N2O reduction from Wastewater treatment facility by the CarbonFiber method.

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It is global recognition that warming will harm the global environment and reduction of greenhouse gas are required. However, It is not taken measures to reduce dinitrogen monoxide N_2O which has a greenhouse effect that is about 300 times as high as carbon dioxide. When ammonia nitrogen flows into the aeration tank of wastewater treatment facility, it is converted from nitrite to nitrate by aerobic nitrifying bacteria, and N_2O is generated. To prevent the generation of N_2O, it is to promote the decomposition of nitric acid to nitrogen.But the anaerobic denitrifying bacteria are not present in the aeration tank of the aerobic condition. When installing the CarbonFiber water purification material in the aeration tank, ammonia nitrogen is denatured from nitrite to nitrate by the aerobic nitrifying bacteria adhering to the surface layer, then decomposed to nitrogen by anaerobic denitrifying bacteria attached next in the deep layer and nitrogen is diffused into the atmosphere. As a result, greenhouse gases N_2O is reduced, and CarbonFiber water purification materials are measures to global warming.

1. Introduction

The waste water treatment performed on city sewage, livestock waste water and organic industrial waste water is the activated sludge method. However, the conventional activated sludge method will only decompose organic matter with the action of the aerobic bacteria in the activated sludge tank and it will not remove the ammonia nitrogen（NH_4-N）, it will only be modified by the activated nitrification bacteria from nitrite（NO_2）to nitrate（NO_3）. With this ammonia nitrogen's metamorphic process, nitrite and nitrate will accumulate in the aeration tank and dinitrogen monoxide（N_2O）is generated. By providing an anaerobic treatment tank with biological nitrogen treatment process in the waste water facility, nitrate will decompose to nitrogen（N_2）and all nitrogen: total nitrogen（TN）is removed but with the aeration on the activated sludge tank, accumulated nitrate will still generate nitrous oxide. Furthermore, dinitrogen monoxide will also generate from the excess sludge and if this sludge is in an anaerobic state, methane（CH_4）will also occur. In recent years, the spread of membrane bioreactor proceeding（MBR）is used in the activated sludge tank as an advance processing system, with the same principle as the standard activated sludge method, dinitrogen monoxide will occur.

2. Technology to control N2O generation

To prevent the occurrence of dinitrogen monoxide it is necessary not to allow the accumulation of nitrite and nitrate in the activated sludge tank and that it is necessary to have anaerobic denitrifying bacteria to decompose nitrite to nitrogen. By making the activated sludge tank in an anaerobic state, denitrifying bacteria will be activated and the decomposition reaction of ammonia nitrogen → nitrite → nitrate → nitrogen is promptly carried out, making it possible to prevent the occurrence of dinitrogen monoxide.

CarbonFiber water purification material MiraCarbon is a biological membrane treatment contact media that is made from 100% CarbonFiber that will adhere aerobic bacteria on its surface layer and anaerobic bacteria in the deeper layer. On the surface layer, the aerobic nitrifying bacteria reaction will make the ammonia nitrogen → nitrite → nitrate and on the deeper layer with the anaerobic denitrifyig bacteria reaction, nitrate is decomposed to nitrogen as its final product that is diffused into the atmosphere. The denitrification process on the activated sludge tank is carried out immediately thus preventing the accumulation of nitrite and nitrate, suppressing the generation of dinitrogen monoxide.

By placing CarbonFiber water purification material MiraCarbon in the activated sludge tank as a biological membrane contact material, it will not only decompose organic matter but it will also remove total nitrogen that can not be removed on conventional process, furthermore, it will also suppress the generation of dinitrogen monoxide that has about 300 times stronger greenhouse effect, reducing the emission of greenhouse gas on waste water treatment facility.

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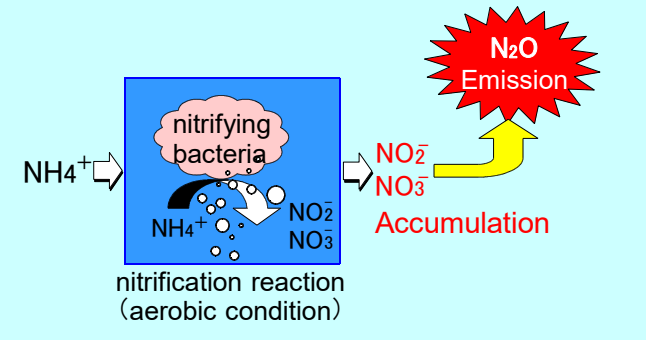

Fig.1 N_2O generated from NH4-N

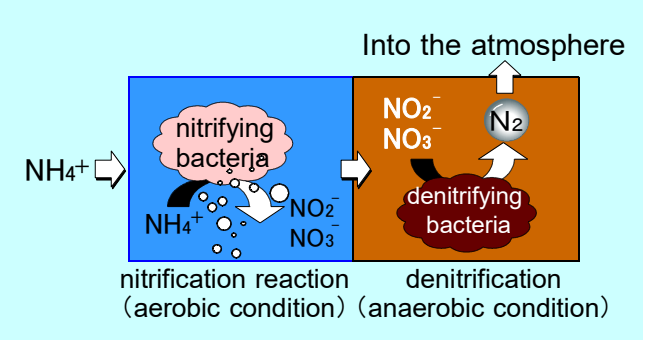

Fig.2 N_2 Degradation of NH_4-N to N_2

3. **CarbonFiber water purification technology**

CarbonFiber water purification material is made from advanced functional material CarbonFiber that is light and strong with the engineering properties of CarbonFiber, with its high biological carbonaceous affinity and excellent electrical characteristics. It has been widely used on rivers, lakes, marsh and etc. as a direct water purification material and it is also used on aquaculture, seaweed bed formation and etc.

The CarbonFiber used as water purification material is made out from PAN type(polyacrylonitrile fiber) 7μm filaments 12K (12,000 pieces) or 15K (15,000 pieces), it is different from generally industrialized CarbonFiber in a way that it uses water soluble sizing processing. High-quality PAN type CarbonFiber used around the world are mostly made by Japan's textile manufacturers, but our company's MiraCarbon is the only one that has been subjected to a water-soluble sizing process.

Water purification by CarbonFiber is achieved by its capacity to capture pollutants with its large surface area with the fine filament of the CarbonFiber. It carries out purification by the biofilm of the microorganisms that will adhere and decompose pollutants. There are also contact materials such as chemical fiber, cotton fiber, fiber made from plastics and etc. that are used with the same purpose of biological membrane treatment.

MiraCarbon's great advantage compared with these materials is that it has larger surface area and its electrical characteristics. It has been scientifically proven that bacterias and microorganisms are likely to adhere with its small electric resistance and that it has high electric conductivity. In addition, it is light and with high elasticity, the 7μm fine filament cluster can hold a large number of microorganisms in between the filaments by swaying in the water and when activated it will be difficult to peel off. Large amounts of microorganisms will attach to the CarbonFiber, making a big cluster that will adhere aerobic bacteria on the surface layer and anaerobic bacteria on the deep layer, making them active with the swaying of the CarbonFiber in the water that will capture organisms and nutrients. Ammonia nitrogen captured by the microorganisms on the CarbonFiber, will decompose the ammonia nitrogen into nitrite and nitrate by the nitrification action of the nitrifying bacteria on the surface layer of the CarbonFiber transforming it into nitric acid, then the nitric acid will be decomposed to nitrogen by the denitrifying action of the denitrifying bacteria on the deep layer of the CarbonFiber, diffusing nitrogen into the atmosphere. As a result, total nitogen is removed and the generation of the product nitrous oxide that was produced from the accumulation of dinitrogen monoxide can be suppressed. Water purification mechanism by CarbonFiber has excellent characteristics that is sustainable and does not require large energy.

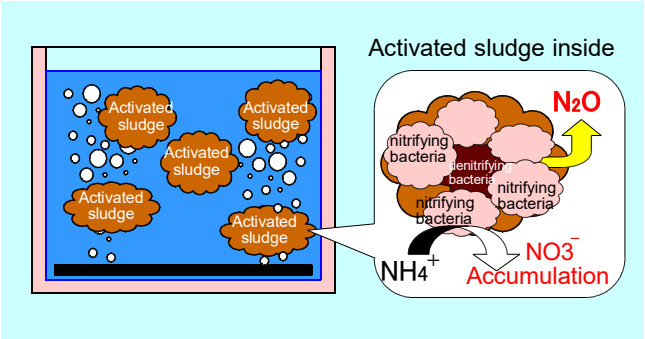

Fig.3 N_2O generation from activated sludge method

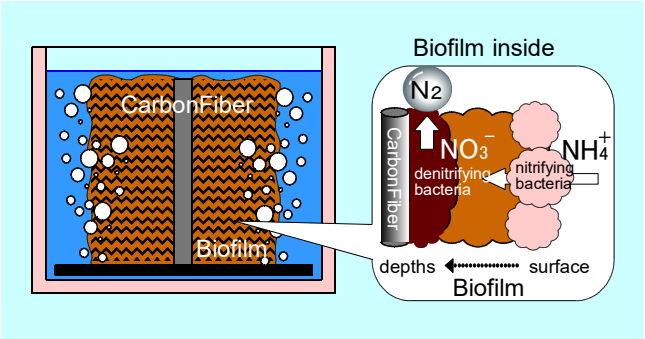

Fig.4 N_2O suppression by CarbonFiber method

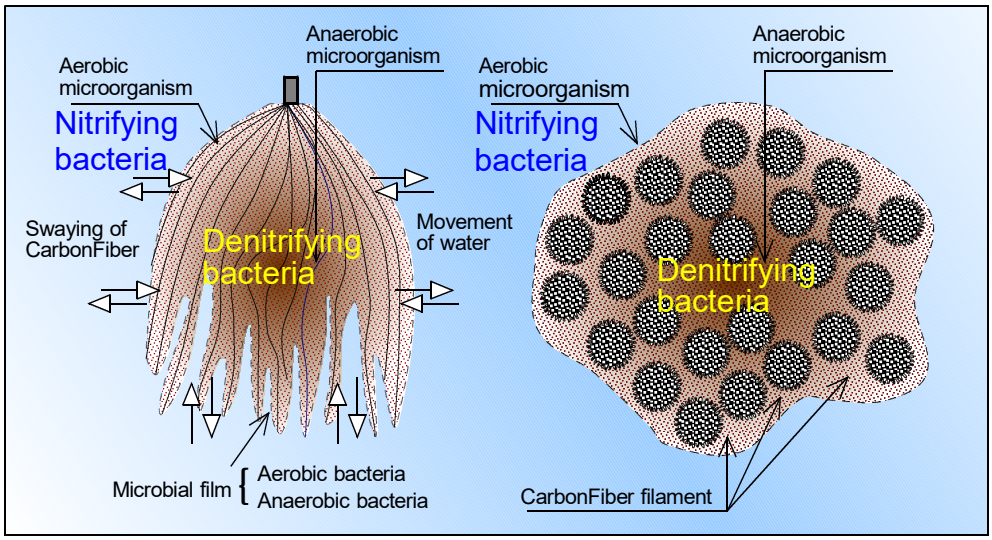

Fig. 5 Mechanism of water purification by the CarbonFiber method

Fig. 6 CarbonFiber installation 1

Fig. 7 CarbonFiber installation 2

4. **Effectiveness of greenhouse gas reduction**

The water purification effect of CarbonFiber is carried out by the action of the bacteria and microorganisms that attached on the CarbonFiber, organic matter is decomposed to water and carbon dioxide by aerobic bacteria on the surface layer and ammonia nitrogen is decomposed to water and nitrogen by anaerobic bacteria on the deep layer. Compared to activated sludge methods that do not use CarbonFiber as a contact material, the decomposition of organic matter by the activated aerobic bacteria on the CarbonFiber is more effective and the treatment time can be shortened.

The biggest advantage of CarbonFiber method is the decomposition of ammonia nitrogen. In the activated sludge method, the action of the aerobic bacteria is mainly used and denitrification effect is can not be expected, but the CarbonFiber method has high denitrifying effect by the action of anaerobic bacteria. Its high denitrification effect suppresses the generation and reduction of the greenhouse gas dinitrogen monoxide compared to the activated sludge method.

CarbonFiber water purification technology has started full-scale work on water purification business using CarbonFiber since 2008. We perform water purification business in Japan, to emerging and developing countries that has prominent environmental destruction. In Japan, the water purification effects in rivers, lakes and marsh has been demonstrated by researchers, environmental organizations and etc. at the beginning of its development but was not commercialized. Since then,CarbonFiber water purification technology has established and adopted technical standardization, production system and design method that the Ministry of Land, Infrastructure and Transportation and other local government started to order our products to improve the environment. The water quality purification effect was introduced in media such as television, newspapers, magazines and etc. Inquiries from overseas has increased, including China with a remarkable environmental destruction and to its neighboring countries like Korea, Taiwan, other countries in ASEAN ,the export began.

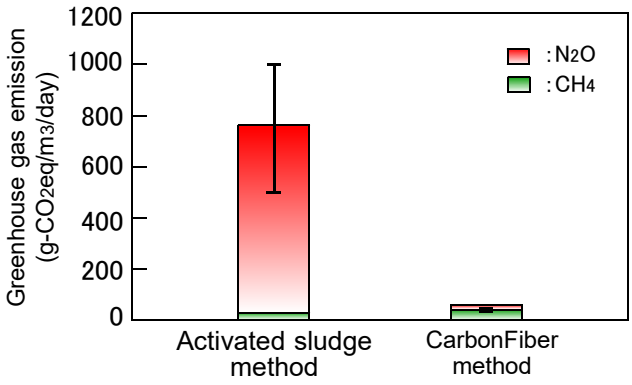

Fig. 8 Comparison of greenhouse gas emissions

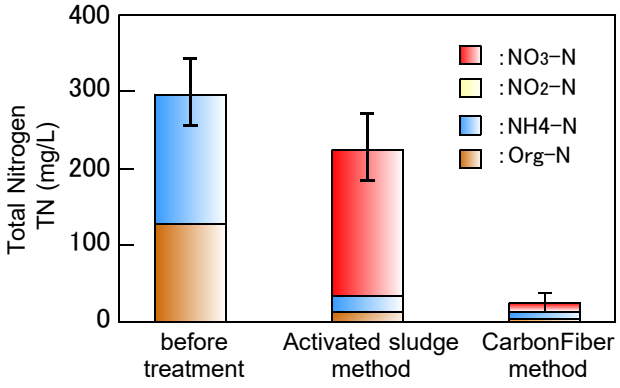

Fig. 9 Comparison of nitrogen reduction

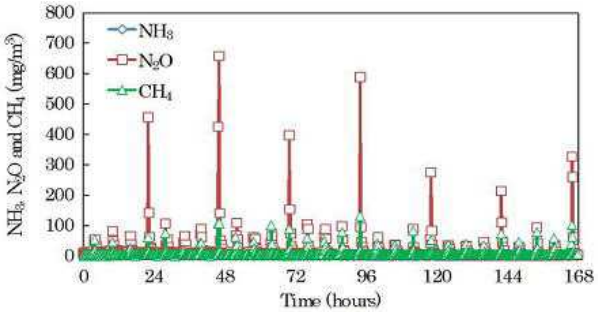

Fig.10 Greenhouse gas generation by activated sludge method

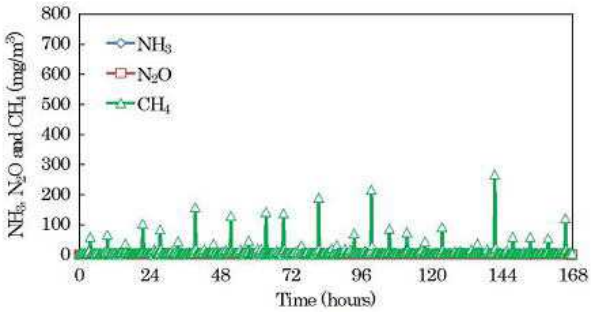

Fig.11 Greenhouse gas generation by CarbonFiber method

The demonstration in Africa started as a result of being exhibited at the 17th UN Conference of the Parties to the United Nations Framework Convention on climate change that was held in Durban, South Africa in 2011. Furthermore, it was demonstrated in TICAD V the 5th African Development Conference that was held in Yokohama City in 2013. The effectiveness of water quality purification by CarbonFiber has been recognized and the use has started for waste water treatment and mine waste water treatment processing on Africa Sub-Sahara region.

The largest achievement overseas is in China which has a remarkable environmental destruction. It has already been recognized and established as a water quality purification technology for rivers and lakes. And because it was adopted in several national demonstration projects its effects on water purification has been proven and high potential business can be expected. If CarbonFiber is used largely as a water purification material in the waste water treatment facilities in China which is the biggest emitter of greenhouse gas, it will greatly contribute to the countermeasures to prevent global warming. In Asia, we have experience in Singapore, Vietnam, Thailand and Malaysia, it is also used for waste water treatment of nickel mines in the Philippines and we can expect to spread in India.

5. Prospect of CarbonFiber technology

In Japan, the sewage treatment population diffusion rate has reached 89.9% at the end of 2015. Except for some remote islands and mountain areas, waste water are treated by sewage facilities, agricultural settlement drainage facilities, septic tanks and etc. And as the environmental consciousness rises, legal regulations are strengthened as well. Private and public industrial waste water, waste water treatment on livestock and others has also improved and all treatment methods are mainly based on the activated sludge method. As a result, dinitrogen monoxide is generated from all activated sludge tanks. The generation of dinitrogen monoxide from the activated sludge tanks has been known conventionally, but in many cases, it is left as it is and there is no measure taken in the process as of now.

With the advances in water treatment technology in the recent years, advanced treatment facilities are represented by the biological membrane treatment, but the construction, operation and maintenance costs has become expensive. Although advanced treatment is beneficial in the purification process of drinking water, it is inevitable in the field of sewage and industrial waste water. Reducing a certain amount of organic matter and nutritive salts is necessary to conserve the Eco-system and it is indispensable for securing fishery

resources in the near waters.

In addition, expensive advanced treatment facilities that were made during the recession period has increased the fiscal burden of the local government at the time of construction, facilities that has aged can not be renewed and has failed to maintain a stable treatment water quality.

By installing CarbonFiber water purification material in the activated sludge treatment tank, the removal of nitrogen which could not be processed conventionally is made possible thus preventing the generation of the greenhouse gas effect dinitrogen monoxide. CarbonFiber water purification material is effective even by only installing it, it does not require special maintenance and energy, so it also reduces the maintenance cost and operation cost, making it a promising water processing method with extremely high cost-effective. With the society recognizing the strong effect of the greenhouse gas dinitrogen monoxide, its generation and prevention measures by using the CarbonFiber method will be in great demand as a countermeasure against global warming, a passive and sustainable water treatment technology.

The sewage treatment population diffusion rate in the world is low, sewage facilities are only being maintained in some parts of the developed countries.

Even in China with its remarkable economic development, the introduction of sewage facilities and advanced treatment facilities are in large coastal cities but in the inland and rural areas, the rudimentary processing methods such as activated sludge, oxidation pond and artificial wetlands are still used. Also, due to the economic development priority, the regulations on industrial waste water is not strict and the waste water from mines and etc. in the inland areas are suspended as it is without treatment. By using CarbonFiber water purification material, it will improve the waste water treatment function and will suppress the generation of dinitrogen monoxide.

In advanced countries such as Europe and Russia, the waste water treatment facilities are in the process of aging and it is time to renew, but due to the economic recession in the recent years and the price slump of resources, new investments are not made and easy water treatment is sought. As of now, the adoption of CarbonFiber is being considered. The adoption of water purification by CarbonFiber will improve the water treatment function and it will reduce the generation of dinitrogen monoxide as its greatest advantage. Developing countries in Asia, Africa and Latin America, the urbanization in the center of major cities has progressed but the infrastructure development is not enough and there are many waste water treatment facilities that are undeveloped.

The water pollution is progressing in the urban areas because the waste water treatment is still being carried out in rudimentary methods such as oxidation pond and lagoon. Oxidation pond and lagoon treatment method has a low processing efficiency, will not only generate dinitrogen monoxide but also cause the generation of methane from the accumulated sludge. In these developing countries, it is desirable to promote sewage facilities at an early stage but it is not necessary to have expensive advanced treatment facilities, activated sludge treatment using CarbonFiber water purification is suitable. It is a sustainable water treatment method with less economic burden, has easy maintenance and low operation cost.

By installing CarbonFiber water purification material even for a short term, on an aging activated sludge tank, oxidation pond, lagoon and etc. it is possible to improve the treatment function and reduce the generation of nitrous oxide. It will be a countermeasure that can be implemented immediately against global warming in developing and emerging countries.

With promoting further research and development in the future, by using CarbonFiber water treatment process, it will reduce the generation of dinitrogen monoxide from waste water facilities, contributing to the prevention of global warming.

Fig. 12 Aging activated sludge tank (Russia)

Fig. 13 Lagoon processing pond (Peru)

6. Conclusion

Currently, the reduction of dinitrogen monoxide emissions from wastewater treatment facilities is not taken attention in general and measures are not taken because of low recognition. The wastewater treatment facility is an important and indispensable industrial process for human beings, aiming at removing pollutants from sewage and preventing water contamination of treated water discharge destinations. Dioxin monoxide is generated when nitrogen oxides accumulate in the activated sludge tank because the main removal index by waste water treatment is organic matter and treatment method is mainly active sludge treatment method.

Even if wastewater treatment facilities are spread all over the world in the future and the problem of water pollution is improved, the generation of dinitrogen monoxide is continuing to increase with the current treatment method, and the problem of global warming is not improved. If the causal relationship between the generation of dinitrogen monoxide and the global warming from the wastewater treatment facility is clear, it can be said that not doing this countermeasure is an inadmissible responsibility.

In the future, improvement of the treatment effect of organic matter and nitrogen oxide by the carbon fiber method water treatment system and reduction of the generation of dinitrogen monoxide from the wastewater treatment facility are widely recognized and widely spread, so that measures against water pollution and prevention of global warming It can contribute to both environmental problems.

7. References

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