

# Exploring the Causes of Manganese Pollution in Groundwater and Prevention Measures in Rural Areas

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**Abstract:** Most rural areas are still drinking groundwater directly, and some of them have the condition that the content of manganese in groundwater exceeds the standard, which adversely affects the health and life of villagers. The article summarizes the causes of groundwater pollution in rural areas, and puts forward the prevention and control measures available for manganese pollution in groundwater in rural areas, in order to provide a reference for groundwater pollution management in rural areas of China and to ensure the safety of drinking water for residents.

**Keywords:** Manganese pollution, Rural areas, Groundwater, Redox conditions.

## 1. Status of Manganese Pollution in Groundwater in Rural Areas

As an important source of drinking water in rural areas of China, the quality of drinking water is closely related to human health and social development (Li et al., 2014). From the 12th Five-Year Plan, China will promote groundwater pollution prevention and control as the focus of groundwater work, and will include the prevention and control of rural living pollution and ecological environment improvement, and the safety of drinking water for rural residents into the development needs of the target. From relevant research reports, it can be seen that China's groundwater manganese pollution has a trend of spreading from urban to suburban and rural areas (Li et al., 2016), and currently in key rural areas, counties and cities, drinking water safety has been fully protected, while most rural areas are still working at a low level. The proportion of our population of 42% of the rural population, there is still a significant proportion of rural residents with groundwater as an important source of drinking water. The literature (Huang et al., 2015; Zhang et al., 2020) showed that groundwater in some rural areas has different degrees of manganese contamination and health risks. Therefore, to pay attention to the problem of groundwater manganese contamination in rural areas, investigate the causes of groundwater manganese contamination in rural areas, for the specific situation, put forward the corresponding pollution prevention and control measures, is an urgent matter to improve the drinking water conditions in rural areas.

## 2. Analysis of the Causes of Manganese Pollution in Groundwater

### 2.1. Direct pollution caused by manganese-related enterprises

Manganese-related enterprises are mainly divided into manganese mining enterprises and manganese electrolysis production enterprises. In the process of manganese mining, there are many hidden dangers that can cause manganese pollution, such as irregular discharge of mine wastewater, random piling of mining waste rocks, and unorganized emission during the processing of manganese powder. The

manganese-containing ores leach manganese ions under the comprehensive effect of external environment and seep into the groundwater under the effect of precipitation leaching, which becomes the main source of manganese pollution in the groundwater of mining areas. The content of manganese in the seriously polluted areas exceeds the standard by more than 300 times. Due to the high sulfur content in coal, high manganese is often associated with coal mining, and the mine water is acidic, which accelerates the dissolution of manganese, resulting in high manganese content in the mine water of coal mines, which leads to the increase of manganese in the water bodies of nearby areas.

Manganese electrolysis enterprises mainly focus on electrolysis of manganese dioxide, supplemented by the production of manganese alloy, with a single industrial composition, low level of network structure, short industrial chain and low added value, which is a rough economy. Some enterprises discharge manganese in excess of the standard, resulting in high manganese content in the nearby surface water and groundwater. Stone processing enterprises cut with manganese steel blades, and the wastewater produced by the rinsing process contains a large amount of manganese.

### 2.2. Endogenous manganese release caused by changes in groundwater environment

The bedrock in nature contains a certain amount of manganese, and the change of water environment will cause the manganese minerals in the rock to release a large amount of manganese ions, which will then enter the groundwater system (Kshetrimayum and Hegeu, 2016). A large number of studies have been conducted at home and abroad to show that there are many factors that affect the release of manganese, such as pH, runoff conditions, organic matter content, redox potential, etc (Bhutiani et al., 2016).

#### (1) pH value

Manganese is generally stable in oxide form when it is tetravalent and difficult to dissolve in water, while it is easy to enter the water body in ionic state when it is divalent. However, when the environment is alkaline and acidic, both divalent and tetravalent manganese will become easier to enter the water body, while the alkaline environment will inhibit the entry of divalent and tetravalent manganese into the water body (Mohan and Chander, 2006). In rural areas, due

to the remote location, individual factories may discharge industrial wastewater secretly, and farmers abuse pesticides and chemical fertilizers due to the lack of scientific guidance, and these chemicals may enter the groundwater to lower its pH value and accelerate the leaching of manganese.

#### (2) Runoff conditions

Uncontrolled industrial water use and unreasonable agricultural irrigation methods may cause groundwater overdraft and affect groundwater runoff conditions. In areas with poor groundwater runoff conditions, the groundwater flow rate is slow and manganese is relatively easier to be enriched there, while in areas with good runoff conditions and fast flow rates, manganese is more easily lost by diffusion, and good runoff conditions generally also have more dissolved oxygen, which can oxidize the manganese ions in water (Suada, 2016).

#### (3) Organic matter

Domestic sewage and farming wastewater in rural areas are often discharged freely without treatment, which contains a large amount of organic matter, and more organic matter will also indirectly lead to higher manganese content in groundwater. This is because the oxidation process of organic matter will consume part of the dissolved oxygen in the water, and the groundwater will become reductive, making it easier to convert the stable high-valent manganese oxides into the low-valent easily soluble salts. The decomposition process of organic matter in a reducing environment also releases carbon dioxide and hydrogen sulfide, enhancing the reducing nature of the groundwater (Neidhardt et al., 2014).

#### (4) Redox conditions

Groundwater is a complex redox system consisting of many inorganic and organic systems, and the redox potential in the water column reflects the redox characteristics of the water column. The level of redox potential is related to various factors such as dissolved oxygen and organic matter content in the water, and the concentration of  $Mn^{2+}$  decreases with the increase of redox potential.

### **3. Groundwater Manganese Pollution Prevention and Control Measures**

Groundwater environmental protection in rural areas should be based on prevention and a combination of prevention and treatment. From the basic situation of groundwater manganese pollution in rural areas and specific research, groundwater manganese pollution has the characteristics of concealment and difficult to be treated. In order to curb manganese pollution in rural groundwater, a series of countermeasures must be taken to prevent and treat manganese pollution in rural groundwater, and targeted measures should be taken in rural areas where pollution has occurred.

#### **3.1. Carry out groundwater manganese pollution remediation**

The location of groundwater is relatively deep and the groundwater situation is complex, so it is difficult to manage the problem of manganese contamination in groundwater. The remediation methods include biological methods, chemical oxidation methods and adsorption methods, but each of them requires huge capital investment. At present, according to the status of manganese pollution in rural groundwater, a few areas with more serious pollution due to the influence of manganese mining need to spend huge amounts of money to

pump out groundwater for a strict groundwater manganese pollution remediation process (Qiu, 2011, 2010). The most economical and effective way for other areas with low manganese exceedance is to popularize the centralized water supply service in rural areas, and the manganese content can reach the drinking water standard after the groundwater is treated centrally by contact oxidation method in the water plant.

#### **3.2. Strengthen the comprehensive management of manganese-related enterprises**

Strengthen the comprehensive management of manganese mines, coal mines and other enterprises to prevent arbitrary discharge of waste ballast and wastewater, and do a good job in preventing soil erosion. Seal some abandoned mines that have been closed to avoid the impact of seepage in abandoned mines on groundwater. Enterprises with outdated pollution prevention and control facilities, serious pollution and risk of groundwater pollution must be rectified within a certain period of time, and those not rectified as required should be shut down to prevent groundwater pollution caused by indiscriminate discharge of enterprises. Pollution prevention and control facilities and relatively advanced technology of enterprises, regular supervision and inspection to ensure the long-term stable operation of pollution prevention and control facilities, and regular inspection to eliminate the possible risks of groundwater pollution.

#### **3.3. Strengthen domestic sewage treatment, scientific use of fertilizers and pesticides**

Improve the current situation of disorderly discharge of domestic sewage in existing rural areas. Conditional villages can lay sewerage pipes into the town sewage treatment plant centralized treatment, or through the village sewage treatment station centralized treatment mode, ecological oxidation ponds and other sewage management mode treatment. After the domestic sewage is properly treated, it is then reasonably utilized. Set up a temporary dumping site for domestic garbage, the garbage dumping site needs to do impermeable treatment to prevent leachate from overflowing and seepage, and the sanitation department collects and transports it to the township garbage transfer station or landfill on a regular basis, and timely treatment can effectively prevent groundwater pollution caused by leaching of domestic garbage.

There is more scattered farming around some villages, and farming and other activities around water sources should be banned, and no-farming areas should be designated. Take unified planning of breeding areas, outlaw scattered breeding, unified management, unified collection and treatment of breeding wastewater and manure and other pollutants, and prohibit external discharge. Actively guide the scientific application of chemical fertilizers and pesticides, and vigorously develop ecological planting patterns. Actively promote crop pest control and physical control techniques.

#### **3.4. Environmental management-related countermeasures**

First of all, strengthen and improve the monitoring of water quality in rural water source protection zones in order to provide technical support for water source protection. Through radio, television and slogans, we can publicize the protection of groundwater and pollution prevention in rural

areas. Through publicity and education, popularize rural residents' knowledge of groundwater manganese pollution hazards, environmental protection knowledge and relevant laws and regulations, so that rural residents are aware of the importance of groundwater safety and the seriousness of groundwater pollution. Rural groundwater pollution has a great relationship with villagers' environmental protection awareness, so in the process of groundwater manganese pollution prevention and control in rural areas, we should enhance rural residents' awareness of groundwater protection, make rural residents realize that everyone is responsible for protecting rural groundwater, so that everyone can be involved in groundwater protection work, and rely on the mass power to improve groundwater protection as well as pollution prevention and control effects.

#### 4. Conclusion

This paper discusses the causes of groundwater manganese pollution in rural areas, and proposes reasonable prevention and control measures for the characteristics of rural areas and the causes of manganese pollution, so as to provide reference for improving the environmental quality of groundwater in rural areas and ensuring drinking water safety.

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