

Hazards Caused by Mining Activities and Corresponding Treatment Technologies

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Abstract. Mining operation brings great economic benefits to human society and seriously threatens the health of the ecological environment. It is urgent to restore the ecosystem and the treatment of the ecological environment in the mining area. Most academic articles only focus on researching a specific mine area, and the solutions proposed are single and not universal, which is difficult to use for reference by other mine restoration work. Therefore, based on a broader perspective, this paper comprehensively and systematically summarizes the public ecological environment problems and treatment methods of different mining operations. The main work is as follows: (1) through the comparative analysis of many mining academic articles, the main environmental hazards are summarized. This paper mainly introduces the threat of mining to the human living environment from the aspects of water source, soil, and biology. (2) Referring to different mining area restoration practices and mining waste treatment cases, the author combined with the main hazardous substances produced by mining and summarized the effective treatment methods and intervention means. This paper summarizes the methods to reduce Mining Hazards in detail from the perspectives of physics, chemistry, biology, and government. These summary contents have extremely important guiding significance for the restoration of the ecological environment of the mining area and the reuse of waste mining resources to maintain the orderly circulation of the ecological environment and realize the sustainable development of the mining area.

Keywords: Mining operation, Mining Hazards, ecological environment.

1. Introduction

The rise of the mining industry has brought benefits to human society and brought a huge negative impact. The current model of the mining industry, namely digging mining, using minerals, and treating minerals. Excavation of mining materials will cause mining things such as reduced vegetation coverage rate, biodiversity reduction, soil pollution, and other direct ecological damage. The use of minerals can also contaminate the air and thus have indirect effects on human health. After the mineral is mined, the ecological loss requires a lot of manpower, material resources, and time and money to make up for. If the effects caused by mining are not addressed or improperly handled, then these negative effects will always endanger the ecological environment and human health. Therefore, mining activities are the main factor of ecological, environmental damage, and environmental vulnerability [1].

There are relevant studies on mining issues at home and abroad, which show that the impact of mining on the environment is mostly negative and often long-term [2]. Even if there are many studies on mining problems at home and abroad, few studies can summarize the negative effects of mining on water, land, soil, human, economy, economy, plants, animals, and so on, and clearly and comprehensively present the harm of mining on ecological and human health and economy. Even if people are aware of the harm of mining to all aspects of our lives, few articles propose measures to address the impact of mining, thus alleviating the harm of mining, few articles summarize the impact of mining and provide different means to reduce the mining impact.

This paper summarizes the negative effects of mining on the environment (water, land, and soil), biology (animals, plants) and by monitoring the dynamic growth of mining areas, assessing the hazards of mining activities, using remote sensing and GIS technology and GIS software analysis, human health and economy. This paper provides a clearer and comprehensive understanding of the impact of mining on all aspects. This paper also summarizes the means to reduce the impact of mining (government intervention, physics, chemical technology, biotechnology), thus helping people better repair areas contaminated by mining and reduce the loss and harm to humans, the ecology, and the environment, to the economy.

2. Hazards of mining

Figure 1 is a generalized conceptual framework that shows the impact of mining on the four categories of environment, biology, human, economy, and the specific impact under each category. The hazards of mining can be roughly divided into negative impacts on the environment (water, land, and soil), organisms (animals and plants), humans (human health), and the economy.



Figure 1. Impact of mining.

2.1. Hazards to the environment

2.1.1. Impact on the water

The impact of mining activities on water pollution has been documented in many studies around the world. Peak removal minePeak removal mining (MTR) is an aggressive form of surface mining that occurs on ridges and tops of steep terrain. The MTR has an adverse effect on surface water. This practice can affect rock and soil up to hundreds of feet from the ground to reach the coal seams. Before cutting begins, the forest is cut and often burned. The rock and soil overlay became loose by explosives, shoveled and placed into large trucks, which are usually transported for short distances to the nearest valley and dumped on the side of the road. The overlayer permanently buried the source stream, and eventually, the entire valley may be filled. Newly discovered rock and soils were exposed to oxygen and rainwater and began to leach long-sealed minerals, metals, and other chemicals. The water flowing from the bottom of the valley is contaminated by these chemicals. Several research teams have conducted important studies on the chemical impact of summit removal mining on water. Research by Vengosh et al. [3] showed that wastewater from valley fillings in MTR usually contains high salinity, selenium, and sulfate concentrations. Palmer et al. argued that sulfate would increase the toxic hydrogen sulfide content. MTR, increases in pH values, conductivity, and total dissolved solids are also observed by Palmer. [4]. After coal mining, the local processing process would pollute billions of gallons of water in the mining area. The contaminated water is stored in a surface reservoir for treatment, then put back to surface water or injected into an abandoned underground mine, with an unknown fate. Papillo's drinking water tests from private wells near mud water storage showed increased metal levels in lead, arsenic, helium, helium, helium iron, aluminum, manganese, zinc, and

uranium [5]. Thus, contaminated water from the mines or processing facilities in some cases significantly affects private drinking water wells [6].

Sewage from acid mine drainage (AMD) flows into surface water bodies and groundwater, posing a threat to humans, domestic animals, and ecosystems. Mine produces large quantities of AMD, AMD that may contain toxic chemicals such as arsenopyrite, sulfur, and pyrite, which can easily penetrate into waterways and cause groundwater pollution [7]. A study by Mensah et al. [8] on the environmental impact of Ghana Prestea mining found that rivers in the mining communities serving as a major source of water for domestic and agricultural use were heavily polluted by mining activities. Figure 2 below shows the mining impact of illicit small-scale mining activities on mining in two different rivers in Ghana (river Ankobra, left and River Aseesre, right). Illegal small-scale mining has caused tailings dams containing toxic chemicals such as cyanide, mercury, arsenic, and other suspended solids. After some time, water contaminated with mining leaked into rivers and streams, thus causing serious water pollution. Tailings dam is characterized by low organic matter content, low pH value, high acidity, high content of heavy metals (arsenic, cadmium, copper, manganese, lead, zinc), poor stability, and poor cohesion [7].



Figure 2. In Ghana, two different rivers (Anobra, left and right) are contaminated by illegal small-scale mining activities [8].

2.1.2. Impact on Land and Soil

The study of the impact on mining by Sheoran et al. noted that both surface mining and underground mining had significant adverse effects on the land [9]. Stockpiles, sludges, gullies, and tailings dams are the most common mining impacts on the land. The mining companies' activities will occupy and destroy the farmers' land, whose land is lost. The barren lands lasted for years after the mine was closed. The barren and barren land is detrimental to peasant cultivation, which significantly impacts their income, food security, and livelihoods [7].

The satellite images of a mine area in Alberta, Canada, were downloaded between 1990 and 2020 between five years, and then analyzed and compared the downloaded satellite images through QGIS software, yielding an intuitive comparison (Figure 3) and the conclusion: during the 30 years of mining in Alberta, the mine area was expanding while land, water, and vegetation were decreasing. Thus, mining has an impact on the type of land use.

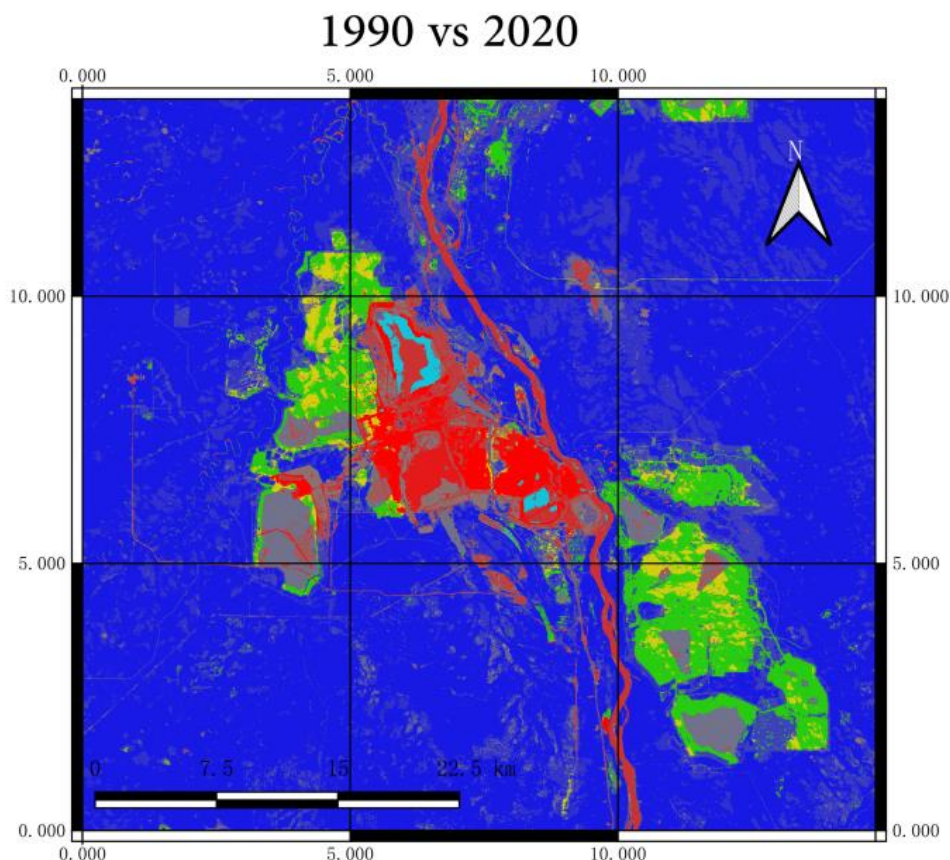


Figure 3. Comparison diagram obtained using the QGIS software. Green means that vegetation becomes a mine, yellow indicates that land has become a mine, light blue indicates that the water body becomes a mine.

One area where the environmental impact on mining cannot be ignored is the impact of mining on soil quality. Most mines cannot support crop production due to severe soil loss (Figure 4) and heavy soil compaction using heavy machinery. According to Mahar et al. [10], mineral mining significantly changed the pH of the soil. The soil of a mine at Central Coal Field Limited (CCL) in North Carolina Ranpura, Jakam Texas, India, PH even reached grades 4.9 to 5.3 besides toxic heavy metals such as nickel, cadmium, and lead. When pH becomes too acidic, it does not fully support healthy plant growth. Some soil microbes with basic functions do not survive in this soil, thus rendering the soil unproductive [7]. The soil around the mining area has a rough texture, acidic pH, high bulk density, high soil hardness [11].



Figure 4. (a, b,c, and d) effects of mining on soil quality; (a and b) spontaneous sprouting of grasses from tailings due to low fertility (lack of N, P, and K), Wind erosion on degraded soil (c) and (d) compacted slurry after abandoned mine in Zambia [12].

2.2. Impact on living organisms

2.2.1. Impact on animals

Mineral mining threatens wildlife due to pollution of water and soil resources, vegetation destruction, and changes in landscape structures. Large and medium-sized forest-dependent mammals need large areas of living space to support their survival needs, and they are often affected by these landscape changes. Mining activities immediately reduced the habitat for forest habitats. In addition, they may lead to reduced animals from overhunting in mining plant areas. Ultimately, the development of mining activities and the construction of associated infrastructure led to habitat loss and fragmentation of forest-dependent species. Some human activities, such as forest suppression, may significantly reduce living populations of wild forest mammals, leading to the extinction of local species [13]. Robeck and Richardson found that mine wastewater affected by AMD destroys aquatic life in water that discharged sewage [14]. The results of Heyl show that as the water quality worsened, invertebrate diversity and numbers decrease as the mine [15].

2.2.2. Impact on the plant

Riparian plants in the mining areas have also suffered a loss of biodiversity in the affected areas. The impact of mining on plants is complex and diverse, depending on the type of mining and the strength of the mining. To facilitate mineral mining, most of the vegetation above the mineral is either cut down or burned, thus affecting the plant capping rate and plant diversity. In most cases, the upper soil is rich in organic matter with most plant nutrients. Thus, removing it affects the soil's biological, chemical, and physical properties, thus affecting plant growth. In addition, Mensah et al. [8] noted that the most obvious impact of mining on the ecosystem is the loss of vegetation cover. Small gold mining has been a major reason for vegetation restoration and mass deforestation in Africa. In small-scale illegal mining, the wasteland left by the open pit and ditch takes several years to make the land more productive and become useful [7].

From the satellite images processed by QGIS (Figure 3), the vegetation cover rate has decreased significantly due to the impact of mining, and more vegetation becomes mining areas. Therefore, mining will cause plant species diversity and vegetation coverage rate to decline, thus affecting the ecology.

2.2.3. Impact on humans

Open-pit coal mining discharges a large amount of particulate matter to the atmosphere due to various operations. They increase the concentration of local pollutants in the atmosphere, such as suspended particulate matter (SPM), inhalable particulate matter (RSPM), ozone, sulfur oxide, and nitrogen oxides, which seriously affect health of the mining residents [16]. According to the relevant evidence of Hendrix [17], people living in coal mining communities have an increased risk of heart and lung disease, cancer, high blood pressure, and kidney disease. They have higher mortality in communities near coal mines and coal-fired power stations. Underground coal miners induce silicosis and pneumoconiosis (CWP) by inhaling dust in the mine. In addition to chemical hazards, heat and humidity can also lead to heat-related diseases [18]. There is evidence of poor air quality in the residential communities near the mine in the mining environment. Delfino et al. [19] argue that the impact of superfine particles ($<0.1 \mu$) diameter is particularly important on human health. Because they are small in size, they allow deeper penetration into the lung tissue and may spread from the lungs to the vascular system. They provide a greater surface unit of area mass, resulting in relatively greater contact with biological tissue. The average number of supertrees in the mining community is 6830 / cubic cm compared to 4770 / cubic cm. Another study found a significant increase in indoor and outdoor particulate counts within the inhalable range ($0.5 < \mu < 5.0$) in near-surface mining communities compared to non-mining control communities. For example, within the inhalable range, the average count of mining communities is approximately 592,000 grains / cubic feet, and the average count of non-mining communities is 334,000 grains / cubic feet ($p < 0.01$). In summary, these studies clearly demonstrate that people living near coal mines have experienced a wide range of health problems [6].

In the past few decades, the relevant people have conducted extensive research in the field of manual and small-scale gold mining. They indicated that the mining area was risky to the health of local residents due to the use of mercury. For example, Bose-O'Reilly et al. [20, 21] noted that a woman from the gold mine whose breast milk of up to 149 µg/l, from mercury contamination by inhaling mercury vapour and eating food (especially fish). And with high levels of potentially toxic elements released in copper waste, improper disposal threatens ecosystems and human health. Human exposure to mining areas, with Ba concentrations, and increased contamination and risk of As, Ti, and mercury concentrations [22].

In short, people living near the coal mines have experienced a wide range of health problems. These include cancer, cardiovascular and respiratory diseases, kidney diseases, developmental problems, depression, poor health-related quality of life, and various disease symptoms. The acts remain after statistical control of age, gender, smoking, obesity, poverty, education, and other co-existence [6].

2.3. Impact on the economy

In countries like Botswana, the Democratic Republic of the Congo, Mozambique, and Guinea, the mining industry alone accounts for more than half of its total export revenue, resulting in a relatively single economic structure and large fluctuations affected by the mining industry [7]. Meanwhile, Canada, the United States, Australia, and China also rely heavily on mining in industrialization and economic transformation [7]. Mining brings benefits to human society and economic losses. The mining industry's current economic and working model, namely digging mining, using minerals, and treatment of minerals. For environmental and ecological restoration, it takes a lot of time and money, human and material resources. So, dealing with the waste from mining and the adverse effects of mining also wastes resources and money. In addition to promoting economic development, it also puts great pressure on the environment and the economy when handling waste. With the economic concept of circular economy and the growing demand for natural resources in emerging economies, low-carbon transformation is imminent. The mining industry is undoubtedly preventing the development of the circular economy and low-carbon transformation and spending a lot of money on restoring natural resources such as damaged land.

3. Methods to Reduce the Impact of Mining

3.1. Physical technology

The pollutants produced by mining mainly include suspended solids, acids, salts and alkalis, heavy metal pollutants (mercury, cadmium, copper, zinc, chromium, lead, nickel, arsenic, and selenium), radioactive elements (uranium, thorium, and radium), eutrophic pollutants (phosphate, nitrate, silica, etc.), gas pollutants (gas, carbon monoxide, sulfur dioxide, nitrogen oxides), road dust, etc. Physical technology to reduce the harm of mining to the environment mainly uses physical adsorbents to remove mining wastewater and harmful substances in my soil.

Using adsorbents to treat mining and metallurgical wastewater is the simplest and effective method. The method is to adsorb the suspended solids and pigments in the wastewater onto the adsorbent by means of exchange, physical and chemical adsorption, and finally achieve the effect of purifying the water source. At present, the adsorbents commonly used in various factories include activated carbon, fly ash, diatomite, etc. Anirudhan et al. [23] found that activated carbon can effectively adsorb heavy metal ions in wastewater, such as Hg (II), Cu (II), and Pb (II) {, #26@@hidden; Anirudhan, 2011 #26; Anirudhan, 2011 #26}. Karnib et al. [24] found that activated carbon can effectively adsorb nickel metal in wastewater, and the removal rate can reach 90%. However, activated carbon also has the disadvantages of high price, difficult regeneration, and limited adsorption capacity. This method has the advantages of low cost, simple process, and excellent effect, but the ash after adsorption needs to be treated. Zhao et al. [25] concluded through a large number of studies that diatomite has excellent physical structure and is a very effective eco-environmental material. It can effectively adsorb heavy

metals in polluted water sources, especially the modified nano diatomite, and the adsorption rate has doubled. However, this emerging technology still has some problems that need to be improved.

3.2. Chemical technology

Different chemicals can be added to the mining area's contaminated soil and water source to convert toxic heavy metals to non-toxic states. OK et al. [26] found that reducing iron powder, lime, humus, and compost were mixed and added to the unmodified soil. Through comparison, it was found that the bioavailability of Cd in the soil treated with modifier decreased by about 50% - 90%, which could inhibit the absorption of Cd by crops. That is, the fixation of heavy metal Cd was realized. Jiang et al. [27] added heavy metal passivation lime, silicon fertilizer, and gypsum to the polluted rice field, which effectively improved the microbial diversity and function in the rice field. Zizhong Zhang et al. [28] proved that when fixing heavy metal pollutants cadmium and lead, the effect of nano hydroxy phosphorus ash is much higher than that of other particles, and Pb5 (PO4) 3OH residues are generated. Cao et al. [29] showed that adding phosphate rock to contaminated soil can remove up to 78% of the lead content in the soil by generating precipitated pb10 (PO4) 6F2. However, Wu et al. [30] found that the production cost of chemicals is high. If they are overused, they will even pollute groundwater sources and soil, resulting in adverse effects.

In addition, the pollution of acid mine wastewater (AMD) is also the focus of researchers. Mensah [31] found that adding inorganic chemicals (such as lime) can neutralize acidic substances and improve the pH value of soil. Sreenivasan et al. [32] found that adding organic materials, organisms, and stones can also balance the acidity and alkalinity of the soil. According to the research of Tetteh et al. [33], adding substances containing oxides to the soil can also effectively improve the stability of the soil. Hilson and others [34] also made it clear that the use of the internal neutralization method is one of the most environmentally friendly treatment technologies. The commonly used chemicals include limestone, hydrated lime, soda ash, caustic soda, ammonia, calcium peroxide, kiln ash, and fly ash. However, considering the economic cost, we can try to mix limestone with other chemicals to treat AMD.

3.3. Biotechnology

Biotechnology, also known as phytoremediation, Mendez and Maier [35] show that existing and potentially harmful pollutants can be reduced by introducing microorganisms and green plants. Phytoremediation [36] proposed a green filtration method -- phytoremediation. This is a beneficial cycle of innovative ideas. By introducing plants with a strong ability to accumulate heavy metals, it can not only remove harmful chemicals in contaminated mining soil and restore the ecological environment of the mining area but also purify the air in the mining area and absorb part of mining noise, to effectively avoid the spread and diffusion of harmful substances. Jishkariani and others [37] have done sufficient research on phytoremediation. They found that trees such as Aesculus, Quercus, Salix, Eldar ricasson, Acer, and stop wood have very high storage capacity, as shown in Table 1. Their leaves and roots can accumulate toxic compounds and purify heavy metals and radioactive elements in groundwater. At the same time, it absorbs harmful gases emitted from the plant through photosynthesis, such as waste gas, carbon oxides, nitrogen oxides (CO, CO2, NO, etc.). Although this method is ideal, it is not feasible for hundreds of thousands of tons of mining waste accumulated. This method can be used only when the industrial waste is reduced to adapt to plant growth.

In addition, microbial technology is also a low-cost, high-efficiency, and environment-friendly way to deal with mining pollutants. The essence of using microbial technology to treat heavy metal polluted water sources is to use the combination of extracellular passive adsorption and intracellular active absorption of growing cells to remove heavy metals from wastewater. Beesley et al. [38] proposed that biochar is the most economical modifier to improve metal pollution in mining areas. Mello et al. [39] found that the roots of maize plants inoculated with endophytic bacteria can effectively accumulate mercury in soil, reducing the content by about 46.32%. Although this method is ideal and basically

harmless, the selection process of microbial remediation strains is very complex, and the mechanism of bioremediation needs to be deeply discussed.

Table 1. Heavy metal uptake by plants.

Plants	Extract Heavy Metals
<i>Silene vulgarisi</i>	Zn
<i>Thlaspi caerulescens</i>	Zn, Cd
<i>Brassica juncea</i>	Pb, Cr, Cd, Ni, Zn, Cu
<i>Helianthus annuus</i>	Cu, Cd, Cr, Ni, Pb, Zn
<i>Polygonum</i>	Cu, Pb, Zn, Ni
<i>Festuca ovina</i>	Pb
<i>Zea mays</i>	Cd, Cu, Ni, Zn, As, Pb

3.4. Government intervention

The pollution of the ecological environment in the mining area has caused serious harm to the health of the local people, animals, and plants. The restoration of the mine is the primary problem of the construction of ecological civilization. As an advocate and practitioner of ecological civilization, the government plays an important role in maintaining the environmental health of mining areas. The government can effectively supervise and manage the ecological environment restoration and governance through legislation, law enforcement, and other means.

In China, the government has issued a series of mine environmental protection and treatment plans to help many areas achieve post mine rehabilitation and treatment. Take Wanshan and Tangsannan Lake in Guizhou as an example. In 2013, under the government's policy guidance, the Wanshan District of Guizhou realized the restoration and reuse of the mine area and built a national mine park based on mercury mine sites, as shown in Figure 5. At the beginning of 1997, Tangshan Municipal government led the people to implement the ecological greening project. The main work is to control and repair the ecological environment of the southern mining area. This area has become a national AAAA level look Park - Nanhua Park, as shown in Figure 6. It not only realizes the restoration of the ecological environment but also effectively drives the redevelopment of the local economy.

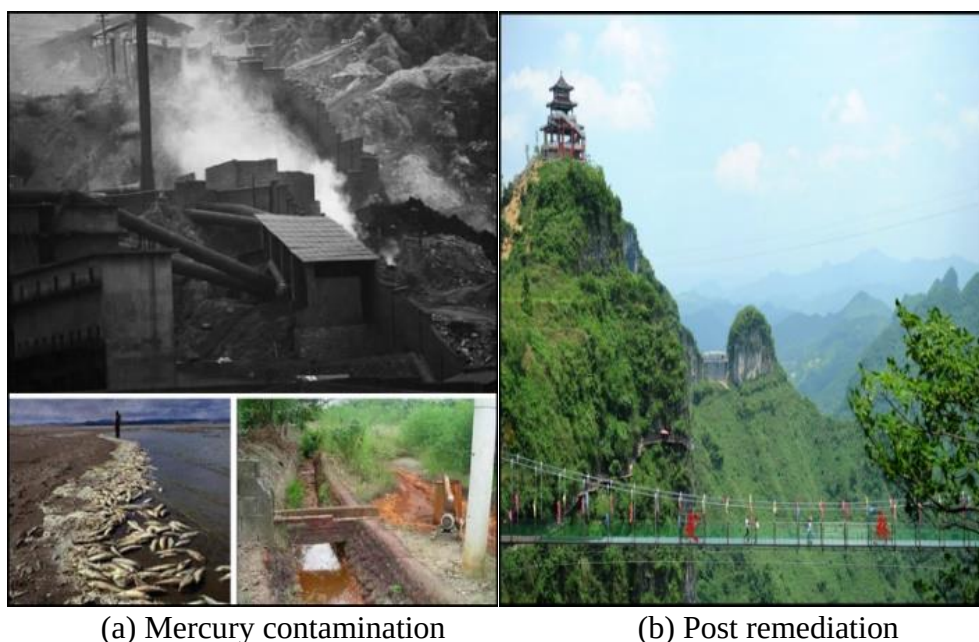


Figure 5. Comparison before and after treatment of Wanshan mercury mining area.



Figure 6. After the treatment of the mining area in the south of Tangshan.

In foreign countries, the government has also made great contributions to mining operations and mine management. In the 19th century, mining provided an important material basis for the two industrial revolutions in western countries and brought the problems of ecological and environmental damage. The governments of various countries have introduced legal provisions to make the mining areas with poor ecological environments and economic decline take on a new look and realize the economic development again. For example, the United States has successively promulgated the reclamation law of 1939, the open-pit mining control and Recovery Act of 1997, the comprehensive environmental response, compensation, and Liability Act of 1980, the small-scale enterprise liability reduction, and brown land Revitalization Act of 2002 and other relevant laws to restore the mined mining area to its original state and improve the damaged ecological environment of the mining area. Similarly, the Sullivan mine in Canada, the Ruhr Industrial Zone in Germany, the Markham coal mine in Britain, and the state-run Akashi Strait Park in Japan all improve the environmental damage and economic decline in the mining area through the repair of the mining area, re-show a new face and realize the secondary development of the economy.

It is worth mentioning that the restoration of the ecological environment in the mining area is a difficult and long process, which needs to consume a lot of time and energy and the joint participation and practice of all social members to realize the real restoration. Although the investment cost is several times higher than the benefits obtained by the mining area, the restoration effect is not ideal. It is difficult to promote the restoration process. To survive and develop future generations, we must recognize the importance of ecological protection, adhere to sustainable development strategy, and maintain the coordination between ecological resources and the environment.

4. Conclusion

Environmental problems caused by mining operations have always been a research hotspot. Mining will have an impact on natural resources. For example, the content of heavy metals in water sources and soil seriously exceeds the standard, and acid-based chemicals are produced, which destroys the acid-base and salt balance of water source and land. In addition, it will affect the species and quantity of animals, make some animals and plants extinct, and make humans more vulnerable to cancer, cardiovascular and respiratory diseases, kidney diseases, and other diseases. At the same time, it will affect the healthy development of the social economy. At present, effective solutions include the use of adsorbents, chemicals, and planting plants with high savings capacity. At the same time, the government also needs to improve and guide the people to abide by relevant regulations. Each method has limitations. In application, it is necessary to refer to the actual situation and combine these methods. This paper promotes the progress of restoration work and promotes the restoration of the ecological environment and the construction of ecological civilization.

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