Utilization of CarbonFiber in Water Use Method and its Marketability

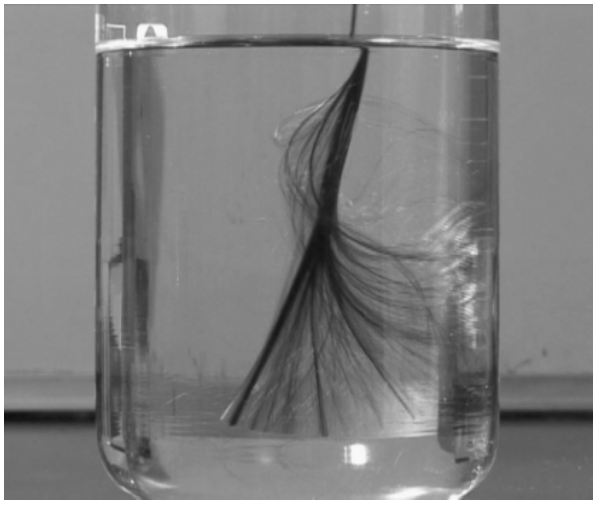
Yukio Kogure President of CarbonFiber Make Water Method Association
1665-1 Shinbo-machi, Takasaki, Gunma, JAPAN TEL：+81-27-384-3445 E-mail：koguyuki@gmail.com

1. Introduction

Since CarbonFiber have superior charactaristics that it is light, strong and imputrescible, CarbonFiber is applied for various industrial products. Another noted feature is its high bioaffinity. It is composed mainly by carbon. It has large surface area and low electric resistance, therefore microbes and bacterias in water are attracted and activated. The CarbonFiber water purification method has been researched by industry-university-government cooperation project about 20 years ago focusing on bioaffinity and physicochemical characters, As the result of reserch, CarbonFiber water purification material was introduced. A water purification effect can be obtained by simply installing CarbonFiber in polluted rivers, and lakes, etc. Several organizations, such as environmental groups, begun installing and demonstrating a water purification effect in many fields. The effect was reported in the media, then CarbonFiber has been applied in fields of public works of Japan and local governments. In addition, it receives attention from overseas and introduced in developing countries such as China where environmental destruction goes on. It has been used in wastewater treatment facilities in recent years and it is expected to be widely applicable as a passive and sustainable method of water treatment. We report the possibility of CarbonFiber for water use and its marketability in this paper.

2. Mechanism of water purification

The reason that CarbonFiber have a function of water purification is based on characteristics of CarbonFiber as materials. CarbonFiber for water purification is manufactured by Tow type of PAN. The difference between the material and general products is the surface of CarbonFiber is treated by water-soluble sizing. The reason of this treatment is that all filaments of water purification materials should unravel and spread in water, in contrast with normal carbon fibers are fixed by plastics in order to have high-strength. Since each tiny filaments of CarbonFiber are light and have high elastic rate, spread fibers are able to sway in water without shrink and being fixed. In addition, CarbonFiber has patterned indented surface, and its total area is large. Because of its low electric resistance, many materials in water adhere on CarbonFiber. Not only pollutants in water, also microbes and bacterias are attracted and fixed. Since it is difficult to leave. Fixed microbe grow actively having gathered pollutants as their feed. As a result pollutants are decomposed and removed, mechanism of water purification is created on surface of CarbonFiber.



Picture 1. Spread CarbonFiber in Water

2. 1 The microbial adhesion mechanism

It is demonstrated by a number of experimentations that amount of microbial adhesion to CarbonFiber which has function of bioaffinity is larger than other chemical fibers and synthetic fibers, and these microbals are less likely to be peeled off and highly activated. Finally scientific basis of adhesion mechanism is clarified by recent researches.

According to comparative researches of microbial cell adhesion between CarbonFiber and the other fibers, all electric potentials of fiber surface and microbial cell surface have negative charge in water. Therefore, two of them have negative charge and repulsion is caused, it is difficult to adhere. However, negative charge of CarbonFiber is lower than other fibers, CarbonFiber has no electric resistance and microbes are easy to adhere. Thus, interaction called intermolecular force react in all materials, and interaction between CarbonFiber and microbes is stronger than that between the other fibers and microbes. Calculating energy from microbal adhesion to the each fibers with calculating surface electric potential of microbial cell and that of each fibers together with interaction of them, the energy barrier in microbial cell adhesion to CarbonFiber disappears whereas an insurmountable energy barrier is observed in the adhesion to the other fibers except CarbonFiber. Therefore it takes time that microbes adhere to other fibers because of breaking through energy barrier although microbes adhere instantly to CarbonFiber. Furthermore, it is revealed that microbes called nitrobacteria, which decompose and remove nitrogen, adhere well to CarbonFiber.

These adhesion mechanism also affect several materials in water such as organic matter and nutrient salts, pollutants easily adhere to CarbonFiber. Absorbed pollutants are preyed and decomposed by biological activity of adhered microbial cell. A large amount of microbes are fixed、grow actively between tiny filaments of CarbonFiber, pollutants such as organic matter and nutrient salts are removed and water is purified. Applying this function to wastewater treatment, CarbonFiber use as a contact media compared to it manufactured from other materials for biological treatment, processing function is improved because microbes are activated.

2. 2 The sway of CarbonFiber

CarbonFiber is light, has high elastic rate, and is able to float in water being long fiber shape and sway by a small movement of water. By the sway of CarbonFiber, pollutants are adhered and microbes in water are fixed. Also, CarbonFiber is assembly of tiny filaments, fixes a large amount of polluted mud and possess it.

After CarbonFiber water purification material for wastewater treatments is into water containing activated sludge, the large amount of polluted sludge, which is microbial aggregate, is attached to CarbonFiber. Then, lump of polluted sludge is formed. Aerobic and anaerobic organisms are mixed in the polluted sludge lump, and mass transfer within the lump is hundreds of times greater than within common microbial films. Mass transfer is occurred by circulation which is produced by the sway of CarbonFiber. This is called net-pump movement which is deformation-recovery repeated motion. Due to its high elastic rate, CarbonFiber has the capability of shape retention and net-pump movement.

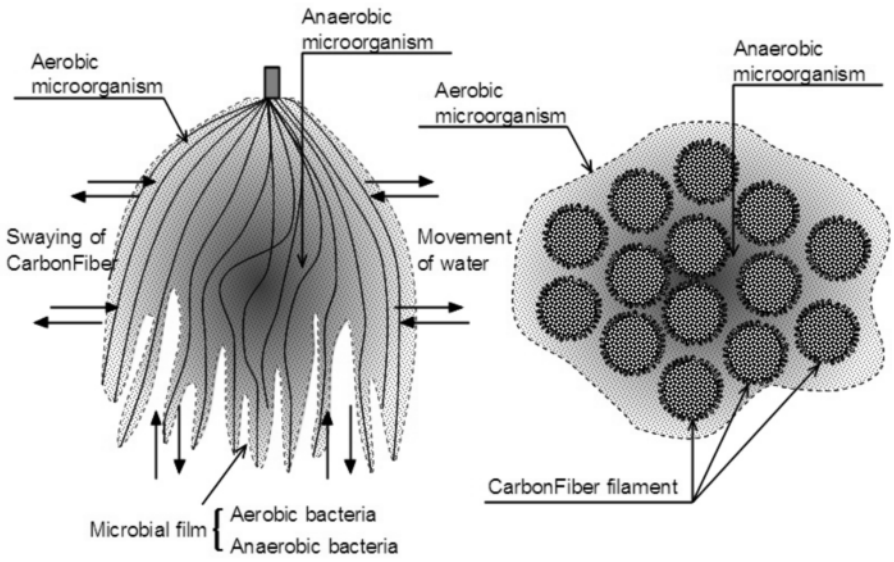


Figure 1. Mechanism of the sway of CarbonFiber

The following points are advantage of using CarbonFiber for water purification.

① High operation system on suspended substance

② A faster system of degradative treatment based on activation of organisms

③ Less polluted sludge and difficult to break away
④ Profound effect of denitrification by nitrification bacteria adhesion
⑤ Cost performance with electronic and low enviromental impactenvironment

Water purification using CarbonFiber improved in transillumination degree (SS), reduction of COD and BOD, total nitrogen (TN) and total phosphorus (TP) also improved numerically.

3. Installation place of CarbonFiber for water purification

Due to its characters, CarbonFiber for water purification material absorb various pollutants and microbes on the surface of CarbonFiber and purify water as biological activity of microbes. Eventually organic matter decomposed into carbon dioxide and water due to functions of decomposing and removing pollutants by microbe. Nitrogen spread over the atmosphere and clearance from the water.

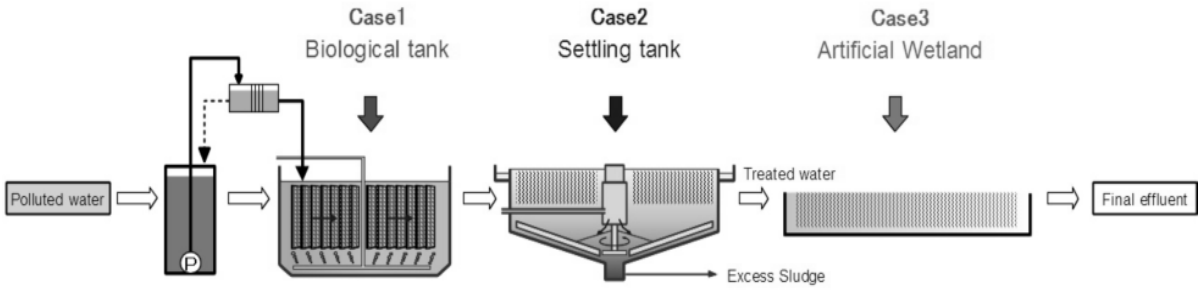


Figure 2. Installation place for Wastewater Treatment

3. 1 Environment water such as rivers and lakes

Water purification in rivers and lakes is a main issue from the beginning of invention of CarbonFiber for water purification material, effects are demonstrated in many fields. Although indigenous bacteria intrinsically exist in rivers and lakes to purify water, water contamination become advanced and purification does not function because of increase in inflow contaminants. Therefore, installing a carrier in water in order that microbes can adhere, then water purification function is restored by activating microbes and contacting with contaminants. This is complement and reinforcement of natural purification function of rivers and lakes, especially demonstrate power in case urban sewage such as residential wastewater and night soil inflow into rivers and lakes. Organic matter in sewage is suitable for proliferation of microbes, fixed microbes with CarbonFiber decrease amount of organic matter by predation and coexistence actively, nutrient source such as blue algae is quitted and its generation is inhibited because nitrobacteria decompose and remove nitrogen.

3. 2 Contact media for biological treatment

Residential wastewater, sewage and factory wastewater are mostly treated with biological treatment based on activated sludge method. Installing contact media which is a microbal carrier, a processing treatment function is improved, and contact oxidation method with contact media made from various material comes into use. Installing CarbonFiber as contact media in this contact oxidation method, processing function is considerably improved. Installation method of CarbonFibers is simple so that function of existed wastewater treatment is improved easily. It is often the case that examples of use for existed wastewater treatment are installing CarbonFiber to a calm flow precipitation separation tank, and stabilize final effluent.

3. 3 Artificial Wetland and Lagoon

Countries such as China, artificial wetland is installed as after process of wastewater treatment to improve water quality by vegetation. Installing CarbonFibers water purification material in this artificial wetland, treated water quality is improved.

It is only developed countries in the world that modern sewerage treatment and factory organic wastewater treatment are fully equipped. In developing countries, there are many treatments called lagoon method which depend on natural purification function. Recently, economic development causes problems of urbanization, processing function decline by more sewage than anticipated flowing into exist lagoon. Installing CarbonFiber in this lagoon, experiments of improving processing function has started.

4. Combined technique of CarbonFiber water quality purification

Although CarbonFiber is a superior contact media, there are some cases that it does not work well by condition. 3 following techniques are considered as measures.

① Circulate Aeration ＋A（Air）

It is mainly a function of aerobic bacterium that attach to CarbonFiber and decompose organic matter, however aerobic bacterias do not activate in environment which is poor in oxygen. Aerating is effective when there is little dissolved oxygen in water. In addition, processing effect is increased by circulating water by aeration, contacting CarbonFiber with pollutant.

② Microbial Supply ＋B（Bio）

CarbonFiber is easy to adhere microbes, however in environment that microbes do not exist or exist little, water quality purification does not progress. When blue algae exist in large quantities and zooplankton decreases in water, contamination become advanced. In this case, it is effective to supply microbe groups becoming a seed microbe.

③ Positive Ion Supply ＋C（Cation）

Because CarbonFiber, pollutants and microbes are charged negative, water purification is advanced when a positive ion is supplied to effect electrical neutralization. The positive ion is metal ion, and metal ion such as iron are minerals which are indispensable to ecosystem. Iron ion reacts with phosphate ion in water and forms iron phosphate and restrains increase of blue alga as nourishment for phytoplankton. Commonly metals are less soluble in water and does not ionize, it is ionized easily and eluted in water when installed in conjunction with CarbonFiber because electronegativity of CarbonFiber is bigger than metals.

5. Conclusion

Due to its superior characters of CarbonFiber, water purification effect of CarbonFiber water purification method in environmental water such as rivers and lakes can be obtained simply by installing CarbonFiber in water. At wastewater treatments where forced water purification operate, function is easily improved. Installing CarbonFiber in artificial wetland or lagoon where is a midpoint of enviromental water and wastewater treatments, it improves water purification function and safe, clean water could be obtained.

These effects are from characters of CarbonFiber which is a passive, sustainable method, and it does not require high maintenance and control cost, high amount of energy and medication. To improve this function further in the future, demands would increase and market would be expand by establishing compound technique with a design, construction method and other techniques.

Water pollution and water shortage has become a global, big problem in many developing countries because they give priority to economic development so that infrastructure maintenance does not catch up with it. CarbonFiber water purification method could become a solution of global common water problems, and its market is expected to expend.

■ Reference

1) "The Guidance For CarbonFiber Water Purification Method" -Enviromental Water Edition-
CarbonFiber Make Watr Method Association
2) "Development of the water environment maintenance technology using microbial adhesion phenomenon to soft tissue of CarbonFiber" Accomplishment report, Foundation of Gunma Regional Invention Center
3) Shinya Matsumoto, Akihito Ohtaki, and Katsutoshi Hori Environmental Science & Technology (2012)
CarbonFiber as an Excellent Support Material for Wastewater Treatment Biofilms