

## Abstract

### Springs of the Münsterland (Germany): Observations on hydrogeology, water supply and management, ecology and didactics

The following themes are discussed within this publication:

The area-specific calculations on the water balance results according to Meßer method (2008) show the distribution patterns of evaporation, the total and direct outflow as well as the outflow into ground water or, respectively, the ground water recharge in the investigated area of Baumberge. It is evident that the ground water recharge, an important figure in the water balance, is subject to variation according to many different parameters, e.g. precipitation, soil conditions, climate, land use and surface gradient. In Baumberge, the biggest influences on the distribution of ground water recharge figures are land use and gradient. Water balance figures were collected for the hydrological year 2008 and for a long-term average. Preliminary results were compared to outflow measurements and the verisimilitude of the investigated area was ascertained. This did not give evidence for any influence of rising deep ground water, but hinted at the hydraulic effectiveness of the Nottuln-Havixbeck thrust fault, since the subsurface watersheds gave distinctly different figures from the watersheds above ground.

For the hydrological year 2008, the outflow of the springs was measured with the help of a measurement grid in the investigated area of Baumberge. The outflow of the springs, which was calculated via the measured outflow, was used as reference for ground water recharge. From the correlation between the springs outflow of the watershed of the intensive investigation area for the hydrological year 2008 and the area of the watershed, a method was developed through which the subsurface watershed area can be approximated. For the watersheds of "Lasbeck" and "Stevern", the subsurface watershed can be assumed to be larger by trend than the above ground watershed.

Hydrochemical investigations for ground- and spring water were done in the hydrological year 2008. Over 500 water samples from 76 different springs were analyzed. The analysis showed that the spring waters possess largely similar chemism, with only slight differences. The chemism of the spring waters are subject to anthropogenic as well as geological influences. Anthropogenic factors are land use of any kind as well as fertilization. Geological influences are composition and position of rock formations, relief, vegetation, season and exposition. Deep ground water which were at first assumed to lie in the investigated area could not be proven to exist.

Because of the algae bloom that appears every summer, one of the springs of the Baumberge, the Berkelquelltopf south-east of Billerbeck, was subjected to an investigation of the current ecological situation, with hopes of formulating ideas for improving its condition. To accomplish this, morphological, chemical and biological measurements were taken, the trophic level of the lake was determined, and the measurements were compared to historical data. In addition, aerial photographs were used to approximate the input of chemical substances from the watershed. It was determined that the lake is being spring-fed by two different ground water carriers,

which have differing redox situation. The Berkelquelle, which is signposted for tourists ("tourist spring"), is responsible for a high input of nitrate. Its watershed lies in the Baumberge, and it is fed by a completely nitrified fractured ground water body. A side inflow carries phosphor into the lake. The inflow is being fed by a near surface ground water body, in which stagnant moisture and oxygen depleting mineralization of organic matter lead to a reductive environment and the release of ammonium, manganese, iron and phosphate. Nitrate and phosphor can lead to eutrophication. The trophic classification of the Berkelquelltopf is that of a eutrophic lake. An investigation into the dominant phytoplankton showed indicator organisms for heavy polluted water. Comparison of recent measurements with historical data showed an increase in the input of nutrients caused by the grassland depletion in the 1960s. Later, a new equilibrium was reached with higher input. The phosphate input via the inflow had not been analyzed before.

The ecological quality of the springs in Baumberge was evaluated in terms of nature conservation. For this, structural mapping and –evaluation was undertaken at 51 springs between January and March 2008. In March 2008, a subsequent evaluation of the macrozoological benthos was undertaken at 16 sites. It was shown that the symbiotic communities are similar in their diversity to those found at different springs, but are made up of species atypical or highly atypical for springs. The in nature conservation often cited link between a high diversity of fauna and a high ecological quality of the associated habitat could therefore not be found via the methods used. The structural evaluation is overall more positive than the evaluation of the fauna. Most springs are natural or near-natural, and only a few of them appear to have been highly marred. Even though the structural mapping was undertaken to assess the quality of the spring as a habitat, there is no discernible correlation with the faunistic evaluation: a highly structured spring is not necessarily a habitat for those species that are usually associated with springs. Structural parameters that are not associated with the larger area of the spring, but rather with the spring itself, are, on the other hand, highly correlated with the number of taxa in general and that of taxa associated with springs. They should receive a higher weighting in the evaluation.

The characterization of the biocoenotic structures of the macrozoological benthos was undertaken at 26 spring mouths in the Baumberge in the spring of 2008. The results of multivariate statistics were compared to and evaluated against two species ecological methods. The multivariate statistical analysis showed that the populating of a spring is influenced to a much stronger degree by the efflux of water than by the type of the spring. An ecological correlation between certain taxa and certain types of substrate was found. This way, the habitat groups "coarse organic deposits" and "pebbly sole structure" could be differentiated. The former was highly associated with intermittent spring mouths. An exception was the heterogenous group "no clear habitat structure", in which no crucial factor for how the spring was populated could be determined. Each habitat group showed stenotopic taxa typical for the three spring types of the Baumberge. The autecological evaluation method after Schmedtje and Colling (1996) showed some agreement with the results presented here. The autecological method after Tachet et al. (2000) (species traits) could not be used for the ecological characterization. Here, to a larger extent than they were by Schmedtje and Colling, the taxa are graded as more autecologically differing or were not considered by the authors. The biocoenotic

structure of the Baumberge springs becomes more reproducible through the applied multivariate analysis, since ecological parameters taken in the field are being included as reference.

The results of microbiological and molecular biological analysis showed a high microbiological diversity, low numbers of bacteria as well as hints towards an active bacterial colonization typical of ground water in four of the springs analyzed. The highest similarities were found between the springs "Stever right" and "Stever left" as well as between "Stever right" and "Arningquelle". There were no contaminations of hygiene, except in the spring "Lasbeck 1". The results for "Lasbeck 1" showed heightened turbidity and phosphate values, a very high diversity of microbes and a contamination with *E. coli*, which hints at an anthropogenic influence.

Subsequent analysis of the ground water fauna of the springs were made to enable a preliminary classification of the animal groups found. The results showed a high diversity at 3 of the analyzed sites, with a high percentage of genuine (stygobiotic) ground water animals. The number and composition of colonies showed a high distinction between the north-westerly springs (Arningquelle, Lasbeck 1) and the south-easterly springs (Stever left and Stever right). Considering the ground water fauna, the spring Lasbeck 1 took an exceptional position.

The Baumberge, in the western Münsterland, is a tourist region with several over-ground springs and a well developed path system, which makes it ideal for spring-themed walks. Springs are a sensitive habitat, which turns combining them with regional touristic efforts into a potentially risky business. But since a lot of the springs of the region are already subjected to an unregulated recreational use, which puts them at a high risk, efforts should be made to illustrate their unquestionable need for protection in an attractive way. There are plans to accomplish this through the design of information boards and visitor pathways.

The ecological evaluation of the springs in the Seppenrader Schweiz (Coesfeld, NRW) was done via structural mapping, macrozoological benthos populations and the hydrochemical analysis of spring water, for both rural springs and those nearer to residential areas. Furthermore, conservation goals and methods were formulated. The following conclusions can be made for the springs of the Seppenrader Schweiz. 1/3 of the springs show a somewhat natural structure. These springs lie in a nature reserve. Spring water collections, being stepped on or over by animals and humans as well as building activities all have negative effects on the spring's structure. 5 of the 18 springs showed a typical or somewhat typical fauna in the samples taken from the macrozoological benthos. These were all springs in rural areas. For half of the springs, an evaluation was made impossible by the sheer lack of species found. The evaluation of the fauna is a lot more positive than that of the structure. Those springs that are near to residential areas show high concentrations of  $\text{NaCl}$  and  $\text{SO}_4^{2-}$ , the rural springs are characterized by high levels of  $\text{NO}_3^-$ . Lowland springs, like those of the Seppenrader Höhen, are rare as well as varied biotopes which are often overlooked because of their inconspicuousness and are thus highly endangered in their very existence. The springs analyzed herein show a high need for immediate action. Furthermore, there needs to be a

change in perspective among the populace, shifting its appreciation of a spring from the spring's usefulness to its naturalness and purity.

Two larger spring reservoirs in the central Ruhrgebiet north of Recklinghausen (Vestischer Höhenrücken) and Castrop-Rauxel (Castroper Höhenfläche) are characterized as to their geology, hydrogeology, hydrology and water balance. The long-term average rainfall is comparable in both regions. Since land use is also similar, the factual evaporation and outflow rates are very similar. A pronounced difference can be seen in the direct outflow rate and the rate of ground water recharge. While the direct outflow rate and the ground water recharge rate show a ratio of 1:1 for the Vestische Höhenrücken, the ratio for the Castroper Höhenflächen is 2:1. Ground water recharge is highly influenced by soils and gradient. The Baumberge (central Münsterland) on the other hand show a higher rate of agricultural land use. Because of the lower density of settlement, the evaporation rate is higher than that of the other two spring reservoirs, causing the outflow rate to be lower. The high ratio of cohesive soils, combined with the high gradient, results in the direct outflow rate being quite high, and the ground water recharge rate being lower than that of the Vestische Höhenrücken and the Castroper Höhenfläche.

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Autor(en)/Author(s): diverse

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