



## Introduction

Most waterborne diseases are caused by pathogenic microorganisms (protozoa, viruses, bacteria and intestinal parasites) which are directly transmitted to the human body when contaminated drinking water is consumed. Several studies have shown that Riverbank Filtration (RBF) is an effective technique to remove pathogens through underground passage. Apart from pathogens many rivers and lakes, are subject to contamination with organic trace compounds. Common sources are industrial or sewage effluents in urbanized areas or agrochemicals in rural regions. The capacity of RBF to effectively or even completely remove many organic contaminants has been confirmed in numerous investigations.

Although RBF processes have been investigated in several studies in Europe and the USA, there is still a gap of knowledge for RBF performance under highly diverging conditions like monsoonal climate or highly degraded surface water quality. In this report we demonstrate the pathogen and organic trace compounds removal efficiencies, even under extremely high contamination level, of RBF systems at three field sites in Delhi, India.

## Approach

The numbers of the pathogenic organisms present in polluted waters are huge: many of them are difficult to isolate and to identify. Therefore, indicator organisms (*faecal coliforms*, *E.coli*, *Enterococci*, *Clostridium perferinges*), which are more numerous and more easy to determine, are used to measure potential faecal contamination of water samples. To indicate an enteric viral contamination of water, bacteriophages such as *somatic bacteriophages* (PRD1) were used. Because of their similar size and structure, somatic coliphages are used as indicators in sand filtration processes. In addition to the bacteriophages, the concentration of four human-pathogenic viruses (Adenoviruses, Noroviruses, Hepatitis-A and Hepatitis-E) was analysed in surface- and groundwater samples. For the analysis of organic compounds a non target analysis was carried out, with the aim to obtain an overview of contamination load by the qualitative identification of critical substances. In addition, existing reports about faecal contamination and organic trace compounds in the context of India in general and Delhi in particular were evaluated and integrated into the survey.

## Results

Based on the microbial results given in this report and on the mentioned literature we conclude that RBF may effectively reduce bacterias and viruses even if the surface water is heavily polluted with pathogens. The non target screening and quantitative analyses of organic trace compounds gives a good overview of contamination load, potential sources of contaminants and the attenuation potential of RBF systems. The results, however, have to be regarded with caution because they are based only on singular measurements from each field site and may not reflect average values. All results were given in site specific overviews, since the sites differ in several environmental and/or hydrochemical paramters.

## More information

### *Contact*

Freie Universität Berlin, Hydrogeology Group, Malteserstr. 74-100, 12249 Berlin, Germany,  
tel.: +49 30 83870629; fax: +49 30 83870742

Dipl.–Geol. Gunnar Lorenzen, e-mail: [lorenzen@zedat.fu-berlin.de](mailto:lorenzen@zedat.fu-berlin.de)

Dipl.–Geol. Christoph Sprenger, e-mail: [chspreng@zedat.fu-berlin.de](mailto:chspreng@zedat.fu-berlin.de)

## TKI Categorisation

Classification									
Supply Chain		Process Chain		Process Chain (cont'd)		Water Quality		Water Quantity (cont'd)	
<b>Source</b>		<b>Raw water storage</b>		<b>Sludge treatment</b>		<b>Legislation/regulation</b>		- Leakage	
- Catchment		- Supply reservoir		- Settlement		- Raw water (source)	X	- Recycle	
- Groundwater	X	- Bankside storage		- Thickening		- Treated water			
- Surface water	X	<b>Pretreatment</b>		- Dewatering		<b>Chemical</b>			
- Spring water		- Screening		- Disposal		- Organic compounds	X		
- Storm water		- Microstraining		<b>Chemical dosing</b>		- Inorganic compounds			
- Brackish/seawater		<b>Primary treatment</b>		- pH adjustment		- Disinfection by-products			
- Wastewater	X	- Sedimentation		- Coagulant		- Corrosion			
<b>Raw water storage</b>		- Rapid filtration		- Polyelectrolyte		- Scaling			
- Supply reservoir		- Slow sand filtration		- Disinfectant		- Chlorine decay			
- Bankside storage		- Bank filtration	X	- Lead/plumbosolvency		<b>Microbiological</b>			
<b>Water treatment</b>		- Dune infiltration		<b>Control/instrumentation</b>		- Viruses	X	<b>Consumers / Risk</b>	
- Pretreatment	X	<b>Secondary treatment</b>		- Flow		- Parasites			
- Primary treatment		- Coagulation/flocculation		- Pressure		- Bacteria	X	<b>Trust</b>	
- Secondary treatment		- Sedimentation		- pH		- Fungi		- In water safety/quality	
- Sludge treatment		- Filtration		- Chlorine		<b>Aesthetic</b>		- In security of supply	
<b>Treated water storage</b>		- Dissolved air flotation(DAF)		- Dosing		- Hardness / alkalinity		- In suppliers	
- Service reservoir		- Ion exchange		- Telemetry		- pH		- In regulations and regulators	
<b>Distribution</b>		- Membrane treatment		<b>Analysis</b>		- Turbidity		<b>Willingness-to-pay/acceptance</b>	
- Pumps		- Adsorption		- Chemical		- Colour		- For safety	
- Supply pipe / main		- Disinfection		- Microbiological		- Taste		- For improved taste/odour	
<b>Tap (Customer)</b>		- Dechlorination		- Physical		- Odour		- For infrastructure	
- Supply (service) pipe		<b>Treated water storage</b>						- For security of supply	

- Internal plumbing		- Service reservoir			<b>Water Quantity</b>	<b>Risk Communication</b>	
- Internal storage		<b>Distribution</b>				- Communication strategies	
		- Disinfection			<b>Source</b>	- Potential pitfalls	
		- Lead/plumbosolvency			- Source management	- Proven techniques	
		- Manganese control			- Alternative source(s)		
		- Biofilm control			<b>Management</b>		
		<b>Tap (Customer)</b>			- Water balance		
		- Point-of-entry (POE)			- Demand/supply trend(s)		
		- Point-of-use (POU)			- Demand reduction		

### TKI Categorisation (continued)

<b>Contains</b>		<b>Constraints</b>		<b>Meta data</b>				
Report	X	Low cost	X					
Database		Simple technology	X					
Spreadsheet		No/low skill requirement	X					
Model		No/low energy requirement	X					
Research		No/low chemical requirement	X					
Literature review		No/low sludge production	X					
Trend analysis		Rural location						
Case study / demonstration	X	Developing world location	X					
Financial / organisational								
Methodology	X							
Legislation / regulation								
Benchmarking								