Research on Environmental Pollution Caused by Acid Rain

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Abstract. In recent years, environmental issues have became a very hot topic again. The focus of this article is on the acid rain issue. This article will introduce how acid rain is formed, the harm caused by acid rain and how humans deal with acid rain to the public. A large number of research results show that although humans recognize the harm of acid rain and reduce the emissions of nitrates, sulfides and other things related to acid rain, the problem of acid rain still exists. The main reason for this phenomenon is the huge demand for fossil fuels. Fossil fuels play an important role in human production and life and are still used in all forms of transportation. Although there are many electric vehicles now, the main way for humans to obtain electricity is still to burn fossil fuels. Acid rain not only has a great impact on human physical and mental health, but also has an indelible impact on animals and plants. Acid rain has a neutralizing effect on alkaline soil, at the same time, it causes more to reduce the nutritional value and mineral content of the soil. This article hopes to find a better solution by sorting out with the summary of almost aspects of acid rain.

Keywords: Acid rain; sulfur dioxide; nitrogen oxides; reason.

1. Introduction

Acid rain has been a problem that has plagued mankind for many years. Since the industrial revolution, the extensive use of fossil fuels has led to large emissions of sulfides, digestates and carbon dioxide, which contribute to the production of acid rain. With the advent of trams, sulfur emissions from transportation should be solved. But today, the primary source of electricity in most countries still comes from burning fossil fuels. Fossil fuel pollution originally caused by traffic is now simply transferred to Fossil fuel power stations. Therefore, many people must know that using trams does not necessarily reduce sulfide and nitrate emissions.

Many environmentalists have begun to realize the harm of acid rain and have made reaches against the cause and effect of the acid rain. Just knowing the causes and hazards of acid rain is not enough, we need to know how to control it. However, the research on the relationship between human activities and acid rain is still insufficient.

Acid rain is the main review of this article. This article conducts research on three aspects: the definition and causes of acid rain, the harm and impact of acid rain on human activities, and current measures for acid rain control. This article hopes that those who still don't know much about acid rain can learn more about the dangers of acid rain through this article. Let more people know how acid rain is produced, what impact acid rain will have on human daily life, what harm acid rain will bring to the entire ecological environment, and how everyone can do their best to reduce the formation of acid rain.

2. Reason of Acid Rain

2.1. Definition of Acid Rain

The definition of acid rain by EPA is "a broad term that includes any form of precipitation with acidic components, such as sulfuric or nitric acid that fall to the ground from the atmosphere in wet or dry forms. This can include rain, snow, fog, hail or even dust that is acidic." Sulfur dioxide (SO_2)

and nitrogen oxides (NO_X) are the main causes of acid rain. SO_2 and NO_X react with water, oxygen and other chemicals in the atmosphere to form sulfuric acid and nitric acid. Some of the sulfur dioxide and nitrogen oxides come from natural changes such as volcanic eruptions and plant decay, but most of them come from the burning of fossil fuels, that is, from human daily life.

2.2. Traffic Volume Increase

Increased traffic is a large part of the increase in fossil fuel use. With the advancement of transportation, human travel has become more and more convenient. Currently, most cars, trains, airplanes, etc. use fossil fuels as energy sources. Between 1990 and 1994, the number of passenger cars in Germany increased from 4.817 to 6.465 million and the number of trucks increased from 264 400 to 459 900 [1]. Because at that time, countries around the world were not aware of the dangers of using fossil fuels and simply enjoyed the convenience brought by fossil fuels. The rapid increase in traffic volume has brought about an increase in sulfide emissions and ultimately led to acid rain.

2.3. Fossil Fuel Power

Fossil fuel power station also releases large amounts of nitrates and sulfides. Most countries around the world still use electricity generated by Fossil fuel power stations as their main source of electricity. Take United State as an example, over 60% electricity power made by fossil fuel (Fig. 1) [2, 3]. Fossil fuel has benfit, it is low cost and can generate enough energy. But at the same time, insufficient efficiency and pollution are also difficult problems for it to solve. At the same time, Fossil fuel power plants also release a large amount of carbon dioxide (caused by combustion), so it is also considered to be the main cause of climate change [2].

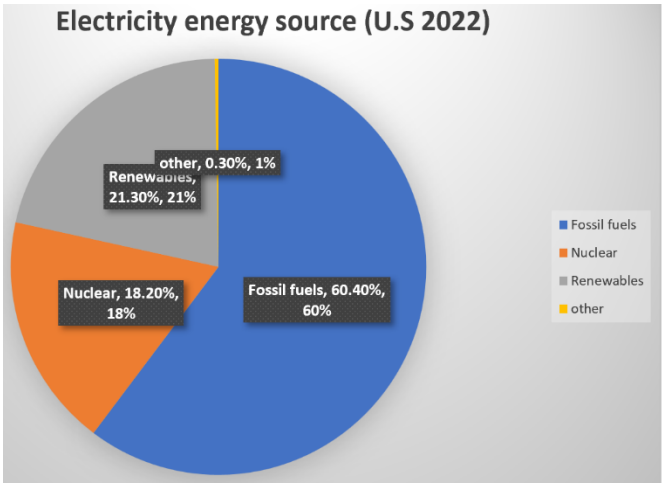

Fig. 1 Graph creidit original, data comes from U.S Energy Information Administration. www.eia.gov/tools/faqs/faq.php?id=427&t=3

3. Damage of Acid Rain

Acid rain can affect the balance of the ecosystem, threaten human health and corrode buildings. It will destroy the normal operation and circulation of the ecosystem. It will directly harm human health and endanger people's physical and mental health. Acid rain will also acidify the water bodies of rivers and lakes, seriously affecting the growth of aquatic plants. Many diseases and pests and other indirect hazards of acid rain make it more difficult to prevent and control crops and seriously affect the quality and yield of crops. It will take a long time to restore the environment damaged by acid rain.

3.1. Soil

The acid rain accelerates soil acidification. Acid rain adds a large amount of aluminum hydroxide to the soil that's why it causes serious loss of mineral elements in the soil. The acidic substances in the soil can cause aluminum to weather, and the weathered aluminum undergoes certain reactions to form aluminum compounds. Excessive aluminum compounds are harmful to human, and that can cause crop poisoning and even death. If acid rain enters groundwater through soil, and then it enters lakes. This not only increases the mortality rate of fish and affects their normal growth, but also causes a series of diseases for those who use this water.

Acid rain exacerbates the disintegration of muddy rocks. Low PH values have stronger water chemical damage and more paths for disintegration of silty mudstone. This transforms the mode of disintegration failure, causing the disintegration residue to become more fragmented. The highly fragmented disintegration residue has a high specific surface area increment index value, indicating a high degree of disintegration of silty mudstone. The increment index of rock specific surface area reflects the degree of fragmentation of silty mudstone by reasonably characterizing the agree of fragmentation of residual materials. It will cause specific minerals to undergo dissolution and increase the pathways for their disintegration and degradation. When the pH is equal to 5 or 3 due to the chemical damage caused by acid rain, the specific surface area increment angle of the disintegration residue pH is equal to 7.0, which is increased by 95% (11.68mm^2/g) and 193% (23.70 mm^2/g) respectively [4].

3.2. Plants

If it is strong acidic acid rain or a large amount of acid rain, forest damage will be very serious, and the damage will be rapid and widespread. SO_2, nitrogen oxides, photochemical oxidants, and heavy metals damage forest through direct, coordinated, or indirect effects, such as the formation of secondary pollutants [5].

3.3. Crops

The significant impact of acid rain on crops is quantity and quality. Acid rain has different corrosion abilities on different crops. Acid-resistant vegetables such as carrots are relatively less affected by acid rain, and their yield will be reduced by about 10% in case of strong acid rain. When moderately sensitive vegetables such as pepper are affected by strong acid rain, their yield decreases by about 15%. Sensitive crops such as cucumbers are greatly affected by acid rain, and the output of cucumbers in the acid rain environment is 20% or more lower than that in normal environments.

Acid rain can alter the soil environment by increasing aluminum compounds, reducing minerals, and altering the microbial population in the soil. Because acid rain changes the soil environment, and the main source of nutrients for crop growth is in the soil. If the nutrients in the soil are scarce, the yield of plants will be low without the nutrients, followed by various pests as well. Substances such as sulfur dioxide in acid rain can cause yellow spots, dead leaves, and dead branches on vegetable leaves. If it is affected by the long-term acid rain, the growth of plant leaves may be affected or even deciduous due to the reduction of chlorophyll. Vegetables lack resistance to growth. Plants may even die, which is a common phenomenon [6]. Acid rain can eliminate bacteria and microorganisms in the soil, reduce soil nutrients, and make the soil plate harder, so that the permeability of the soil will go down. And Hard soil is not conducive to the healthy growth of crops. It obstructs the crops breathing and absorbing the nutrients. Acid rain will directly erode the protective layer of plant leaves, weaken its photosynthesis ability, and reduce the yield and quality of crops [5].

3.4. Humans

Some elements in acid rain have a stimulating effect on the human skin and the ability to induce skin diseases. A large number of acidic substances in acid rain can cause significant damage to the human retina, respiratory system, cornea and other parts of body. What's more, it can induce other related diseases. Eye diseases are red eye diseases,etc. Respiratory system diseases are bronchitis and

may even trigger lung disease. These acidic substances exist in a particulate state and can smoothly enter the human lungs. Some particles can reach the deep tissues of the lungs, causing lung related diseases such as edema and sclerosis. According to a survey, compared to clean areas, children in areas heavily polluted by acid rain have lower blood pressure values and an increasing trend in their white blood cell count, indicating a higher and increasing incidence of major disease infections [5]. The SO_2 in acid rain is very easy to cause human respiratory diseases. The mild symptoms of infection are hoarse vocal cords and so on. Symptoms of severe infection are dyspnea and other kind of sickness.

3.5. Buildings

Acid rain has a certain corrosion ability on buildings. And acid rain has different corrosion abilities on different materials, whether they are metal, wood products, or cement products. Acid rain can also react chemically with substances contained in buildings, which is the reason for the problem of cement dissolution on the surface of buildings. Building cracks are a common manifestation. When a building experiences corrosion, it will be more likely to be destroyed. In addition, acid rain also reacts with the paint protection layer on the surface of buildings, even rigid materials such as bridges are inevitable.

4. Measurement to Control Acid Rain

Emission control of atmospheric pollutants is the main method to control acid rain. The most important part is the appropriate control of pollution in areas with excessive industrial concentration and necessary evacuation. The new law in Germany in 1980 stipulated that the SO_2 emitted by new factories with a power generation of over 400 megawatts must not exceed 400 milligrams per cubic meter - that is, at least 95% of sulfur must be removed from the gas; Small power plants with a power generation capacity between 200-400 megawatts must reduce sulfur by at least 60% and must not exceed 2000 milligrams per cubic meter [10]. This policy shows that the importance of pollutants controls in industrial. The control of vehicle exhaust is another way to reduce emissions. Vehicle emissions can be reduced by restricting vehicle travel and limiting maximum speed. From 2011, Vehicles were restricted by license plate numbers in Beijing and Shanghai [7]. The main pollutant is sulfur dioxide and nitrogen oxide, so the United States established the "Acid Rain Plan" in the 1990, with the goal of reducing annual sulfur dioxide emissions by 10 million tons and nitrogen oxide emissions by 2 million tons [8]. From 1990 to 2004, the emission of sulfur dioxide in the United States had decreased from 17.3 million tons to 10.3 million tons, a 40% reduction in 24 years. The emission of sulfur dioxide in the United States had decreased from 17.3 million tons to 10.3 million tons, a 40% reduction in 24 years [8]. This made acid rain in American significantly reduces. Changing energy structure and using clean energy is another way to reduce emission. Using renewable or nuclear energy produce less air pollutants than using oil or coals. For instance, in 1990, Germany used 24 TWh renewable energy while used 169 TWh lignite and 143 TWh hard coal [9]. To cope with the increasingly severe acid rain phenomenon, Germany changed energy structure. Until 2022, Germany uses 238 TWh renewable energy and uses 108.3 TWh from lignite and 54.3 TWh from hard coal [10].

Controlling pollutants from the source is also one of the ways to cope with acid rain. Reduce the content of sulfur and nitrogen compounds in coal through washing to reduce polluting gases. Washing is the process of screening coal based on its density and particle size. The coal with density low 1.4 kg/L is qualified. Coal washing can remove 50% -80% of ash and 30% -40% of total sulfur from coal. Burning washing coal can effectively reduce the emissions of smoke, SO_2, and NO_x. Washing 100 million tons of power coal can generally reduce the emission of 600000 to 700000 tons of SO_2 and remove 16Mt of gangue [11].

Cleaning emissions are also effective in controlling acid rain. Use some solid reagent to react with pollutants before they enter the atmosphere. Before the flue gas is discharged from the chimney, lime is sprayed to react with SO_2 to generate $CaSO_4$, and the $CaSO_4$ can be used as building materials. In

addition to using water or aqueous solutions of acids, alkalis, and salts to absorb nitrogen oxides in exhaust gas, some factories will reduce nitrogen oxides in exhaust gas to N_2 under high temperature and catalyst presence conditions.

Improving energy efficiency can also reduce pollutant emissions. Coal blending is mainly used to improve coal utilization efficiency. Coal blending is the process of mixing different types of raw coal in appropriate proportions. After blending, Coal combustion will be more thorough and the combustion products will be cleaner.

5. Conclusion

To this day, the problem of acid rain is still a difficult problem that humans have to face. Acid rain is partly caused by nature, but mainly by human activities. The automobile exhaust brought by the increasing traffic volume once caused Beijing to be shrouded in smog all day long. Fossil fuels have been used since the industrial revolution. Even now, most of the electricity is still generated by burning fossil fuels. Acid rain still causes considerable damage. Destroy the ecological environment; pollute the soil, leading to the death of crops; increase the acidity of the water system, leading to the death of fish. Corrosion of buildings, leading to their collapse. Acid rain can even harm humans directly or indirectly, irritating the skin and causing skin disease complications, affecting the respiratory system, etc. But the good news is that human society has faced up to this problem and taken considerable measures to solve it. Germany reduces air pollution by limiting SO_2 emissions, and some cities in China use vehicle restrictions to solve environmental problems caused by car exhaust. More and more countries are turning to clean or green energy to replace fossil fuels. Advances in technology allow humans to reduce the sulfur and carbon content of fossil fuels. Humanity is working hard to reduce the impact of fossil fuels on the environment. A complete solution to acid rain and fossil fuel use remains challenging, but it is also an issue that must be addressed in the future. This article hopes that more and more countries, organizations, and individuals will realize the harm caused by acid rain and do their best to reduce sulfide and nitrate emissions.

Author Conreibutions

All the authors contributed equally, and their names were listed in alphabetical order.

References

[1] Dumitru Cebrucean, Viorica Cebrucean, Ioana Ionel, CO2 Capture and Storage from Fossil Fuel Power Plants, Energy Procedia, 2014, 63: 18-26.

[2] Gantz H., Erstellung eines Emissionskatasters fu¨r Verkehr. In: SANA-Annual Report A, 1993, 1: 4.

[3] Frequently Asked Questions (Faqs)-U.S. Energy Information Administration (EIA). www.eia.gov/tools/faqs/faq.php?id=427&t=3

[4] Li K.P., Zhao X.Y., Xiao D., Mechanism of silty mudstone slaking aggravated by acid rain-induced chemical damage. 2019, 1590: 2693-2702. (In Chinese)

[5] Ren L.P., Analysis of the hazards and prevention of acid rain. New courses, 2020, 11: 229. (In Chinese)

[6] Yin Y.F., Zhang M.X., Zhang S.Y., Rural technology, 1674-7909. 2020, 34: 061.

[7] Wu D., Wang S.G., Shang K.Z., A Review of Acid Rain Research in China 2006, 2006, 02: 1006 – 7639.

[8] Li Z., Analysis of the Evolution of Acid Rain Control Policies in the United States, 2016.

[9] Anita Singh and Madhulika Agrawal, Acid rain and its ecological consequences, 2008, 29(1): 15-24.

[10] Lackey R.T., Roger L.B., Science, Policy, and acid rain 1997, 15(1): 9-13.

[11] Neeloo B., David G., Streets, Wesley K.F., Acid rain in Asia, 1992, 16: 541-562.