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## **Norway : The Impact of Harmful Algal Blooms on Food Security and Corresponding Measures**

### **Chapter 1. Introduction**

With complex causes, a special kind of harmful algal blooms (HABs) have gradually spread around the world. Algal bloom is defined as a rapid increase or accumulation in algal species which appear in freshwater or marine water systems, and these algal blooms are often recognized by people through their pigments that discolor in the water.<sup>[1]</sup> While harmful algal blooms are the ones that have negative impacts on other organisms or even can lead to much more harmful events such as contaminating seafood, cutting down the harvest of fishery industry, affecting the fishery economy, etc. Neurotoxin and other toxins from these contaminated seafood can also be debilitating or even fatal, which can seriously affect the food security causing human beings' illness or death,

Over the past few years, several severe harmful algal blooms have occurred in different regions around the world, mostly taking place in the United States, Singapore, New Zealand, Britain and several European countries, with Norway among them. The governments around the world have taken some measures, but those harmful algal blooms' recurring phenomena in multiple geographical regions are hard to defeat. Recently, another serious harmful algal bloom took place in Norway, causing huge losses.

### **Chapter 2. Some facts about Norway**

#### **2.1. Geographical and Biological Status of Norway**

Norway, a country located in Northern Europe, comprises both the western and northernmost portion of the Scandinavian Peninsula. It has a total area of about 385,000 square kilometers and a population of 5,312,300 (as of August 2018).<sup>[2]</sup> Norway is close to the North Atlantic Ocean and the Barents Sea, and it also has a long coastline, which stretches approximately 29,000 kilometers including mainland and fjords. Norway's climate is mainly influenced by the ocean. With mild lowland temperatures on the sea coasts, although in the interior of the mainland is colder than the coast, its temperature is also a lot milder than other areas in the world on such a northerly latitude. The maritime influence on climate in Norway creates a paradise for sea creatures. Forty-five fresh-water species of fish live in Norway, 150 salt-water species of fish have been found there. One thousand species of fresh-water invertebrates and three thousand and five hundred species of salt-water invertebrates have been identified in Norwegian sea.<sup>[2]</sup>

Moreover, fish plays an important role in Norway's economy, owing to the vast coastline and mountains covering large areas of the country. Along the coast Norway people typically make a living out of fishing.

#### **2.2. Norwegian Family and Norwegian fishing methods**

A typical family in Norway is made up of two parents and a child. However, with a relatively high divorce rate, the average household size in Norway is roughly 2.22 to 2.21 persons per household.<sup>[3]</sup>

In a Norwegian aquafarm, fish farmers normally feed Norwegian salmon with all-natural diet consisted largely of raw materials and plants, such as fish products extracted from wild fish, all kinds of vitamins, different minerals and antioxidants. All these complicated diets are aimed at ensuring the best-tasting flavor, the sustainability and food security of salmon.

### **2.3. Norwegian Diet**

With blessed geographical conditions, ancient Norwegian created a special kind of diets depending on those raw materials that they could find in and around their living areas including the mountains and the coasts. A large number of the traditional Norwegian diets are made from food and ingredients that have a very long shelf-time, which is an essential factor for the local life. This is because Norway's unique position and climate that it has a cold and endless winter making the Norwegian have to pay more attention on those long shelf-time food, especially fish (which can be easily found in the offshore areas). Both freshwater and saltwater fish are important parts of the Norwegian diet. And generally, Norwegian consume more fish than other meats. A great many fish dishes created by Norwegian are prevailing nowadays. These dishes ingredients vary from salmon, cod to herring, mackerel. Due to seafood's availability, Norwegian like to cook the seafood by smoking, salting and pickling. People who live near the coastline are more likely to be fond of fresh produce, for instance, poach a fish and add a bit of herbs and salt, sometimes pepper.

Salmon is one of the most consumed fish in Norway, and it is also one of the most internationally popular traditional Norse dishes' ingredients--smoked salmon. Recently, salmon is also a major export of Norway, that could be considered as the most important Scandinavian contribution to modern international cuisine. The main species of salmon farmed in Norway is Atlantic salmon, representing 93% of total Norwegian aquaculture production (FAO 2016).

### **Chapter 3. Impacts of Harmful Algal Blooms**

As for the coastal country Norway, harmful algal blooms are extremely harmful to the country's food safety. These hazards can be mainly divided into three aspects:

#### **3.1. Aquatic Product Output Reduction.**

Generally speaking, the harmful algal bloom is not transparent, which makes it possible for blooms to block the sunlight from reaching fish and plants that exist in the deeper level of ocean. However, plants and fish in the marine system need light to breathe and survive or they would die off due to lack of nutrients. What's worse, as algal blooms grow, they will gradually use up the oxygen in the water bodies and cause the destruction of the plants and the fish. Furthermore, the growing density of the harmful algal bloom rises the possibility of reduces oxygen saturation during the night by respiration, which can suffocate the fish and the plants. The negative impact can even be more harmful when the algal blooms take place in a fish farm, exacerbating the huge loss. For instance, in May 2019, millions of farmed salmon have died in northern Norway due to an algae bloom. The Norwegian Directorate of Fisheries had estimated economic loss from the 10,000 tonnes of farmed salmon is as much as 620 million Norwegian Kroner. <sup>[3]</sup>

And eventually, the death of the fish and plants contributes to food crises in Norway. Till today, Norwegian's consumption of seafood still ranks top in Europe, and salmon, as the most popular seafood, takes up approximately 15% of Norwegian average total home consumption in food.

#### **3.2. The Quality of the Seafood are affected.**

Different kinds of harmful algal blooms can have different impacts on the quality of the seafood. The most common impact that the harmful algal blooms have is contaminating the seafood with their own toxins, which can lead to serious food safety issues. What's worse, the toxins in the seafood won't be removed by simply heating or cooking. Another adverse effect is that the harmful algal blooms can destroy the balanced situation of the sea creatures' living condition, and therefore, harm the quality of seafood. And when the quality of seafood are influenced, the safety of food for human beings won't be secured.

And since the toxins from harmful algal blooms can not be easily washed away, and usually people can't find out whether the seafood they are having is contaminated or not, the possibilities of people being poisoned by the seafood is considerably high. An example of this is in 2002, in Norway, several

hundred people got ill after eating the self-harvested brown crabs. This event happened at the same time as a kind of algal bloom named *Dinophysis acuta*, which caused high amounts of DSP toxins in blue mussels. The cause of this was that crabs had accumulated toxins by eating blue mussels.<sup>[4]</sup> In 2017, the Norwegian Food Safety Authority recalled mussels from the manufacturer Snadder and Snaskum after discovering algae in the shells. According to the Norwegian Food Safety Authority, eating the mussels can lead to vomiting, diarrhea and stomach cramps.<sup>[5]</sup>

### **3.3. The quality of the drinking water are affected.**

Some harmful algal blooms are developed from blue-green algal. These kind of harmful algal blooms can produce toxins and affect the drinking water quality. Although when the blooms are not serious, people can simply deal with those toxins by using common water treatments, during a severe algal blooms, the water purification system won't be that useful any more. WHO once reported several collective poisoning events in USA, Australia and China related to the using of contaminated drinking water.

## **Chapter 4. Causes**

As for the causing factors of harmful algal blooms, they are assumed to be complicated. I would like to analysis it in four aspects:

### **4.1. Climate change with its resultant global warming.<sup>[6]</sup>**

According to NOAA scientists, global warming contributes to warmer waters which makes atmospheric conditions more suitable for algae to grow in more regions. This is one of the main reasons why harmful algal blooms could have broken out at such a high latitudes. Proper temperature is needed for certain algae to thrive in water. At the same time, the extremely high temperatures caused by global warming have led to the speeded-up decomposition of the nutrients such as nitrates and ammonia, which make it easier for algae to survive and grow into large scale.

### **4.2. The existence of dead organic substances.**

Generally speaking, there are many kinds of microorganism present in the air as well as in water. They are all searching for proper media to survive.<sup>[7]</sup> At the same time, there usually exist lots of nutrients such as nitrogen and phosphorus in the water, due to the decomposition of dead organic substances. And the algal blooms are those gatherings of algal species, therefore, with a great atmosphere provided by dead organic substances, the harmful algal blooms thrive.

### **4.3. water eutrophication.**

Eutrophication is a kind of phenomenon caused by water pollution. Generally, it is caused by inordinate amounts of nutrients such as nitrogen and phosphorus in water.<sup>[8]</sup> The existence of large amounts of these nutrients in the water bodies will lead to the rise of algal blooms. There are two main reasons for water eutrophication. First, it might cause by people's activities. These nutrients in the water are mainly originated in land and farms where people will use materials or fertilizers that consist of nitrogenous and phosphoric. And another vital factor in this process is rainwater. It washes away the leachable nutrients from the soil and brings them into larger water bodies, such as rivers or streams, which eventually flow to lakes and oceans. Secondly, it might caused by bad drainage system. Sometimes, when the water purification system of one place is not properly installed or regularly maintained, the system may not be able to treat those sewage properly. Then the water that goes into the ocean or lake might be contaminated, which can cause serious water eutrophication as time goes by.

## **Chapter 5. Solutions & Recommendation**

### **5.1. Existing measures**

#### **5.1.1. In Norway**

Since the situation Norway facing is severe, the Norway government has already taken some measures. After the outbreak of a severe algae outbreak earlier in 2019, the government of Norway has allocated 10 million kroner to funding aquaculture research, aiming to deal with the harmful algal blooms in Norway.<sup>[9]</sup>

### **5.1.1. Around the world**

With the global spreading trend of the harmful algal bloom, efforts have also been made worldwide to reduce and prevent the negative effects of harmful algal blooms in the past few decades. The followings are some of the actions included: monitoring the algal species and the proportion of algal toxins in the water bodies, promoting cooperation in their own communities, country, sometimes regions, reducing nutrients exist in the water, providing warning and guidance about the harmful algal blooms, etc.

## **5.2. Suggested methods**

However, until very recently, harmful algal blooms are still thriving and spreading rapidly around the world. There have not been enough effective actions to tackle with these annoying things. We should not only study it carefully, but also take actual steps to put the information we have studied into use. The followings are some measures come up by the author that might help to deal with harmful algal blooms:

### **5.2.1. Preparation of coping with harmful algal blooms**

#### **5.2.1.1. Continued support of monitoring and management of algal blooms.**

These actions make it possible to provide the updated information and alerts to the public in time, and can also give proper notice for human beings about those health threats brought by harmful algal blooms. The persistence of ongoing programs and policies require long term acknowledgement from the local, regional, national, and even international levels.

Governments should test lakes and ponds to identify water quality regularly, evaluate the nutrient levels of the water and the health state of the seafood, in order to learn about the current situation of the water before they get out of control. Over time, water quality data can be used to predict the outbreak of a harmful algal bloom and prevent its impact without closing the water body or interfering with irrigation system and drinking water services.

#### **5.2.1.2. Modelling and Prediction.**

With the development of technology, more and more problems can be easily solved in an accurate and mathematical way. Future progress in dealing with harmful algal blooms will also largely depends on the creativity and innovation of individual investigators or scientific researchers developing new mathematical models and new approaches. Continued support of mathematical or modeling research on harmful algal blooms will be of great help to decrease their negative impacts, especially those with complex dynamics. At the same time, from these research we can design detailed policies to deal with those regional species that appear only in Norway.

#### **5.2.1.3. Arising people's awareness.**

Sometimes, when an algal bloom breaks out, it would be harder for governments than for civilians to predict in advanced. So the governments should help educate the citizens about the basic knowledge about harmful algal blooms, including its nature, its impacts, and give helpful tips in case a person is poisoned.

What's more, we can release several initiatives to appeal the people to play their own role in dealing with the harmful algal blooms and can also put up some related posters or arrange some public lectures in the places where harmful algal blooms are rampant.

### **5.2.2. Long-term precautions against harmful algal blooms**

### 5.2.2.1. International Cooperation.

Since the harmful algal blooms are not only a problem in Norway but also a worldwide problem, they then requires an international understanding to promote worldwide actions. It is necessary for Norway's government to cooperate with other countries in Europe, or even around the world. For instance, communicating with the broader countries of researchers who are studying harmful algal blooms. Or we can have some regular international meetings to exchange one another's successful experience and latest information in dealing with harmful algal blooms.

What's more, since the causes of harmful algal blooms are closely related to global warm and pollution these crucial topics around the world, we can apply to cooperate with those organizations and forums, and step on a wider stage to share our opinions in dealing with harmful algal blooms, calling on more people to realize the problems of harmful algal blooms.

Another thing that might be help is setting a "code of conduct" among the fish farmers and the seafood providers. Because if we want to properly deal with the harmful algal bloom, the farmers will have to pay the price. Although the communities or the governments can provide some compensation, it might not enough. Sometimes the break out of harmful algal blooms may influence one place's reputation, which makes the owners unwilling to admit the outbreak of algal blooms originated from their places. And if we set a so-called "code of conduct", it's not like laws that strict, but with more conviction than just sharing information.

### 5.2.2.2. Proper disposal of organic materials.

After agricultural work, organic materials such as leaves should be bagged and removed from the soil in order to prevent them from accumulating in the water bodies. Because if organic materials are allowed to decompose in freshwater, they will release extra nutrients, which causes water eutrophication, which contributes to harmful algal blooms.

### 5.2.2.3. Reduce nutrients in the water.

Some lakes and ponds themselves naturally possess more nitrogen or have more serious nutrient problems than the others, so the first thing to do when dealing harmful algal blooms that originated in these water bodies is to reduce the nutrients by all means. For example, some application can remove free reactive phosphorus from the water bodies, thus reduce the phosphorus that can contribute to restricting algal blooms from growing, improving water clarity and permanently reducing useless nutrients in the water bodies.<sup>[13]</sup>

### 5.2.2.4. Cut down the actions we human beings are taking that badly impact our seas and oceans

Actions such as enhancing water purification can provide cleaner water, protect the environment and reduce the harmful algal blooms at the same time. These actions are not again others interests and can rise the owners' reputation. So these actions can be an option to those kind-hearted businessmen that want to help deal with harmful algal blooms.

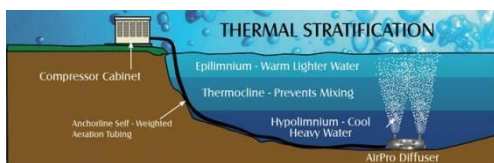


Figure1: aeration equipment

### 5.2.3. Control methods in response to the outbreak of harmful algal blooms

#### 5.2.3.1. Set up effective life support systems.

This kind of systems require aeration equipment and oxygen diffusers, which create a barrier to harmful algal blooms.<sup>[14]</sup> When combined with other methods, can help circulate water around the whole system and facilitate phosphorus and nitrogen to turn into nutrient forms that do not support

algal blooms to thrive.

#### **5.2.3.2. Establish a beneficial buffer.**

This method can help prevent organic substances and trash from getting into lakes or ponds, which can also prevent the outbreak of harmful algal blooms.<sup>[13]</sup>

#### **5.2.3.3. Physical controls**

These methods are the ones that physically remove algal cells from the water bodies or kill algal cells through physical means.<sup>[14]</sup> Typical examples include: Flocculation, Water Column Mixing, Cell Harvesting and Removal, etc.

#### **5.2.4. Chemical controls**

These methods rely on the release of algal substances through a variety of mechanisms to interfere with algal cell growth. There are several chemical control methods likely to be field demonstration ready in the next five years and therefore included in the Proposed Action.<sup>[14]</sup> These methods include the use of whole macroalgae, using macroalgal isolates, adding copper, etc.

### **Chapter 6. Conclusion**

With global warming and the acceleration of global modernization, harmful algal blooms continue to spread in water bodies around the world, and seriously harm the food safety of human beings, endanger the safety of people's diet, and affect the daily lives of people in various countries. Recently, Norway, the United States, Canada and other countries that have been or are being affected by algal blooms already have successful experiences and methods for reference. However, as the spread of harmful algal blooms continues, we need to pay more attention to it, and the cooperation of international forces may become the focus of future responses to harmful algal blooms.

This article summarizes the impact of harmful algal blooms on the three major aspects of aquatic product output, seafood quality and drinking water quality. It focuses on the government's response methods, and proposes the establishment of life support systems and buffer zones, through laboratory physical or chemical methods, etc. These solutions with great room for development help people understand the harm of harmful algal blooms further, and provide strong operable solutions to areas facing outbreaks of harmful algal blooms to reduce the corresponding losses. Based on this circumstances, we should also reflect on the reasons for the continuous emergence of natural phenomena similar to harmful algal blooms in human society. And it has become a serious problem that how can we promote international cooperation to seek common ground while reserving differences under the reality of globalization, promoting the sustainable development of human and nature.

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