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The response to the aggravate impact of DOM caused by the increase in human activities on natural water body

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Abstract:

The dissolved organic matter (DOM) act as an important role of the whole aquatic ecosystem can provide not only the nutrients to the water body but also regard as an material cycle. The DOM can originates from numerous sources, including terrestrial source from oil and the allochthonous source which increase because of the human activities. The excess DON in water will cause the overdose nutrients in water in turn lead to the growth of the algae blooms. This will affect the oxygen level in the water body which is harmful to aquatic life. Finding the proper treatment to remove this DOM is essential for managing water quality, ensuring water safety. Although there are numerous existing treatments to remove this excess DOM in water, the high-cost of the method and the scale it can be used is still a limitation. The new method like the usage of the nanomaterial and the graphene seems a better way.

Keywords: Dissolved organic matter, Membrane filtration, Eutrophication.

1. Introduction

In the aquatic dissolved organic matter (DOM) is essential. DOM plays an important role in carbon biogeochemical cycle and water quality evolution of aquatic systems, use [1]. The dissolved organic carbon (DOC) which is the carbonaceous component of DOM is regarded as a substance which can pass through either a 0.45 or 0.7 μm filter [2]. It is the most common analysis to measure the concentration of the DOM. However, the accumulation of the DOM caused by the human and agriculture runoff in urban water bodies may lead to some harmful effects. The importance of the DOM is reflected by changing the microbial, mobilization and the cycling of the nutrient [3]. The change in DOM can in turn affect primary production, biodiversity, eutrophication [4], and drinking water quality it can even react with some metal oxides to from toxicity, as a result find a suitable method to remove these harmful compounds from the water body is essential. Although there are already some technologies used to treat DOM in water like the aeration activated carbon (GAC), they have some drawbacks like the high-cost or the scale problems. The aim of this article is to find a relatively good method for DOM treatment and propose some improvement measures.

2. Definition and Characteristics of

the DOM

DOM is a complex amalgam which consist of the dissolved molecules and the colloids the small particles float in the water of the organic compound in the aquatic origin and it is regarded as the central component of the biogeochemistry and the freshwater. DOM can not be regarded as a chemical solution nevertheless it is more like a colloidal suspension suspension [5]. DOM is a key source to provide the nutrient to the aquatic bacterial including the heterotrophic bacteria and metazooplankton [6]. However, not all chemical forms of the DOM can be regarded as the ailment of the organisms as the photochemical transformation of DOM may influence its bioavailability. The DOM is also defined as an organic material which can pass through the filter which is less than 0.7um and the molecular weight range from 100 to 100,00 Da [7].

The dissolved organic matter (DOM) in water bodies is regarded as a combination of the low molecular weight substances (e.g. organic acid) and the high molecular weight substances(e.g. humic acid), and this organic material is able to pass through the filter(0.45 μm).While DOM as a natural component, the sources can be divided into three kinds ,the allochthonous parts(mainly sourced from the vegetation decomposition), autochthonous parts (which is sourced from the respiration of planktonic) and factitious pats [8]. Nevertheless the DOM from autochtonous sources can degrade easily thus some of the DOM in water can be treated by the self-cleaning of the nature and we will focus on treating human-driven activity like agriculture and the urbanization which might magnify its presence in water bodies [9]. The use of the fertilizers and animal's manure will increase the concentration of the DOM as they flow into the river. In addition the city and industry wastewater may lead to the similar result attribute to the discharging of the organic-rich sewage.

Fig.1 is an example of the Poyang Lake and it can be divided into two parts. The low weight molecule (LWM) which is covered in blue and the high weight molecule (HWM) which is orange, respectively take the proportion of 43% and 57%. It can be seen that the HWM which is harder to be decomposed because of the stronger intermolecular force even account a larger proportion. Regardless of whether there is human intervention in this outcome, the high rate of large molecules means that DOM is more difficult to decompose, and the required time will be longer, ultimately leading to a series of potential threats to the surrounding environment.

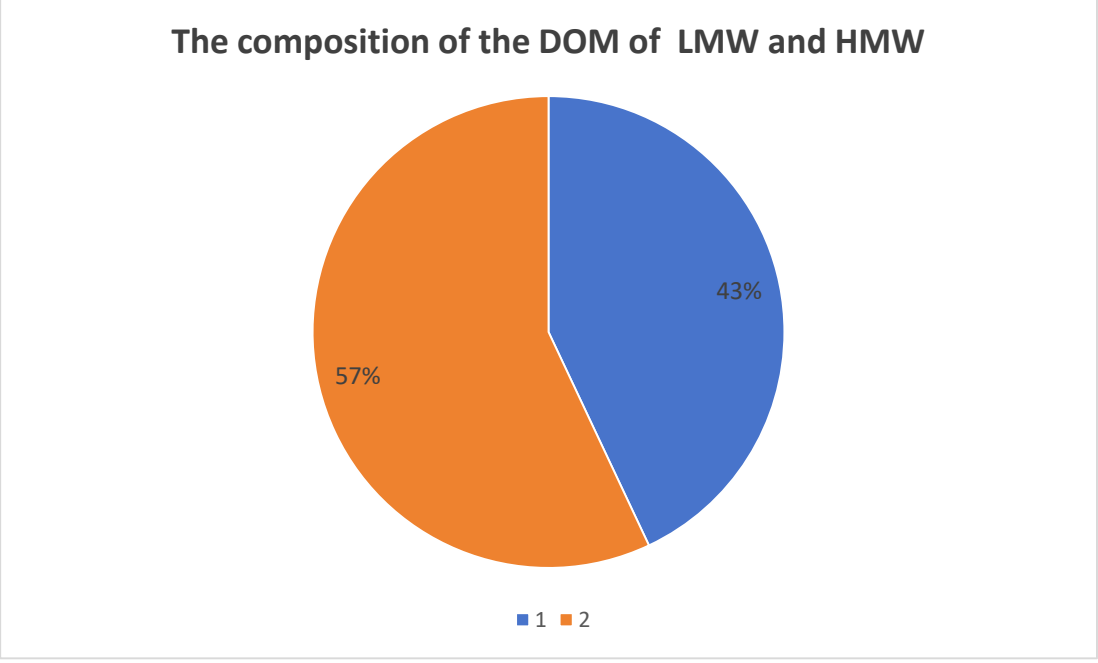

Fig1.The composition of the DOM [10]

The DOM originate from the soil organic with the rainfall and this will bring the excess nutrition pass through the mineral soil horizons. However, there is an evidence show that there is a decreasing trend witnessed in the HMW and increase in the LWM, moreover a decrease in the PH value of the water may also decrease the molecular weight [7]. The other source we mentioned which is allochthonous DOM, this is originated from the leaf litter and some

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particulate organic carbon, however the degradation of such DOM has never been assessed.[11] Microalgae is also a important source of the organic matter because they can absorb the solar energy and transfer them to the nutrients release to the surrounding water by photosynthesis reaction after the cell dead. Moreover, the photosynthetic reaction with fixed carbon is also released [12].

3 The Effect of the DOM on Nature

3.1 Eutrophication

The source of the DOM in water bodies usually comes from the migration of solutes in upstream water bodies and the degradation of artificial waste [13]. Most of the DOM contain the nutrients such as the nitrogen phosphorus and carbon. With the accumulation of excess organic molecules in calm water, harmful algal blooms become more and more frequent. This phenomenon is called eutrophication of water, which leads to the depletion of dissolved oxygen in the water. Advanced aquatic organisms suffocate and are killed in a short period of time. In the long run, eutrophication might deteriorate the local aquatic biosphere and even the climate system [14]. This will accumulate the inland water algal biomass which in turn can cause the increase in the autochthonous biological DOM thus increase the concentration of the DOM in water column. Moreover, the excess algal blooms will also reduce the water quality and lower the supply of the oxygen level led to problem such as dead zones. Most of the indigenous DOM consist of the humic condensates which face different degradation to microorganism. These compounds are able to absorb the peak of the UV-B range and the increase in oxidation reaction is witnessed in the DOM exposure to the sunlight.

In freshwater ecosystem, human activities accelerate the eutrophication is an essential and widespread problem. Various human activities such as the sewage disposal and the aquaculture may lead to not only the eutrophication but also may influence the bacterial communities [15]. The excessive nutrients such as the phosphorus and nitrogen are considered to aggravate the microbial growth limitation it is highly expected to be utilized frequently in the microbial loop [16]. DOM has the direct and indirect influence on people's lives as it will affect the food web directly which act as a fuel to the microbial -based food webs and the indirect aspects such as the altering light availability to the primary producers [17].

The excess nutrients will also influence the optical composition of the DOM. AS there is a large difference between the allochthonous which is regarded as the phytoplankton-derived DOM and the terrestrial-derived DOM, the trophic state may ride the concentration of the first type of the DOM as it provides the energy and nutrient to promote the growth of the algae and phytoplankton thus increase the proportion of the allochthonous in water [18].

3.2 The Reaction of the DOM to form Toxicity

The aquatic ecosystem is polluted by the metal oxides because of the agriculture runoff and the urban runoff. The organic compound will be brought from the land to the water bodies by irrigation [19]. Although DOM is regarded as a natural component, the increase in the human activities contribute to the increase in its presence [20]. When the DOM (such as Hydrocarbon and Aromatic Benzene) react with the metal oxide will produce toxic complexes and may be both harmful to the human and environmental health include carcinogenicity, respiration issue to human body and influence the health of aquatic organism by making the water toxic.

4 Treatment

4.1 Ordinary treatment

The first treatment to remove the DOM in water is by activated carbon with their strong absorption power. This method has already put in a large scale both in the city and industrial water treatment as in China as they are cheap. this activated carbon often has a huge surface area which DOM can be absorbed easily by their numerous sites. As a result the stability of the the activated carbon in the water treatment especially in the backwashing process [21].

To achieve this goal, the government need to pour a lot of powdered POC which is the most effective process into the water [22] otherwise they need to construct the huge facilities to intercept the DOM pouring in the river. Moreover, DOM has a limit absorption capacity once it get saturated it is less effective to remove the DOM. As the development of the low-cost of the preparation of the DOM is not very perfect, as a result it can be expansive to be purchased especially in the large scale applications.

4.2 Membrane filtration

As we mentioned, the type of the DOM can be divided in the HMW and LMW and the membrane filters have the capacity to separate and interrupt the substance based on their molecular weight. They have a large number of pore structures at the microscopic level that allow water molecules to pass through and have the ability to intercept large molecules in water. The advance of this material is once it is fouled, a new layer can replace it quickly [23]. However, the high operation cost in one of the drawbacks

using the membrane than other method of treatment as it need to be cleaned at regular intervals. The rejection capacity of a membrane is largely influenced by its pore size because the capacity is based on the electrostatic interaction [24]. As a result, the effectiveness is limited in the LMW of DOM lead to the incomplete removal of DOM in turn leading worse water quality

5 Further trend and suggestion

Although there are numerous method to remove DOM from the water, the high cost for operation is still a big problem. The cost issue is the main reason preventing the large-scale deployment of these measures: difficult to produce facilities. So below has promotion solution to degrade the DOM Adsorbents or membrane materials in water treatment systems should become more sensitive, more targeted towards tiny molecules, and not obstruct the flow of water molecules in order to address small molecule pollutants, such as microplastics. The usage of graphene or nanomaterials [25] is part of the solution: Because of its characteristics, graphene can be used in the sectors of membrane materials and adsorbents at the same time. [26] The cost of getting resources is lower than that of other materials because of their applicability in other high-end manufacturing areas. It is yet unknown how much it will cost to maintain graphene goods in the water treatment sector.

Using a photocatalyst—a material that speeds up a chemical reaction when exposed to light, generally ultraviolet or visible light-is the process of photocatalysis. When it comes to treating water, photocatalysis aids in the breakdown of organic pollutants like DOM. Studies have indicated that including catalysts, such titanium dioxide, into the sample can greatly enhance photocatalysis's efficiency [27]. This method is environment friendly as it can breakdown the DOM into non-toxic substance without the harmful addition. More over the TiO_2 used in the reaction is cheap and is possible to form the harmless CO2 and H2O ultimately. The high stability and the experiment condition which is easy to achieve prove this method is possible as well [27].

6. Conclusion

Overall, it is clear that the human activities are an important factor which accelerate the accumulation of the DOM in water body in turn affect the whole aquatic system as well. To prevent this situation, people have taken a serious of measures include using the activated carbon which can absorb the DOM on it or take the membrane material which prevent DOM passing through it. However, the high cost of the operation is still a serious problem. The new technology and improvement like the nanomaterials and the photocatalysis see more practical. More and more technological advancements are needed to enable people to adopt more affordable and efficient treatment methods, which might enhance the quality of the natural water around metropolitan areas. One of the key responsibilities of scientists is to develop a more efficient and reproducible form of government.

References

[1] Chen Z, Wen Y, Xiao M, et al. Characteristics of Dissolved Organic Matter Impacted by Different Land Use in Haihe River Watershed, China. Int J Environ Res Public Health. 2023, 20(3):2432.

[2] Ritson, J.P., Graham, N.J.D., Templeton, M.R., et al. The impact of climate change on the treatability of dissolved organic matter (DOM) in upland water supplies: A UK perspective. Science of The Total Environment, 2014, 473-474.

[3] Lu, Qingyuan, He, Ding, Pang, Yu, et al. Processing of dissolved organic matter from surface to sediment pore water in a temperate coastal wetland. Science of The Total Environment, 2020, 140491.

[4] Xenopoulos, M.A., Barnes, R.T., Boodoo, K.S. et al. How humans alter dissolved organic matter composition in freshwater: relevance for the Earth's biogeochemistry. Biogeochemistry, 2021, 154 : 323-348.

[5] Nebbioso Antonio, Piccolo Alessandro. Molecular characterization of dissolved organic matter (DOM): a critical review. Analytical and Bioanalytical Chemistry, 2013, 405(1):109-124.

[6] Barbara Sulzberger, Edith Durisch-Kaiser. Chemical characterization of dissolved organic matter (DOM): A prerequisite for understanding UV-induced changes of DOM absorption properties and bioavailability. , 2009, 71(2), 104-126.

[7] Aitkenhead-Peterson, J.A. Sources, Production, and Regulation of Allochthonous Dissolved Organic Matter Inputs to Surface Waters. Aquatic Ecosystems, 2003, 25-70.

[8] Fernando L. Rosario-Ortiz, Shane A. Snyder, I.H. (Mel) Suffet. Characterization of dissolved organic matter in drinking water sources impacted by multiple tributaries. Water Research, 2007, 41(18) :4115-4128.

[9] Shuhang Wang, Wenwen Wang, Junyi Chen, et al. Characteristics of Dissolved Organic Matter and Its Role in Lake Eutrophication at the Early Stage of Algal Bloomsâ: A Case Study of Lake Taihu, China. Water, 2020, 12(8) :2278.

[10] Li Yani, Xu Huacheng, Jiang Helong. Molecular weight distribution, fluorescence characteristics of dissolved organic matter and their effect on the distribution of heavy metals of Lake Poyang. Journal of Lake Science, 2020, 32(4):1029-1040.

[11] Meyer J., Wallace J. Eggert S. Leaf Litter as a Source of

ISSN 2959-6157

Dissolved Organic Carbon in Streams. Ecosystems, 1998, 1 : 240-249.

[12] Stefan Bertilsson, Jeremy B. Jones Jr. Supply of Dissolved Organic Matter to Aquatic Ecosystems. Aquatic Ecosystems, 2003 : 3-24.

[13] Jiang X, Liu D, Li J, et al.Eutrophication and salinization elevate the dissolved organic matter content in arid lakes. Environmental Research, 2023, 233: 116471.

[14] Yongqiang Zhou, Thomas A. Davidson, Xiaolong Yao, et al. How autochthonous dissolved organic matter responds to eutrophication and climate warming: Evidence from a cross-continental data analysis and experiments. Earth-Science Reviews, 2018, 185 :928-937.

[15] Lei Zhou, Yongqiang Zhou, Xiangming Tang, et al. Eutrophication alters bacterial co-occurrence networks and increases the importance of chromophoric dissolved organic matter composition. Limnology and Oceanography, 2021, 11756.

[16] Eero Asmala, Lumi Haraguchi, Stilg Markager, et al. Eutrophication Leads to Accumulation of Recalcitrant Autochthonous Organic Matter in Coastal Environment. Global Biogeochemical Cycles, 2018, 32(11): 1673-1687.

[17] Findlay Stuart, Sinsabaugh Robert L. Unravelling the sources and bioavailability of dissolved organic matter in lotic aquatic ecosystems. Marine and Freshwater Research, 1999, 50(8) : 781.

[18] Liu S., Hou J., Suo C., et al. Molecular-level composition of dissolved organic matter in distinct trophic states in Chinese lakes: implications for eutrophic lake management and the global carbon cycle. Water Research, 2022, 217, 118438.

[19] Kolya H, Kang CW. Toxicity of Metal Oxides, Dyes, and Dissolved Organic Matter in Water: Implications for the Environment and Human Health. Toxics, 2024, 12(2):111.

[20] Shen M. et al. Occurrence, Bioaccumulation, Metabolism and Ecotoxicity of Fluoroquinolones in the Aquatic Environment: A Review. Toxics, 2023, 11:966.

[21] Deqian Liu, Qiang Xie, Xiaoqing Huang, et al. Backwashing behavior and hydrodynamic performances of granular activated carbon blends. Environmental Research, 2020, 184 : 109302.

[22] Ittisupornrat Suda, Phihusut Doungkamon, Kitkaew Duangta et al. Performance of dissolved organic matter removal from membrane bioreactor effluent by magnetic powdered activated carbon. Journal of Environmental Management, 2019, 248 :109314.

[23] Marc Altman, Raphael Semiat, David Hasson. Removal of organic foulants from feed waters by dynamic membranes. Desalination, 1999, 125(1-3) : 65-75.

[24] A.W. Zularisam, A.F. Ismail, Razman Salim. Behaviours of natural organic matter in membrane filtration for surface water treatment-a review. Desalination, 2006, 194(1-3) : 211-231.

[25] A. Barhoum, K. Deshmukh, M.L. Garcia-Betancourt, et al. Nanocelluloses as sustainable membrane materials for separation and filtration technologies: Principles, opportunities, and challenges. Carbohydrate Polymers,2023, 137(1) : 121057.

[26] Joshi et al. Graphene oxide: the new membrane material Applied Materials Today Volume 1, Issue 1, November 2015, Pages 1-12

[27] Chen Zhao, Zhihua Wang, Chaoyang Wang, et al. Photocatalytic degradation of DOM in urban stormwater runoff with TiO_2 nanoparticles under UV light irradiation: EEM-PARAFAC analysis and influence of co-existing inorganic ions. Environmental Pollution, 2018, 243(A) : 177-188.