Riverbank Filtration Hydrology

Impacts on System Capacity and Water Quality

Edited by

Stephen A. Hubbs

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Riverbank Filtration Hydrology

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Dedication

This book is dedicated to our meeting hosts in Bratislava, Slovak Republic, who provided warm hospitality and excellent facilities for this workshop.

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Preface

The workshop from which this book is taken was held to share knowledge from the US and Europe on the science of riverbank filtration hydrology. Participants at the workshop represented all known elements of science that impact the hydrology of riverbank filtration: surface water hydrology, particle filtration, biological processes, and geochemical processes.

Those unfamiliar with the science of Riverbank Filtration might want to start with Chapter Fourteen, which includes some of the basic concepts of riverbank filtration hydrology. This chapter was written with the RBF novice in mind. It also includes extensive site data from RBF facilities in Europe and the US.

The first four chapters cover the basic hydrology of riverbank filtration, with a focus on those factors impacting system capacity and water quality through the clogging processes. Chapters Five and Six evaluate the impacts of biological and geochemical processes, and their impacts on flow and water quality. Chapters Seven and Eight provide examples of how modelling is used to predict yield and water quality in RBF facilities.

Chapters Nine through Thirteen document case studies from RBF facilities in Europe and the US. Chapter Six also contains extensive data on the many RBF sites located in the Netherlands. These chapters provide valuable practical experience from managers and scientists of RBF facilities across Europe and the US which should be helpful to those considering RBF as a water supply.

Chapter Fourteen was written after the workshop, and provides a listing of key measures developed during the workshop to be considered when designing RBF facilities. This chapter was written to provide a compilation of data from successful RBF sites to gain better insight into future sites being considered for RBF facilities. Data from many Riverbank Filtration sites are provided for these key measures.

Discussion from this workshop indicated that further research is needed into the impact of gas bubble formation on the flow through riverbeds, and through porous media in general. Several of the workshop participants had observed the formation of gas in laboratory settings, and outgassing has been observed in at least two field sites. This is an area warranting further work.

SIGNIFICANCE OF HYDROLOGIC ASPECTS ON RBF PERFORMANCE

Everything is linked to everything else

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Abstract: Clogging of the riverbed is still an important factor causing uncertainness in the planning stage of riverbank filtration plants. Several attempts have been made to develop tools, which are suitable to predict this process. But up till now, these tools are only a slight help for the engineering of riverbank filtration plants. On the other hand there exists a lot of experience about clogging from the operation of riverbank filtration plants. But to utilize this experience for a new plant, the hydrological and morphological aspects of the river and the aquifer have to be analyzed carefully to create a basis for the transfer of available knowledge. This paper deals with the relevant properties of rivers, concerning riverbank filtration: the runoff regime and the runoff dynamics, the river-aquifer interactions, the stream processes – erosion, transport and deposition – and the progress of the clogging process itself.

Key words: Characteristics of rivers concerning RBF: runoff regime and runoff dynamics, river morphology, erosion, bed load transport, deposition, structure of the riverbed, river-aquifer interaction, the clogging process.

1. INTRODUCTION

Clogging is caused by the continual percolation of water, which contains suspended matter. This process will appear in impounded basins, artificial groundwater recharge and riverbank filtration (RBF). Clogging in impounded basins is sometimes a desired process to reduce water losses. The upper layer in basins for artificial groundwater recharge is removed and cleaned at regular intervals. A first lesson to be learned from artificial

Stephen A. Hubbs (ed.), Riverbank Filtration Hydrology, 1–20.

groundwater recharge is that the so-called “Schmutzdecke” is essential for the purification of the percolated water.

Mechanical clogging of parts of the riverbed during long-term operation of RBF wells is principally unavoidable. The main task during the planning of RBF plants is to choose a suitable site for the plant near the river and to determine the type and the site arrangement of the wells.

The planning process of a groundwater plant is opened with a careful and very detailed site catchment area analysis, based on the geologic situation, the properties of the aquifer, the regional hydrology and the existing as well as possible future risks for contamination. The results of this investigation are used to determine type, size and location of the wells, to estimate long-term quantity and quality of the abstracted ground water and to check the necessity of protective measures for sustainable groundwater quality.

The step from planning groundwater plants to riverbank filtration (RBF) plants involves a significant expansion of the total catchment area, usually including the whole upstream drainage basin of the river and in detail the regions of the river upstream and downstream the location of the wells. Of particular importance for sustainable yield of the RBF wells is the unavoidable clogging process in the infiltration area. The decrease of the hydraulic conductivity of the riverbed by clogging will emerge in several steps and finally be balanced out between the position and shape of the cone of depression of the wells and the self-cleaning power of the river.

Based on a detailed site catchment area analysis, completed by pumping tests, all tools are available to predict the long-term behavior of groundwater wells very precisely. This is quite different with RBF wells due to the difficult assessment of the clogging process. Several attempts have been made to overcome this problem by theoretical and experimental means (Riesen, 1975). But the clogging process as a result of the dynamic river-aquifer interaction is rather complex and, up till now, this process cannot be calculated in advance employing some formula.

RBF is employed since more than 130 years along European rivers and a lot of experience on RBF well arrangement and operation is available (Hunt et al., 2002). This experience may be linked to relevant characteristics of the river to utilize it as a tool not only for the estimation of the clogging process but also for the optimal arrangement of RBF wells. This chapter will focus the attention on river characteristics and the mechanical clogging process.

1.1 Safe Drinking Water – A Reason to Utilize RBF

The legal definition of drinking water quality is a negative definition worldwide: Threshold limit values are limits for substances and microorganisms found in water. Values based on toxicological data have been derived to safeguard health on the basis of lifelong consumption. When looking at carcinogenesis and mutagenesis as non-threshold phenomena, other principles are applied in addition: Threshold limit values defined by precautionary aspects for preventing adverse affects of a general nature. Threshold limit values for aesthetic parameters are provided to prevent unpleasant changes, such as in taste, color and odor. Any water, which complies with these threshold limit values, can be classified and supplied as drinking water (WHO, 2004).

But the definition of a high quality drinking water is a quite different matter. The hydrologic cycle is an approved method of nature to provide high quality drinking water. A positive definition of a high quality drinking water is therefore based on pure groundwater without any contamination with reference to the hydrologic cycle. Such a definition can be found for example in DIN 2000, a Technical Standard in Germany (DIN 2000, 2000).

The preference of groundwater for water supply or, if not available, of a natural (riverbank filtration) or artificial (infiltration, groundwater recharge) subsoil passage of river water is a result of the conclusions drawn from the early outbreak of epidemic cholera in Hamburg, Germany (1892), caused by drinking water drawn from the Elbe River. This preference is now reflected in the concept of the DIN 2000.

To focus the attention on water quality aspects, it is expedient to vary the virtual point of raw water extraction. There are two important purification steps in the hydrologic cycle of nature. One step is evaporation, which separates H_2O from natural substances, chiefly salts, and all impurities. This step needs too much energy to be employed in urban water supply and this step creates totally demineralized water, which is not convenient for water supply. A second more interesting purification step is infiltration and subsoil passage of water. This step incorporates the physicochemical and biological processes to treat water and to balance out the physical (e.g. temperature), chemical (e.g. carbonate balance), and biological (e.g. low assimilable organic carbon concentration (AOC)) properties of the water.

The most advantageous water supply is to extract raw water after infiltration and subsoil passage from suitable aquifers (groundwater) regarding water quality aspects. The next most advantageous water supply is riverbank filtered water and replenished groundwater. Both types of raw water utilize the benefits of the powerful natural purification step:

- Removal of particles and turbidity
- Removal of bacteria, viruses, parasites
- Biodegradation of micro-pollutants, NOM, THM-precursors
- Reduction of mutagenic activity
- Smoothing out variations in temperature and concentration
- Compensation for peaks and shock loads.