

Sustainable Groundwater Management Concepts & Tools

Case Profile Collection Number 12

Nepal: Approach to Mitigation of Groundwater Arsenic Contamination Including New Groundwater Legislation

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An action plan to address serious groundwater contamination by naturally-occurring arsenic in the Terai Plains of Nepal, within a wider approach to groundwater quality management including institutional reform and improved legal provisions, is summarized. The specialist professional services of GW•MATE were supplemented by a modest fund for the MOWR-DOI to implement a number of immediate activities – through the so-called ATFGL Project which commenced in 2002.

Role of Groundwater in Nepal

- Nepal has abundant renewable water resources. The annual rainfall varies from 500 mm/year in some western areas to more than 4,000 mm/a on the southern slopes of the Himalayan range, with 70-80% occurring in summer (monsoon) and generating runoff to more than 6,000 watercourses. Groundwater of good quality is available at shallow depth and maintains the base flow of most rivers and is used intensively in the absence of surface water. The most important groundwater basins are located in the Terai Plains and in some of the mid-hill valleys, such as Kathmandu and the Dang.
- Extensive groundwater development for irrigation in the Terai started in the 1960s further to USAID-supported groundwater investigations. Today about 200,000 ha are under groundwater irrigation by some 60,000 shallow tube wells and 1,000 deep tube wells, with a total groundwater abstraction of 700 m³/a. Concomitantly, shallow tube wells were constructed for domestic water supply, as an alternative to open dug wells, rivers and ponds. About 200,000 shallow hand pump tube wells now serve most of the 11 million population of the Terai.

Figure 1: Alluvial aquifer system of the Terai Plains with indication of highest-reported groundwater arsenic concentrations



Groundwater Management Issues

- Groundwater development was low-cost and initially hardly led to any conflicts. As a consequence, abstraction increased without any specific plan or resource management in place, and gradually led to stress on the resource. In the heavily-populated Kathmandu Valley (1.4 million population), over-pumping at certain locations has caused considerable decline of the water table – the Nepal Water Supply Corporation wells show a lowering of 15-20 m during 1985-95. In addition, there is a problem of groundwater pollution in shallow aquifers, due to wastewater infiltration. Similar problems are expected to develop elsewhere.
- A major groundwater quality issue relates to arsenic contamination in the Terai. This contamination is a natural phenomenon and its mitigation requires a broad approach. Other potential natural groundwater quality problems are associated with high concentrations of dissolved methane, manganese and iron. Diffuse groundwater pollution from agricultural pesticides and fertilizers may also become an issue in the Terai.
- The testing of arsenic in groundwater was initiated by the Department of Water Supply & Sewerage (DWSS) in 1999 with support of the World Health Organization (WHO), after questions were raised as to the similarity between hydrogeological conditions in the Terai and Bangladesh. Since then many efforts have been made by agencies involved in rural water supply to assess the occurrence of arsenic in groundwater, and a National Arsenic Steering Committee (NASC) was established in 2001 to oversee and coordinate the work.
- About 20,000 shallow wells equipped with hand pumps have been tested to date, out of a total of 200,000. Some 30% show concentrations above 10 ppb (the provisional WHO drinking-water guideline value) and 5% higher than 50 ppb (the Nepalese drinking-water standard). Higher values (over 100 ppb) have been found in 4 districts, of which Nawalparasi is the most affected. In the absence of a clear-cut institutional framework and of a groundwater quality database, it was difficult to determine the management interventions needed. However, it was clear that there is need for a groundwater management (rather than purely development-oriented) approach.

Institutional Arrangements for Groundwater

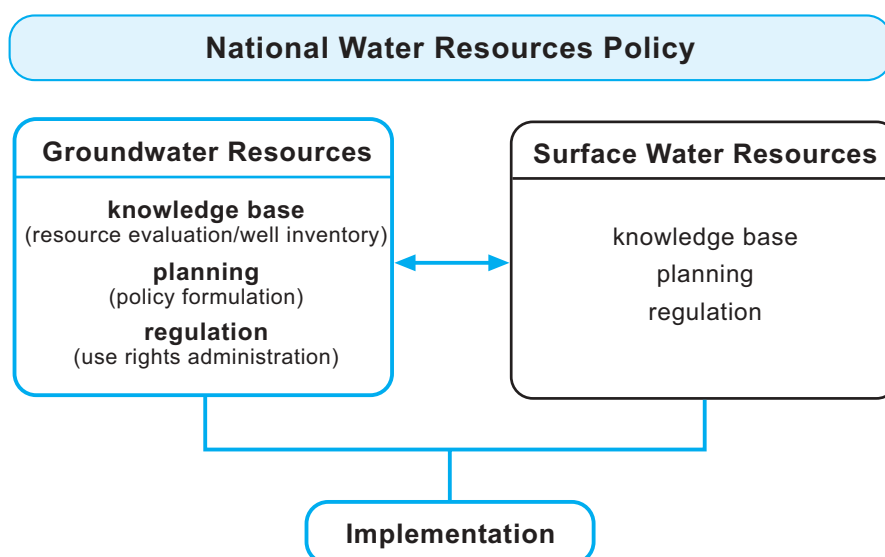
- A number of government agencies deal with groundwater (Table 1). None of these agencies is vested with authority to address the regulatory issues like resource inventory, planning and allocation. WECS performs water resources policy and planning functions, but only at a very general level and not including resource data basing, licensing or registration of water use nor water quality aspects. In reality there is no separation between regulatory and development functions, but the two types of function should preferably be kept separate since an institution cannot perform development activities and control such activities at the same time.

Table 1: Pre-existing institutional arrangements relating to groundwater in Nepal

GOVERNMENT AGENCY	GROUNDWATER RELATED TASKS
Ministry of Water Resources (MoWR) <ul style="list-style-type: none"> • Department of Irrigation • Groundwater Resources Development Board • Groundwater Resources Development Project 	development of groundwater for irrigation
Ministry of Physical Planning & Works (MoPPW) <ul style="list-style-type: none"> • Department of Water Supply & Sanitation (DWSS) 	drinking water supply (surface water and groundwater)
Ministry of Industry & Commerce (MoIC) <ul style="list-style-type: none"> • Department of Geology & Mines (DoGM) 	geological survey and databases
Ministry of Population & Environment (MoPE)	groundwater quality protection (incidentally)
Ministry of Science and Meteorology (MoST) <ul style="list-style-type: none"> • Department of Hydrology & Meteorology 	collection and storage of climate data
Water & Energy Commission Secretariat (WECS)	water resources policy and planning functions

- Government intends to modify this ‘development-only focus’ by setting the stage for a regulatory institution in charge of groundwater resources management (Figure 2), while resource development would remain in the hands of the existing institutions. A draft bill has been developed at the initiative of the GWRDB to amend the existing Water Resources Act (1963), with provisions for the establishment of an Underground Water Authority in charge of groundwater data collection/processing, use planning, regulation, monitoring and research. However, it failed to consider important issues, such as the need to regulate certain groundwater uses, to register water wells in critical areas, and the need to license drilling companies to ensure that water wells are drilled adequately and that information on them is recorded. The WECS is now in the process of further amending the Water Resources Act and refinement of the provisions for groundwater will have to fit into this process.

Figure 2: General scheme of water resource regulatory functions



Addressing Groundwater Arsenic Problems

- The main objectives of the AFTGL Project, which focused its attention on a pilot investigation area in Nawalparasi District, are:
 - **on the technical side:** standardizing and strengthening groundwater quality sampling and analytical procedures (with emphasis on arsenic), and hydrogeological and hydrochemical studies related to the origin, release and migration of arsenic.
 - **on the institutional and legal side:** consolidating the existing groundwater agencies under a national regulatory body, finalizing draft legal provisions on groundwater, incorporating them into the Water Resources Act and preparing groundwater regulations.

Technical Component

- A main point of concern was the standardization of testing procedures and quality assurance, both for field kits and laboratory analyses, since an inter-laboratory analytical check had revealed large differences in results among the three (accredited) private laboratories. This was confirmed by inter-laboratory work associated with GW•MATE field work (Table 2).

Table 2: Inter-laboratory comparison of groundwater arsenic analyses (in ppb)

SAMPLE No.	WELL TYPE	FIELD KIT	NEPAL					NETHERLANDS	
			LAB A	LAB B	LAB C	LAB D	LAB E	LAB X	LAB Y
1	STW –HP	10-30	5	5	<10	<20	<10	10	9
2	STW –HP	300-500	104	11	101	20	115	120	120
3	STW –HP	50-70	46	50	63	20	60	66	61
4	DTW –MP	<10	<5	<5	<10	<20	<10	<2	<2
Analytical method		HACH	SDDC	AAS	SDDC	SDDC	SDDC	AAS	AAS

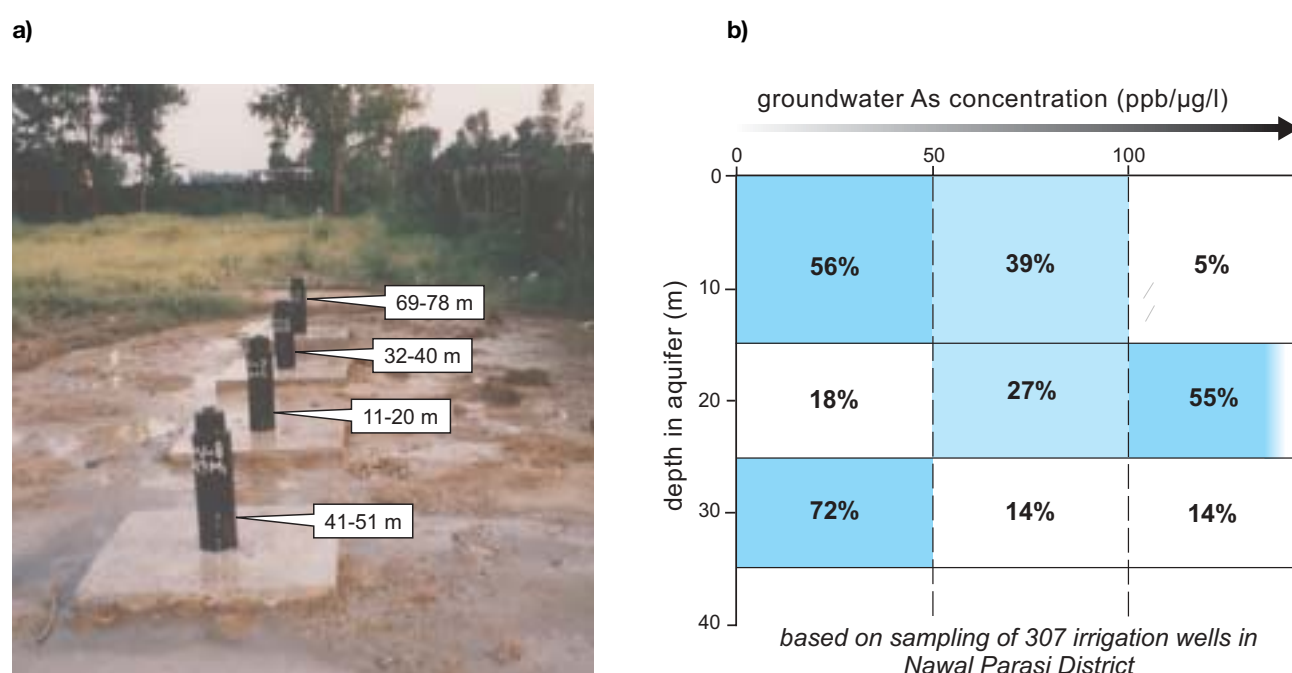
- A sub-committee was established in 2002 to prepare a protocol on sampling procedures, the use of field test kits, standard laboratory analytical methods and quality control. The sub-committee held a workshop with all stakeholders in 2003 and agreed the draft of a 'National Protocol for Arsenic Testing in Water', which is already being put to use and is in the process of being formally approved.
- Most of the 17,000 wells in the Terai previously tested were shallow wells with hand pumps used for drinking purposes. The testing of deeper irrigation tube wells had less priority from a public health standpoint, but it was considered important to include some in the national survey for the following reasons:
 - to provide information on the occurrence of arsenic at greater depths (below 40 m)
 - deep irrigation tube wells are a potential source of drinking water, if arsenic free.

The program showed that groundwater from almost all of the 522 deep irrigation wells tested currently has arsenic concentrations of less than 50 ppb and only 2% exceeded 10 ppb.

- The distribution and extent of groundwater arsenic contamination which was revealed raised a number of questions that need to be answered in order to devise effective prevention and mitigation measures:
 - Why do levels vary widely between wells which are located in close proximity?
 - What is the scale of any seasonal trends in arsenic levels?
 - At what depth can we expect to find arsenic-free water?
 - What changes in levels are likely to occur over time?
 - To what extent is elevated groundwater arsenic the result of perturbation of the natural situation caused by the drilling and pumping of water wells?
 - What indicators could be used to detect arsenic-affected areas?
 - Is there a chance that deeper aquifers could become contaminated in the future?

- An investigation program was initiated to answer these questions and to provide a basis for defining further research needs. The scope of work had to be limited in order to fit the modest budget available, but included the drilling and testing of monitoring wells (2 sets of 4 wells to different depths / Figure 3a), the collection of hydrogeological data and the systematic analysis of arsenic and other parameters (both field measurements and laboratory analyses) at 100 sampling stations (rivers, springs, dug wells and wells equipped with hand pumps) in the Parasi Bazaar area (4 km²). One handpump was tested hourly over 1 day.

Figure 3: Evaluation of variations of groundwater arsenic concentration with depth in aquifer: (a) purpose-drilled monitoring well array and (b) sampling of irrigation wells with differing screen depth



- The work was completed in October 2003, with the support of the US Geological Survey, which was carrying out complementary research in the same area. The hydrochemical survey, together with the testing of deep irrigation tube wells (Figure 3b), showed that groundwater arsenic concentrations generally decrease with depth. Further, it has provided improved understanding of the irregular spatial distribution of arsenic in shallow groundwater and clear directions for the required follow-up activities.

Institutional & Legal Component

- Considering the present institutional arrangements and progress with on-going reform, a number of possible scenarios for groundwater management were examined:
 - continue 'business as usual', leaving the situation to evolve without intervention
 - data-related functions being transferred from the GWRDB to a new department of the MWR vested with groundwater regulatory functions

- the GWRDB becomes the ‘Groundwater Authority’ carrying out regulatory functions
 - data-related functions are transferred to the Ministry of Science & Technology (MoST)-Department of Hydrology & Meteorology (DoHM) (currently in charge of surface water data), and they also become the ‘Water Resource Authority’
 - data-related functions of the GWRDB and of DoHM are transferred to a new MoWR ‘Water Resources Management Department’
 - a ‘Water Resources Authority’ is established under the Prime Minister to perform regulatory functions in respect of groundwater, surface water and water quality.
- There is general agreement on the need for separation of the regulatory and development functions. However, the limited available professional capacity in Nepal suggests that the initial institutional set-up for groundwater management should be built on what is now available, introducing change gradually. Discussions on possible long-term solutions will be carried on amongst all stakeholders as part of the reform process led by the WECS and the scenarios highlighted above will form a useful background in this process.
 - As an immediate step, the GWRDB could be divested of its ‘irrigation development function’ and become the regulatory agency for groundwater – this only requires amendments to the Groundwater Resources Development Committee Order (1975) to change the composition, function, mode of operation and name of this institution. This interim arrangement could facilitate the initial need for work to obtain a better knowledge of groundwater resources, quality and uses within selected (critical) areas – such as the Kathmandu Valley and the Terai Plains. Such work could be carried out under the original Water Resources Act and once the new Water Resources Act is in place it will be possible to transfer the fully-fledged regulation of groundwater use and development. In the specific case of arsenic contamination, the transformed GWRDB should be vested with the overall supervision of investigation, monitoring and mitigation.
 - The groundwater legislation work also involved two drafting processes:
 - legal provisions on groundwater for the amended Water Resources Act, covering data collection, water-well inventory, groundwater use registration, duty to supply data and information, water resources planning, licensing of water-well drillers and groundwater pollution control – a gradual approach was proposed, based on the declaration of critical areas where priority measures should be introduced and only certain groundwater uses should be licensed
 - groundwater-specific regulations to implement the provisions of the amended Water Resources Act – a detailed outline of these regulations was prepared under the project, and a national legal consultant was recruited in order to develop a first draft of the groundwater regulations.

Overall the approach was one of close cooperation with GWRDB, DOI and the WECS.

Way Forward

- The Nepal case provides a practical example of the integrated approach to the solution of groundwater management issues. The intervention on arsenic contamination falls within a broader groundwater management framework. It is linked to the need for improved institutional arrangements supported by companion legal provisions. The legal drafting goes hand-in-hand with technical studies aimed at providing the minimum knowledge base required for sound groundwater management.

- The project results were discussed in a national seminar on 28 November 2003, organized by DOI and the GWRDP, in the context of the WECS-led process. The aim of the seminar was to disseminate the results, stimulate participant feedback and to identify further action in support of sound groundwater management. The main conclusions of the seminar were:
 - measures to change the institutional set-up for groundwater may be taken immediately and as a first step the Groundwater Resources Development Committee Order (1975) should be amended with regard to the composition, functions, mode of operation and name of the GWRDB
 - the modified institution should be vested with functions it can perform under the present Water Resources Act and other legislation, while in the longer term an autonomous body responsible for groundwater management should be designated
 - further investigations are needed in order to determine the relationship between the occurrence of arsenic and different geomorphological, geological and hydrochemical patterns, the manner in which arsenic is released into groundwater and its migration with (vertical and horizontal) groundwater flow
 - in parallel with these investigations, a detailed analysis should be conducted of the management measures which it might be necessary to implement, based on interim investigation results and companion legal and institutional requirements.

Publication Arrangements

The GW•MATE Case Profile Collection is published by the World Bank, Washington D.C., USA. It is also available in electronic form on the World Bank water resources website (www.worldbank.org/gwmate) and the Global Water Partnership website (www.gwpforum.org).

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