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Review on Water Treatment Techniques Used for Riverbank Filtration

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Abstract

Water Treatment is defined as the selection of sampling sites and sampling frequency to determine physical, chemical, and biological properties of water. The main approaches to water treatment were identified as hydrogeologic and statistical. The various methods available in the hydrologic literature have been evaluated by considering the spatial scale of the monitoring program, the objective of sampling, data requirements, temporal effects, and range of applicability. Considerable advance has been made over the last two decades that now permit the application of methodical and testable approaches to water quality monitoring, design riverbank filtration, although they mostly serve for preliminary analysis and design. The main goal of these studies was to characterize the ability of riverbank filtration to provide a cost-effective, stand alone pretreatment for filter-media technologies. Results indicate that the use of riverbank filtration can reduce membrane treatment costs by 10-20 percent. In addition, overall recommendations were developed to help other utilities evaluate this technology as a potential lower cost alternative for minimizing treatment costs. The opinion on Ground-Water Quality Monitoring Network Design is that as there continues to be advances in hydro geochemistry, ground-water hydrology, and risk and geo statistical analysis, methods for ground-water quality monitoring network design will be improved and refined, and they will become ever more useful in the important mission of water treatment.

Keywords: River bank filtration; water treatment; water supply; potable water.

1. Introduction

The issue of drinking water supply is addressed around the world with different treatment technologies. One possibility of growing interest to water utilities is the technology of bank filtration. River bank filtration (RBF) has been used for more than 100 years as a natural treatment process for the production of drinking water (Sontheimer, 1980 and 1991; Kühn and Müller, 2000; Sacher and Brauch, 2002). Riverbank filtrate includes both groundwater and river water that has percolated through the riverbank or riverbed to an extraction well. One of the primary objectives of this study was to assess the pollutants removal capabilities of RBF independent of any groundwater dilution. RBF systems can significantly reduce the concentrations of many surface-water pollutants (Shubert, 2000; Wang et al., 2000; Kuehn and Mueller, 2000); however, predicting and quantifying those reductions is difficult. bank filtration facilities situated in favourable hydrogeological settings can provide relatively inexpensive high-quality water that needs little further treatment (Tufenkji et al., 2002). However, around the world the design and operation of bank filtration sites vary depending on the different treatment objectives.

In the literature, several studies have shown much promise for the removal of fractions of natural organic matter from surface waters by bank filtration(Kuehn, 2003; Ray et al., 2002; Cosovic et al., 1996). Trace organic pollutants in bank filtration have been studied in various research projects since improved analytical methods allow their detection in ranges below 1 mg/l. Many recent studies have revealed the occurrence of pesticides or industrial chemicals (Hiemstra et al., 2003; Heberer et al., 2001; Verstraeten et al., 2002) in bank filtrate. While these approaches represent an attempt at demonstrating the efficacy of RBF as a treatment technology for reducing pathogen concentrations in drinking-water sources, it is generally acknowledged that they do not provide adequate assessments of pathogen removal by RBF. Due to the huge number of possible contaminants in river water, a necessary restriction has to be made on organic substances that may be relevant to drinking water production (Sacher and Brauch, 2002 and 1999; Sacher et al., 2001a). Contrast media were found to be very polar, persistent and difficult to remove in waste water treatment (Jekel and Wischnack, 2000). Nowadays, the major raw-water resource for drinking-water supplies whereas bank-filtrated (or Infiltrated) water is about 16 percent (Sacher and Brauch, 2002; Brauch et al., 2001). Compared to this, the direct abstraction of river water is of minor importance (less than 1 percent). Ziegler (2001) showed the magnitude of this effect for parts of the Berlin water cycle by simulating the theoretical concentration increase in drinking water for a substance that is not removed during soil passage.

In many cases (and mostly along larger rivers), a clear distinction between bank-filtrated water and groundwater is difficult, and the raw water used for drinking-water production is bank-filtrated water blended with groundwater. Hence, the occurrence and fate of organic contaminants in river water and bank filtrated water are of great concern for water suppliers worldwide using surface water or artificial groundwater as a drinking-water resource.

2. Riverbank Filtration Systems

Surface water in river systems is dynamic , it is flowing downstream ,it is evaporating or taken up by riparian vegetation, it is infiltrating into groundwater (or it is entering the river from the groundwater through its bank and bed), and its ability to do all of this is highly impacted by the geologic composition of the immediate environment .There is also a dynamic interaction between surface and groundwater's in natural settings. When the river floods, water from the river gets stored in the soils in the bank areas and the low-lying areas between the floodplains. When the river level drops , the stored water from the bank areas slowly drains back to the river .

Riverbank filtration takes advantage of the infiltration of river water into a well through the riverbed and underlying aquifer material . This is a natural filtration process in which physic-chemical and biological processes play a role in improving the quality of percolating water. After a certain zone of mixing and reducing , the infiltrated water is at its cleanest, almost all river contaminants are removed. Wells are installed in this zone to pump the water to be used for drinking . The purity of this water and its suitability for drinking is outstanding , even in examples where there is an event that introduces a shock load of contaminants in to the river .Due to the geologic media's ability to remove the contaminants and travel time of water abstracted for natural filtration, the impact of such an event is minimal and requires .

2.1. Conceptual Design of Riverbank Filtration Systems

When considering the application of RBF, it is incumbent upon the engineer to recognize that the following parameters may affect the performance of an RBF system: Available river water that can be induced to flow in to the aquifer.

- Quality of river water.
- Commercial river traffic (a source of pollution; dredging may also be necessary).
- Flow velocity and bed load characteristics.
- Seasonality of river flow.
- Stability of the river channel.

Most RBF systems are constructed in alluvial aquifers located along riverbanks. These aquifers can consist of a variety of deposits ranging from sand, to sand and gravel, to large cobbles and boulders. Ideal conditions typically include coarse-grained, permeable water-bearing deposits that are hydraulically connected with riverbed materials. These deposits are found in deep and wide valleys may have a wider range of options since wells (vertical and horizontal collector wells) can be placed at greater depths (which can provide higher capacities) and can be placed farther away from the river to increase the degree of filtration. In a narrow, shallow valley, horizontal collector wells may be more advantageous than vertical wells since well screens can be placed at the lowest elevation and extended out beneath the riverbed, and longer lengths of screen can be installed to minimize entrance velocities.

RBF systems can even be constructed in low permeability zones (typically, clay and silt layers) within an alluvial aquifer. If the confining layers are extensive and continuous, well screens can be placed above the confining layer to obtain maximum filtration, whereby the well may not be classified as groundwater under the direct influence of surface water; and well screens can also be placed both above and below the confining layer to maximize the capacity available if low permeability zones are discontinuous on a local or regional scale, it should be possible for water to infiltrate from the surface-water source and migrate downward to the screen around these semi-confining layers. Some utilities have reported that redox zones form down-gradient of these low permeability zones. Redox zones are areas where the oxygen concentration is very low and reduced species of chemicals are present.

The conditions of each project site must be suitable for vertical wells, directionally-drilled Horizontal wells, or horizontal collector wells. including cost comparisons. Typically, a horizontal collector well can develop a capacity equivalent to multiple vertical wells and multiple (directionally drilled)horizontal wells or galleries; therefore, total system costs must be developed to facilitate this comparison to include both capital and long-term operation and maintenance costs.

2.2. Applicable Processes

The treatment effectiveness of RBF results from a combination of several applicable processes such as clogging of the riverbed, the dilution with groundwater after infiltration, subsurface filtration (filtration, adsorption, biodegradation, ion exchange, oxidation/reduction) and additional treatment steps.

Riverbank filtration is a highly dynamic process on account of the changes in the quality of river water due to river water level and the variations in the physical (temperature, suspended solids), chemical (type and concentration of compounds) and biological (type and concentration of viruses, bacteria and protozoa) properties (Schubert, 2005a).

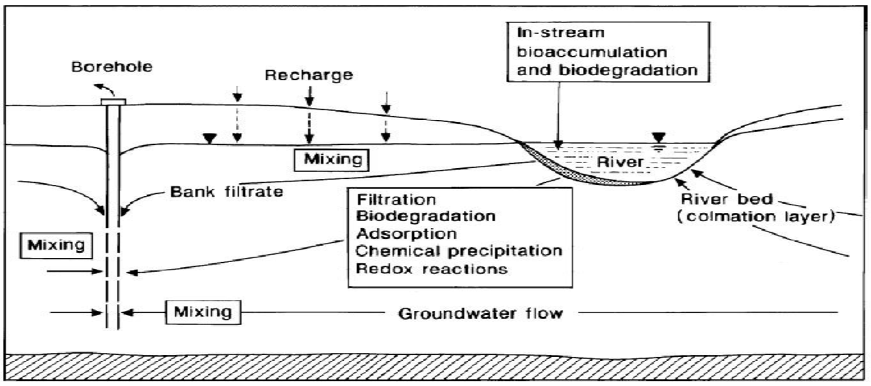

Figure 1: Riverbank Filtration Processes. Source: Amy et. al., 2006, 104.

An examination of the basic hydraulic, physicochemical and biological processes in bank filtration will help to define several criteria for the appropriate site for RBF.

This section describes applicable RBF processes according to the path of the water from the river until the transfer to the distribution system. An overview of RBF processes is given in Figure 1.

2.3. Temporal Changes Affecting Bank Filtration

During the last 30 years, River water quality has improved significantly. Many actions to reduce nutrients and pollutants were necessary. These measures comply with the best available technology in production, as well as wastewater treatment along the River.

These quality improvements were accompanied by a decrease of ammonia and DOC in river water. Oxygen concentrations reached saturation. The higher oxidation capacity of bank filtrate is linked to more efficient natural attenuation processes within the aquifer. This enabled the Waterworks to reduce treatment expenses. Natural attenuation processes are affected periodically by flood events. The water level increases up to 5 m, which leads to a higher influx of river water into the aquifer. Thus, oxygen and organic carbon flux also increase by a factor of 3 to 4. The aerobic microbes adapted to the lower flux are not able to degrade the entire organic carbon during flood events. Another decrease of natural attenuation processes becomes evident in the removal of bacteria. While mostly raw water already fulfills the Drinking Water Standard, higher colony counts are observed in the production wells following flood events (Irmscher and Teermann, 2002; Schubert, 2002). These findings explain the need of subsequent purification processes: the so-called “second protective barrier”.

3. Summary and Outlook

For the future, bank filtration is viewed as a promising approach to increase limited groundwater resources and to provide a sustainable pretreatment step with multiple-barrier functions regarding chemical and microbial parameters.

To reduce technical treatment expenses, river water of high quality, together with a profound knowledge of the natural attenuation processes within the aquifer, is essential. Rivers, successful efforts have improved water quality significantly. More efficient natural attenuation processes accompanied this improvement during bank filtration, which enabled the Waterworks to reduce expenses in water treatment.

Temporal changes of river-water quality and hydraulics still influence natural attenuation processes during bank filtration. They have to be well-understood to design adequate treatment steps and to define specific target values on river-water quality. The multi-protective barrier concept, including both natural and technical purification, is still necessary to ensure drinking water of continuously high standards.

The technology has developed steadily to meet the demands of water treatment. However, during the development process, the assumptions on which the treatment methods were based and selected often changed, and abandoned technologies, often in modified and improved form, reappeared. Still design has significantly improved over the last few years. In began there is no membrane materials change still in the mid

1990s, converted to natural materials to avoid beading of the water droplets, and is now natural filter materials issues were addressed with new proprietary inner membrane materials and the distillation technology has shown significant progress.

"The technology has now evolved to the point where with large manufacturing volumes unit costs could be greatly reduced by a factor in the future"

Additionally user response has been quite positive. Most found it cheaper to purchase a low priced rather than water treatment plant at high prices. A few drawbacks on the technology however, are that the stills are not producing optimal amounts to meet production needs in the winter. Only about 40% of users are receiving sufficient water production all year round. (Foster et al. 2005) . However, supplemental water cost is still far less than residents having to purchase water throughout the summer when premiums are at their highest. It is evident that this technology and these technology stills allow a practical, relatively inexpensive way for residents to obtain drinking water. As seen in these overall river bank filtration stills have astounding worldwide potential to address potable water needs and ultimately, saving lives.

References

[1] B.Wett, H.Jarosch, K. Ingerle, (2002) Flood induced infiltration affecting a bank filtrate well at the river Enns, Austria. J. Hydrol., 266, 222–234.

[2] C.Doussan, G.Poitevin , E. Ledoux; M. Detay, (1997) River bank filtration: Mdelling of the changes in water chemistry with emphasison nitrogen species. *J. Contam. Hydrol., 25*, 129–156.

[3] D. C. Schafer, (2000) Groundwater modeling in support of riverbank infiltration for Louisville Water Company. In *Proceedings of the International Riverbank Filtration Conference;* Julich, W., Schubert, J., Eds.; IAWR: Dusseldorf, Germany,; pp. 259–275.

[4] F. Jüttner, (1995) Elimination of terpenoid odorous compounds by slow sand filtration and river bank filtration of the Ruhr River, *Germany. Water Sci. Technol*., 31, 211-227.

[5] G. J.Medema, M. H. A. Juhasz-Holterman, J. A. Luijten, (2000) Removal of microorganisms by bank filtration in a gravel–sand soil. In *Proceedings of the International Riverbank Filtration Conference;* Julich, W., Schubert, J.,

[6] Eds.; IAWR: Dusseldorf, Germany,; pp. 161–168.

[7] J. F. Schijven, P.Berger, I. Miettinen, Bank Filtration for Water Supply; C.Ray , Ed. Kluwer *Academic Publishers: Norwell, MA, in press*.

[8] M. Sophocleus, (2002) Interactions between groundwater and surface water: The state of the science. *Hydrogeol. J., 10*, 52–67.

[9] J. Schubert, (2000) How does it work? ,Field studies on riverbank filtration. In *Proceedings of the International Riverbank Filtration Conference;* Julich, W., Schubert, J., Eds.; IAWR: Dusseldorf, Germany,; 41–55.

[10] J.H.M.van Lieverloo,G.J. Medema & D. van der Kooij, (2006). Risk assessment and risk management of faecal contamination in drinking water distributed without a disinfectant residual, *J. Water Supply: Res & Technol – Aqua*, 55, 1, 25-31.

[11] W.J. Weiss, E.J.Bouwer, W.P.Ball, C.R.O'Melia, R.Aboytes, T.F. Speth, (2004) Riverbank filtration: Effect of ground passage on NOM character. *J. Water Supply Res. Technol.—Aqua*, 53, 61-83.