Impact of Climate Change on Environment and Marine Species of the Artic Ocean

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Abstract. As one of the four oceans on earth, the Arctic Ocean plays a vital role in affecting the ecological environment of the earth. Due to vegetation degradation, natural disasters and human activities, acid rain, global warming and ozone layer destruction as the main forms of climate change have brought serious negative impacts on the Arctic Ocean ecosystem and its environment. Currently, the Arctic Ocean is one of the regions of the world most affected by climate change. Climate change is caused by many factors. Vegetation degradation and atmospheric particulate matter caused by natural or human activities are major contributors to global climate change. Climate change has led to a dramatic rise in Arctic temperatures and increased mercury pollution. Pollution and reduced sea ice are also affecting many plant and animal species. In this paper, the causes of climate change and the effects on the environment and biodiversity in the Arctic Ocean are studied, and the improvement measures are proposed. In the future, people should pay more attention to carbon emissions, advocate low-carbon life, and pay attention to environmental protection. This study provides a theoretical basis for people to pay more attention to the abnormal changes of the Arctic Ocean environment and pay more attention to improving the environment.

Keywords: Arctic Ocean; marine ecosystem; impact; climate change.

1. Introduction

Climate changes have walked into people's sight and even considered as a crisis for years for its intimidation toward the society. The Arctic Ocean is one of the most influenced areas in the world, especially around marine environments. The ocean environment is changed, directly effecting its marine, costal, and near shore ecosystems. Which leads to economic lost in local communities and to the world. As anthropogenic pollution continuously aggravates climate change, more and more severe issues have occurred. People have quite limited acknowledgement about the Arctic marine environment regarding how rapid and unpredictable the climatic pollution is. Awareness must therefore be raised to conduct damage control, solve existing issues and prevent potential problems.

There are diverse researches against the climate change effect on Arctic Ocean and its surrounding environments contributing to the arctic environmental study, and reviews about this topic elaborating excellent interpretations. Still, a lot of information is lacking from the Arctic Ocean for people to further analyze and make improvement measures. Assisted by previous studies from multiple scholars, research results are categorized by causes, effects, and improvements with an intention of gathering latest information and conclude current arctic situation.

Sea water in the Arctic is this review's main focus. This article discussed the climate change issue from types, effects, and solutions. First, introducing the main climate change kinds, as in global warming, acid rain and ozone layer destruction. Both natural and anthropogenic factors are crucial for the climate result. Then discussed the consequence climate change has impacted on environments, animals, and plants, which also has significant result in the dependent economy. Last listed possible solution methods hoping to provide insights and inspirations for people to have better ideas.

2. Climate Change

In recent years, climate change, as the most urgent environmental concern in the world, has attracted the attention of most of the countries in the world. Climate change means the statistically distinct changes in climate mean temperature and climate deviation, such as changes in mean temperature, precipitation, and extreme weather phenomenon [1]. Climate change will cause weather patterns unpredictable. There is a possibility of climate change to cause more frequent and intense natural disasters such as floods, hurricanes, heavy rains and storms. In the polar regions, ice sheets and glaciers are melting faster due to climate warming, leading to sharp increases in sea levels in different parts of the earth. In addition, rising temperatures can cause the water to swell. Due to increasing flooding and erosion, sea level rise has begun to damage the coastline [2].

2.1. Types of Climate Change

According to the United Nations Framework Convention on Climate Change (UNFCCC), climate change is mainly manifested into three forms, which are global warming, acid rain and ozone layer destruction. Among them, global warming is the most urgent concern, which will harm the earth's various biomes and ecological environment.

2.1.1 Acid rain

Natural disasters, such as volcanic eruptions, produce harmful gases such as sulfur dioxide and nitrogen oxide. People use fossil fuels like coal and natural gas a lot. When these fossil fuels are burned, they produce sulfur oxides or nitrogen oxides. These harmful gases rise into the air and will settle to the ground in the form of rain, snow and fog. If there is no cloud rain when the acid is formed, the acid will gradually deposit in the form of gravitational sedimentation, which is called dry deposition. Fig. 1 is the formation process of acid rain.

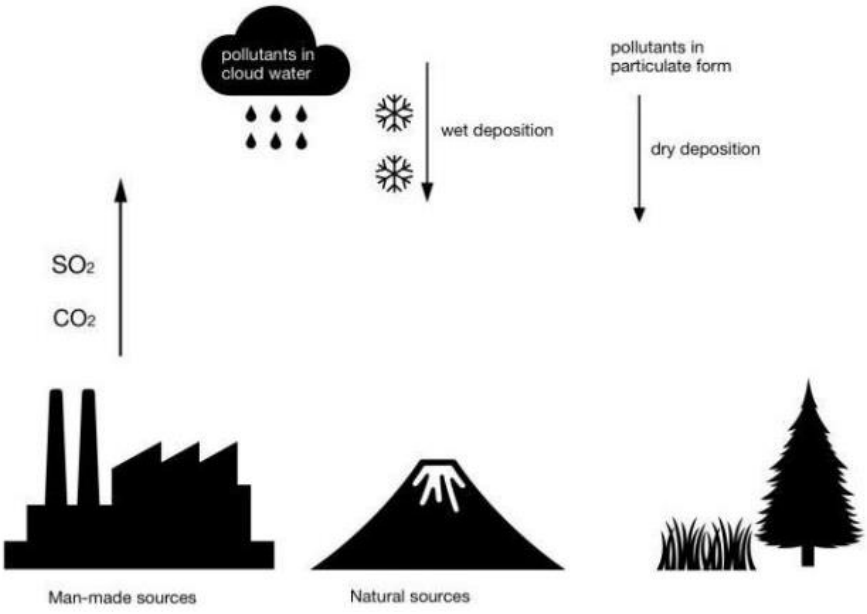

Fig 1. The formation process of acid rain. (Picture credit: Original)

2.1.2 Global warming

“Global warming” is affecting the whole world. In the UK, temperatures in the summer of 2022 reached 40°C, and the heat caused the railway to warp. Spain and Portugal recorded more than 1,000 heat-related deaths in July, 2022. The high temperature also brings drought and wildfires, once the Netherlands is famous in the world for flood control, but in early August 2022, it was declared to be in a state of water shortage, grass and crops wilt, and the land is dry and cracked, resulting in no crops [3].

2.1.3 Ozone layer destruction

The ozone layer is able to filter out 99% of the ultraviolet light in the sunlight. Ultraviolet light causes serious harm to human health and ecological environment. Excessive ultraviolet light coming into the human body can cause problems with the immune system of human. The ecological environment will also have serious effects because of excessive ultraviolet radiation. One research shows that the changes in number of phytoplankton communities is highly correlated with changes in the coverage of ozone, and that reductions in plankton species and abundance can affect fish and shellfish production. It can therefore be inferred that increased UV radiation disrupts aquatic plants, animals, and the entire aquatic food chain [4].

2.2. Cause of Climate Change

The causes of climate change can be attributed into natural factors and human factors, and human factors are the main causes of climate change. Among the human factors, it is mainly caused by human activities since the industrial revolution.

2.2.1 Vegetation degradation

Due to economic development and the increase of human activities, vegetation is constantly being destroyed, among which deforestation is particularly serious. In order to obtain more land and wood resources, people cut down forests excessively, resulting in a large reduction in forest area. The land surface of the earth is dotted with many plant communities, such as forests and grasslands. The feedback effect of vegetation on climate affects global climate change by influencing local atmospheric circulation or through biogeochemical cycles. Vegetation has a strong climate regulation function, and the degradation of this system will inevitably reflect the global climate change. It is found that the probability and degree of climate anomaly are smaller in areas with obvious vegetation increase. However, in the areas where vegetation increase is small or vegetation degradation is small, the probability of climate anomaly is large and the range of change is also large [5].

2.2.2 Atmospheric particulate matter

Volcanic eruptions cause volcanic ash and gases such as sulfur dioxide and hydrogen sulfide to enter the atmosphere and disperse globally through chemical reactions. When these acidic gases enter the stratosphere, they mix with the air and form acid rain.

High temperatures, droughts and other phenomena can cause widespread fires in biome areas such as forests or grasslands. Large wildfires release greenhouse gases such as methane and carbon, exacerbating the greenhouse effect and causing global warming. And wildfires can cause large areas of vegetation to decrease, indirectly contributing to climate change [6].

Humans use a huge amount of fossil fuels, coal and oil as energy sources on a daily basis. Burning these materials releases greenhouse gases such as carbon dioxide and sulfur dioxide into the earth's atmosphere. These greenhouse gases absorb heat from the rays from sun in the atmosphere, causing the earth's average temperature to rise.

3. Impact on Environment of Arctic Ocean

The Arctic Ocean ecosystem and its environment has been drastically affected by climate change, mostly anthropogenic impacts. Unprecedented changes were taking place among the artic area due to pollution and warming, pressuring local communities and ecology. Not only to the marine and near shore ecosystem but also to the benefit of human socio-economy [7]. Research shows that the pollutant components in the Artic Ocean are mainly settlement waste, riverine inputs, emissions from human activities, and atmospheric pollution. In addition, over past years, near-surface air temperature increased 3.1°C, which is a concerning number that could result in severe damage to artic ecosystem balance [8]. Now the Arctic transformation and its potential trend seem to beyond people’s control yet there is still a notable amount of statistics are lacking to the unsolved issue.

3.1. Climate Warming

The Arctic experiences acute warming speed in the earth, even twice as much as the global warming [9]. As the consequence of climate warming, sea surface temperature raised, sea ice thickness decreased and scattered as its melt water increased, along with the growing freshwater input and precipitation, resulted sea level raise and change in ocean current dynamic [8].

3.2. Riverine Input

The Arctic Ocean is affected by rivers more than any other oceans do. Riverine freshwater influx has been increasing over the past decades, mostly from Eurasian rivers and partly from North American rivers since the late 20s. Permafrost thaw and erosion are the basic component of riverine freshwater input nutrients. Water-borne nutrients and organic matter were considered influenced by the increasing discharge. Nitrogen is also vital in river influx. UV exposure kept increasing as melted ice revealing more sea surface, further improving the chemistry reactions [10].

3.3. Mercury emission

One of the most noticeable and intimidating elements in arctic pollution is mercury (Hg). Projects showed that climate change is strongly affecting arctic Hg contamination [11]. Hg emission sources considerably from natural legacy Hg content that already exist in the arctic and majorly from anthropogenic pollution which transmitted to the arctic via atmosphere and waterflow execrating the Hg pollution, especially after industrial age [7]. 50% of the anthropogenic emissions are estimated from Asian region regarding from the 2015 inventory. Currently the significant atmospheric Hg emission is to people's most urgent concern. Globally distributed gaseous elemental mercury has duration in the air for up to 1 year before deposited or absorbed into the circulation. Gaseous oxidized mercury and particle-bound mercury are found to have a shorter process and become a more obvious phenomenon during spring season for marine areas. Thus, sea water contains higher Hg level than the terrestrial surface which would consequence to accumulation of marine food source dependent species [11].

4. Impact on Marine Species of Arctic Ocean

Climate change have affected the Arctic Ocean biosystem in vary ways, plants and animals as two major life kinds in the ocean are therefore influenced. Marine kelp forests distribution shifts driven by climate warming are mainly the observed issue about marine botanical species [9]. Marine animal species are more impacted by anthropogenic factors, changes include biodiversity, species distribution, marine pathology, etc. This section reviews diseases spreading among mammals, reduced fish crowd populations, toxin accumulation among food chains [12].

4.1. Impacts on Arctic Botanical Species

Marine forest refers to large scale seaweeds biome that grow underwater. This forest type supports many species. It is usually formed by small algae base with Laminariales or Fucales (Phaeophyceae) as top layers, with different component of dependent community shows varied biological traits. In general marine forests have a trend to extend distribution during the warming sea water temperature, there will be threats targeting to the cryophilic, cryotolerant, and cryophobic floras [9].

4.2. Impact on Arctic Animal Species

Warming climate in the Arctic causes reduced ice coverage and thickness, increasing the exposure of mammals and diseases or pathogen. Presence of sea ice temper virus (PDV) was found among otter and seal species, confirming the analysis that mammals encounter risks to contagious pathogen as sea ice reduces [13]. Besides, while maritime transport has negative impact on the ocean environment by oil spill, fish fauna is directly influenced as well. Arctic cod fish species have experienced several oil exposures, showing a result of declined quantity of populations from

simulating experiments and history shipping oil leak events. The decline would intensify if oil contamination event meets cod group fresh recruitment at the same time. Juvenile period cod are more venerable to oil and can result stronger impact on cod fish population dynamics [14]. In addition, Hg emission has great impact on the Arctic Ocean as mentioned above in 3.3, food chain and biotic accumulations have close association with this phenomenon. Arctic and sub-arctic Aquatic animals possess higher levels of Hg than terrestrial animals since sea water in the Arctic contains more Hg than near surface atmosphere. Still, some of the terrestrial herbivore species would also depend on marine and near shore food source when terrestrial food sources are not sufficient or available. This action leads to higher Hg exposure and accumulation differ. There are other factors might affect Hg accumulation in animals as well and still need further investigation [12].

5. Improvement Measures

5.1. Reduce Carbon Emissions

In order to better cope with climate warming caused by increased carbon dioxide concentrations, economies need to shift from a high carbon economic model based on fossil fuels to a low carbon economic model. The application of intelligent technology is able to help reduce the carbon emissions from the production process with high energy consumption, improve the energy efficiency of the industrial supply chain, and reduce the greenhouse gas emissions of the entire industrial chain. For the government, industrial intelligence can strengthen the monitoring of government environmental protection departments on the emission of carbon dioxide and other pollutants from enterprises, and achieve the purpose of carbon reduction through the implementation of reasonable environmental regulation strategies [15].

Globally, energy consumption in transportation accounts for 29.1% of terminal energy consumption. Even when flat, urban traffic carbon emissions are still the fastest growing sector. Governments of all countries should focus on infrastructure, fossil energy, new energy vehicles and clean energy [16].

5.2. Promote Trade and International Cooperation

Building a sustainable system of trade, investment and international cooperation, and coordinating international sustainable development policies, can reduce the cost of coordinated governance of climate change and biodiversity conservation. Countries can build green supply chains, industrial chains and value chains, explore the sustainable trade model under the global reshaping and double-cycle model, and strengthen the construction of green “Belt and Road”. Companies should pay more attention to Marine, biodiversity, environment and health related issues, as well as resources, energy, climate and other issues [17].

6. Conclusion

The Arctic Ocean's contribution to the earth's ecological environment is extremely important. The loss of Arctic sea ice and mercury pollution caused by climate change need to be addressed as soon as possible. This paper discusses the types and causes of climate change, and how to improve the damage to the environment and organisms in the Arctic Ocean. Climate change is mainly reflected in the forms of acid rain, global warming and depletion of the ozone layer. Factors such as the destruction of vegetation areas, natural disasters, and human activities can contribute to climate change. The Arctic Ocean is warming very fast, causing sea levels to rise and ocean currents to change. Increased river input can also cause permafrost to thaw. At the same time, mercury pollution has become one of the most concerned problems. These changes threaten the Arctic's flora and fauna. Reducing carbon emissions is one of the most effective ways to mitigate global warming. Developing new energy sources, implementing low-carbon lifestyle and strengthening the monitoring of pollutant emissions are crucial. Countries can build a cooperation system for environmental protection and

sustainable development and strengthen the construction of the “Belt and Road”. The government and enterprises should pay more attention to ecological and environmental problems.

Authors Contributions

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

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