Natural Treatment Systems for Safe and Sustainable Water Supply in India: Results from the “SaphPani Project”

Best Management Practice Fact Sheet on

Bank Filtration

What is bank filtration?

Bank filtration (BF) or riverbank filtration (RBF) is a process in which the subsurface at a river or lake bank serves as a natural filter and biochemically removes potential contaminants present in the surface water (Figure 1). It is used for the natural treatment of water, mainly for potable supply but also for industrial purposes and for irrigation. The process of BF is initiated by pumping water from a well next to an adjoining water body. The difference in water levels (gradient) between the pumping well and the surface water induces water to flow through the permeable bed or bank into the aquifer and towards the well. Ground- and surface water levels, water quality data and information about the subsurface and riverbed help in characterising the BF system and determining its efficiency

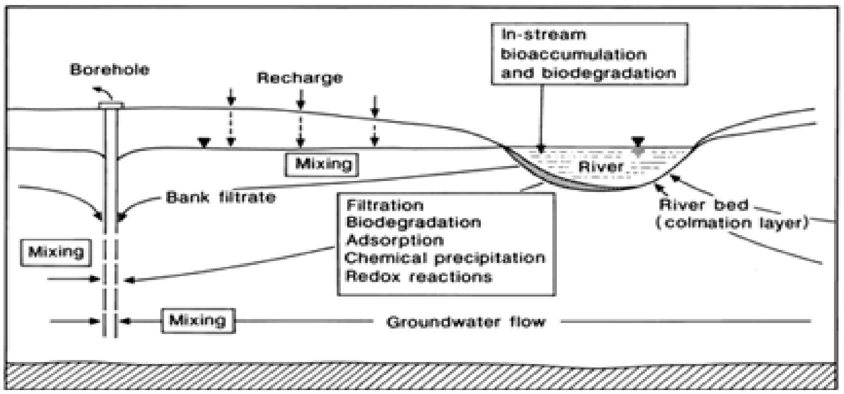

Figure 1: Principle of BF (Hiscock & Grischek, 2002)

Figure 2: Existing and potential BF sites in India (Sandhu et al., 2011)

Where can bank filtration be used?

BF can be used at sites where groundwater resources are limited, treating directly pumped surface water followed by conventional treatment is costlier than treating bank filtrate and/or surface water with water quality fluctuations require enhanced treatment to meet the desired quality (Grischek et al., 2002).

Favourable conditions for BF are sites with a continuous river flow, stable river banks and unhindered flow of surface water into the alluvial subsurface; an alluvium thickness of more than 10 m (but sites with thickness ⩾ 5 m also exist); suitable quality of groundwater and slightly erosive riverbed conditions. BF has been used successfully for more than a century in Europe at around 30 sites, for many decades in North America and also at some sites in India (Figures 2 & 3; Saph Pani D1.1, 2012 & D1.2, 2013; Special Issue on RBF, 2012). Information about the subsurface conditions, system design and water quality for some BF sites in India is accessible online (e.g. Saph Pani D1.1, 2012 & D1.2, 2013).

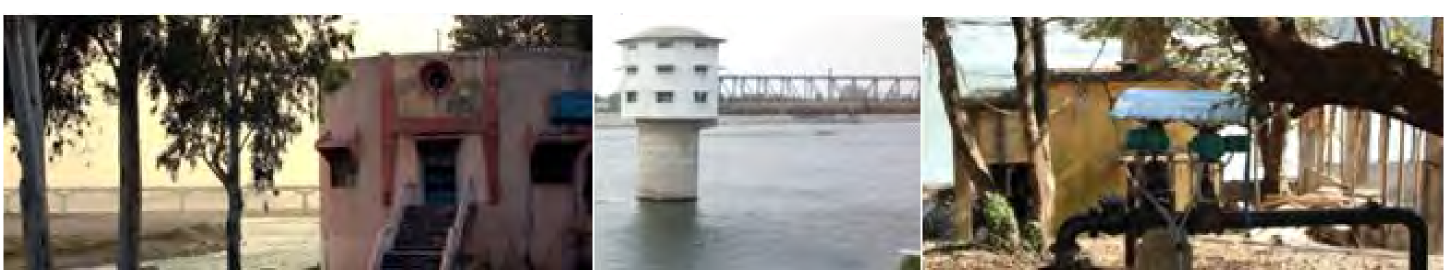

Figure 3 (L-R): BF wells in Haridwar (Ganga), Ahmedabad (Sabarmati) and Nainital (lake)

Maintenance

BF is a low-cost and low-maintenance system. Routine maintenance must be conducted to all the installations associated with the BF system. This includes inspection and repair of eventual cracks and fissures in the pump-house and well-chambers to prevent direct entry of surface water (flood- or storm-water). Water pipes and armatures in the well must be checked for leaks and repaired immediately. Pumps must be routinely inspected and overhauled. If well aging becomes noticeable through a slow decrease in the discharge rate and an increasing drawdown, or turbidity or sand content of the pumped water increases slowly or suddenly, then well rehabilitation measures must be undertaken.

Attenuation of contaminants by bank filtration

Scientific studies on water quality aspects during bank filtration in India have been conducted at sites in Uttarakhand (Dash et al., 2008, 2010; Sandhu and Grischek, 2012; Bartak et al., 2014), in Delhi (Lorenzen et al., 2010; Sprenger et al., 2014) and in Mathura (Singh et al., 2010). An improvement of physical, chemical, and biological water quality parameters through the underground passage from the surface water body to the abstraction well demonstrates the efficiency of BF (Table 1).

Table 1: Removal efficiency of typical parameters by BF (SaphPani D4.5, 2014)

Water quality issues	Parameter	Removal in percent or as otherwise indicated
Physico-chemical and organoleptic	Colour	50 – 100
	Turbidity	50 – 100
	Total suspended solids	90 – 100
Pathogens	Bacteria	2 - 6 Log_{10}
	Viruses	2.1 - 8.3 Log_{10}
	Giardia	1 - >2 Log_{10}
	Cryptosporidium	1 - >2 Log_{10}
Inorganics	Ammonium	53 – 90
	Nitrate	50 – 100
	Phosphate	$\geqslant 64$
	Heavy metals	30 – 99
Organics	Biological oxygen demand	up to 82
	Dissolved organic carbon	27 – 53
	Polycyclic aromatic hydrocarbons	up to 100
	Atrazine	14 – 80

Compared to conventional surface water pumping, BF has advantages in terms of significant removal of particles, turbidity and pathogens, dissolved organic carbon and trace organics (such as pesticides, hydrocarbons, and pharmaceuticals) and sometimes dissolved mineral ions. In some cases, some of these contaminants present in surface water are completely removed. BF also has a high capacity to buffer the effect of shock-loads of contaminants in surface water and changes in water quality. BF wells ensure safe water supply even during severe floods, provided they are technically well designed.

Socio-economic and environmental benefits

When considering the need for barriers to prevent contamination of drinking water, BF offers the first important barrier between the source of the water and point of abstraction in terms of a significant removal of pathogens and turbidity in India (SaphPani D1.2, 2013). The removal of contaminants and use of BF provides various socio-economic values as listed in Table 2. In India in the state of Uttarakhand, BF has increased the per-capita availability of water. BF has a high potential for future application in India, where alternative solutions are required to mitigate water scarcity and reduce the over-exploitation of groundwater (Essl et al., 2014).

Table 2: Socio-economic value of bank filtration (Ray et al., 2002)

Services and benefits	Value
Contaminant removal (pathogens / chemicals)	Reduced medical costs , longer life span, improved productivity, capital cost reduction, cancer risk reduction & enhanced environment
Reduced maintenance	Capital cost reduction
Improved reliability (as source-water)	Drought protection
Removal of nutrients	Reduced post-treatment costs, lower regulatory scrutiny & lower monitoring costs
Enhanced community supply	Increase in per capita-availability & less time spent to access / collect water

Cost aspects

The typical costs associated with BF systems comprise capital and operating costs. The former include costs for site-investigations (~ 5-10 % of total capital cost), well-construction costs (drilling, casing, filter-screen & -gravel, pump, well-head, pump-house & disinfection equipment) and electricity supply infrastructure to the well. Operation costs are incurred for personnel, electricity and maintenance of equipment. Indicative capital costs incurred during 2010-2012 for BF systems comprising one 200 mm diameter and 18 m deep production well with a discharge of ~1,000 m^3/day, one monitoring well, automated well-control, disinfection equipment and a generator for back-up power is around Indian Rupees 2,100,000.

Limitations of bank filtration

Undesirable effects of BF on water quality may include increases in hardness, ammonium, dissolved iron and manganese. Lack of oxygen in the subsurface can cause the formation of hydrogen sulphide and other malodorous sulphur compounds. Depending upon site-specific conditions, aquifer thickness in some regions is limited (hills, hard-rock regions), thus use of horizontal collector-pipes, caisson wells or a combination of both can be an alternative to vertical wells. Land-side groundwater can sometimes be contaminated through sewage, especially downstream of habitations, and this can pose a threat to BF sites. Along the banks of the lower courses of the Ganga and its glacial-fed tributaries, clay layers near the surface exist. These can extend beneath the riverbed and thereby impede the flow of water from the river into the subsurface.

Risk assessment and management of bank filtration sites in India

Water safety measures to manage risks associated with BF sites in India, which are consistent with the WHO guidelines, have been developed using the BF site in Haridwar as a case-study (Bartak et al., 2014). Risks from inorganic chemicals, salinity, nutrients and turbidity were acceptable in Haridwar. The risk to human health from bacterial pathogens is low. However, high removal capabilities even for viral and protozoan pathogens is reported in literature for BF (e.g., Sprenger et al., 2014) but in a longer-term assessment, these risks need improved characterisation. Further general recommendations highlight the need for improved protection and sanitary measures of the area around wells, characterization of surface and groundwater quality, and management of monsoon effects such as floods (Bartak et al., 2014; Saph Pani D1.2, 2013).

Policy issues on bank filtration in India

The National Water Policy of India emphasizes the provision of drinking water and water quality as important priorities to be addressed. Thus, BF can be considered as an alternative or supplement in many cities and towns, where the existing water supply schemes are being expanded or optimised to meet the growing water demand. Consequently, the technical and socio-economic feasibility of using BF for urban and decentralised water supply schemes can be considered in the City Development Plans or various schemes such as the 'Jawaharlal Nehru National Urban Renewal Mission', the Asian Development Bank's current 'North Eastern Region Capital Cities Development Investment Programme' and the planned 'Uttarakhand Urban Sector Development Investment Programme' and the World Bank's 'National Ganga River Basin Project' (Sandhu and Grischek, 2012). This would also serve as a first step towards meeting the goals of the Government of India's 'National Action Plan on Climate Change'.

Online resources at: http://www.saphpani.eu/downloads

SaphPani D1.1 (2012) Database of relevant pollutants in urban areas and their attenuation at RBF sites
SaphPani D1.2 (2013) Guidelines for flood-risk management of bank filtration schemes during monsoon in India.
SaphPani D4.5 (2014) Matrix for feasibility assessment of natural treatment systems and selection of post-treatment.

Peer-reviewed articles

Bartak R., Page D., Sandhu C., Grischek T., Saini B., Mehrotra I., Jain C. K. and Ghosh N. C. (2014) Application of risk-based assessment and management to riverbank filtration sites in India. Journal of Water and Health doi:10.2166/wh.2014.075 (Available online 31 May 2014)

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Essl L., Starkl M., Kimothi P. C., Sandhu C. and Grischek T. (2014) Riverbank filtration and managed aquifer recharge as alternative water supply technologies for India: strengths–weaknesses–opportunities–threats analysis. Water Science and Technology: Water Supply 14(4), 690-697.

Grischek T., Schoenheinz D. and Ray C. (2002) Siting and design issues for riverbank filtration schemes. In: Riverbank Filtration – Improving source-water quality, Ray C., Melin G. and Linsky R. B. (eds.), Water Science and Technology Library, 43, Kluwer Academic Publishers, Dordrecht, The Netherlands, pp. 291-302.

Hiscock K. M. and Grischek T. (2002) Attenuation of groundwater pollution by bank filtration. Journal of Hydrology 266(3-4), 139-144.

Lorenzen G., Sprenger C., Taute T., Pekdeger A., Mittal A. and Massmann G. (2010) Assessment of the potential for bank filtration in a water-stressed megacity (Delhi, India). Environmental Earth Sciences 61(7), 1419-1434.

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Sandhu C. and Grischek T. (2012) Riverbank filtration in India – using ecosystem services to safeguard human health. Water Science and Technology: Water Supply 12(6), 783-790.

Sandhu C., Grischek T., Kumar P. and Ray C. (2011) Potential for riverbank filtration in India. Clean Technologies and Environmental Policy 13(2), 295-316.

Singh P., Kumar P., Mehrotra I. and Grischek T. (2010) Impact of riverbank filtration on treatment of polluted river water. Journal of Environmental Management 91(5), 1055-1062.

Special Issue on River Bank Filtration (December 2012) Journal of Indian Water Works Association

Sprenger C., Lorenzen G., Grunert A., Ronghang M., Dizer H., Selinka H.-C., Girones R., Lopez-Pila J. M., Mittal A. K. and Szewzyk R. (2014) Removal of indigenous coliphages and enteric viruses during riverbank filtration from highly polluted river water in Delhi (India). Journal of Water and Health 12(2), 332-342

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