Desalination and Water Treatment
www.deswater.com

doi: 10.1080/19443994.2014.889434

54 (2015) 637–641
April

Taylor & Francis
Taylor & Francis Group

Analyses of rural drinking water resources quality in the north area of Shaanxi

Chun-Ling Lin[a,*], Jiao-Xia Zhang[b], Lan Lan[c]

[a]*College of Chemistry and Chemical Engineering, Xi'an Petroleum University, Xi'an 710065, China*
Tel. +86 29 88272701; Fax +86 29 88272701; email: chunling405@xsyu.edu.cn
[b]*College of Materials Science and Engineering, Jiangsu University of Science and Technology, Zhengjiang 212003, China*
[c]*Publication Quality Supervision and Inspection of GAPP-ShaanXi Branch Center, Xi'an 710065, China*

Received 11 June 2012; Accepted 14 January 2014

ABSTRACT

Improving the sanitary quality of rural drinking water resources is the important means to ensure health care for rural residents. The 10 samples of rural drinking water resources in the north area of Shaanxi province were evaluated by pH value, the content of total hardness, sulfate, chloride, chemical oxygen demand and fluoride. The test results showed that five samples are conformed to the rural drinking water standard. The content of total hardness, sulfate and fluoride were impermissibly high in unqualified water samples. So choosing the water source to drill the deep well or taking water treatment facilities of water quality purify and softening to reduce the content of excessive elements to ensure drinking water health security is imminent according to the actual situation.

Keywords: Rural area; Drinking water resources; Water quality; Test

1. Introduction

Water is the source of life. Access to safe drinking water is a basic requirement for human survival. The safety of rural drinking water and sanitation situation will greatly reflect the development of rural socio-economic and the quality of life for rural residents, which is also an important indicator to affect the level of the health of rural residents [1]. With the development of rural construction in the recent years, the geological factors and the surroundings has changed enormously, the security of rural drinking water resources have become a major livelihood issue. Ensuring the safety of drinking water, which related to the health and sustainable economic development, is an important event [2]. In addition, the improvement of rural water and sanitation situation is an effective measure to reduce disease and promote health even to save lives. It is also an important part during the construction of new socialist countryside and the necessary requirement of people oriented and harmonious society [3]. There are few researches on rural drinking water resources in north Shaanxi of China, so understanding the situation of rural drinking water in this area will favor of providing the scientific basis and strategies for the safety of local rural drinking water in the future.

*Corresponding author.

2. Materials and methods

2.1. Materials

Potassium biphthalate (AR, Tianjin Proudly Fine Chemical Research Institute); phosphate mixture (AR, Tianjin Proudly Fine Chemical Research Institute); sodium borate (AR, Tianjin Proudly Fine Chemical Research Institute); ammonium chloride (AR, Zhiyuan Chemical Company); magnesium sulfate (AR, Zhiyuan Chemical Company); ethylene diamine tetraacetic acid (AR, Kaifeng Chemical Company); chrome black T indicator (AR, Tianjin Da Mao Reagent Company); sodium sulfide (AR, Tianjin Hong Yan Reagent Company); sodium chloride (AR, Tianjin Hong Yan Reagent Company); sodium fluoride (AR, Tianjin Yao Hua Reagent Company); potassium permanganate (AR, Tianjin Ke Mi Ou Company); barium chloride (AR, Tianjin Ke Mi Ou Company); aluminum potassium sulfate (AR, Tianjin Ke Mi Ou Company); silver nitrate (AR, Sinopharm Chemical Reagent Limited Corporation); sodium oxalate (AR, Tianjin Bai Shi Company); sodium citrate (AR, Tianjin Ke Mi Ou Company); sodium sulfate anhydrous (AR, Tianjin Ke Mi Ou Company); hydroxylammonium chloride (AR, Tianjin Ke Mi Ou Company); sodium hydroxide (AR, Tianjin Ke Mi Ou Company); absolute ethyl alcohol (AR, Tianjin Ke Mi Ou Company); hydrochloric acid (AR, Tianjin Ke Mi Ou Company); ammonium hydroxide (AR, Tianjin Ke Mi Ou Company); sulfuric acid (AR, Tianjin Ke Mi Ou Company); hydrogen peroxide (AR, Tianjin Ke Mi Ou Company).

The number of water samples was 10, numbered from 1 to 10. The water samples were collected before one week of the experiment from underground water of different area in north Shaanxi of China. The samples were stored in sealed polyethylene bottles.

2.2. Water quality analysis method

The analysis method was single-factor evaluation. Namely, according to the GB5750–2006 (The standard test methods for drinking water), the parameters of the water samples included: pH value, the content of total hardness, sulfate, chloride, chemical oxygen demand (COD), and fluoride. If the one parameter exceeds the standard value, we think the sample does not meet drinking water requirements according to GB5749-2006 (the health standards of drinking water).

3. Result and discussion

3.1. pH test results

The pH is one of the most important water quality parameters in water treatment operation. The drinking water resources in the normal pH range have not yet been found the toxic effects on human health. The World Health Organization's "Drinking Water Guidelines" did not raise the normative pH value based on the human health, the pH range of national standard only based on the perspective of the proposed pipeline corrosion. It is between 6.5 and 9.5. When the pH value is too low, the pipes will be corroded, and when the pH value is too high, the containers are easy to scale. Fig. 1 shows the pH test results of the water samples, and the pH of the 10 samples is between 6.5 and 9.5, which are corresponding with the national standard [4,5]. It indicated that the content of acid and alkali in water is within the allowable range and could meet the national drinking water standards.

3.2. The test results of chloride ion content

Chloride ions exist in natural water as sodium, calcium, and magnesium ions. The chloride ion (Cl^-) and the corresponding cations (Na^+, Ca^{2+}, Mg^{2+}, etc.) formed in the water. Chloride ion is widely distributed in natural water, almost all of the underground water contains Cl^-, but the content varies greatly. When content in the water is too high, the taste varied due to the different cations, such as Na^+ cations will produce the salty taste, and when the cation is Al^{3+}, although the content of Cl^- is low, the water tastes bitter. When people or animals drink the water contains too high content of Cl^-, the poisoning will happen, may seriously poison to death [4]. So the detection of chloride content in drinking water is necessary. Fig. 2 shows the test results of the chloride content in the samples, it can be seen that the chloride ions content in the 10 samples of drinking water resources are all in the range according to the national standard ≤300 mg/L, which indicated that the chloride ion content of water samples all met the standards.

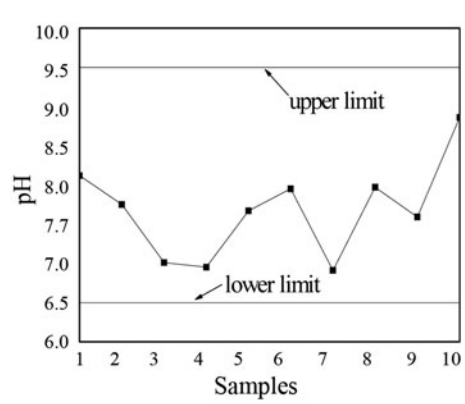

Fig. 1. The test results of pH.

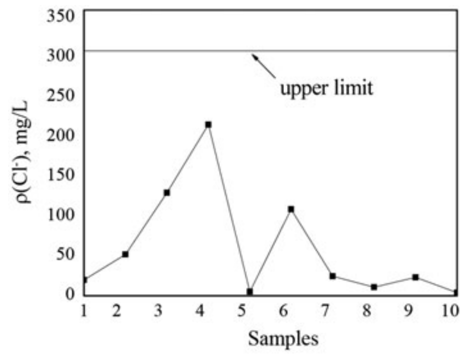

Fig. 2. The test results of chloride content.

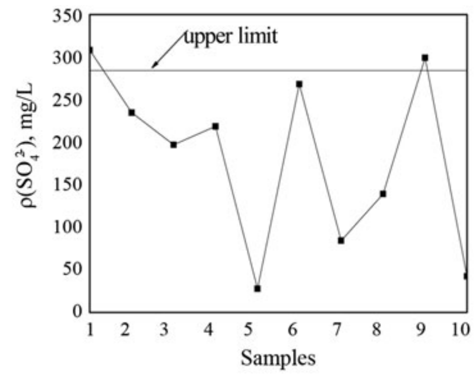

Fig. 3. Test results of sulfate content.

The chloride in underground water sources comes from two kinds of sources called natural sources and man-made sources, respectively. The natural sources come from the underground water that flew through the chloride geological layer, or the underground water close to the sea. The artificial sources rise from the industrial wastewater and domestic sewage [6]. The samples of Weibei area were collected from the vicinity of the water without chloride formation, which is also away from the beach. At the same time, with less other rural industries emit, which result in the low chloride content, to meet the drinking water requirements.

3.3. The test results of the sulfate content in water samples

The main source of sulfate in drinking water is the sulfate in mineral layer, and it mostly exists in the form of calcium sulfate and magnesium sulfate. The increased content of sulfate in drinking water resources comes from the influx of sewage, fertilizer, sulfur in hot water and mine drainage, the sulfuric acid industrial wastewater used in the manufacture of paper. When the humanbeings or animals drink water contains large amounts of sulfate, the following situations will occur, such as diarrhea, dehydration, and gastrointestinal disorders. Fig 3 shows the test results of sulfate content in the water samples. It can be seen from Fig. 3 that except for sample 1 and sample 9, two sulfate content of water samples slightly higher than the national standard limit (≤300 mg / L), 9.11 and 5.69%, respectively, while other water samples are all up to the national requirements. Maybe due to the lower residual chlorine concentration in water triggered the growth of sulfate-reducing bacteria in water, the corruption occurred, so that the corresponding sulfide generated. Finally, the sulfate content increased.

3.4. The test results of total hardness in water samples

The main natural source of hardness in water is edimentary rocks, underground seepage and the soluble polyvalent metal ions in the process of soil erosion. Two kinds of major ions are calcium and magnesium ions. They exist in many sedimentary rocks in which most common are limestone and chalk. They are found not only in industrial products, but also in a common food ingredient. It is generally believed that moderate hardness is good for health. At present, there is no conclusive evidence for if the water hardness will affect human's health. But high hardness will make the hot water system to produce scaling problems and increased the consumption of soap, but extremely soft water will increase the corrosion of pipelines. In consideration of people's wash sensory acceptance and life needs, it is necessary to keep a reasonable hardness limits of water. Fig. 4 shows the test results of the total hardness of water samples. It can be seen from Fig. 4 that except for sample 4 and sample 7 whose test results of hardness are higher than the national standard limit 550 mg/L, respectively, higher than 96.40 and 54.01%, while the other water samples all met the national target requirements.

3.5. The test results of fluoride ion content in water samples

Fluorine is an essential trace element for the human beings. Lack of fluoride will cause the susceptibility to dental caries. Fluoride is widely present in natural water. Many of the human tissues contain fluoride, but it primarily aggregate in teeth and bones. Excessive fluoride is hazardous to human's health. The lethal dose of sodium fluoride for human beings is 6–12 g. The skeletal fluorosis may appear when the concentration is up to 2.4–5 mg/L [7]. Fig. 5 shows the

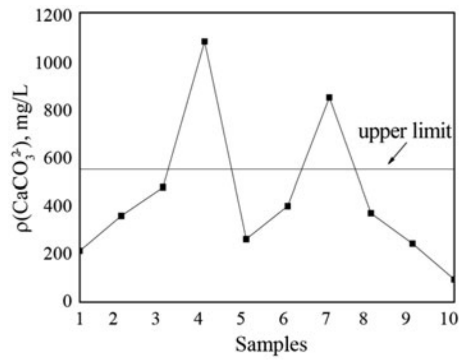

Fig. 4. The results of total hardness.

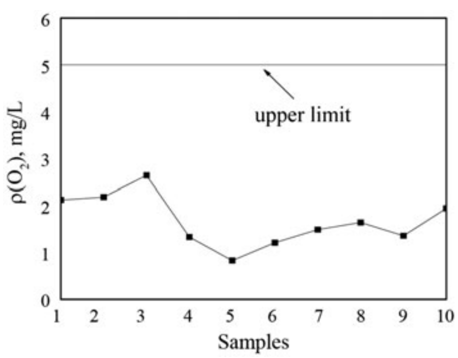

Fig. 5. Test results of fluoride ion content.

test results of fluoride content in water samples. It can be seen from the figure that sample 1, sample 6, and sample 9, these three water samples' fluoride ion content were higher than the national standards for fluoride ion content limit (1.2 mg/L), and higher than 67.5, 4.17, and 67.5%, respectively, while other samples were all up to the national requirements. Combined with the experimental results of Fig. 3, it can be found that the sulfate content and the fluoride content in sample 1, 6, and 9 were both high. The quality problems may be mainly caused by the geological structure from the rock and soil layer [8]. Due to the regional geological characteristics of the north area of Shaanxi province, the fine particles of sediment (clay and silt) provided a rich source of fluoride in the groundwater. Especially, samples 1 and 9 were collected from the flat low-lying areas in the loess, where is rich in minerals, the calcium fluoride formed and deposited, resulting in the enrichment of fluoride in the soil. Under the condition of salinization or soda, it naturally promotes the activation of fluoride to dissolve into the water to form a high-fluorine groundwater [9]. Meanwhile, the pollution source comes from farming, rural life, and distributed livestock and poultry will cause the high level of fluoride.

3.6. The test results of COD in water samples

When the oxygen consumption in the water is too high, the anaerobic bacteria will increase, the water will become smelly, which may cause a large number of deaths of aquatic plants and animals. Fig. 6 shows the test results of COD in water samples are all lower than the national standard limit 5 mg/L, and the qualified rate is 100%. The high oxygen consumption indicates the high content of organic matter in water. Otherwise, the lower volume of oxygen consumption indicated that the water contains less organic matter content. The high organic content in water is mainly caused by industrial pollution. So it is proved that there is little industrial pollution in the water samples, so the oxygen consumption is mainly caused by the water quality problems of their own and the pollution from farming, rural life and distributed livestock and poultry.

In the summary, five samples achieved the water test standards and the pass rate was 50%. Unqualified water samples: the sulfate content and the fluoride content in sample 1; the total hardness of water samples exceeded in sample 4 and sample 7; the fluoride content exceeded in sample 6; sulfate content and the fluoride content exceeded in sample 9. Overall, the qualified rate of the rural drinking water resources is low in north of Shaanxi province in China, the prominent problem is the content of sulfate, total hardness, and fluoride.

To ensure the safety of the rural drinking water resources for the rural resident, there must be prevention and treatment of sewage. For example, to strengthen supervision and inspection, ecological restoration, promote the development of organic agriculture, construct the environmental protection projects of agricultural and to strengthen the propaganda work on the protection of water sources [10,11].

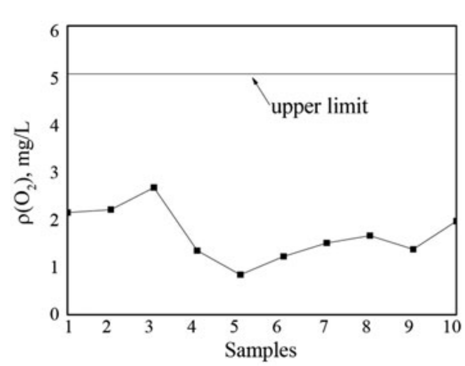

Fig. 6. Test results of chemical oxygen demand (COD).

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