Health and Economic Profits from Riverbank Filtration in India

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Introduction

This project investigates a small Riverbank Filtration (RBF) system in the tropical monsoon climate of rural western India. As in much of India, the residents of the village of Kariyampalli do not have reliable access to safe drinking water and face problems with contaminated surface water and with the potential for groundwater depletion. RBF addresses both issues of polluted surface water supplies (Schmidt et al, 2003; Boving et al, 2010) and the overuse of groundwater, a worldwide problem with recent data showing severe examples in northern India (Rodell et al, 2009).

Objective

Dissolved silica (Hooper and Shoemaker, 1986) and stable isotope (Sklash and Farvolden, 1979) levels are examined to determine the percentage of bacterial and metal contaminant removal that can be attributed to groundwater dilution versus other RBF processes.

Riverbank Filtration (RBF)

In Riverbank Filtration a shallow well is drilled near a surface water source to improve the water quality by drawing river water through the aquifer material.

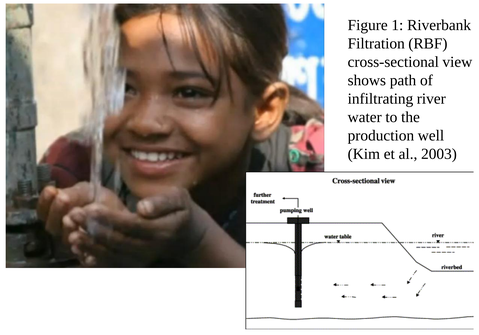
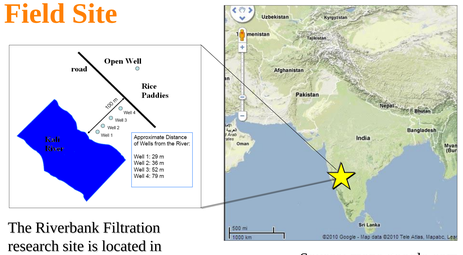


Figure 1: Riverbank Filtration (RBF) cross-sectional view shows path of infiltrating river water to the production well (Kim et al., 2003)

Additionally, the project is set up so that local villagers will take over management and upkeep of the well. Local water users fees are used for this maintenance. The allocation of any profits from the sale of the water are to be voted on by locally elected board members.

Field Site



The Riverbank Filtration research site is located in India's Western Ghats

Source: maps.google.com

Materials and Methods

- Stable isotopes: isotope-ratio mass spectrometer
- Dissolved silica: UV-vis spectrophotometer
- Metals: Inductively Coupled Plasma Mass Spectrometer (ICPMS)
- Bacteria: IDEXX Most Probable Number (MPN) enumeration technique

Isotope Data

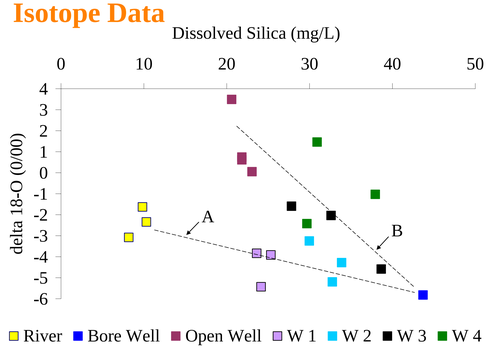


Figure 2. Mixing line A shows Wells 1 and 2 falling between river water and groundwater (Bore Well). Mixing line B shows evaporative effect of rice paddies on Open Well and Wells 3 and 4.

Dissolved Silica Data

Water Source	Average Percent Kali River water
Kali River at Kariyampalli (KKR)	100.0%
RBF Well 1	61.8%
RBF Well 2	45.9%
RBF Well 3	27.6%
RBF Well 4	50.7%
Kariyampalli Open Well (KOW)	57.8%
Mainal Bore Well	0.0%

Table 1: Dissolved silica concentrations show water from RBF Well 3 to have a mixture of approximately ¾ groundwater and ¼ Kali River water.

Metals Data

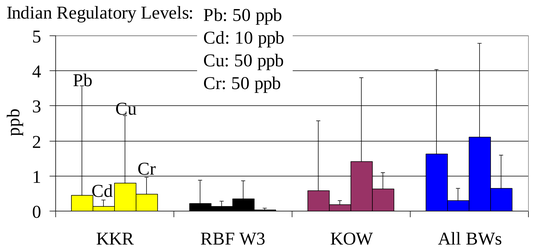


Figure 4. RBF water has lower average metals levels than other local drinking water options. Error bars show maximum ranges.

Bacteria Data

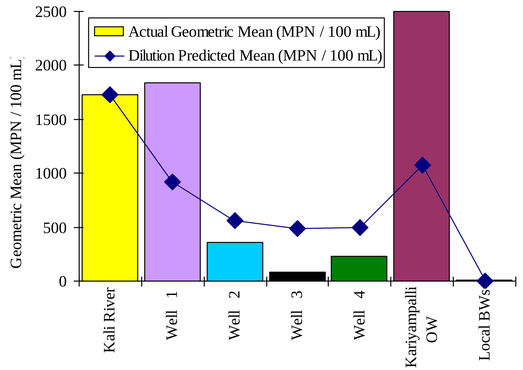


Figure 5: Total Coliform bacteria show an average reduction of 95.1% (geometric mean) with a maximum removal rate of 99.8 % from the river to the pumping well (Well 3). Dilution levels calculated with dissolved silica data are shown as predicted values (diamonds). Detection limits of IDEXX system are minimum: <1 MPN / 100 mL and maximum: >2,419.6 MPN / 100 mL.

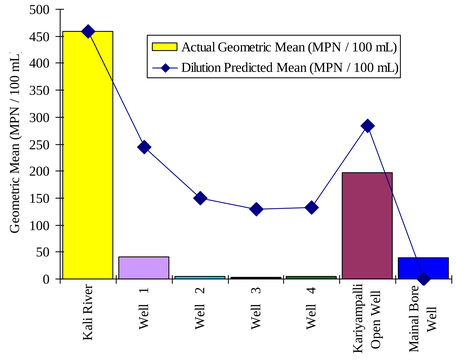


Figure 6. *E. coli* bacteria show an average reduction of 99.2% (geometric mean) and a maximum removal rate of 99.9% from the river to the production well (Well 3). Dilution levels calculated with dissolved silica data are shown as predicted values (diamonds).

Discussion

The silica mixing model uses the Kali River and local groundwater from the Bore Well as end members to calculate average percentage of surface water and groundwater in the RBF wells. This model shows an average of 27.6% river water in the production well, RBF Well 3. Although other wells in the RBF well field show a change in silica concentration with time, Well 3 shows a constant percentage of groundwater in samples taken before and after 11 months of regular pumping. Isotopic data suggest that irrigation with river water on the rice paddies as well as evaporation at the same rice paddies near the research site are affecting Wells 3 and 4. When considering both metals and bacteria pollutant levels, the pumping well produces safer water than any other drinking water source in the area.

Conclusions

- Isotopes: Wells 1 & 2 are similar to Kali River
  Wells 3 & 4 are influenced by nearby irrigation and evaporation
- Silica: Well 3 is an average of 27.6% river water
- Metals: Well 3 versus dilution predicted mixture:
  Lead: 82.4% improvement
  Cadmium: 46.7% improvement
  Copper: 80.2% improvement
  Chromium: 93.7% improvement
- Bacteria: Total Coliform: ≥ 95.1% average removal
  E. coli: 99.2% average removal
- Groundwater dilution by itself does not explain metals and pathogen removal
- RBF water is safer than other drinking water sources in the area, while also reducing groundwater drawdown

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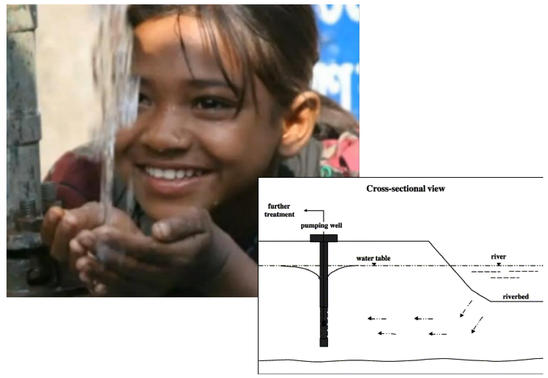

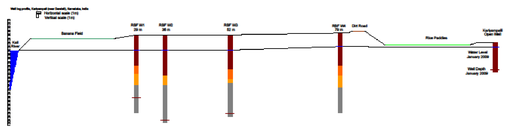

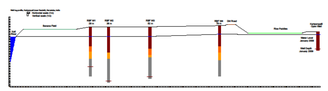

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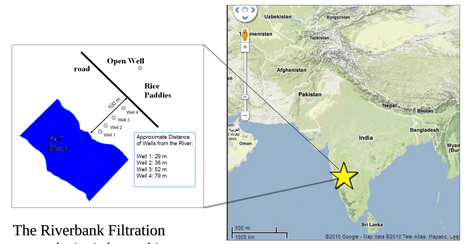
Riverbank Filtration (RBF)

In Riverbank Filtration a shallow well is drilled near a surface water source to improve the water quality by drawing river water through the aquifer material.

Figure 1: Riverbank Filtration (RBF) system diagram: cross-sectional view shows path of infiltrating river water to the production well (Kim et al., 2003)



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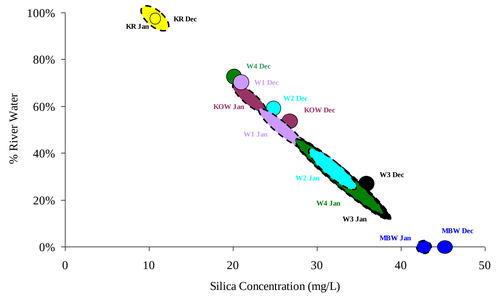

Figure 3. Silica concentration demonstrates percentage of Kali River water drawn into RBF wells 1, 2 and 4 increases with time pumping. Closed lines represent samples taken 11 months after those with dashed lines.

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