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「アジア地域における経済発展による環境負荷評価及びその低減を実現する政策研究」

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Analysis and Mapping of Arsenic in Ground Water of Terai region in Nepal

Krishna Pahari[1], Prashanta Malla[2]

(Nepal Development Research Institute[1],

Genesis Consultancy Pvt. Ltd.[2]

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Krishna Pahari[1], Prashanta Malla[2]
(Nepal Development Research Institute[1],
Genesis Consultancy Pvt. Ltd.[2]
Kathmandu, Nepal)

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Abstract

Even though Nepal is predominantly a mountainous country, the southern part of the country consists of flat alluvial plains called Terai. Many people in this region depend on ground water extracted through tube wells, which contains significant amount of arsenic. Using the data from blanket testing of tube wells, a database of arsenic information has been developed and the information has been mapped for the eight affected Terai districts. This information, together with the analysis of arsenic information contributes towards the preparation of the report on the State of Arsenic in Nepal.

Ⅰ. Introduction and the Study Area

Nepal is predominantly a mountainous country with more than 80% of the total area covered by hills and mountains. However, the southern belt of Nepal consists of flat alluvial plains called the Terai region, inhabited by almost half of the total population of the country. Arsenic contamination of natural waters has become an issue of growing concern around the world during the past decade, to the extent that the World Health Organization (WHO) declared in 2001 that groundwater contamination on the Bengal delta is potentially largest environmental catastrophe in modern history. Because much of southern Nepal lies within the same Ganges drainage basin as West Bengal and western Bangladesh, it is important to examine the existence and extent of arsenic contamination in the ground water in Nepal. The problem of arsenic contamination of groundwater in Nepal is confined to the Terai region, covering about 20 districts out of a total of 75 in the whole country. In the Terai subsurface, a multiple aquifer system consists of both unconfined and semi-confined shallow aquifers and confined deep aquifers. The upper 50-60 m of sediment provide good productive shallow zones, and most groundwater production occurs in the upper 250 m. The arsenic distribution from the eight districts indicates that highly contaminated areas are few and sporadic. Usually high arsenic concentration is found in the central and the southern parts of the districts as compared to the northern part.

The first study on arsenic was carried out in Nepal by the Department of Water Supply and Sewerage (DWSS) and the WHO in late 1999. The initial 268 analyzed samples revealed the potential presence of arsenic in ground water in Jhapa, Morang and Sunsari Districts (Sharma, 1999). In 2001, the Nepal Arsenic Steering Committee (NASC) was set up by the government to address the arsenic issue in the country. The NASC includes major stakeholders from

government and non-government sectors working in water and sanitation. National Interim Policy on Arsenic was the first document prepared by NASC to guide stakeholders to work on this issue (NASC 2001). Since then there have been a number of initiatives in studying, awareness building and implementing various steps to address this issues. These include The State of Arsenic in Nepal – 2003 (ENPHO 2004). The current study is to contribute to the new report on the state of arsenic in Nepal including the latest information.

Ⅱ. Data and Methodology

1. The data on tube wells

Following up on the recommendations of a study report (DWSS 2002), the DWSS, with assistance from UNICEF, has completed the massive tests (blanket test) of all the wells in the ten Terai districts. Out of these, data from eight districts are processed and analyzed in this stdy. The blanket test data was provided by the DWSS in the EXCEL format for total of 345,175 records in eight districts out of which 26,398 records had blank arsenic concentration and coordinates. Thus data from a total of 318,777 tube wells was used from the blanket test and additional data of 11,308 tests from the 2003 report was added to it for the eight districts giving a total of 330,085 data for the eight districts. Table 1 shows the summary of data for different districts and Map 1 shows the eight Terai districts in Nepal for which data from blanket test have been analyzed and mapped.

2. GIS based mapping of arsenic information

Since the data from the blanket test included the coordinates of the test wells using Global Positioning System (GPS), it was possible to map the location of wells and to examine the spatial distribution of the arsenic concentration in wells.

The spatial data layers, which include rivers, roads and the VDC boundaries, were provided by the UNICEF. These are based on the 1:25,000 scale topographical maps prepared by the Department of Survey. In order to have a correct overlay between the different sources of data, spatial data layers acquired from the UNICEF were also converted to the coordinate system adopted by the department of survey.

Table 1 Summary of Tube Well data

District	Records from Blanket Test	Records From 2003	Total Records
Kanchanpur	37,697	177	37,874
Kapilbastu	37,209	2,490	39,699
Nawalparasi	28,465	3,211	31,676
Parsa	17,708	2,247	19,955
Rautahat	46,687	2,053	48,740
Saptari	55,502	570	56,072
Sarlahi	50,140	326	50,466
Siraha	45,369	234	45,603
Total	**318,777**	**11,308**	**330,085**

3. Arsenic Information Management System

A standard database system was designed and developed in Microsoft Access on the basis of attributes identified in creating district level data sets with similar fields as in the "State of Arsenic Report 2003". Some additional fields were also provided to identify the missing information and application of database for the future.

Integrated data sets created through the data integration of the VDC level data from the blanket test data were converted into a newly developed system in order to create an integrated national database of arsenic tested tube wells in Nepal. This database comprises of information of 330,085 wells of eight districts collected during 2004/5 and 2003 combined.

III. Results and Discussion

Through the spatial and analytical analysis of dataset, a number of findings and outputs have been made. The details of these will soon be made available in the new State of the Arsenic Report under preparation. Some key findings and outputs have been described below:

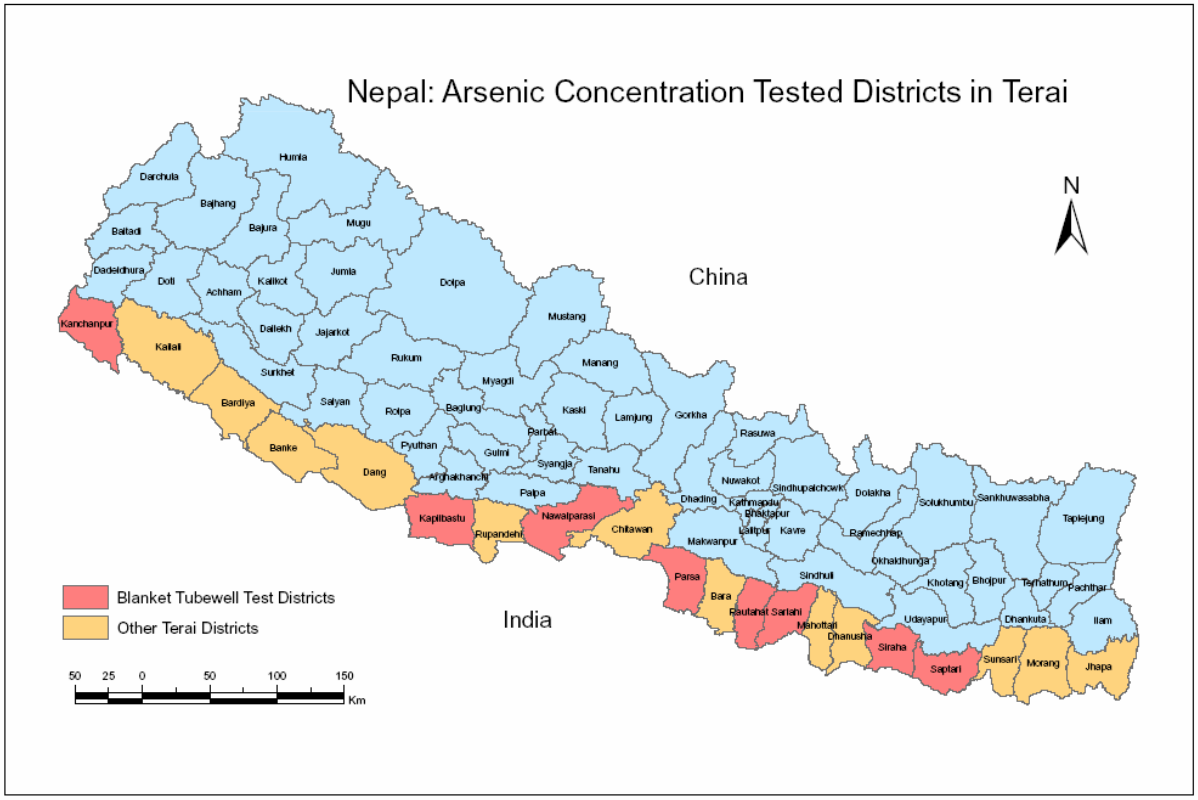

Figure 1: Arsenic Tested Districts in Terai, Nepal

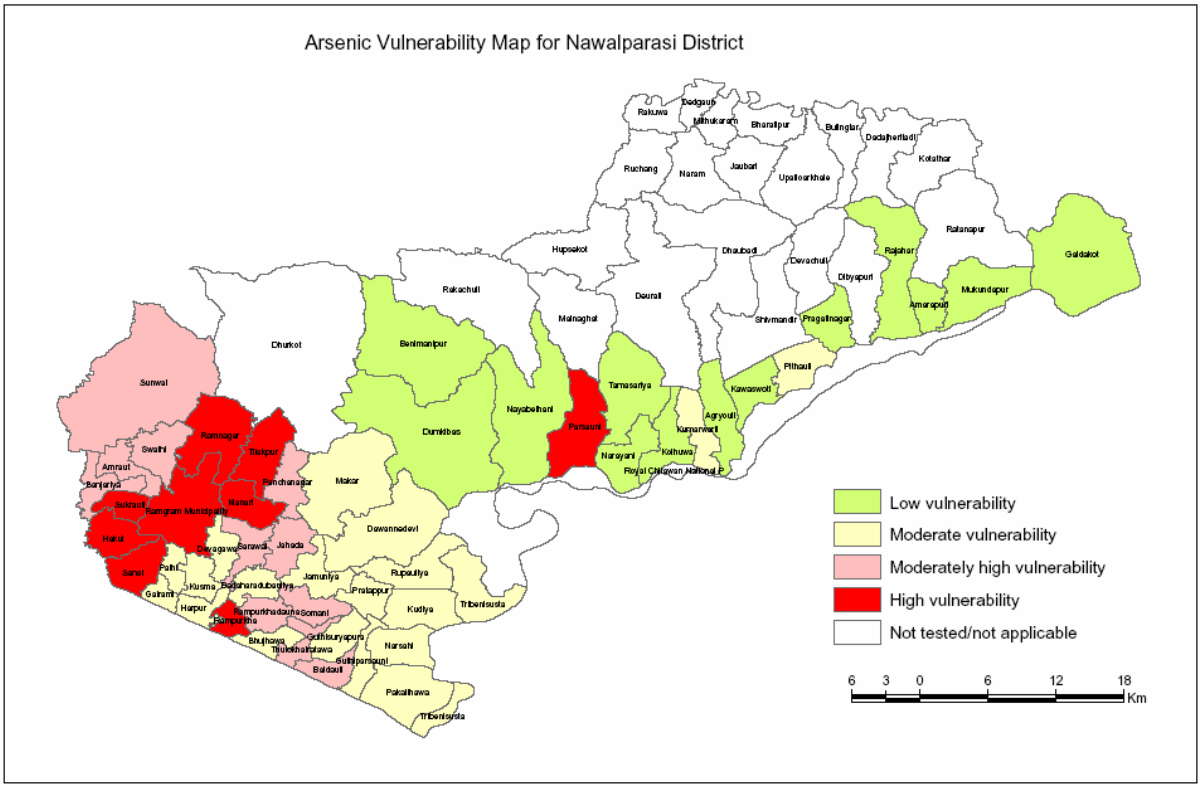

Figure 2: Arsenic vulnerability of VDCs in Nawalparasi

1. Tube wells by Arsenic concentration in districts

The situation of arsenic concentration in different districts has been shown in Table 2. It can be seen that Nawalparasi has the highest percentage of tube wells with very high concentrations of arsenic (>50 ppb). Besides, remaining districts also have significant arsenic concentration

Table 2: Arsenic concentration in tube wells by districts

District	Total no.	Arsenic concentration		
		0 – 10 ppb (%)	11 – 50 ppb (%)	> 50 ppb (%)
Kanchanpur	37,874	90.60	7.79	1.61
Kapilbastu	39,699	90.76	6.32	2.92
Nawalparasi	31,676	76.20	12.11	11.69
Parsa	19,955	90.59	6.78	2.63
Saptari	56,072	94.65	4.36	0.99
Sarlahi	50,466	85.02	13.78	1.21
Siraha	45,603	84.66	12.77	2.57
Rautahat	48,740	80.74	17.04	2.22
Total	**330,085**	**86.79**	**10.35**	**2.85**

2. Population and Households using Arsenic contaminated water

More than 99% of the tested tube wells also have information about the population and as shown in Table 3, the analysis showed that about 15% of the population has been using water from the tube wells exceeding arsenic concentration of 10 ppb. This proportion is highest in Nawalparasi with 31% of the population using water from tube wells exceeding this arsenic concentration level.

3. VDCs and communities Vulnerability to arsenic

Village Development Committees (VDCs) are the lowest administrative units in Nepal. An analysis was also made by the VDCs (or municipalities in towns), to see the communities vulnerable to arsenic contamination. Thus VDCs within the districts were classified as low, moderate, moderately high and high vulnerability to arsenic based on the percentage of tube wells exceeding WHO guidelines (Low for 0% of

tube wells exceeding WHO guidelines, moderate for 1-25 % exceeding WHO guidelines, moderately high for 26-50% and high for more than 50% exceeding the guidelines). Table 4 gives a summary of such vulnerability to arsenic by VDCs for the eight districts. It can be seen from the table that Nawalparasi, Sarlahi, Siraha and Rautahat have significant number of VDCs with high levels of vulnerability to arsenic. Map 2 shows arsenic vulnerability map for Nawalparasi, one of the eight tested districts.

Table 2: Population using Arsenic tested tube wells

District	Total Population	Population exposed to Arsenic concentration		
		0 – 10 ppb (%)	11 – 50 ppb (%)	> 50 ppb (%)
Kanchanpur	408,139	90.29	7.45	2.26
Kapilbastu	712,917	91.23	6.28	2.49
Nawalparasi	448,023	68.92	16.86	14.22
Parsa	663,273	91.81	6.30	1.89
Saptari	839,278	93.71	4.88	1.41
Sarlahi	840,738	83.13	15.49	1.38
Siraha	730,269	86.55	10.92	2.52
Rautahat	827,205	74.62	22.23	3.15
Total	5,469,842	85.40	11.47	3.13

Table 3: Arsenic vulnerability of VDCs by districts

District	Total VDCs	Tested VDCs	Vulnerability (no. of VDCs)			
			Low	Moderate	Moderately high	High
Kanchanpur	24	20	1	16	3	0
Kapilbastu	78	78	2	70	6	0
Nawalparasi	77	53	13	20	11	9
Parsa	90	83	5	69	5	4
Saptari	132	115	7	103	4	1
Sarlahi	100	95	15	54	15	11
Siraha	111	108	13	72	15	8
Rautahat	100	97	4	62	23	8
Total	712	649	60	466	82	41

4. Mapping arsenic database into Arsenic Information System

A new interface for data entry, validation and reporting was also created as part of this study. The system "Arsenic Information Management System" is a general purpose arsenic database management system which is able to create, edit and report the various statistical parameters in automated way. This system is expected to be self sufficient in maintaining, updating and generating reports on the arsenic issue in the district as well as national level.

Ⅴ. Conclusion

The arsenic information from the eight Terai districts have been documented, mapped and analyzed, and an Arsenic Information Management Systems has been developed. This is expected to be helpful in making appropriate, informed decision for assisting the affected communities. Further work is underway to bring out the latest report on State of Arsenic Report in Nepal.

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