A

Report on

Evaluation Study of Health Impacts Due to Arsenic Contamination in the Selected Communities of Terai Regions in Nepal

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ABBREVIATIONS AND ACRONYMS

µg/L	Microgram per liter
AAN	Asia Arsenic Network
As	Arsenic
ATSDR	Agency for Toxic Substances and Disease Registry
CBS	Central Bureau of Statistics
CCA	Chromated Copper Arsenate
CDES	Central Department of Environmental Science
CDG	Central Department of Geology
DHM	Department of Hydrology and Meteorology
DWSS	Department of Water Supply and Sewerage
ENPHO	Environment and Public Health Organization
FAO	Food and Agriculture Organization
GDWQ	Guidelines for Drinking-Water Quality
IARC	International Agency of Research on Cancer
IOE	Institute of Engineering
IOM	Institute of Medicine
JRCS	Japan Red Cross Society
MCL	Maximum Contaminant Level
MIT	Massachusetts Institute of Technology
NASC	National Arsenic Steering Committee
NP	Nagarpalika
NRC	National Research Council
NRCS	Nepal Red Cross Society
PPb	Parts per billion
RVWRMP	Rural Village Water Resources Management Project
SES	Socio Economic Status
U.S.	United States
UN	United Nations
UNF	United Nations Foundation
UNICEF	United Nation's Children Fund
USEPA	United State Environmental Protection Agency
VDC	Village Development Committee
WHO	World Health Organization

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Dr. L. R. Pathak.

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EXECUTIVE SUMMARY

Arsenic contamination in drinking water has been one of the biggest epidemics of the global concern including Bangladesh, India and Nepal. The long term continued exposure to arsenic leads to Arsenicosis, which has no definite medical cure. Thus, assessment of the socio-economic dimensions of the arsenic hazard becomes a first step toward preventive measure.

The general objective of the study is to evaluate the health impacts of arsenic contamination on human health through drinking water in Ramgram and Lahan Municipality and Swathi, Hakpara, Santpur, Dumariya VDCs of Nawalparasi, Siraha and Rautahat districts respectively. The study sites are selected on the basis of high vulnerability and low uncertainty level. The tools and techniques applied were the Questionnaires, Direct Observation, FGD, Interview and Computer software programming.

In the present study, 312 people were selected from 312 risk households who used to drink water from arsenic contaminated tube wells. The overall percentage of risk tube well (>50 ppb as level) in selected areas was found to be 12.3%. 84(3.0%) in Lahan Municipality, 101(34.6%) in Hakpara VDC, 629(44.4%) in Ramgram Municipality, 23(14.7%) in Swathi VDC, 39(2.7%) in Santapur VDC and 29(2.4%) in Dumariya VDC.The total number of population at risk was found out to be 11204. The overall knowledge of Arsenic among these risk household were found to be low (42%, totally unaware). Two third of the respondent (75.5%) of the community do not purify drinking water. Analysis of community view toward mitigation, 72.3% of respondents preferred Arsenic filters as the immediate mitigation option and 59.3% of them preferred deeper tube wells as the long term mitigation option. The most of the respondents got information about arsenic contamination in the tubewell from the testing campaign of DWSS 68.2% in Nawalparasi, 45.1% in Rautahat and 81.0% in Siraha districts respectvely. The study found out that 67.9% (212 out of 312) respondents said that there was no any institution to response the alternative source of drinking water free from arsenic. Majority of the respondents (74.6%, 232 out of 311) preferred governmental

participation in solving the arsenic crisis. Assessing knowledge of communities whether they are informed of harmful effects of arsenic in drinking water, it was found out that about half of the respondents (49%, 152 out of 310) were aware.

More than two third of the health workers were aware of arsenic in the affected study area (84.3%). Narrowing down the assessment whether they know about the most common features seen during Arsenicosis, more than half of the respondent (51.0%) said that they do not know. 82.4% of the respondents were lacking Arsenicosis diagnosing ability. However, the findings differ from the individual districts. The most interesting part of the result is that none of the health workers are found to be dealing with the Arsenicosis patients. A significant percentage (39.2% out of 51) of the health workers suggested the need of trainings for the health workers in Arsenic and Arsenicosis.

The study found out that there were altogether 6 NGO/INGO, 5 GO and 2 educational institutions (TU) working in the field of arsenic mitigation. The study also found that the coordination among these institutions are lacking. Likewise, the mitigation approaches taken by various institutions could cover up only the fractions of affected people.

Recommendations are made for an immediate unified water resources POLICY with integrated PLANNING and MANAGEMENT. Breadth and depth of household information on Arsenic contamination, its seriousness, and technology options available need to be expanded for which empowerment of local communities can be the potential option of solution of the problem. Health workers need to be trained to provide counseling, assurance and mental support using WHO guide book (manual) on detection, management and surveillance

CHAPTER -1
INTRODUCTION

1.1 Background

1.1.1 Arsenic

Arsenic is a shiny metalloid considered as one of the oldest, most dangerous poisons, and is a well defined contaminant, which has various acute and chronic health effects on the human health. When dissolved in water or in gaseous form, humans cannot detect its presence. Arsenic compounds depending on the intake severely damages human health. Ultimately infected persons die, either immediately and acutely from a variety of effects or indirectly after a chronic exposure, which eventually causes skin and internal cancers, [**WHO:** Environmental Health Criteria 224, Arsenic and Arsenic Compounds, http://www.inchem.org/documents/ehc/ehc/ehc224.htm, 2001].

Groundwater is abundant in lowland Terai region where it is an important resource for domestic and agricultural use. The region is estimated to have around 800,000 tube wells, which supply groundwater for some 11 million people (World Bank, 2004). As of September 2003, 25,000 water analyses of arsenic had been carried out and results indicate that 69% of groundwater sampled had arsenic concentrations less than 10 µg /L, while 31% exceeded 10 µg/ L, and 8% exceeded 50 µg/ L (Tuinhof and Nanni 2003; Shrestha *et al.*, 2004).

Public health services are the cornerstone of efficient public health activities where the role of public health professionals is crucial. These are mandatory for early diagnosis, tracing the spread of infection, and supporting epidemiological studies to understand the disease profile in a community. There is the dire need to increase access, quality, and safety of care of the health professional in Nepal in one hand whereas on the other hand the situation analysis of their existing knowledge is in very nascent stage.

Arsenic mitigation involves coping with the hazard and requires increased public awareness, community, participation, and intervention by the government and non-governmental organizations (Paul). As these interventions are external forces to these rural societies, community participation and societal response to the hazard emerge as the most important internal components of the mitigation process. Awareness and perception of the hazardous impacts of arsenic contamination in drinking water on public health play a very important role in increasing community participation in the mitigation process.

1.1.2 Arsenicosis

Arsenicosis is the effect of Arsenic poisoning, usually over a long period such as from 5 to 20 years. It is caused by exposure over a period of time to arsenic in drinking water. It may also be due to intake of arsenic via food or air. The multiple routes of exposure contribute to chronic poisoning. Arsenic contamination in water may also be due to industrial processes such as those involved in mining, metal refining, and timber treatment. Malnutrition may aggravate the effects of arsenic in blood vessels.
[http://www.who.int/water_sanitation_health/diseases/arsenicosis/en/]

1.2 Rational of the study

Very few research works have been carried out in Nepal in order to assess the knowledge of arsenic and arsenicosis among the health workers and people in the affected regions. Although drinking arsenic- rich water over a long period is unsafe due to its well-known health effects, there are no available medical options that can either block or cure arsenicosis. The preventive measures are only the effective means to combat with the situation. One part of preventive measure is knowledge assessment aiming for strengthening health workers to fight against this burden of the country whereas the other part is assessment of the socio-economic dimensions of the arsenic hazard mitigation. The present study has attempted to cover both important dimensions to address the arsenic issues.

1.3 Objective

The overall objective of the evaluation study is to assess the health impact due to arsenic contamination**.**

Specific Objective

1. To assess the population at risk of arsenic contamination.
2. To assess the knowledge of health workers about arsenic and arsenicosis.
3. To review the mitigation measures and various activities carried out by different organizations.
4. To analyze the effectiveness, sustainability and continuity of those activities.

CHAPTER -2

SOURCES OF ARSENIC CONTAMINATION AND ITS HEALTH EFFECTS

2.1 Physical and Chemical Properties of Arsenic

Arsenic (As) is a silver-gray brittle crystalline solid that also exists in black and yellow amorphous forms. (Welch et al., 1988, Budavari, et al. 1989). The valence states of arsenic are: -3, 0, +1, +3, and +5. Elemental arsenic (valence 0) is rarely found under natural conditions. The +3 and +5 states are found in a variety of minerals and in natural waters. The valence state affects the toxicity of arsenic compounds. While arsine (-3) is the most toxic, the following are successively less toxic: Organo-arsines, arsenites (+3), arsenates (+5), arsonium metals (+1), and elemental arsenic (0). Arsenic species are classified as either organic or inorganic (EPA, 2000).

2.2 Sources of Arsenic

There exist two major types of arsenic sources: Natural and anthropogenic.

2.2.1 Natural Sources of Arsenic

Arsenic occurs in the environment in rocks, soil, water, air, and in biota. Most arsenic in the environment exists in rock or soil (ATSDR, 1998).

2.2.1.1 Earth's Crust

Arsenic is a major constituent of many mineral species in igneous and sedimentary rocks. Among igneous rock types, the highest arsenic concentrations are found in basalts. Sedimentary rocks particularly iron and manganese ores often contain higher average arsenic concentrations than igneous rocks Arsenic may be released from these ores to ground water (Welch *et al.,* 1988).

2.2.1.2 Soil and Sediment

Arsenic concentrations in soils depend in part on the parent materials from which the soils were derived. Because arsenic can be fixed in inorganic and organic compounds in soil, soil may also be a sink for arsenic (EPA, 2000).

2.2.1.3 Geothermal Waters

Geothermal water can be sources of arsenic in surface water and ground water. Flow of arsenic-enriched geothermal water from hot springs may result in high concentrations of arsenic in surface water systems (ATSDR, 1998).

2.2.2 Anthropogenic Sources of Arsenic

From man-made sources, arsenic is released to terrestrial and aquatic environments and to the atmosphere. The anthropogenic impact on arsenic levels in these media depends on the level of human activity, the distance from the pollution sources, and the dispersion and fate of the arsenic that is released (EPA, 2000).

2.2.2.1 Wood Preservatives

Chromated copper arsenate (CCA) is the most widely used wood preservative.

2.2.2.2 Agricultural Uses

Past and current agricultural uses of arsenic and arsenic compounds that include lead arsenate, arsenic trioxide, sodium arsenate, calcium arsenate, copper acetoarsenite (Paris Green), copper arsenate, and magnesium arsenate in various pesticides, herbicides, insecticides, defoliants, and soil sterilants and Arsenic compounds that are currently used in raising livestock as feed additives and for disease prevention may be the agricultural source of arsenic (Azcue and Nriagu, 1994).

2.2.2.3 Industrial Uses and Releases

Arsenic and arsenic compounds are used in a variety of industrial applications like burning of fossil fuels, combustion of wastes (hazardous and non-hazardous), pulp and paper production, glass manufacturing, and cement manufacturing can result in emissions of arsenic to the environment (USEPA, 1998).

2.3 Health Effects of Chronic Arsenic Poisoning

Following long-term exposure (generally 5 to 15 or more years) to arsenic, the first physical changes are usually observed on the skin. Typically this manifests in the appearance of small black or white marks (Melanosis), then thickening of the skin on the palms and the feet (Keratosis), followed by skin lesions and eventually skin cancer. Internal cancers are a late phenomenon, and usually take more than ten years to develop. In advanced stages of arsenocosis, parts of the body develop gangrene, making the victims appear similar to leprosy patients. The early symptoms of arsenicosis (eg. Melanosis) appear to be reversible and/or can be arrested if exposure to arsenic-contaminated water is avoided (UNF, 1999).

With history of chronic arsenic exposure and arsenical skin lesions, other indicators of chronic arsenicosis are: Weakness, Anemia, Peripheral neuropathy, Hepatomegaly with portal zone fibrosis (with/without portal hypertension), Chronic lung disease and Peripheral vascular disease. Infrequent manifestations, which have been reported to occur by some investigators in people giving a history of chronic arsenic exposure and which may be arsenic unrelated are: Conjunctivitis, Keratitis, Rhinitis, Cardiovascular disease, Gastrointestinal disease, Hematological abnormalities, Cerebrovascular disease, Dysosmia, Perceptive hearing loss, Cataract, Nephropathy, Solid edema of the limbs, and Diabetes mellitus (Mazumder *et al.,* 1998).

2.4 Diagnosis of Chronic Arsenic Poisoning

Although chronic arsenic toxicity produces varied non-malignant manifestations as well as cancer of skin and different internal organs, dermal manifestations such as hyper pigmentation and hyperkeratosis are diagnostic of chronic arsenicosis (Mazumder 2000).

Arsenical hyperkeratosis appears predominantly on the palms and the plantar aspect of the feet, although involvement of the dorsum of the extremities and the trunk has also been described. An indurated, gritlike advance to form raised, punctated, 2-4 mm wart like keratosis that are readily visible (Tay, 1974).

A history of arsenic exposure through inhalation or ingestion is helpful in corroborating a diagnosis of arsenicosis. Spotty raindrop pigmentation of the skin distributed bilaterally and symmetrically over trunks and limbs is the best diagnostic feature of arsenical hyper pigmentation. The duration of the patient's arsenic exposure with the date of onset of symptoms does not follow a particular time frame. Hence, a history of chronic arsenic exposure for more than 6 months is essential for diagnosis of arsenic related skin manifestation (Mazumder, 2000).

Diagnostic criteria for Blackfoot disease include objective signs of Ischemia, i.e., absence or diminution of Arterial pulsation, Pallor on elevation or Rubor on dependency of Ischemic extremities and various degrees of Ischemic changes in the skin, as well as subjective symptoms of Ischemia, i.e., Intermittent claudication, Pain at rest, and Ischemic neuropathy (Mazumder, 2000).

Skin cancer of chronic arsenicosis have lesions that are frequently multiple and involve covered areas of the body, contrary to non arsenical skin cancer which usually presents as a single lesion and which occur in exposed parts of the body (Tseng, 1977; Zaldivar *et al.,* 1981).

2.5 Global Distribution of Arsenic Contamination

The extent of the arsenic problem world-wide is as yet unknown. Before arsenic was identified as the unambiguous cause of wide-scale health problems in Bangladesh, such occurrences were considered relatively isolated. Although the exact global scenario of the problem is yet to be revealed the problem globally has been found to exist in different parts of the world. A number of large aquifers in various parts of the world have been identified with problems from Arsenic occurring at concentrations above 50 µg/l Often significantly so, the most noteworthy occurrences are in parts of Argentina, Bangladesh, Chile, Northern China, Hungary, India (West Bengal), Mexico, Romania, Taiwan and many parts of the USA, particularly the south-west. These include natural sources of contamination as well as mining–related sources. Arsenic associated with geothermal waters has also been reported in several areas, including hot springs from parts of Argentina, Japan, New Zealand, Chile, Kamchatka, Iceland, France, Dominica and the USA. Mining related arsenic problems in water have been identified in many parts of the world, including Austria, Ghana, Greece, India (Madhya Pradesh), South Africa, Thailand and the USA.

2.6 Exposed Population in Nepal

According to the population census data 2001, the population of Nepal is 23.4 million. Out of this about 10.4 million people (45% of total) live in 20 Terai-districts of Nepal, were about 8 % of total tube wells were found contaminated, in average. Since ninety percent of the Terai population (9.4 million) is supposed to use tube wells for their drinking and others purpose, eight percent of its population, i.e. 0.75 million is estimated as the exposed population (RVWRMP, 2004). If the estimation is made according to individual district-population and its exposed-population, this total exposed-population lowers to 0.46 million. In case of the affected area one can estimate the total Terai area that is 30000 km^2 as the arsenic-affected area. So far, only few studies about prevalence of arsenicosis have been done in Nepal. From the studies, it is estimated that about 2.6 % of the total population, exposed to arsenic contaminated water with a concentration more than 50 ppb, have a prevalence of arsenicosis (RVWRMP, 2004).

The present estimation of number at risk population from arsenic in drinking in Nepal is 0.3 million which is 3.4% of the total population. Similarly, the number of arsenicosis patients identified so far counts 8,600 (World Bank, 2005)

2.7 Maximum Permissible Level of Arsenic in Drinking Water

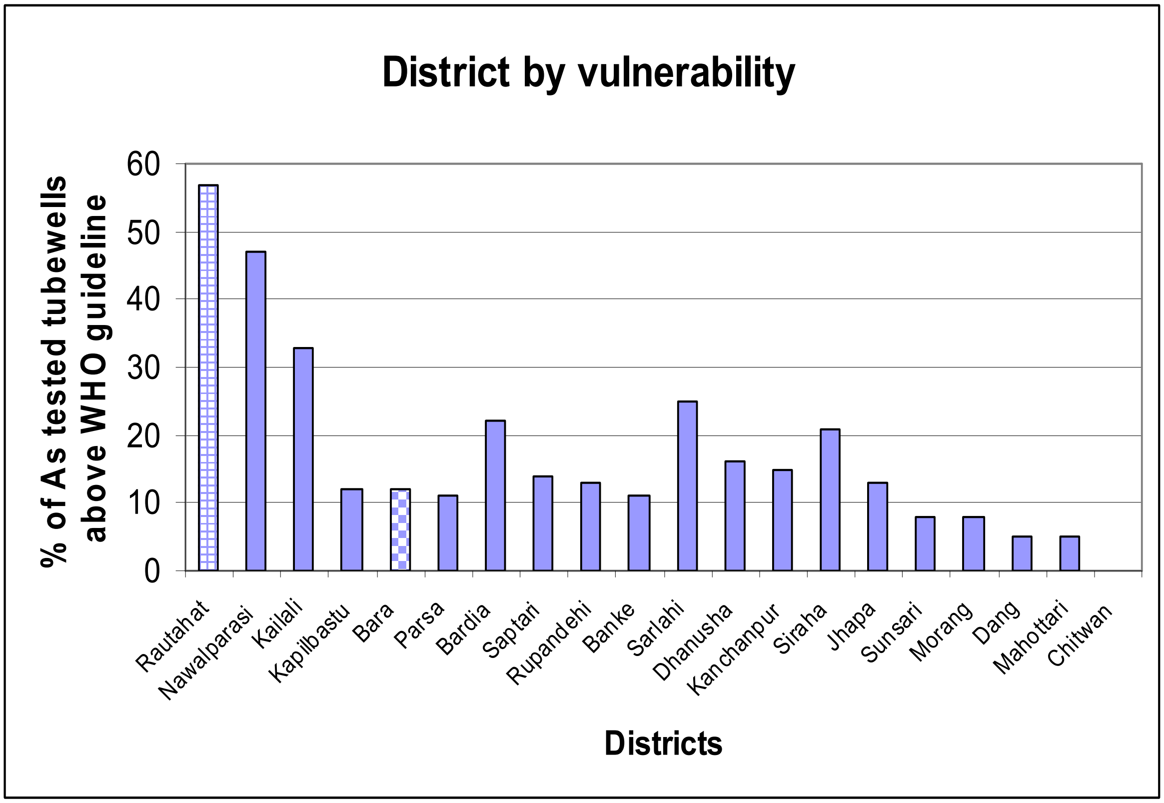
The world health organization (WHO) has fixed a provisional guideline for maximum concentration of arsenic in water is tolerable for human body. Under the guideline, the WHO recommended that the concentration 0.01 mg/liter arsenic in water is safe and tolerable. This is the provisional guideline and it is not compulsory to follow. In Nepal, the maximum permissible level of arsenic in water has been fixed at 0.05mg/litre. The standard is different in Europe, America and other regions.

Table 1: Districts by vulnerability and uncertainty levels

Districts by vulnerability and uncertainty levels				
District	**Vulnerability**		**Uncertainty**	
	Level	**% Of As tested TW above WHO guideline**	**Level**	**Proportion of HH using As tested TW to total HH (%)**
Rautahat	High	57	Low	27
Nawalparasi	Mod. High	47	Medium	17
Kailali	Mod. High	33	High	1
Kapilbastu	Moderate	12	Low	27
Bara	Moderate	12	Low	28
Parsa	Moderate	11	Low	34
Bardia	Moderate	22	Medium	11
Saptari	Moderate	14	Medium	7
Rupandehi	Moderate	13	Medium	15
Banke	Moderate	11	Medium	7
Sarlahi	Moderate	25	High	3
Dhanusha	Moderate	16	High	2
Kanchanpur	Moderate	15	High	1
Siraha	Moderate	21	High	3
Jhapa	Moderate	13	High	1
Sunsari	Moderate	8	High	1
Morang	Moderate	8	High	1
Dang	Moderate	5	High	1
Mahottari	Moderate	5	High	5
Chitwan		0	High	1

Source: The state of Arsenic in Nepal, 2003

Fig No 1



Source: The state of Arsenic in Nepal, 2003

CHAPTER-3
REVIEW OF PAST WORK ON ARSENIC IN NEPAL

DWSS & WHO (1999) carried out the first Nepalese studies on arsenic in groundwater followed by NRCS & JRCS (2000). Both studies provided evidence of arsenic contamination in Terai region of southern Nepal. Furthermore, an initial health survey in 2001-2002 found evidence of arsenic-related Dermatosis and elevated amounts of arsenic in human hair and nail samples in four districts where tube well drinking water contained arsenic above 50 ppb (parts per billion). This initial evidence of arsenic contamination and associated health effects led to the creation of the National Arsenic Steering Committee (NASC) to help coordinate efforts by government and non-government agencies to address the potential problems of arsenic contamination in the rapidly growing region of southern Nepal. **Sharma (1999)** carried out study on possible contamination of groundwater with arsenic in Jhapa, Morang and Sunsari, Eastern Terai. Out of 268 water samples tested for arsenic, 244 of them were found safe (below WHO guideline, 10 ppb) 2 of them showing a concentration level higher than 50 ppb. Most of the contaminated samples lie within active flood plains near Koshi River. **Tandukar N. (2000)** conducted a study to explore the severity of arsenic contamination of groundwater in Rautahat district of central Terai in Nepal. The results shows that some samples exceeded WHO drinking water quality standard and few of them exceeded India and Bangladesh standards. High Arsenic is found to be associated with high iron content. Arsenic contamination is found to be higher in shallow aquifer and most of the contaminated tube wells are located in active flood plain of River Bagmati. It is found that the concentration of arsenic in groundwater of the study area does not remain constant throughout the year. Villagers were using arsenic contaminated water without taking any precautions and without having any knowledge about the severity and ultimate effects of arsenic. Hence people, especially women of the affected area, should be made aware of Arsenicosis, its prevention and precautions to be adopted. **Khatiwada *et al.* (2002)** reported a study to evaluate the extent and sources of groundwater contamination in Kathmandu Valley, Nepal. Water sampling was carried out in selected deep wells and shallow sources to check the arsenic, iron, manganese and sulfate. Both natural and anthropogenic water quality problems were observed in the groundwater system of Kathmandu valley. **NRCS JRCS and ENPHO (2001)** collaboratively conducted a household survey on the health impact of arsenic contaminated ground water in Parsa district under the drinking water quality improvement program. A total of 473 households with 3,579 populations were surveyed with a questionnaire. Out of that, a population of 2,732 present at the time of the survey was observed to detect the arsenicosis-like skin problems. Overall prevalence of the arsenicosis among the exposed population was 1.8 percent. Recommendations made were to continue an ongoing water testing and survey or research programs, replacement of water supply with non-contaminated sources (surface water or deep bored tube-wells) or containment programs, appropriate nutritional education, palliative treatment and follow-up observation of detected cases. **NRCS and ENPHO (2003)** made a cross-sectional, descriptive type study on arsenic status of the tube wells installed by NRCS in Rautahat district. The study was carried out from October 2001 to May 2002 with the objectives of identifying arsenic related health problems, analyzing mitigation measures adopted by NRCS and providing appropriate strategy as recommendations for prevention and management of arsenicosis. Altogether 815 NRCS installed tube wells from 25 VDCs have been considered for the study, of which 157 tube wells are found to have arsenic concentration above acceptable level (>50 ppb). A total of 1,338 households with 7,441 persons exposed to arsenic contaminated drinking water (> 50 ppb) for more than 2 years have been considered for the study. A total of 167 are confirmed to have symptoms, Melanosis on the trunk and Keratosis on the palm. The prevalence rate of arsenicosis was 2.2% among the exposed population. **Sah *et al.* (2003)** carried out a study on possible natural sources of arsenic poisoning of ground water in Terai Plain of Nepal. Studied found out that aquifer sediments of Terai Plain do not contain sulphide minerals like pyrite, arsenopyrite, galena and sphalerite but it contains Fe-concretions, Fe-coatings rich in arsenic and possible, they represent the immediate source of arsenic in groundwater of Terai Plain. There is less possibility of groundwater contamination by arsenic from the recharge zone. **Kanel *et al.* (2004)** conducted a study entitled "Arsenic Contamination in Groundwater in Rautahat, Nepal". This study is directed to investigate the occurrences of arsenic contamination and its mechanism to release in groundwater in Gaur Municipality, Rautahat District, Nepal. In the observation, the groundwater was found to be rich in iron, manganese and bicarbonates, which support iron reduction hypothesis as the main mechanism of mobilization of arsenic in the groundwater. The arsenic concentration was varied from 0 to 62µg/L in groundwater samples from shallow tube wells. Among analyzed samples, 2 % exceeded 50 µg/L concentration and 36 % were between 10-50 µg/L concentrations and rest of samples (62%) were below 10 µg/L concentration. The high arsenic concentration found in large number of tube wells indicates that several million people are consuming arsenic contaminated water (without any pretreatment) at serious risk of arsenic poisoning. However, there is no counter treatment of arsenic diseases and arsenic remediation is the only one option to save the lives of millions of people. **Ahamed *et al.* (2004)** carried out a study in two rural villages of Nawalparasi district, where the existence of arsenic contamination has been reported. Almost all tube wells in one of the two villages (Goini, G) exceeded (ranging from 0.104 mg/L to 1.702 mg/L) the maximum permissible limit for arsenic in drinking water in Nepal (0.05 mg/L), and only a few tube wells (19.5%) in the other village (Kunuwar Big, KB) were below this level (0.004 mg/L to 0.972 mg/L). Prevalence rates of arsenicosis diagnosed on the basis of the presence of dermatological manifestations were 11.3% (56 out of 495 examined) and 6.5% (34/525) in G and KB, respectively, with an overall prevalence rate of 8.9%. **World Bank (2005)** mentions that the present estimation of number at risk population from arsenic in drinking in Nepal is 0.3 million which is 3.4% of the total population. Similarly, the number of arsenicosis patients identified so far counts 8,600. **Adhikari (2006)** carried out a cross-sectional study to sketch out the impacts of arsenic contamination on human health through drinking water in Santpur VDC, Rautahat District, Nepal. 124 people were examined from 36 risk households who used to drink water from 42 tube wells. The overall prevalence of arsenicosis symptomatic patients among the risk household of Santpur VDC was found to be 15.3% (19 out of 124). The study recommended that Proper investigations need to be carried out to define the various clinical manifestations of arsenicosis. **Pathak, (2005)** conducted a study on Detection and management of arsenicosis in the selected local communities of Terai regions of Nepal. The study revealed that in Rautahat, 93.33% of the health workers were not familiar with arsenicosis cases and that of Bara was 70%. Out of 250 household sampling done, 4.78% of population is affected from arsenicosis problem. The study revealed that maximum populations are being affected above 25 years of their age.

CHAPTER- 4

METHODOLOGY

4.1 Description of the Study Area

4.1.1 Rautahat District

Rautahat district is situated in Narayani zone and belongs to central region. The total area of the district is 1126 sqkm. Geographically the area lies between the latitude $26^{\circ}45^{1}00^{11}$ to $27^{\circ}15^{1}00^{11}$ North and the longitude $85^{\circ}10^{1}00^{11}$ to $85^{\circ}30^{1}00^{11}$ East and confined to the Terai plain. The study area is bordered on the north by Makawanpur district, Sarlahi district on the east, Bara district on the west and the Bihar state of India on south.

Physiographically, the district can be divided into the Churia hills in the north and the Terai region in the south. The Terai region can be further divided into densely forested higher altitude Bhabar zone in the north and the alluvial plane in the south. The maximum and minimum altitude of the area is 865m and 72m, amsl respectively.

The total population of Rautahat district is 4, 14,005 where male and female population is 213,994 and 200,011 respectively. Density of population is 368 per square kilometers. Road facilities and development of semi-urban centers makes the district densely populated. Most of the people are crowded within the urban centers where as the population density of rural area seems comparatively low. The community of the district is of mixed type where People of various religion, casts, and ethnic groups are present. Agriculture is the main occupation in the rural part.

There is only one government hospital is the district which is located in the district headquarter, Gaur. There are no any health centers in the district. There is one Primary health centre, 2 Ayurvedic clinics, 10-health post, and 47 sub-health post in the district. According to the population census data 2000, doctor population ratio for the district is 1:82,801 (CBS, 2000).

4.1.2 Santpur VDC

Santpur VDC lies 8 km west of Chandranigahapur on the way to district headquarter Gaur. The total population of the village accounts for 12,647 where 6488 are males and

6159 are females. The total household in the village is 2482. Considering the population and total household, average household size of the village is 5.68 family members per household. About 41.5 percent of the total population of this village is literate.

4.1.3 Dumariya VDC

Dumariya VDC lies adjacent to Santpur VDC. The total population of the village is 12,993 where 6,619 are males and 6,374 are females. The total household in the village is 2,166. Considering the population and total household, average household size of the village is 6 family members per household. About 41.3 percent of the total population of this village is literate.

4.1.4 Nawalparasi District

Nawalparasi is located in Lumbini zone of the Western Development Region of Nepal, which covers a total area of 2,162 square kilometers. It is bounded by Palpa and Tanahun districts on the north, Rupandehi and Palpa districts on the West, Chitwan and Tanahun districts on the east and Chitwan districts and UP state of India on the South. Elevation of the district ranges from 91m-1936m above the sea level. Geographically the area lies between the latitude $7^{\circ}21^{1}00^{11}$ to $27^{\circ}47^{1}00^{11}$ North and the longitude $83^{\circ}36^{1}00^{11}$ to $84^{\circ}25^{1}00^{11}$ East and confined to the Terai plain. It is drained by Narayani and other small tributaries.

There are 73 VDCs and 1 municipality (Ramgram) in the district. Parasi Bazar is the district headquarter. The district is inhabited by 5,62,090 population with an annual growth rate of 2.54 (Population census, 2001). Majority of the population of the district speak Bhojpuri, Tharu and Nepali languages.

Health facilities in the district seem poor. There is only one government hospital is the district which is located in Ramgram municipality. There are five Primary health centre, 6 Ayurvedic clinics, 8-health post, and 63 sub-health post in the district.

4.1.5 Swathi VDC

The total population of the village is 9,702 where 4,903 are males and 4,799 are females in 1,645 total household. Considering the population and total household, average household size of the village is 5.9 family members per household. About 56.6 percent of the total population of this village is literate.

4.1.6 Ramgram Municipality

The total population of the municipality accounts for 22,630 where 11,570 are males and 11,060 are females in total household 3,893. Considering the population and total household, average household size of the municipality is 5.81 family members per household. About 54.1 percent of the total population of this municipality is literate.

4.1.7 Siraha District

Siraha district is situated in Sagarmatha zone and belongs to eastern developmental region. The total area of the district is 1188 sqkm. Geographically the area lies between the latitude $26^{\circ}37^{1}00^{11}$ to $26^{\circ}16^{1}00^{11}$ North and the longitude $88^{\circ}05^{1}00^{11}$ to $88^{\circ}32^{1}00^{11}$ East and confined to the Terai plain. The Siraha district is bordered on the north by Udayapur district, Saptari district on the east, Dhanusha district on the west and the Bihar state of India on south.The maximum and minimum altitude of the area is 895m and 76m, amsl respectively.

The total population of Siraha district is 572,339 where male and female population is 293,933and 278,466 respectively. Density of population is 482 per square kilometers. The community of the district is of mixed type where People of various religion, casts, and ethnic groups are present. Agriculture is the main occupation in the rural part.

There are two government hospital, three Primary health centre, 3 Ayurvedic clinics, 12-health post, and 93 sub-health post in the district.

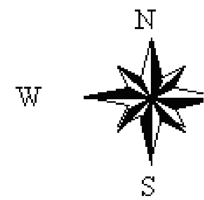
4.1.8 Hakpara VDC

The total population of the village accounts for 4242 where 2167 are males and 2075 are females. The total household in the village is 733. The average household size of the village is 5.79 family members per household. Among total population, about 16.1 percent is literate.

4.1.9 Lahan Municipality

The total population of the municipality is 27,654 where 14,532 are males and 13,122 are females. The total household in the municipality is 5,262. Considering the population and total household, average household size of the village is 5.26 family members per household. About 55.8 percent of the total population of this village is literate.

STUDY DISTRICTS



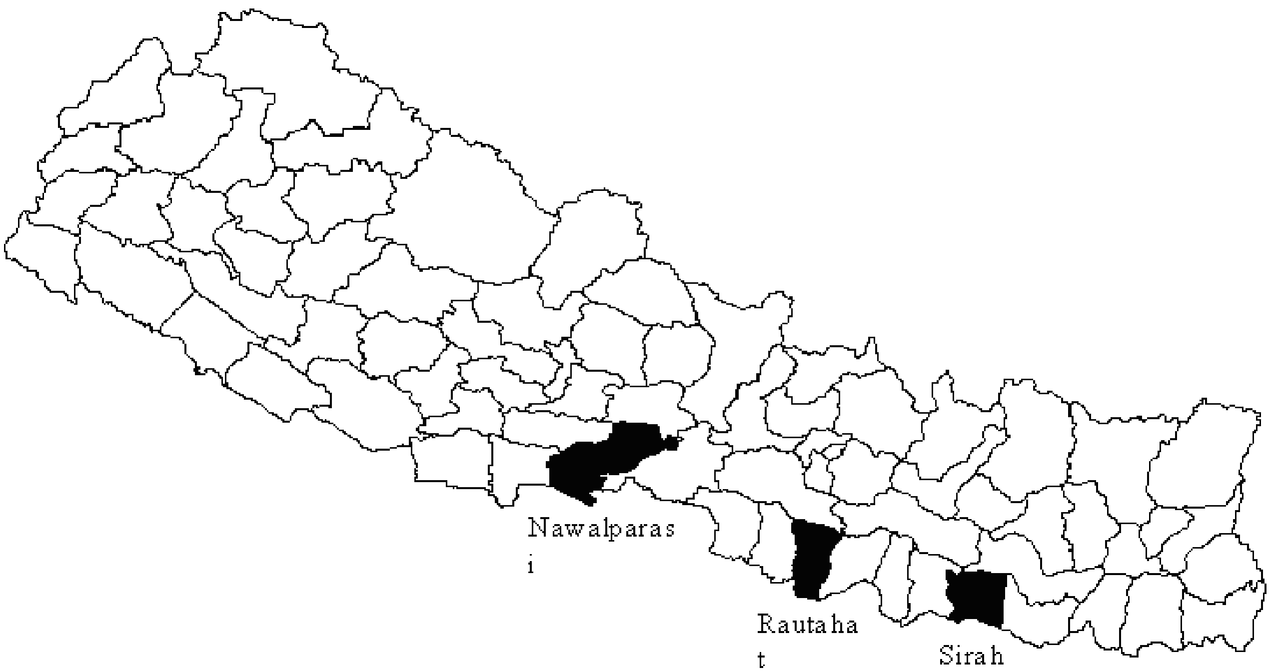


Table 2: Selected Sites and their Relevance for the Study

Districts	Vulnerability Level	Uncertainty Level	Proportion of HH using As tested tubewells to the total HH (%)	Selected Communities	Total pop^n	Vulnerability	Uncertainty Level	Proportion of HH using As tested tube-wells to the total HH(%)
Nawalparasi	Moderately High	Medium	17%	Ramgram Municipality	22,630	4 (high)	4 (low)	61%
				Swathi VDC	9702	3(Modertely high)	3 (Low)	43%
Rautahat	High	Low	27%	Santapur VDC	7835	4 (high)	2	37%
				Dumariya VDC	12993	4 (high)	2	17%
Siraha	Moderate	High	3%	Lahan Muncipality	23988	3 (high)	1	3%
				Hakpara VDC	4242	1	1	10%

Source: The State of Arsenic in Nepal, 2003

4.2 Study Design

This is a cross-sectional study conducted in the targeted study area to assess the existing water use and to know the knowledge of arsenic and arsenicosis among the health professionals and targeted communities of Terai districts. Health workers were purposively selected from respective hospitals, health post and sub health posts to assess their knowledge. Households exposed to high level of arsenic concentration in drinking water were selected on the basis of blanket testing data of DWSS (2004). In this regard, 312 households using tube well water with high arsenic concentration were selected. The targeted household was defined as a risk household in this study. The overall respondents/institutions were selected for health professionals and also institutional assessment at central level. The schematic diagram of the study design is shown in the (Figure No 2)

Fig No 2

Study Design

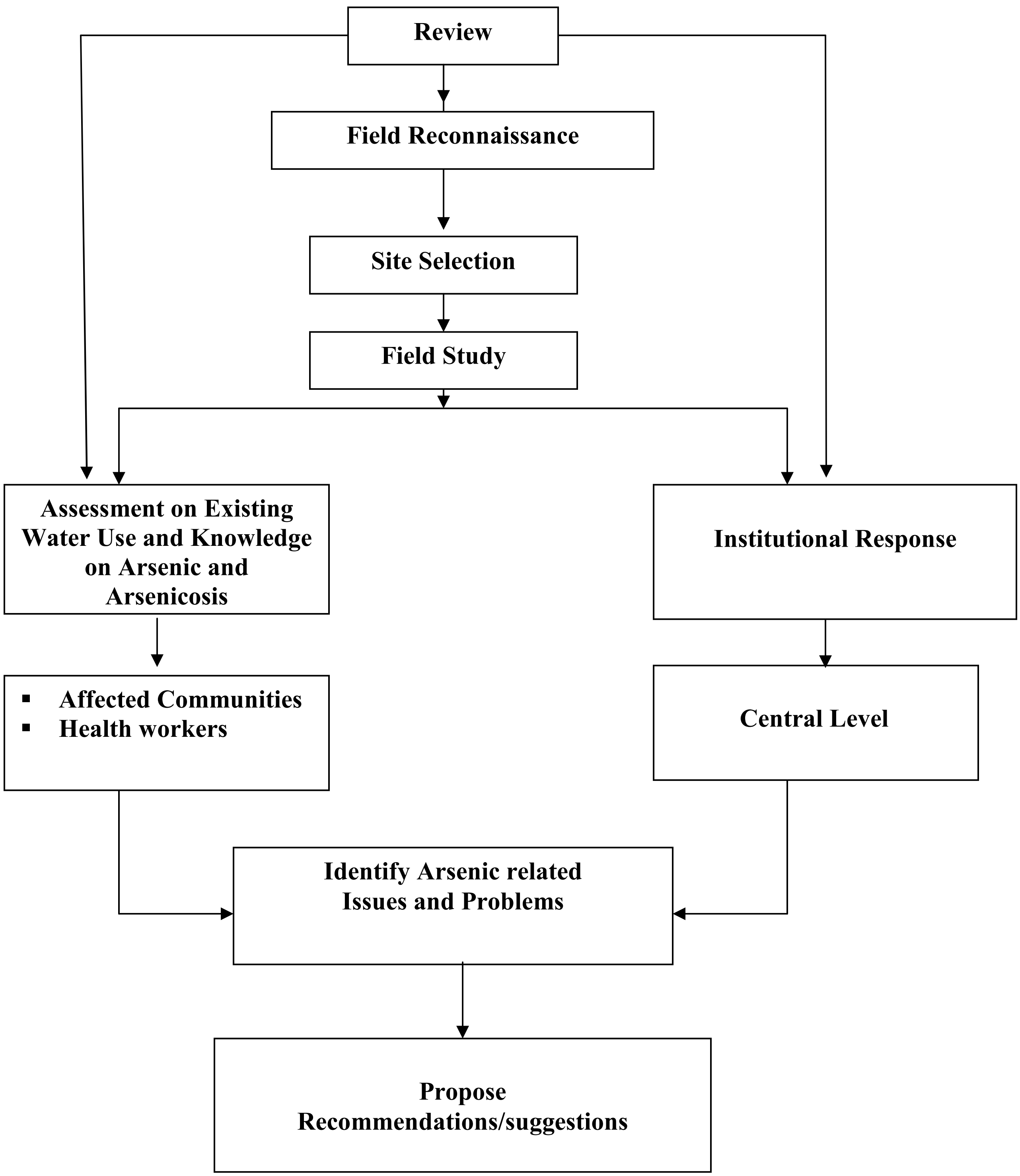
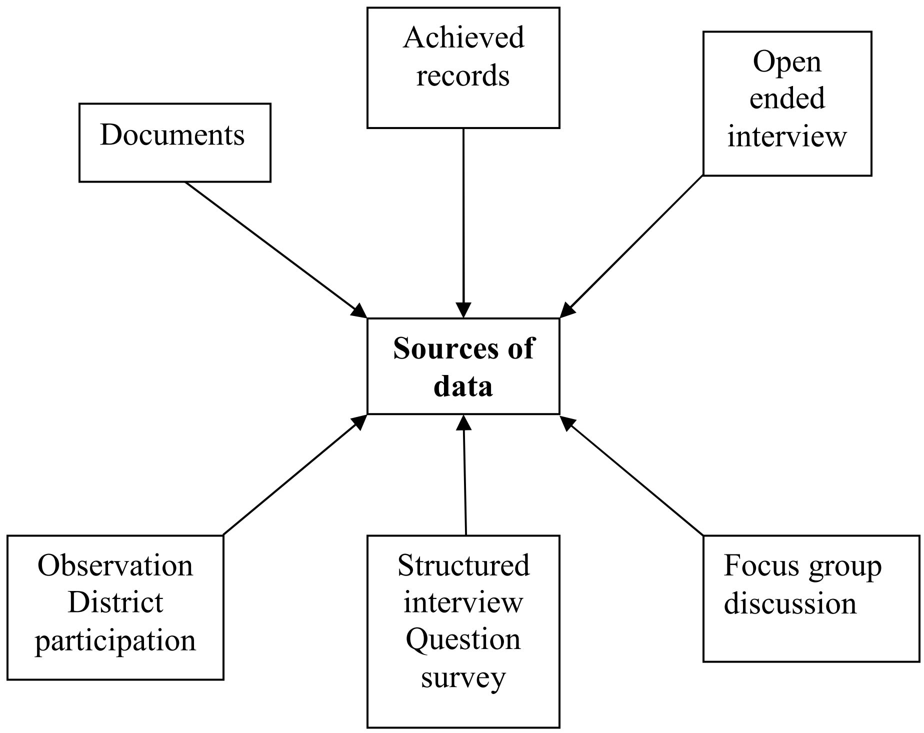


Fig No 3

Sources of Data



Diagrammatic Representation

4.3 Inclusion and Exclusion Criteria for the Community and Health Survey

4.3.1 Inclusion Criteria

1. Family head was the key informant for assessing the knowledge about arsenic, its human health impacts and mitigation measures among the community.
2. Family members included in the list of DWSS data were included.

4.3.2 Exclusion Criteria

1. Members of household other than mentioned in the DWSS were excluded.
2. Visitors or guests of household were excluded in all kinds of data collection.

4.4 Ethical Considerations

Before data collection, the purpose and the procedure of this study were explained to the household head or key informant and other interested family members. Participation of the subjects in all kinds of data collection was voluntary.

4.5 Collection of Relevant Data through Questionnaire

Data was collected through detailed fieldwork conducted from March 20 to April 20, 2006. A total of 312 sample households were selected and surveyed from the study areas. A detailed questionnaire was used to conduct the interview with the head of each household. The questionnaire contained questions regarding the sources of drinking water, socio-economic conditions of the households, perception of arsenic contamination of drinking water. All the questions were asked in Nepali since most villagers did not speak nor understand English. Data was cross-tabulated and interpreted to explore the respondents' water use trend, knowledge and perception of the arsenic hazard, its mitigation process, and its variation among various socio-economic groups.

4.6 Collection of Information from Central Level Organization

Structured questionnaires were administered to the chief of the central level organization working in the field of arsenic. Repeated follow-up visit was made to them to ensure the original information.

4.7 Data Processing and Analysis

4.7.1 Data Editing

Data were edited as soon as possible to detect errors, mission and to make sure that the data were accurate, uniform and well arranged.

4.7.2 Coding

Information was coded so that they were easily classified and tabulated.

4.7.3 Classification and Tabulation

All the data were classified according to the need of the objectives and tabulation was done for summarizing the data and displaying statistically.

4.7.4 Data Analysis

Data were analyzed by means SPSS 14.0 version, table, bar diagram, multiple bar diagram, pie chart.

4.8 Limitations of the Study

1. This study is limited to the households selected based upon the information provided by the DWSS. In some cases, the information of DWSS was found to be misprint.
2. Because of the domestic conflicts and time limitation the regular arrangement of field visit was disrupted.

CHAPTER -5
RESULT AND DISCUSSION

5.1.0 Study Finding of Community Survey

5.1.1 Distribution of Arsenic Concentration in Tube well by Risk Level

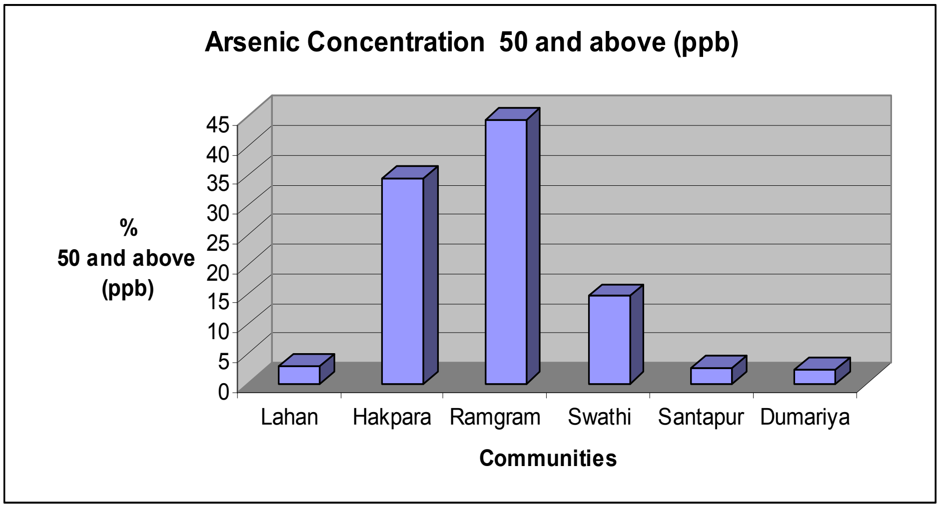
Analyzing the data provided by Department of Water Supply and Sewerage (DWSS), 905(12.3% of 7362) tube wells were found to have arsenic contamination above 50 ppb. The highest percentage of tube wells with arsenic level above 50 ppb was found in Nawalparasi district (629 out of 1417, 44.7%) followed by Hakpara (101 of 292, 34.6%). Out of total 7362 samples within all the selected 6 VDCs/Municipality, majority (4372 out of 7362, 67.5%) was found out to be within the safe limit of WHO (10 ppb). 1485 out of 7362, 20.2% of the tested tube wells were found within the range of 10-50 ppb which is above the WHO standard; however lies within the Nepal's Standard. The individual VDC and Municipality arsenic concentration in drinking water by risk level is presented in table 3.

Table 3: Distribution of Arsenic Contamination in Tube well by Risk Level

Communities	Arsenic concentration in ppb			Total
	0-10	10-50	50 & above	
Lahan Municipality	2380(84.1%)	366(12.9%)	84(3.0%)	2830
Hakpara VDC	52(17.8%)	139(47.6%)	101(34.6%)	292
Ramgram Municipality	494(34.9%)	294(20.7%)	629(44.4%)	1417
Swathi VDC	92(59.0%)	41(26.3%)	23(14.7%)	156
Santapur VDC	998(67.9%)	433(29.5%)	39(2.7%)	1470
Dumariya VDC	956(79.9%)	212(17.7%)	29(2.4%)	1197
Total	4972(67.5%)	1485(20.2%)	905(12.3%)	7362(100.0%)

Source: DWSS, 2006

Fig No 4



Arsenic Contamination in Tube Well by Risk Level

5.1.2 Population at Risk

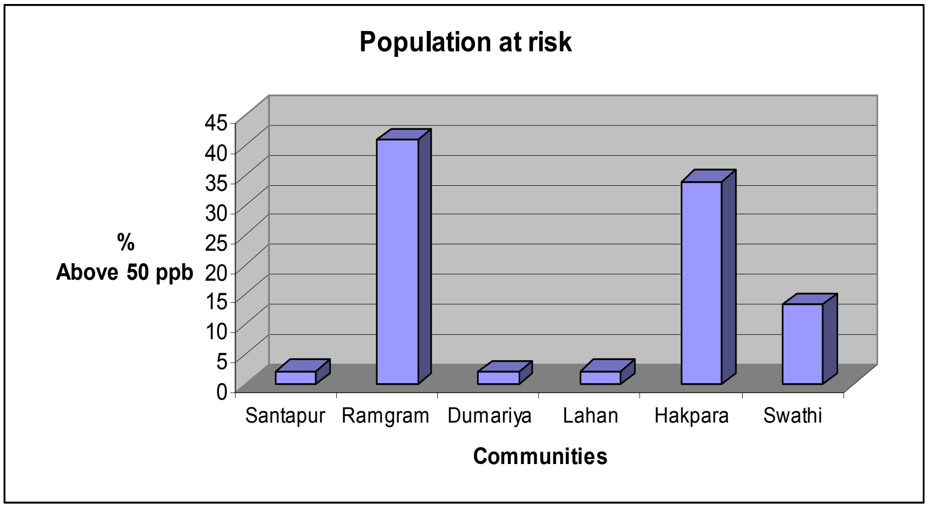
Considering the Guideline adopted by Nepal (50ppb) as safe, the population consuming water above this value was considered a population at risk. The total number of population at risk was found to be 11204. Ramgram Municipality was found to have high percentage (40.87%, 7910) of population at risk, following Hakpara VDC with 1476 persons (33.97% of the total population consuming tube well water). Population at risk of the individual study area is presented in table 4.

Table 4: Population at Risk

Population at risk	
Communities	above 50 ppb
Santapur VDC	383 (2.11%)
Ramgram NP	7910 (40.87%)
Dumariya VDC	339 (2.06%)
Lahan NP	898 (2.15%)
Hakpara VDC	1476 (33.97%)
Swathi VDC	198 (13.34%)
Total	11204

Source: DWSS 2006

Fig No 5



Source: DWSS, 2006

5.1.3 Characteristics of Respondents

A total of 312 households were selected for the survey in 4 VDCs and 2 Municipalities of 3 districts on the basis of arsenic contaminated water. Of the 312 respondents, six age groups were classified. Three age groups: 25-34, 35-44 and 45-54, which consisted a majority of respondents (61.85%), were having respondents in nearly equal proportion. All the respondents were above the age of 18 years. Among them majority were males (64.10%) and the rest (35.89%) were females. The distribution of age group with respect to the gender is given in table 5.

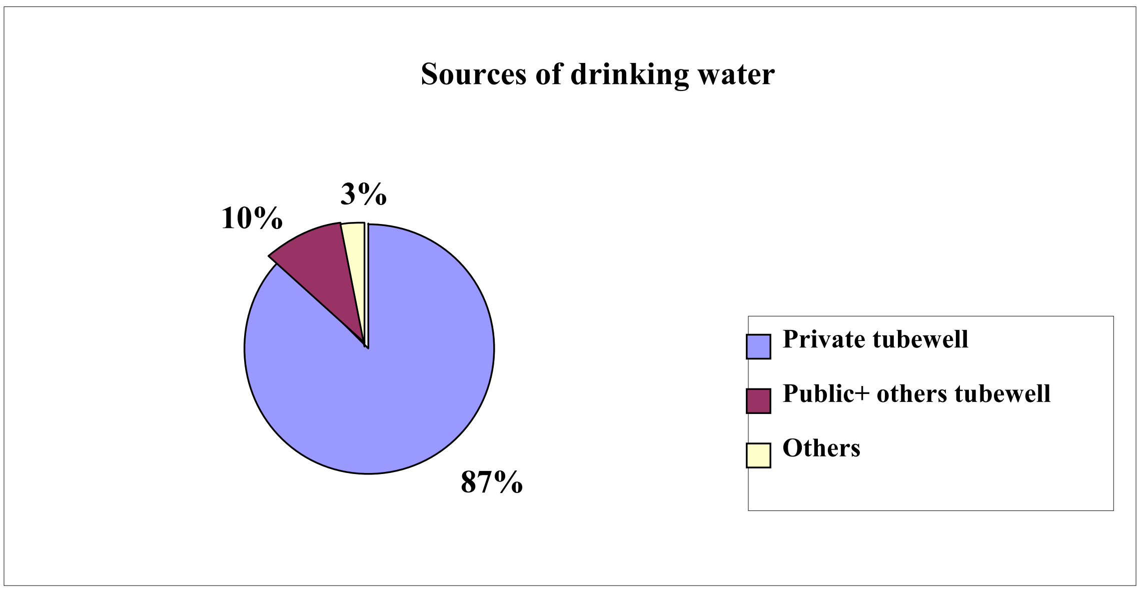
Table 5: Distribution Respondents by Age group and Gender

Age group (Year)	Male		Female		Total No(%)
	No.	%	No.	%	
18-24	33	10.57	23	7.37	56 (17.9%)
25-34	34	10.89	31	9.93	65 (20.83%)
35-44	41	13.14	22	7.05	63 (20.19%)
45-54	47	15.06	18	5.76	65 (20.83%)
55-64	20	6.41	8	2.56	28 (8.97%)
65+	25	10.06	10	3.20	35 (11.21%)
Total	**200**	**64.10**	**112**	**35.89**	**312**

5.1.4 Sources of Drinking water

Most of the respondents of the communities (87%) had their own tube well. Other 10% of the respondents were dependent upon the others tube well. Almost the entire respondents depending upon the others tube well were doing so because of their consciousness of the harmful effects of drinking arsenic contaminated water. Rests of the 3% respondents were using other sources of water like tap, dug wells etc.

Fig No 6



Sources of Drinking water

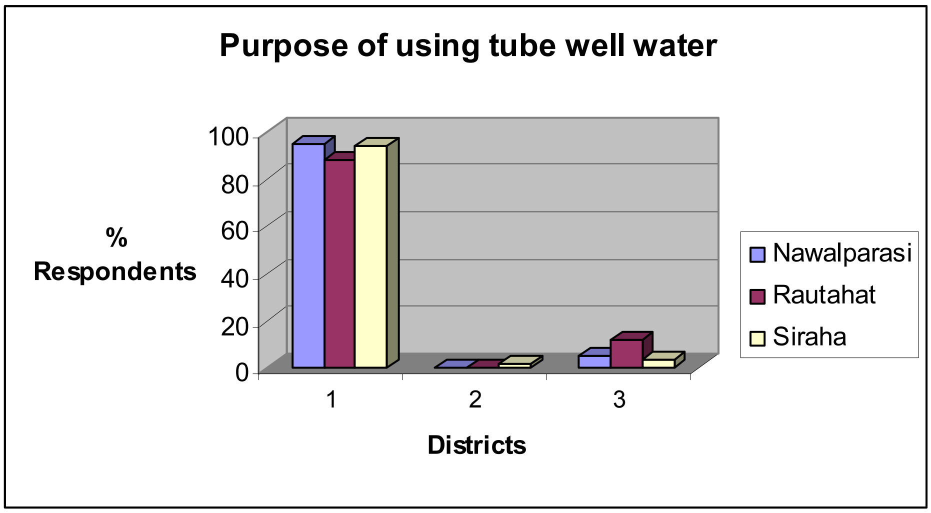
5.1.5 Tube well water Usage:

Almost all of the respondents were using tube well water for all purpose including drinking and cooking 95%, 88.18%, and 94.11% in Nawalparasi, Rautahat and Siraha districts respectively. Others were using for other purposes like washing clothes, washing dishes, feeding livestock etc 5%, 11.82%, 5.89% in Nawalparasi, Rautahat and Siraha serially. According to the respondents, the major reasons for changing from own tube - well to other was due to the existence of high arsenic in water.

Table 6: Purpose of Using Tube well water

Purpose of using tube well water	District			Total
	Nawalparasi	Rautahat	Siraha	
For all purposes	95 (95%)	97 (88.18%)	96 (94.11%)	288 (92.30%)
Not usage of tube well water	0 (0%)	0 (0%)	2 (1.96%)	2 (0.64%)
Using for other purposes rather than drinking and cooking	5 (5%)	13 (11.81)	4 (3.92%)	22 (7.05%)
Total	100	110	102	312

Fig No 7



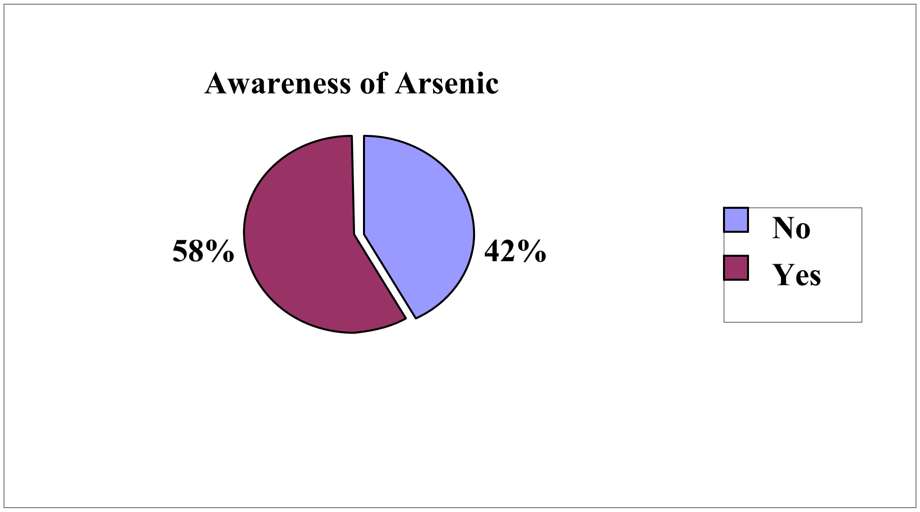
Different purposes of using Tube well water

1-*For all Purposes* **2**-*Not usage of tube well water* **3**-*Using for other purposes rather than drinking and cooking*

5.1.6 Knowledge on Arsenic

Slightly over half of the respondents (58%) have heard about arsenic through the various sources. However, significant portion of the respondents (42%) were totally unaware of it. They responded that they have not yet heard about arsenic and negative impacts of arsenic to the human health.

Fig No 8



Respondents' knowledge on Arsenic

5.1.7 Source of Information on Arsenic knowledge

The information sources of arsenic contamination in ground water are arsenic testing activities of DWSS, Media like television, radio, newspaper etc and relatives/neighbors. The most of the respondents got information about arsenic contamination in the tube well from the testing campaign of DWSS, 68.2% in Nawalparasi, 45.1% in Rautahat, 81.0% in Siraha districts. Another important source of information was found out to be Radio 17.5%, 17.10%, 2.70% and Television 11.10%, 36.60%, 10.80% in Nawalparasi, Rautahat and Siraha districts respectively. Other source of information includes Newspaper 1.60%, 1.20%, 2.70% and relatives 1.6%, 0%, 0% in Nawalparasi, Rautahat and Siraha districts respectively.

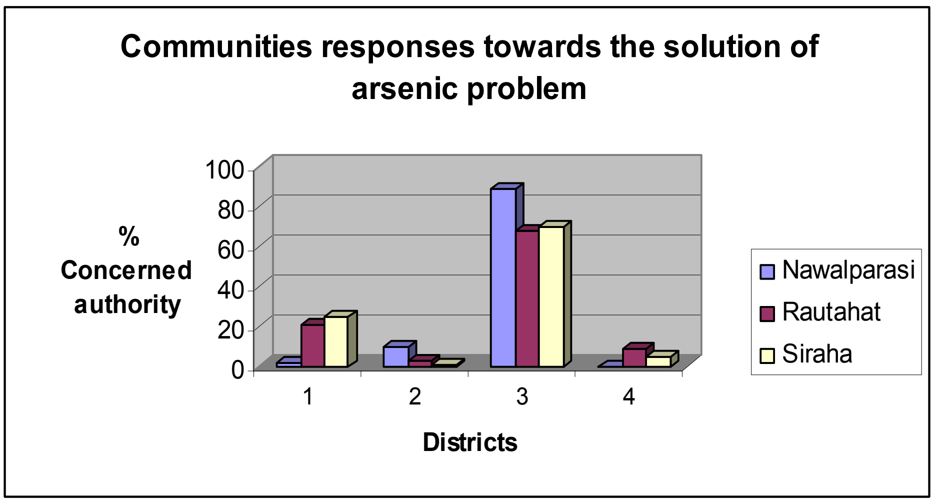
5.1.8 Desired subjects of Participation to solve the Arsenic problem

Majority of the respondents (74.6%, 232 out of 311) preferred governmental participation in solving the arsenic crisis. In the respective communities of Nawalparasi district, it was 87.9%, (87 of 99). Personal responsibility was pointed out by 16.1 %(50 of 311) following the community responsibility by 4.5% (14 of 311).

Table 7: Persons responses towards the Solution of Arsenic problem

Districts	Self	Community	Government	NGO	Total
Nawalparasi	2(2.0%)	10(10.1%)	87(87.9%)	0(0%)	99(100.0%)
Rautahat	23(20.9%)	3(2.7%)	74(67.3%)	10(9.1%)	110(100.0%)
Siraha	25(24.5%)	1(1.0%)	71(69.6%)	5(4.9%)	102(100.0%)
Total	**50(16.1%)**	**14(4.5%)**	**232(74.6%)**	**15(4.8%)**	**311(100.0%)**

Fig No 9



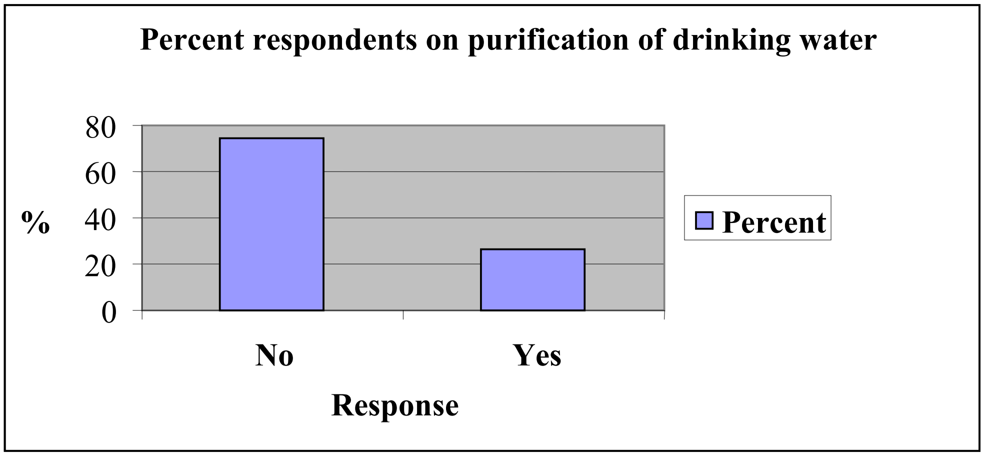
Person responses towards the Solution of Arsenic problem

1-*Self* **2-*Community*** **3-*Government*** **4-*NGO***

5.1.9 Water Purification Practice

More than two third of the respondents (75.5%) of the communities do not purify drinking water.

Fig No 10



Water Purification Practice

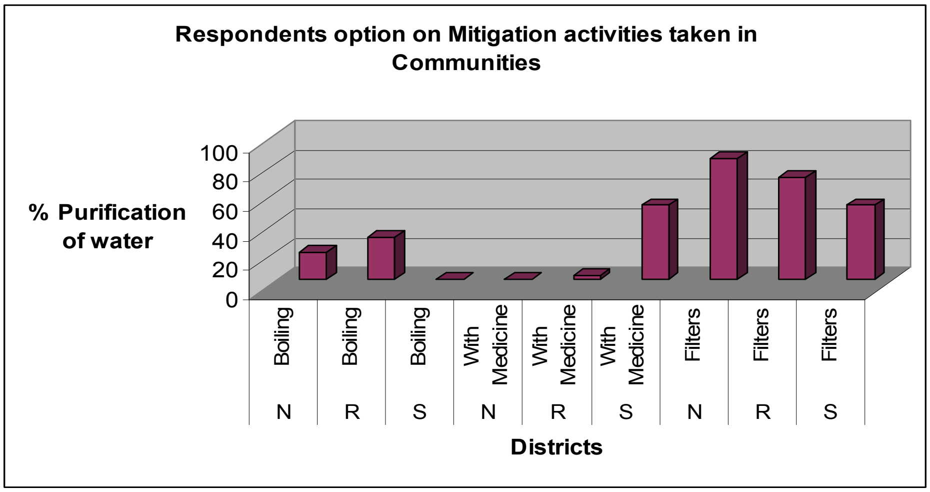
5.1.10 Mitigation Activities taken

The highest percentage of respondents preferred arsenic filters as the mitigation option i.e. 27% in Nawalparasi (Ramgram and Swathi), 26.36% in Rautahat (Santapur and Dumariya) and 4% in Siraha (Lahan and Hakpara) districts. The next mitigation option followed by the respondents was boiling 6%, 10.9%, 0% in the selective communities of Nawalparasi, Rautahat and Siraha district respectively. According to respondents, such figure of boiling preference is due to the misconception that arsenic would disappear on boiling. Medicine preference follows for the pathogens treatment.

Table 8: Mitigation activities taken in the Community Level

District	Process of purification of drinking water			Total
	By boiling	With medicine	Filters	
Nawalparasi	6 (18.2%)	0 (0%)	27 (81.8%)	33
Rautahat	12 (28.6%)	1(2.4%)	29 (69.0%)	42
Siraha	0 (0%)	4 (50.0%)	4 (50.0%)	8
Total	18 (21.7%)	5 (6.0%)	60 (72.3%)	83 (100.0%)

Fig No 11



Mitigation Activities Taken in Communities

N-*Nawalparasi* **R-*Rautahat*** **S-*Siraha***

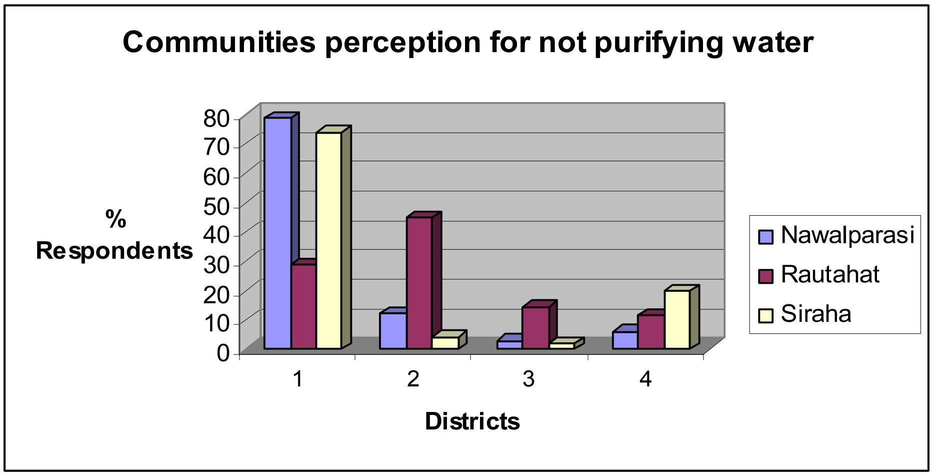
5.1.11 Perceptions lying behind not purifying water

Among the total (312), 229 total respondents who preferred not to purify water, majority (61.1%) were doing so because they do not think the water purification necessary and of which comprises 78.5%, 29.0%, 73.7% of selective communities of Nawalparasi, Rautahat and Siraha districts respectively. In Rautahat, 44.9% of selective communities preferred not to purify because of its being expensive.

Table 9: Reasons for not purifying water

Districts	Reasons for not purification of drinking water				Total
	Not necessary	Expensive	No time	Others	
Nawalparasi	51(78.5%)	8 (12.3%)	2 (3.1%)	4 (6.2%)	65 (100.0%)
Rautahat	20 (29.0%)	31(44.9%)	10 (14.5%)	8 (11.6%)	69 (100.0%)
Siraha	70 (73.7%)	4 (4.2%)	2 (2.1%)	19 (20.0%)	95 (100.0%)
Total	141(61.6%)	43 (18.8%)	14 (6.1%)	31(13.5%)	229 (100.0%)

Fig No 12



Reasons for not purifying water

1-*Not necessary* **2-*Expensive*** **3-*No time*** **4-*Others***

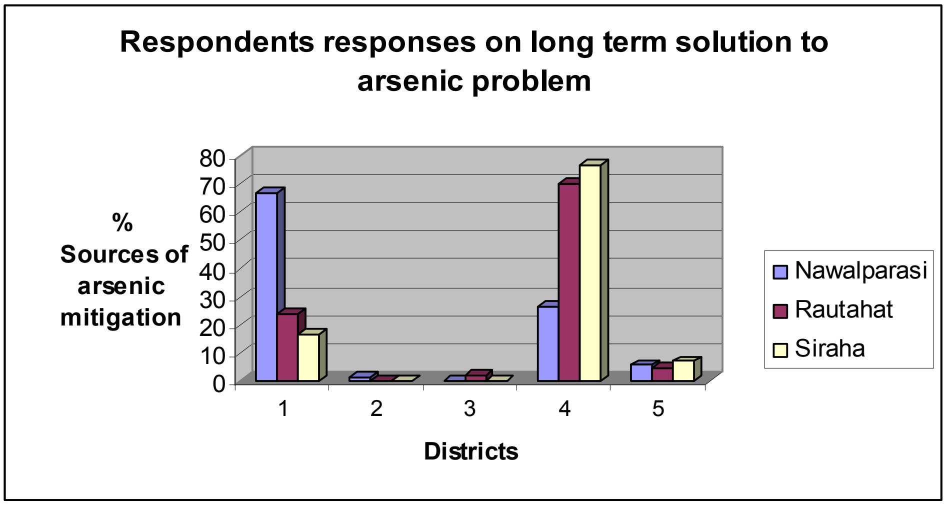
5.1.12 Respondents Perception on long term solution to the Arsenic problem

More than half (59.3%) of the total respondents in the present study prefer deeper tube wells as the long term mitigation option (26.7%, 70.0%, 76.5% in the respective communities of Nawalparasi, Rautahat and Siraha districts respectively). In the respective communities of Nawalparasi district, which is considered as the most affected area in the country, majority of respondents (66.7%) preferred filtering tube well water.

Table 10: Respondents view on long term Solution to the Arsenic problem

District	**Long term solution responses from the communities to the Arsenic problem**					**Total**
	Arsenic Removal Filter	**Rainwater harvesting**	**Community pond**	**Use deeper tube well**	**Others**	
Nawalparasi	60 (66.7%)	1 (1.1%)	0 (0%)	24 (26.7%)	5 (5.6%)	90 (100.0%)
Rautahat	26 (23.6%)	0 (0%)	2 (1.8%)	77 (70.0%)	5 (4.5%)	110 (100.0%)
Siraha	17 (16.7%)	0 (0%)	0 (0%)	78 (76.5%)	7 (6.9%)	102 (100.0%)
Total	**103 34.1%)**	**1 (3%)**	**2 (0.7%)**	**179 (59.3%)**	**17 (5.6%)**	**302 (100.0%)**

Fig No 13



Respondents view on long term Solution to the Arsenic problem

1-Arsenic removal filter 2-Rain water harvesting 3-Community pond

4-Use deeper tube well 5-Others

5.1.13 Efforts spent by Different Institutions Providing Safe water

A Community Scenario

Assessing the approach of various institutions at the community level for providing safe water, the study found that 67.9% (212 of 312) respondents reply that there was no any institutions to response the alternative source of drinking water free from arsenic. 32% (100 of 212) reply that they got advice from different institutions about the alternative source of safe drinking water.

Table 11: Scenario on Institutional Approach at Community Level for Safe water

District	Responses on previous advice regarding to alternative sources of drinking water by different organization		Total
	Yes	No	
Nawalparasi	19(19.0%)	81(81.0%)	100(100.0%)
Rautahat	46(41.8%)	64(58.2%)	110(100.0%)
Siraha	35(34.3%)	67(65.7%)	102(100.0%)
Total	**100(32.1%)**	**212(67.9%)**	**312(100.0%)**

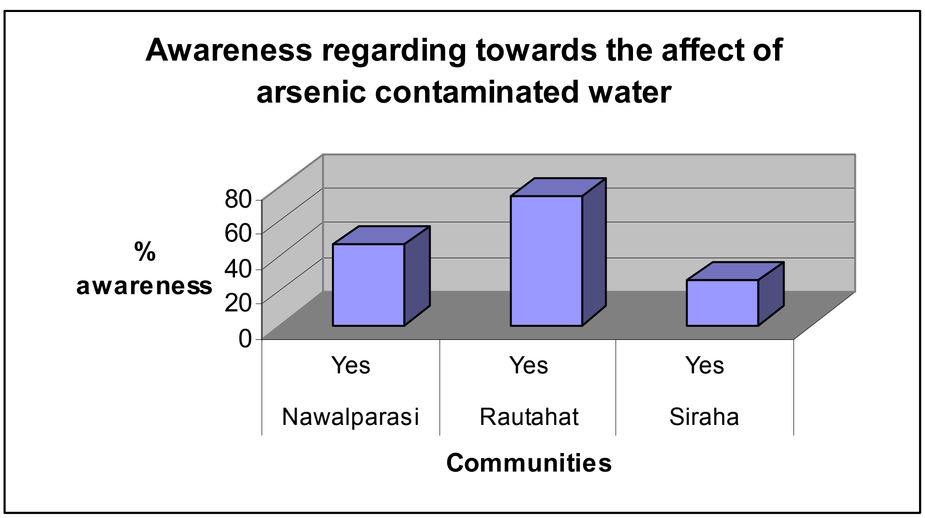
5.1.14 Knowledge on Arsenic health affects

Assessing knowledge of communities whether they were informed of harmful effects of arsenic in drinking water, it was found that about half of the respondents (49%, 152 out of 310) were aware. The percentage was found out to be higher in the communities of Rautahat district (72.4%, 80 of 109). Majority of the respondents 74.5% (76 of 102) were unaware in the respective communities of Siraha district.

Table 12: Communities responses towards affects of Arsenic water consumption

District	Awareness regarding to the affects caused by consumption of arsenic contaminated water		Total
	Yes	No	
Nawalparasi	46 (46.5%)	53 (53.5%)	99 (100%)
Rautahat	80 (73.4%)	29 (26.6%)	109 (100.0%)
Siraha	26 (25.5%)	76 (74.5%)	102 (100.0%)
Total	152 (49.0%)	158 (51.0%)	310 (100.0%)

Fig No 14



Awareness regarding towards the affect of Arsenic contaminated water

5.2 Study findings on Health Workers level

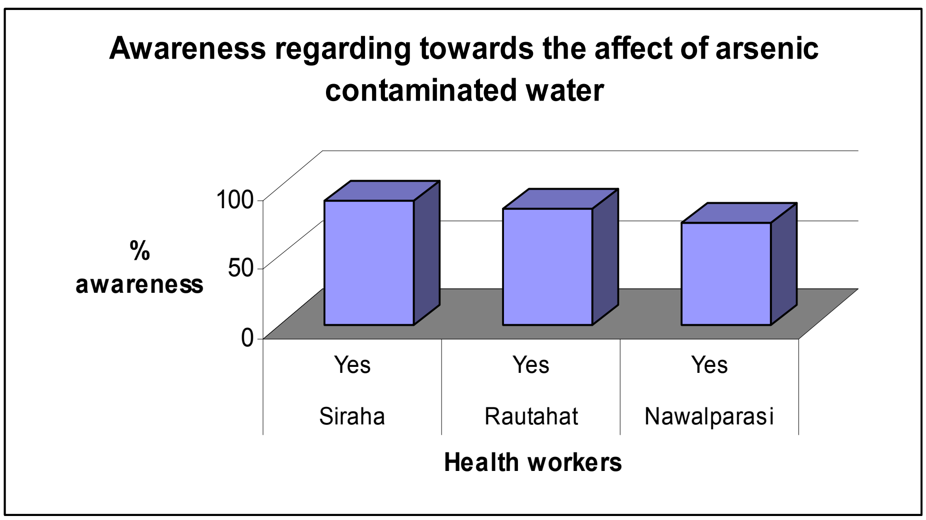
5.2.1 Level of Awareness

More than two third of the health workers were aware of arsenic in the study areas (84.3%). Comparing district wise the highest awareness among the health workers were found in Siraha district. However, the difference in the sample size might be one factor for such result.

Table 13: Level of Arsenic awareness

District	Yes	No	Total
Siraha	25(89.3%)	3(10.7%)	28(100.0%)
Rautahat	10(83.3%)	2(16.7%)	12(100.0%)
Nawalparasi	8(72.7%)	3(27.3%)	11(100.0%)
Total	**43(84.3%)**	**8(15.7%)**	**51(100.0%)**

Fig No 15



Awareness regarding towards the affect of Arsenic contaminated water

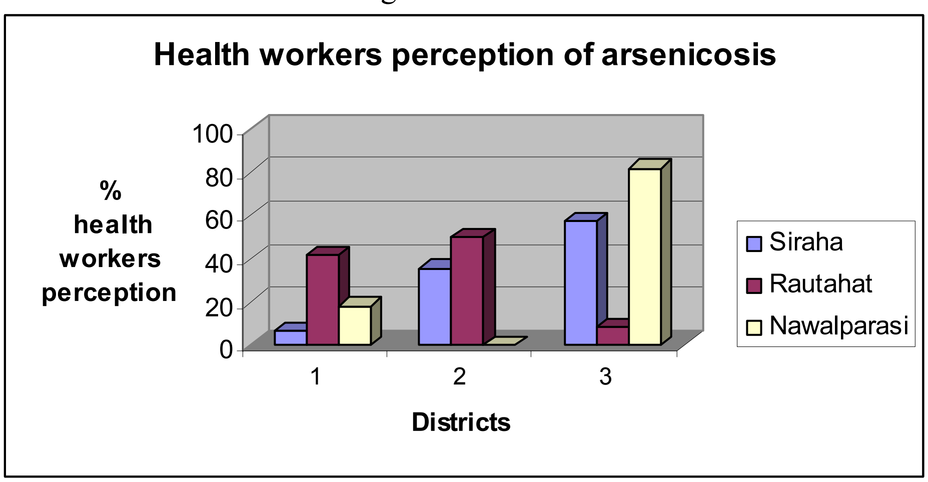
5.2.2 Assessment of Health Workers knowledge on Arsenic and Arsenicosis

Narrowing down the assessment of knowledge focusing upon whether they know about the most common features seen during arsenicosis, more than half of the respondent (51.0%) said that they don't know. Considering this answer, the actual knowledgeable health workers were less out of 51 total respondents. The significant percentage of respondents 35.7%, 50.0% and 0% in Siraha, Rautahat and Nawalparasi believed that the most common features seen during arsenicosis is skin itching, which is grounded on the wrong conception.

Table 14: The most common features seen during Arsenicosis

Districts	Skin pigmentation changing	Skin itching	Not aware	Total
Siraha	2 (7.1%)	10 (35.7%)	16 (57.1%)	28 (100.0%)
Rautahat	5 (41.7%)	6 (50.0%)	1 (8.3%)	12 (100.0%)
Nawalparasi	2 (18.2%)	0 (0%)	9 (81.8%)	11(100.0%)
Total	**9 (17.6%)**	**16 (31.4%)**	**26 (51.0%)**	**51(100.0%)**

Fig No 16



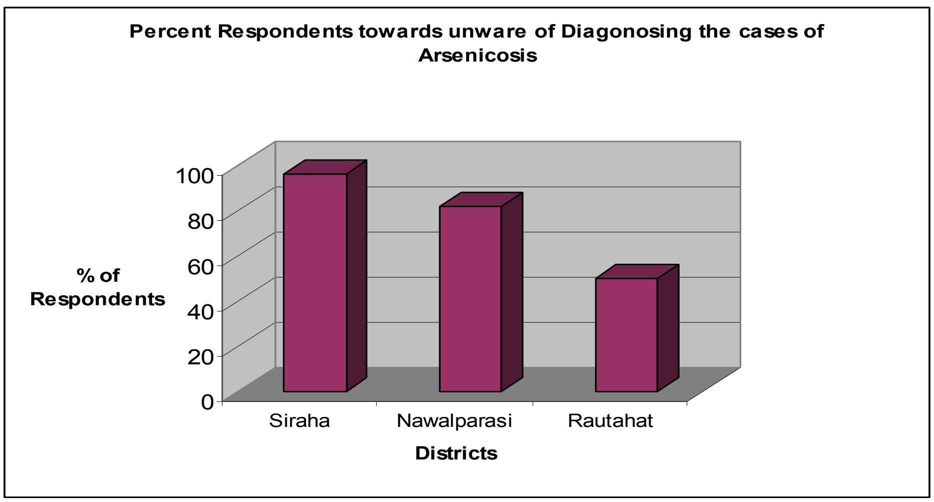
Assessment of Health Workers knowledge on Arsenicosis

1-*Skin Pigmentation changes* **2-*Skin itching*** **3-*Don't know***

5.2.3 Arsenicosis diagnosing ability of Health Workers

Further narrowing down the assessment, health workers were asked whether they could diagnose the case of arsenicosis or not. Significant portion of the respondents (82.4%) said that they were unable to diagnose the case of arsenicosis. The findings differed from the individual districts. Siraha had the highest percentage of the respondent unable to diagnose the arsenicosis case (96.4%) following Nawalparasi (81.8%) and Rautahat district (50.0%) respectively.

Fig No 17



Percent respondents of Arsenicosis diagnosis ability of Health Workers

5.2.4 Access of Arsenicosis patient to the Health Workers

The most interesting part of the present result is that none of the health workers were found to be dealing with the arsenicosis patients. This is not due to the reason that there are no any such patients in the affected area; rather it is due to the fact that health workers are not actually knowledgeable with dealing the case of arsenicosis with certainty.

5.2.5 Suggestion of Health Workers to Mitigate the Arsenic problem

A significant percentage (39.2% of 51) of the health workers suggested the need of trainings for the health workers on arsenic and arsenicosis. Another significant percentage (33.3% of 51) reply that they had not any idea concerning the mitigation.

5.3 Central Level Institutions working in the field of Arsenic

Structured questionnaires and in-depth interviews were taken among the chief personnel of existing total 13 central level institutions involved in arsenic mitigation activities to qualitatively review the mitigation measures and analyze the effectiveness, sustainability and continuity of those activities.

The study found out that there were altogether 6 NGO/INGO, 5 GO and 3 educational institutions (TU) working in the field of arsenic mitigation. The study also found that the coordination among these institutions are lacking. Likewise, the mitigation approaches taken by various institutions could cover up only the fractions of affected people.

The study found out that there was no any convenient technology for the arsenic mitigation. Arsenic was not tested in all the affected districts. The monitoring system was found to be less efficient. Health survey could not cover up all affected population. There was no proper coordination between central level and district level organizations. The study on the safe aquifer as an alternative solution was not getting proper attention. Only the filter has been getting in priority neglecting the environmental consequences of sludge disposal.

Though there is the only one coordinating institution named National Arsenic Steering Committee (NASC), the committee which seems ineffective for the policy and implementation level coordination and monitoring.

The qualitative result finding of the institutional response on their activities and funding sources is given in table No,17.

Table 15: Central Level Institutions working in the field of Arsenic

S. N.	Organization	Type	Activities	Funding
1.	Nepal Water for Health	NGO	Mitigation activities like awareness, distribution of tubewell, biosand filter and Kanchan filter are carried out.	Water AID, UK, DFID-UK
2.	Rural Water Supply and Sanitation Fund Development	NGO	Arsenic test was carried out by using Arsenic Kit. Awareness activities were carried out.	IDA, DFID
3.	Environment and Public Health Organization.	NGO	Research named Provision of Safe Water in Rural Parsa District and Safe Water Supply for Health and Economic development in rural villages of Nepal is carried out. Mitigation activities like awareness, distribution of biosand filter, Kanchan Arsenic Filter and Arsenic Filter and Arsenic Iron removable plant was carried out.	World Bank, PAF, SIMAVI
4.	Nepal Red Cross Society	NGO	Research topic" An overview of Arsenic contamination and its mitigation in Nepal Red Cross Society Program Areas is carried out. Mitigation activities like distribution of Biosand filter, two gagri filter, Kanchan Filters and Arsenic Tubewell, Arsenic Iron Removable Plant and Improved Dug Well were distributed. NRCS is the leading Organization in Arsenic investigation and mitigation.	Japanese Red Cross Society, Tokyo, Japan
5.	World Health Organization	INGO	WHO first assessed the risk of Arsenic in drinking water in 1958 by producing their International Standards drinking water.	-
6.	UNICEF	INGO	UNICEF funds other Organization like ENPHO, DWSS to test Arsenic but does not conduct tests solely. There is one person in the distribution with the Organization to whom UNICEF is funding.	-
7.	Department of Water Supply and Sewerage	NG	Mitigation activities like blanket Arsenic testing awareness, distribution of tubewell, biosand filter and granular ferric hydroxide are carried out.	NG, UNICEF
8.	Department of Health Service	NG	No any activities are carried out.	IDA, DFID
9.	NHRC	NG	Research activities	NG, WHO
10.	Ministry of Health and Population	NG	MOHP is not a member of NASC.	-
11.	Nepal Arsenic Steering Committee	NG	Actively working for a national policy on control and mitigation of Arsenci in drinking water. Meeting is held in every month.	UNICEF, NG
12.	Tribhuvan University	Institute of Medicine(I.O.M.)	Mitigation activities like As testing were carried out in the laboratory.	TU, WHO
13.	Tribhuvan University	CDG (Natural Resource Division)	Research named " Studies for Possible Natural Sources of Arsenic Poisoning of Ground water in Terai Plain of Nepal	
14.	Tribhuvan University	CDES	Only Students are doing the thesis.	-

5.4 Conclusion:

Narrow look on Issues and Policy implications

Arsenic contamination in drinking water has been a global concern. It has affected many countries of the world for example South Africa, America, Chile, Ghana, Mexico, China, India and Bangladesh. In south Asia region, India and Bangladesh are badly affected.

The Terai region of Nepal has similar geography to India and Bangladesh and similar practice of extraction of groundwater for drinking. Therefore, contamination of ground water with arsenic might be similar. The contamination of the underground water has become a great challenge for provision of safe drinking water to the large population of the region.

This is the cross sectional study that was carried out in three distinct phases: Review phases, Field study phase and Data processing and Analysis phase. Field study phase comprised of Site selection, Field Reconnaissance, questionnaire, FGD survey in communities, Health Workers and central level institutions. The communities have been chosen on the basis of level of vulnerability to arsenic contamination and very low uncertainty level designated by the study of NASC/ENPHO in 2003.Based on the study report, 4 Village Development Committees (VDCs) and 2 municipalities of Nawalparasi, Rautahat and Siraha districts

The study focuses great attention towards: identification of population at risk, assessing the knowledge of health workers about arsenic and arsenicosis and review of mitigation measures and analyzing their effectiveness, sustainability, continuity carried out by different institutions.

The study concludes that significant portion of the people from the selective communities of Nawalparasi, Rautahat and Siraha knew less about arsenic. Significant portion of the respondents (42%) were totally unaware of it. They responded that they have not yet heard about arsenic and negative impacts of arsenic to the human health.

The study found out that majority of the people (75.5%) of arsenic affected communities was consuming without purifying. Among the respondents who prefer to purify water, the highest percentage of respondent's preferred Arsenic filters as the mitigation option i.e. 27% in Nawalparasi, 26.36% in Rautahat and 4% in Siraha district. The next mitigation option followed by the respondent was boiling 6%, 10.9%, 0% in Nawalparasi, Rautahat and Siraha district respectively.

Similarly, More than two third of the health workers were aware of arsenic in the affected study area (84.3%). However, only few knew about arsenicosis. Above two third of the health professional 82.4% were unable to diagnose and manage arsenicosis cases. District wise, Siraha had the highest percentage of the respondent unable to diagnose the arsenicosis case (96.4%) following Nawalparasi(81.8%)and Rautahat district (50.0%)respectively.

The study found out that there were altogether 6 NGO/INGO, 5 GO and 3 educational institutions (TU) working in the field of arsenic mitigation. The study also found that the coordination among these institutions are lacking. Likewise, the mitigation approaches taken by various institutions could cover up only the fractions of affected people.

5.4.1 Issues

The study found out that despite the efforts taken by several of the institutions in the past, the number of household arsenic removal units distributed remains only fractions of the quantities actually needed. Other alternative solutions like improved dug well and wells are also not working properly because of the convenience of the shallow tube wells. The study result also showed that most of the respondents preferred the arsenic filters as the best mitigation options following deep tube wells. So the policy for arsenic solution as an immediate step calls for household level filtering systems. However, disposal of arsenic-rich sludge, or washings from arsenic removal units, is an important environmental health issue. The issue is that sludge is significantly more concentrated and thus more difficult to dispose of safely which creates a new environmental concern that it leaches into solution and recontaminate the local groundwater is noteworthy to consider in a context to choose the appropriate technology.

The community of the study areas preferred piped water systems by aid of the government. When evaluating the piped water system in terms of arsenic contamination, we can say that piped water systems, with their central treatment facility, are advantageous over the household level technology because the system can be managed and monitored at one single point. Furthermore, a central filtration system also allows for the treatment of pathogenic contamination of surface water.

Another issue raised by the study is the role of health institution and health workers. Health workers' knowledge and Skills towards arsenic and arsenicosis was found out to be very less. Most of them do not know the exact about arsenicosis and its health impact. They could not recognize its signs and symptoms. It is not possible for them to detect, manage and surveillance of arsenicosis cases in their community. It is seen that they are not familiar with preventive measures, primary treatment and referral mechanism. Health Workers are not involved in any activities carried out by different organizations regarding Arsenic. They are not aware of any mitigation programs like local filter systems (Biosand filter, 2 gagri filter, Kanchan arsenic filter). The low level of knowledge and awareness about the health implications of arsenic contamination in health workers of arsenic-affected areas shows that the breadth and depth of household information on arsenic contamination, its seriousness, and technology options available need to be expanded.

The fissure between the central and local bodies is noteworthy to mention in the present study findings. We all know that, Issues in Arsenic affected communities are involved with level of information, ensuring choice and options, monitoring of water quality, and most importantly in coping with the situation. These dimensions of the arsenic crisis clearly raise the issue of the role of local governments in the drinking water sector in Nepal. Local governments are by nature closest to a crisis of the sort being experienced in the drinking water sector where actual solution paths being adopted will be specific to the local context. So the empowerment of local communities and making them independent service providers in arsenic affected areas is the potential option of solution of the problem.

Arsenic problem is identified but no National mitigation program is seen. In spite of its higher occurrence too, Ministry of Health has not yet included Arsenic issue in five year and Annual plan. Arsenic issue is not included in National Health Training and Information Education and communication program. Operational research regarding Arsenic, its source, occurrence, Health impact and mitigation is not seen being done in Co-ordinated approach. Social mobilization is a key factor for the success of any Programs, however it is not seen in the program till date. Besides this, no linkage is to be seen with other Community based social sector program like Poverty alleviation activities.

CHAPTER-6
FEASIBILITY OF OPTIONS (MITIGATION)

The immediate concern is to find a safe source of drinking water in areas where water supply contains unsafe level of arsenic. Two main options are to be considered:

1. Finding a new safe source   2. Removing Arsenic from the contaminated water

Source substitution:

Three main source of water is to be considered as substitute for contaminated water.

1. Ground water   2.Rain water   3. Surface water

Arsenic removal:

A number of chemical methods for arsenic removal are available including coagulation (filtration), Activated alumina, Ion exchange and Membrane process. All arsenic removal technologies generate some kind of arsenic rich waste.

Selection of Arsenic removal technology:

So many options and type of arsenic removal technologies are available but it is not easier to say which is best. However, one has to fulfill some basic technical and socio-economic criteria. Among technical criteria's are required quality, adequate quantity, reliable & robust, operational safety, no undue adverse effect on the environment. Socio-economic criteria's are economically feasible, institutional capability, convenient communication interventions and finally it should be socially acceptable.

Available modes of Water supply:

1. Shallow hand tube well   2. Rain water harvesting.   3. Dug well
3. Pond sand filter (PSF)   5. Piped water supply   6. Deep tube well

RECOMMENDATIONS

1. There is an urgent need for a unified **Water Resource Policy** with integrated **Planning** and **Management.**

2. Activities carried out by different organizations are not well coordinated among each other so, it is difficult to say whether it is need based or not. So it is suggested to have strong and functional central level **Co-ordination mechanism**.

3. The government needs to have long term planning process starting from testing the tube wells, identifying the patients mitigation measures and policy formulation and its implementation.

4. There is a need for strong focus on capacity building at the local or community level for technical implementation and monitoring for that formation of user group through-out the affected area with support from NGOs and local government.

5. **Massive awareness raising program** using electronic and multimedia devices need to be launched to overcome various superstitions, misconceptions, to disseminate knowledge and information regarding Arsenic and Arsenicosis for community and Health workers.

6. Doctors, Paramedical and other health workers could not identify Arsenicosis and its signs and symptoms. So **doctors and health workers need to be trained** not only to provide treatment for the patients but also to provide counseling, assurance and mental support using WHO guide book (manual) on detection, management and surveillance.

7. Issues related to Arsenicosis both clinically and public health needs to be incorporated in the undergraduate medical curriculum.

8. Need to have **operational research** on various aspects of Arsenicosis and its treatment.

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