6.5. RESULTS WITH SALTS (W. KÄSS)

6.5.1. Lithium Tracing Test at Zavrhovc (April 16, 1994)

The kation lithium was used as a tracer together with bacteriophages (compare chapter 6.4) in the second tracing experiment in spring 1994. As briefly described in chapter 6.1 (Tab. 6.1) the injection of 30 kg lithium chloride solved in 110 l of water took place on April 16, 1994 at 10:25 and was followed by the injection of 20.5 l phage suspension at 10:30 (compare chapter 6.4) in the rocky doline below the Zavrhovc farm. The salt suspension was rinsed down with about 1 m^3 water. After flushing of both tracer injections was performed with 3.5 m^3 water.

As observation points for lithium the spring Hubelj (altitude: 240 m a.s.l.) and the two smaller karst springs in the vicinity of the Hubelj spring, Gorenje (243 m a.s.l.) and Skuk (520 m a.s.l.) were chosen.

Results

Hubelj

Between April 16, 13:00 and May 25, 1:00 the total of 232 samples were investigated. The extremely low background between 0.01 and 0.04 µg/l allowed a good recognition of influences from the tracing, even when they were very low. Between April 20 and 26 a significant Li-increase above the background could be detected (Fig. 6.33).

For the interpretation the background was subtracted (net-values for the increase above the background) and the breakthrough-curve between April 19, 1:00 and April 27, 23:00 was fivefold smoothed (Fig. 6.34).

The injected 30 kg LiCl only contain 16.4 %, resp. 4.92 kg lithium. By means of the discharge values, made available by Hydrometeorološki Zavod, Ljubljana, a recovery of 70.52 g lithium was calculated for the lithium passage during the period above given. These are only 1.43 % of the injected quantity.

A second Li-passage took place between May 19 and the end of the observation on May 25, 1:00. This passage was aroused by heavy rainfalls which caused a discharge of the Hubelj-spring up to 31,600 l/s (Tab. 6.21):

A rough calculation of this second lithium passage between May 19, 13:00 and May 25, 1:00 resulted in an additional lithium recovery of 81.95 g. Thus 152.7 g lithium, resp. 3.1 % reappeared completely with this test in the spring Hubelj. In Fig. 6.35 the cast-line for the whole observation time is depicted.

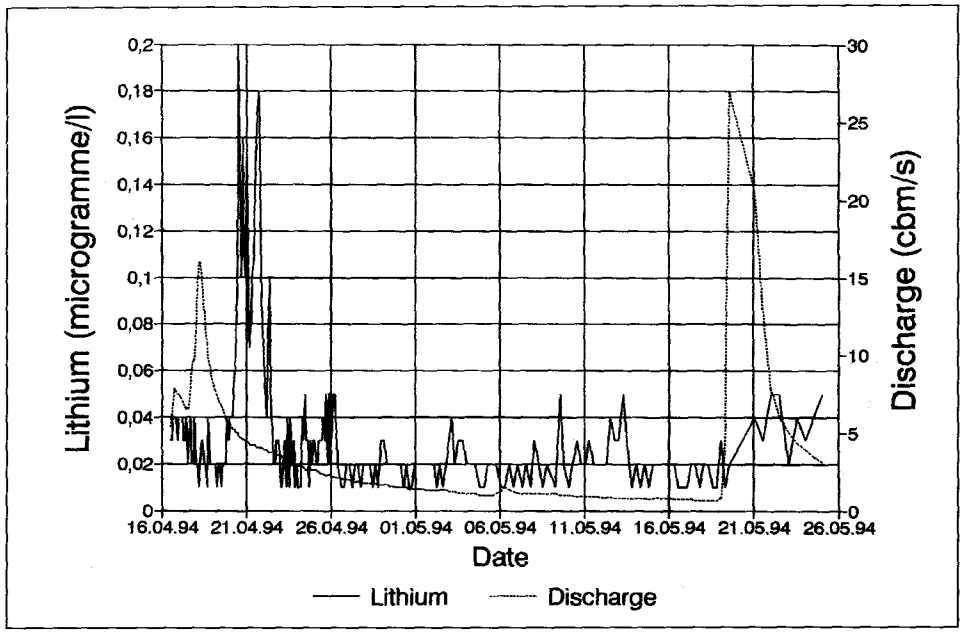

Fig. 6.33: Second tracing experiment: analysed lithium-values in the spring Hubelj in connection with the discharge of the Hubelj (m^3/s).

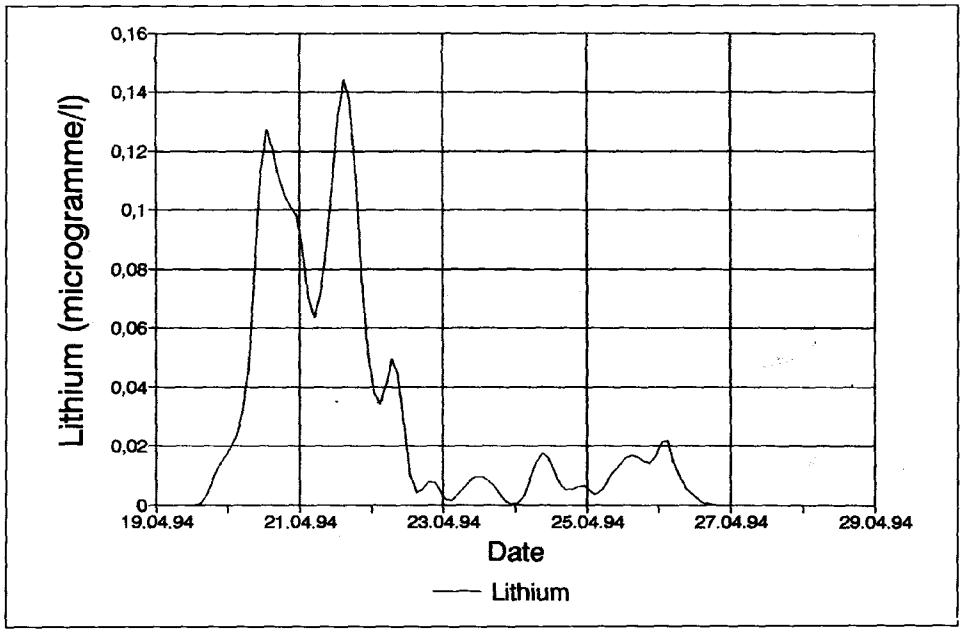

Fig. 6.34: Lithium-netto-values in the Hubelj spring between April 19 and 27.

Tab. 6.21: Lithium passage in the spring Hubelj between May 19 and 25 due to a significant increase in the discharge.

Day	Time	Li (µg/l)	Q (l/s)
18.5.1994	13:00	0.01	677
18.5.1994	19:00	0.01	677
19.5.1994	1:00	0.02	792
19.5.1994	7:00	0.01	4,220
19.5.1994	13:00	0.02	27,000
19.5.1994	17:00	not observed *	31,600
21.5.1994	1:00	0.04	20,500
21.5.1994	13:00	0.03	13,100
22.5.1994	1:00	0.05	7,880
22.5.1994	13:00	0.05	6,130
23.5.1994	1:00	0.02	5,060
23.5.1994	13:00	0.04	4,390
24.5.1994	1:00	0.03	3,910
24.5.1994	13:00	0.04	3,450
25.5.1994	1:00	0.05	3,170
* the sampling was interrupted because of high water!			

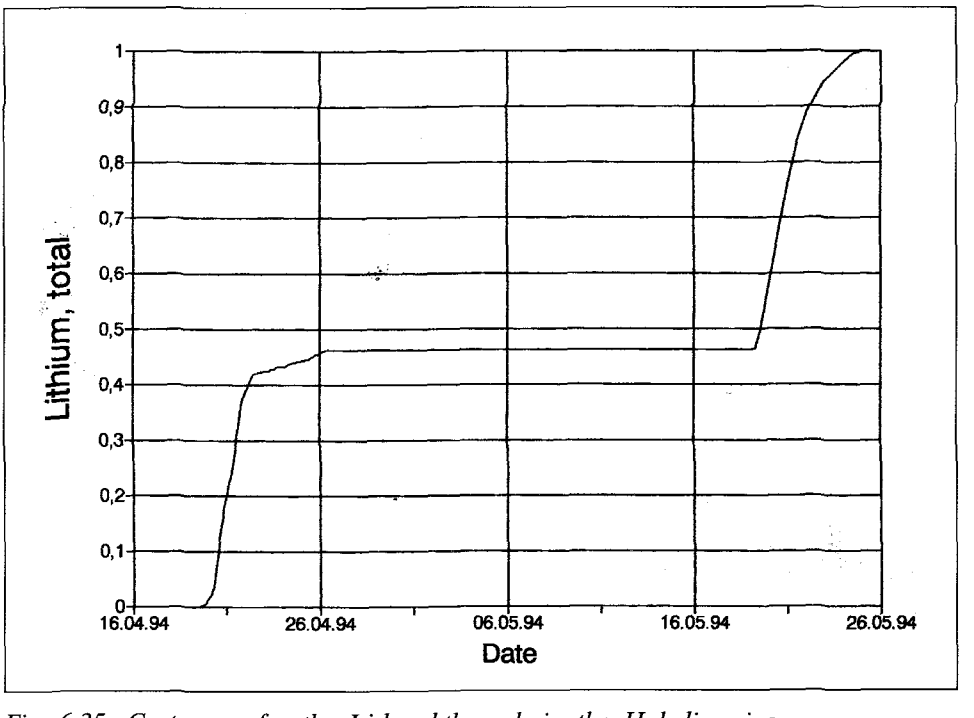

Fig. 6.35: Cast-curve for the Li-breakthrough in the Hubelj spring.

Gorenje and Skuk

No lithium passage was observed at the other two observation points, Gorenje and Skuk.

For the observation of a possible lithium breakthrough in the karst spring Gorenje 50 water samples were analysed for the observation period from April *16, 12:15 to May 24, 13:00. The highest Li-value observed was 0.11 μg/l, the* lowest 0.06 μg/l, with a medium value of 0.0866 μg/l. The standard deviation was 0.013 and the variance 0.00017.

Period of observation: 16.4., 12:00 - 24.5., 13:00 with 51 samples. Highest Li-value: 0,08, lowest value: 0,04, medium value: 0,0586 μg/l. Standard deviation: 0,0088, variance: 0,000078.

6.5.2. Strontium Tracing Test at Mrzli log (April 16, 1994)

A second salt injection was carried out with the kation strontium in the framework of the second combined tracing experiment. As injection point the deepest doline (784 m a.s.l.) of the karst depression Mrzli Log was selected (Fig. 6.1). The tracer solution consisted of 50 kg strontium chloride hexahydrate, resp. 16.3 kg strontium, dissolved in 120 l of water and 7 kg pyranine dissolved in 40 l of water. The injection took place simultaneously at April 16 at 11:00 after a preflushing of the doline with about 1,000 l and was followed by a after flushing of about 6,000 l.

Main aim of this injection was to define the watershed between the Hubelj spring at the one side and the karst springs Podroteja and Divje Jezero at the other side (Fig. 6.1). Therefore 6 karst springs were selected as observation points for a possible strontium breakthrough (Tab. 6.22).

Tab. 6.22: Observation points for a possible strontium recovery for the combined tracing experiment in Mrzli Log (April 16, 1994) with the distance from the injection point, the altitude of the spring outlet and the incline.

Observation points		Distance (m)	Altitude (m a.s.l.)	Incline
1	DIVJE JEZERO	7221	350	0.060
2	PODROTEJA	7630	330	0.0595
3	VIPAVA 4/1	9594	99	0.0713
4	VIPAVA 4/7	9594	99	0.0713
5	GORENJE	10183	243	0.053
6	HUBELJ	9255	240	0.059

Results

Divje Jezero

Observation period: 19.4, 9:20 - 27.5., 18:25
Amount of samples: 44
Highest value: 31 µg/l Sr
Lowest value: 18 µg/l Sr
Medium value: 23 µg/l Sr
Standard deviation: 2,81
Variance: 7,9
Result: No Sr-passage

Podroteja

Observation period: 19.4, 9:25 - 20.7., 12:00
Amount of samples: 51
Highest value: 45 µg/l Sr
Lowest value: 19 µg/l Sr
Result: The Sr-values constantly increased from the beginning to the end of observation (Fig. 6.36). Whether this has been influenced by the tracing, remains open.

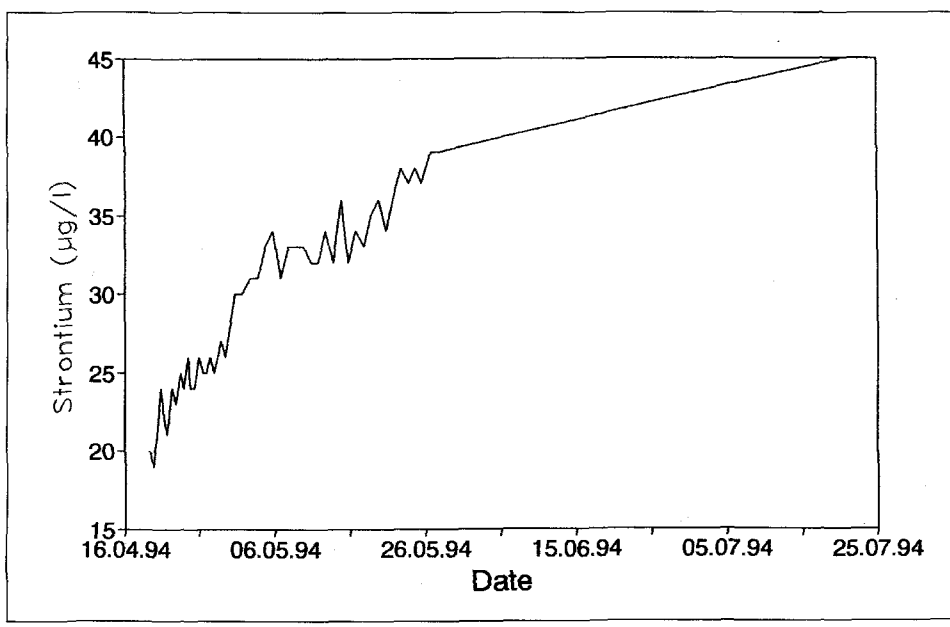

Fig. 6.36: Strontium values in the Podroteja spring.

Vipava 4/1 (Kapelica)

Observation period: 16.4, 10:00 - 28.7.,9.00
Amount of samples: 198
Highest value: 113 μg/l Sr
Lowest value: 27 μg/l Sr
Medium value: 49 μg/l Sr
Standard deviation: 17,8
Variance: 319
Result: The Sr-content constantly increased from the beginning to the end of the observation with some interruptions.

Vipava 4/7 (Pod Farovžem-L.)

Observation period: 16.4, 13:00 - 28.7.,9.00
Amount of samples: 198
Highest value: 113 μg/l Sr
Lowest value: 27 μg/l Sr
Medium value: 49 μg/l Sr
Standard deviation: 14,9
Variance: 221
Result: The Sr-content increased from the beginning to the end of the observation with distinct interruptions (Fig. 6.38).

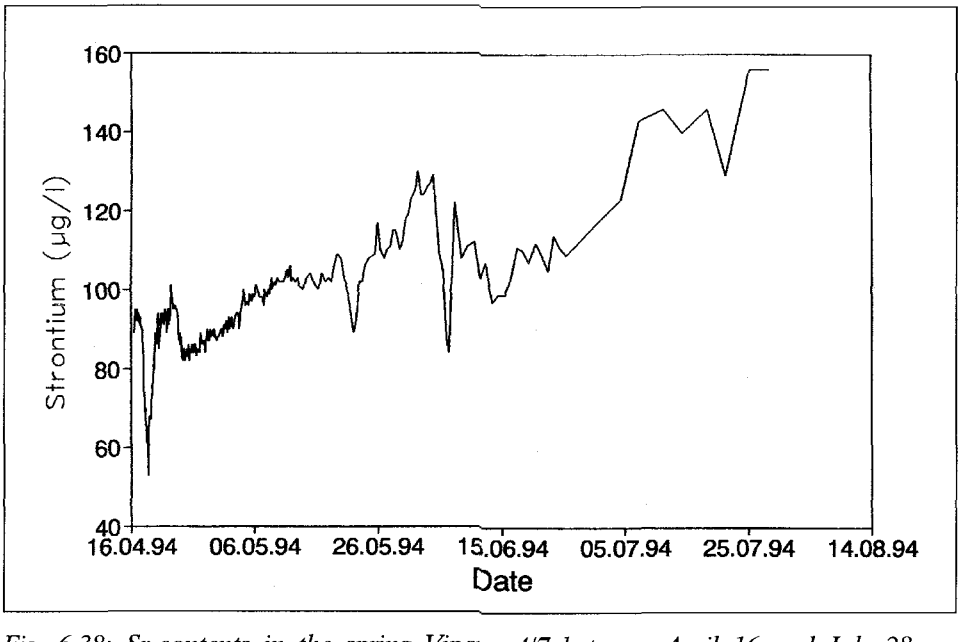

Fig. 6.38: Sr-contents in the spring Vipava 4/7 between April 16 and July 28.

Gorenje

Observation period: 16.4, 12:15 - 24.5., 13:50
Amount of samples: 50
Highest value: 19 µg/l Sr
Lowest value: 9 µg/l Sr
Medium value: 13,5 µg/l Sr
Standard deviation: 1,88
Variance: 3,53
Result: No Sr-passage

Hubelj

Observation period: 16.4., 12:00 - 25.5., 1:00
Amount of samples: 232
Highest value: 9 µg/l Sr
Lowest value: 2 µg/l Sr
Medium value: 4,96 µg/l Sr
Standard deviation: 1,42
Variance 2,04
Result: No Sr-passage

6.6. MATHEMATICAL MODELING WITH THE MULTI-DISPERSION-MODEL (A. WERNER & P. MALOSZEWSKI)

6.6.1. Introduction

Numerous tracer experiments have been carried out within the research program of the 7thSWT on the Trnovski Gozd plateau (Slovenia). The area between the springs Mrzlek, Lijak and Hubelj (Fig. 6.1) formed one main focus of the investigations of the ATH. In the following the mathematical interpretation of the uranine tracer experiments of the input location Belo Brezno (Fig. 6.1, Tab. 6.1) will be described. At this place one tracer test was performed in each of the years 1993, 1994 and 1995 (compare chapter 6.3.2). Therefore it was possible to evaluate mathematically experiments with different hydrological boundary conditions. The main output was the karst spring Mrzlek in a distance of 19.8 km to the injection point and not the nearby located Hubelj spring (6.9 km distance). As described previously current discharge measurements of the Mrzlek spring are not available, due it's outlet in the dammed Soča river.