Road to Sustainable Arsenic Management in Bangladesh: The Deep Aquifer Issues

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Presentation Outline

- Introduction
- Deep Aquifer as a Source of Safe Water
- Deep Aquifer Definitions
- Development of Deep Aquifer Database
- Deep Aquifer Mapping
- Water Quality Issues
- Current Development Strategy
- Conclusions
- Recommendations
Number of Water Points Installed by DPHE

Number Operational in June 2007

<table>
<thead>
<tr>
<th>Type of Water Source</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>STW</td>
<td>1076792</td>
</tr>
<tr>
<td>DTW</td>
<td>204812</td>
</tr>
<tr>
<td>SW</td>
<td>3835</td>
</tr>
<tr>
<td>RWH</td>
<td>771</td>
</tr>
</tbody>
</table>
Status of Arsenic in Wells

% Exceeding 50 ppb

DPHE Region

Dha  | Chi  | Syl  | Bar  | Far  | Raj  | Ran  | Khu  | CHT  | BAN  |
-----|------|------|------|------|------|------|------|------|------|
10   | 19   | 9    | 6    | 29   | 4    | 1    | 23   | 0    | 12   |
Proportion of Shallow & Deep Wells

[Bar and column charts showing the proportion of shallow and deep wells across different regions (Dha, Chi, Syl, Bar, Far, Raj, Ran, Khu, CHT).]

[Bar charts showing the percentage of shallow and deep wells across different regions (Dha, Chi, Syl, Bar, Far, Raj, Ran, Khu, CHT).]
Mitigation Implemented

Number of Options

% of Total Number of Options

% of Functional Options

(Data Source: APSU)
Mitigation by sources of water

Sources of Water

Mitigation Option
Relative Risks of Various Sources

Fig. 3. Burden of disease by technology and season

Daly/1,000 person-years

0 2 4 6 8 10 12 14 16 18

Technology

DTW D Med
LCL
UCL

STW D Med
LCL
UCL

DTW W Med
LCL
UCL

PSE W Med
LCL
UCL

RW W Med
LCL
UCL

Viral
Bacterial
Protozoal
Skin
Lung
Bladder

DALY = Disability-adjusted life year; DTW = Deep tubewell; DW = Dog well; LCL = Lower confidence level; DALYs; Med = Median DALYs; PSI = Pond sand filter; KW = Rain water; UCL = Upper confidence level; DALYs; W = Wet season

(Howard et al., 2006)
FINAL REPORT

Development of Deep Aquifer Database and Preliminary Deep Aquifer Map
(First Phase)

March 2006

General Water Circle
Department of Public Health Engineering
CPHE Bhaban (5th Floor)
Mishkal Capran Mandal, Nil Moni
Chota-1000, Bangladesh

APSU
Asian Policy Support Unit
<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Upper/Composite Aquifer</td>
<td>1&lt;sup&gt;st&lt;/sup&gt; Aquifer</td>
<td>Upper Shallow Aquifer</td>
<td>Upper Aquifer</td>
<td>Upper Holocene Aquifer</td>
</tr>
<tr>
<td>2</td>
<td>Main Aquifer</td>
<td>2&lt;sup&gt;nd&lt;/sup&gt; Aquifer</td>
<td>Lower Shallow Aquifer</td>
<td>Mid Aquifer</td>
<td>Middle Holocene Aquifer</td>
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<tr>
<td>3</td>
<td>Deep Aquifer</td>
<td>3&lt;sup&gt;rd&lt;/sup&gt; Aquifer</td>
<td>Deep Aquifer</td>
<td>Deep Aquifer</td>
<td>Late Pleistocene - Holocene Aquifer</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Plio-Pleistocene Aquifer</td>
</tr>
</tbody>
</table>
Lateral Variations in Aquifers

(Ahmed, 2003)

Alam et al., 1990)
Morton and Khan (1979) describe the deep aquifer from Barisal and Patukhali districts as the one that occurs at depths ranging from 238 to 328m.

Jones (1985) describes the saturated deep Tertiary sequences, identified from the electrical logs of oil and gas wells at the depths of 1000 to 3000m, as the deep confined aquifers.

MPO (1986) based on the information of Jones (1985) proposed the term Lower Aquifer Sequence for the aquifers occurring underneath the main aquifer of UNDP, 1982.
Deep Aquifer Definitions -2

- Khan (1991) defined deep aquifer as “those aquifers whose waters have no access vertically upward or downward but flow very slowly along the dips and slopes of the aquifer. The depths of the deep aquifers containing useable water range from 600 feet to 3000 feet on the Dinajpur platform and 800 feet to 5000 feet in the basin”.

- DPHE/UNICEF/WB (2002): It was agreed at the meeting that deep aquifer should not be defined in terms of depth where the depth would depend on local/regional hydrogeological conditions. There should be an aquitard or aquiclude separating the shallow and deep aquifers.

- DPHE & BGS (2001) considered the red brown Dupi Tila of the Chandina area, and Barind Madhupur Tracts and grey sub-150m deep aquifers composed of cyclic, vertically stacked aquifers in the subsiding delta as the deep aquifer.
Deep Aquifer Definitions -3

- JICA (2002) hydrogeologically defined deep aquifer as consisting of D and E formations of Pleistocene age at depths of 160 to 220m in their study area in Jessore, Jhenaidah and Chaudanga districts of SW Bangladesh.

- Ravencroft (2003) defined deep aquifers as those accessible to current water well technology (<350m) and already developed by hand tubewells and locally by production tubewells (e.g. Khulna). He termed the deep aquifers of Jones and Khan as “super-deep” aquifers and commented that it was unlikely that their exploitation would be economically viable for the foreseeable future.

- Zheng et al. (2005) defined shallow (<28m) and deep (40-90m) aquifers in a local case study based on hydrogeological and hydrogeochemical contrasts.
Deep Aquifer Definitions – approaches

From the various definitions it is evident that deep aquifer can be defined in a number of ways such as:

- By depth: 150m as the boundary as adopted in the BGS & DPHE (2001).
- Hydrostratigraphically: presence of a thick low permeability layer, i.e. silt and clay layer in between the shallow and deep high permeability layers (aquifers), i.e. sand and gravel layers.
- Hydraulically: an observable head difference between the two aquifers.
- Hydrogeochemically: possesses groundwater with distinctly different hydrogeochemical facies.
- Geologically: belongs to two different geological units, e.g. Holocene and Pleistocene.
Deep Aquifer Definitions -Proposed

- Deeper Holocene/Late Pleistocene-Holocene aquifer separated by one or more sufficiently thick (~10m) clay/silty clay aquitard or Pleistocene Dupi Tila aquifer overlain by Pleistocene Clay or separated by Holocene clay from the alluvial aquifer.

- In the coastal region the Pliocene Tipam formation may also serve as the deep aquifer.

- It is proposed that there should not be a fixed depth attached to the definition of deep aquifer.
DEEP AQUIFER MAPPING

- Distribution of Data Points

No of Drags

- 0
- ≤ 10
- 10 - 20
- 20 - 30
- 30 - 40
- > 40 - 50

Log Distribution according to Depth

- ≤ 50 m
- > 50 - 100 m
- > 100 - 200 m
- > 200 - 300 m
- > 300 - 400 m
- > 400 m
Chandpur Sadar Upazila
Shallow Aquifer

Deep Aquifer
Satkhira Borelog Location
Satkhira District Modeling
Data Coverage in Southern Bangladesh
Kushtia-Jessore-Khulna Regional Mapping
Hydrostratigraphy of the Kushtia-Jessore-Khulna Region
Khulna Region Hydrostratigraphic Model
Comilla-Noakahli Regional Mapping
EW Hydrostratigraphic Cross Sections
Depth to the Aquitard 2 in the Southern Region
Thickness of the Aquitard
Water Quality of the Deep Aquifer - Arsenic
Arsenic Data from DPHE Zonal Labs

Table 6.1: Samples exceeding Bangladesh and WHO standards for arsenic in the districts of Bangladesh:

<table>
<thead>
<tr>
<th>Division</th>
<th>Bangladesh Standard (0.05 mg/L)</th>
<th>WHO Standard (0.1 mg/L)</th>
<th>Total Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>DHA (1608)</td>
<td>&gt;0.01 mg/L</td>
<td>&gt;0.05 mg/L</td>
<td>1608</td>
</tr>
<tr>
<td>CHI (1724)</td>
<td>&gt;0.01 mg/L</td>
<td>&gt;0.05 mg/L</td>
<td>1724</td>
</tr>
<tr>
<td>SYL (293)</td>
<td>&gt;0.01 mg/L</td>
<td>&gt;0.05 mg/L</td>
<td>293</td>
</tr>
<tr>
<td>KHU (1846)</td>
<td>&gt;0.01 mg/L</td>
<td>&gt;0.05 mg/L</td>
<td>1846</td>
</tr>
<tr>
<td>BAR (588)</td>
<td>&gt;0.01 mg/L</td>
<td>&gt;0.05 mg/L</td>
<td>588</td>
</tr>
<tr>
<td>TOT (6059)</td>
<td>&gt;0.01 mg/L</td>
<td>&gt;0.05 mg/L</td>
<td>6059</td>
</tr>
</tbody>
</table>

% of Sample

- >0.05 mg/L
- >0.01 mg/L

Division

DHA (1608)  CHI (1724)  SYL (293)  KHU (1846)  BAR (588)  TOT (6059)
Depth Distribution of Arsenic

As concentrations (mg/L)

Screen Depth (mgbgl)

Depth Distribution of Arsenic

<150m
>150-200m
>200-250m
>250-300m
>300-350m
Iron in Deep Groundwater
Chloride in Deep Groundwater
Manganese in Deep Groundwater

Left:
- Map showing manganese concentration levels in groundwater.
- Legend indicating concentration levels:
  - <0.1 mg/L
  - 0.1-0.4 mg/L
  - >0.4 mg/L

Right:
- Graph showing percentage of samples within different manganese concentration ranges.
- Mn concentrations (mg/L):
  - ~0.1
  - >0.1-0.4
  - >0.4

- Screen depth (mbgl):
  - <150 m
  - 150-200 m
  - 200-250 m
  - 250-300 m
  - >300 m
Mitigation Strategy

- National Arsenic Policy 2004
  - access to arsenic-safe water for drinking and cooking will be ensured;
  - all patients will be managed effectively;
  - public awareness will be raised about impact of arsenic contaminated water;
  - capacity will be built at all levels for implementation of mitigation options, surveillance and monitoring of water quality and diagnosis and management of patients;
  - impact of arsenic on agriculture will be assessed.
Inter-ministerial Committee on Deep Aquifer

- A committee has been constituted at the ministry of Local Government
- Representatives of Universities, Research Institutes and Government Departments
- Approval has to obtained from this Committee for installing DTW by any GOB Department
- The Committee Reports to the National Committee of Expert
- Has given approval to applications made by BAMWSP and GOB5 projects of DPHE
- Ineffective for sometime now though DTW installation going on in many areas of the country!
Conclusions

- There is not enough data to prepare national scale deep aquifer map
- There are inconsistencies in borelogs available
- First step towards compilation of a deep aquifer database
- RockWorks can be used for preparing sections, fence diagrams and hydrostratigraphic models
- Good beginning of converting piles of paper data into digital database and preparing maps
Recommendations

- Recording and Preservation of Lithologs and well construction at DPHE and all other agencies using a Standard Format should be made mandatory.
- A comprehensive Deep Aquifer Investigation including WQ study should be undertaken urgently.
- Wise use of deep groundwater should be advocated until proper assessment has been made.
- Deep Groundwater should be used only for potable uses.
- Care should be taken in installing DTWs to avoid cross contamination.
- Monitoring Network should be designed and installed for resource and quality surveillance.
Dhanyabad
Thank You All