

January

2008

Final Report

A HEALTH IMPACT SURVEY IN ARSENIC
AFFECTED AREAS IN THREE VDCs OF
KAILALI DISTRICT



Submitted to:



RVWRMP

Dhangadhi, Kailali

Submitted by:



Environment and Public Health
Organization

Naya Baneshwor, Kathmandu, Nepal

Tel: 01-4493188, 4468641, Fax: 01-4491376

January, 2008

Final Report

**A HEALTH IMPACT SURVEY IN ARSENIC
AFFECTED AREAS IN THREE VDCs OF
KAILALI DISTRICT**

Submitted to:



**Rural Village Water Resources Management Project
(RVWRMP)**

Dhangadhi-5, Taranagar, Kailali

Tel: 091-526262, 526263

Fax: 091-526261

Submitted by:



Environment and Public Health Organization

Naya Baneshwor, Kathmandu, Nepal

Tel: 01-4493188, 4468641, Fax: 01-4491376

www.enpho.org

Prepared by:

Mr. Makhan Maharjan

Working Team:

Mr. Bhushan Tuladhar

Dr. Manen Prasad Gorkhaly

Mr. Makhan Maharjan

Ms. Lerica Gorkhaly

Mr. Shashank Pandey

Mr. Manoj Kumar Chaudhari

Mr. Avimanyu Chaudhari

Ms. Lila Chaudhari

Ms. Kalpana Chaudhari

Dr. Narayan Pd. Upadhyaya

Ms. Rosha Raut

Ms. Nirita Giri

Mr. Manorath Bajagain

Mr. Bishnu P. Koirala

Mr. Bhaj Ram Maharjan

Abbreviations

ABF	Arsenic Bio-sand Filter
DACC	District Arsenic Coordination Committee
DDC	District Development Committee
DWSS	Department of Water Supply and Sewerage
ENPHO	Environment and Public Health Organization
AAS-HG	Hydride Generation- Atomic Absorption Spectrometer
NASC	National Arsenic Steering Committee
NDWQS	National Drinking Water Quality Standard-2062
NGO	Non-governmental Organization
NRCS	Nepal Red Cross Society
RVWRMP	Rural Village Water Resources Management Project
RWSSSP	Rural Water Supply and Sanitation Support Programme
SEARO	South-East Asian Regional Office
UNICEF	United Nations Children's Fund
VDC	Village Development Committee
WHO	World Health Organization
GV	Guideline value
SD	Standard deviation
HAs	Hair arsenic concentration
Has_M	Male hair arsenic concentration
Has_F	Female hair arsenic concentration
NAs	Nail arsenic concentration
NAs_M	Male nail arsenic concentration
NAs_F	Female nail arsenic concentration
TWAs	Tube well water arsenic concentration
UAs	Urine arsenic concentration
mg/L	milligram per litre
mg/Kg	milligram per kilogram
µg/L	microgram per litre
µg/Kg	microgram per kilogram
ppb	parts per billion

Acknowledgements

ENPHO would like to thank Rural Village Water Resources Management Project (RVWRMP) for providing an opportunity for undertaking this health impact survey. We wish to thank Mr. Kari Leminen (Team Leader, RVWRMP, Dhangadhi, Kailali), Mr. Albert Grela (Human Resources Department, RVWRMP, Dhangadhi, Kailali) and Ms. Kalawati Pokharel (Health and Sanitation Specialist, RVWRMP) for their cooperation. We would also thank Mr. Resham Phuldel (MIS & GIS Expert, RVWRMP, Dhangadhi, Kailali) for VDC maps of the study area.

We are thankful to all people in Chaumala, Kota Tulsipur and Lalbojhi VDCs for their cooperation in successful accomplishment of this survey.

TABLE OF CONTENTS

ABBREVIATIONS	i
ACKNOWLEDGEMENTS	ii
TABLE OF CONTENTS	iii
EXECUTIVE SUMMARY	v
1 INTRODUCTION.....	1
1.1 Background.....	1
1.2 Objectives of the Study	1
1.2.1 General Objective	1
1.2.2 Specific objectives	1
1.3 Rationale of the survey	1
1.4 Brief introduction of the Rural Village Water Resources Management Project (RVWRMP)	2
1.4.1 Arsenic Mitigation Programme of RVWRMP	3
1.5 Arsenic and its health effects	4
1.6 History of arsenic study in Nepal	5
1.7 Types of specimen for arsenic exposure indicator	6
1.8 Limitations of the survey	7
2 METHODOLOGY.....	7
2.1 Survey area.....	7
2.1.1 Kailali District	7
2.2 Study population.....	11
2.3 Study design	11
2.4 Survey tools	12
2.5 Inclusion and Exclusion Criteria.....	13
2.5.1 Inclusion criteria	13
2.5.2 Exclusion criteria	13
2.6 Ethical considerations	13
2.7 Data Collection	13
2.7.1 Acquisition of arsenic-related documents/reports and IEC materials.....	13
2.7.2 Project Staff Orientation and Training	14
2.7.3 Interview	14
2.7.4 Physical examination for skin manifestations of chronic arsenic ingestion	15
2.7.5 Collection, storage and transportation of samples	18
2.7.5.1 Sample collection and preservation.....	18
2.7.5.1.1 Tubewell water	18
2.7.5.1.2 Urine.....	18
2.7.5.1.3 Hair and Nails	19
2.7.6 Arsenic measurement	19
2.7.6.1 Water	19
2.7.6.2 Biological samples (urine, hair and nail).....	20
2.7.7 Water intake measurement and estimation of daily arsenic intake.....	20
2.7.8 Data processing and analysis	20
2.7.9 Validity and Reliability	20
3 RESULTS AND DISCUSSIONS.....	22

3.1	Respondents and characteristics	22
3.2	Drinking water sources and usage	23
3.3	People's knowledge on 'arsenic' and 'water testing conducted'	24
3.4	Tubewell water arsenic contamination	26
3.5	Correlation between 'Field Kit' and 'HG-AAS' arsenic concentrations	26
3.6	Urine arsenic concentrations	27
3.7	Correlation between tubewell water and urine arsenic concentrations	28
3.8	Hair and nail arsenic concentrations	29
3.9	Physical examination and skin manifestations	30
3.9.1	Tubewell water arsenic concentrations, prevalence of arsenicosis cases and manifestation types	32
3.9.1.1	Tubewell water arsenic concentrations and prevalence of arsenicosis cases	32
3.9.1.2	Skin manifestation types	32
3.9.2	Daily water consumption	34
3.9.3	Re-examination and verification of the arsenicosis cases	34
3.9.4	Arsenic safe options (mitigation measures)	36
3.10	Information, Education and Communication (IEC) Materials on Arsenic	38
3.10.1	Proposal on IEC Materials	39
4	COONCLUSIONS AND RECOMMENDATIONS	39
5	REFERENCES	40

Maps

Arsenic concentration Map of Chaumala VDC	8
Arsenic concentration Map of Kota Tulsipur VDC	9
Arsenic concentration Map of Lalbojhi VDC	10

ANNEXES

Annex-1	Survey Tools
Annex-2	List of Arsenic-Related IEC materials
Annex-3	Data set for Surveyed Households
Annex-4	Data set for tested Water Samples
Annex-5	Data set for Urine Samples
Annex-6	Data set for Hair and Nail Samples
Annex-7	List of Arsenicosis Patients
Annex-8	Photographs (Arsenicosis cases)

EXECUTIVE SUMMARY

Though several thousand tubewell water samples from arsenic contaminated Terai (Nepal) have been analyzed to determine arsenic contamination levels, scarce data are available on the health effects of chronic arsenic poisoning. This study was, thus, undertaken from July-December 2007 aiming to identify arsenicosis cases, know the extent of manifestations and status of arsenic exposure among risk population in three arsenic affected VDCs; namely Chaumala, Lalbojhi and Kota Tulsipur in Kailali district selected by DACC based on blanket arsenic testing analysis report for RVWRMP, Dhangadhi, Kailali. In present survey, households with tubewell water arsenic concentration above the national standard of 50 ppb were only included.

Shallow tube wells were the major water sources used by the people for drinking and other domestic purposes. Measurement of arsenic concentrations in 50 tubewell water, 150 spot urine (male-76 and female-74), 26 hair (male-13 and female-13) and 26 nail (male-13 and female-13) samples were done at laboratory by HG-AAS. Identification of arsenicosis cases was done according to "*A Field Guide for Detection, Management and Surveillance of Arsenicosis Cases*", WHO Technical Publication No. 30, SEARO, New Delhi, 2005. Data were collected by administering pre-developed three different types of tools. Besides, daily water intake through drinking was measured. Prior to data collection, project staff orientation and two-days training was organized for field staff. All the arsenicosis cases (suspected case or probable case) identified by health workers were re-examined and verified by a Health Expert having experience on diagnosing arsenic-related health effects. In present survey, the geographical distribution, demographic characteristics and living styles of the people in three VDCs are almost similar. Hence, data are analyzed *en bloc*.

A total of 777 households were surveyed in three VDCs. The surveyed households in Chaumala, Kota Tulsipur and Lalbojhi were 306 (39.4%), 444 (57.1%) and 27 (3.5%), respectively. Of the total respondents, males were 53.0% and females were 47.0%. The minimum and maximum ages of male respondents were 9 years and 90 years, respectively with the mean of 35.9 ± 16.4 years and the minimum and maximum ages of female respondents were 5 years and 80 years, respectively with the mean of 30.4 ± 12.2 years. The overall mean age of the respondents was 33.4 ± 14.8 years with the minimum and maximum ages of 5 years and 90 years, respectively. Of the total surveyed households, 5.1% of households had migrated to the survey area from neighboring or other districts. People's livelihood primarily depends on agriculture.

Almost all the households (99.6%) surveyed were using shallow tubewells for water for all domestic purposes including drinking and cooking. Tubewells (94.8%) in the survey area were installed by the people themselves except a very few (5.2%), which were installed by governmental or non-governmental organizations. In present survey, people's knowledge on 'arsenic' and 'water testing carried out' was also gathered by asking if they *knew 'what is arsenic ?'* and *'if they were aware of their tubewell water testing'*. It was revealed that two-third of the respondents (66.7%) didn't know 'what is arsenic', however, almost all of them (98.5%) knew about water testing carried out. The source of information on arsenic to one-third of respondents (33.3%) was technicians working on arsenic removal filters, print and audio/visual media (such as newspapers, radio and TV), governmental organizations), arsenic testing group, neighbours and friends etc. Similarly, only less than one-third of the respondents (28.4%) were aware that arsenic in their drinking water was high, whereas about 5.0% respondents (4.9%) considered that arsenic level in their drinking water was low, and two-third of the respondents (66.7%) didn't know arsenic level in their tubewell water.

The surveyed households, in three VDCs, were exposed to water arsenic ranging from 53 ppb to ≥ 500 ppb, with mean value of 105.2 ± 70.6 ppb. Similarly, the minimum, maximum and mean tubewell depth were 14 ft, 258 ft and 48.9 ± 16.9 ft, and the minimum, maximum and mean tubewell age were 1 year, 27 year and 5.4 ± 4.8 year. A positive significant correlation ($r=0.652$, $p<0.001$) is existed between arsenic concentrations obtained from 'Field Kit' and HG-AAS testing, Tubewell water arsenic concentrations of 'Field Kit' and 'Lab' (HG-AAS), suggesting the reliability of the 'Field Kit' results.

Despite using the same tubewell water, the mean urinary arsenic level for male ($34.4 \mu\text{g/Kg}$) was low compared to that for female ($44.8 \mu\text{g/Kg}$), which might be due to the consumption of water from other sources by males. The urine arsenic levels for 14.5% male and 33.8% female exceeded the arsenic exposure indicator level of $50 \mu\text{g/Kg}$, suggesting current exposure to arsenic through drinking water or other sources. A weak significant positive correlation existed for male and female urine arsenic concentrations ($r=0.318$, $p<0.01$), and the mean urine arsenic concentrations between sexes was statistically significant ($p<0.05$). Tubewell water arsenic concentrations (TWAs) were significantly correlated with urine arsenic concentrations (UAs) for both sexes. The hair arsenic levels for 30.8% male and 23.1% female exceeded the arsenic exposure indicator level ($>1 \text{ mg/Kg}$ of hair). The hairnail arsenic levels for 23.1% male and 15.4% female exceeded the arsenic exposure indicator level ($>1.5 \text{ mg/Kg}$ of nail). Hair arsenic concentration was significantly

correlated with hair arsenic level for male but not for female, and nail and urine arsenic concentrations were correlated for both sexes.

Of the 5992 population (male 3049 and female 2943) in total, 3889 villagers (64.8%) comprising 1785 male (54.1%) and 2104 female (45.9%) participated in the physical examination for arsenic-related skin manifestations. By age groups, participants in 15-49 age group was the highest followed by 5-14 age group and <5 age group. Among examined population, 26 persons (17 male and 9 female) were found to suffer from chronic arsenic toxicity. The prevalence of arsenicosis cases for male was 0.9% and for female 0.4%, with the overall prevalence of 0.7%. The prevalence of arsenicosis was found higher for subjects in the higher age groups. By age group, the subjects in 50-64 age group and 65+ age group were found to be suffered from chronic arsenic toxicity in both sexes as compared to the lower age groups. There were 5 young male patients aged from 4 to 12 years, the youngest being a 4-year old boy. The prevalence of arsenicosis cases was found increased corresponding to the higher arsenic concentration groups of 51-100 ppb, 101-200 ppb and 201-500 ppb, suggesting the risk of exposure to elevated arsenic level. Skin manifestations observed were mostly keratotic lesions alone or in combination with pigmentation changes (96.2%) and pigmentation change alone or in combination with keratotic lesions was observed in 15.4% cases. Keratotic lesions alone were observed in 11.5% of the total arsenicosis cases, while it was 3.9% for pigmentation changes. Keratotic lesions observed were mostly in mild (early) stage, just in a visible or palpable stage. Since the arsenicosis cases observed either keratotic lesions or pigmentation changes were in early stage, they are expected to recover soon if further exposure is stopped by using arsenic free water. But if they continue the consumption of arsenic contaminated water, there is a possibility that the prevalence will increase with advancement of manifestations to moderate or severe stages.

Water consumption by only drinking in 24 hours during the survey period was collected from a total of 130 persons comprising both male and female aged ≥ 15 years. Males consumed mean of 2.46 litre and females 2.10 litre of water in 24 hours, which was statistically insignificant for sexes ($p > 0.05$). In overall, mean amount of water consumed was 2.26 ± 1.11 litre. It was revealed from the survey that people of all age groups in the survey area were mainly exposed to arsenic through drinking water. Arsenic intake from other sources, for example, arsenic in food and water added in preparing foods are additional risks.

Despite knowing high arsenic concentration, majority of the people were continuously using arsenic contaminated tubewells for domestic purposes due to the unavailability of alternate safe source(s) nearby or no arsenic safe option(s). Of the surveyed households,

34.6% households (269) possessed filter(s) - 261 concrete ABFs and rest simple filters. The use of arsenic free water for consumption is the most important for preventing or lessening of the toxic effects of arsenic. In Chaumala VDC, ABF (concrete) was found to be installed in many surveyed households, whereas arsenic mitigation programmes had not yet undertaken in Kota Tulsipur and Lalbojhi VDCs. Interestingly, some ABFs were found good with no cracks and leakages, while some were found with cracks and leakages. Technical components of ABF construction or workmanship should be assessed in depth for identifying and solving the observed problems of the filter.

Both print and audio/visual IEC materials related to arsenic have already been developed and produced by governmental and non-governmental organizations targeting mainly two different groups: General public (brochures, pamphlets, posters, calendars, stickers, TV Documentary, TV Commercial etc) *for mass awareness on arsenic issue and* Frontline workers such as trainers, community motivators etc (Training Manual, Flip Chart, Flex) for using in trainings and orientations. NASC with financial support from UNICEF has been recently reviewing the existing IEC materials and also developing a set of new materials (Print and Audio/Visual) on four different arsenic mitigation options (arsenic safe tubewell/improved dugwell, Kanchan Arsenic Filter and Rainwater Harvesting). In consideration to availability of various IEC materials, RVWRMP is proposed here either to acquire the available materials from the concerned agencies or reprint the required materials with permission from NASC.

The survey revealed arsenic exposure and existence of chronic arsenic poisoning resulted from the consumption of arsenic contaminated tubewell water in Kailali district. Based on the present findings, following recommendations are made.

- Mitigation measures should be taken at the earliest for providing arsenic free water to the arsenic exposed households to prevent from chronic arsenic poisoning or worsening of the situation. It is strongly recommended for providing arsenic free water at the earliest with priority to the households with young patients identified in this survey.
- Awareness building and motivational programmes should be organized in the arsenic affected areas so that people stop the use of arsenic contaminated water and accept and use the arsenic safe water options.
- Monitoring of the provided arsenic safe options should be done to check for technical defects or change in water quality and proper usage.

- For future convenience, installation and maintenance dates should be kept on each provided alternative options (ABF, dug well etc). This will help to know the period of switching to consumption of arsenic safe water, time for cleaning and compare the improvement in health conditions of the patients accordingly.
- Periodic monitoring of tubewells having arsenic concentration between 50-100 ppb should be done.
- Health professionals in the local health posts or hospitals or paramedical persons should be trained on diagnosing arsenic-related health implications and its management, which will greatly help in undertaking preventive measures.
- Since the present survey was limited to a small area in Kailali district, there is scope for conducting health impact studies in other arsenic contaminated areas.

1 INTRODUCTION

1.1 Background

High arsenic level in drinking water has become a public health concern in many Asian countries, including Nepal. Groundwater arsenic contamination and its health effects, in Nepal, is a new issue which was known only in late 1999. Arsenic contamination in groundwater, in Nepal, has become a public health concern, particularly in 20 Terai districts, where half of the total population of the country lives. Although arsenic content had been reported for hundreds of thousands of tubewells in Nepal, so far only a few published data is available which could sufficiently explore the magnitude of health effects due to chronic exposure to arsenic through tubewell water. Thus, it has been needed to conduct more health surveys in arsenic affected areas to reveal the prevailing situation of arsenicosis toxicity and the extent of manifestations, which will significantly contribute in future mitigation programmes, development of health policies and management strategies.

Hence, Rural Village Water Resources Management Project (RVWRMP), Dhangadhi, Kailali has assigned Environment and Public Health Organization (ENPHO) for undertaking this health impact survey in three high arsenic contaminated Village Development Committees (VDCs) in Kailali district.

1.2 Objectives of the Study

1.2.1 General Objective

To know arsenic-related skin manifestations and status of arsenic exposure among risk group in three VDCs of Kailali district.

1.2.2 Specific objectives

- ✧ Identify arsenicosis cases and know the extent of manifestations among the people exposed to high arsenic (above the national standard) in the study areas
- ✧ Know the arsenic exposure by analyzing biological samples from subjects
- ✧ Know the mitigation measures adopted
- ✧ Suggest recommendations for future action

1.3 Rationale of the survey

Though all the tubewells in Kailali district have been already tested for arsenic, data on health impact due to arsenic exposure through drinking water was not available. Thus, the findings of this study revealed the health impacts and extent of manifestations due to

chronic arsenic exposure in the study VDCs. Furthermore, this study highlighted the importance of mitigation measures for providing arsenic safe drinking water to the people living in arsenic affected area.

1.4 Brief introduction of the Rural Village Water Resources Management Project (RVWRMP)

Rural Village Water Resources Management Project (RVWRMP) started its activities in October 2006 and will continue till the end of August 2010. RVWRMP works in nine (9) hilly/mountainous districts of the Far- and Mid-Western Nepal and additionally with arsenic mitigation in Kailali District. Its main objective is to improve the quality of life of the local people, improve environmental conditions and increase opportunities to rural livelihoods, through rational, equitable and sustainable practices of water resources planning and use.

The project idea is develop the use of water resources on the basis of comprehensive Water Use Master Plans (WUMPs) to be prepared for 80 priority VDCs selected by DDCs. WUMPs will be prepared by the concerned VDCs and the communities themselves, facilitated by social Support Organizations and technical consultants. Community Organizations (CO), comprised of representatives of all the households in each settlement, will be the backbone of the inclusive approach of the Project; separate COs will be formed for women and men of the community and special attention will be paid on inclusion of women, Dalits and other vulnerable groups in the COs and at the VDC level in Water Resources Management Committees (WRMC). After preparation of WUMP, the people's participation in all project activities and the sustainability of the schemes will be implemented by User's Committees (UCs), with the help of local support organizations, and the COs will form a basis for people's participation in all project activities and the sustainability of the schemes. In this way the project aims at ensuring active and meaningful participation of women, Dalits and other deprived groups in all phases of the project, from planning to post-construction, and at creating ownership and sustainability at the local level.

Living standards of the excluded groups will be raised by improvements in agricultural production and creating other income generating activities. The project will take into consideration the new political situation of Nepal and the context in which the project is being implemented. It will support and respect inclusive, broad-based national priorities of the Interim Government and link the peace with the development process in order to prevent further conflicts. It will strive to ensure that it works in the interest of the

peace process, respects “Do No Harm” principles and complies with values and norms expressed in the Basic Operating Guidelines (BOGs). It will strive to ensure that poor and discriminated way and to promote inclusion and actual power sharing in community based organizations as well as in the non-governmental organizations (NGOs). This is in line with the policy of Finnish Government for Nepal.

Implementation procedures and guidelines will be established on the basis of experience from Rural Water Supply and Sanitation Support Programme (RWSSSP) in Lumbini Zone and other ongoing water sector projects with adequate modification as required to suit the current prevailing situations, government policies, rules, and regulations. The closest projects to cooperate and harmonize with are the Water Resources management Project of Helvetas (WARM-P), The Rural Energy Development Programme (REDP) of the World bank/UNDP and AEPC, and the Community Based Water Supply and Sanitation Sector Project (CBWSSSP) of the ADB and the DWSS. The guidelines may also be amended as deemed necessary following the changes occurred in future in Government policies, rules and regulations. A major addition to these guidelines is the development of a ‘Gender and Social inclusion Policy and Action Plan’.

1.4.1 Arsenic Mitigation Programme of RVWRMP

RVWRMP has been implementing arsenic mitigation activities with WARM-P of Helvetas Nepal in Kailali district with objectives to prevent people from arsenic exposure through drinking water, reduce health risk of affected population through safe water supply and awareness and develop entrepreneurship and capacity of local people and organization(s) at local level to promote arsenic bio-sand filter (ABFs).

For piloting three ‘hot spot’ VDCs, namely Chaumala, Kota-Tulsipur and Lalbojhi have been selected by the District Arsenic Coordination Committee (DACC) in the meeting held on 18 January 2007 in DDC office based on blanket testing analysis report. The WARMP has already initiated mitigation activities in Chaumala VDC (Ward No. 1) and RVWRMP has joined from Ward No. 7 of Choumala and will jointly continue to others. Pilot schemes in Arsenic Mitigation will focus on provision of arsenic safe water to affected households by distributing ABF (concrete type), mass awareness generation, capacity building by training to Mistries and Entrepreneurship, performance monitoring of ABF and further improvement of the technology, conduct health impact study and exploration of district basket funding concept with DDC and other district sector agencies.

1.5 Arsenic and its health effects

1.5.1 Arsenic and its source of contamination

Arsenic is a metalloid element present naturally in the earth's crust. It is the 51st most abundant element on earth, with an average level of 1.8 mg/kg in the earth's crust. Normal background concentrations are 0.2-15 mg/kg in the lithosphere, less than 15 mg/kg in soils, 0.02-2.8 ng/m³ in the atmosphere, and less than 1 µg/L in aquatic environment (WHO, 2001).

Arsenic is a transitional reactive element that forms chemical and organic complexes together with other metals, carbon and oxygen. Dominant natural arsenic bearing rocks, include realgar (AsS), orpiment (As₂S₃), arsenopyrite (FeAsS) etc. Due to several geo-physical events and natural chemical reactions, especially the oxidation and reduction processes, several arsenic compounds in soluble forms get released inside the earth crust and contaminate the ground water.

Anthropogenic sources of arsenic are numerous. They include the application of arsenical pesticides on land, incineration of arsenic containing substances, industrial wastewater discharge, mine tailing/landfill leaching, and manufacturing and use of wood preservatives and pesticides and paint industries may elevate concentration of arsenic in water and soil.

1.5.2 Acceptable level of arsenic in drinking water

According to National Drinking Water Quality Standard-2062 (NDWQS), the maximum allowable limit of arsenic is 50 ppb, whereas the World Health Organization (WHO) has set the guideline value of arsenic content at 10 ppb for drinking water. Depending upon the physical, social, economic and cultural conditions, each country fixes its national standard. The maximum permissible level of arsenic in drinking water in severely arsenic affected neighbouring countries like India and Bangladesh is also set 50 ppb.

1.5.3 Health effects of arsenic

Arsenic contamination in groundwater and its health effects has been a public health concern in many Asian and Latin American countries, including Nepal. The main source of arsenic exposure is ingestion of drinking water with high levels of arsenic. Chronic exposure to arsenic is known to cause skin lesions characteristic to arsenic toxicity, cancers of the skin, kidney, lung and other organs, and adverse effects on almost all body systems. Several epidemiological studies on chronic arsenic exposure through contaminated water have reported various cancer and non-cancer health effects (NRC,

1999, 2001; WHO, 1981; IARC, 1987; Guha Mazumder et al., 1998; Guo et al. 2001; Tseng et al., 1968; Tseng et al., 2003).

Skin manifestations characterized by pigmentation change (melanosis or leucomelanosis) and keratosis have long been considered to be the hallmark signs of chronic arsenic toxicity. Several preceding studies in India and Bangladesh, and a few recent studies in Terai Nepal have reported skin lesions to be the most common health effects in populations exposed to arsenic through drinking water (Ahmad et al. 1997, 1999; DWSS/UNICEF, 2002; Shrestha et al., 2003; RWSSSP, 2002; RWSSSP, 2003b; RWSSSP, 2004; NRCS/ENPHO, 2003; Maharjan et al., 2005, 2006a, 2007).

1.6 History of arsenic study in Nepal

With the spread of news of massive arsenic-poisoning caused by consumption of arsenic contaminated tube well water in Bangladesh and West Bengal, India, the arsenic contamination was apprehended in Nepal particularly in Terai region having similar alluvial and fertile plain characteristics that encountered in Bangladesh and West Bengal. The first study on arsenic contamination was conducted in Eastern Terai region of Nepal by the Department of Water Supply and Sanitation (DWSS) in 1999, indicated the possibility for arsenic contamination in groundwater of Terai (DWSS/WHO, 1999). Furthermore, the findings of another preliminary study on arsenic contamination in tubewells water in eleven Terai districts conducted by Nepal Red Cross Society (NRCS) in 2000 revealed the need of a comprehensive study on arsenic contamination in tubewells water to find out the extent of arsenic distribution in southern Nepal (NRCS/ENPHO, 2000; NRCS/WETC, 2000). Later governmental and non-governmental organizations or agencies working in drinking water sector such as DWSS/UNICEF, Rural Water Supply and Sanitation Support Programme (RWSSSP), Nepal Water for Health (NEWAH), Rural Water Supply and Sanitation Fund Board (RWSSFDB) etc started testing arsenic content in tubewell water samples from Terai in their respective project areas (RWSSSP, 2003a; DOI/HMG, 2004; NASC/ENPHO/USGS, 2004; NASC/GENESIS, 2007).

According to the blanket arsenic testing result of 736,475 tubewells in 20 terai districts as of September 2007, 10.2% tubewells were found with arsenic concentration above 10 ppb of WHO GV and 2.3% exceeded the national standard of 50 ppb. The arsenic contamination of the tubewells in the districts varied from 0.0% to 12.3% in consideration to national standard. Out of 20 districts, the higher percentage of arsenic contaminated tubewells were found in Nawalparasi, Bara and Kailali districts sequentially

followed by Bardia, Kanchanpur and Kapilbastu districts and so on. In Kailali district, out of total 84,543 water samples tested, arsenic concentration in 11.9% samples exceeded the WHO GV and 3.4% samples exceeded the national standard (Table 1.1).

Table 1.1: Status of arsenic contamination in 20 Terai districts of Nepal (NASC, 2007)

S.No.	District	Samples tested	Samples with Arsenic			Max. conc ⁿ (ppb)	% of samples exceeding	
			0-10 ppb	11-50	>50 ppb		10 ppb	50 ppb
1	Jhapa	771	710	60	1	79	7.9	0.1
2	Morang	947	539	388	20	70	43.1	2.1
3	Sunsari	67,085	64,150	2,519	416	75	4.4	0.6
4	Saptari	57,094	53,873	2,630	591	98	5.6	1.0
5	Siraha	46,625	39,194	6,112	1,319	250	15.9	2.8
6	Dhanusha	60,783	58,026	2,305	452	140	4.5	0.7
7	Mahottari	1,325	1,200	112	13	80	9.4	1.0
8	Sarlahi	50,573	43,235	6,748	590	98	14.5	1.2
9	Rautahat	50,506	39,967	9,393	1,146	500	20.9	2.3
10	Bara	39,837	35,203	3,147	1,487	254	11.6	3.7
11	Parsa	28,424	26,071	1,595	758	456	8.3	2.7
12	Chitwan	411	410	1	0	8	0.2	0
13	Navalparasi	32,219	23,844	4,418	3,957	1,200	26.0	12.3
14	Rupandehi	75,396	72,316	2,567	513	2,620	4.1	0.7
15	Kapilbastu	39,915	36,060	2,662	1,193	589	9.7	3.0
16	Dang	743	710	30	3	81	4.4	0.4
17	Banke	45,191	43,083	1,840	268	270	4.7	0.6
18	Bardiya	848	673	149	26	181	20.6	3.1
19	Kailali	84,543	74,460	7,193	2,890	213	11.9	3.4
20	Kanchanpur	53,239	47,330	4,313	1,596	450	11.1	3.0
Total		736,475	661,054	58,182	17,239		10.2	2.3

1.7 Types of specimen for arsenic exposure indicator

According to the Arsenicosis Case Definition Algorithm of "A Field Guide for Detection, Management and Surveillance of Arsenicosis Cases", WHO Technical Publication No. 30, SEARO, New Delhi, 2005, a clinically confirmed case need to be also further confirmed by positive laboratory arsenic test. Laboratory support provides ancillary information in instances where probable cases cannot be clinically confirmed. In this consideration arsenic measurement was done in following three different specimens.

Water – Arsenic contaminated water used for drinking and cooking purposes is the major source of arsenic ingestion. Arsenic exposure can be established by testing the water that is currently being consumed.

Urine – Both organic and inorganic forms of arsenic are excreted in the urine which will test positive for arsenic. Thus, recent exposure to arsenic can be measured from urine samples provided the subjects have not been consuming sea-food in the preceding four days.

Hair and Nail – hair or nails provide circumstantial evidence for history of past exposure within the preceding nine months.

1.8 Limitations of the survey

This study was limited to three VDCs of Kailali district and the surveyed households include only the users of tubewells with high arsenic (above national standard; 50 ppb). Thus, the findings of this study neither represent Kailali district nor the entire study VDC. Also, present survey on arsenic-related health effects is limited to only dermatological symptoms. Since young people were usually not present in the house or village, biological samples were collected only from the adult individuals (≥ 15 years). With the change of water sources from arsenic contaminated to arsenic free (permissible level) by some of the households, in present study, arsenic dose could not be estimated from tubewell water arsenic level and water consumption amount.

2 METHODOLOGY

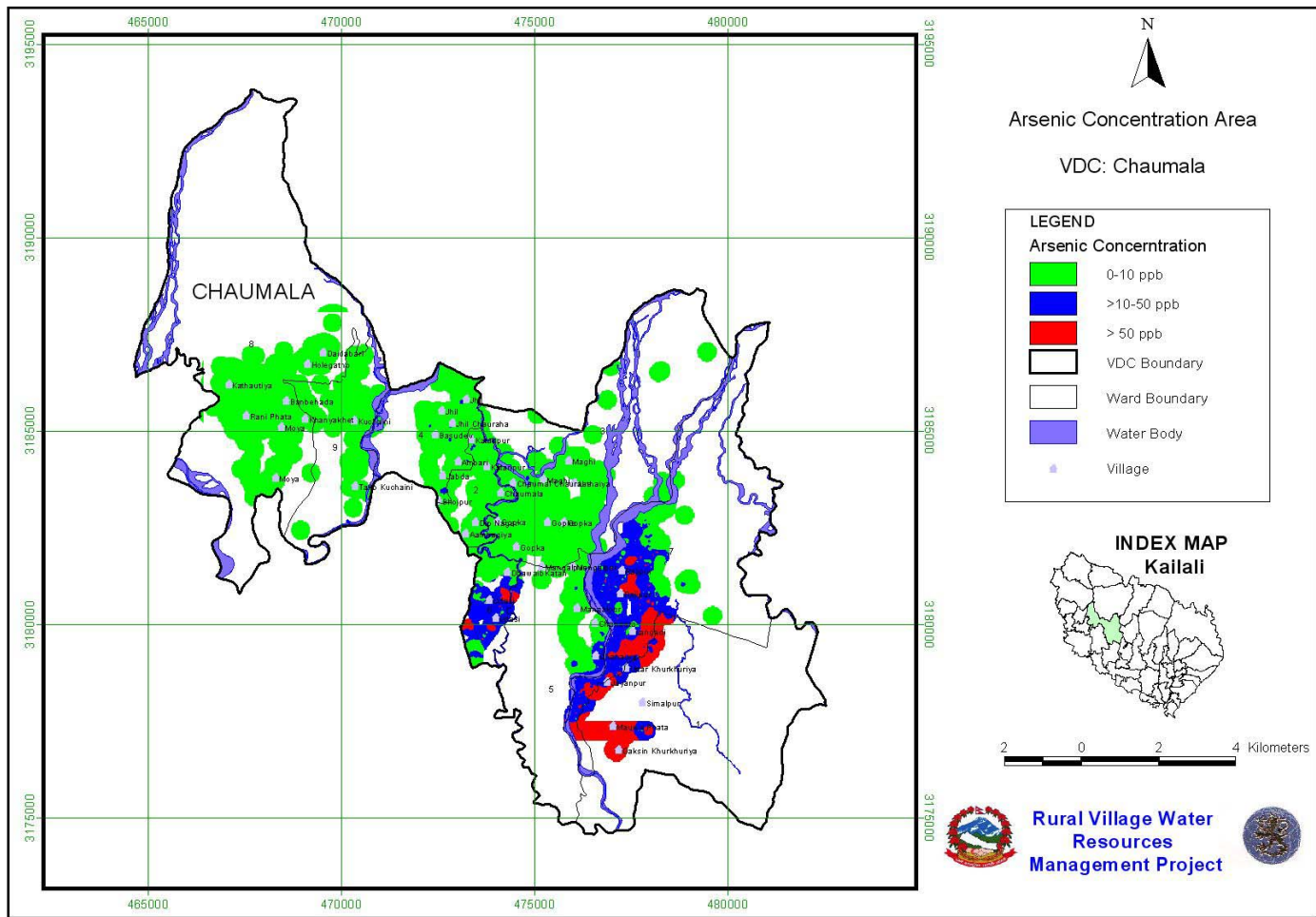
2.1 Survey area

This survey was conducted in three arsenic affected VDCs; namely Chaumala, Lalbojhi and Kotatulsipur in Kailali district selected by DACC based on blanket arsenic testing analysis report.

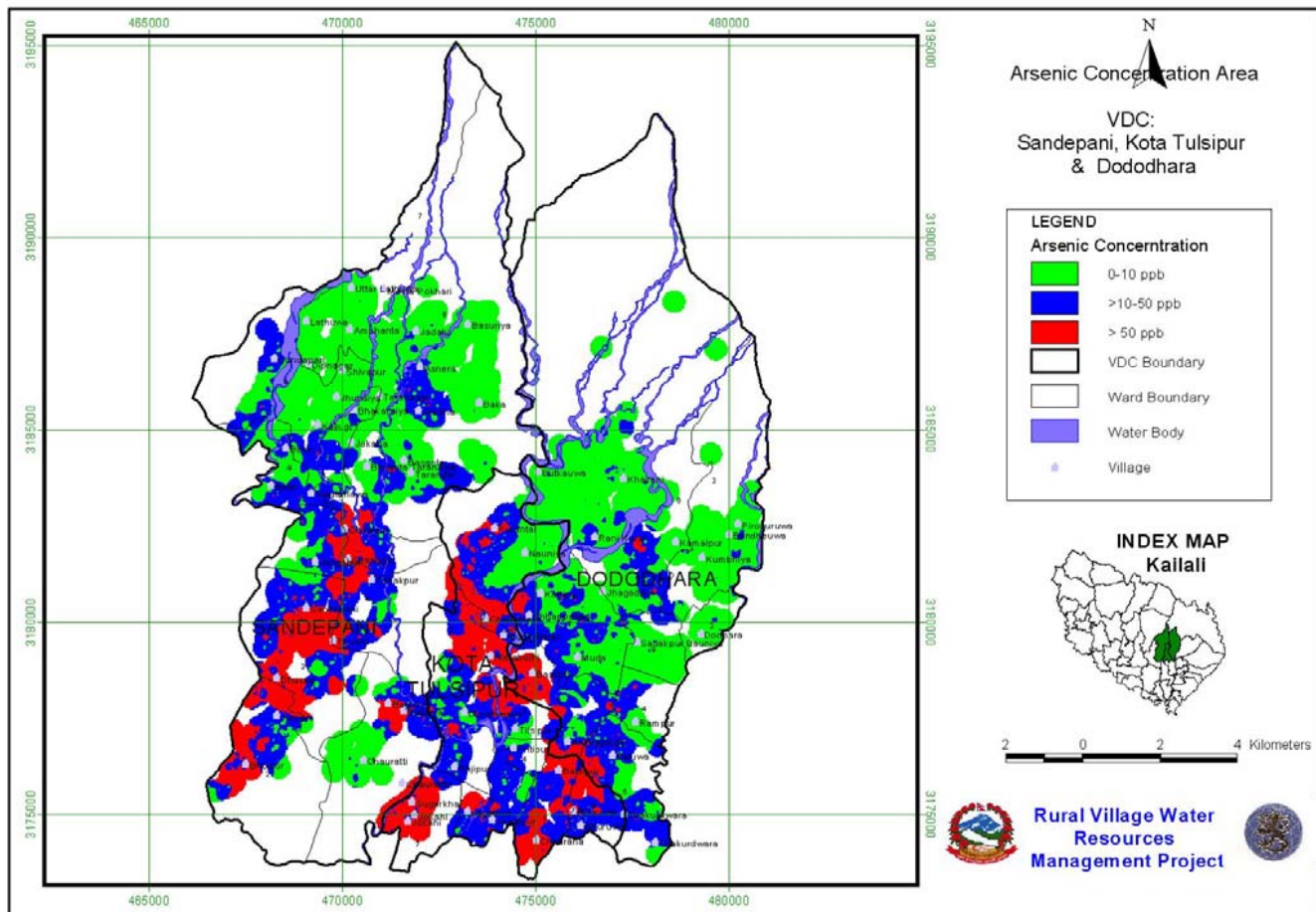
2.1.1 Kailali District

Kailali district lies in Seti Zone in Far-Western Region of Nepal. It lies at Latitude $28^{\circ}22' - 29^{\circ}0'$ and longitude $80^{\circ}15' - 81^{\circ}15'$. It covers an area of 3,235 square kilometers. It shares its borders with Bardia and Surkhet districts in the east, Surkhet and Doti districts in the north, Kanchanpur and Dadeldhura districts in the west and U.P (India) in the south. The district lies between 179 meters to 1957 meters above the sea level. Major rivers flowing in the district are Karnali, Mohana, Pothraiya, Karrha, Kanara etc (NRA, 1997).

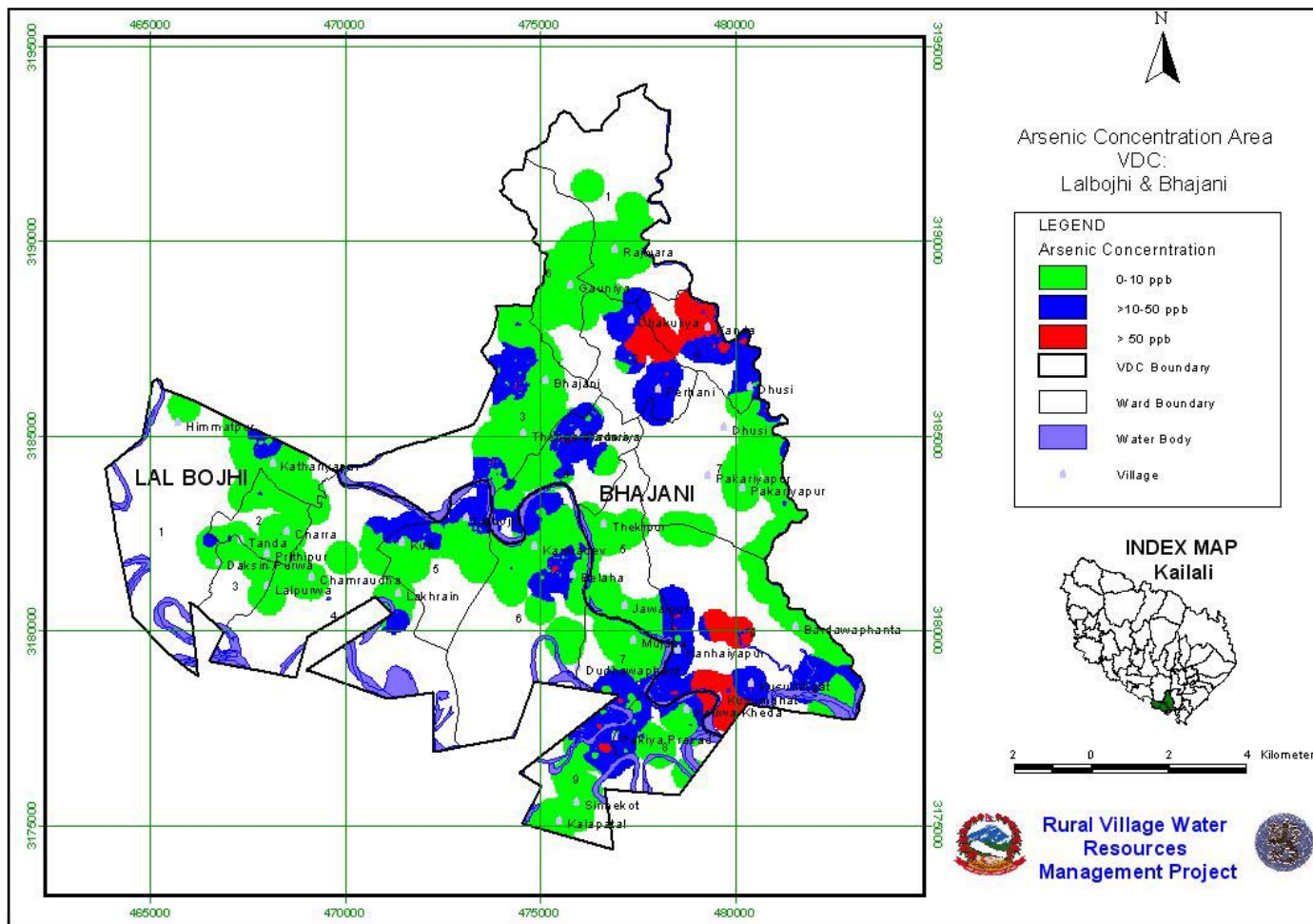
In Kailali district, there are 42 VDCs and 2 Municipality (Dhangadi and Tikapur) with Dhangadi as its district headquarters. According to 2001 census, the total population of the district is 616,697 with annual growth (1991-2001) of 3.93%. Majority of the people speak Tharu language (ISRSC, 2002).



Arsenic concentration Map of Chaumala VDC



Arsenic concentration Map of Kota Tulsipur VDC



Arsenic concentration Map of Lalbojhi VDC

2.2 Study population

For this study, a household is considered as a *sampling unit*. A household using water with arsenic concentration above 50 ppb is defined as a *risk household* and all family members of the households consuming high arsenic contaminated water is considered as the *risk population*.

According to the available arsenic testing result in Kailali district, there was a total of 5,992 risk population living in 777 risk households in three survey VDCs (Table 1.2).

VDC	Ward Numbers covered	Number of	
		Risk Households	Risk Population
Chaumala	1,4,6 and 7	306	2,274
Kota Tulsipur	1,2,3,4,5,6,7,8 and 9	444	3,529
Lalbojhi	1,4,5,6,7 and 9	27	189
Total		777	5,992

2.3 Study design

A cross-sectional survey was conducted in between July-December 2007. The schematic diagram of the study design is given on next page.

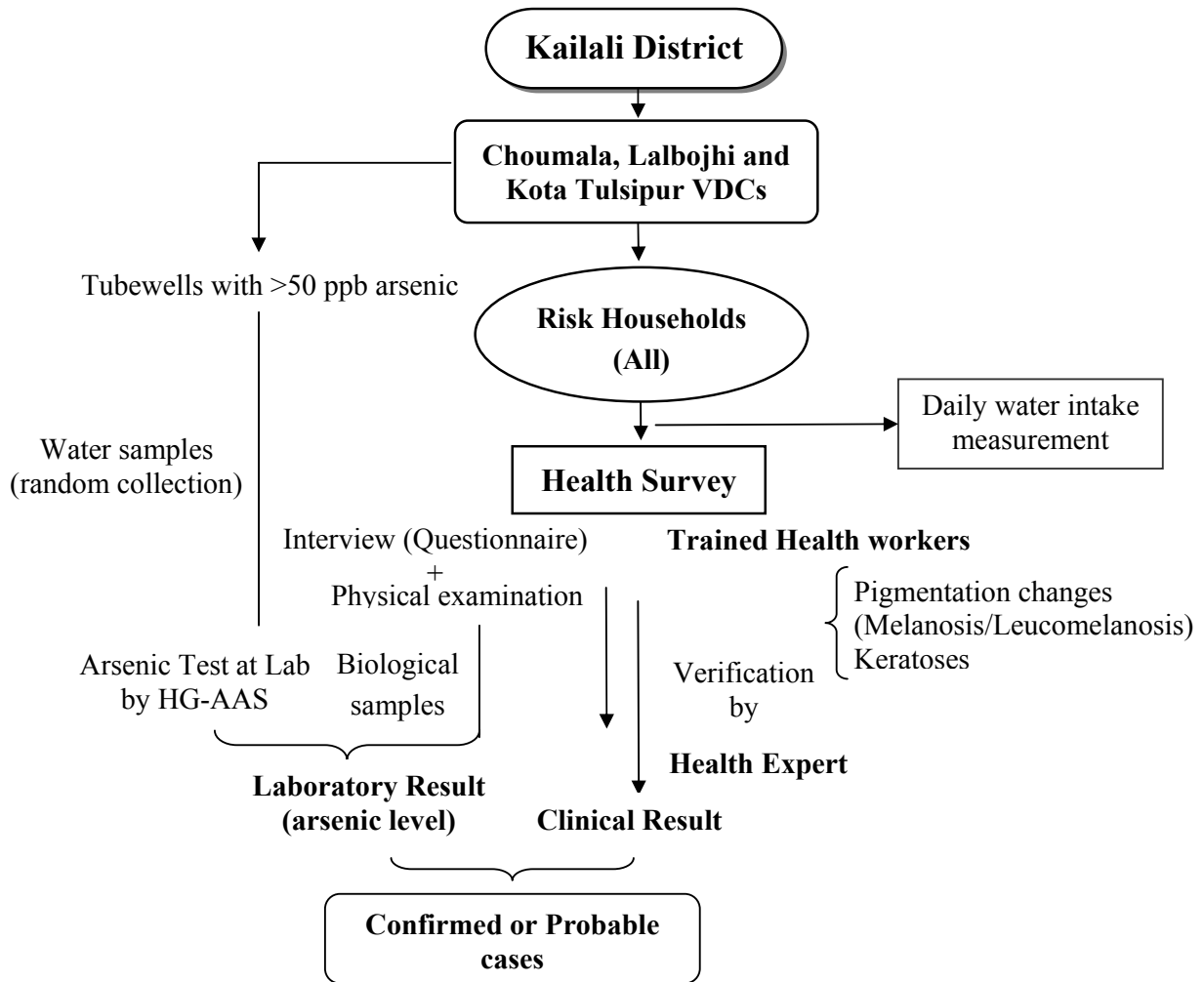


Figure 1.1: Schematic flowsheet diagram of the study

2.4 Survey tools

Three different sets of structured questionnaire sheets (viz., Tool No. 1, Tool No. 2 and Tool No. 3) were developed both in Nepali and English languages for data collection. Questionnaire sheets in Nepali version were pre-tested in 10 households of Jagatpur village in Kailali district, and modification was made based on the pre-testing and discussion with a contact person Ms. Kalawati Pokharel, Health and Sanitation Specialist, RVWRMP. Revised questionnaire sheets are given in Annex 1.

Tool 1 Questionnaire sheet to collect household information, drinking water sources, mitigation measures adopted etc.

Tool 2 Questionnaire sheet to record information of all family members (age, sex etc).

Tool 3 Questionnaire sheet related to physical examination for characteristic skin manifestations of chronic arsenic exposure (arsenicosis).

2.5 Inclusion and Exclusion Criteria

2.5.1 Inclusion criteria

- For physical examination, all family members of the targeted households who were continuously living in the study areas at least for six months were included.
- A person, though not a family member, living in the target household for more than six months from the date of survey (e.g. helpers) was included in the survey.

2.5.2 Exclusion criteria

- Members of household, not available at the time of survey were excluded.
- Members of household not living in the study areas for more than six months continuously were excluded.
- Visitors or guests of target household were excluded in all kinds of data collection.

2.6 Ethical considerations

Prior to any data collection, the purpose and the procedure of the study was explained to the household head or key informant and other interested family members. The verbal consent was obtained from each participant prior to examination for arsenic-related skin manifestations. Similarly, for biological sample (urine, hair or nail) collection, only interested subjects to participate in the survey were included. Participation of the subjects in all kinds of data collection and sample collection was voluntary.

2.7 Data Collection

2.7.1 Acquisition of arsenic-related documents/reports and IEC materials

Available documents/reports on arsenic problem in Nepal were collected from different governmental and non-governmental organizations working on drinking water and sanitation sector such as Department of Water Supply and Sewerage (DWSS)/UNICEF, National Arsenic Steering Committee (NASC), Nepal Red Cross Society (NRCS) etc. Similarly, available IEC materials related to arsenic were collected. Most of the reports

and IEC materials are already available at Resource Centre of ENPHO. List of collected IEC materials is given in Annex 2.

2.7.2 Project Staff Orientation and Training

Prior to data collection, project staff orientation and two-days training on 'A Field Guide for Detection of Arsenicosis Cases' based on recently published WHO Technical Publication No. 30, Regional Office for South-East Asia, New Delhi, 2005 was organized for Health Workers from 30-31 July 2007 in Joshipur, Kailali.



Following orientation and training, field work was started. A contact person Ms. Kalawati Pokharel, Health and Sanitation Specialist, RVWRMP had visited the field in Kotatulsipur for monitoring the survey. During field visit, Ms. Pokharel supervised the field workers to work carefully respecting the social and cultural norms and values of the communities.



Ms. Kalawati Pokharel from RVWRMP with health workers in the field

2.7.3 Interview

Two teams each comprising two trained health workers (a male and a female) on identifying arsenicosis cases purposively visited all the risk households in three target VDCs for the survey. Data related to household information, drinking water, mitigation measures adopted etc were collected using Tool No.1 and Tool No. 2 in Nepali version.

Information was collected by interviewing a household head or a knowledgeable family member, in case if a household head was not present.

2.7.4 Physical examination for skin manifestations of chronic arsenic ingestion

Health workers conducted physical examination of all household members who were available during the visit for identifying arsenic-related skin manifestations, and findings were recorded in Tool 3 in Nepali version. Examination was made following “*A Field Guide for Detection, Management and Surveillance of Arsenicosis Cases*”, WHO Technical Publication No. 30, SEARO, New Delhi, 2005. In this survey, arsenicosis is defined as a chronic health condition arising from prolonged ingestion of arsenic above the national standard (>50 ppb) for at least six months, manifested by characteristic skin lesions of melanosis and keratoses, occurring alone or in combination, with or without the involvement of internal organs. The patients with ‘keratosis’ were further sub-categorized into ‘mild’, ‘moderate’ or ‘severe’ on the basis of thickening of the skin and appearance of papules or nodules according to the above mentioned WHO's Field Guideline. Health workers during the survey also distributed available IEC materials on arsenic such as brochures and leaflets to the villagers, which helped convincing the people on importance of using arsenic safe water for preventing from arsenic-related health effects.



Interviewing a respondent

All the arsenicosis cases (suspected case or probable case) identified by health workers were re-examined and verified by a Health Expert having experience on diagnosing arsenic-related health effects, who had also participated in Regional Consultation on “*A Field Guide for Detection, Management and Surveillance of Arsenicosis Cases*” held in SEARO-WHO, New Delhi, 2002.



Health workers examining villagers for 'melanosis on trunk'



Examination for 'keratosis on sole'



**A health worker examining a villager for
'keratosis on palm'**



A health worker showing arsenic-related health effects



A boy interestingly looking a distributed IEC material

2.7.5 Collection, storage and transportation of samples

2.7.5.1 Sample collection and preservation

2.7.5.1.1 Tubewell water

Water samples from a total of 50 tubewells were randomly collected from three VDCs and tested for cross-checking with blanket arsenic testing results. Water sample was collected in a pre-acid washed polypropylene bottles after running water at least for 5 minutes and immediately acidified with concentrated HCl (APHA, 1995).



Tubewell water sampling

2.7.5.1.2 Urine

Spot urine samples were collected from both males and females of different age-groups targeting those who usually live in the village and consume water from the regular water source. Since children or young ones usually go outside house or village and consume water from other sources, samples were collected from adults (i.e., household heads; a male and a female) who usually stay in the house or village and consume water from a regular source to see if there is any correlation between drinking water arsenic and urinary arsenic levels, and sexes. A total of 150 urine samples were collected from 75 households randomly selected from the list of arsenic exposed total households in three VDCs.

Samples were collected following the steps given below:

- First, the subjects were explained about the purpose and method of sample collection, and their verbal consent was obtained.
- About 5 ml spot urine sample was collected in a small, clean plastic tube, which was labeled and kept inside ice-box with enough ice and cooling packs. Sample details such as sample ID, sampling date, name, sex, age and address of sample donor were separately recorded in a sheet.
- Field collected samples were stored in a deep freeze at the earliest. Frozen samples were later transported to ENPHO Research Laboratory, Kathmandu for arsenic detection, and preserved in a deep freeze till analysis.

Disposal of used materials

The used urine sampling cups etc were collected in a paper box and burned everyday in a safe place.

2.7.5.1.3 Hair and Nails

A total of 25 hair and 25 nail samples were collected from a sub-set of 25 households in three target VDCs. For a female, about 30 hairs 6 cm long from the base of the hair were collected, and the hair beyond 6 cm was discarded. For males, about 60 short hairs from the base were collected. Nail samples were collected from the same subjects by clipping every finger and toe nails. Each collected sample was separately kept in a plastic bag with Sample ID. Sample details such as sample ID, sampling date, name, sex, age and address of sample donor were separately recorded in a sheet.



2.7.6 Arsenic measurement

2.7.6.1 Water

Measurement of total arsenic in water samples was done by an atomic absorption spectrophotometry (SOLAAR 969AA Spectrometer, Thermo Elemental, UK), equipped with a flow injection hydride generator (HG-AAS), in the research laboratory of ENPHO, Kathmandu, Nepal. The samples were pre-reduced with 5% (w/v) KI and 5% (w/v) ascorbic acid in 10% (v/v) HCl, and tested. The accuracy of assay was ensured by including a standard reference material, NIST SRM 1640, with $26.67 \pm 0.41 \mu\text{g}/\text{kg}$ arsenic.

2.7.6.2 Biological samples (urine, hair and nail)

Measurement of total arsenic in biological samples was done by an Atomic Absorption Spectrophotometry (SOLAAR 969AA Spectrometer, Thermo Elemental, UK), equipped with a hydride generator (HG-AAS), in the Research Laboratory of ENPHO, Kathmandu, Nepal. Measured samples were first wet-ashed by heating with a mixture of conc. nitric acid (HNO₃), perchloric acid (HClO₄) and sulphuric acid (H₂SO₄), and then pre-reduced with 5% (w/v) KI and 5% (w/v) ascorbic acid in 10% (v/v) hydrochloric acid (HCl). Assay accuracy was ensured by inclusion of a reference material, NIES CRM No.18 (Human Urine, National Institute for Environmental Sciences, Tsukuba, Japan) with total arsenic of 0.137 ± 0.011 mg/L.

2.7.7 Water intake measurement and estimation of daily arsenic intake

Measurement of daily water intake by drinking by the people during the survey period in the study areas was conducted for adults of both sexes who were interested to voluntarily participate in the survey. For this purpose, a clean one litre mineral water bottle was distributed to each participant and requested to drink water from that bottle only and to refill the bottle with water when it becomes empty starting from morning (after wake up) to time of going to bed (24 hours). The number of times of water filling and the amount of water remained were recorded by health workers in the following day to calculate the daily water intake (DWI).



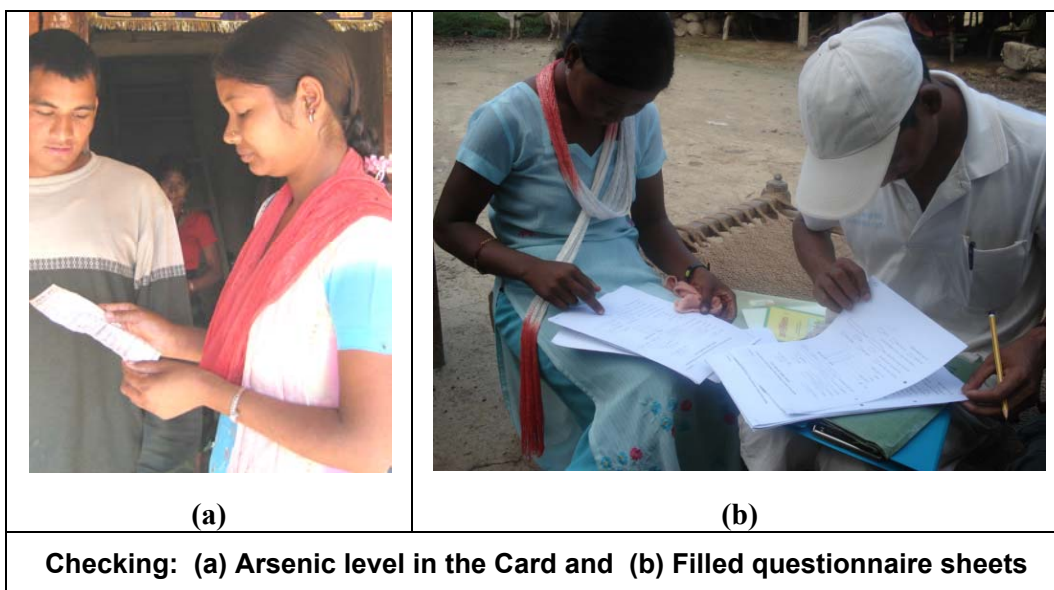
2.7.8 Data processing and analysis

All filled-up data collection sheets (Tool 1, Tool 2 and Tool 3) were sent to ENPHO Office, Kathmandu for data processing. Data was processed in Access program to spreadsheet, and laboratory results of tubewell water and biological samples were processed in spreadsheet. Analysis of the data was done using SPSS Version 13.0 statistical software. Statistical significance was set at p-value <0.05.

2.7.9 Validity and Reliability

To increase the validity and reliability of the survey, following activities or processes were followed during the survey period.

1. Prior to health survey or data collection, the developed questionnaire and examination sheets were pre-tested in Kailali district, and necessary modifications were made.
2. To increase the competency, health workers were provided orientation on data collection and two days training on 'A Field Guide for Detection of Arsenicosis Cases' based on "A Field Guide for Detection, Management and Surveillance of Arsenicosis Cases", WHO Technical Publication No. 30, SEARO, New Delhi, 2005.
3. Health workers were oriented on water and biological samples (urine, hair or nail) collection, preservation and storage procedures.
4. Filled questionnaire sheets were checked by health workers on the same day to find if any information was missed.
5. Water testing report provided to the tubewell owner, if available, was checked for arsenic level.
6. Team Leader/Field Coordinator made frequent field visits for tracking the scheduled project activities and providing necessary instructions to health workers.
7. Health Expert re-examined and verified all suspected or probable arsenicosis cases identified by health workers.
8. Water and biological samples (urine) were collected and preserved following standard procedures in the field, during storage and in the laboratory till analysis.

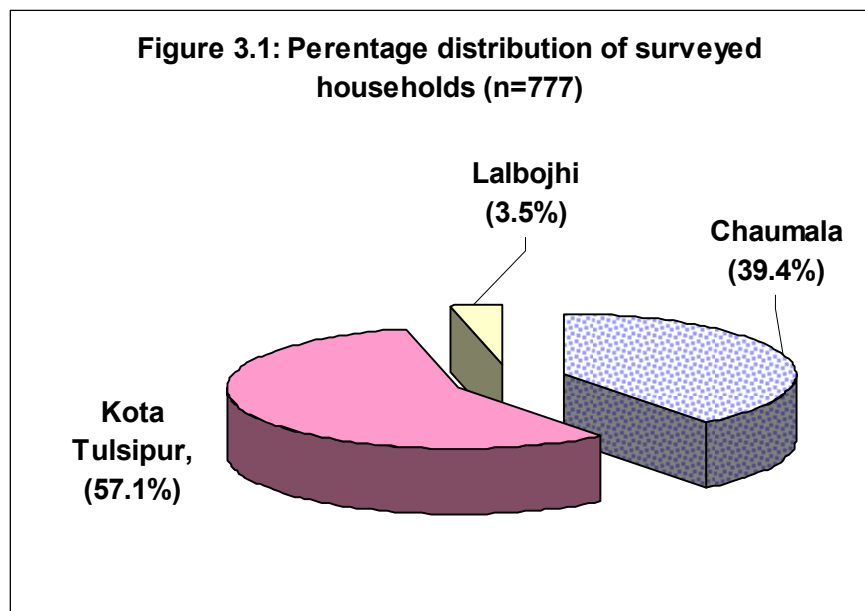


3 RESULTS AND DISCUSSIONS

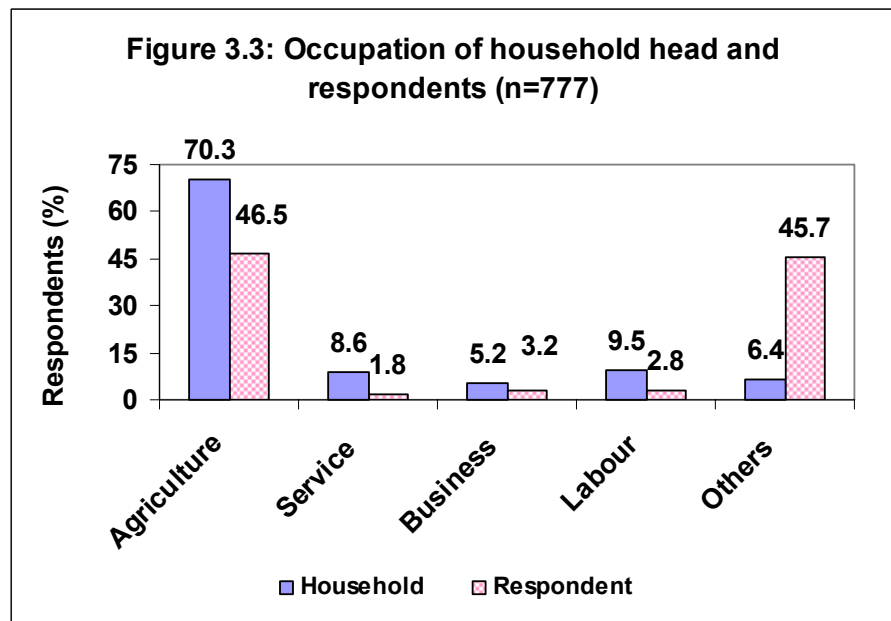
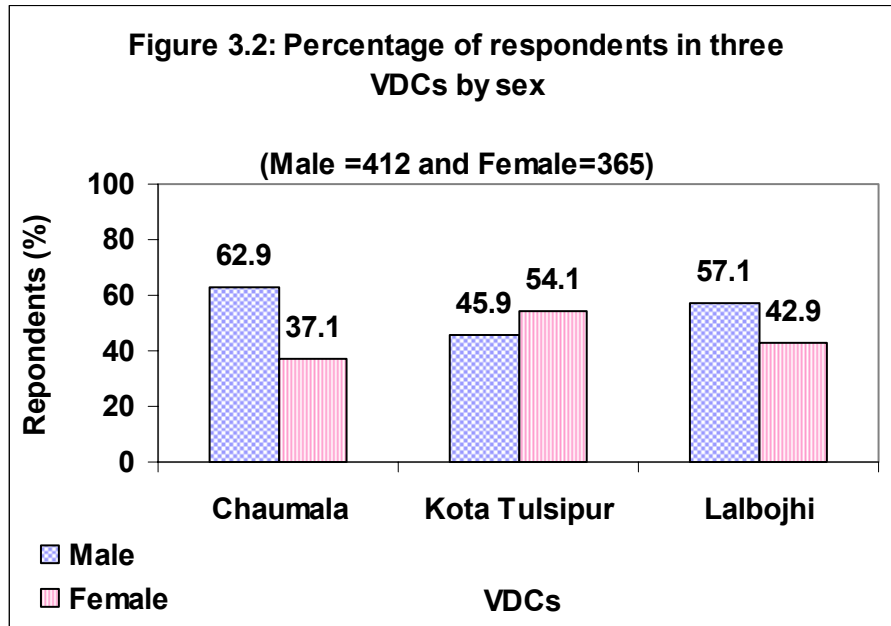
In present survey, the geographical distribution, demographic characteristics and living styles of the people in three VDCs (Chaumala, Kota Tulsipur and Lalbojhi) are almost similar. Hence, data, in present survey, are analyzed *en bloc*, wherever possible.

3.1 Respondents and characteristics

A total of 777 households were surveyed in three VDCs. The surveyed households in Chaumala, Kota Tulsipur and Lalbojhi were 306 (39.4%), 444 (57.1%) and 27 (3.5%), respectively (Figure 3.1).



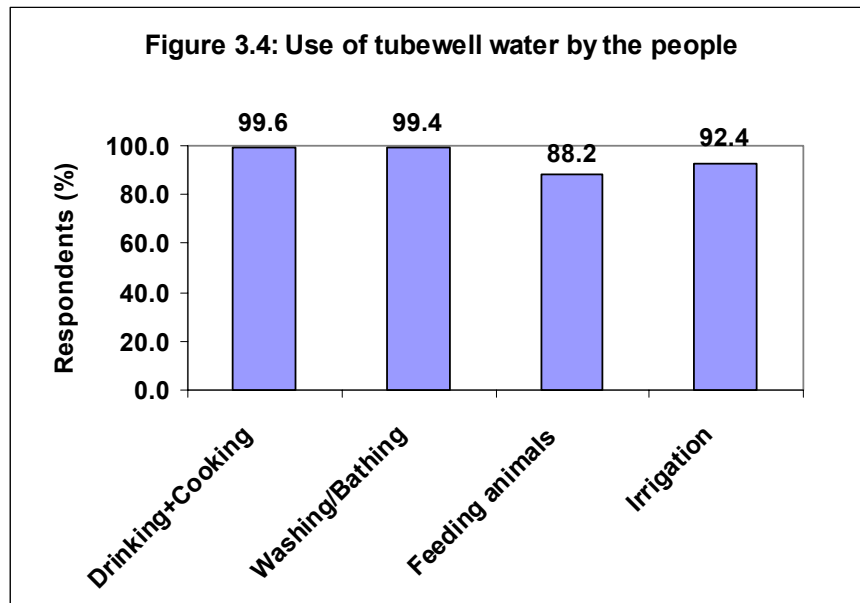
Of the total 777 respondents, males were 53.0% and females were 47.0%. The respondents by sex in three VDCs are shown in Figure 3.2. The minimum and maximum ages of male respondents were 9 years and 90 years, respectively with the mean of 35.9 ± 16.4 years and the minimum and maximum ages of female respondents were 5 years and 80 years, respectively with the mean of 30.4 ± 12.2 years. The overall mean age of the respondents was 33.4 ± 14.8 years with the minimum and maximum ages of 5 years and 90 years, respectively. Out of total 777 surveyed households, 5.1% of households had migrated to the survey area from neighboring or other districts. People's livelihood primarily depends on agriculture (Figure 3.3). Occupation under 'others' include students, housewives, social workers, politicians etc.



3.2 Drinking water sources and usage

Almost all the households (99.6%) surveyed were using shallow tubewells for water for all domestic purposes including drinking and cooking. People largely rely on tubewell water for cooking, cleaning utensils, bathing, washing clothes, feeding animals etc (Figure 3.4). A very few people were using other sources (dugwell, 0.1% and tap, 0.3%) for water. Tubewells (94.8%) in the survey area were installed by the people themselves except a

very few (5.2%), which were installed by governmental or non-governmental organizations (VDC, LWF etc).



3.3 People's knowledge on 'arsenic' and 'water testing conducted'

In present survey, people's knowledge on 'arsenic' and 'water testing carried out' was also gathered by asking if they *knew 'what is arsenic ?'* and *'if they were aware of their tubewell water testing'*. It was revealed that two-third of the respondents (66.7%) didn't know 'what is arsenic', however, almost all of them (98.5%) knew about water testing carried out. The source of information on arsenic to one-third of respondents (33.3%) was technicians working on arsenic removal filters (GOT's Nepal, HELVETAS etc), print and audio/visual media (such as newspapers, radio and TV), governmental organizations (DWSS, VDC etc), arsenic testing group, neighbours and friends etc (Figure 3.5).

Similarly, only less than one-third of the respondents (28.4%) were aware that arsenic in their drinking water was high, whereas about 5.0% respondents (4.9%) considered that arsenic level in their drinking water was low, and two-third of the respondents (66.7%) didn't know arsenic level in their tubewell water (Figure 3.6). It's important to mention here that arsenic level in all the surveyed households in three VDCs were above the national standard for drinking water. The findings suggest for the need of mass awareness programmes on arsenic issue in the survey area.

Figure 3.5: Sources of information on arsenic to respondents (n=259)

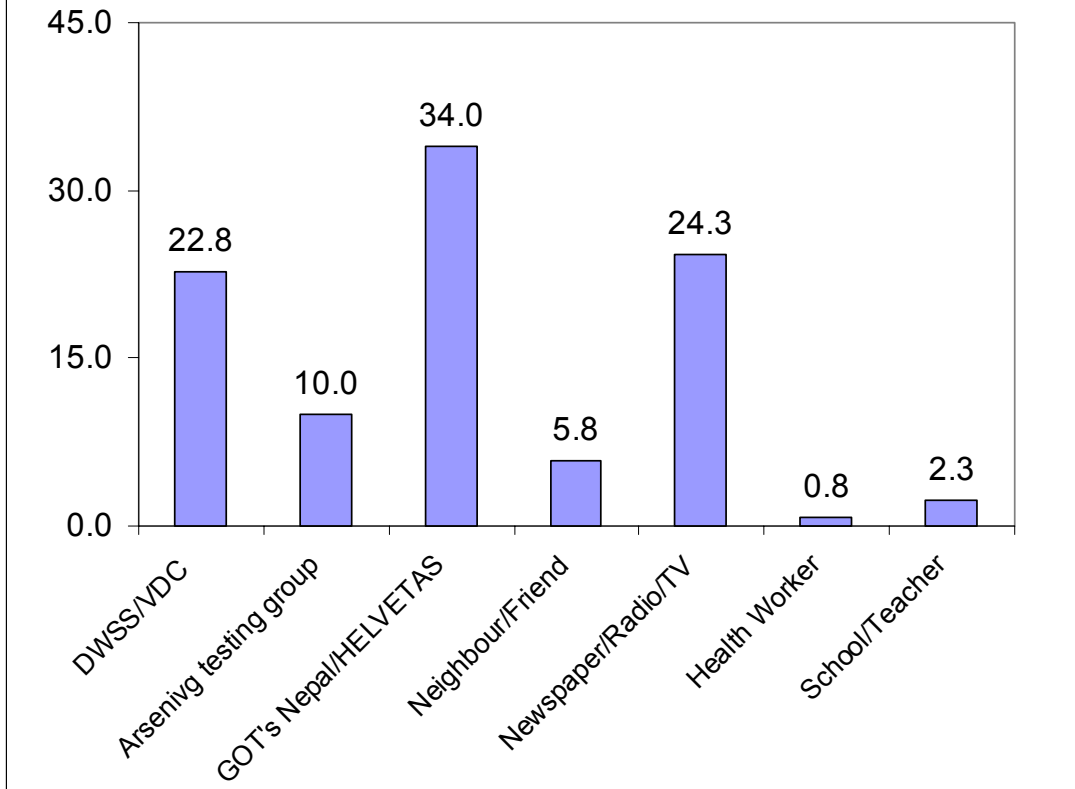
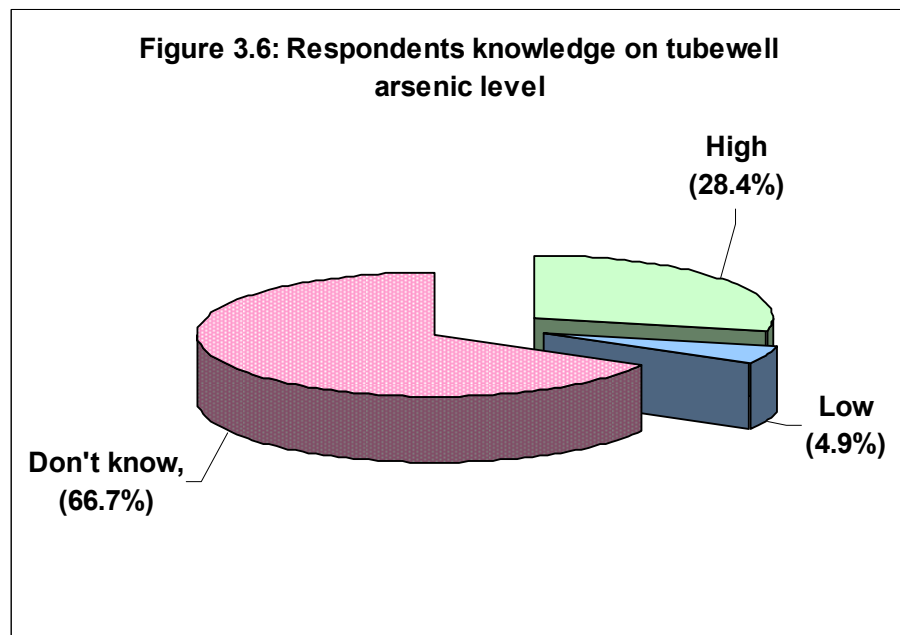


Figure 3.6: Respondents knowledge on tubewell arsenic level



3.4 Tubewell water arsenic contamination

As mentioned earlier in 'Introduction' (Section 1.6), arsenic testing of tubewell water had been already done under blanket arsenic testing. In present survey, households with tubewell water arsenic concentration above 50 ppb were only included. The surveyed households, in three VDCs, were exposed to arsenic ranging from 53 ppb to ≥ 500 ppb, with mean value of 105.2 ± 70.6 ppb. Similarly, the minimum, maximum and mean values for tubewell depth age are given in Table 3.1. The arsenic concentrations of tubewells classified into different ranges are presented in Table 3.2 (Figure 3.7).

Table 3.1: Parametric values of tubewells for tubewell arsenic concentration, depth and age

n = 777	Arsenic, ppb (n=777)	Tubewell	
		Depth, ft (n=767)	Age, yr (n=767)
Mean	105.2	48.9	5.4
Std. Deviation	70.6	16.9	4.8
Minimum	53	14	1
Maximum	500	258	27

3.5 Correlation between 'Field Kit' and 'HG-AAS' arsenic concentrations

A total of 50 tubewell water samples randomly collected from three VDCs were tested for arsenic at laboratory by HG-AAS. The results obtained from 'Field Kit' and 'HG-AAS' testing are presented in Annex 4, and parametric values for these two techniques are given in Table 3.3.

The common variables for two different testing techniques, in this survey, were depth and age of the tubewells. A positive significant correlation ($r=0.652$, $p<0.001$) is existed between arsenic concentrations obtained from 'Field Kit' and HG-AAS testing (Figure 3.8). This suggests the reliability of the 'Field Kit' results.

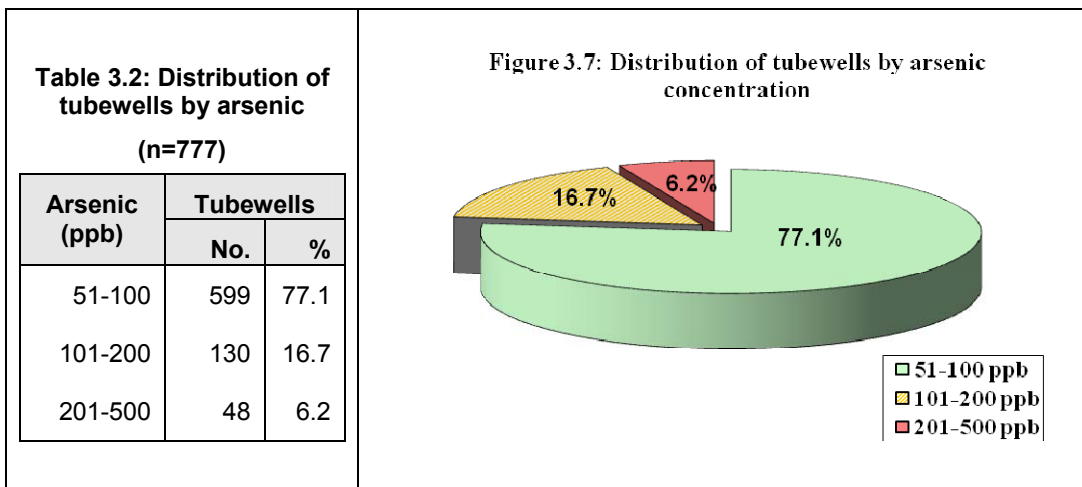
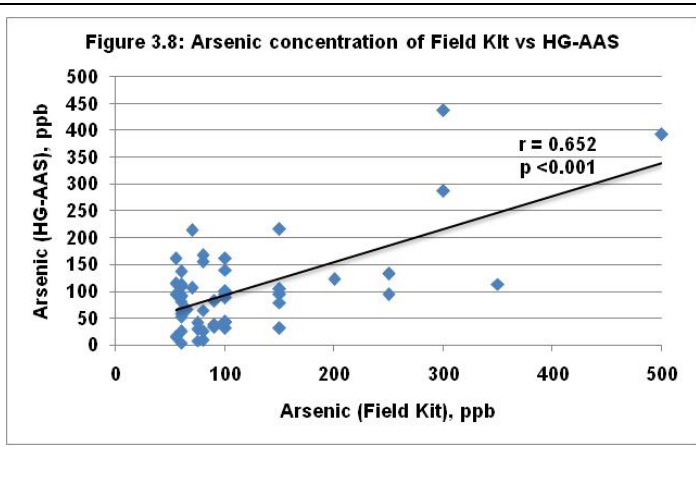


Table 3.3: Parametric values of 'Field Kit' and 'HG-AAS' arsenic

n=50	Arsenic (ppb)	
	Field Kit	HG-AAS
Mean	118.6	104.3
Std. Deviation	91.3	86.5
Minimum	55	10
Maximum	500	438



3.6 Urine arsenic concentrations

A total of 150 spot urine samples (male = 76 and female = 74) collected from three VDCs were tested at laboratory by HG-AAS for arsenic. The parametric values for tested samples by sex are presented in Table 3.4. Despite using the same tubewell water, the mean urinary arsenic level for males (34.4 $\mu\text{g}/\text{Kg}$) was low compared to that for females (44.8 $\mu\text{g}/\text{Kg}$), which might be due to the consumption of water from other sources by males. The urine arsenic levels for 14.5% male and 33.8% female exceeded the arsenic exposure indicator level of 50 ($\mu\text{g}/\text{Kg}$), suggesting current exposure to arsenic through drinking water or other sources. A weak significant positive correlation existed for male and female urine arsenic concentrations ($r=0.318$, $p<0.01$), and the mean urine arsenic concentrations between sexes was statistically significant ($p<0.05$). Similar findings have been reported in preceding studies (Buchet et al. 1981; Ahmad et al., 2001; Watanabe et al., 2001; Maharjan et al., 2005)

Table 3.4: Parametric values for urine arsenic concentrations ($\mu\text{g}/\text{Kg}$)

Parameters	Male	Female	Total
n	76	74	150
Mean \pm SD	34.4 \pm 36.4	44.8 \pm 37.3	39.5 \pm 36.9
Median	19.5	34	24.6
Minimum	ND (<11)	ND (<11)	ND (<11)
Maximum	182	192	192
% of samples having arsenic above exposure indicator	14.5	33.8	24.0
r	0.318 ($p<0.01$)		
p-value (Paired-T test) (n=74, each sex)	0.042		

It is important to mention here that urine arsenic indicates the recent or ongoing arsenic exposure through consumption of arsenic contaminated water or foods. Consumption of contaminated water is the major source of arsenic ingestion. In present survey area, people seldom consume seafoods that largely contribute in total urine arsenic. Thus, in present survey, it is assumed that contaminated tubewell water was the major source of arsenic exposure.

3.7 Correlation between tubewell water and urine arsenic concentrations

Tubewell water arsenic concentrations (TWAs) were significantly correlated with urine arsenic concentrations (UAs) for both sexes (Table 3.5, Figure 3.9). Similarly, a significant positive correlation existed between urine arsenic concentrations for male-female pairs (Table 3.5, Figure 3.10).

Table 3.5: Correlation matrix for tubewell water, male urine and and female urine arsenic concentrations

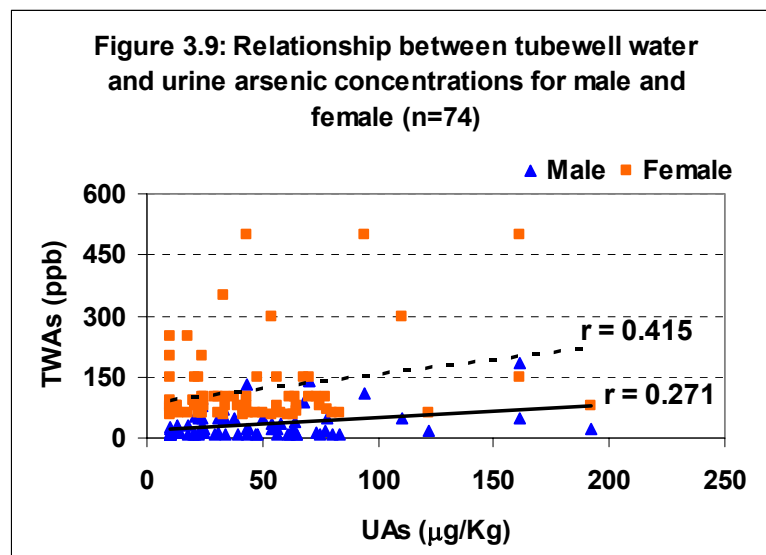
n=74	TWAs	UAs_M	UAs_F
TWAs	1	0.415**	0.271*
UAs_M		1	0.318**
UAs_F			1

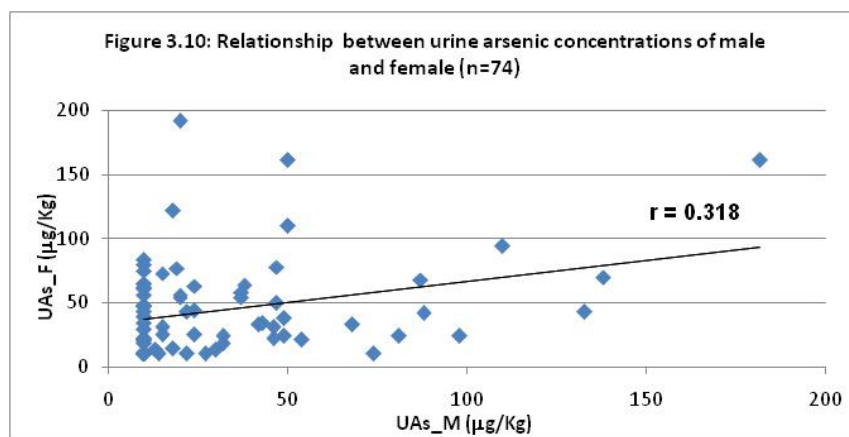
** Correlation is significant at the 0.01 level (2-tailed)

* Correlation is significant at the 0.05 level (2-tailed)

M = Male, F = Female, TWAs = tubewell water arsenic

UAs_M = Male urine arsenic and UAs_F = Female urine arsenic





3.8 Hair and nail arsenic concentrations

A total of 26 hair samples (male 13 and female 13) and 26 nail samples (male 13 and female 13) collected from three VDCs were tested at laboratory by HG-AAS for arsenic as chronic arsenic exposure indicator (Annex 6). Hair and nail samples were collected from the same 13 male-female pairs of the same household. Sample donors, in most cases, were household heads or husband-wife.

Table 3.6: Parametric values for hair and nail arsenic concentrations (µg/Kg)

Parameters	Hair		Nail	
	Male	Female	Male	Female
n	13	13	13	13
Mean±SD	777.0±360.8	894.8±744.3	1150±680.5	1136.9±872.3
Median	768	722.0	1009	852
Minimum	325	307	131	203
Maximum	1549	2996	2624	3143
% of samples having arsenic above exposure indicator	30.8	23.1	23.1	15.4
r	-0.095 (p>0.1)		0.543 (p>0.05)	
p-value (Paired-T test) (n=13, each sex)	0.629		0.951	

The parametric values of hair and nail arsenic concentrations along with tubewell water and urine arsenic concentrations for male and female are presented in Table 3.6. The hair arsenic levels for 30.8% male and 23.1% female exceeded the arsenic exposure indicator level (>1 mg/Kg of hair). The nail arsenic levels for 23.1% male and 15.4% female exceeded the arsenic exposure indicator level (>1.5 mg/Kg of nail).

Table 3.7: Correlation matrix for tubewell water, hair, nail and urine arsenic concentrations for male and female

n=13	TWAs	HAs_M	HAs_F	NAs_M	NAs_F	UAs_M	UAs_F
TWAs	1	0.711**	0.043	0.561*	0.879*	0.605*	0.609*
HAs_M		1	-0.950	0.369	0.734**	0.478	0.695*
HAs_F			1	-0.430	-0.035	-0.207	0.004
NAs_M				1	0.543	0.055	0.658**
NAs_F					1	0.607*	0.648**
UAs_M						1	0.202
UAs_F							1

** Correlation is significant at the 0.01 level (2-tailed)

* Correlation is significant at the 0.05 level (2-tailed)

M = Male, F = Female, TWAs = tubewell water arsenic, ppb

HAs_M = Male hair arsenic, HAs_F = Female hair arsenic

NAs_M = Male nail arsenic, NAs_F = Female nail arsenic

UAs_M = Male urine arsenic, UAs_F = Female urine arsenic

3.9 Physical examination and skin manifestations

Of the 5992 population (male 3049 and female 2943) in total, 3889 villagers (64.8%) comprising 1785 male (54.1%) and 2104 female (45.9%) participated in the physical examination for arsenic-related skin manifestations. By VDC, 1251 villagers (566 male and 685 female) in Chaumala, 2553 villagers (1182 male and 1371 female) in Kota Tulsipur and 85 villagers (37 male and 48 female) in Lalbojhi were examined. Examined people in three VDCs by sex in percentage is given in Figure 3.11. By age groups, participants in 15-49 age group was the highest followed by 5-14 age group and <5 age group.

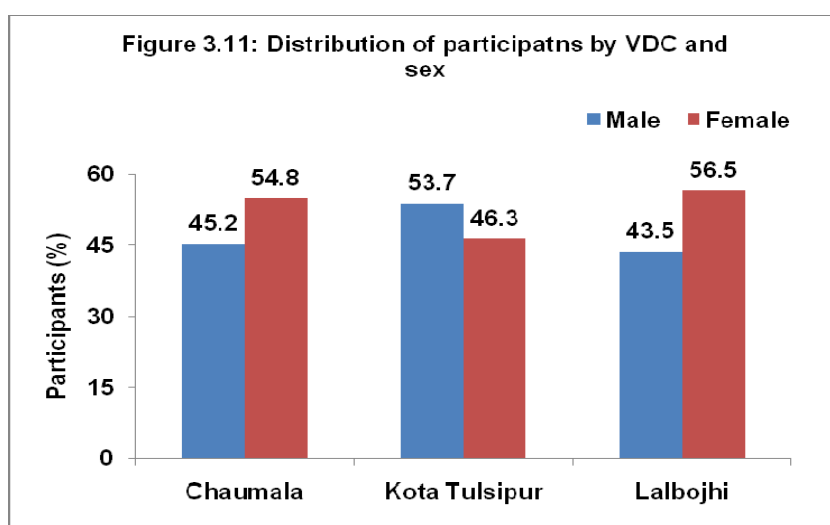


Table 3.8: Distribution of the examined subjects by age group and sex

Age group (yrs)	Male	Female	Total
<5	199 (11.2)	193 (9.2)	392 (10.1)
5-14	577 (32.3)	545 (25.9)	1122 (28.9)
15-49	776 (43.5)	1139 (54.1)	1915 (49.2)
50-64	146 (8.2)	156 (7.4)	302 (7.8)
65+	87 (4.8)	71(3.4)	158 (4.1)
Total	1785 (100.0)	2104 (100.0)	3889 (100.0)

Number of individuals in age group is given in the parentheses as %.

Among examined population, 26 persons (17 male and 9 female) were found to suffer from chronic arsenic toxicity. The prevalence of arsenicosis cases for male was 0.9% and for female 0.4%, with the overall prevalence of 0.7%. The prevalence of arsenicosis was found higher for subjects in the higher age groups. By age group, the subjects in 50-64 age group and 65+ age group were found to be suffered from chronic arsenic toxicity in both sexes as compared to the lower age groups. The prevalence of arsenicosis cases for each age group by sex are given in (Table 3.9). There were 5 young male patients aged from 4 to 12 years, the youngest being a 4-year old boy (Annex 6).

Table 3.9: Arsenicosis patients by age group of the observed subjects

Age group (years)	Male	Female	Total
<5	1/199 (0.5)	0/193 (0.0)	1/392 (0.3)
5-14	4/577 (0.7)	0/545 (0.0)	4/1122 (0.4)
15-49	6/776 (0.8)	6/1139 (0.5)	12/1915 (0.6)
50-64	4/146 (2.7)	2/156 (1.3)	6/302 (2.0)
65+	2/87 (2.3)	1/71(1.4)	3/158 (2.0)
Total	17/1785 (0.9)	9/2104 (0.4)	26/3889 (0.7)

Arsenicosis patients in age group are given in the parentheses as %.

3.9.1 Tubewell water arsenic concentrations, prevalence of arsenicosis cases and manifestation types

3.9.1.1 Tubewell water arsenic concentrations and prevalence of arsenicosis cases

Table 3.8 shows distribution of examined subjects and arsenicosis patients by sex into three different arsenic concentration groups and prevalence of arsenicosis for the arsenic concentration groups. Tubewell water arsenic concentrations are categorized into three groups: 51-100 ppb, 101-200 ppb and 201-500 ppb. By tubewell water arsenic concentrations, more than two-third of households (77.1%) are in the first group of 51-100 ppb arsenic followed by 16.7% of households in the second group of 101-200 ppb arsenic and 6.18% of households in the third group of 201-500 ppb arsenic. The prevalence of arsenicosis cases was found increased corresponding to the higher arsenic concentration groups, suggesting the risk of exposure to elevated arsenic level.

Table 3.10: Distribution of arsenic concentrations, sex-wise observed population and arsenicosis prevalence rate

Arsenic (ppb)	No. of surveyed households	Observed			Arsenicosis prevalence rate
		Male	Female	Total	
51-100	599	1390 (10)	1609 (6)	2999 (16)	0.53%
101-200	130	312 (4)	375 (1)	687 (5)	0.73%
201-500	48	83 (3)	120 (2)	203 (5)	2.46%
Total	777	1785 (17)	2104 (9)	3889 (26)	0.67%

Number of arsenicosis patients given in the parentheses.

3.9.1.2 Skin manifestation types

Skin manifestations observed were mostly keratotic lesions alone or in combination with pigmentation changes (96.2%) and pigmentation change alone or in combination with keratotic lesions was observed in 15.4% cases. Keratotic lesions alone were observed in 11.5% of the total arsenicosis cases, while it was 3.9% for pigmentation changes (Table 3.9). According to the prescribed criteria (WHO, 2005), keratotic lesions observed were mostly in mild (early) stage (Annex 7), just in a visible or palpable stage. Keratotic lesions were observed in the palms alone or both in palms and sole, whereas pigmentation change (melanosis) was found spotty on the trunk or chest.

Table 3.11: Distribution of arsenicosis patients and symptom types

Symptoms	Number of Arsenicosis Patients		
	Male	Female	Total (%)
KP	6 (35.3)	3 (33.3)	9 (34.6)
KP, KS	7 (41.2)	3 (33.3)	10 (38.5)
MC	0 (0.0)	1 (11.1)	1 (3.8)
MC, thickening of palms and soles	0 (0.0)	1 (11.1)	1 (3.8)
MT, KP	2 (11.8)	1 (11.1)	3 (11.5)
KP, thickening of palms and soles	1 (5.9)	0 (0.0)	1 (3.8)
MT, KP, KS	1 (5.9)	0 (0.0)	1 (3.8)
Total	17 (100.0)	9 (100.0)	26 (100.0)

MT = Melanosis on Trunk, KP = Keratosis on Palms, KS = Keratosis on soles

The prevalence of arsenicosis for male was twice as compared to female, suggesting male are more susceptible to chronic arsenic toxicity. Though there might be other hidden factors like nutritional status of the subjects or genetic factors that cause sex difference for arsenicosis cases, ingestion of more arsenic through increased amount of drinking water by male might have contributed for the higher prevalence of arsenicosis in male. Since the arsenicosis cases observed either keratotic lesions or pigmentation changes were in early stage, they are expected to recover soon if further exposure is stopped by using arsenic free water. But if they continue the consumption of arsenic contaminated water, there is a possibility that the prevalence will increase with advancement of manifestations to moderate or severe stages.

Several preceding studies in India and Bangladesh, and a few recent surveys in Terai, Nepal have reported skin lesions to be the most common health effects in populations exposed to arsenic through drinking water (Ahmad et al. 1999; Guha Mazumder et al. 1998; NRCS/ENPHO 2001a, 2001b, 2002a, 2002b, 2003; Maharjan et al. 2005, 2006a, 2007). Though there are limited studies on health effects of arsenic poisoning, the available data in Nepal have shown melanosis as the dominant manifestation. It is noteworthy that in present survey, keratosis was dominant. The prevalence rate in present survey was low compared to preceding studies in other districts (Nawalparasi, Bara, Parsa and Rautahat), where the prevalence was found on average 2.2% (NRCS/ENPHO, 2001, 2002, 2003; DWSS/UNICEF, 2002; RWSSSP, 2003b; Maharjan et al., 2005, 2006a, 2007). In consistency to present finding, the prevalence of arsenicosis in arsenic affected communities in Kapilvastu was found 0.7% (RWSSSP, 2004; Maharjan et al. 2006a).

3.9.2 Daily water consumption

Water consumption by only drinking in 24 hours during the survey period was collected from a total of 130 persons comprising both male and female aged ≥ 15 years. The numbers of participants by sexes were 58 male with mean age of 36.86 ± 18.25 years, and 85 female with mean age of 35.78 ± 15.39 years.

Males consumed mean of 2.46 litre and females 2.10 litre of water in 24 hours, which was statistically insignificant for sexes ($p > 0.05$). In overall, mean amount of water consumed was 2.26 ± 1.11 litre. The minimum and maximum arsenic concentrations of the tubewell water in daily water consumption survey were 55 ppb and 500 ppb, respectively with mean value of 109.12 ± 67.47 (Table 3.12). It was revealed from the survey that people of all age groups in the survey area were mainly exposed to arsenic through drinking water. Arsenic intake from other sources, for example, arsenic in food and water added in preparing foods are additional risks.

Table 3.12: Mean daily water consumed and arsenic concentrations for participant age groups

Age Group (years)	n	Mean daily water consumed (litre)	Mean water arsenic concentration (ppb)
5-14	6	2.27 ± 0.83	139.17 ± 107.72 (60, 350)
15-49	97	2.35 ± 1.16	104.43 ± 64.52 (55, 500)
50-64	16	2.05 ± 1.03	124.06 ± 67.46 (55, 300)
65+	11	1.80 ± 0.75	112.27 ± 70.83 (55, 500)
Total	130	2.26 ± 1.11	109.12 ± 67.47 (55, 500)

Minimum and maximum arsenic concentrations are given in the bracket.

3.9.3 Re-examination and verification of the arsenicosis cases

In the fourth week of November to first week of December 2007, Dr. Manen Prasad Gorkhaly, a Health Consultant having ample experience on diagnosing arsenicosis cases visited the survey VDCs for re-examination and verification of arsenicosis cases identified by health workers. Dr. Gorkhaly re-examined all suspected arsenicosis cases identified by health workers, and also randomly examined some villagers in Chaumala, Kota Tulsipur and Lalbojhi VDCs for arsenic-related symptoms.



Health Consultant in the Field

Team members during the field visit;

- Provided advises to arsenicosis patients and family members for using only arsenic free water for consumption purposes, and suggested that water from arsenic contaminated tubewell should be used for washing, bathing, gardening, animal feeding etc other than drinking and cooking. They were also suggested for consuming plenty of locally available vegetables (green leafy vegetables) and fruits (carotene rich fruits like carrot, papaya, pumpkin, guava, mangoes etc).
- Explained the family members and others present about the toxic effects of chronic arsenic poisoning and assured that the symptoms of arsenic-related health effects are non-contagious.
- Informed the villagers about the arsenic safe alternative sources such as identified arsenic safe tubewell/deep tubewell, arsenic removal filters (Kanchan Arsenic Filter/Arsenic Bio-sand Filter), improved dugwell, arsenic, rainwater harvesting etc.
- Refrain from tobacco products and alcoholic beverages, if possible.

On 4th December 2007, Dr. Manen Prasad Gorkhaly, Health Consultant and Mr. Makhan Maharjan, Project Team Leader visited RVWRMP Office, Dhangadhi, Kailali for a meeting with Mr. Kari Leminen, Team Leader, RVWRMP. Unfortunately, Ms. Kalawati Pokharel, a contact person of the project was in Humla district in connection to office work. Dr. Gorkhaly briefed about the field observations and identified arsenicosis patients, and Mr. Maharjan briefed about the project activities to Mr. Leminen.

3.9.4 Arsenic safe options (mitigation measures)

Most of the households, in present survey area, were using contaminated tubewells for domestic purposes including drinking and cooking despite knowing high arsenic level and health hazards. According to the respondents, they were using arsenic contaminated tubewells due to the unavailability of alternate safe source(s) nearby or no arsenic safe option(s). Besides this, the trend of installation of new tubewells for meeting water needs was found, which is again the risk for arsenic exposure since blanket arsenic testing in Kailali district has already been completed and the newly installed tubewells will be left untested.

The use of arsenic free water for consumption is the most important for preventing or lessening of the toxic effects of arsenic. Under arsenic mitigation programmes, different types of arsenic removal options such as safe tubewells, improved dugwells, arsenic removal filters etc have been provided in arsenic affected communities (NRCS, 2005; Maharjan et al., 2006b). Of the surveyed households, in present survey, 34.6% households (269) possessed filter(s). Of the total 269 filters, 261 were arsenic bio-sand filter (ABF-concrete) and rest 8 were simple filters. ABF (concrete) was found to be installed in many surveyed households in Chaumala VDC, particularly in Daxin Tole, Simalpur Tole, Uttarapur Tole, Jayanpur Tole, Supari Aap Tole, Rajipur and Kuti Tole by Water Resources Management Project (WARM-P)/GOT's Nepal. Arsenic mitigation programmes had not yet undertaken in Kota Tulsipur and Lalbojhi VDCs (WARM-P/Got's Nepal, 2006a; 2006b). In Chaumala, households possessing ABF were found highly interested on using the filter for arsenic safe water. Interestingly, some ABFs were found good with no cracks and leakages, while some were found with cracks and leakages. Survey team members were complained by some villagers for the cracks and leakages in the filter.

Recently, RVWRMP in collaboration with HELVETAS Nepal has assessed technical components of ABF construction or workmanship in depth for identifying and

solving the observed problems of the filter. With the findings, an improved version of filter has been developed which has overcome the above mentioned problems.



3.10 Information, Education and Communication (IEC) Materials on Arsenic

Both print and audio/visual IEC materials related to arsenic have been developed and produced by governmental and non-governmental organizations. These materials have been produced targeting mainly two different groups:

1. General public (brochures, pamphlets, posters, calendars, stickers, TV Documentary, TV Commercial etc)
- for mass awareness on arsenic issue
2. Frontline workers such as trainers, community motivators etc (Training Manual, Flip Chart, Flex)
- for using in trainings and orientations

List of available IEC materials is given in Annex 2.

NASC with financial support from UNICEF has been recently reviewing the existing IEC materials and also developing a set of new materials on four different arsenic mitigation options (arsenic safe tubewell/improved dugwell, Kanchan Arsenic Filter and Rainwater Harvesting). The materials under preparation are print and audio/visual, which are listed below.

Print Materials:

1. Brochure (In Nepali and English)
2. Fact Sheets (In Nepali and English)
3. Posters (in Nepali)
4. Dangers (in Nepali)
5. KAF O&M Sticker (in Nepali)
6. Training Manual (in Nepali)
7. Flexes (mitigation options and health, in Nepali)
8. Flip Chart (Arsenic Testing - in Nepali)
9. Flip Chart (Mitigation Options - in Nepali)

Fact sheets are targeted for policy and decision makers.

Audio/visual Materials:

1. Radio messages (Radio spots & Jingles – in Nepali, Bhojpuri, Maithili, Abadhi and Tharu)
2. TV Documentary (in Nepali)
3. TV Commercial (in Nepali)

3.10.1 Proposal on IEC Materials

In consideration to availability of various IEC materials (for General Public, Frontline Workers and Policy Makers), RVWRMP is proposed here either to acquire the available materials from the concerned agencies or reprint the required materials with permission from NASC. This will save not only the time but also the efforts and resources.

4 COONCLUSIONS AND RECOMMENDATIONS

The survey revealed arsenic exposure and existence of chronic arsenic poisoning resulted from the consumption of arsenic contaminated tubewell water in Kailali district. With the spatial and unequal distribution of arsenic in groundwater and other unknown factors yet to be explored, there is individual or sex variation in arsenic toxicity despite living in the same environment. Since almost all the identified arsenicosis patients were in the mild and moderate stages, they are expected to recover if further exposure were avoided and proper case management provided, otherwise they are likely to develop severe irreversible symptoms of diseases including cancer. Based on the present findings, following recommendations are made.

- Mitigation measures should be taken at the earliest for providing arsenic free water to the arsenic exposed households to prevent from chronic arsenic poisoning or worsening of the situation. It is strongly recommended for providing arsenic free water at the earliest with priority to the households with young patients identified in this survey.
- Awareness building and motivational programmes should be organized in the arsenic affected areas so that people stop the use of arsenic contaminated water and accept and use the arsenic safe water options.
- Monitoring of the provided arsenic safe options should be done to check for technical defects or change in water quality and proper usage.

- For future convenience, installation and maintenance dates should be kept on each provided alternative options (ABF, dug well etc). This will help to know the period of switching to consumption of arsenic safe water, time for cleaning and compare the improvement in health conditions of the patients accordingly.
- Periodic monitoring of tubewells having arsenic concentration between 50-100 ppb should be done.
- Health professionals in the local health posts or hospitals or paramedical persons should be trained on diagnosing arsenic-related health implications and its management, which will greatly help in undertaking preventive measures.
- Since the present survey was limited to a small area in Kailali district, there is scope for conducting health impact studies in other arsenic contaminated areas.

5 REFERENCES

- Ahmad SA, Bandaranayake D, Khan AW, Hadi SA, Uddin G, Halim MA. (1997) Arsenic contamination in groundwater and arsenicosis in Bangladesh. *Int J Environ Health Res*, 1997, 7:271-276.
- Ahmad SA, Sayed MHSU, Hadi SA, Faruquee MH, Khan MH, Jalil MA, et al. (1999) Arsenicosis in a village in Bangladesh. *Int J Environ Health Res* 9:187-195.
- Ahmad SA, Muyeen-us-Safa AKM, Sayed MHSU, Khan MH, Faruquee MH, Jalil MA Bhuiyan MSA, Barbhuiya MAK and Elias M. (2001) Arsenic in Drinking Water and Urinary Level of Arsenic. *Environ Sci*, 8 (5): 417-423.
- APHA. (1995) Standard Methods for the Examination of Water and Wastewater. 19th ed. American Public Health Association, Washington, D.C.
- Buchet JP, Lauwerys R. Roels H. (1981) Urinary excretion of inorganic arsenic and its metabolites after repeated ingestion of sodium metaarsenite by volunteers. *Int Arch Occup Environ Health* 48:111-118.
- DOI/HMG. (2004) Proceeding of the Seminar on 'Arsenic Study in Groundwater of Terai' and Summary Project Report, Arsenic Testing and Finalization of Groundwater Legislation Project, 2004, Department of Irrigation (DoI), HMG/N.
- DWSS/UNICEF. (2002) A Study on Health Effects of Arsenic Contaminated Drinking Water in Nawalparasi District, Nepal. A Report, Kathmandu, Nepal. June 2002.
- DWSS/WHO. (1999) Research Study on Possible Contamination of Groundwater with Arsenic in Jhapa, Morang, and Sunsari districts of eastern Terai of Nepal. A Report of the WHO Project, DWSS, HMG/Nepal.
- Guha Mazumder DN, Haque R, Ghosh N, De BK, Santra A, Chakraborty D, et al. (1998) Arsenic levels in drinking water and the prevalence of skin lesions in West Bengal, India. *Int J Epidemiol* 27:871-877.
- Guo X, Fujino Y, Kaneko S, Wu K, Xia Y, Yoshimura T. (2001) Arsenic contamination of groundwater and prevalence of arsenical dermatitis in the Hetao plain area, Inner Mongolia, China. *Mol Cell Biochem*, 2001, 222:137-140.

- IARC. (1987) Monographs on the Evaluation of the Carcinogenic Risk to Humans: Arsenic and arsenic compounds (Group 1). Supplement 7, International Agency for Research on Cancer, Lyon 1987.
- ISRSC. (2002) District Demographic Profile of Nepal. Informal Sector Research and Study Center, Kathmandu, Nepal.
- Maharjan M, Watanabe C, Ahmed Sk, and Ohtsuka R. (2005) Arsenic contamination in drinking water and skin manifestations in Lowland Nepal: The First Community-based Survey. *Am. J. Trop. Med. Hyg.*, 73(2): 477-479.
- Maharjan M, Shrestha RR, Ahmed Sk, Watanabe C, and Ohtsuka R. (2006a) Prevalence of arsenicosis in Terai, Nepal. *J Health, Popul Nutr*, 24(2, Pt 1):251-257.
- Maharjan M, Dangol B, Tuladhar B, Shrestha RR, Ngai TKK and Murcott S. (2006b) Groundwater arsenic contamination and mitigation in Terai, Nepal. Proceedings of the 1st International Symposium on Health Hazards of Arsenic Contamination of Groundwater and its Countermeasures from Toroku to Asia (November 3-4, 2006), 65-76.
- Maharjan M, Watanabe C, Ahmed Sk, Umezaki M and Ohtsuka R. (2007) Mutual interaction between nutritional status and chronic arsenic toxicity due to groundwater contamination in an area of Terai, Lowland Nepal. *J. Epidemiol. Community Health* 2007;61:389-394.
- NASC. (2007) Summary of Arsenic Testing Database in Terai, Nepal. National Arsenic Steering Committee (NASC)/GENESIS.
- NASC/ENPHO/USGS. (2004) The state of Arsenic in Nepal-2003. National Arsenic Steering Committee (NASC)/ ENPHO/USGS, Kathmandu, Nepal.
- NASC/GENESIS. (2007) The state of Arsenic in Nepal-2005. National Arsenic Steering Committee (NASC)/GENESIS.
- NRA. (1997) NEPAL, District Profile. National Research Associates (NRA), Kathmandu, Nepal. pp. DP-634.
- NRC. (1999) Arsenic in Drinking Water. National Research Council, Academic Press, Washington, D.C.
- NRC. (2001) Arsenic in Drinking Water: 2001 Update. National Research Council, National Academic Press, Washington, D.C.
- NRCS. (2005) Drinking Water Quality Improvement Programme. (2000-2005): An Overview, NRCS.
- NRCS/ENPHO. (2000) Research on arsenic contamination in the groundwater of Terai, Nepal. A Final Report, ENPHO, Kathmandu, Nepal.
- NRCS. 2000a. Research on arsenic contamination in the groundwater of Terai, Nepal. A Final Report, April 2000, WETC, Kathmandu, Nepal.
- NRCS/ENPHO. (2001a) Household health survey around arsenic contaminated tubewells in Nawalparasi District. A Report, ENPHO, Kathmandu, Nepal.
- NRCS/ENPHO. (2001b) Health effect of arsenic contaminated drinking water in Parsa, Nepal. A Report, ENPHO, Kathmandu, Nepal.
- NRCS/ENPHO. (2002a) Health effect of arsenic contaminated drinking water in Bara, Nepal. A Report, ENPHO, Kathmandu, Nepal.
- NRCS/ENPHO. (2002b) Health effect of arsenic contaminated drinking water in Rautahat, Nepal. A Report, ENPHO, Kathmandu, Nepal.

- NRCS/ENPHO. (2003) Health Survey in Arsenic Affected Communities (Parsa, Bara, Rautahat and Nawalparasi) carried out for Nepal Red Cross Society under Drinking Water Quality Improvement Program. A Report, NRCS/ENPHO.
- RWSSSP. (2003a) A Comprehensive Report on Groundwater Arsenic Contamination - RWSSSP Program Area (Kapilvastu, Rupandehi and Nawalparasi District). A Report, Novemer 2003, ENPHO, Kathmandu, Nepal.
- RWSSSP. (2003b) Health Survey in Nawalparasi District – RWSSSP Project Area. A Report, ENPHO, Kathmandu, Nepal.
- RWSSSP/FINNIDA. (2004) Health Survey in Arsenic affected areas of RWSSSP in Rupandehi and Kapilbastu district, A Report, Sep 2004.
- RWSSSP/FINNIDA. (2002) Health Survey in Arsenic affected communities of Nawalparasi, Rupandehi and Kapilbastu for Rural Water Supply & Sanitation Support Program. A Report, RWSSSP/ENPHO.
- Shrestha RR, Shrestha MP, Upadhyaya NP, Pradhan R, Khadka R, Maskey A, Maharjan M, et al. (2003) Groundwater arsenic contamination, its health impact and mitigation program in Nepal. *J Environ Sci Health, Part A-Toxic/Hazardous Substances & Environmental Engineering*, A38(1):185-200.
- Tseng CH, Chong CK, Tseng CP, Hsueh M, Chiou HY, Tseng CC, et al. (2003) Long-term arsenic exposure and ischemic heart disease in arseniasis-hyperendemic villages in Taiwan. *Toxicol Lett* 137:15-21.
- Tseng WP, Chu HM, How SW, Fong JM, Lin CS, Yeh S. (1968) Prevalence of skin cancer in an endemic area of chronic arsenicism in Taiwan. *J Nat Cancer Inst* 40:453-463.
- Watanabe C, Inaoka T, Kadono T, Nagano M, Nakamura S, Ushijima K, et al. (2001) Males in rural Bangladeshi communities are more susceptible to chronic arsenic poisoning than females: Analyses based on urinary arsenic. *Environ Health Perspect* 109(12):1265-1270.
- WARM-P/GOT's Nepal. (2006a). Work Completion Report of Khurkhuriya Arsenic Mitigation Pilot Scheme. A Report. GOT's Nepal.
- WARM-P/GOT's Nepal. (2006b). Arsenic Contamination Study at Rajipur Village in Kailali district. A Report. GOT's Nepal.
- WHO. (1981) Task Group on Environmental Health Criteria for Arsenic: Arsenic. Environmental Health Criteria 18, World Health Organization, Geneva, 1-174.
- WHO. (2001) Environmental Health Criteria 224: Arsenic and Arsenic Compounds. 2nd ed. World Health Organization, Geneva.
- WHO. (2005) *A Field Guide for Detection, Management and Surveillance of Arsenicosis Cases*, WHO Technical Publication No. 30, edited by Deoraj Caussy, SEARO, New Delhi, 2005.

ANNEXES

Annex-1

Data Collection Sheets (Survey Tools)

Tool No. 1

Rural Village Water Resources Management Project (RVWRMP)

Health Survey Questionnaire

Form No.

Date: Day Month Year

District

VDC

Tole/Locality

Ward No.

Tubewell No.

As (ppb)

Full Name of Household Head

Full Name of Respondent

Sex

Age

Household size

Males

Females

Occupation: Household Head

Agriculture

Service (Govt/Private)

Business

Labour

Others:

Respondent

.....

1. Does your family belong to this place from the beginning or it was migrated ?

(a) Indigenous

(b) Migrated

If **MIGRATED**, from which place?

District

VDC

2. Where do you get your current drinking water from ?

Tubewell

Dugwell

Tap

Other(s)

3. If tubewell, whose tubewell you are using for drinking water ?

(a) Own tubewell

(b) NRCS installed tubewell

(c) Neighbour's tubewell

(e) Others:

4. How long have you been consuming water from the current source?
 yr(s) Month(s)
5. For what other purposes you use tube well water other than drinking? (*Ask only if tube well is the water source for Q. No. 2*)
 (a) Cooking (b) Bathing/Washing (c) Feeding cattle
 (d) Irrigation/Gardening (e) Others:
6. Are you aware of the arsenic contamination in tubewell water ?
 Yes No
- If **Yes**, what was the information source ?
 (a) Red Cross (b) DWSS (c) VDC
 (e) Friend/Neighbors (f) Radio/TV (g) Newspapers
 (f) Others:
7. Has water of the tube well you are using been tested for ARSENIC?
 Yes No
- If **YES**, do you know – who tested it ?
 (a) NRCS (b) DWSS (c) Don't know (d) Others:
8. Please tell if you know the arsenic concentration level of your tube well water?
 High Low Do not know
- If **HIGH**, are you still using arsenic contaminated tube well for drinking water?
 Yes No
- If **YES**, why?
 (a) No other source (b) Neighbors doesn't allow to collect water
 (c) Other source far (d) Neighbors asks money for collecting water
 (e) Other reason:
9. Are you using any *Arsenic Removal Option(s)* for drinking water?
 Yes No
- If **YES**, which option ?
 (a) Simple Filter (b) Arsenic Removal Filter
 (c) Others:
10. Is there skin lesion(s) with you/family member(s) in your family or anybody in your locality ?
 Yes No If **YES**, please tell his/her name(s) ?

S.No.	Name	Place
1		
2		
3		
4		
5		

Name of Health Worker:

Signature:

Tool No. 2

Physical Examination Sheet for Family Members -2064

(For recording physically examined family members)

Form No.

Date:/...../.....

S. N.	Name	Sex (M/F)	Age (yrs/mths)	Skin Lesions ? (Yes/No)	Symptom(s)	Remarks (if any)
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						

Name of Health Worker:

Signature:

Physical Examination Sheet-2064
(Arsenic-related symptoms)

Form No.

Date: Day Month Year

Name of Patient Age Sex

Occupation:

1. Observed symptoms (Symptoms can be multiple):

(a) Melanosis on Trunk (MT) (b) Melanosis on Palms (MP)

(c) Melanosis on Soles (MS) (d) Keratosis on Palms (KP)

(e) Keratosis on Soles (KS)

(f) Others (if any):

2. Level of 'Keratosis on Palms' ? (Only if 'd' is selected in Q. No. 1)

(a) Mild (<2 mm)

(b) Moderate (2-5 mm)

(c) Severe (>5 mm)

3. What is the condition of skin lesion(s) as compared to before?

(a) Improving (b) Deteriorating

(c) No change (d) Don't know

4. Do you have any of the following health problems ? (Answer can be multiple)

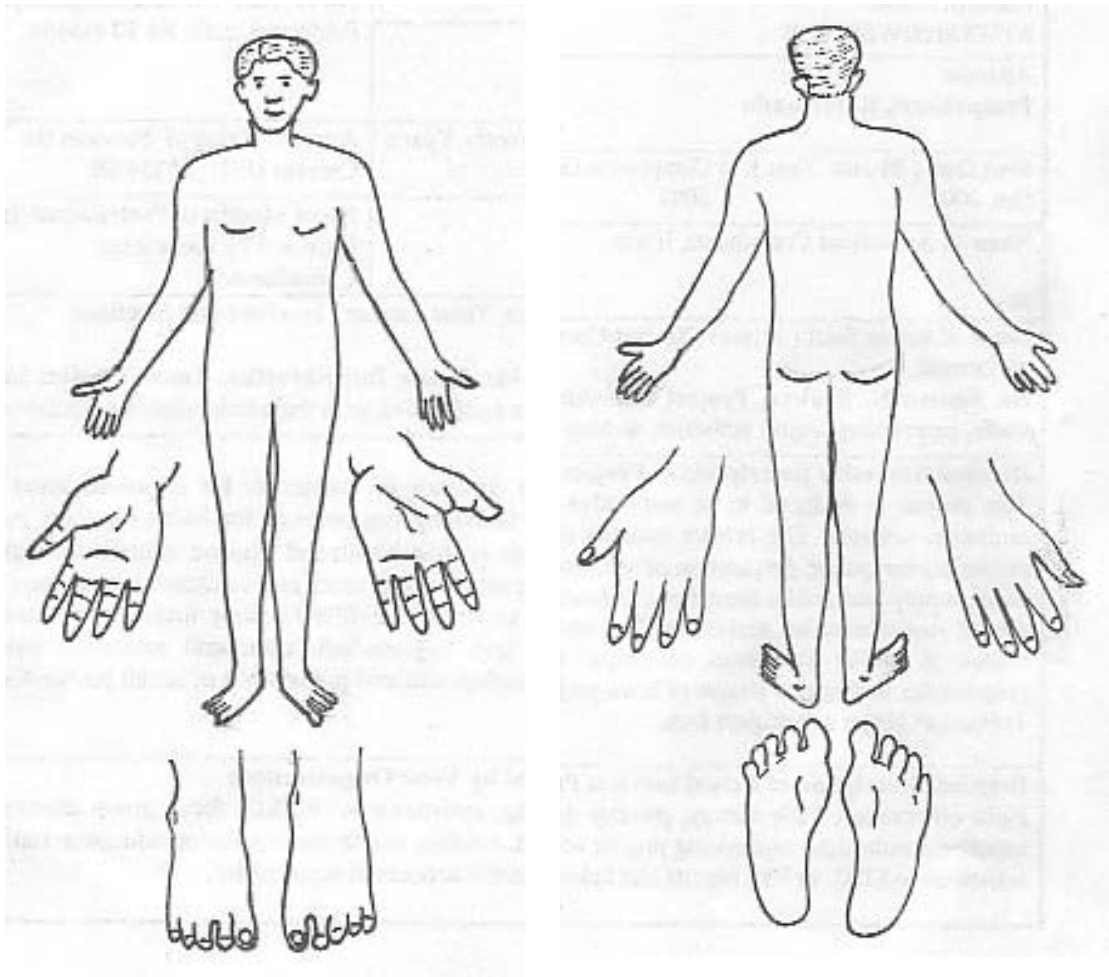
Diabetes Hypertension Cough

Tingling or Numbness Weakness Urinary

5. Do you smoke ? Yes No If YES, duration:yr(s)

1. Do you drink alcohol ? Yes No If YES, duration: yr(s)

Figure for recording location and distribution of skin lesions during examination



Remarks (if any):

.....

.....

.....

.....

Name of Health Worker:

Signature:

Annex-2

List of Arsenic-Related IEC materials

IEC Materials:

1. Documentary on Arsenic and its Health Effects. National Arsenic Steering Committee (NASC).
2. Arsenic ra Hamro Swasthya (Brochure, in Nepali) – National Arsenic Steering Committee (NASC).
3. Arsenic le Swasthya ma Parne Asarharu (Poster, Nepali language) - National Arsenic Steering Committee (NASC).
4. Rampyari Ko Katha (Flash Card, in Nepali) - National Arsenic Steering Committee (NASC).
5. Arsenic Testing (Flip Chart, in Nepali). National Arsenic Steering Committee (NASC).
6. Arsenic-Training Manual (Training Manual, in Nepali). National Arsenic Steering Committee (NASC).
7. Kanchan Arsenic Filter (Brochure, in Nepali) – ENPHO, MIT, RWSSSP, 2062.
8. Kanchan Arsenic Filter (Brochure, in English) – ENPHO, MIT, RWSSSP, 2005.
9. Arsenic Biosand Filter (Kanchan Filter) (Brochure, in English) - ENPHO, MIT, RWSSSP, 2004.
10. Kanchan Arsenic Filter (Pamphlet, in Nepali) – ENPHO/NRCS.
11. Kanchan Arsenic Filter (KAF Sticker, in Nepali). ENPHO/NRCS.
12. Kanchan Arsenic Filter (Promotional Sticker, in Nepali) – ENPHO/NRCS.
13. Kanchan Arsenic Filter (Note Book Sticker, in Nepali) – ENPHO/NRCS.
14. KAF Calender (in Nepali). 2063/2004. ENPHO/NRCS.
15. Kanchan Arsenic Filter (Brochure, in English) – ENPHO, NRCS, MIT, SIMAVI, PAF, UN-Habitat. 2005.
16. Arsenic-related Health Effects (Flex, in Nepali). ENPHO/NRCS, 2005.
17. Field Technician's Handbook on Arsenic Mitigation (in English). NRCS, 2005.
Arsenic ra Hamro Swasthya (Brochure, in Nepali) – National Arsenic Steering Committee (NASC). 2064.

Annex-3

Data set for Surveyed Households

Annex-4

Data set for Water Samples

Annex-5

Data set for Urine Samples

Annex-6

Data set for Hair and Nail Samples

Annex-7

List of Arsenicosis Patients

Annex-8
Photographs
(Arsenicosis cases)



Melanoses on chest



Keratosis on palms and soles



Keratosis on palms and soles



Keratosis on palms and soles



Keratosis on palms and soles



Keratosis on palms and soles



Keratosis on palms and soles