Correlation Studies of Arsenic Level in Drinking Water and hair Samples of Females in District Sheikhupura, Pakistan

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ABSTRACT

Arsenic is present in the environment because of both anthropogenic and natural sources. Exposure to arsenic through drinking water for longer duration can cause various health effects. Now a days Pakistan is also facing serious health concerns due to arsenic contamination in drinking water. The study area for the present research work is District Sheikhupura, which is an industrial as well as agricultural city in the province of Punjab, Pakistan. Arsenic concentration from different drinking water sources and hair samples of female population of District Sheikhupura was measured by using Atomic Absorption Spectrophotometer (AAS). The higher mean arsenic (70 ± 22.1ppb) concentration was measured in hand pump water as compared to other water sources. The guideline value for arsenic recommended by World Health Organization (WHO) is 10ppb. Sheikhupura and Sharaqpurtehsils are most affected region in the study area.The result also showed a positive correlation between Arsenic levelin drinking water and hair samples of the female respondents. The study provides research-based evidence about the relationship of arsenic exposure and its health impacts among female population in the study area. This research has significant value to assess the correlation between arsenic in drinking water and in the biological sample among young females. The result of this study warrants urgency for the remedial measure to control water contamination and provision of clear drinking water to general population.

Keywords
Pakistan, Arsenic, drinking water, hair samples, health, and female population

Introduction

Water pollution is a big threat to the general health for the people of Pakistan. It is expected that around 40% of all reported diseases in Pakistan are attributed to poor water quality. The water quality standards established by organizations and WHO are openly violated (Azizullahet al, 2011).

The groundwater, with high Arsenic levels, is a global problem and considered as one of the prime pathways of Arsenic exposure to humans. Exposure to Arsenic can induce various types of cancers (bladder, lung, skin, kidney and liver), in addition it may also cause diabetes, cardiovascular disease, developmental and reproductive defects (Benbrahim - Tallaaand Waalkes, 2008). Dietary exposure of arsenic has been found...
to be the major route of entry into general population (Bae et al., 2013).

There are variety of substances coming from different sources are added to water, air, soil and food chain. It is also accumulated in different biological samples such as hair, skin, nails, blood and urine (Villa-Lojo et al., 2002). Recently hair and nail are being used as most acceptable biological biomarker. Hair and nail samples can be used as good indicator of arsenic exposure because arsenic persists longer in these samples (Gebel, 2000). Arsenic is moved from blood to hair root and retained by binding to sulphhydryl groups of keratin and finally move into hair shafts (Hindmarsh, 2002).

Kazi et al. (2009) carried out a survey on ground and surface water arsenic contamination. They developed a strong relationship between arsenic concentration in biological samples and drinking water. Arsenic concentrations in biological samples (hair and blood) were above the range of permissible values. Another group of researchers Vega et al. (2001) gives strong proof of correlation between chronic arsenic exposure through drinking water and associated health risk. The present study carry out to determine the arsenic level in drinking water and find out the correlation of arsenic concentration in drinking water and hair samples of female inhabitants of Sheikhupura district.

The objectives of the present study are following:

1. Find out the level of Arsenic in drinking water of the study area and identification of point sources with high risk level with respect to Arsenic concentration.
2. Assess the level of Arsenic concentration in hair samples of female.
3. Exploring the significant correlation between Arsenic contamination level in drinking water and in the hair samples among females for health risk assessment.

**Materials and Methods**

Present study was carried out to evaluate correlation of arsenic concentration in drinking water with biological sample (hair) of female population from district Sheikhupura.

**Study area**

The study area for the present research work is District Sheikhupura. District Sheikhupura comprises of 5 Tehsils (sub-districts) including Ferozwala, Muridke, Sheikhupura, Sharaqpur and Safdarabad.

**Determination of arsenic concentration in water samples**

Two hundred drinking water samples were collected from houses of female who gave their hair samples in 100 ml polythene plastic bottles. Water samples were pretreated for arsenic detection by adding 2 mL of 30% H$_2$O$_2$ and sufficient concentrated HNO$_3$ to result in an acid concentration of 1% (v/v). Heated the solution at 95ºC, until digestion was completed or until the volume is slightly less than 50 mL. After Cooling transfer to a volumetric flask, and bring back to 50mL with reagent water. Pipet 5 mL of this digested solution into a 10-mL volumetric flask, added 1 mL of the 1% nickel nitrate solution and dilute to 10 mL with reagent water (EPA7060-A, 1994).
Determination of arsenic concentration in hair samples

Two hundred hair samples were collected from female living in different areas of District Sheikhupura. 0. G of hair samples were weighed with the help of analytical balance (Sartorious TE31-DS, Germany). Each sample was washed with deionized water and then with methanol to decrease any external contamination without leaking arsenic out of hair.

Decomposition of hair samples

8 mL conc. HNO₃ was added in each sample after which the crucible was covered with the crucible lid and placed on a hot plate. Hair was digested at 70°C - 85°C for about 25 minutes or until the hair is completely digested and the solution becomes clear. The crucible was not allowed to go dry until the digestion was complete. After cooling to room temperature inside the fume hood, 1 mL of 30% H₂O₂ was added to each sample, and heated again on hot plate at the lowest setting (first setting i.e. 42°C) just until bubbling stops. After this, heat was increased to about 80°C or as needed until the volume is reduced to about 2.5 mL. The contents of each crucible were quantitatively transferred to a cleaned and dried 100 mL volumetric flask. The digestion vessel was rinsed three times with 1.5 mL each with deionised water and added to the volumetric flask and made up to volume with deionised water. The remaining solution was filtered using Whatman paper (2 micron). It was then transferred to a cleaned sample bottle, labelled well and stored in the refrigerator until ready to be analysed (Peter, Eneji. and Ato, 2012).

Data Analysis

All data was analyzed using SPSS and Minitab V 11 software.

Results and Discussion

Like Bangladesh, India, Iran and other countries in the world that are exposed to very high levels of arsenic in their drinking water (Nordstrom, 2002), Pakistan is now facing the threat of arsenic contaminated water.

Pakistan Council of Research in Water Resources (PCRWR) conducted a survey on arsenic contamination of ground water in the Punjab districts. The ground water was professed ‘dangerous’ having arsenic concentration above the WHO recommended level (10ppb).

The result of the present study showed that the arsenic contaminated drinking water in Sheikhupura District is a matter of serious concern. In some areas the level of arsenic in water and hair samples were above the permissible limits.

The respondents belonged to age of 15-25 years and were the students of intermediate and graduates. The first question was asked about the source of water used for drinking purpose at home. Majority of the population (53%) were using motor pumps as the source of drinking water while 28.5% were taking drinking water from other sources like WASA/Town committee. Only 2.5% respondents were consuming clean drinking water being sold in the market by different companies such as Nestle and Gourmet etc. (Fig.1).

There are five types of drinking water sources from where the samples were collected. Of all of the sources arsenic concentration above the permissible limits of WHO (2003) for arsenic(10 ppb) in drinking water except the water bottles. The
The maximum mean value ± SD of arsenic was observed in the source of hand pump water 70 ± 22.1 and minimum value observed is of i.e. 8.6 ± 1.7 in bottle water (Fig.2). The significance level is p=0.007. The reason for this is that hand pump draw water from 80 to 100 feet downwards and therefore the water is more contaminated as compared to water and sanitation authority (WASA) which pump water from almost 500 feet and above deep.

The drinking water samples were analyzed for arsenic detection collected from all the five tehsils of district Sheikhupura. The maximum mean value and standard deviation was observed in tehsil of Sheikhupura with mean concentration ± SD 63.46 ±22.3 ppb. The minimum value was observed in tehsil of Muridke with mean concentration ± SD 36.7± 20.4 ppb. In all five tehsils the mean arsenic concentration was significantly high (p=0.05) than WHO value (10ppb) Fig.3. Sheikhupura is an industrial as well as an agricultural tehsil. The high concentration may be due to industrial untreated effluent or agricultural activities. According to Rahman et al (2005), it was reported that in 1983-85, that 14 villages in south Bengal were affected by chronic arsenic toxicity due to industrial contamination. A study carried out by Chatterjee et al (1993) found that due to discharge of industrial effluent, after production of the insecticides Paris Green (copper acetoarsenite) by a local factory at the Behala, ground water has become contaminated with arsenic.

The mean values of arsenic concentration in hair samples was found higher in respondents of tehsil Sheikhupura 1.40±0.72 µg/g and lower was found in tehsil Ferozwala (0.41±0.55 µg/g) as shown in fig.4. The most probable reason is that the respondents living in Sheikhupura tehsil have higher intake of arsenic contaminated water and its accumulation is evident in the results of level of arsenic in hair samples as compared to respondents of other tehsils where arsenic level is comparatively less in drinking water. Our results of arsenic concentration in hair samples in all tehsils were higher than the normal level of As in hair range from 0.08-0.2 µg/g (Arnold et al, 1990).

Kaziet al.(2009) find out the similar result. They determined that concentrations of Arsenic in hair were evidently increased in people consuming drinking water of high level of Arsenic concentration as compared to those people consuming municipal treated water of low level of Arsenic concentration.

The results are also analyzed by splitting the ages into three groups consisting on 15-18, 19-22 and 23-25 years. The maximum concentration of arsenic is found in the third group i.e. female students of age group 23-25 years have high mean As in hair samples (1.62±0.1) µg/g. The minimum mean arsenic concentration ± standard deviation that found in first age group was 0.4 ± 0.07µg/g. Trend shows increasing value of arsenic level in the higher age group leading to decreasing value in the lower age group (Fig.5). This may be due to longer time of exposure to Arsenic contaminated water. For female exposed to high arsenic concentrations in drinking water for longer duration, the arsenic concentration in water may contribute significantly to exogenous arsenic in hair through bathing (de Peyster and Silvers 1995). Gabriela, Barbro & Marie (1998) in Northern Argentina concluded that arsenic concentration was higher in major food items all of which were prepared and cooked by using arsenic contaminated local water. This clearly describes that female population of district Sheikhupura probably ingest arsenic from rice and other vegetables they mostly take along with the amount in drinking water.
Fig. 1 Percentage of different water sources used by respondents in study area

Fig. 2 Comparison between mean arsenic conc. in different water sources of study area with WHO value.

Fig. 3 Comparison between mean arsenic conc. in different tehsils with WHO value.
Fig. 4 Comparison between mean arsenic conc. in hair samples of respondents of different tehsils

Fig. 5 Age group wise comparison of mean concentration of Arsenic(µg/g) in female hairs from 15-25 years of age

Fig. 6 Correlation between mean arsenic concentration in drinking water Samples (ppb) and hair (µg/g) of young females from different tehsils of study area
Correlation was found between drinking water (ppb) and hair samples (µg/g) of female respondents of different tehsils of study area. There was a positive correlation between arsenic in hair samples of females and water samples of the five tehsils of District Sheikhupura. The correlation value \( r = 0.894 \) was found for water and hair samples of different tehsils. It shows if the arsenic concentration is greater in water than it is also high in hairs samples of the same females (fig.6). These findings are similar to Rahman et al.,(2005) who find out the significant correlation between Arsenic level in drinking water and in the biological samples for cases where biological samples were available along with the drinking water samples.

The analysis of the result shows similar trends in term positive correlation \( r = 1.0 \) between mean arsenic concentration in drinking water and hair samples of female of different age groups i.e. 15 to 25 years.

In year 2013, Mazumder et al., reported the daily arsenic exposure through diet and water among those people living in arsenic contaminated areas and correlate it with biological samples (hair and urine). Significant high arsenic concentration in hair and urine was associated with increased arsenic ingestion through diet and water in people living in arsenic contaminated areas while low level of arsenic was observed in biological samples of people living in non-endemic regions.

The study deals with the arsenic determination in water and hair samples of young female. Drinking water is the direct source of ingestion in to the young female. It is found that all five tehsils of district Sheikhupura have average arsenic concentration above than the WHO reference value (10ppb). The drinking water of Tehsils Sheikhupura and Sharaqpur is highly contaminated as compared to other tehsils (63.46 ±22.3 and 61.6± 22.9) respectively. Strong correlation was found between arsenic concentration in hair samples and drinking water. The highest arsenic concentration was found in the hair samples of respondents of tehsil Sheikhupurawho use more Arsenic contaminated water. It is evident from the results of the study that the
drinking water quality of district Sheikhupura is not satisfactory; hence badly affecting the general environment and health of the people.

References


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