Assessment of Groundwater Pollution and its Causes in the Plain Area of Yili River Valley

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Abstract. This paper, adapting the method of Average Comprehensive Pollution Index and Nemero Pollution Index, aims to evaluate the groundwater pollution of the plain area of Yili river valley in Xinjiang uygur autonomous region. And the cause of the pollution was discussed as well. The results showed that: First, the main influencing factors are total hardness, sulfate, as well as three nitrogen. Second, the main reasons for the groundwater pollution are industrial and mining enterprises which present star-like in this area. What’s more, the domestic sewage with zonal distribution and the planar distribution of agricultural waste water are also included. This study is of great importance to the analysis and prediction of groundwater environmental impact. Located in the northwest of Xinjiang uygur autonomous region, with its most humid climate, the most abundant precipitation as well as the richest soil and coverage of vegetation within the area of Xinjiang and Tianshan, the Yili river valley has been hailed as the “wet island” and “treasure of biological resources” of the semi arid region\textsuperscript{[1]}. Yili river valley is rich in water resources. And main river that it flows through is the Yili River, an international river that runs across China and Kazakhstan, the total length of which is 1236.5 km, with its length at home 442km\textsuperscript{[2]}. The present researches on the Yili river valley is relatively poor, with the materials relating to the water environment not so rich\textsuperscript{[3-8]}. With the influence of human activities, the flow field, water quality and hydro-chemical characteristics of groundwater in this area have been changed accordingly. The evaluation of contaminated situation of groundwater in this area can provide a sound scientific basis for the rational utilization of water resources in this region. Meanwhile, it works as a solid guide for the sustainable development and integrated management of water resources within this region\textsuperscript{[9]}

Study Area

The study area belongs to the Yili Kazak autonomous prefecture, Xinjiang uygur autonomous region, which includes eight counties and one city, namely, the city of Yining, Yining county, Huocheng, Chabuchar county, Xinyuan county, Gongliu county, Nilka county, the Turks county, Zhaosu county, and the geographical coordinates of which is between latitude 42 degrees to 45 degrees north, and longitude 80 degrees to 85 degrees east. Generally speaking, the study area is located on the South border of Bortala mongol autonomous prefecture, the west border of Tacheng, Bayingolin mongol autonomous state, the north border of Akesu area, as well as the east border of Kazakhstan.

With abundant rainfall, the study area has its typical humid continental temperate climate. And the space and time difference of temperature in this area is obvious. The lowest temperature is in January, the monthly average temperature of which is 8 degrees Celsius to 15 degrees Celsius; the highest temperature arrives at June to August, the average temperature of which is 13 degrees Celsius to 23 degree Celsius. There are more than 120 rivers and streams in this basin, the biggest ones are the Yili River and its three tributaries, the Turks river, the Kunas River and the Kashi River. What’s more, the river flow is obviously changed with the seasons.
The main groundwater types in bedrock mountainous area are bedrock fissure water and carbonate rocks fracture-karst water, the water chemistry type of which is \( \text{HCO}_3^-\text{SO}_4^2^-\text{Na}-\text{Ca} \). While the groundwater type in the plain area is mainly Quaternary pore water in loose rock. And its water chemistry type is mainly made up of \( \text{HCO}_3^-\text{Ca} \), \( \text{HCO}_3^-\text{Ca-Mg} \), \( \text{HCO}_3^-\text{SO}_4^-\text{Ca-Mg} \). And sampling points are shown in Figure 1.

![Figure 1. Sampling point distribution map.](image)

### Assessment of Groundwater Pollution

**Statistical Characteristics of Hydro-chemistry Parameters**

A descriptive statistical analysis of hydro-chemistry parameters, which is related to groundwater, can help to better understand the enrichment and variation laws of chemical constituents in groundwater \[10\]. The calculation results are shown in Table 1. The results show: The variation coefficients of \( K^+, \text{Na}^+, \text{Cl}^- \) and \( \text{F}^- \) are higher, which indicates that they are the sensitive factors that change with the environmental factors. The variation coefficients of \( \text{Ca}^{2+} \), \( \text{HCO}_3^- \), \( \text{PH} \) and \( \text{H}_2\text{SiO}_3 \) are relative less, indicating that their content in groundwater is accordingly stable. The mean and standard deviation of \( \text{Ca}^{2+} \), \( \text{Na}^+ \), \( \text{SO}_4^{2-} \), \( \text{HCO}_3^- \), \( \text{Cl}^- \) are higher, which indicates that these ions are the main ions in the groundwater of this area.

<table>
<thead>
<tr>
<th>Number</th>
<th>Max (mg/l)</th>
<th>Min (mg/l)</th>
<th>Mean (mg/l)</th>
<th>Standard Deviation (mg/l)</th>
<th>Coefficient of variation (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( K^+ )</td>
<td>60.70</td>
<td>0.40</td>
<td>3.00</td>
<td>6.63</td>
<td>220.63</td>
</tr>
<tr>
<td>( \text{Na}^+ )</td>
<td>272.00</td>
<td>3.60</td>
<td>57.65</td>
<td>65.87</td>
<td>114.25</td>
</tr>
<tr>
<td>( \text{Ca}^{2+} )</td>
<td>184.40</td>
<td>16.00</td>
<td>75.93</td>
<td>33.89</td>
<td>44.64</td>
</tr>
<tr>
<td>( \text{Mg}^{2+} )</td>
<td>121.50</td>
<td>2.40</td>
<td>29.67</td>
<td>21.49</td>
<td>72.44</td>
</tr>
<tr>
<td>( \text{Cl}^- )</td>
<td>263.70</td>
<td>2.80</td>
<td>41.18</td>
<td>47.37</td>
<td>115.03</td>
</tr>
<tr>
<td>( \text{SO}_4^{2-} )</td>
<td>566.80</td>
<td>0.00</td>
<td>146.18</td>
<td>137.37</td>
<td>93.98</td>
</tr>
<tr>
<td>( \text{HCO}_3^- )</td>
<td>746.90</td>
<td>48.80</td>
<td>275.27</td>
<td>128.11</td>
<td>46.54</td>
</tr>
<tr>
<td>( \text{NO}_3^- )</td>
<td>92.60</td>
<td>0.30</td>
<td>15.50</td>
<td>14.71</td>
<td>94.88</td>
</tr>
</tbody>
</table>

*Table 1. Statistics value of groundwater hydro-chemistry parameters.*
**Assessment of Groundwater Pollution**

This paper mainly adopts the Comprehensive Pollution Index method when it comes to study method \[11\]. The class III standards of “Groundwater Quality Standards” (GB/T14848-9) and the “Living Standards for Drinking Water Health Standards” (GB5749-2006) work in this paper as the main references\[12\]. The eight indicators including total hardness, total dissolved solids, sulfate, chloride, nitrate, nitrite, ammonia were evaluated. The evaluation results are shown in Table 2.

Table 2. The evaluation results of groundwater pollution.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>NH(_4^+)</th>
<th>Cl(-)</th>
<th>SO(_4^{2-})</th>
<th>NO(_3^-)</th>
<th>NO(_2^-)</th>
<th>F(-)</th>
<th>TDS (mg/l)</th>
<th>Total hardness (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum exceeded multiples</td>
<td>56.5</td>
<td>14.82</td>
<td>52.62</td>
<td>69.74</td>
<td>52.75</td>
<td>44</td>
<td>47.17</td>
<td>62.36</td>
</tr>
<tr>
<td>The number of overweight</td>
<td>9</td>
<td>1</td>
<td>18</td>
<td>20</td>
<td>12</td>
<td>8</td>
<td>6</td>
<td>15</td>
</tr>
<tr>
<td>Excessive rate (%)</td>
<td>10</td>
<td>1.11</td>
<td>20</td>
<td>22.22</td>
<td>13.33</td>
<td>8.89</td>
<td>6.67</td>
<td>16.67</td>
</tr>
<tr>
<td>Grade</td>
<td>III</td>
<td>I</td>
<td>III</td>
<td>IV</td>
<td>III</td>
<td>III</td>
<td>III</td>
<td>III</td>
</tr>
</tbody>
</table>

As the evaluation results shows below, three nitrogen overweight seriously, which exceeds 45.55 percent. The main reason is the overuse of pesticide and fertilizer and the development of animal husbandry, which can find better explanation when contrasted with the paper of Yuling Hao’s in 1990. In 1990, except the total hardness, all of the index in this area was grade I and II. While the sample in this paper was sampled in 2014, only 24 years from 1990. The three nitrogen, TDS, total hardness, sulfate of the groundwater from the sample in 2014 were higher than the standard. And expect Cl\(-\), all of the index were III grade and IV grade. Hence, the exploitation and utilization of groundwater in this area is unreasonable and it is urgent to manage and protect the groundwater in this region.

According to Nemero Pollution Index method to calculate the water quality and pollution assessment, the degree of groundwater pollution is divided into groundwater pollution zoning map, as shown in Figure 2. The distribution of pollution level in each county is shown by the graph.

**Analysis of Groundwater Pollution Sources**

According to the observation of the field and the evaluation results of groundwater pollution, the pollution reasons are as followed:

1. **Dot-like pollution sources**

   Dot-like pollution sources are mainly from industrial and mining enterprises. In the west side of No.75, near the county lattu, due to the mining of uranium, heavy metals in groundwater seriously exceed the standard, which results in the high rate of residents cancer incidence. While the excessive exploitation of coal in coal mine factory in No.53 leads to poor water quality at that area. Because of the exploitation of gypsum mine, the total hardness of groundwater and the excessive sulfate in nilka county.
(2) Zonal pollution sources

The residents in the study area are mainly distributed on both sides of the river. With the increase of population as well as the development of economy, the discharge of domestic increases year by year and a large number of domestic waste water is discharged directly to landfill, without any treatment, resulting in serious surface water pollution. Since the river is located in the Quaternary loose sand and the main recharge sources of groundwater is surface water, the sewage and industrial water pollution can easily lead to serious groundwater pollution.

(3) Planar pollution sources

Planar pollution sources are mainly from agricultural pollution, including the pollution of pesticides and chemical fertilizers and livestock. The farming and animal husbandry have developed in the region. A large number of cattle and other livestock’s excreta is directly discharged without treatment, resulting in the seriously overweight of three nitrogen in groundwater, accounting for 52.91% of the total exceeded factors, and the rate of which has long reached to 45.55%. In the farming region, especially the grazing area, such as Kunes farm, water pollution is serious, with high incidence of esophageal cancer.

Control Measures

In order to make sustainable use of groundwater resources, groundwater should be given protection while being exploited and utilized. Without the proper use of groundwater resources, the balance of the ecosystem would be broken. Therefore, according to the current situation of groundwater pollution, some protective measures are put forward:

First, control the sewage discharge of industrial and mining enterprises. The $SO_4^{2-}$ and total hardness of the sewage discharged by industrial and mining enterprises are far beyond the standard. Local enterprises should strengthen its supervision, so that industrial and mining could deal with the waste water before discharging. For those who do not meet the emission standards, the relevant government departments should make a deadline for rectification.

Second, for agricultural and animal husbandry pollution, we should adopt the advanced agricultural irrigation technology and the scientific method of grazing. Reduce the use of pesticide and chemical fertilizer, adopt the irrigation and drip irrigation, replacing the original irrigation method. And the organic pollution generated by livestock and domestic waste shall be discharged after treatment.
Third, due to the slow flow of groundwater, water pollution is not easy to be found. Therefore, the groundwater quality in the area should be monitored in real time to predict the trend of groundwater quality. For the area of poor water, it is time to find out the causes and to make the pollution sources under effective control to avoid a large range of water pollution.

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References