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Preliminary Evaluation for Major Health Risks of Heavy Metals in Drinking Water Sources of Huainan City in China

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In this paper, the authors have investigated main concentration of heavy metal pollutants in drinking water in the urban area of Huainan city of China. The source of health risks of heavy metals in drinking water is also evaluated. The monitoring results revealed that carcinogens of health risk is higher whereas the chromium in a waterworks intake of personal annual average risk degree is the highest at 7.527×10^{-5} a^{-1}. Part time index is higher than that of the United States Environmental Protection Agency (USEPA) and the International Radiation Protection (ICRP) Committee. Heavy metal Hg, Pb, Cu , Zn and Tl in drinking water causes non-carcinogenic average annual health risk value as 10^{-12} a^{-1}-10^{-9} a^{-1} which is far below the International Commission on Radiation Protection (ICRP) recommended level as (5×10^{-5} a^{-1}).

Keywords: Health risk assessment, Drinking water, Heavy metals.

INTRODUCTION

Water is the origin of all lives in nature and is the important foundation of human survival. Along with the development of urban industry, heavy metal pollution in the drinking water is getting attention of people. Its toxic pollution, strong concealment, pollution, *etc.* can destroy the balance of ecosystem. A lot of heavy metal elements (Hg, Pb, Zn, Cu, As, *etc.*) can cause harm to a large extent[1-7]. In particular, Cr, Hg, Cd of these toxic metal elements are widely distributed in the natural environment and can cause harm to human health through drinking water. Pb will lead to symptoms such as headache, tinnitus, visual impairment, Hg is the main material of exogenous endocrine, can affect the growth of human reproductive function and thyroid gland and secretion function, Cd causes, harmful effect on the nervous system and increased risk of cancer[8-10]. Thus the evaluation of heavy metals in drinking water on human health risk assessment is particularly important.

At present, many researchers are using health risk assessment model for assessment of regional water environment health risk due to heavy metals. Shen et al.[11] reported urban drinking water health risks of heavy metals have a higher risk of chromium in China. Shen *et al.*[12] reported health risk assessment of Siling Reservoir Watershed in Zhejiang Province, China. Chen[13] determined the heavy metals in drinking water in a certain region of Shaanxi province and carried out the health risk assessment. Recently, a chemical corporate in southwest China had dumped 5000 tons of toxic chromium tailings near a big river in Yunan Province. It contaminated the drinking water source of over ten million people[14]. In China, the environmental pollution caused by heavy metals has become increasingly prominent. There is an urgent need to properly resolve these complex environmental problems. With the improvement of people's living standard, the concept of healthy drinking water will being more attention to water security. Therefore, research on the source of drinking water, heavy metals pollution and their potential health risk evaluation is of great significance.

EXPERIMENTAL

Study area: Huainan city is located in Anhui province in north-central (east 116° 21'-117° 11' 59" 21", 32° 32' north latitude 45-33° 00' "24"), 16.5-240 meters above sea level. The main surface water system is the Huai he river, which is 76.11 km long and 400 meters wide. At the same time, the Huainan city has warm temperate and semi-humid continental monsoon climate zone. Basic characteristics are: clear four seasons, mild climate, sufficient sunlight, heat, rainfall is moderate, the city's average annual rainfall of 939.3 mm, for the rainy season from many to September each year, including 6-8 months for the flood season, the rainfall amount accounts for more than 80 % of annual rainfall.

Setting sampling section: In case of main source of drinking water, water samples of the Huai he river, a total of three sampling sections were set. Set 1 sampling section one, the water intake (consists of two sampling points), four water intake set 1 sampling section (consists of two sampling points), field collection of intake set 1 sampling section (consists of two sampling points).

Samples collection: Samples were collected during March 2011 to February 2012. 250 mL plastic bottles were used to collect 156 samples with a portable instrument measuring temperature, electrical conductivity, pH value after addition of few drops of nitric acid. While the pH value was under 2, the preservation is sealed and kept at 4 °C. Hg, Cd, Pb, Cu and zinc, As, Cr adopt ELAN 6100 DRCII type inductively coupled plasma mass spectrometry (ICP-MS, Perkin Elmer companies) are measured. Other reagents with extra high purity are used. All the vessels used in the experiment are soaked overnight with nitric acid of 15 %, with ultrapure water wash three times, dried and set aside.

Evaluation model: This paper adopts the EPA recommended health risk assessment model[15,16] for drinking water quality risk assessment. Generally speaking, after the heavy metal enters the body through drinking water, the pollution caused by the health risk assessment model mainly includes the carcinogen (genotoxic substances), health carcinogens (trunk toxic substances) model and the risk of health risk model[17-20]:

$$R_c = SR_{ci} = \Sigma[1\text{-}\exp(-D_i \cdot q_i)]/70 \quad (1)$$

$$R_n = SR_{ni} = \Sigma(D_i/R_fD_i) \times 10^{-6}/70 \quad (2)$$

In eqn 1, the R_{ci} for chemical carcinogens was fed through into the way to produce the annual average individual cancer risk (a^{-1}); Di for chemical carcinogenic substances (trunk toxic substances) I unit weight average daily exposure dose (mg kg^{-1} d^{-1}); Qi to chemical carcinogens were fed through into the way to generate carcinogenic intensity coefficient (mg kg^{-1} d^{-1}).

In eqn 2, the R_{ni} for trunk of toxic substances the average annual personal health risk; R_fD_i for trunk toxic substance reference dose (mg kg^{-1} d^{-1}); D_i is exposed to daily exposure dosage through drinking water way, 70 for the human life expectancy (unit: a^{-1}).

Heavy metals entering human body through drinking water has daily exposure dose (D_i):

$$D_i = [2.2 \times \Delta C_i]/70 \quad (3)$$

In eqn 3, 2.2 for adults average daily water quantity (unit: L); ΔCi for drinking water is the measured concentration of each metal (mg L^{-1}). Assuming the metal toxic effects of pollutants on human health hazards, there is no antagonism or cooperative relationship. The heavy metals to human body through drinking water way produce the total health risks:

$$R_{total} = Rc + Rn$$

According to the world health organization (WHO) and the International Agency for Research on Cancer (IARC) a comprehensive evaluation of carcinogenic chemicals reliability and establishment of classification system, combined with the routine monitoring data of Huainan city, determines the evaluation factors as: chemical carcinogens Hg, Pb, zinc, Cu, chemical carcinogens As, Cr, Cd (Table-1).

RESULTS AND DISCUSSION

Heavy metal content analysis of Huainan city: Heavy metal contents in the drinking water in 2011-2012 are shown in Table-2.

Water chemical carcinogenic factors in the evaluation results and analysis: According to the risk evaluation model the evaluation of health parameters can be calculated by chemical carcinogens in the average personal risk are shown in Table-3.

As shown in Table-3, the average cancer risk due to As, Cr, Cd caused by drinking water were 3.437×10^{-5} a^{-1}, 7.527×10^{-5} a^{-1}, NG, respectively. With risk level from high to low is for Cr, As, Cd. Water intake with As, Cr, Cd caused by drinking water has average cancer risk as 1.332×10^{-5} a^{-1}, 6.263×10^{-5} a^{-1}, NG, respectively with rank as Cr, As, Cd. Field collection of intake water As, Cr, Cd drinking water has the risk of cancer average as 5.619×10^{-5} a^{-1}, 7.308×10^{-5} a^{-1}, NG, respectively

TABLE-1
CHEMICAL CARCINOGENS CARCINOGENIC FACTOR Q_i AND NON CARCINOGENS REFERENCE DOSE R_fD_i VALUES (mg kg^{-1} d^{-1})

Chemical				Carcinogens		
Hg^{2+}	Pb^{2+}	Zn^{2+}	Cu^{2+}	As^{2+}	Cr^{2+}	Cd^{2+}
1.0×10^{-4}	1.4×10^{-3}	3.0×10^{-4}	5.0×10^{-3}	15	41	6.1

TABLE-2
MAIN WATER SOURCE OF HUAINAN CITY HEAVY METAL CONCENTRATIONS IN THE WATER

Sampling point	Data type	Concentration of heavy metal elements (µg/L)						
		Hg^{2+}	Pb^{2+}	Zn^{2+}	Cu^{2+}	As^{2+}	Cr^{2+}	Cd^{2+}
Water intake-1	Maximum	0.13	NG	1.59	1.94	8.40	5.74	NG
	Minimum	0.09	NG	0.04	0.68	3.02	1.22	NG
	Average	0.11	NG	1.33	1.77	5.11	4.10	NG
Water intake-2	Maximum	0.12	0.23	2.20	2.31	2.01	4.00	NG
	Minimum	0.07	0.19	0.67	2.29	1.74	2.56	NG
	Average	0.09	0.21	1.33	2.30	1.98	3.41	NG
Water intake-3	Maximum	0.11	NG	1.95	1.17	11.17	5.94	NG
	Minimum	0.07	NG	1.01	0.08	5.88	3.23	NG
	Average	0.09	NG	1.46	1.02	8.36	3.98	NG

TABLE-3
CARCINOGENIC SUBSTANCES BY DRINKING WATER MEANS THE RISK OF CANCER

Sampling point	Data type	Carcinogenic risk (10^{-6} a^{-1})			Carcinogenic risk (10^{-6} a^{-1})
		As^{2+}	Cr^{2+}	Cd^{2+}	
Water intake-1	Maximum	56.46	105.27	NG	161.73
	Minimum	20.32	22.44	NG	42.76
	Average	34.37	75.27	NG	109.64
Water intake-2	Maximum	13.53	73.44	NG	86.97
	Minimum	11.71	47.05	NG	58.76
	Average	13.32	62.63	NG	75.95
Water intake-3	Maximum	75.03	108.93	NG	183.96
	Minimum	39.55	59.33	NG	98.88
	Average	56.19	73.08	NG	129.27

TABLE-4
CARCINOGENIC SUBSTANCES BY DRINKING WATER HEALTH RISKS

Sampling point	Data type	Health risk (10^{-10} a^{-1})			
		Hg^{2+}	Pb^{2+}	Zn^{2+}	Cu^{2+}
Water intake-1	Maximum	5.83	NG	23.79	1.74
	Minimum	4.04	NG	0.60	0.61
	Average	4.93	NG	19.9	1.59
Water intake-2	Maximum	5.38	0.074	32.92	2.07
	Minimum	3.14	0.061	10.02	2.06
	Average	4.04	0.067	19.9	2.07
Water intake-3	Maximum	4.93	NG	29.18	1.05
	Minimum	3.14	NG	15.11	0.072
	Average	4.04	NG	21.85	0.92

with rank as Cr, As, Cd. The main source of drinking water of Huainan city has the greatest risk to the health because of Cr in water as a few numerical intake have been more than the recommended standards of the international commission. Chromium has become the main component in the source of drinking water of Huainan city.

Chemical carcinogens evaluation results and analysis in drinking water: According to the risk evaluation model and evaluation of health parameters have been calculated by way of drinking water, the chemical non carcinogens in the average individual risk are shown in Table-4.

As can be seen from Table-4, non toxic chemicals that cause cancer (Hg, Pb, zinc, Cu) caused by personal risk sorting for zinc > Hg > Cu > Pb, three water intake the highest average heavy metals to human health risk. Processing enterprises is mainly due to the water surrounding the smelting, chemical industry, power plant emissions of sewage and waste electronic waste caused by improper handling, so, for the region's environmental regulation is imminent. In general, most of the health risks of heavy metals average concentration in the level of risk is concentrated between 10^{-12} a^{-1} and 10^{-9} a^{-1}. In drinking water, the health risk caused by carcinogenic chemical effect, will pose no harm to human health. A water intake in carcinogenic heavy metals material produced by way of drinking water health risk order: Zn > Hg > Cu > Pb, Three water intake of water for: Zn > Hg > Cu > Pb, Set in the intake of water for: Zn > Hg > Cu > Pb.

Conclusions

(1) The water quality in the urban area of Huainan city drinking water can meet the national surface water quality standard. But the Cr, As individual time monitoring value exceeds the IV class water quality standards and has become a main carcinogenic factor of drinking water source of Huainan city. Therefore, Cr, As of water should be considered as a risk decision. The focus of the object and its long-term effect value is remarkable. From the perspective of the situation of continuous monitoring, the acceleration in the Huai river basin in Huainan period of water pollution, pollution distribution scope expands unceasingly, the trend of deterioration of water quality has become increasingly serious.

(2) The heavy metals in drinking water supply in the urban area of Huainan city health hazard caused by carcinogens than non carcinogens health hazards is caused by pollution. The cause of this result may be the result of the industrial "three wastes" emissions of Huainan city soil pollution and water pollution. Therefore, we need to strengthen the water source conservation and emissions standard enterprise management for control and protection of water sources.

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