Environmental impact analysis of mine tailing reservoir

J Z Gong¹,²

¹Hebei Institute of Geophysical Exploration, Langfang 065000, China

E-Mail: gjz212@tom.com

Abstract. Under certain conditions landscape topography which utilizes mine tailing reservoir construction using is likely to increase lateral recharge source regions, resulting in dramatic changes to the local hydrological dynamic field and recharge of downstream areas initiated by runoff, excretion state, elevated groundwater depth, shallow groundwater, rainfall direct communication, and thinning of the vadose zone. Corrosive leaching of topsoil over many years of exposure to chemical fertilizers and pesticides may result in their dissolution into the groundwater system, which may lead to excessive amounts of many harmful chemicals, thereby affecting the physical and mental health of human residents and increase environmental vulnerability and risk associated with the water and soil. According to field survey data from Yujiakan, Qian'an City, and Hebei provinces, this paper analyzes the hydrogeological environmental mechanisms of areas adjacent to mine tailing reservoirs and establishes a conceptual model of the local groundwater system and the concentration-response function between NO₃⁻ content in groundwater and the incidence of cancer in local residents.

1. Introduction

Water pollution is exacerbating the groundwater crisis in China. Experts from the China Geological Survey Bureau determined that 90% of groundwater in China suffers from various degrees of contamination, 60% of which suffers from serious pollution. According to information published by the China Geological Environmental Monitoring Institute China currently exhibits a groundwater trend that indicates worsening pollution levels from point to the surface, from shallow to deep, and from urban to rural [1].

Simultaneously, cancer rates are rising dramatically, and the relationship between cancer and water pollution has gradually become the focus of attention.

Comparrig the elemental content of soil, water, agricultural areas, human hair and other medium of high cancer incidence and low risk areas, certain eco-geochemical survey data reported by Li Zhong-Hui, et al., (2012) has identified key geochemical factors which lead to high incidence of cancer in Sichuan Yanting, and predicted the incidence of cancer within the Chengdu Economic Zone [2].

Based on investigation and monitoring, Yang Gonghuan, et al., (2013) established a database of environmental and health factors in Huaihe River Basin. Through spatial analysis, an association model between environmental and health issues was proposed to lay the foundation for the implementation of integrated monitoring[3].

Recently, concurrent with the vigorous development of mineral resources and the construction of the tailing reservoir, the impact on the quality of the surrounding groundwater has become an increasingly
prominent and serious threat to human health. In this paper, iron ore from Qian'an City, Hebei Province, and the Xixiakou-Yujiakan region are used as an example in specific case studies.

2. Epidemiological survey of cancer villages
Drinking the water that comes into contact with untreated sewage upstream as well as other sources of air, soil and other environmental contamination can cause serious damage to internal body mechanisms, resulting in massive cancer incidence in local villages.

In 2009, Sun Yuefei confirmed the presence of over 247 cancer villages in China, with two specific geographical distribution characteristics. First, a multi-centered centralization and regular intersection of azonality and zonality were observed, indicating that the villages are not uniformly distributed. Second, in basic agreement with differences in rainfall, population distribution and regional economy, the number of cancer villages decreases from the eastern portion to the western portion in a gradual gradation. In regard to various causes, cancer villages can be divided into three categories. First are the environmentally polluted cancer villages which result from industrial, agricultural and domestic pollution. Second are lifestyle-based cancer villages that reflect vocation, as well as diet and hygiene habits. Last are original environmental cancers which are related to local geographic environment such as geology and hydrology[4].

Experts estimate the number of cancer villages in mainland China to be approximately 459, and gradually to the central and western diffusion. According to statistics representing the years 2009-2015, 37 people in Yujiakan village were identified as cancer patients, indicating an incidence of 1.37% (2012, China cancer 0.2478% ) , representing 21 males and 16 females with cancer onset from 1 year to 77 years, indicating an average of 52.6 years and an average age at death of 62.9 years. Digestive system cancers account for 12 people, the number is the most. Some couples or fathers and sons simultaneously cancer.

2007-2015, 117 patients with cardiovascular disease, disease incidence 4.33%, among them, cerebral thrombosis, cerebral hemorrhage 84, heart disease 33. The average pathogenesis age 62.15 years, age at death 71.61 years old. Some couples even father and sons while sick. 2009--2014 year show a gradual increasing trend.

| Table 1. Cancer and cardiovascular diseases distribution circumstances of Qian'an City, Yujiakan. |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Cancer onset age | 1-5 | 46-50 | 52-60 | 63-70 | 72-77 / year old |
| Patients number  | 1   | 1    | 6    | 8    | 4    | 4    |
| Cancer types     | Lung | colon | renal | breast | leukemia | gastric | liver | esophageal | other |
| Patients number  | 8   | 4    | 3    | 3    | 3    | 2    | 3    | 8    |
| Cardiovascular diseases | 25-4 | 41-50 | 51-6 | 61-70 | 71-80 | 82-93 / year old |
| Patients number  | 0   | 0    | 0    | 0    | 0    | 0    |
| Fall ill age     | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
| Patients number  | 6   | 6    | 2    | 18   | 15   | 17   | 22   | 23   | 8    |

The village is expected to average life expectancy of 69.88 years, low 4.12 years than the national average life expectancy of 74 years.

The villagers were shocked by the harsh realities of the immediate. In puzzling apart, targeting the village drinking groundwater quality. Villagers found, whenever the northwest monsoon winds, gray tailings flying in the sky. Wells water gradually worse taste, slightly sour, used to fish difficult to survive.
3. Groundwater quality impact of iron ore tailing reservoir

There is a medium-sized sedimentary-metamorphic magnetite bed in Xixiakou village north, start mined from 1980 Generation, waste water generated during the mining, through a pipe discharged into the tailing reservoir in Yujiakan North Hill. 2008, Xixiakou iron ore reservoir dam heightening three meters, become a suspended lake on the ground, daily water surface above 5-20 meters in the south side Yujiakan village. 2009-2014, followed by a series of hydro-geological effects.

The area belongs to the new Archean era miniature folding platform structure, Yanshan south erosion - denuded hills and mountains landscape, slightly inclined, northwest was up about 30 meters than southeast. Quaternary genetic types are the late Pleistocene alluvial fan (skirt) accumulation, in the piedmont hydrogeological zoning of Luanhe River system, full fresh water area, mainly diving, partial confined water. Alluvial fan shaft unit inflow more than 40t / (h • m), alluvial fan edge unit inflow 10 ~ 40t / (h • m). The lower part of the aquifer without continuous aquitard, good vertical hydraulic connection, often the lower part of the aquifer mining and dewatering, confined aquifer and the lower aqueous layer aquifer group consisting uniform [5].

The aqueous layer exhibits the dual structure, wherein within the range of 0.5 to 10 meters containing gravel clay, loam, the lower part is weathered bedrock fissure of the Mid Archean Qianxi rock group (Ar2Q) websterite hornblende plagioclase granulite, New Archean tonalite rocks(Ar3Tog) and light-colored granite (Ar3γ). Aquifers rich aqueous up 5000m3 / d or more, permeability coefficient> 150m3 / d, rainfall infiltration coefficient of 25-30%[6].

Under normal conditions, the shallow groundwater recharge main source of atmospheric precipitation. During the summer heavy rainfall, flood into the southeast of Qinglonghe River. In winter and spring non-season rainfall, the performance area is a typical village dry state, water resources is very scarce.

Heightened tailing reservoir, representing increased a huge source of lateral recharge zone, resulting in the region a dramatic change of hydrodynamic field and recharge - runoff - excretion state, specific performance in the following several aspects:

(1) Groundwater depth from the original 10 meters rise to about 2 meters, local area during the rainy season more shallow; (2) In fractured bedrock at the village, many water seepage drain point decline springs, forming a trickle; (3) Shallow groundwater with rainfall to direct communication, vadose zone thinned dramatically or even disappear, in dissolving, leaching, previous years accumulated chemical fertilizers and pesticides in topsoil, integrate mixed into the groundwater system, leading to a variety of harmful ingredients exceeded.

Since the 1980s, application of groundwater system research methods, in terms of establishing a conceptual model of groundwater, Chinese scholars have made significant progress, the Groundwater System Block Diagram of Northeast Songnen Plain, representative in the northern region. Hydrogeological conceptual models mainly reflecting spatial distribution of the whole structure composed of boundary conditions, recharge and discharge, hydrodynamic conditions, water chemical characteristics and its corresponding parameters[7].

According to the spatial distribution of the survey area heterogeneous aqueous medium, recharge and excretion evolution with time, mineral dissolution material transport and changes in vadose zone waters, Author try to set up a local hydrogeological conceptual model (figure 1).
Figure 1. Schematic diagram of tailings reservoir to groundwater effect in YuJiakan Qian'an City.

a. Tailing reservoir above the village become a suspended lake.

b. The water level is raised leading to village low-lying formation of perennial streams.

c. Shallow aquifer structure-containing gravel clay, fertilizer and pesticide infiltration properties.

d. Weathering crust aquifer.
4. Groundwater quality evaluation

According to the analysis results of the experiment in Hebei Province Water Environment Monitoring Center, we can find: (1) according to the national drinking water quality standards GB/T14848-93 and drinking water health standards GB5749-85, the area most water samples NO$_3^-$ exceeded several times to dozens ten times. Secondly, few water samples hardness, salinity, SO$_4^{2-}$ and Cl$^-$ exceeding 1-2 times; (2) Spatial distribution of all village water samples NO$_3^-$, gradually increased from the north higher ground to the lower south content doubled by 10-20-50-100-300-500-700mg/L, entire villages all belong to the scope of excessive, the most serious in village southeast, content contours form closed ring shape distribution; (3) Overall quality of II, III class water, evaluation from the good, poor to very poor. Compared to 1983[5], by 2015, in addition to decreased pH outside, remaining harmful components have increased.

The village cancer patients mainly in the low-lying area elevation 100-90m, groundwater NO$_3^-$ 50-765 mg/L polluted area, show some spatial correlation between the two(table 2, figure 3).

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**Figure 2.** Hydrogeological photos in YuJiakan Qian'an City.

e. Deep aquifer structure, Qianxi rock group granulite.

f. The villager drinking wells.

**Figure 3.** Shallow groundwater NO$_3^-$ content (mg/L) contour map of YuJiakan Qian'an City.

Note: dashed line is the elevation, solid line NO$_3^-$ content, black dots for cancer patients address distribution.
Table 2. Interrelation between groundwater NO$_3^-$ content and the number of cancer patients in YuJiakan Qian'an City.

| Groundwater NO$_3^-$ content /mg/L | 10-20  | 20-50 | 50-100 | 100-300 | 300-500 | 500-765 |
|-----------------------------------|--------|-------|--------|---------|---------|---------|
| Distribution area / km$^2$        | 0.704  | 0.805 | 0.135  | 0.233   | 0.050   | 0.032   |
| Number of cancer patients         | 0      | 2     | 5      | 6       | 8       | 11      |
| Patients density / people / km$^2$| 0      | 2.48  | 37.0   | 25.8    | 160     | 344     |

Between groundwater NO$_3^-$ content(x) and the patients density(y), We can create a system of linear equations:

\[ Y = 0.5363x - 26.42 \quad \gamma = 0.9680 \quad \gamma_{0.05} = 0.7067 \quad n = 6 \]

5. Causes of groundwater environmental pollution and health hazards

On the Hebei plain surface soil nitrogen element geochemical maps, the district topsoil N in 1121 - 1269 mg/L, the province's average of 1048 mg/L, This area 1.5 m deep soil N content of 825 mg/L or more, compared with the region's average of 581. It is positive abnormal distribution, become groundwater nitrate supply source region.

North China Plain diving around occurred the different levels of nitrite (NO$_2^-$-N) pollution, Hebei, Shandong, Henan part of the area, groundwater nitrate content excessive mainly in agricultural areas, Nitrogen fertilizer is caused by infiltration of groundwater[8].

Liu Guangdong (2004) has establish a dose - response relationship between Nitrate contamination and health damage. Predicted the increased deaths number of groundwater pollution exceeded region, Constructed a total evaluation function of human capital loss[9].

Modern medical research shows, Cancer and genetic factors, environment, lifestyle, etc., have shown some correlation. Yanting County, Sichuan Province, a high incidence of cancer, mainly related soil and food, low levels of selenium molybdenum, food and drinking high levels of nitrates[2].

A team of experts from Chinese Center for Disease Control has studied lasted eight years, the results show, in Huaihe River Basin, irrigation polluted areas compared with the control areas, gastrointestinal cancer prevalence 5 times, child cancer mortality higher than the national average of 68.81 / 100,000, fully confirmed the high incidence of cancer is directly related to the water pollution [3].
6. Conclusions and recommendations

Since the construction of the mine tailing reservoir, increased peripheral lateral groundwater recharge source, resulting in significantly improved downstream water depth, combined with precipitation on surface soil leaching dissolution. As a result, the quality of groundwater beyond national standards, Thereby affecting the residents physical and mental health. In order to do this, we proposed increase water depth, shield shallow groundwater, to mitigate the hazards of environmental pollution.

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