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STATUS OF ARSENIC CONTAMINATION IN GROUNDWATER OF MAKAR VDC OF NAWALPARASI DISTRICT, NEPAL

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Abstract

Arsenic is one of the 92 natural elements found in Earth crust which is referred as" King of Poison". Arsenic contamination in groundwater has been recognized as a great threat to water supply and public health in many countries in the world (WHO 1993). Therefore this research work was done with the objectives to assess the concentration of arsenic in groundwater at Makar VDC of Nawalparasi district by both field kit test and Atomic Absorption Spectrometry (AAS) test methods and assess the possible natural sources of arsenic mobilization in groundwater and further identify the safe and contaminated aquifers and their distribution below the ground. Based on the field and laboratory analysis it is concluded that the aquifer lying in between 30-70 feet is contaminated with arsenic in toxic level (>50 ppb) while the horizons of aquifers shallower or deeper than this depth are found safe. Present study also showed about 38%, 23 %, 19% and 20 % of aquifers as safe tolerable, toxic and very toxic respectively. Study on the mineralogical composition of the soil and sediment showed that it is rich in arsenic bearing minerals like pyrite, biotitic, iron-coatings and opaque minerals. These minerals are considered potential sources of release of arsenic in groundwater under reducing environment. No adverse health effects are seen on people although the concentration is found in toxic level. This might be either due to hesitation of people to expose their infected organ in front of the research students or the researcher's inability to indentify the symptoms, as it has no normal symptoms and need the experts from the medical field. Present study is able to pinpoint the depth of contaminated aquifer, which is useful for the safe drinking water development strategy.

Key Words: arsenic contamination, sources of arsenic, ENPHO field kit, AAS test, health impacts

Introduction

Arsenic is one of the most dangerous and predominantly found elements, a shiny metal that is found in rocks, soil, natural water and organism. It is an extremely toxic, not visible in water, no taste and no smell. There exists a large debate on the source and release mechanism of arsenic in groundwater. But now, it is widely accepted to be geological sources of arsenic in water. It has been found that inorganic arsenic is more toxic than organic and within the inorganic form; the trivalent (arsenite, As^{+3}) is more toxic than pentavalent (arsenates, As^{+5}), (Nagarnaik et.al, 2002). It is reported that arsenite is the major water-soluble species in groundwater. The most commonly reported symptoms of chronic arsenic exposure are hyper pigmentation, de-pigmentation, keratosis and peripheral vascular disorders, skin cancer and a number of internal cancers (BGS and DFID 2001). The patient shows inability to walk, debilitating pain and watery eyes. The Terai community of Nepal is also suffering from the diseases induced by the use of arsenic contaminated water. Both keratosis and melanosis are found in the local people who have been using arsenic contaminated water for long time (Sah et al. 2003).

Water indented for human consumption should be safe from pathogenic agents and harmful chemicals. Arsenic (which is a heavy metal) presence in GW of Terai is becoming a serious problem in Nepal. Groundwater being important source in Terai has been a great threat for humans, plants, and animals and whole environment. Considering the serious problem in neighboring Indian state of West Bengal and Bangladesh, for the first time in 1999 the Department of Water Supply and Sewerage (DWSS) with assistance of World Health Organization (WHO), Nepal decided to conducted a systematic research on possible contamination of groundwater with arsenic, which shows that arsenic concentration of water was above WHO guideline value and found the people suffering from arsenicosis. It directly or indirectly effect on social and economic status of people (Paudyal .K.R, 2011)

Most of people living in Nawalparasi district depend on groundwater and they are using this water for drinking and irrigation (ENPHO/ RWSSSP, 2003). Therefore, this study aims to explore the effect of arsenic in health and socio-economic impact of arsenic contaminated groundwater in rural areas of Nawalparasi district. This study might be useful for the policy maker and development workers to demarcate the safe and contaminated aquifers in the area. Moreover, mitigation measures need to be carried out in these tube wells to prevent from possible hazards and to purpose the way of curing to effected people. In this regard, this study aims to explore the sources of contamination of groundwater by arsenic in Nawalparasi district (Makar VDC) of Terai region of southern Nepal. This study may also help to compare the past studies conducted related to the arsenic contamination as a time and seasonal variations.

Materials and Methods

This research was carried out within the four wards (2-Chisapani; 3-Karmaiya; 4-Bardhaghat; 8-Laguna) of Makar VDC of Nawalparassi district as this district is one of the most vulnerable and high ranked district for arsenic pollution on groundwater (Latitude: 27^{o} 40' N to 27^{o}67' N and Longitude: 83^{o}55' E to 83^{o}91' E; Elevation Range: 1076 feet from the sea level), which is situated in Western Development Region, East-West of Mahendra Highway.

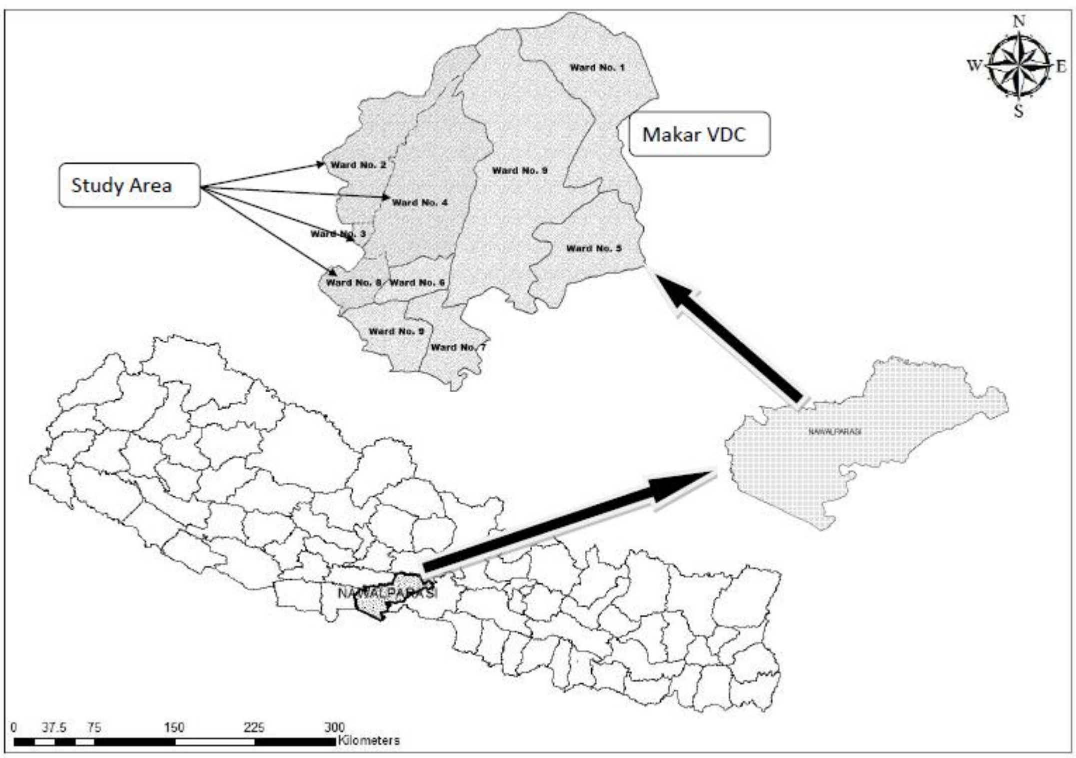

Fig 1:Map of Study area

Both quantitative and qualitative methods were used for the study. Quantitative method was used to analyze the degree and extent of arsenic content in groundwater, river water and pond water on the field by using ENPHO KIT, 150 different samples were tested by this method, which were later verified by measuring arsenic concentration of ten water samples in the ENPHO laboratory by AAS (Atomic Absorption Spectrometer) method. The quantitative method was further used to explore the possible natural sources of arsenic mobilization in groundwater, for this, four representative soil samples (covering river bed, bank and different levels of terraces) were taken for the compositional analysis in the lab. four soil samples were analyzed in Central Department of Geology, Tribhuvan University, Kirtipur for its mineral content and surface coatings. For that a binucular microscope was used to examine the sediments grains. The composition and texture of soil and sediments was studied under the x 50 magnification binocular microscope. The ratio of different minerals or rock fragments was found by grain counting methods under the microscopes. Qualitative method was done through field visits and questionnaire survey. Qualitative method was used to understand the information related to well type, well depth, date of construction, consumption purpose, consumption rate, and health effects.

Results

Status of Arsenic Contamination in different tube well samples

Four Wards of Makar VDC of the Nawalparasi district were surveyed to access the status of arsenic concentration using ENPHO test kit. The validity of the concentration of the dissolved arsenic was also verified by AAS technology in laboratory. Studied showed 23, 19 and 20 percent of aquifers of the study area were found as tolerable, toxic and very toxic respectively (WHO Guideline). The status of the arsenic contamination in different tube well samples is given in Fig: 1

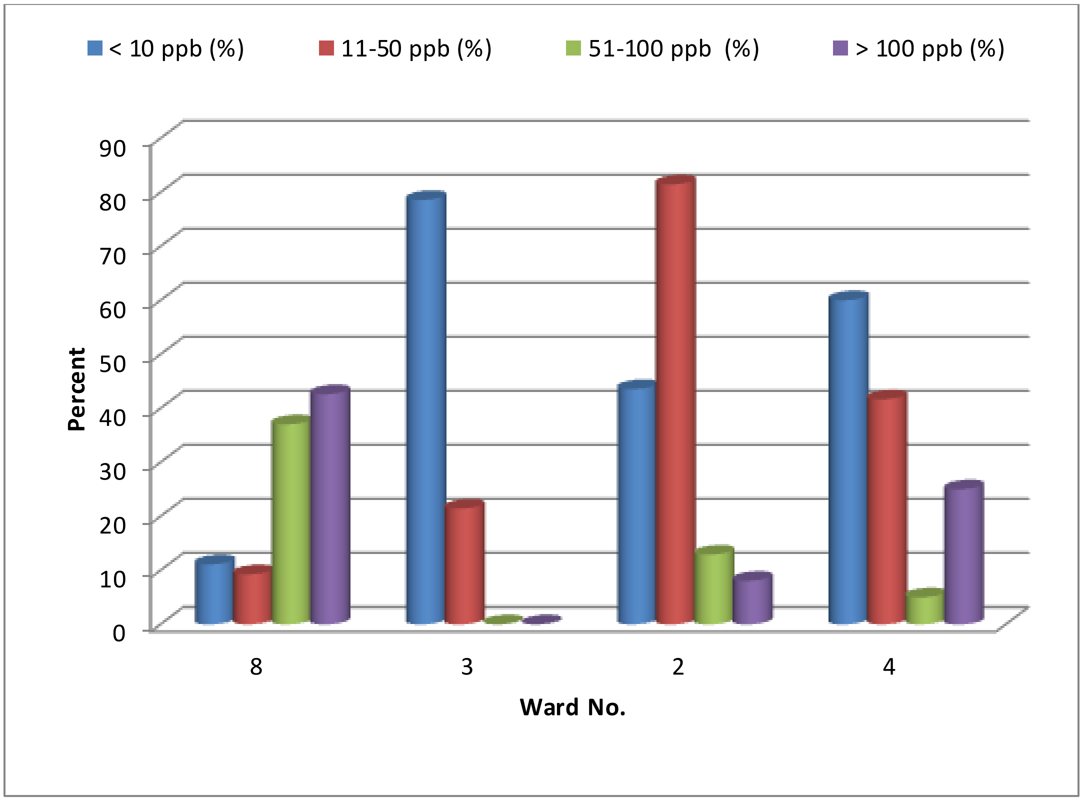

Fig.2: Status of arsenic contamination in different tube well samples

Distribution of Arsenic Contaminated Tube wells

Of the total 150 wells tested from four wards, 94 wells were found contaminated with the arsenic having concentration greater than 10 ppb, which is more than 62%. The ward wise distribution of the water-tested tube well is given in Fig 3.

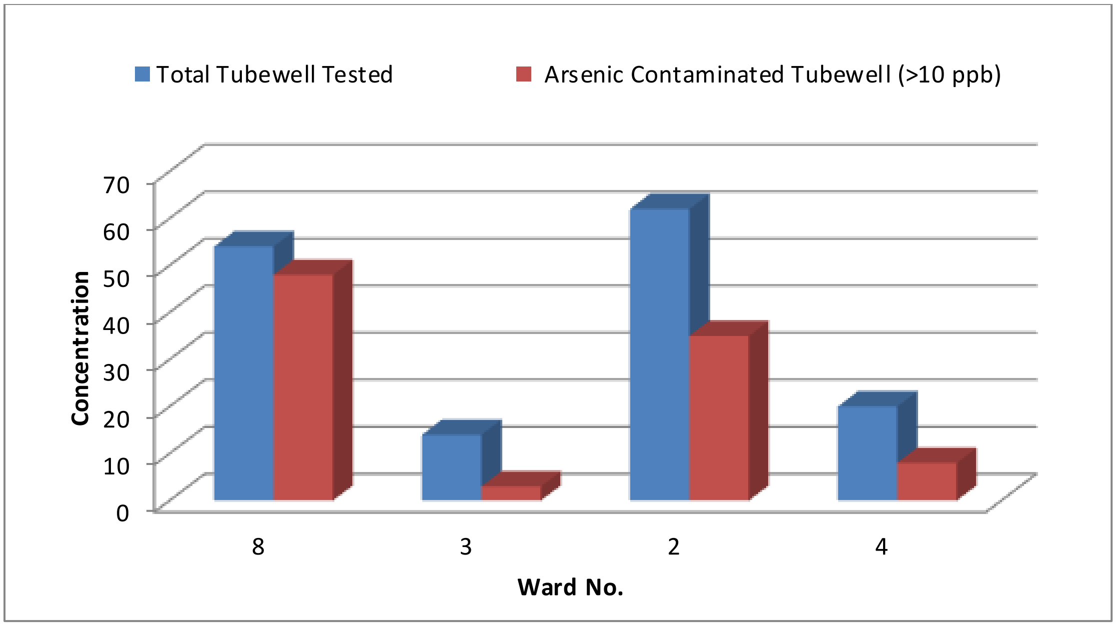

Fig. 3: Ward Wise Distribution of Water Tested Tube Wells in Makar VDC

Sources of Arsenic Mobilization in the Ground Water

Table 1: Laboratory Analysis of Sediments from the Study Area

S.N.	Sample No.	Location	Identification/Description	Remarks
1.	S_1	Ward No.2	Micaceous medium to find sands composition quartz + feldspar + biotite (1:1:1) and Fe coating rock fragments abundant.	Rarely Fe-coatings
2.	S_2	Ward No.3	Yellow to brown, fine to medium grained sand with abundant ferruginous concretions + quartz + biotite + muscovite+rock fragments in 1:1:1: ½ ratio.	Fe-coating
3.	S_3	Ward No. 4	Coarse, gravely sands with quartz +plagioclase+ biotite + muscovite + rock fragments (2:1:1:1:1/2)	Abundant Fe-coatings.
4.	S_4	Ward No.8	Grey-brown, pebbly sands with quartz + brown rock fragments with abundant chlorite and weathered alkali feldspar. Opaque and colored minerals are more than 10% (pyrite, magnetite and hematite minerals).	Fe-rock fragments/brown silty mass.

Terai plain contain ferruginous concretion which could be source of arsenic contamination (Shah. et al., 2003.).To analyze the sources of arsenic mobilization in ground water, sediment analysis was done which results the presence of Fe-coating minerals which signifies the sources of arsenic in study area. Table 1 shows the result of laboratory analysis of the Sediments from study area.

Distribution of Safe and Contaminated Aquifer

Of the total tested samples, 23%, 19% and 20 % were found at tolerable, toxic and very toxic limit respectively as classified by WHO guideline. The toxic level of arsenic (>50 ppb) is found in the depth between30-70 feet. There is no toxic level of arsenic in the depth shallower or deeper than this depth. The relation of arsenic contamination with depth of well is given in Fig: 4.

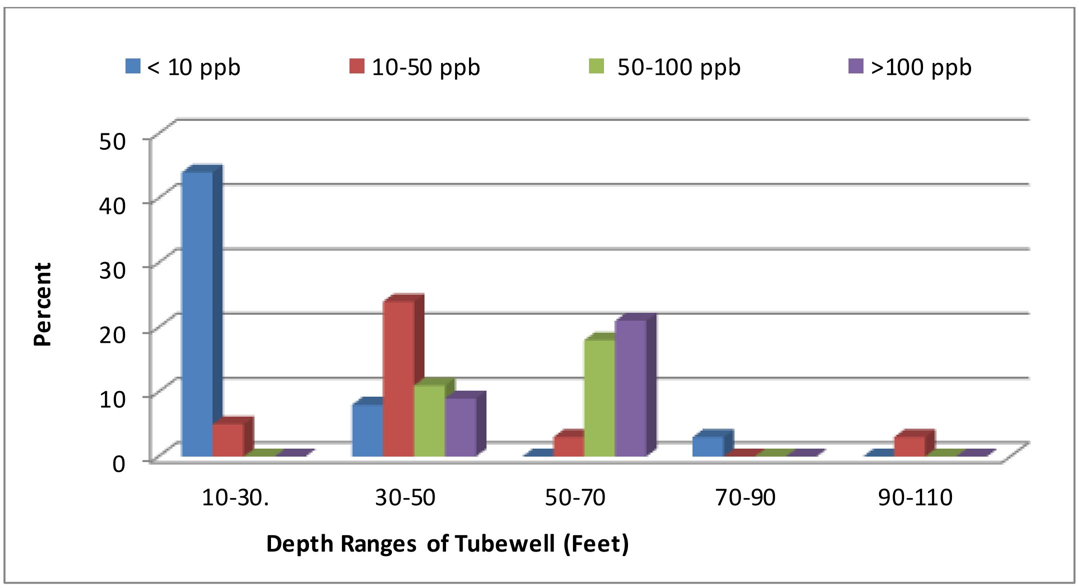

Fig. 4: Relation of Arsenic Contamination level with depth of tube wells

Discussions

After over all study on the concentration of arsenic in drinking water sources of the present study area, the following points are selected for discussions:

Four wards of Makar VDC of Nawalparasi district were surveyed to assess the status of arsenic contamination in groundwater. Effort was made to test the water samples both from the surface and groundwater using the field kit. The validity of the concentration of dissolved arsenic was also verified by the Atomic Absorption Spectrometry (AAS) techniques in the laboratory. There is good reliability of the ENPHO test kit.

The reliability of ENPHO Field Kit was determined by testing 10 samples by AAS method. The As concentration obtained from AAS and ENPHO Field Kit were very close (Fig 5). Thus, explaining the reliability of the study.

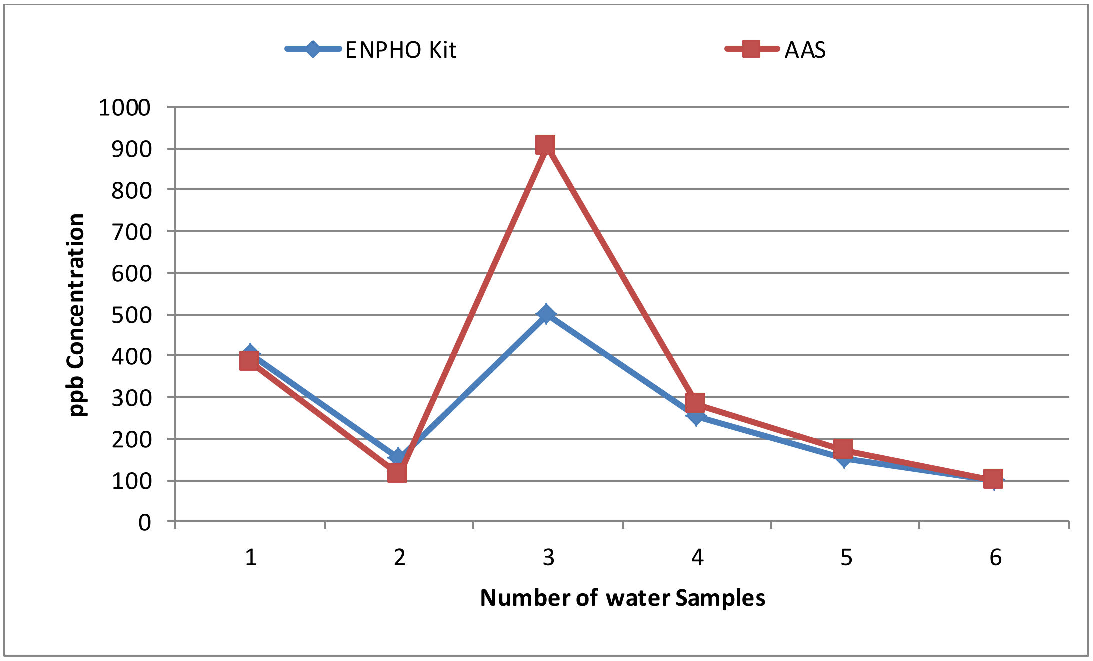

Fig 5: Correlating ENPHO Kit data and AAS data

Study showed 23.3, 19.3 and 20 percent of aquifers of the study area were found as tolerable, toxic and very toxic respectively. More than 62 percent of aquifers are contaminated by arsenic, as this district is the highest affected district among 20 terai district of Nepal (DWSS 2002), which means these aquifers have arsenic concentration more than 10 ppb and do not falls under safe category of WHO Guideline for Drinking Water.

Study on the mineralogical composition of the soil showed that it is rich in arsenic bearing minerals like pyrite, biotite, iron-coatings and opaque which are potential sources of arsenic and release the arsenic under reducing environment which is also supported by the study of Nordstrom D K, 2002. When water comes to contact with such aquifer in this depth, having reducing environment, arsenic mixes in water. This is the reason why arsenic is not found in surficial condition.

Distribution of concentration of arsenic is controlled by geological material not by topography, land use, artificially used fertilizers, pesticides and other organic additives. The toxic level of arsenic (>50 ppb) is found in the depth between30-70 feet. There is no toxic level of arsenic in the depth shallower or deeper than this depth. It clearly informs us that the aquifer in this depth is contaminated with arsenic rich sediments. Under reducing condition in this depth arsenic can release slowly to the water. Depth wise variation is due to the uneven distribution of arsenic containing aquifer. The range from 30-70 feet might be due to the inclination of the aquifer beds. It means the contaminated aquifer is developed within 30-70 feet only within the study area. There is no risk to develop the wells shallower than 30feet and deeper than 70 feet.

The validity of analysis of the sediments and its interpretation on depth is based on the assumption that the source or provenance of these sediments in the past and present is the northern part of the Terai. Actually, the sediments were derived from the Siwaliks and the further north of the Himalaya. It justifies the same provenance of the presently deposited sediments by rivers at its bank, bars and terrace with the deep-seated aquifer materials of the past.

No adverse health effects are seen on people although the concentration is found in toxic level. There are two possibilities: it might be either due to the survey on younger or people would hide the diseases or they know nothing about its effects. As we know the severe effects of arsenic mostly seen in hidden parts of our body. Diseases do not appear in organs that frequently expose to sunlight. That is the reason why arsinocosis is not found in face and hands. Most researches argue that the effect is seen mostly on old age who use arsenic contaminated water for a long time continuously. Some who possibly affected could hesitate to disclose their diseases in front of research students. On the other hand, the movement and migration of people is very high in the present study area (VDC Profile 2012), which might be one cause for not recording the effects of arsinocosis.

Conclusion

Out of total samples tested 62.67% were found contaminated with arsenic in ground water. It is categorized further as 38 percent safe, 23 percent tolerable, 19 percent toxic and 20 percent very toxic. Source of arsenic in groundwater was found geological materials like soil, sediment and bedrocks. This is justified further by the presence of arsenic bearing mineral like pyrite, magnetite, and hematite, ferruginous coatings in sand and silts, rustlings on clays in the soil. When arsenic bearing soil reach to the reducing environment at certain depth, then arsenic starts to release slowly from the sediments mixing to the ground water. In the study area, arsenic contaminated aquifer was found in between 30-70 feet depth. This shows that the arsenic contaminated source aquifer is lying in between this depth whereas the depth less or more than this range is found safe water from the arsenic. The source of arsenic is purely natural not artificial. Arsenic contamination was not found on surface water as well as water taken from the shallow depth, which indicates that there is no role of people for arsenic contamination. There is no role of fertilizer and pesticides to release arsenic in the present study area.

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