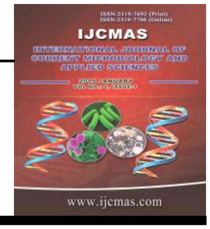

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 4 Number 3 (2015) pp. 1009-1017**
http://www.ijcmas.com

Original Research Article

Assessment of risk human health induce to chrome, nickel, lead and cadmium of the tap water; Jask City, Iran

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A B S T R A C T

Entrance of such toxic heavy metals as Cd, Cr, Mn, Pb, As and Ni of a high concentration into drinking water sources due to the exhaustion of municipal or industrial wastewater can be hazardous for human health. In the present study,120 samples of tap water were collected from 8 regions of Jask town during winter season, 2013. Concentration of heavy metals (Cr, Ni, Pb and Cd) was measured via a spectrophotometer model DR2800. Then, using the existing equations, human health state of male and female adults, children and infantswere measured under the effect of the heavy metals. The mean concentration of these heavy metals are 24.11±4.8, 45.7±6.2, 4.8±.33 and 1.61±.39 µg/l, respectively. Moreover, the concentration of Ni is significantly higher than Cr, Pb and Cd (p value<0.05). The order of the hazard quotient induced by Cr in drinking water for the different age groups is: male adults >infants>female adults > children. Alsofor Cr, Cd and Ni this order is: male adults > female adults > infants > children. The mean concentration of Cr, Ni, Pb and Cd in the tap water of Jask is lower than the standards set by WHO and EPA. Since the HQ of such heavy metals as Cr, Ni, Pb and Cd is less than 1, it could be said that alltap water consumers in Jask are within the safe and secure domain in terms of human health risk.

Keywords

Heavy metals, Risk assessment, Age group, Drinking Water, jask City

Introduction

Over 70% of the surface of the planet earth is covered in water. However, because of its salt, it is not usable in many developing and poor countries. Moreover, 3% of the surface of the earth is covered in drinkable water, of which only 0.6% is usable and can be obtained from wells, rivers, lakes, etc. The rest is not yet consumable since is located in the two Poles [1]. In recent years, the pollution of drinking water with heavy metals has drawn the attention of many environmental researchers. The existence of heavy metals in water sources can be due to natural processes such as soil erosion, or due to human activities such as exhaustion of municipal, industrial or agricultural wastewater [2, 3]. Entrance of heavy metals into water sources would lower their quality for either drinking or agricultural purposes [4]. Heavy metals have such properties as biological accumulation, toxicity and environmental sustainability [5]. Some heavy metals including Cadmium (Cd), Chrome (Cr), manganese (Mn), Lead (Pb), Arsenic (As) and Nickel (Ni) in high concentrations can be hazardous for human beings or other living creatures [6]. In very low concentration, Cr can improve body functioning. In a high concentration, however, it can severely damage liver and kidneys and can cause cancer [7]. The standard limits set by the World Health Organization (WHO) and the United States Environmental Protection Agency (EPA) for the Cr of drinking water are respectively 50 and 100 μg/l. A high concentration of Ni in water can cause cardiac arrest in children younger than 10 years of age [8]. Similarly, consuming water with a high concentration of Ni can have such acute effects as diarrhea, nausea, vomit and nervous effects. In the long run, it can damage kidneys and liver and can lead to cancer [9]. The standard limits for Ni in drinking water set by WHO and EPA are respectively 70 and 100 μg/l. Lead is also a very toxic element that can have such chronic effects as headache, stomachache, brain and kidney damage [10, 11]. Children are more sensitive to the toxicity of Pb. Their exposure to its high concentration can have such acute effects as behavioral disorder, memory loss, learning failure and in the long run, it can afflict them with anemia [11]. The standard limits set for Pb by WHO and EPA in drinking water are 10 and 15 μg/l,respectively [12]. Exposure to Cd can have acute and chronic effects on living creatures [13]. Its chronic effects include kidney and skeletal diseases, itai-itai and cancer [14]. The standard limits set by WHO and EPA for the Cd of drinking water are 3 and 5 μg/l, respectively. Due to the significance of these metals for human health, a myriad of research has been conducted on drinking water sources. As an instance, an investigation conducted in Tehran measured the concentration of Cu and Pb in drinking water samples. It revealed that the mean Cu concentration was about normal. However, Pb concentration was a little above the standard limit [15]. Due to its climate, our country Iran has a limited number of drinking water sources especially in southern provinces such as Boushehr, Hormozgan and Sistan-o-Baluchestan (16). Because of the healthcare-related hazards of heavy metals in drinking water, the presence of some military and ship-producing industries, corrosion of water distribution system and the lack of a wastewater collection network in Jask, the present study attempted to assess the hazard of heavy metals in tap water for human health.

Materials and Methods

Study Area

Jask harbor is located in the southeast of Hormozgan province, 220 kilometers away from Bandar Abbas (capital city of Hormozgan). Its geographic coordinates are 25°39'11" N and 57°47'21" E (figure 1)[17]. This town is 2 meters above the see level and has a hot and humid climate [18]. In this town, drinking water is supplied by a surface water source: Jagin dam. This water enters the distributional network without any treatment process and only goes through a chlorination process.

Location of Jask harbor in Hormozgan province, Iran

Sample collection

This descriptive, cross-sectional research was conducted in December, January, February and March in 2013. To obtain a proper relative mean concentration of the heavy metals (Cd, Pb, Ni and Cr) in its drinking water, Jask was divided into 8 regions based on its area and population: Yekbeni, Loran, Sarrig, Moghsa, Kampan, Zolmabad, Sarkalleh and Gharibabad.

The required data were collected in three time intervals (in the mid ten days of each month). In each month 40 samples[1]and a total of 120 water samples in winter were collected (15 water samples throughout winter) from the water distribution network.

Measuring the concentration of heavy metals

According to the instructions on chemical water sample selection, the tap water sample was poured into polyethylene bottles which had been washed with 20%Nitric acid and distilled water. Moreover, 1 milliliter of nitric acid (65%) was added for each 1 liter of the sample water, to lower the PH to <2 (so as to maintain the heavy metals in the sample). The samples were then transported to the chemical lab of Minab Water and WastewaterCompany to be kept at a temperature of 4°C. To be condensed, the samples passed through a Whatman glass microfiber filter (GF/C) [19, 20]. Eventually, the concentration of heavy metals was measured in the condensed samples by means of an atomic absorption spectrophotometer model DR2800.

Measuring the concentration of Cd, Pb, Ni and Cr was done respectively via the following methods: 1.5-Diphenylcarbohydrazide, PAN, Dithizone and Dithizone Method Power Pillows [21]. Statistical analyses were done via SPSS 16 using the One-way ANOVA method as well as a correlation coefficient (α = 5%). The results were also stated in mean and standard deviation.

Human health risk assessment

Chronic daily Intake (CDI) indices

Heavy metals manage to enter body in a multiple ways such as skin touch, respiration and through mouth. However, a body of research has indicated that they mostly enter body orally [20, 22]. In order to estimate the chronic daily intake (CDI) through drinking water, the following equation was used:

Equation 1: $CDI = C \times DI/BW$

In his equation:C is the concentration of heavy metals in water (µg/l), DI is the amount of daily water consumption. For male adults (17-65 years of age), female adults (17-65 years of age), children (4-14 years of age) and infants (less than 2 years of age) it is respectively equal to: 2.723, 2.129, 0.431 and 0.327 l/p-d.BW is the body weight which for male adults, female adults, children and infants is respectively equal to 10, 30, 64 and 76 kg [3, 23].

[1] 5 samples from each region

Hazard Quotient Index (HQ):

Hazard quotient for the assessment of non-cancerous hazards is estimated via the following equation:

Equation 2: HQ = CDI/Rfd

Oral toxicity reference dose values (Rfd) for Cd, Cr, Ni and Pb were respectively .0005, 1.5, .02 and .36 mg/kg-d [24, 25]. A population is safe and sound only if HQ is lower than 1 for each heavy metal [26].

Results and Discussion

The mean concentration of Cr, Ni, Pb and Cd are 24.11±4.8, 45.7±6.2, 4.8±.33 and 1.61±.39 μg/l, respectively. Moreover, the concentration range of the same metals are 0-43.6, 0-79.7, 0-8.9 and 0-2.6 μg/l,respectively (Table 1). According to the statistical analyses of One-way ANOVA, a significant divergence was observed among the mean concentrations of Cr, Ni, Pb and Cd (p value<0.05). The results of this study along with the concentration of heavy metals have been compared in a body of research in Iran and the world (Table 2). The mean concentration of Ni is significantly higher than Cr, Pb and Cd (P-value<.05). The concentration order of heavy metals is: Ni>Cr>Pb>Cd. The proportion of the concentration of heavy metals (Cr, Ni, Pb and Cd) to the standard set by WHO is respectively: 48.2%, 65%, 48.7% and 53%. This proportion to the standard limit set by EPA is respectively: 24%, 45%, 32.5% and 32.2%. The proportion order of the mean concentration of Cr, Ni, Pb and Cd to the standard set by WHO is: Cr<Pb<Cd<Ni. This proportion to the standard set by EPA is: Cr<Cd<Pb<Ni. The number of samples higher than the standard set by WHO is only related to the Ni of Yekbeni regions (7 samples) and Gharibabad (6 samples). Moreover, the concentration of Cr, Pb and Cd of the samples collected from all regions of Jask was observed to be lower than the standards set by WHO and EPA (fig 2).

As it can be observed in fig 2, the highest and lowest Cr concentration belonged to Kampan and lavaran regions, respectively. Those of Ni were observed in Gharibabad and Lavaran. The highest and lowest Pb concentrations were in Gharibabad and Sarrig. Those of Cd were observed inMoghsa and Kampan. The CDI induced by Cr in male adults, female adults, children and infants was 0.00086, 0.0007, .00035 and 0.00079 μg/kg-d, respectively. That of Ni in the same age groups was 0.00164, 0.00152, 0.00066 and 0.0015 μg/kg-d, respectively. For Pb, it was 0.00017, 0.00016, 0.00007 and 0.00016 μg/kg-d, respectively. The same value for Cd was found to be 0.00006, 0.00005, 0.00002 and 0.00005 μg/kg-d respectively. Finally, the Cr-induced hazard quotient in the 4 age groups of male adults, female adults, children and infants was 0.00058, 0.00053, 0.00023 and .00053, respectively. In the same groups, the Ni-induced hazard quotient was found to be 0.082, 0.076, 0.032 and 0.074. For Pb this value was observed to be 0.00049, 0.00045, 0.00019 and 0.00044. For Cd the same quotient was estimated to be 0.115, 0.107, 0.046 and 0.105 (Table 3). The hazard quotient order of Cr in drinking water across the age groups was found to be: male adults>infants>female adults>children. The same order for Ni was male adults>female adults>infants>children. For Pb this order was found to be male adults>female adults>infants>children. And finally for Cd the order followed was male adults>female adults>infants>children. The highest and lowest hazard quotients induced by the heavy metals were observed respectively in male adults and children age groups. Since the water consumed by the former group was higher than the others, the HQ of this group was also higher than the other groups. Although infants consumed less water than children during the day, due to their lower body weight, they had a higher hazard quotient (table 3). The highest and lowest hazard quotient among the 4 heavy metals belonged to Cd (in male adults) and Pb (in children), respectively. Since the Rfd of Cd is lower than the other heavy metals (0.0005 mg/kg-d), it has a higher hazard quotient. HQ of heavy metals (Cr, Ni, Pb and Cd) is lower than 1. Therefore, the consumer population of drinking water is safe from the hazard of cancer. In Mohammad et al.'s study, the HQ of adults for Cr, Pb and Cd, Ni were found to be lower and higher than the HQ in our research,respectively [20]. Moreover, in Kavkar et al.'s study, HQ of Cr (0.0129) and Ni (0.0508) were higher and lower than that of our study,respectively [30].

Analyzing the correlation matrix of heavy metal concentrations can yield useful information about their source and direction of movement [31]. A significant positive correlation was observed between Cd and Cr (r=0.694) as well as Ni and Cr (r=0.536). A significant negative correlation was observed between Pb and Cr (r= -0.391) (α=0.01) (table 4). Mahmoud et al. as well as Shokarzadeh et al. also confirmed the significant correlation of Cd-Cr and Pb-Cr [20, 32].

Conclusion

The mean concentration of Cr, Ni, Pb and Cd in the tap water of Jask is lower than the standard limits set by WHO and EPA. The order of the mean concentration of the target metals is in fact: Ni>Cr>Pb>Cd. A significant correlation was observed between Cd-Cr, Ni-Cr as well as Pb-Cr. The highest and lowest HQ was respectively that of male adults and children. In terms of the hazard quotient of Cr, Ni, Pb and Cd, the consumer population of tap water in Jask is within the secure domain.

Table.1 Mean, range and SD of the concentration of heavy metals (Cr, Ni, Pb and Cd) in different regions of Jask (μg/l)

	Cd		Pb		Ni		Cr	
Regions[2]	range	mean	range	mean	range	mean	range[3]	mean
Yekbeni	0-2.6	2.4±0.73	0-6	3.8±0.3	0-76.7	62.5±3.4	0-43.4	38.2±2.3
Lavaran	0-2.3	1.9±0.54	0-4.4	3.6±0.3	0-43.4	19.6±1.3	0-15.1	13.7±1.9
Sarrig	0-1.2	0.8±0.23	0-2.2	1.6±0.12	0-50.1	36.5±2.9	0-16.6	15±1
Moghsa	0-2.6	2.4±0.74	0-7.7	5.9±0.4	0-26.3	24.3±1.6	0-34.3	29.3±3.8
Kampan	0-1	0.7±0.24	0-8	7.6±0.4	0-57.7	55.1±2.9	0-43.6	42±5.4
Zolmabad	0-2.3	1.5±0.43	0-4.4	3.1±0.24	0-63.6	59.6±2.4	0-39.9	38.8±3.1
Sarkalleh	0-1.5	1.3±0.4	0-6.6	5.6±0.41	0-55.5	48.6±5.6	0-16.8	14.5±2.4
Gharibabad	0-2.6	1.9±0.51	0-8.9	7.8±0.37	0-79.7	62.5±3.4	0-18.8	16.4±2.4
Mean		1.61±0.39		4.8±0.33		60.1±5.1		24.11±4.8

[2] The mean concentration of the 15 samples collected from each region (a total number of 120 samples during the whole winter)

[3] Concentration of some samples was lower than indicated by the instrument

Table.2 Comparison of the concentration of heavy metals (Cr, Ni, Pb and Cd) in this study and other studies in Iran or the world

	Cd	Pb	Ni	Cr	Reference
Tunceli (Turkey)	<0.05-1.27	0.031±.02	<0.6-2.21	<0.01-3.99	[27]
Tehran (Iran)	1.55±2.34	3.18±3.44		1.06±.72	[28]
Mashhad[4](Iran)	1.05±.8	11.9±6.2	-	11.5±15.4	[29]
Ahwaz (Iran)	1.2	20	-	-	[19]
Jask (Iran)	1.61±.39	4.8±.33	45.7±6.2	24.11±4.8	This study

Table.3 Chronic daily intake and the hazard quotient of heavy metals (Cr, Ni, Pb and Cd) in the tap water of Jask

	C (μg/l)	DI (l/d)	BW (kg)	CDI (μg/kg-d)	RFD (mg/kg-d)	HQ
Cr	24.11	2.72	76	0.00086	1.5	0.00058
	24.11	2.12	64	0.0008	1.5	0.000531
	24.11	0.43	30	0.00035	1.5	0.00023
	24.11	0.32	10	0.00079	1.5	0.000534
Ni	45.78	2.72	76	0.00164	0.02	0.082
	45.78	2.12	64	0.00152	0.02	0.076
	45.78	0.43	30	0.00066	0.02	0.032
	45.78	0.32	10	0.0015	0.02	0.074
Pb	4.87	2.72	76	0.00017	0.36	0.00049
	4.87	2.12	64	0.00016	0.36	0.00045
	4.87	0.43	30	0.00007	0.36	0.00019
	4.87	0.32	10	0.00016	0.36	0.00044
Cd	1.61	2.72	76	0.00006	0.0005	0.115
	1.61	2.12	64	0.00005	0.0005	0.107
	1.61	0.43	30	0.00002	0.0005	0.046
	1.61	0.32	10	0.00005	0.0005	0.105

Table.4 Correlation matrix of heavy metal concentration in the tap water of Jask (n =120)

	Cr	Ni	Pb	Cd
Cr	1			
Ni	0.536 **	1		
Pb	-0.391 *	0.14	1	
Cd	0.694 **	0.05	0.294 *	1

**Significant correlation, p valuelevel 0.01 (2-tailed)
* Significant correlation at the p valuelevel 0.05 (2-tailed)

[4] The mean of spring and summer

Fig.1 Location of Jask harbor in Hormozgan province, Iran

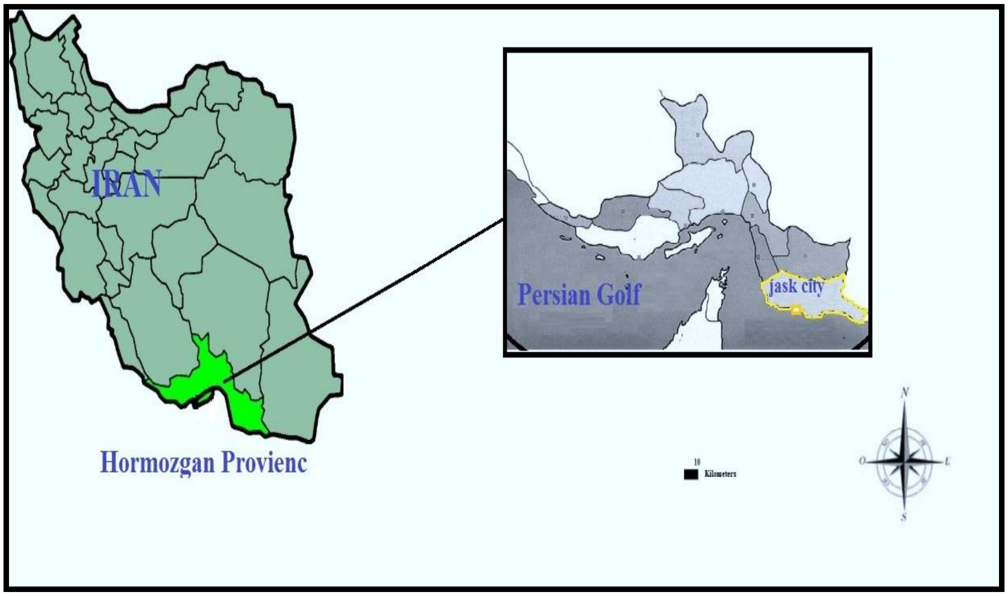
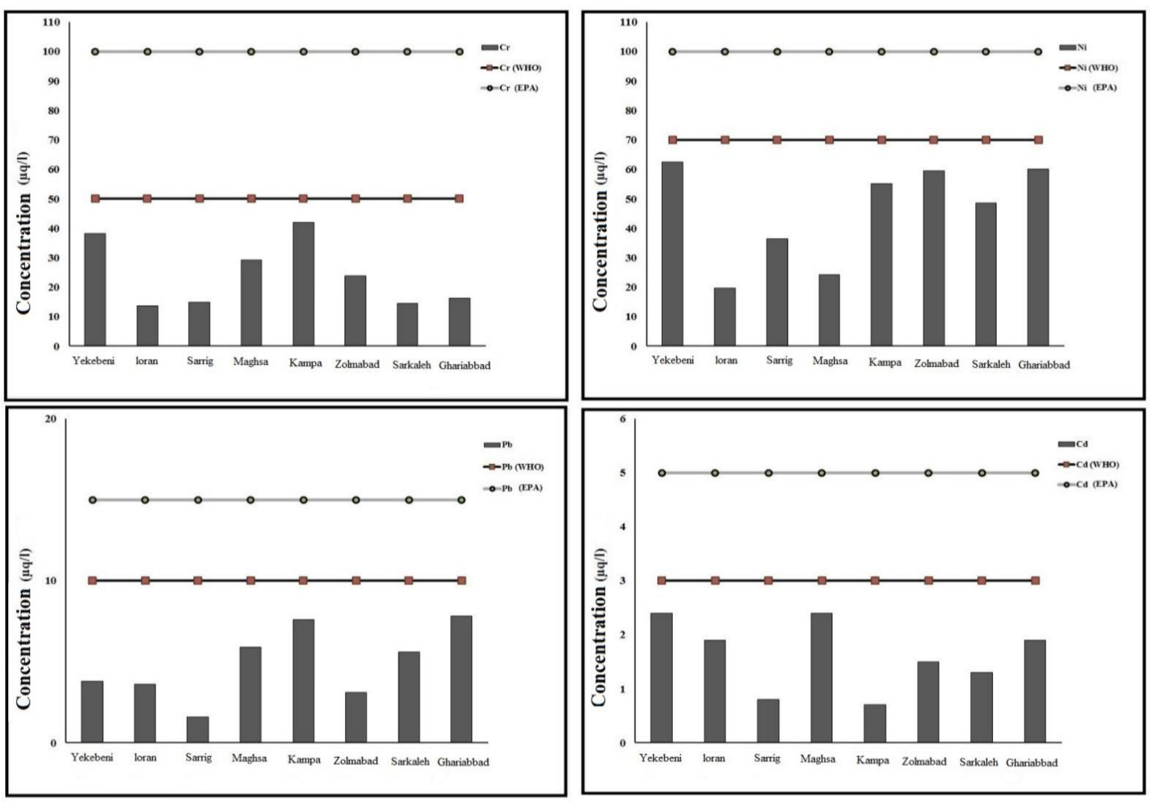


Fig.2 Comparing the concentration of heavy metals (Cr, Ni, Pb and Cd) in different regions of Jask with WHO and EPA standards



Acknowledgement

We should like to express our thanks to all the staff of the chemical and microbiological lab of the Water and Wastewater Company in Minab.

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