Basic information on groundwater regimes

The three groundwater regimes (pluvial, pluvio-nival and nivo-glacial) can be identified both in groundwater levels and spring discharges. The spring discharge regime is expressed in terms of the average course of the Pardé coefficient over individual months; the groundwater level regime is expressed in terms of the groundwater regime coefficient.

Analogous to the *watercourse discharge regime*, which describes the long-term average annual discharge, we can also talk about a *groundwater regime*. In unconsolidated and solid rock near the surface, there are typical patterns in both groundwater levels and spring discharges, with a regularly recurring course over the seasons. New groundwater is formed when precipitation and snowmelt water infiltrate the surface or when riverwater enters the ground at certain places. Any abatement or delay in these long-term patterns is determined by the hydrogeological conditions (geometry and permeability of the aquifer, nature and thickness of the unsaturated zone, distance to the watercourse).

Average Pardé coefficient of spring discharge

The dimensionless *Pardé coefficient (PK)* is traditionally used to determine the discharge regime of *watercourses*. It is defined as the ratio of the average monthly mean discharge (MQ(month)*multi-year*) to the average annual discharge (MQ(year)*multi-year*) over a full measurement period:

$$\mathrm{PK(month)} = \frac{\mathrm{MQ(month)}\mathit{multi\text{-}year}}{\mathrm{MQ(year)}\mathit{multi\text{-}year}}$$

To determine the groundwater regime at springs, the annual cycle of the *average PK values* for the spring discharges of the months January to December is used. Since the coefficient is calculated on the basis of the average monthly values recorded over several years, rapid and short-term fluctuations of the spring discharge – e.g. in the case of heavy precipitation – are not reflected. Similarly, those months or years with particularly low or high differences in runoff are averaged out. Consequently, the annual variation in the average PK values represents a characteristic average seasonal variation of the spring discharge over the observation period.

Since the Pardé coefficient for spring discharge is calculated on the basis of discharge alone, this approach can also be applied to springs in unconsolidated rocks and in fractured and karst bedrock. Spring discharge in unconsolidated aquifers generally reaches average monthly PK values of 0 to 2, in fractured aquifers 0 to 3, and in karst aquifers 0 to 5.

Groundwater regime coefficient of groundwater level

When describing the groundwater regime at groundwater levels, the Pardé coefficient must be modified so that it can be used to measure groundwater levels independent of the choice of the elevation reference point. The multi-year average monthly groundwater level (AMGL(month)*multi-year*) and the multi-year annual average (AMGL(year)*multi-year*) are first set in relation to the lowest multi-year monthly average (AMGL(min)*multi-year*) before they are set in relation to each other. The groundwater level regime coefficient (GLRC) is thus described as follows:

$$\mathrm{GLRC(month)} = \frac{\mathrm{AMGL(month)}\mathit{multi\text{-}year} - \mathrm{AMGL(min)}\mathit{multi\text{-}year}}{\mathrm{AMGL(year)}\mathit{multi\text{-}year} - \mathrm{AMGL(min)}\mathit{multi\text{-}year}}$$

Since the calculations are based on multi-year averages, short-term fluctuations in the groundwater level are averaged out. Likewise, years with a particularly small or large groundwater level fluctuation range are levelled out. In this way, the groundwater regime coefficient represents a characteristic average seasonal pattern of groundwater levels. For aquifers with a dominant factor which controls levels relatively constantly, such as snowmelt, the differences between the multi-year average annual rate and the rate of a single year are small. However, in aquifers which react to individual precipitation events and thus have high short-term variability in groundwater levels, the annual cycle in individual years can deviate significantly from the long-term average cycle.

The GLRC calculation is independent of the aquifer type and can therefore be applied to groundwater levels in both unconsolidated and solid rock.

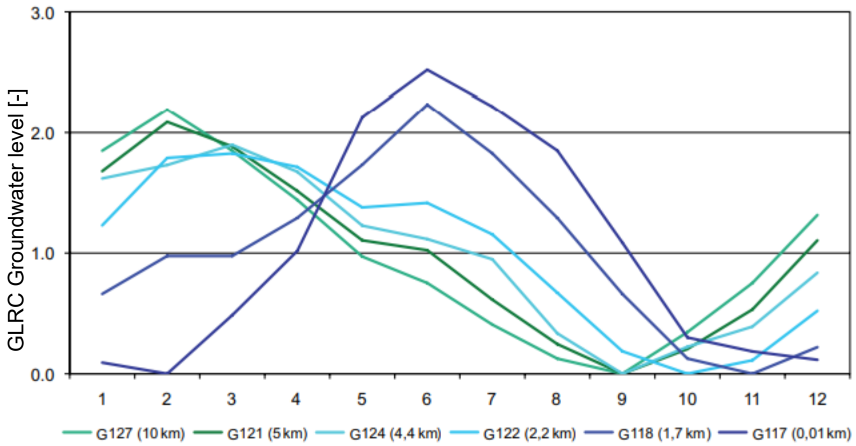

Figure: Transition from a site-typical pluvial groundwater regime to an imported nivo-glacial groundwater regime in the Bernese Seeland with decreasing distance between the monitoring site and the Hagneck Canal.

Literature

Schürch, M.; Kozel, R.; Biaggi, D.; Weingartner, R. (2010): Typisierung von Grundwasserregimen in der Schweiz – Konzept und Fallbeispiele. Gas Wasser Abwasser gwa 11/2010: 955-965.

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