Investigating Hydraulic Connections Between Shallow, High Arsenic Aquifers and Deeper, Low Arsenic Aquifers in Bangladesh

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December 17, 2012
Outline

• Urban Pumping and Rural Aquifers
• Objectives
  – Current Araihazar hydrology
  – Finding recharge windows between high arsenic, shallow aquifers and deep aquifers
• Conclusions
• Fastest Growing Mega City in the world 15 million people growing by 7% annually
• ¼ of people are homeless
Boro Rice Cultivation and Number of Wells

Harvey et al., 2006 Chemical Geology
Urban and Rural Pumping Volumes per Area of Land

Pumping Intensity (m^3/km^2)

- Dhaka Drinking
- Rural Drinking
- Rural Irrigation

Michael & Voss, 2009 *Hydrogeology J.*
Historical Water Levels in Mult-Level Nests

Water Level Elevation (masl)

- Water Level Elevation (masl)

- Water Level Elevation (masl)
Locations of Manual Water Levels in 35-238 m Wells in March
≤100 ft
Or 30 m
Objectives

• Assess potential downward migration of high arsenic, shallow groundwater to deeper aquifers in response to Dhaka pumping
• Identify potential recharge windows of shallow groundwater to deeper, low arsenic (>30 m) aquifer
Locations of Manual Water Levels in 35-238 m Wells in March

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Manual Water Levels in Community Wells and Megna River in Feb/March, 2012

\[ y = -0.0005x + 1.73 \]
\[ R^2 = 0.88 \]

20-200 m/year

\[ y = -0.0004x + 0.93 \]
\[ R^2 = 0.70 \]

16-160 m/year

-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5

Water Level Elevation (masl)

Distance West from Megna (m)

104-150 m

205-237 m

Megna

Flow Due West
Conceptual Model of Groundwater Flow During Dry Season

Community Well Depth (m)
Distance West of Megna (m)

Megna River > Dhaka (21,000 m)

35-55 m
56-73 m
104-150 m
205-238 m

20-200 m/year
Locations of Water Level Loggers in Araihazar
Continuous Water Levels in Megna River and Deep (>200m) Aquifer

Average Monthly Rainfall (mm)

Water Level Elevation (masl)

Average Monthly Dhaka Rainfall (mm)

Continuous Water Levels in Megna River and Deep (>200m) Aquifer

Water Level Elevation (masl)

Average Monthly Rainfall (mm)

Average Monthly Dhaka Rainfall (mm)

Apr/1 May/1 Jun/1 Jul/1 Aug/1 Sep/1 Oct/1 Nov/1
Continuous Water Levels in Megna River and Deep (>200m) Aquifer

Average Monthly Rainfall (mm)

Water Level Elevation (masl)

Average Monthly Dhaka Rainfall (mm)
Continuous Water Levels in Megna River and Deep (>200m) Aquifer

Average Monthly Rainfall (mm)

Water Level Elevation (masl)

Average Monthly Dhaka Rainfall (mm)

Continuous Water Levels in Megna River and Deep (>200m) Aquifer

Flow West

Flow East

Switch Point
Detecting Recharge Windows from Shallow, High Arsenic Aquifers (<30 m) to Deeper, Low Arsenic Aquifers
Constraining Window with Downhole EM/Gamma Logging
Recharge Window
No Clay/Silt <60 m

Semi-Confined
Likely Clay/Silt <60 m
Constraining Window with Downhole EM/Gamma Logging
Conclusions

• Dhaka depression cone is increasing downward and westward hydraulic gradients

• The increase in downward vertical gradients raises the possibility of downward migration of high arsenic water

• The flow towards Dhaka seems to peak in the early monsoon but reverse in the late wet season (August-October)

• Geo-physical, -chemical and –hydrological data shows evidence of a recharge window at least 300 m wide that may be important in recharging the deeper aquifer and a possible location for future movement of high arsenic water.
Acknowledgements

• Lex van Geen, Ivan Mihajlov, Rajib Mozumber, Brian Mailloux, Martin Stute (Columbia U SRP Arsenic Project)

• Mahfuzur Khan and Holly Michael (U Delaware)

• Lee Slater, Dimitrios Ntarlagiannis (Rutgers)

• Mike Steckler (Columbia U)

• Dhiman Mondal (SUNY Queens)

• Kazi Matin, Imtiaz Choudhury, Shovon Barua (Dhaka U)
Continuous Water Levels

Rapid Fluctuations in Water Levels from Irrigation Pumping allows Identification of Separate Aquifers
Seasonal Range of Water Level Elevations In B Nest

Same as previous graph, but shows range of Water Levels measured in B Nest over 10 years
Level Loggers at Site MB
Progression of Silt/Clay Layers from Central Araihazar to Megna River
Potential Model of Arsenic Migration from Paleo-channels to deeper aquifers

Recharge window

Semi-confined aquifer

Recharge window

Mcarthur et al., 2008