16.5
October	7.5
Precipitation	
Winter	324.5
Summer	549.5
February	45
June	110

3 THE RESTORED LANDFILL AREA

3.1 *The capping system*

For the capping system a composite liner system [Figure 3] was used. The effectiveness of this liner system is equal to the reference system of the TASi [2].

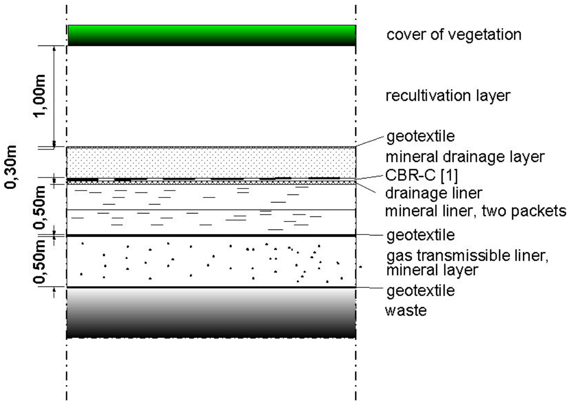

Figure 3: Layer composition of the landfill “Asbach”

In the composite liner system a CBR-C is combined with a mineral liner. This mineral liner was installed in two packets, each compacted in 25 cm. This sealing is explained as slightly clayey to slightly fine sandy silt. The permeability was detected between 10^{-9} [m/s] and 10^{-10} [m/s]

On the top of the mineral liner, a drainage liner is installed, followed by a CBR-C. The CBR-C is capped by a mineral drainage liner, which has a permeability of $5*10^{-4}$ [m/s] and contains sandy gravel.

The recultivation layer [Figure 4] has a thickness of 1,0m in the minimum.

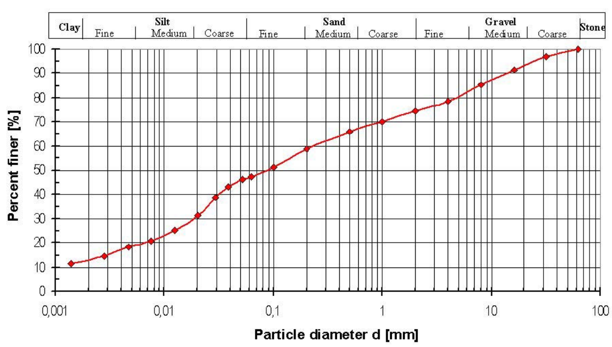

Figure 4: Grain-size curve, recultivation layer; silt (U; M [6]), U= 148, C_c= 1,5 $\Rightarrow$ gap graded

The vegetation cover basically consists of gras and is cutted twice a year. No bushes can be found.

Figure 5: Vegetation cover in the summer 2003

3.2 *The integrated measuring system*

As mentioned a measuring system was installed during the construction works. For this measuring system the capped area has been divided in 16 sub areas (in the following referred to as “area”) with an individual drainage system (red lines in Figure 6).

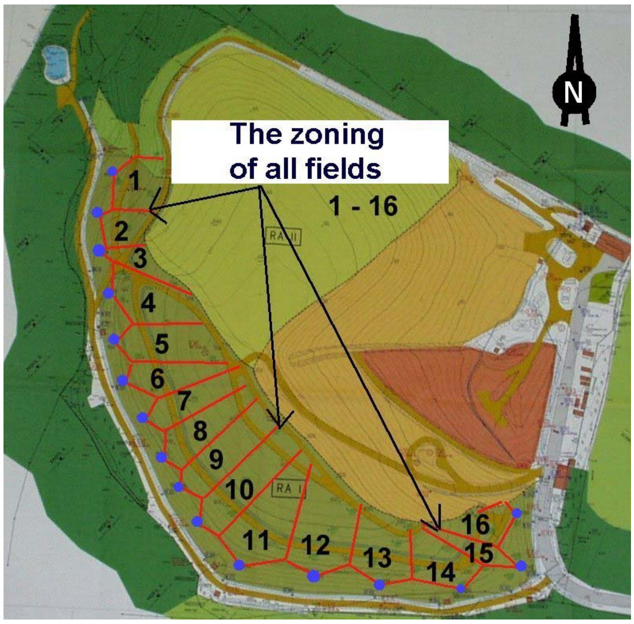

Figure 6: The zoning of all 16 fields as you can see on the groundplan

The areas reach from 900 to 2.700 m².

In each part a reservoir has been integrated. In this reservoirs the run-off in the drainage liner at the bottom of the CBR-C is collected.

Since 1995 this run-off was measured by absorbing the flow and recording the body of water that enters the spill-water reservoir. This procedure has been performed 4 times per year. As the data collection was obstacled by the measuring procedure and the frequency of the measuring and therefore no exact information about the effectiveness of the CBR-C could have been given, the need for an automatic measuring system became clear.

In 2001 the Institut for Soil mechanics and Foundation Engineering of the University of the Federal Armed Forces has been mandated to install an automatic system.

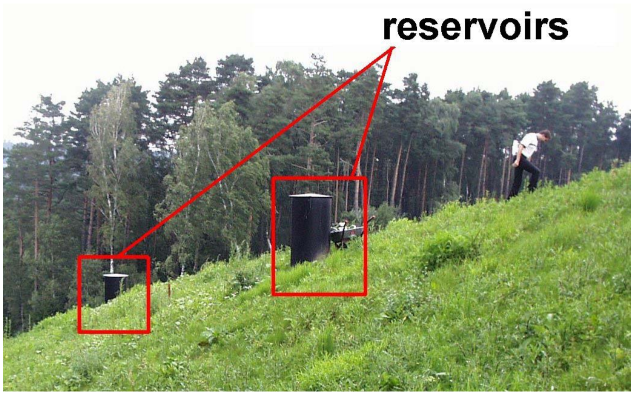

Figure 7: Two of sixteen reservoirs on the landfill (area 2 and 3)

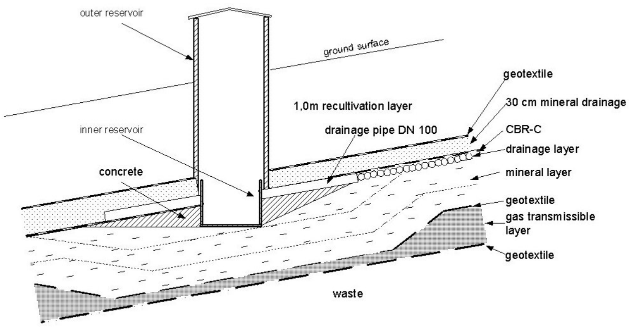

Figure 8: The reservoirs as it is installed in the capping system

3.3 *The measuring fields*

As mentioned above, the area of 22,000 m² is divided in 16 areas. Of interest are besides the different sizes of the areas:

- Inclination
- Solar-radiation and the
- Exposure

Table 2 Area description

Area [Nr.]	Size [m²]	Inclination [°]	Solar-Radiation	Exposure	Compartement
1	1,000	20.5	Low	West-North/West	
2	1,125	16.1	Low	West-North/West	1
3	1,875	10.2	Low	West-North/West	
4	1,540	7.7	Low	West	
5	2,000	7.5	Low	West	
6	2,125	7.7	Low	West	
7	2,250	7.59	Low	West	2
8	2,250	7.59	Low	West	
9	2,700	8.5	Low	West	
10	2,530	7.4	Low	West	
11	1,875	8.34	Low	West	
12	2,025	8.34	High	South	
13	1,500	9.1	High	South	3
14	1,375	10.3	High	South	
15	1,181	11.8	High	South-South/East	4
16	920	12.68	High	East	

In all these parameters the areas are different from each other. For example the areas 1 to 3 (compartement 1) have a steeply slope and the solar-radiation due to a nearby forest is less intense.

The areas 4 to 11 (compartement 2) have a flater slope than 1 to 3, but the solar-radiation is showing the same intensity.

Areas 12 to 14 (compartement 3) have almost the same slope like 4 to 11, but the solar radiation is more intensive, as there are no forests in the areas.

Summarizing the testing, it can be stated, that the areas 15 to 16 (compartement 4) are a mixture of all areas.

4 THE "NEW" MEASURING-SYSTEM

The fact that there is a need of a large number of single tests and continuous measuring, a new measuring system has been integreated in the existing system. In January 2003 the new measuring method started.

4.1 *The measuring system*

In order to measure the run-off, it has been decided to use double-pan balances. These balances had to be integrated in the inner reservoir [Figure 8] of each area.

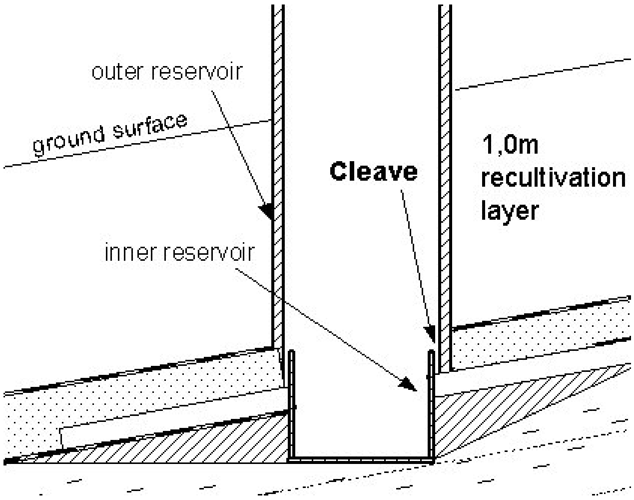

Figure 9: Cross section, inner and outer reservoir

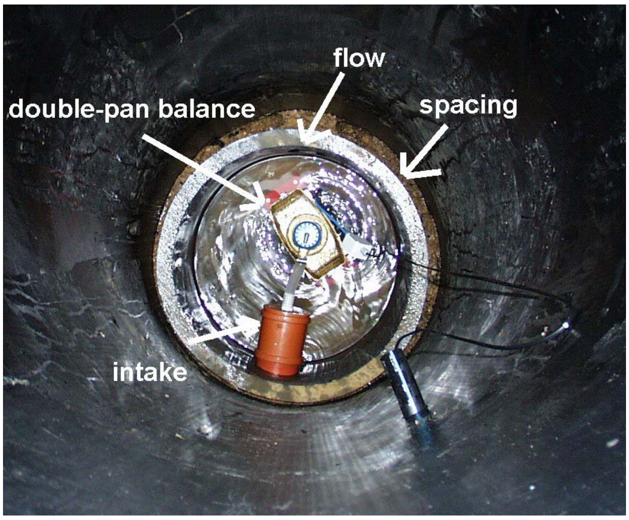

Figure 10: The integrated double-pan balance in the inner reservoir

Figure 11: Double-pan balance as it's been integrated in the inner reservoir

Each pan has a capacity of 100 ml and after each tilt, an impulse is registrated on a computer system.

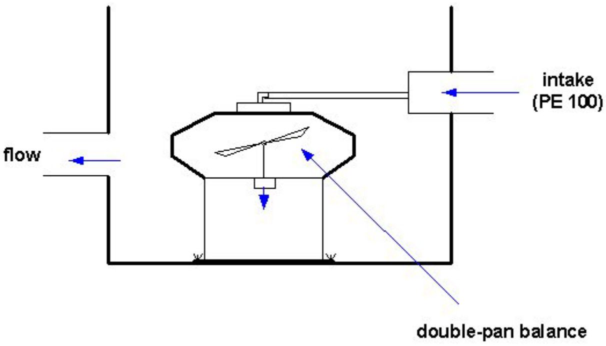

Figure 12: Principle sketch of the measuring system

This allows the controlling of the behaviour of the CBR-C without any manual work and without locking up the flow. A contiuous measuring is now possible.

Regarding the mineral layer below the CBR-C, the measuring results, are only showing the minimum permeability of the CBR-C. The absorbtion of water by the mineral liner has to be considered. The permeability of the mineral liner is not beeing measured.

5 MEASURING RESULTS

5.1 *Measuring Results from 1996 until 2002*

In 1996 the works for the capping system have been finalized and the measuring started in July 1996. In the first year of measuring every month, from July to December, was registered. Starting from the second year measuring was done only 4 months per year. In March, June, September and December the run-off was regestrated by water collectors in the area reservoirs. Caused by the construction, it was possible, that the collected water partly could drain off uncontrolled through the spacing between the inner and the outer reservoir. Incidences like this are caused by a water level that was higher than the inner reservoir volume. Therefore, in some areas the exact runoff couldn't be measured.

At the same time, the precipitation was registrated, and the analysis of the hole system's behaviour respectively possible damages became possible.

The following diagram shows the results of the measuring during the years 1996 to 2002. The areas with no waterdeficit as a result of the spacing between the inner and outer reservoir are highlighted.

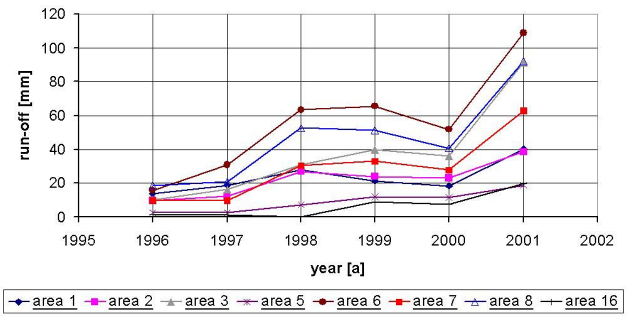

Figure 13: Run-off on the bottom of the CBR-C in the years 1996 until 2001 [4]

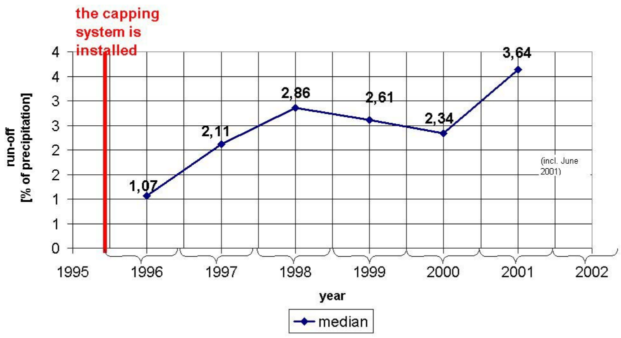

Figure 14: Run-off on the bottom of the CBR-C in the years 1996 to 2001 (% of precipitation)

In Figure 13 it can be seen, that the range of the permeability of the CBR-C increased from 2 mm to a range of 20 mm. The highest run-off has been registrated in 2001 with 3.64 % of the precipitation. Figure 14 demonstrates the medial increasing of the permeability since 1996. But only for the areas without any leakage because of the cleave [Figure 9].

By rating this results one shall bare in mind, that in the diagrams only the measuring-results of the areas with no waterwaste in cause of the spacing between the inner and the outer reservoir are shown. The other areas will show higher values [Figure 9 and Figure 10].

5.2 *Measuring Results 2003*

The works for the installation of the "new" measuring method have been finalized in January 2003. The first recording of run-off water was done on January 13th 2003.

At the same time, the recordings with a new weatherstation started. This station is recording the precipitation rate, the solar radiation and the temperature.

With the new system it is now possible to register every modification of CBR-C permeability in each area.

The measuring results for the year 2003 are depicted in Figure 15 to Figure 18. In these charts the run-off on the bottom of the CBR-C in relation to the precipitation is obvious. It was decided beforehand to present here only characteristic areas.

As stated in chapter 3.3, the measuring field can be divided in four main compartments.

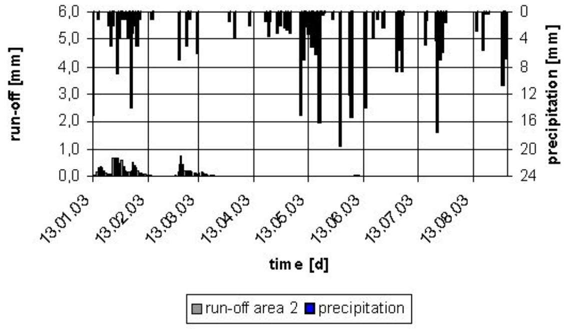

Figure 15: Run-off in 2003, area 2, represents compartement 1

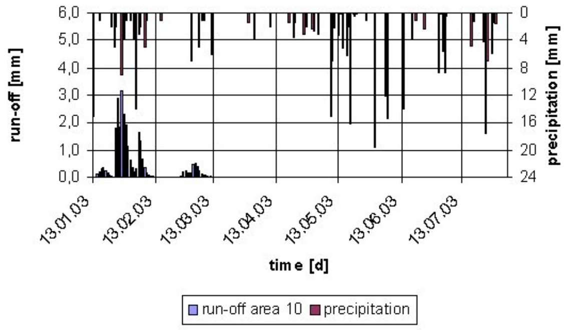

Figure 16: Run-off in 2003, area 10, represents compartement 2

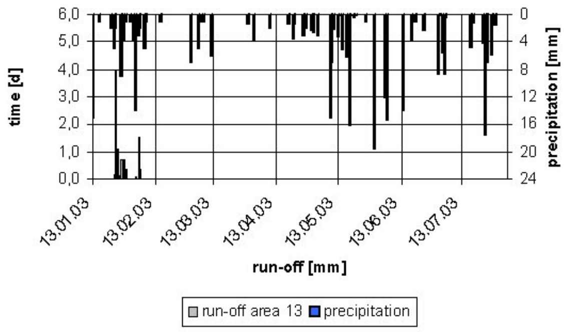

Figure 17: Run-off in 2003, area 13, represents compartement 3

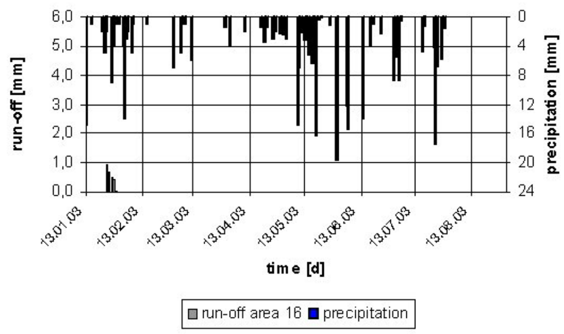

Figure 18: Run-off in 2003, area 16, represents compartement 4

The first one has a very steeply slope and the radiation is not high caused by the nearby forrest. For this compartment area 2 [Figure 15] is characteristic.

The second compartment features the same solar radiation like the first part, but the slope is not that steeply. To represent the second compartment it was decided to refer to the measuring results of area 10 [Figure 16].

To represent a compartment with a higher solar-radiation than compartment one and two and the same acclivity like part two, area 13 is displayed in Figure 17.

Figure 18 represents a compartment with a similar solar-radiation like part three, but the slope is more steeply.

Comparing the four different compartments with the results of the new measuring method, it has become obvious, that all are showing similar features obtained to the fact of run-off in the first quarter of 2003. The run-off ends in each area in a time frame of three months (latest end in the end of march [Figure 15]) but the intensity shows a different behaviour.

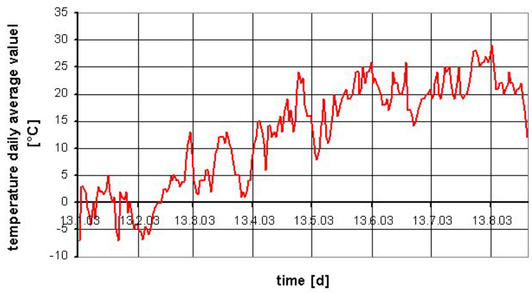

Figure 19: Temperature daily average in 2003 (the diagram ends in August 2003)

No run-offs for the remaining month in 2003 can be caused due to the very arid summer that took place in 2003 [Figure 19] and the character of the recultivation layer [Figure 4].

6 COMMENTARY AND INTERPRETATION OF THE MEASUREMENTS

Comparing the measurements of all compartements one can recognize differences in the intensity of the run-off. This may caused by many reasons.

Compartment 1 and 2 [Figure 15 and Figure 16] show a higher rate than 3 and 4. This may be due to the exposure (compartement 1 and 2: west and three and four: south). The second influence is the value of the solar-radiation. This value is more intens in the compartements 3 and 4, so the evaporation has a higher value in these areas than in the compartement 1 and 2.

The comparison of compartement 1 and 2 brings out, that the run-off in compartment 2 is higher than in compartement 1. This may be due to the slope. Compartement 1 has a steeply slope and compartement 2 is more flat. The same effect may be recognized by comparing compartement 3 and 4.

Other reasons for the varieties may be the quality of the work during the installation of the capping system and the possible variablity of the thickness of the recultivation layer.

Since April 2003 no run-off on the bottom of the CBR-C was registrated. The reason for this result is the longtime aridness and the character of the recultivation layer. The layer is dried out.

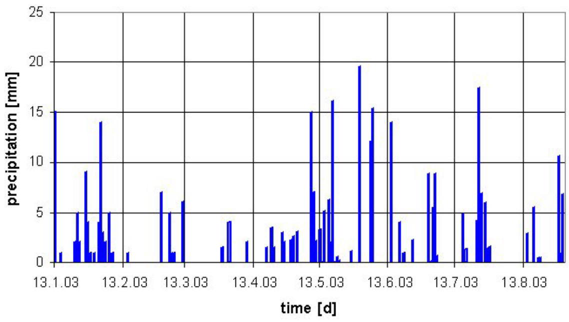

Figure 20: Precipitation in 2003 (January until August)

In the summer 2003 the rain duration was short but intens. The main part of the rain will be escaped by surface run-off.

7 CONCLUSION

The integration of a measuring system in the landfill Asbach during the installation of the capping system made it possible to control the behaviour of an CBR-C in a long-time research.

The first cognitions after a term of seven years show differences of the value of the permeability regarding the hole area of 22,000 m². The reason for the differences may be caused by the exposure and the acclivity of the slope.

The high value of the permeability in some areas may be due to the quality of the laying work of the CBR-C and the quality of the production of the whole capping system.

Looking at the behaviour of the CBR-C in the next years by means of the “new” measuring system, new and more exact congnitions will be obtained. Just the autumn of 2003 will show the behaviour of a CBR-C after a very arid summer.

8 REFERENCE

[1] Zanzinger, H., Koerner, R., Gartung, E., 2002: Clay Geosynthetic Barriers, Preface, pp. 9 – 10

[2] TA Si, 1993: Dritte Allgemeine Verwaltungsvorschrift zum Abfallgesetz, Technische Anleitung zur Verwertung, Behandlung und sonstigen Entsorgung von Siedlungsabfällen, Bundesanzeiger Jg. 45, Nr. 99a, TA Si, Bundesministerium f. Umwelt, Naturschutz u. Reaktorsicherheit

[3] BLACE-LocClim © Schmid, Jürgen, Ars-Soli Ingenieurgesellschaft, ® Bayer. Klimaatlas 1996

[4] Schmid, J., Schmitz, S.M., 2003: Zu standortoptimierten Oberflächenabdichtungssystemen auf Basis von Messfeldergebnissen über Wirksamkeit und Alterungsverhalten; 1. Symposium Umwelttechnik Weimar, Tagungsband

[5] Schmid, J., 2002: Messfeldergebnisse zur Wirksamkeit von Rekultivierungsschichten mit Schlussfolgerungen für Entwurf und Bemessung, in: Neue Entwicklungen bei Oberflächenabdichtungen von Deponien, ISSN 0173-2447, Heft 16, Mitteilungsreihe am Institut für Bodenmechanik und Grundbau, Universität der Bundeswehr München

[6] Mitchell, J.K., Fundamentals of Soil Behaviour, John Wiley&Son, Inc., 1976