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PHYSICOCHEMICAL ANALYSIS OF DRINKING WATER FOR THE DETECTION OF ARSENIC FROM MANGA MANDI PUNJAB, PAKISTAN

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Abstract: Arsenic is a carcinogenic factor that threatens the health of millions across the globe. About 80% of Pakistan's entire population has no access to safe drinking water. As has been reported in many areas of Punjab province and people have been suffering from many diseases in rural areas of Punjab. To detect the presence of As in drinking water as well as to determine the physical parameters that are pH, total dissolved solid and electrical conductivity of drinking water. In this study, 369 samples of drinking water were randomly collected from Manga Mandi and analyzed. Levels of As was measured by atomic absorption spectroscopy. About 66% of drinking water samples showed As concentration above the WHO drinking water guidelines. Only 34% of samples were found within the WHO standards. Among physical parameters electrical conductivity was found to exceed the permissible limit. It is concluded that people of Manga Mandi use untreated ground water for drinking purposes that may be contaminated from anthropogenic sources, agricultural and industrial wastes. Installation of filtration plants and regular monitoring of water is recommended to improve the quality to reduce the risks of life threatening diseases.

Keywords: arsenic, physical parameters, health effects, drinking water.

1. INTRODUCTION

Arsenic is naturally present at high levels in the ground water of a number of countries. It is highly toxic mainly in its inorganic form. Arsenic is highly concentrated in hydrous ferrous oxides and sulphur compounds and easily solubilized in water from these minerals depending on temperature, pH, and redox reactions (Smedley & Kinniburgh, 2002). Microbial reduction of Fe(III) oxides or hydroxides promotes the As mobilization from sediments to groundwater in the hyporheic zone (Xie et al., 2014). Millions of people worldwide are exposed to As by natural levels of As in foods, fruits, meats and fish, as well as food processed with As-containing water. Foodborne As contamination is a major global human disease burden (Oberoi et al., 2014).

Genetic susceptibility and lifestyle factors may increase As toxic effects. Arsenic has been associated to high risks of several types of diseases such as cancers, diabetes, hypertension, vascular disease, neurogical disorders, reproductive problems and skin lesions (Hopenhayn, 2006).

It is also associated with the spontaneous abortion, stillbirth, birth weight, neonatal and child mortality (Quansah et al., 2015; Ahmed et al., 2018). Potential exposure in tap water during pregnancy are associated with an increased risk of gestational diabetes in context of low level exposure of less than 50µg/L (Marie et al., 2018). In Bangladesh, almost 57 million people are at risk of As-induced disease because of chronic contamination of their drinking water with concentrations of As that exceed the WHO guideline (Yunus et al., 2016).

Arsenic is a powerful endocrine disruptor which alters gene regulation at a very low concentration by the closely related glucocorticoid, mineralocorticoid, progesterone and androgen steroid receptors (Davey et al., 2007). This is also a neurotoxin for human development, causing detrimental impacts on memory, intelligence, and cognitive development (Tolins et al., 2014).

In China, endemic arsenicosis is considered a great public health problem, Shanxi Province and Inner Mongoliaare considered highly affected and endemic areas are continually arising, the population exposed to high amounts of As have become more than three million and more than 30000 As patients have been confirmed (Sun, 2004).

High levels of As in drinking water are a danger to India's public health. About 85 per cent of the water in India's rural areas comes from groundwater and an estimated million people are at risk of As contamination (Monrad et al., 2017). In US 90% of As present in seafood, of which only a small proportion consist of toxic forms, and the large proportion occurs in non-toxic form. Recent studies documented that large quantities of seafood consumption may produce carcinogenic metabolites in humans (Borak & Hosgood, 2007).

High prevalence of stroke in Denmark was caused by low concentration (<50µg/L) of As in drinking water. Associations between As exposure and occurrence of stroke have been studied, and the findings indicate that As in drinking water is related to increased prevalence rates of stroke also at low concentration (Ersbøll et al., 2018).

In Pakistan, alarmingly high levels of As have been found because of the rise in As pollution due to the urbanization and industrialization, As issues were only found in Punjab and Sindh. About 3% of Punjab's population was reported to As contamination in drinking water of more than 50 µg / L and in Sindh 16 and 36 % of the population subjected to As contamination of more than 50 µg / L and 10 µg / L (Sanjrani et al., 2017).

Five cities are highly contaminated by As in Pakistan, namely Lahore, Bahawalpur, Sheikhupura, Multan and Hyderabad. According to the recent report there are more than 50 million people are susceptible to As poisoning as people use groundwater polluted with As for drinking and other households (Podgorski et al., 2017). Agriculture studies in Pakistan found As in vegetables in low concentration because people use groundwater for crops and pesticides also produced As in vegetables (Samrana et al., 2017).

This study aims to assess the As level along with other quality assurance parameters of drinking water in Manga Mandi. The recent trends regarding As contamination of water in Punjab has alarmed the scenario with hazardous consequences. This study would help in the strategic planning for the improvement of quality of water and will provide the better opportunity in reducing the disease burden and improving the life quality of the people residing in that area.

2. METHODOLOGY

The analytical cross sectional study was conducted in university of Lahore and comprised drinking water samples from Manga Mandi district of Punjab Province. Non-Probability sampling technique were used for the collection of samples. Water samples were taken from the kitchen taps and areas in vicinity to industries were mainly targeted. Locked/closed houses and households not willing to participate were excluded. The data collected was then linked to the mean concentrations of respective parameters and recommendations were set in comparison with the WHO guidelines.

3. MATERIAL AND METHODS

369 houses are targeted for the collection of drinking water samples in Manga mandi. Samples were collected from the kitchen taps. Sampling was made in sterilized sampling bottles. Briefly, collected samples were transferred immediately to ice bags. The collected samples were shifted to laboratory for further analysis. Collected samples were sent to the Environmental Protection Agency for physiochemical analysis and the analysis was done by;

- pH-meter
- TDS/conductivity meter
- Atomic absorption spectrometer

The As is analyzed on Atomic Absorption Spectrometer equipped with As lamp**.** pH, TDS and Electrical conductivity were determined by digital meters equipped with electrodes.

3.1. Statistical Analysis

Data was analyzed statistically using SPSS 22. For quantitative data mean ± standard deviation was calculated for As and other physical and chemical properties. Frequency and percentage were calculated for categorical data. One sample t-test of As was applied to compare our mean with WHO Standards. P value less or equal to 0.05 was considered as significance. Other chemical and physical parameters were compared with WHO standards with their mean or average.

4. RESULTS

4.1. Determination of arsenic

Quantitative analysis of As in the samples of drinking water were determined through atomic absorption spectroscopy.

Table 1. Frequency distribution of samples identified with As

Nr.	Concentration of arsenic (µg/L)	Frequency (%)
1	0.00	46 (12.47)
2	0.01-10.00	124 (33.60)
3	10.10-100.00	196 (53.12)
4	100.00-200.00	3 (0.81)

Arsenic shown in the Table 1 and Figure 1, out of total 369 samples, 46 (12.47%) samples were completely free from As. From the remaining samples, 124 (33.60%) were contained the WHO permissible amount of As in then i.e. <10µg/L while 196 (53.12%) were contained up to 100µg/L of the As. Only 3 (0.81%) were found highly contaminated i.e. contained more than 100µg/L of the As.

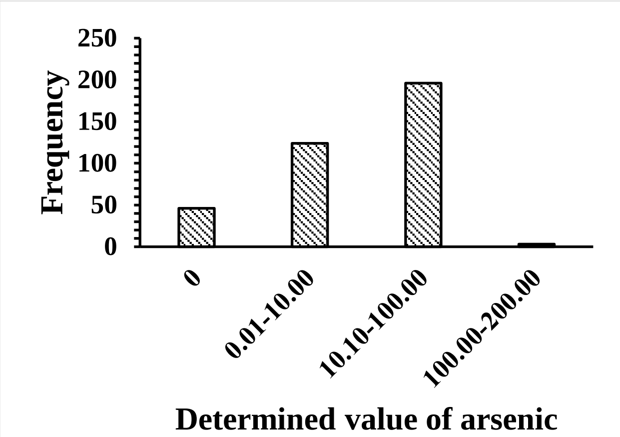

Figure 1. Frequency distribution of samples identified with As

Table 2 describes the statistical representation of data. From the total 369 samples of the water, maximum detected value of the As was found to be 157.20µg/L with the mean of 19.72µg/L and standard deviation of 21.76µg/L.

4.2. Comparisons of means:

One sample t-test is used to compare the means of the sample with the standard. Results of the one sample t-test as shown in Table 3 shows that p-value of the sample is less than 0.001. This concludes that average (19.72µg/L ± 21.76) of the obtained samples is greater than WHO admissible range i.e. 10µg/L.

The comparative number of samples as per the WHO admissible criteria and out of it is shown in Figure 2. This showed that 34% samples are in the acceptable range of As contents while 66% lies outside from the acceptable range and thus the overall water quality is poor.

4.3. Other Chemical parameters:

Besides As other chemical parameters like Nitrate and Fluoride were also found in drinking water of Manga Mandi. Mean from the samples of Nitrate and Fluoride were 2.7502 and 0.9808 respectively. By comparing them with WHO allowable range of 10 and 1.5 respectively, it was found that they are within the range.

4.4. Physical parameters

Physical tests of the obtained samples include Total Dissolved Solids (TDS), Electric conductivity and pH determination. Table 5 describes the descriptive statistics of three physical tests performed on each sample. The minimum pH of the samples was found to be 7.07 and highest 8.83 while its average falls at 7.48 ± 0.24. The average pH of the samples was within the admissible range as per WHO guidelines i.e. 6.5-8.5.

Table 2. Descriptive Statistics of As

Element	N	Minimum (µg/L)	Maximum (µg/L)	Mean	Std. Deviation	WHO admissible value
As	369	0.00	157.20	19.72	21.76	10µg/L

Table 3. One-Sample Statistics

	Test Value = 10					
	t	Df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
As	8.582	368	0.000	9.72	7.49	11.95

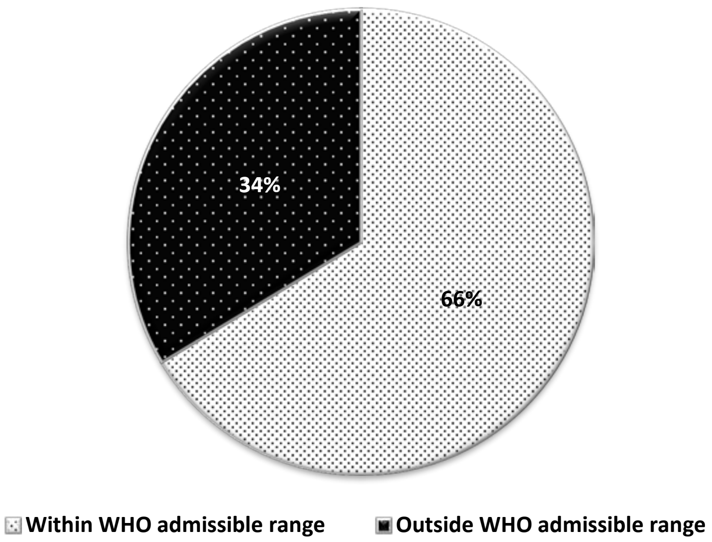

Figure 2. Chart showing number of samples within and outside the WHO admissible range of As

Table 4. Descriptive statistics of nitrate and fluoride

Chemical parameters	N (no. of samples)	Mean	Std. Deviation	WHO (World Health Organization) Admissible Value
Nitrate	369	2.75	4.74	10mg/L
Fluoride	369	0.98	0.84	1.5mg/L

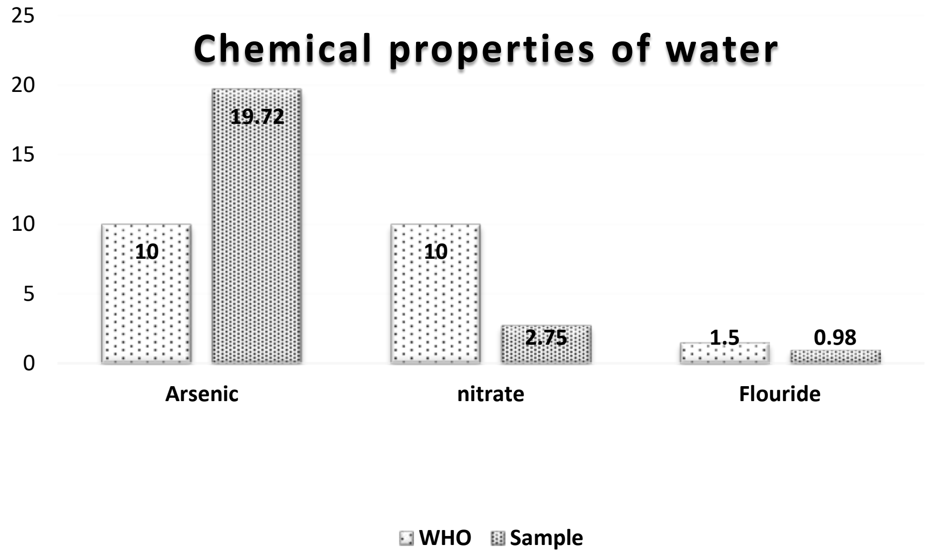

Figure 3. Mean concentration of chemical parameters of As(µg/L), nitrate(mg/L) and fluoride(mg/L) of drinking water compared with the WHO guidelines

The total dissolved solids were found between the ranges of 349-5931µg/L with the average of 839.05 ±593.42µg/L. The average of the TDS was also found in the acceptable range of WHO i.e. 1000µg/L. The electrical conductivity was fall in the range of 582-9885µs/cm with the average of 1398.39 ±989.04µs/cm which is above the permissible range as per WHO guidelines. This can be interpreted with the TDS as a small increase in the TDS leads to greater increase in the electrical conductivity of the water.

5. DISSCUSSION

5.1. Arsenic

Arsenic concentration in ground water were detected in few cities of Pakistan. In Manga Mandi,

Table 5. Descriptive Statistics of Physical Parameters

Physical parameters	N (no. of samples)	Minimum	Maximum	Mean	Std. Deviation	WHO (World Health Organization) Admissible Range
pH	369	7.07	8.83	7.48	0.25	6.5-8.5
TDS (µg/L)	369	349.00	5931.00	839.05	593.41	1000µg/L
Electrical conductivity (µs/cm)	369	582.00	9885.00	1398.39	989.04	400µs/cm

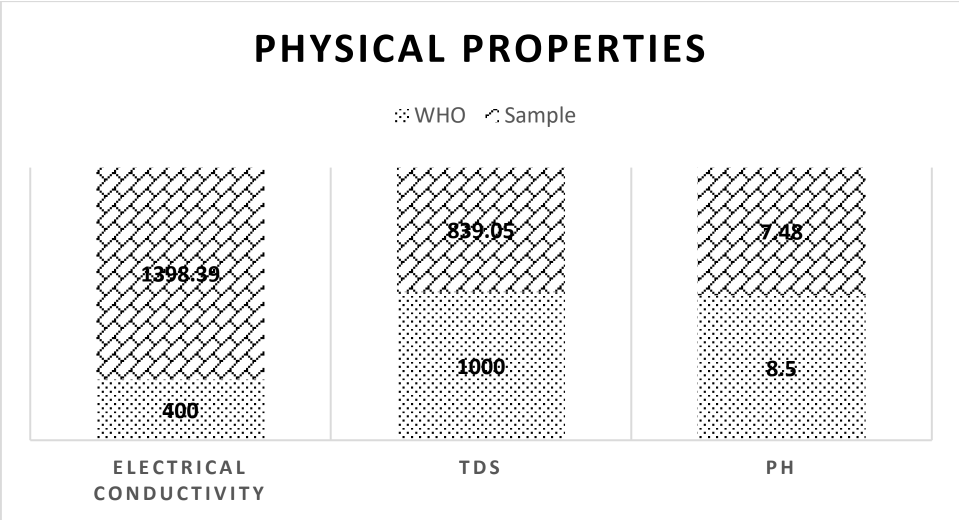

Figure 4. Mean concentration of physical parameters of electric conductivity (µs/cm), TDS (µg/L) and pH of drinking water comparison with the WHO guidelines

levels of As in drinking water are measured. Many factories and industries are running in this area. There are very few areas in Manga Mandi that have access to improved sanitation facilities. People usually use ground water as a source of drinking water and cooking purposes. Atomic adsorption technique was used for the detection of As. The As concentration in drinking water above the WHO guideline value of 10 µg/L is one of the critical environmental concerns considering As toxicity. About 66% of drinking water samples in manga Mandi showed As concentration above the WHO drinking water limit.

In Muzaffarabad Pakistan, As concentration in 58% of samples taken from the ground water exceeded WHO guideline value. Concentrations still remain below 25 µg / L in rural areas. Because aquifer sediments are absorbed as in oxic shallow groundwater and recharge soils. However, in some urban areas shallow groundwater is found to contain elevated As levels. Geochemical evidence shows that unconfined sewage and other sources of polluting organics lead to a reduction in the release of hydrous ferric oxide (HFO) from sorbed groundwater (Nickson et al., 2005). The findings of our study in Muzaffarabad are quite similar to those of our study. In Manga Mandi, As concentration in drinking water exceeds 8 per cent more than in Muzaffarabad, which is above the standards of the WHO.

In Jamshoro Sindh, Pakistan, the geological and anthropogenic forms of As emissions is measured in surface and groundwater supplies. Arsenic levels in most of the water samples exceeded the WHO standard value of 10 µg / L. The high level of As in this region might have been due to intensive water harvesting from the Indus River irrigation scheme, which causes high salt concentration in this semi-arid environment and contributes to the accumulation of As in shallow ground water. High levels of iron have been detected in groundwater as a potential source of advancement (Baig et al., 2009).

In Pakistan, more than 47 million people are estimated to live in areas where more than 50% of groundwater wells produce As concentrations above the WHO limit of As in drinking water permitted. Data from 43 studies were used to identify As variability in the groundwater of Pakistan, and to equate it with global data. Approximately 73 % of the mean As concentration in the 43 studies was greater than the World Health Organization's (WHO) allowable drinking water limit (10 µg / L), while 41% was higher than the allowable As limit in Pakistan (50 µg / L). Punjab and Sindh had high concentrations of

As that were almost equal to those recorded in the world's most polluted areas (Shahid et al., 2018).

Heavy metal contamination was studied around the Daye Copper Smelter, Hubei Province, China and measured potential health hazards for local children. Samples from soil, trees, fish and water wells were obtained. The findings revealed that these samples contained high concentrations of (Cd), (Cu), (Pb), and (As). In necessary soil, Cd and As reached the overall allowable food standard (MPL) in China by 82% and 39% respectively. Community children remain at high risk of exposure from heavy metals. The principal risk contribution was seed intake (Cai et al., 2019).

The sources of human exposure to As include drinking water, wheat, processed food items, vegetables, fungi, animal products etc. Citizens living across Bangladesh and West Bengal, India are considered as at the greatest risk. It has been stated in this study that rice and rice related foods are the primary cause of human exposure to As. Rice growing in other non-contaminated areas like Australia can also contain high As levels. A global concern is the issue of rice import / export around different countries. The inorganic and organic levels of As influence the associated As toxicity in the food. Arsenic reports in rice-based products including baby food from various countries revealed that even infants are at high risk of As exposure (Upadhyay et al., 2019).

5.2. Physical Parameters

Physical parameters results showed that pH and TDS levels in most of the drinking water samples collected from Manga Mandi are within the WHO guidelines. However, it has been found that Electrical conductivity of drinking water in this region does not meet the WHO guidelines. Results indicate that water was not substantially ionized in the study region and has a lower degree of ionic activity due to small dissolved solids.

Physical parameters of ground water were assessed and compared with WHO standards and its related diseases in Bahawalpur City, Pakistan. Study reported a decline in groundwater quality in this town and the situation was even worse in one region, i.e. Islamic colony, where residents diluted 48%, 55%, and 41%, respectively, with a faint, brackish, and mud scent. EC, TDS, hardness, pH etc. is far from the appropriate WHO requirements. Such poor quality of water had caused serious waterborne diseases such as diarrhea, cholera etc. About 36 per cent of people in the affected area suffered serious illnesses (Mohsin et al., 2013).

In Greece, drinking water quality was evaluated from various region. EC, TDS and pH, as well as related to the treatment of drinking water and dissolved organic carbon were included in physiochemical analysis. Most problems have been identified in the islands of the Cyclades, particularly those characterized by shortage of water resources. The major problems of drinking water quality are correlated with conditions of the water supply network, pollution of 'parent' water, and in particular groundwater contamination of both anthropogenic and natural toxins, as well as intrusion of seawater into aquifers (Karavoltsos et al., 2008).

Drinking water quality in Pakistan is slowly decreasing day by day. Close to 20% of the whole population of Pakistan has access to clean drinking water. The remaining 80% of the population are forced to use contaminated drinking water due to the shortage of safe and stable sources of drinking water. The primary source of waste is raw sewage, which is generally drained into drinking water system reservoirs. The secondary cause is the discharge of hazardous substances into the water bodies from industrial and agricultural sources. Human activity causes waterborne diseases that account for nearly 80% of all diseases and 33% of deaths (Daud et al., 2017).

6. CONCLUSION

From the present study, high content of As concentration in drinking water collected from area under study found to exceed the WHO guideline value. Among physical properties high electrical conductivity of drinking water was observed. It is concluded that people use untreated water or groundwater for drinking purposes which contains high concentration of As along with other harmful contents. It may be due to either anthropogenic activities or contamination with industrial or agricultural chemicals because there are lot of factories around the area. Arsenic and other chemicals might be originated from the wastes of these factories. So untreated water with these properties contains high risk of life threatening diseases like cancer, skin lesions and gastrointestinal infections etc.

7. RECOMMENDATIONS

Preventive and monitoring steps to reduce the As content in drinking water ought to be as per following;

1. Filtration plants should be installed by the local government for safe drinking water supply to the community.
2. A regular monitoring system of the water quality should be carried out.

3. Government should take the strict measures against the poor management of industrial wastes.

4. Urgent measures should be taken to enhance the sanitary conditions.

5. People should be encouraged to drink and use safe water to avoid harmful consequences.

6. District government must hold awareness campaigns on the significance of healthy drinking water for human health.

Limitations

This research is limited to analyzing As and few physical parameters of drinking water. Due to the consumption of untreated drinking water in this region, further studies can be conducted to determine the diseases and health effect.

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