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Regional distribution of longevity population and chemical characteristics of natural water in Xinjiang, China

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HIGHLIGHTS

- LI%, CI% and UC on county level in Xinjiang generally decrease from south to north.
- There is regional variation of hydro-chemical characteristics in Xinjiang.
- Regional variation of hydro-chemical characteristics matches that of longevity.

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ABSTRACT

Xinjiang Province, China is recognized for the longevity of its inhabitants. To study the temporal and spatial variation of longevity region and chemical characteristics of natural water of longevity region in Xinjiang, three population censuses on county-level and 51 natural water samples from Hotan Prefecture, Xinjiang were collected and analyzed. 103 natural water samples were collected from the public papers. Population statistics on county-level showed that the number of centenarians per 100,000 inhabitants (OC) in Southern Xinjiang was 7.4(year 1990), 4.9(year 2000) and 2.1 times (year 2010) more than that of Northern Xinjiang, respectively. And distribution of the longevity index (LI%), centenarity index (CI%) and number of centenarians per 10,000 over 65 year-old subjects (UC) on county-level decreased from south to north. Natural water in Northern Xinjiang was mainly fresh soft water, and it was mainly fresh hard water and brackish hard water in Southern Xinjiang. Water quality of natural water in Northern Xinjiang was superior compare to that of Southern Xinjiang, while number of centenarians 65 year-old & over per 10,000 subjects in Northern Xinjiang were less than that of Southern Xinjiang before 2010. The research indicates that keeping on drinking water with high total hardness (TH) and Mg/Ca ratio might be good for the health.

1. Introduction

Historically, longevity has been a symbol of health in most societies (Ozaki et al., 2007). Both health and longevity are global interests. Xinjiang Province, China is recognized for the longevity of its inhabitants (MHACI, 1987; Morishita, 1991; Kawamura et al., 2001). In 1984, International Natural Medicine Society (INMS) recognized Xinjiang Province as the world's fourth longevity region (MHACI, 1987; Morishita, 1991). Centenarians in Southern Xinjiang made up 87.1% of the total centenarians in Xinjiang, while centenarians of Northern Xinjiang only account for 12.9% (MHACI, 1987). According to the fifth national census (in 2000), longevity index (LI% is the ratio between the population ultra-nonagenarians (above 90 years) and those above 65) and number of centenarians per 10,000 over 65 year-old subjects (UC) of Xinjiang are higher than those of all other provinces in China (Fan, 2006).

Longevity is the consequence of joint contributions of environment, health care, lifestyle, heredity and psychological factors (Christensen and Vaupel, 1996; Ljungquist et al., 1998). Relationship between environment and longevity was studied by many researchers (Hamilton et al., 1973; Morishita, 1991; Foster and Zhang, 1995; Christensen and Vaupel, 1996; Ljungquist et al., 1998; Lv et al., 2011). Hamilton et al. (1973) found that compositions of elements present in human tissues are similar with the value of average crust. Water quality is an important factor. It is vital because safe drinking water supply major and trace elements that are essential to human body. These elements are significantly better assimilated in drinking water compare to those of food (Keller, 1978). So, drinking water can

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be an important source of assimilable elements. These elements could be either beneficial or harmful to health (Leoni et al., 1985; Foster and Zhang, 1995; Fordyce et al., 2000; Fraga, 2005; Villaescusa and Bollinger, 2008; Mandinic et al., 2010).

The population age structure on province level in Xinjiang has been analyzed by Fan (2006) and MHACI (1987), but little information is available on the temporal and spatial variation of longevity population on county level. Meanwhile, it has not been known that the regional differentiation of hydro-chemical features of natural water in longevity area of Xinjiang. Therefore, six censuses (1953, 1964, 1983, 1990, 2000 and 2010 national census) were collected to analyze the temporal and spatial variation of longevity population on county level in Xinjiang Province. Fifty-one natural water samples were collected and analyzed in Hotan, Southern Xinjiang, and 103 water samples in other area of the province were cited (Zhang et al., 1995; Pang et al., 2010; Zhu et al., 2011). The objectives include: (1) to study the temporal and spatial variation of elders (people above 80 and 100 years) and the features of three indexes (LI% (ratio of ultranonagenarians to those above 65 years old), centenarity index (CI%: ratio of centenarians within the ultranonagenarians) and UC (number of centenarians per 10,000 over 65 year-old subjects)) on county level in Xinjiang Province; (2) to study the chemical characteristics of natural water in Xinjiang Province; and (3) to analyze relationship between the spatial variation of chemical characteristics of natural water and that of longevity population on county level in Xinjiang Province.

2. Material and methods

2.1. Regional settings

Xinjiang is an autonomous region located in the northwest of the People's Republic of China (Fig. 1A). It is the largest Chinese administrative province and spans over 1.6×10^6 km^2. It splits into two large basins by the Tianshan Mountain: the Junggar Basin in the north and the Tarim Basin in the south (Fig. 1A). Xinjiang is divided into two areas by the Tianshan Mountain: Northern Xinjiang and Southern Xinjiang (Fig. 1A). According to the sixth national census in 2010, there were 11,273,037 males and 10,547,183 females living in Xinjiang. Most of Han Chinese lives in northern Xinjiang. Uyghurs account for about 90% of the population in Southern Xinjiang. Geographically, most residents in Xinjiang live in area of the alluvial–proluvial plain in the junction zone of basins and piedmonts. The people live in villages and small towns is still depend on local water sources—melt-water from glacier, spring water, river water and groundwater nearby (XETCAS et al., 1965).

Xinjiang belongs to temperate continental arid climate. The Northern Xinjiang is controlled by an arid temperate continental climate. The mean annual precipitation rate is 60–150 mm in the Junggar Basin. The average evapotranspiration is approximately 2000 mm/a. Southern Xinjiang has a warm temperate continental arid climate, with the mean annual precipitation of 100 mm. The potential evapotranspiration is approximately 2000–3000 mm/a in Southern Xinjiang. In general, the precipitation rate in Northern Xinjiang is higher than that of Southern Xinjiang, while atmospheric temperature is the other way around.

Xinjiang is located in the south-central part of the Eurasian plate, immediately north of the Himalayan fold belt and Tibetan plateau. According to the tectonic unit, Southern Xinjiang belongs to the Tarim Platform, while Northern Xinjiang belongs to the Tianshan–Altay Fold Belt (Fig. 1 B) (Peng, 1981; Xu et al., 2009). The major rocks distributed in Southern Xinjiang are Archaean granulite; Proterozoic metasedimentary and carbonatite; Sinian tillite and sandstone; Cambrian carbonatite with granite-porphyry, Ordovician and Silurian argillaceous clastic rock and limestone; Devonian sandstone and carbonatite with local granodiorite; Carboniferous clastic rock and carbonatite of neritic facies; Permian granite and clastic rock; and Meso-Cenozoic sandstone, gypsum and loose sediments. Majority of exposed rocks in Northern Xinjiang are: Sinian and Early Cambrian sericite–siltstone; Ordovician and Silurian argillaceous clastic rock, limestone and granite; Devonian and Carboniferous argillaceous clastic rock, limestone and granodiorite; Permian sandy conglomerate and granite; and Meso-Cenozoic sandstone, mudstone and loose sediments (Zhang et al., 1998; Rui et al., 2002).

2.2. Sampling and analytical methods

Demographic data at the county level in Xinjiang is mainly based on the 1990 Fourth National population census (BCXJ, 1992), 2000 Fifth National population census (BCXJ, 2002) and 2010 Sixth National population census (XJLG, 2012). Only population age structure data on the province level is recorded in the 1953 First National population census, 1964 Second National population census and 1983 Third National population census. Characteristics of population age structure of the first three censuses are listed in Table 1. In order to reduce the effect of migration and birth rate (Fan, 2006; Magnolfi et al., 2007), three newly indexes were applied. The indexes are: LI% (ratio of ultra-nonagenarians to those above 65 years old, called longevity index), CI% (ratio of centenarians within the ultra-nonagenarians, called centenarity index) and UC (number of centenarians per 10,000 over 65 year-old subjects).

Fifty-one drinking water (including river water and shallow groundwater) samples were collected in Hotan (Fig. 1C) in September 2010 and October 2012. Sampling containers are colorless polythene plastic barrels. They were cleaned in following procedures: 1. soaked in nitric acid for 24 h; 2. rinsed with 10% hydrochloric acid; 3. washed with tap water; 4 finished cleaning with distilled water; and 5. washed with sampling water three times on the sampling spots. The pH was determined in situ. All water samples were stored in clean plastic bottles at 4 °C before further analysis. The details of the sampling method could be found in Methods for chemical analysis of water and wasted water (The Fourth Edition) (MEPPRC, 2002).

The concentrations of major cations (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, SiO_2) and anion (SO_4^{2-}) were determined by ICP-OES (PerkinElmer, Optima 5300 DV). Chlorine (Cl^{-}) concentration was measured by chlorine ion-selective electrode method (Hirokazu et al., 1985). Bicarbonate (HCO_3^{-}) was determined using acid-base titration method within 3 days of sampling. Nitrate (NO_3^{-}) concentration in water was determined through UV spectrophotometry (MEPPRC, 2002). The precision of analyses were tested throughout by running duplicate analyses of selected samples. The detection limit for major cations (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, SiO_2) and anion (SO_4^{2-}) is <0.01 mg/L. The detection limit is <0.08 mg/L for NO_3^{-}. Minimal detectable concentration for Cl^{-} is 5.00 mg/L (Hirokazu et al., 1985). A balance of ionic charge is shown in Fig. 2. The error percentage in the samples ranged from ±1 to ±10%, indicating a high reliability of the analytical data. Total dissolved solid (TDS) was equal to the sum of major ions plus SiO_2, and then subtracting the half of bicarbonate (HCO_3^{-}). Total hardness (TH) was calculated by the concentration of Ca^{2+} and Mg^{2+}.

The chemical composition of natural water (48 water samples) in the Erlqis, Junggar and Yili watersheds in Northern Xinjiang came from Zhu et al. (2011). The chemical composition of natural water in the Tarim (21 water samples), Gaz (9 water samples), Aksu (9 water samples) and Hotan (16 water samples) watersheds in Southern Xinjiang came from Pang et al. (2010) and Zhang et al. (1995) respectively.

3. Results

3.1. Demographics

All six censuses show that the number of centenarians per 100,000 inhabitants (OC), LI%, CI% and UC in Xinjiang were higher than national