World Scientific Research Journal Volume 7 Issue 3, 2021
ISSN: 2472-3703 DOI: 10.6911/WSRJ.202103_7(3).0029

The Pollution Status of Ground Water and Treatment Methods in China

Zetao Xiong[1], Lin Wang[1, a, *]

[1]Miami College, Henan University, Kaifeng, Henan Province, 475002, China

[a]wanglin@henu.edu.con

Abstract

Groundwater refers to the water occurring in rock voids, usually also refers to the water in saturated aquifers below the underground water surface. It is an important part of water resources and one of the essential water sources for urban, industrial and agricultural water. In recent years, excessive exploitation of groundwater, infiltration of surface sewage and poor public awareness of protection have led to a series of environmental problems, seriously affecting normal production and life. According to Ministry of Water Resources of China, it is systemically concluded the current situation of ground water pollution, the causes, and features. In addition, existing treatment methods are summarized to provide basis and suggestion for ground water treatment in future.

Keywords

Ground water; Current situation of pollution; Causes of pollution; Treatment methods; Preventive measures.

1. INTRODUCTION

Ground water is below earth's surface, which realizes refresh and replenishment by water circulation. As a result of human activities, the chemical compositions, physical properties and ecological environment of groundwater have been changed, which makes the quality of groundwater decline and seriously endangers human production and life. For other thing, it is characterized by concealment, slow flow and poor self-purification capacity. Therefore, once it is polluted, it will be more difficult and costly to be controlled. Moreover, the general control method is not thoroughly treated, and secondary pollution is easy to occur. According to the "Monthly Report on Groundwater Dynamics" reported by the Ministry of Water Resources in January 2016, about 60% of the groundwater quality in 18 provinces and municipalities surveyed by sampling is below standard, which indicates that the groundwater pollution in China has been extremely polluted.(Ministry of Water Resources, 2016) Groundwater quality is directly related to the health of the people and the sustainable development of the region, which requires the whole society to build consensus and participate in the protection and management together.

2. SOURCE OF GROUND WATER POLLUTION

2.1. Industrial Pollution

In the industrial production industry, the main pollution is linked with waste sites, solid waste storage, landfill leachate infiltration, sewage infiltration and so on. Toxic and harmful substances, such as nitrogen and sulfur oxides and hydrogen chloride, are discharged in the process of production, under the action of water resource circulation, infiltrating into

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202103_7(3).0029

underground runoff through rivers and causing pollution. In the process of water circulation, pollutants enter into various links, causing extensive pollution effects. According to the investigation of Wu et al. (2020), the TP concentration of groundwater in Gucheng River Basin, Jinning District, Kunming city seriously exceeded the standard, and the reason was that the protection measures of nearby phosphogypsum slag field were not in place, which led to the infiltration of phosphorous filtrate and caused pollution. Industrial pollution is the main way of groundwater pollution.

2.2. Agricultural Pollution

In the process of crop cultivation, a large number of fertilizers are used, but only a small part of them is absorbed by the crops, and most of them remain in the soil (Yang et al., 2020). Under the effect of rain, they enter into the groundwater through underground runoff, causing a number of pollutants. Secondly, in some areas, industrial wastewater and municipal wastewater that does not achieve standard are used to directly irrigate crops, which also affects the groundwater quality. At the grass-roots level, especially in rural areas, livestock waste is not effectively treated and a large amount of contaminated organic matter seeps into ground water (Qu et al., 2020). In addition, in the aquaculture industry, aquaculture personnel will add a large number of hormone substances, and the wastewater is not often effectively treated, which will also affect the groundwater quality (Tian et al., 2020).

2.3. Municipal Pollution

For the municipal ecosystem, the main way to pollute the groundwater is the infiltration of all kinds of domestic sewage which contains a large amount of organic matter. In China, due to the lack of garbage classification awareness, it is impossible to carry out the refined treatment of garbage, and the landfill disposal capacity is limited. If measures of protection are lost or the anti-seepage films are broken, the generating landfill leachate is going to directly pollute surface water and groundwater. Indiscriminate disposal of rubbish, especially batteries which contain heavy metals, is also a cause of pollution. It is also an important external factor that relevant government departments lose supervision position, the laws and regulations are not perfect, and the society has not formed a consensus on protection.

It is different from the surface water pollution, which has the following several significantly different characteristics: firstly, due to it is in the subsurface, burial condition is complex, and the groundwater monitoring network construction in China is not complete, so there are still some shortcomings in the nationwide real-time groundwater monitoring(Wang et al. , 2020). When affected by groundwater pollution, it probably has existed for a long period of time, which means the existence of characteristics of concealment(Zhang et al. , 2020). Secondly, groundwater flow is an important part of water resources cycle. Compared with surface water, its flow is slow, with weak self-purification ability, and the ecosystem is generally more fragile. Once polluted, it is extremely difficult to restore the original water quality and ecological conditions, which means irreversibility. Finally, the public's awareness of protection is lack, and phenomenon such as over-mining and sewage infiltration occur frequently, which have caused a series of problems like surface subsidence. The utilization, monitoring and management of groundwater resources involve many government departments. Currently, the cross-departmental cooperation is inefficient, the consultation and communication are not timely and in place, the information sharing mechanism of multiple departments is not complete, and the relevant laws and regulations also have loopholes, which means humanlike.

3. STATUS OF GROUNDWATER POLLUTION

China is a country with serious water shortage. Although it is rich in fresh water resources, the amount of water resources per capita is less than a quarter of the world's average level.

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202103_7(3).0029

According to the China Water Resources Bulletin 2019 issued by the Ministry of Water Resources, the country's total water consumption in 2019 was 602.12 billion m3, of which 93.42 billion m3 were underground water supply, accounting for 15.5% of the total water supply(Ministry of Water Resources, 2019). All provincial-level administrative regions have exploited groundwater resources. China's Ministry of Water Resources has set up groundwater monitoring sites in key areas to monitor groundwater quality. The classification of groundwater quality from 2010 to 2018 is shown in Figure 1. Among them, the monitoring objects in 2010-2011 were 9 provinces and cities including Beijing, Liaoning, Jilin, Heilongjiang, Shanghai, Jiangsu, Hainan, Ningxia and Guangdong. From 2012 to 2013, 10 provinces and cities were monitored in Beijing, Liaoning, Jilin, Heilongjiang, Henan, Shanghai, Jiangsu, Anhui, Hainan and Guangdong. In 2014, 17 provinces and cities in northern China were monitored. From 2015 to 2018, the monitored objects were Songliao plain, Huang-Huai-Hai plain, Shanxi province, basin and plain in northwest China, and Jianghan plain(Ministry of Water Resources, 2010-2018).

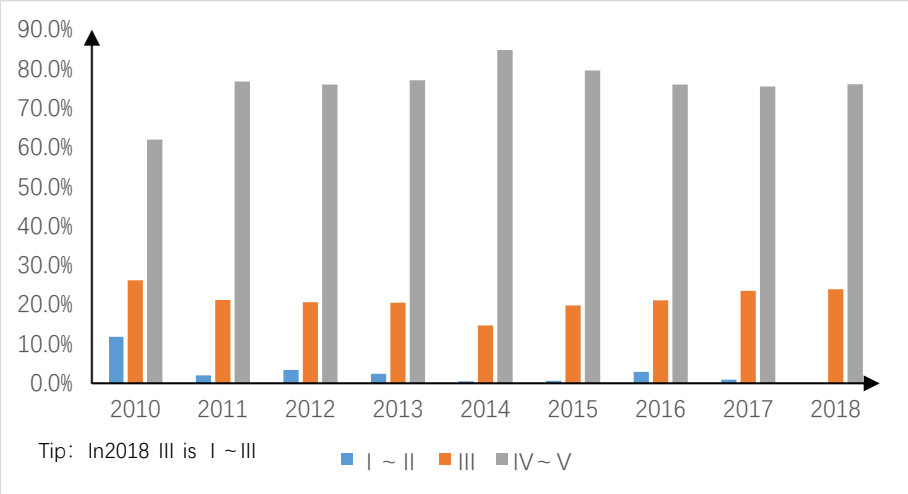

Figure 1. Classification of groundwater quality from 2010 to 2018

From Fig.1, the monitored areas groundwater quality is given priority to with IV - V water for a long time, which indicates water quality remain poor. Especially after 2014, the northern provinces and cities as the main monitoring objects, it stayed long period of III class and above. From 2015 to 2017, the bulletin of water Resources of the Ministry of Water Resources all pointed out that the water quality evaluation results were generally poor, the pollution of "tri-nitrogen" was relatively serious, and heavy metals and toxic organic pollutants existed in some areas to a certain extent. According to the 2018 Water Resources Bulletin of the Ministry of Water Resources, the main groundwater pollution projects include manganese, iron, total hardness, total soluble solids, ammonia nitrogen, fluoride, aluminum, iodide, sulfate and nitrate nitrogen, and some of them may be affected by the hydrogeological environment. It can be seen that the groundwater quality of some provinces and cities in China is terrible with many pollution items, and heavy metals and toxic organics exceeding the standards in some areas.

4. EXISTING GOVERNANCE METHODS

4.1. In-situ Repair Technique

Direct treatment of groundwater pollution in aquifers is called in-situ remediation technology.

The gas phase extraction technology of contaminated soil is to extract air containing pollutants from the soil, and then have a series of gas pollution technology treatment. Through the process discharging the air into atmosphere, after meeting standard. It has a more ideal

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202103_7(3).0029

effect for volatile organic compounds. However, the technology has a small range of application and is often used in the treatment of soil volatile pollutants. Air disturbance technology refers to a treatment technology in which air is injected into soil aquifer to raise water level. Centering on gas injection wells, groundwater pollutants move upward with air. It is often used in combination with gas phase extraction technology of polluted soil, and is mostly used to control volatile pollutants in groundwater. Heat treatment technology is the technology of using heat energy to control groundwater pollution(Ma et al. , 2019). The groundwater is heated to high temperature to make the pollutants and groundwater turn into gaseous phase. Then the gaseous substances are collected to the surface for further treatment by the pre-set extraction well. According to the type of gaseous mixed pollutants, different methods can be used for secondary treatment, such as redox method and activated carbon method. What's more, it is one of the technologies that can remove non-aqueous phase liquid(Liu et al. , 2016). Electrodynamic repair technology uses the electrochemical theory, under the action of artificial applied electric field, positively charged metal ions move towards the cathode of the electrolytic cell and negatively charged metal ions move towards the anode of the electrolytic cell. The pollutants in anode and cathode are aggregated and collected for centralized treatment. Electric remediation technology is very effective for the treatment of metal ions in groundwater. Moreover, it is cheap and environmentally friendly.

Chemical oxidation technology puts oxidants into groundwater and uses oxidation reaction to transform pollutants into non-toxic or low-toxicity substances, common oxidants including potassium permanganate, hydrogen peroxide and sulfate, etc. This treatment method has advance in low cost, short treatment cycle and obvious effect. It is not easy to cause secondary pollution and widely used in particular; Chemical reduction technology puts reductants into groundwater and uses reduction technology to transform pollutants into non-toxic or low-toxicity substances. For instance, the more toxic Cr6+ is reduced to the less toxic Cr3+. The commonly used reductants are divalent iron, polysulfide and bimetallic materials. In addition, the reduction method can also treat the high density non-aqueous liquid pollution which is difficult by other technologies; Permeable reaction-wall technology to construct a reaction-filled wall downstream of an already contaminated groundwater gradient. Similar to the biofilm treatment process in sewage treatment plants, the polluted groundwater can be removed through the adsorption, degradation and precipitation of the pollutants by the reaction materials during flowing through the reaction wall. In the actual construction process, a trench is usually dug in the groundwater channel, and the trench is filled with reactive materials, which depends on the type of pollutants, such as activated carbon and lime. However, this technology is limited to the blockage of the reaction wall and the replacement of media. Microbial remediation technology, it is that degrading groundwater pollutants by the biochemical action of microorganisms. Aerobic degradation is the most commonly used method, but it is susceptible to the conditions of oxygen and nutrients in groundwater. It has superior treatment effect on oil and insecticide. Microbial technology is simple to operate, environmentally friendly, small secondary pollution, low cost, and biodegradable activity maintained for a long time, which indicates continuous repair. However, the microbial repair cycle is long and can't be repaired immediately. Circulation well technology, a three-dimensional circulation in-situ treatment technology using a combination of air disturbance technology, gas phase extraction technology, redox technology and microbial technology(Liu et al., 2020).

4.2. Ectopic Restoration and Natural Attenuation Techniques

Ectopic remediation technology mainly refers to extraction and treatment technology, which is a common method to treat groundwater industrial solvents, heavy metals, petroleum and other pollutants. Groundwater is pumped to surface through wells, treated by a series of sewage equipment, and then returned to the underground aquifer after reaching the standard. The

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202103_7(3).0029

technology can be used to control the pollution plume, limiting its diffusion in the ground. Consequently, avoiding to cause secondary pollutants of other natural resources. Natural attenuation technology, in the process of contaminant infiltration, soil has ability to degrade or change chemical and physical properties, such as soil particles for the adsorption of pollutants, soil microorganisms on the degradation of pollutants and subsurface water body for pollutants dilution effect. This natural occurrence and purification effect is natural attenuation without human intervention. Therefore, natural attenuation technology has few impacts on local ecology and costs much less than other technologies. It is best used when the source of pollution has been removed. However, the restoration effect rest with the environment in polluted area and the difficulty of natural attenuation. Phytoremediation is a technique utilizing plant growth. During growth process, plants can absorb pollutants into roots, branches or leaves, and degrade pollutants through various metabolism in the body. Phytoremediation is often used to decrease flow speed and inhibit the spread of contaminated water to clean areas.

5. GROUNDWATER CONTROL MEASURES IN CHINA

The development and utilization of groundwater resources in China involves many departments. Pollution prevention and control work is managed by the department of ecological and environmental protection, water quality exploration by the Ministry of Land and Resources, and the development and utilization of groundwater resources by the Ministry of Water Resources. The cross-departmental communication and coordination mechanism needs to be further optimized, which needs to be solved from various aspects, like strengthening cross-regional comprehensive supervision and management and reasonably planned regional industrial layout. It ultimately benefits the treatment process by reasonably and scientifically formulating a series of ground environment planning; A integrating groundwater environment monitoring network needs to be established. At present, China's groundwater monitoring system relatively exists shortcomings, mainly resulting from backward monitoring measures and obsolete equipment. For enhancing the solution, for one thing it requires the government to increase funding and concentrate on constructing groundwater environment monitoring network covering all areas. For other thing, strengthening data monitoring in key areas and drinking water sources(Sheng et al. , 2019). At the same time, keeping pace with construction of the data management platform. Last but not least, improve information testing technology, and realize cross-department data sharing. What's more, it is essential to put groundwater pollution prevention in the first place, for its concealment and irreversibility. Once the pollution happens, it will spend a large amount of time and money on repairing. Moreover, in the short term, difficultly transforming situation, and in the long term, it is hard to recover to previous conditions. Preventive measures include strictly controlling industrial pollution, strengthening the control of agricultural pollution sources, and actively taking measures to prevent sewage from seeping down.

6. CONCLUSIONS

Groundwater pollution in China is becoming more and more serious, mainly caused by industry, agriculture, and urbans. Groundwater pollution has the characteristics of concealment, irreversibility and humanness, so it is difficult and costly to control, perhaps the effect of control is not obvious. Due to the late start of groundwater treatment technology in China, it is still in the development stage, and there are some problems, such as the lack of key parameters, the immaturity of remediation technology, and remediation funds. In the 1980s, the U.S. Environmental Protection Agency (EPA) published the Superfund Site Contaminated Groundwater Remediation Action Guide, and by 2009, the U.S. government was spending hundreds of millions of dollars a year on contaminated sites. Due to the inevitable limitation of

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202103_7(3).0029

any single repair technology, the comprehensive application of multiple repair methods probably has a broad market prospect in the future. In the process of groundwater pollution treatment, on the one hand, government should strengthen the research and development of remediation technology, and promote the development of remediation equipment and engineering and other supporting industries. On the other hand, it is necessary to improve pollution prevention measures, responsibility mechanism, groundwater monitoring network, and relevant legislations and regulations. Establishing a pollution emergency response system to reduce follow-up treatment costs through effective prevention of pollution.

ACKNOWLEDGEMENTS

This research was funded by the Research and Practice Project of Higher Education Teaching Reform in Henan Province, grant number 2019SJGLX202. This research was funded by the Teaching Reform project of Henan University, grant number HDXJJG2018-12.

REFERENCES

[1] Wang Baoyan, Xiao Wei. Study on the status quo of groundwater pollution and countermeasures [J]. Environment and Development, 2020, 32(10): 38-39.

[2] Qu Liping. Exploration on environmental pollution caused by livestock and poultry breeding in rural areas and countermeasures [J]. The Chinese Livestock and Poultry Breeding, 2020, 16(10): 31.

[3] Tian Yongsheng. Discussion on pollution prevention and control of aquaculture industry from the perspective of vegetarianism [J]. Environmental Ecology,2020,2(10):91-97.

[4] Zhang Dingguo. On groundwater pollution environment evaluation [J]. Environment and Development,2020,32(08):36+38.

[5] Wu Xue, Zhang Ying, He Jia, Zhang Jian, Zhou Hongbin, He Ping. Present Situation and Countermeasures of Groundwater Pollution Prevention and Control in Kunming [J]. Environmental Protection Science, 2020, 46(04): 101-106.

[6] Yang Hongyu, Wang Chao. Groundwater pollution in drinking water source area and its treatment approach [J]. Resources Economization & Environmental Protection,2020(07):143.

[7] Liu Lijun. Research on environmental protection for polluted groundwater remediation technology [J]. Environment and Development,2020,32(06):113-126.

[8] Sheng Xinyu. Summary of groundwater pollution ways and development direction of their treatment[J]. China Southern Agricultural Machinery,2019,50(14):203.

[9] Ma Jianfeng,Yan Jiuyin. Discussion on the status quo of groundwater pollution and research progress in control technology[J]. Environment and Development,2019,31(05):77-78.

[10] Zheng Caiqing, Zhi Guoqiang, Li Tianfu, Guo Honglong. Analysis of Current Situation and Countermeasures of Groundwater Pollution in China[J]. Environmental Science Survey, 2018, 37(S1):49-52.

[11] Liu Zhiyang. Review on remediation technology of groundwater[J]. Environment and Development, 2016, 28(02): 1-4.

[12] Bulletin on Water Resources of the Ministry of Water Resources of China, 2010-2018, http://www.mwr.gov.cn/sj/

[13] Groundwater Dynamics Monthly Report of the Ministry of Water Resources of China in January 2016, http://www.mwr.gov.cn/sj/