ARSENIC CONTAMINATION OF GROUNDWATER AND ITS MITIGATION IN THE PROVINCE OF PUNJAB (PAKISTAN) IN THE LIGHT OF THE SITUATION IN SOUTH ASIA

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STUDY AREA

Punjab is one of the four provinces of Pakistan, which is biggest in population and second in area

- Punjab extends over an area of 205,345 km²
  26 percent of the total area of Pakistan
- Population 80 million
- Total districts 34
- World’s largest canal network for irrigation
- Groundwater level receding 30-60 cm/annum
Punjab Area

<table>
<thead>
<tr>
<th>Country</th>
<th>Area (KM²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Punjab</td>
<td>205,345</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>143,998</td>
</tr>
<tr>
<td>Nepal</td>
<td>147,181</td>
</tr>
</tbody>
</table>
Historical Map of Punjab
Groundwater Screening

A systematic screening of groundwater for arsenic contamination started in Pakistan relatively late, in early 2000

- First screening was undertaken in the Attock and Rawalpindi districts of Punjab jointly by UNICEF and PCRWR
- Covered an approximately 60% of the districts and the remaining area was still untouched
- Detail testing was carried out only in eight out of 34 districts
- Twelve districts were still untouched
- A detailed study was carried out in 2004-5 by UNICEF and PCRWR covering all the remaining districts
Arsenic Screening in Punjab

Samples collected from all districts of Punjab up to date are 36,304. The samples having arsenic less than 10 µg/L or nil were 60.0% of total samples.

The samples in the range of 10-50 µg/L were 31.0% of the total samples.

The samples greater than 50 µg/L were 9.0% of the total samples.

The maximum arsenic 250-500 µg/L found in:

Bahawalpur, Layyah, Multan, Muzaffar Garh, Okara and Sahiwal districts.
Arsenic Screening in Punjab

- 60% As < 10 µg/L
- 31% As > 10 µg/L
- 9% As > 50 µg/L
Arsenic Contamination in Punjab
Maximum As

Area

- Attock
- Bahawalnagar
- Bhakkar
- Chakwal
- D.G.Khan
- Faisalabad
- Gujranwala
- Gujrat
- Hafizabad
- Jhelum
- Jhang
- Kasur
- Khanewal
- Khushab
- Lahore
- Layyah
- Lodhran
- M.B.Din
- Mianwali
- Multan
- Muzaffargarh
- Narowal
- Okara
- Pakpatan
- Rahim Yar
- Rajan Pur
- Rawalpindi
- Sahiwal
- Sargodha
- Sheikhupura
- Sialkot
- T.T.Singh
- Vehari
## Arsenic Contamination in Pakistan (UNICEF and PCRWR)

<table>
<thead>
<tr>
<th>Province</th>
<th>Total Samples</th>
<th>As &gt; 10 µg/L (%)</th>
<th>As &gt; 50 µg/L (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Field</td>
<td>Lab</td>
<td>Field</td>
</tr>
<tr>
<td>Punjab</td>
<td>31,693</td>
<td>4,611</td>
<td>32.5</td>
</tr>
<tr>
<td></td>
<td>10.0</td>
<td>9.0</td>
<td></td>
</tr>
<tr>
<td>Sindh</td>
<td>67,556</td>
<td>4,825</td>
<td>24.0</td>
</tr>
<tr>
<td></td>
<td>7.8</td>
<td>17.0</td>
<td></td>
</tr>
</tbody>
</table>
Arsenic and Groundwater Parameters

1. Groundwater Depth
   No clear relationship between As contamination and water table depth i.e. both shallow and deep water sources had contamination

2. Groundwater pH
   Arsenic concentration did not relate to pH variation

3. Groundwater Electrical Conductivity
   No significant relationship between As concentration and electrical conductivity

4. Groundwater Iron
   As concentration did not relate with iron concentration
Arsenicosis in Pakistan
Removal systems have been made by using locally available housing and PCRWR developed filter media.

Three options were considered:

1. Clay Pitcher Arsenic Removal Filter
2. Gravity Flow Arsenic Removal Cartridge Filter
3. Arsenic Removal Cartridge Filter
Arsenic Mitigation Technologies Developed in Pakistan

Clay Pitcher Arsenic Removal Filter

Arsenic Removal Cartridge Filter
Arsenic Mitigation Technologies Developed in Pakistan

Solar Disinfection (SODIS) of Drinking Water
Arсенic Mitigation Technologies Developed in Pakistan

1. Clay Pitcher Arsenic Removal Filter

- **Housing:** Clay Pitchers
- **Capacity:** 20 L
- **No. of holes:** 10 - 12 (1.0 mm diameter)
- **As contamination:** 300 µg/L

**Material:**

- Silver coated sand (2.0 kg)
- Arsenic removal media developed by PCRWR (3.0 kg)
- Cast iron turnings (3.0 kg)
- Plain sand (3.0 kg)
2. Gravity Flow Arsenic Removal Cartridge System

Housing: Clay Pitchers
Capacity: 20 L
No. of ceramic cartridges: Two
As contamination: 100 µg/L

Material: Arsenic removal media developed by PCRWR
3. Arsenic Removal Cartridge Filter

Housing: Small housings
Openings: Two (Inlet/Outlet)
No. of ceramic cartridges: One
As contamination: 100 µg/L
Material:

Arsenic removal media developed by PCRWR
Silver coated sand
Mitigation Measures

Arsenic Mitigation Technologies Developed in Pakistan

Water Filtered vs Arsenic

Water Filtered (L) vs Arsenic (µg/L)

Number of Samples

- Water Filtered (L)
- As (µg/L)
## Arsenic Mitigation Technologies Developed in Pakistan

<table>
<thead>
<tr>
<th>Technologies</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay Pitcher arsenic removal filter (20 L)</td>
<td>Pak Rupees 840 (US$ 14.0)</td>
</tr>
<tr>
<td>Gravity flow arsenic removal filter (20 L)</td>
<td>Pak Rupees 1740 (US$ 29.0)</td>
</tr>
<tr>
<td>Arsenic removal cartridge filter</td>
<td>Pak Rupees 1620 (US$ 27.0)</td>
</tr>
</tbody>
</table>
Social Mobilization and Awareness

Marking water sources “Green”

Marking “Red”
Conclusions

1. In Punjab, 18 districts out of 34 had arsenic contamination in both shallow and deep water sources (As well over 50 µg/L)
2. 36,000 samples: 31% contain 10-50 µg/L, while 9.0% had As over 50 µg/L
3. Max As contaminated samples 250-500 µg/L found in southern and eastern Punjab
4. As contamination is not uniform in all districts
5. Serious arsenic contamination over 1000 µg/L has also been found in two central districts in Sindh
Conclusions

6. As contamination does not relate to pH fluctuation
7. As contamination does not indicate any linkages with electrical conductivity
8. As contamination is not correlated with iron
9. Epidemiological survey for arsenicosis of 10 districts out of 34 did not show major public health problems
10. Arsenic mitigation in Pakistan is in its very early stages
11. Groundwater level receded at a rate of up to 60 cm per annum
Recommendations

Water Management

➢ Groundwater Act should be developed and implemented as an emergency measure
➢ Screening of all tube wells should be undertaken
➢ As testing facilities should be available at an affordable cost
➢ Groundwater pumping rate should be minimized for irrigation

Alternative Water Supply

➢ Alternative water supply options should be introduced keeping in view social, cultural and economic status of population
➢ Simple and sustainable surface water treatment options should be introduced to the public
Recommendations

- Capacity development programs should be started at local and community level.
- Appropriate, sustainable and affordable arsenic removal technologies should be developed and introduced.

Health

- Detection and reporting of arsenicosis cases should be implemented at the national level.
- Epidemiological survey in all districts of Punjab should be carried out as a priority to determine the prevalence of arsenic related skin lesions in population.
- Arsenicosis related study should be incorporated in the Medical Sciences Curriculum.
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