The structure and dynamics of groundwater systems in northwestern India

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India is the largest user of groundwater in the world (92% for agriculture)...



Wheat fields near Patiala, Punjab

...but at a cost

Total loss ~18-20 km³/yr in Punjab, Rajasthan, Haryana

Likely 'the largest rate of groundwater loss in any comparable-sized region on Earth' (*Tiwari et al. 2009*)





1. The first integrated, detailed picture of water-level decline across northwestern India (CGWB + state groundwater board data)



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 Integrated summary of aquifer characteristics across the study area (CGWB aquifer-thickness logs)

120

77°0'E

75°0'E

76°0'E





Aquifer system consists of large sedimentary fans

 \Rightarrow This shows that:

Aquifer bodies are long, narrow channel deposits

Aquifer bodies are not laterally extensive – can't be correlated

Typical dimensions 1-10 km across, 1-50 m thick





72'0'E 73'0'E 73'0'E 73'0'E 73'0'E 73'0'E 75'0'E 75'0'

N.0.18

N.0.62

- Existing CGWB data provide raw material for very good understanding of aquifer properties
- Should be applied throughout the Indo-Gangetic basin





www Basal channel scour surface

Multistory sand bodies (MSB)

3. Fine-scale characterisation of aquifer architecture based on drilling and coring







Lessons:

Δ

- Shallow groundwater shows recharge from both meteoric and canal sources
- Deeper groundwater recharged only from meteoric source
- Stable isotopes (when systematically analysed across region) provide strong fingerprinting of groundwater sources

-60

-70

-80

-90

Canal water samples River water samples Annual weighted avg. precipitation



5. First simple predictive model of aquifer-body occurrence



Lessons:

4.5

- Existing CGWB data plus simple geology-based rules provide an expectation of where to find aquifer material
- Model accuracy improves as more data are added easy to incorporate new wells
- No proprietary algorithms or 'black-box' approaches needed

x-coordinate (UTM)

0.0

7.D

4. First simple predictive model of aquifer-body occurrence

2.2

Training and knowledge transfer

Bilateral student exchange India-UK – 5 months

Indian postdoc to UK – 24 months

Staff visits (weeks-months)

Engagement with Dr Mihir Shah and Gol review of CWC and CGWB

Training workshop for CGWB scientists: 18-19 March 2016, Delhi

Recommendations

Use geomorphic framework to guide data integration and interpretation

Projects should encompass groundwater catchments across states

Use probabilistic approaches rather than deterministic aquifer maps (with high uncertainties)

Incorporate geomorphology, sedimentology, statistical analyses into aquifer mapping and characterisation

Need for holistic view of surface and groundwater together

