A study on various pollutants in water and their effect on blood of the consumers

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Abstract

Water pollution is one of the most dangerous problems which is commonly ignored in our country. Pakistan ranks very low in the world, regarding drinkable water. Both surface and underground water are contaminated with toxic metals and pesticides and arsenic ($\mu\text{g/L}$) were found to be 50. The quality parameters set by the WHO are persistently violated. The water quality is seriously affected by improper disposal of industrial, domestic waste and agrochemicals. These pollutants are responsible alone, or along with other factors for a variety of health problems. This article discusses drinking water being supplied in Sahiwal (Pakistan) to students living in the hostel along with an emphasis on the major pollutants, their effects and consequent health problems. The data presented in this article have been collected in Sahiwal. The water samples were collected from the main supply and the blood samples were of the consumers of that water.

Keywords Water pollution · Data analysis · Toxic metals · Domestic waste · Health problems

Introduction

Food and water are the basic necessity of life along with oxygen (Furusawa et al. 2008). Water is responsible for the survival of life on earth (Carducci et al. 2003; Girones et al. 2010; Hilaire et al. 2008). Our earth mostly has hard water which is not fit for drinking (Leurs et al. 2010). The rest which can be used for this purpose is present in a small amount and the reserves are decreasing (Mehta 2012). From the past few decades, this issue has become bigger in Pakistan and clean drinking water is also not available (Faruqui 2004; Nabi et al. 2019; Rosemann 2005; Subramaniam et al. 2012). The water that is presently being consumed is contaminated with poisonous chemicals like arsenic, fluoride, nitrates, etc. (Basu et al. 2014; Sarkar and Paul 2016). The arsenic salts consist of arsenic calcium arsenate, lead hydrogen arsenate, cupric hydrogen, arsenate and acidic copper arsenate. A big part of the population is suffering from hepatitis, cholera and other water-borne diseases (Ahmed et al. 2016; Davies et al. 2015; Khan et al. 2013; Khan et al. 2018; Qadri et al. 2018; Shah et al. 2016). There is an increase in the scarcity of clean drinkable water in developed cities. Water pollution is a global problem for living organisms and the environment (Chaudhry and Malik 2017; Schwarzenbach et al. 2010). According to the United Nations, more than

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80% of wastewater flows back into the environment without being treated or reused (Alvim et al. 2020; Connor 2015; Mustafa 2020; Usman et al. 2020). In some countries, this figure is around 95% (Lyu et al. 2016). Every year approximately one billion people are drawn sick by using polluted water, especially low-income groups (Bartram et al. 2005; Gleick 2002). It caused 1.8 million deaths worldwide in 2015 (Mayo and Hanai 2017). In almost all cases, the effect is damaging not only to individuals but also to the overall population. Agriculture is one of the major causes, as the use of fertilizers and pesticides given to crops, for better growth are washed into rivers and lakes by rain which eventually pollutes the water (Bu et al. 2019; Prashar and Shah 2016; Sharma and Singhvi 2017; Sun et al. 2012). Toxic substances from farms, towns and factories are readily dissolved in drinking water and pollute it (Barra et al. 2005; Häder and Erzinger 2017; Hong et al. 2019). These wastes include heavy metals as they are a constituent of colors and dyes used by various industries. These eventually find their way into water supplied for domestic use. High levels of such metals in water interfere with the biochemical reactions of the human body. Some of them are carcinogenic, while others interfere with immunity. Water pollution is one of the major threats to public health in Pakistan as the quality of water is not managed and monitored (Jabeen et al. 2015). Pakistan ranks at number 80 among 122 nations regarding drinking water quality. This is due to persistent violations of parameters set by the WHO (Azizullah et al. 2011).

The increased concentration of arsenic in drinking water has been reported in many countries of Southeast Asia and the United states (Anawar et al. 2002; Chowdhury et al. 2000). This heavy metal is one of the most disturbing chemicals as its trivalent form, and arsenite in which it exists is more toxic than other forms (Atsdr 2007). Hematological parameters like hemoglobin (Hb), red blood cells (RBCs), packed cell volume (PCV), mean corpuscular hemoglobin and mean corpuscular hemoglobin concentration have been used frequently to assess the oxygen-carrying ability of blood as well as an indicator of water pollution caused by heavy metals (Mazumder 2008).

Among the heavy metals found in water, arsenic effect on human health has been evaluated around the world. The reason for these regulatory changes is that this metal can cause serious effects even at low concentrations. There is a strong association between chronic intake of arsenic and various diseases (Abdul et al. 2015; Kapaj et al. 2006; Saha et al. 1999; Singh et al. 2007). Exposure to arsenic affects not only affects hair and nails but also internal organs like brain and lungs. In addition to this, the adverse effects can be witnessed in increasing cases of various health-related problems like cardiovascular problems, dermal issues, pregnancy complexities, neurological, diseases related to gastrointestinal and respiratory systems, cancer, diabetes mellitus,

etc. (Chakraborti et al. 2017). This leads to a greater need to measure arsenic in communities and individuals using drinking water. Communities consuming water with arsenic levels greater than 5 µg/L should consider a program to document arsenic levels in the population. These levels are of importance for humans in clinical nutrition because both high and low intakes predispose a person to various types of cancers (Bogden and Klevay 2000). It has also been linked along with other pollutants as a contributory factor in the development of diabetes (Longnecker and Daniels 2001).

So, a study was conducted at Sahiwal Medical College to estimate the amount of heavy metals in water that was consumed by students and their effect on their blood. This study will help to identify the heavy metals present in water their levels and their effect on a population of students of medical college consuming it. The hypothesis is used as: Is contaminated water causing an effect on the blood picture of young students. The aims and objectives of the study were: To identify the amount of pollutants and heavy metals in the water and observe their effect on young healthy students of Medical College. The study population consisted of young healthy students not suffering from any acute or chronic disease. The inclusion criteria followed as: Students were chosen by random selection. The age of the students was between 18 and 20 years. All of them were consuming water samples that were analyzed while living in college hostel. They were not suffering from any acute or chronic disease. The exclusion criteria were: Only students of Sahiwal Medical College were included. Students suffering from any acute or chronic disease were excluded. Also, patients suffering from any autoimmune conditions, inflammatory conditions, conditions like celiac disease, Crohn disease, parasitic infections, having a history of peptic ulcer and long menstrual cycles and with lead poisoning were not included in the study.

Materials and methods

Water samples were analyzed by atomic absorption spectrometry. The total metal content was calculated by flame atomic absorption spectrometry. To calculate the concentration of heavy metals in the water, a typical type of standard calibration curves with good linear regression and better relative standard deviation were achieved. To confirm the validity of measurements, standard reference material NIST SRM 1643-e was used. A complete blood count was done on an automated analyzer. A well-mixed blood sample was placed on a rack of the analyzer. The cell counting component estimated the number and different types of cells in the sample. Hemoglobin was measured with a hemoglobiometer. Blood cell counting was done by flow cytometry (Briggs et al. 2009). The microhaematocrit method

of Snieszko was used to determine hematocrit/PCV. The derived hematological indices like mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH) and mean corpuscular hemoglobin concentration (MCHC) were calculated using standard formulae. MCH was calculated in picograms = $\text{Hb/RBC} \times 10$ and $\text{MCHC} = (\text{Hb in 100 mg blood/PCV}) \times 100$. Total amount of arsenic was determined by reducing As (V) to As (III) with potassium iodide (KI) and ascorbic an HCl solution. A stock standard solution (1 g/L) of arsenic was supplied by Merck (Merck, Darmstad, Germany). The AA-6650 atomic absorption spectrophotometer was used having a deuterium lamp background correction system with a GFA-EX7 graphite furnace and an ASC-6100 autosampler. Light source included hallow cathode lamps with measurements done by integrated absorbance. A wavelength of 193.7 was used. Pyrocoated graphite tubes, with integrated platforms or L'vov platforms (Shimadzu Co. Ltd., Japan), were used for the atomization of arsenic. Samples were analyzed under optimum conditions after adjustment of the instrument. The calibration curve was used for the determination of arsenic. A STOCK standard solution of arsenic and granular activated charcoal was used, Working solutions were made by dilution of standard one, Argon was used in an atomizer with glassware kept in 10% nitric acid for 48 h, PH of 6.0 was selected for process, Acidic eluents were selected as arsenic was not absorbed in higher PH. Certain abnormal cells were identified manually (such as with the help of a microscope). The results are shown in Tables 1 and 2 and Figs. 1 and 2.

Results and discussion

Hematological parameters like hemoglobin (Hb), red blood cells (RBCs), packed cell volume (PCV), mean corpuscular hemoglobin and mean corpuscular hemoglobin concentration tabulated in Table 2, and their average values with standard deviation are presented in Fig. 2. Chronic exposure to even low doses of heavy metals causes a decrease in red blood cells, hematocrit and hemoglobin. However, the levels of blood indices depend on the quantity of heavy metal that is absorbed. It is worth mentioning that MCH and MCHC levels reflect the health of hemoglobin of a person. A low MCH reflects iron deficiency anemia. This was seen in most of our patients who complained of fatigue, dizziness and weakness. The findings of Table 1 and Fig. 1 are persistent with the study done in the west Bengal where anemia was reported in 45% of persons consuming arsenic-contaminated water (Shah and Altindag 2004). An MCH value below 27.5 pg is considered low MCH. The most of the patients included in our study had decreased MCH value. This indicates the presence of low volume of hemoglobin per red blood cell among the studied population. Major reasons of low hemoglobin are trauma, major surgery, blood loss or a diet low in iron. Another rare cause of low MCH is the presence of thalassemia under which a low count of blood cells is mingling in the blood circulation. This suggested that the average quantity of hemoglobin was reduced in students

Table 1 Results of the data collected for different parameters

S. no.	Analysis	Method no.	Result	WHO limits
1	pH at 25 °C	4500-H ⁺ B	7.58	6.5–8.5
2	Total alkalinity as CaCO ₃ (meq/L)	2320 B	1.9	
3	Carbonates (mg/L)	2320 B	95	–
4	Bicarbonates (mg/L)	2320 B	115.9	
5	Total hardness (mg/L)	2340 C	207	500
6	Calcium hardness as CaCO ₃ (mg/L)	2340 C	50	–
7	Magnesium hardness as CaCO ₃ (mg/L)	2340 C	157	–
8	Total suspended solids (mg/L)	2540 D	–	NIL
9	Total dissolved solids (mg/L)	2540 C	634	1000
10	Calcium as Ca ²⁺ (mg/L)	3500-Ca	20	–
11	Magnesium as Mg ²⁺ (mg/L)	3500-Mg	37.68	–
12	Potassium as K ⁺ (mg/L)	3500-K	5.0	–
13	Sodium as Na ⁺ (mg/L)	3500-Na	160	200
14	Chloride as Cl [–] (mg/L)	4500-Cl	83.90	250
15	Sulfate as SO ₄ ^{2–} (mg/L)	4500-SO ₄	105.2	250
16	Conductivity at 25 °C (μS/cm)	2510 B	1271	–
17	Nitrate as NO ₃ [–] (mg/L)	4110-B	1.88	50
18	Nitrite as NO ₂ [–] (mg/L)	4110-B	–	0.5
19	Fluoride F [–] (mg/L)	4110-B	0.35	1.5
20	Arsenic (μg/L)	3500-As	50	10

Table 2 The blood parameters of the sample of 50 students

S. no.	Hb	WBC	Hct	MCV	MCH (27–32)	MCHC (31–35)	RBC
1	14.2	7.9	49.9	99.4	28.3	28.5	5.02
2	13.6	6.8	51	99	26.3	26.6	5.17
3	13.4	6.5	49.2	87.9	23.9	27.2	5.6
4	14	6.9	49.5	92.2	24.9	28.3	5.35
5	13.8	7.7	5.45	51.4	25.3	26.8	5.45
6	13.0	7.6	46.8	97.5	27.1	27.8	4.80
7	10.8	9.3	42.4	68.5	17.4	25.5	6.19
8	14.0	9.3	49.4	95.6	28.2	29.1	5.37
9	13.7	8	53.3	95.0	24.4	25.7	5.61
10	12.0	8.7	47.6	101.9	28.6	32.2	4.67
11	12.8	6.6	49.8	101	26.0	25.7	4.93
12	12.0	6.7	48.0	95.6	23.8	24.9	5.04
13	13.2	4.5	50.7	92.2	24.0	26.0	5.50
14	9.0	5.5	38.2	88.8	20.9	23.6	5.5
15	9.9	5.2	41.4	92.6	24.1	23.9	4.47
16	12.0	7.6	51.0	79.1	18.6	23.5	6.45
17	10.5	6.2	41.9	101.0	27.6	25.1	3.81
18	10.4	5.3	44.7	76.9	17.9	23.3	5.81
19	13.7	5.9	50.7	98.2	27.7	27.0	4.94
20	15.1	8.5	53.5	94.9	26.8	28.2	5.64
21	11.9	7.2	45.6	111	29.2	26.1	4.08
22	11.2	5.5	38.8	106	30.6	28.9	3.6
23	14.2	6.4	47.8	87.4	26.0	29.7	5.47
24	9.9	10.2	36.0	79.6	21.9	27.5	4.52
25	10.3	6.6	38.0	78.4	21.2	27.1	6.6
26	12.2	6.2	47.8	97.6	24.9	25.5	4.90
27	15.3	9.3	56.6	96.1	26.0	26.0	5.89
28	13.4	5.6	43.0	91.1	28.4	31.2	31.2
29	13.2	9.5	43.8	90.7	27.3	27.3	4.83
30	14.9	7.3	50.8	86.1	25.3	29.3	5.90
31	9.4	7.1	34.5	79.9	21.8	27.2	4.32
32	11.0	8.6	39.6	83.5	23.2	27.8	4.74
33	14.5	6.9	47.2	80.7	24.8	30.7	5.85
34	11.2	8.0	43.3	66.0	17.1	25.9	6.56
35	14.4	8.9	52.2	99.8	26.4	30.9	5.45
36	14.9	6.4	53.8	98.0	27.1	27.7	5.4
37	12.2	5.2	51	80.3	19.2	23.9	6.35
38	12.04	7.1	42.4	84.3	24.7	29.2	5.03
39	10.1	6.7	40.6	77.9	19.4	24.9	5.21
40	11.1	6.4	42.1	90.7	23.9	26.4	4.64
41	11.2	9.5	39.1	87.5	25.0	28.6	4.48
42	13.0	7.6	44.8	90.9	26.4	29.0	4.93
43	12.4	6.9	44.7	92.7	25.7	27.7	4.82
44	11.1	7.0	41.9	88.2	23.4	26.5	4.75
45	8.8	7.8	35.1	84.4	21.2	25.1	4.16
46	8.2	5.0	30.9	84.4	22.4	26.5	3.66
47	13.6	8.3	48.0	86.0	24.4	28.3	5.58
48	10.8	6.8	40.5	87.9	23.4	26.5	4.61
49	12.0	8.2	42.8	93.2	26.1	28.0	4.59
50	12.4	7.1	42.4	84.3	24.7	29.2	5.03

Fig. 1 Results of the data collected for different parameters. 1. pH at 25 °C, 2. total alkalinity as CaCO₃ (meq/L), 3. carbonates (mg/L), 4. bicarbonates (mg/L), 5. total hardness (mg/L), 6. calcium hardness as CaCO₃ (mg/L), 7. magnesium hardness as CaCO₃ (mg/L), 8. total suspended solids (mg/L), 9. total dissolved solids (mg/L), 10. calcium

as Ca²⁺ (mg/L), 11. magnesium as Mg²⁺ (mg/L), 12. potassium as K⁺ (mg/L), 13. sodium as Na⁺ (mg/L), 14. chloride as Cl⁻ (mg/L), 15. sulfate as SO₄²⁻ (mg/L), 16. conductivity at 25 °C (μS/cm), 17. nitrate as NO₃⁻ (mg/L), 18. nitrite as NO₂⁻ (mg/L), 19. fluoride F⁻ (mg/L), 20. arsenic (μg/L)

Fig. 2 Mean and standard deviation of blood parameters of 50 samples

consuming contaminated arsenic water. Since hemoglobin is the protein that carries oxygen and this explains the presence of fatigue in most of our patients. As we know MCH value is related to MCHC. This explains that the decrease in MCH and MCHC are interlinked, the only difference that MCHC takes the volume or size of RBC into account while MCH does not. Low MCHC reported in students consuming contaminated water is closely related to anemia which is hypochromic microcytic showing that cells in the blood are smaller than normal and have decreased hemoglobin. This suggests that fast heartbeat, fatigue and weakness are most probably related to the consumption of this water, causing low MCHC and MCH, since other common causes were ruled out in history and examination.

This study can go a long way in suggesting that the students affected should use clean filtered water free from heavy metals and other pollutants and those affected should

take iron-rich foods and iron supplements. In addition, it is a great matter of concern for life on earth that the concentration of arsenic in the water is damaging the environmental and human health perspectives.

Conclusions

The present study showed that hematological parameters are reliable indicators of toxic response following exposure to arsenic. Arsenic intoxication shows an anemic condition. It is assumed that these changes in hematological indices may provide valid information for protection against arsenic toxicity through stimulation of the immune system.

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Data availability The data are given in the paper.

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

Ethical committee approval The ethical committee approved this research under the reference number EC/2019-2/DCSCE.

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