Variations of harmful elements in kitchen faucets drinking water stagnation

Tingting Huang[1, 2, 3]

[1]Nanan Testing Institute of Quality and Metrology, Quanzhou, Fujian, China

[2]National Quality Supervision and Inspection Center of Plumbing & Sanitary Ware (Fujian),Quanzhou, Fujian, China

[3]Nanan Market Supervision and Management Law Enforcement, Quanzhou, Fujian, China

tthuang411@foxmail.com.cn

Abstract. This issue studied the 16 harmful elements changes in the stagnated drinking water in kitchen faucets. The experiment tested the conductivity, pH and harmful element concentration of the faucets' stagnated drinking water and the source water. The experiment analyzed the factors that may affect the precipitation of harmful elements from faucets. The sample water source included tap water, well, mountain springs, was tested by ICP-MS. Depending on the result, the median concentration of Pb, Ni, Cu, Se, Mo, Sb, Tl increased markedly. The statistical analysis by SPSS 20.0 shows that the concentrations of Ni, Cu, Mo, Cd, Sb, Tl, Pb were statistically significant differences between stagnated drinking water and source water. And the conductivity, pH and the faucets age have no impact on the faucets precipitation. Stagnation time can effect on the Ni, Sb and Tl precipitation of faucets. There is a significant correlation between the precipitations of some kinds of elements we researched, possibly synergistic precipitation. It can infer that faucets material affects the harmful elements precipitation

1. Introduction

Water is the source of life. The quality of water is closely related to human health. The quality of drinking water is determined to the quality of the water supply and also affected by the entire water pipeline network [1]. As the terminal equipment of a drinking water system, faucets play very important roles. If the water stagnated in faucets for a longer time, would have the physical and chemical reactions happen between water and faucets, so the water quality would change at the same time [2]. The precipitation of harmful elements of the faucets is a complex electrochemical corrosion process, which may be affected by such as drinking water quality, faucets material, faucets age, stagnation time [3]. This issue took the daily using faucets of the residents as the study samples, and the two standards of NSF/ANSI 61-2016 and GB18145-2014 were considered comprehensively, chose the 16 kinds of harmful elements to study the change of the concentration in the stagnation water, found the corresponding relationship. It aimed to provide a scientific basis for the residents ' safe drinking water and industrial production.

2. Materials and Methods

2.1. Sample Collection

The experiment choose 50 groups of the sample from the normal daily use of the kitchen faucets for the residents with copper alloy, no heating, no water treatment and purifying equipment.

Faucets keep on discharging 5 min after stopping the use of kitchen drinking water at the night. And the residents put an end to the activities that may contaminate the faucets. Do not discharge water until we collect the stagnation water 10 mL with polyethylene tube directly at the next morning as stagnation water and record the stagnation time. Continue to discharge the water for 5 min, and collect 10 mL water from the faucets with other new polyethylene tube as source water.

2.2. Test Items

2.2.1. Regular Items of Water Quality. pH and conductivity.

2.2.2. Harmful Elements in Water. According to the standards of GB 18145-2014 and NSF/ANSI 61-2016 , we selected the harmful elements of Be, B, As, Cr, Mn, Ni, Cu, Se, Mo, Cd, Sb, Ba, Hg, Bi, Tl, Pb as studying target.

2.3. Test Instrument and Methods

2.3.1. Instruments. Nexion^{TM} 350X ICPMS (USA PerkinElmer company), Mini-q Reference Ultra-Pure Water system (USA Millipore company), PH meter (Mettler - Toledo Mettler-toledo), Conductivity meter (Mettler - Toledo Mettler-toledo).

2.3.2. Reagents. 1000μg/mL of Beryllium (GSB 04-1718-2004) 100 mg/L of Antimony (GSB07-1277-2000), Selenium (GSB07-1253-2000) were purchased from the Environmental Protection Department's Standard sample Institute.1000 μg/mL of Lead (GBW08619), Cadmium (GBW08612), Nickel (GBW08618), Mercury (GBW08617), Copper (GBW08615), Arsenic (GBW08611), Chromium (GBW08614), Manganese (GBW (E) 080157) were purchased from the China Institute of Metrology Science.1000 μg/mL of Thallium (BWJ 4005-2016) was purchased from Beijing Century Aoke Biotechnology Co., Ltd. 1000 μg/mL Barium (GBW (E) 080347) and 100 μg/mL Molybdenum (GBW (E) 080133) were purchased from the nuclear industry Beijing Institute of Chemical Metallurgy.1000μg/mL of Beryllium (GSB 04-1718-2004) was purchased from the National Nonferrous metals and electronic Materials analysis and Testing Center GB (Beijing) inspection and Certification Co., Ltd. Nitric acid (GR) was purchased from Shanghai Chemical Reagent Co., Ltd.

2.3.3. Test Methods. Following consideration of the factors of abundance, interference and sensitivity, selected ^{208}Pb、^{111}Cd、^{202}Hg、^{52}Cr、^{60}Ni、^{63}Cu、^{205}Tl、^{138}Ba、^{75}As、^{121}Sb、^{82}Se、^{209}Bi、^{55}Mn、^{98}Mo、^{4}Be、^{11}B isotopes for testing.

Instrument Working Condition: RF(1.6 KW), Carrier Gas (Argon): 0.90 L/min , Cooling gas (Argon): 15.0 L/min , Helium: 4.5mL/min , Sweeps/reading (20), Readings/replicate (2) , Number of Replicate (2) , Detector Mode (Dual) , The detection mode is Standard mode.

The experiment tested the pH and conductivity immediately after the collection and input 2% nitric acid for stability, and tested the concentration of harmful elements according to the above conditions by ICP-MS.

2.3.4. Statistical Analysis. In order to facilitate statistics, the detection result that is less than the limit of detection (LOD) was defined was identified as the value of the LOD.

The test results were statistically analyzed with SPSS 20.0 software.

3. Results

3.1. The Basic Situation of Water Quality

In this subject, the water sources have tap water, well, spring water. Different sources of water caused that the test result of the stagnated water and source water quality distribution range were wide. The conductivity of tap water is generally between 160.0~180.0 S/m, pH is around 7.00. And the conductivity of well water is generally > 250.0 S/m, the mountain spring electrical conductivity is more than <100.0 S/m, pH is both between 5.87~8.00.

In table 1, the concentration of the median value of Pb, Ni, Cu, Se, Sb increased markedly after stagnated in faucets overnight, and no significant changes were seen for the other elements. Compared the concentration of the stagnated water in its source water, the median value of an equal element ratio of Pb, Ni, Cu, Se, Mo, Sb, Tl were greater than 1. The conductivity, pH and other elements did not change obviously. 86% of the concentration of Ni in stagnated water increased, and 76% of Cu, 74% of Sb, 68% of Pb.

According to GB 5749-2006 "Standards for drinking water quality", some samples were unqualified. After stagnated in faucet, the unqualified rate of Ni rose from 2% to 26%, increased by 12 times. Pb rose 1 time, Cd and Tl also had different degrees of elevation. But the unqualified rate of Mn Drop down to 8% from14%.The other elements all complied the standard. The unqualified source water was mainly from well.

Table 1. Test results of various items (N=50).

Test items	LOD (μg/L)	Stagnated water (G)		Source water (Z)		The ratio between G and Z	
		Range (μg/L)	Median (μg/L)	Range (μg/L)	Median (μg/L)	Range of the ratio	Ratio median
Pb	0.157	0.157~332.955	3.334	0.157~52.815	0.825	0.171~131.814	1.276
Be	0.021	0.021~0.428	0.021	0.021~0.614	0.021	0.125~1.726	1
B	0.673	0.673~34.679	3.593	0.673~37.347	3.543	0.119~4.236	1
As	0.081	0.081~1.232	0.422	0.081~1.254	0.440	0.184~2.574	1
Cr	0.596	0.596~7.367	0.596	0.596~0.865	0.596	0.656~	1
Mn	0.163	0.163~354.416	3.034	0.163~341.138	3.452	0.370~12.066	1
Ni	0.081	0.856~1742.192	6.297	0.282~38.218	3.181	0.201~174.293	3.259
Cu	0.259	0.101~804.563	36.886	0.259~218.583	10.272	0.077~131.035	3.679
Se	0.408	0.408~2.950	0.628	0.408~3.219	0.437	0.347~10.956	1.234
Mo	0.015	0.017~15.688	1.800	0.019~4.823	1.687	0.466~10.485	1.342

Cd	0.208	0.208~25.270	0.208	0.208~1.827	0.208	0.463~214.239	1
Sb	0.048	0.048~3.449	0.194	0.048~2.762	0.135	0.609~33.451	1.371
Ba	0.431	6.550~429.147	55.373	5.126~415.122	56.341	0.044~1.722	1
Hg	0.036	0.036~0.081	0.036	0.036~0.081	0.036	0.767~1.342	1
Bi	0.009	0.009~0.187	0.009	<0.009	<0.009	0.67~5.356	1
Tl	0.005	0.005~0.335	0.033	0.005~0.287	0.035	0.325~11.145	1.466
Conducti-vity	/	35.6~510.0	184.5	63.85~505.7	183	0.28~4.14	0.99
pH	/	5.87~7.97	6.71	5.59~7.51	6.68	0.92~1.09	1

3.2. Statistical Analysis

3.2.1. Analysis of the Difference of Harmful Elements between the Stagnated Water and Source Water. Statistical analysis was carried out to determine if the measured data sets it stagnated water and source water were significantly different. The data was tested by Friedman nonparametric test. In this study, the differences were considered to be significant if the sig. value was less than 0.05. The differences of Ni, Cu, Mo, Cd, Sb, Tl, Pb concentration between stagnated water and source water were statistically significant. Other items had no significant differences.

3.2.2. The Influence on the Faucets Harmful Elements Precipitation. Based on the above research, we study the seven significant difference elements forward. The correlation of the concentration ratio of stagnated water and source water, the time of stagnation, faucets age, conductivity and pH were tested by Pearson correlation test. Correlation was considered to be significant if the sig. was less than 0.05. Data were plotted when the correlation was significant. There were no correlations between the conductivity, pH, faucets age and the concentration ratio. But the correlations between stagnation time and Ni, Sb, Tl were significant which that indicated stagnation time can affect the Ni, Sb, Tl precipitation of faucets. Meanwhile, Ni with Cd, Sb, Tl and Mo with Cd and Sb with Tl and Cd with Sb, Tl, Pb also had significant correlation (see Table 2), which indicated that some kinds of elements may have synergistic precipitation elements or may have synergistic precipitation, that is, the material of the faucets affects its precipitation.

Table 2. Pearson correlation test results (N=50).

		Stagnation time	Ni	Mo	Cd	Sb	Tl	Pb
Stagnation time	Pearson Correlation	1	.826**	.028	.085	.333*	.277*	.176
	sig.（2-tailed）		.000	.848	.555	.017	.049	.217
Ni	Pearson Correlation	.826**	1	.008	.476**	.553**	.649**	.183
	sig.（2-tailed）	.000		.958	.000	.000	.000	.197
Mo	Pearson Correlation	.028	.008	1	.328*	.066	.088	.257
	sig.（2-tailed）	.848	.958		.019	.644	.539	.068
Cd	Pearson Correlation	.085	.476**	.328*	1	.484**	.686**	.369**
	sig.（2-tailed）	.555	.000	.019		.000	.000	.008

Sb	Pearson Correlation	.333*	.553**	.066	.484**	1	.321*	.232
	sig.（2-tailed）	.017	.000	.644	.000		.022	.102
Tl	Pearson Correlation	.277*	.649**	.088	.686**	.321*	1	.043
	sig.（2-tailed）	.049	.000	.539	.000	.022		.762

**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).

4. Conclusions

The research showed that the water quality was affected by water source, and the result distribution of the test items was varied. Overall, The median concentration of Pb, Ni, Cu, Se, Mo, Sb, Tl in stagnated water was greater than its sources water, especially the unqualified rate of Ni, Pb, Cd, Tl increased significantly, which indicated that the stagnated water quality was affected by the harmful elements precipitation of faucets.

The results were tested by SPSS 20.0 software. The concentrations of Ni, Cu, Mo, Cd, Sb, Tl, Pb were statistically significant differences between stagnated water and source water. The Pearson correlation test result showed that the conductivity, pH of water quality, faucets age has no significant correlation with the precipitation of harmful elements. The concentration ratio of Ni, Sb, Tl of stagnated water and source water and stagnation time had a significant correlation. The significant correlation also existed in various elements. It indicated that the harmful elements in faucets may be influenced by stagnation time and material. We need to explore further.

References

[1] Gang L.,Ya Z.,Willem-Jan K.,Cuijie F.,Wentso L.,Gertjan M.,Walter V. M. (2017) Potential impacts of changing supply-water quality on drinking water distribution: A review. Water Res. **,**116 **:**135-48.
[2] Samuels E.R., Méranger J.C. (1984) Preliminary studies on the leaching of some trace metals from kitchen faucets. Water Res., 18: 75-80.
[3] Zlatanovic L.,Hoek J.P.,Vreeburg J.H.G. (2017) An experimental study on the influence of water stagnation and temperature change on water quality in a full-scale domestic drinking water system. Water Res. , 123: 761-72.