Scholar Publishing Group
Academic Journal of Environmental Biology
https://doi.org/10.38007/AJEB.2020.010401
ISSN 2789-8407 Vol. 1, Issue 4: 1-8

Nanotechnology in Environmental Biotechnology

Ernest Foomen*

Taif University, Saudi Arabia

**corresponding author*

Keywords: Nanotechnology, Environmental Biotechnology, River Water Pollution, Environmental Benefits

Abstract: In recent years, people have become more and more interested in biomonitoring. It is very important to clearly understand what happens to organisms when pollutants enter the environment, and the research of nanotechnology in the field of biomonitoring helps to achieve these Target. Environmental biotechnology has a wide range of applications. This paper takes water pollution control in the field of environmental biomonitoring as an example, uses nanobubble technology to remove and treat water pollution in a river, and analyzes the removal rate of this technology on water chemical oxygen demand, nitrogen, phosphorus, etc. It reflects the application effect of this technology in sewage treatment. Experiments show that the CODcr, NH4+-N, TN, and TP in the treated river all show a downward trend, and the removal rate is about 30%-50%, indicating that the nanobubble repair technology can improve the water quality of the river and achieve certain environmental benefits.

1. Introduction

Water pollution has become one of the most serious environmental problems, and pollutants such as toxic heavy metals, pesticides, nitrogen, phosphorus, anionic surfactants and detergents can be detected in water bodies, all of which are harmful to human health, aquatic animals and adverse effects on the ecosystem [1]. Therefore, this paper uses nanotechnology to deal with water pollution, which is of great significance for building a better environment.

At present, many scholars have carried out research on the application of nanotechnology in the field of environmental biotechnology. For example, a scholar synthesized a silver nanocluster using the interstitial isolation method, and used the silver nanocluster to detect heavy metal pollution in water. The template used for silver nanoclusters is inorganic glass [2]. In addition, zeolite is also a good template choice, it can provide a good interstitial, and it is also a highly porous negatively charged aluminosilicate crystalline material. These properties make it very easy for silver atoms to be incorporated into the pores, and the fluorescence-emitting silver nanoclusters can be synthesized under the induction of light [3]. A certain scholar constructed a sandwich-type biosensor using magnetic nanomaterial Fe3O4, captured dopamine through the interaction between catechol and iron ions, and then separated the Fe3O4 dopamine complex from the solution under the action of a magnetic field, and then achieved The purpose of analyzing the detection of dopamine [4]. A scholar used gold nano-labeled antibody to prepare an immunobiosensor for the detection and analysis of organophosphorus pesticide paraoxon, with a detection limit of 12 μg/L. The application of this biosensor can monitor soil pollution and reduce pesticide use [5]. The application of nanotechnology in environmental biotechnology has achieved good results, effectively solving a large number of environmental problems.

In this paper, several nanotechnologies are first introduced, and then a river is sampled to detect the water quality indicators of the river, and the nanobubble technology is used to remove river pollutants. Changes in the situation to verify whether nanobubble technology can be used to control water pollution.

2. Nanotechnology

Silver nanoclusters: Silver nanoclusters (AgNCs) refer to fluorescent nanomaterials composed of several silver atoms (usually 2-20) together with a size close to the Fermi wavelength (less than 2 nm) [6]. Compared with bulk metal materials, nano-scale metal materials have many special properties. With the continuous reduction of the size, the number of surface atoms/total atoms increases greatly. Due to insufficient coordination number and high surface energy, the surface of the material has a strong affinity, and it is easy to combine with other atoms to form a stable structure. As the size of the material is reduced to the nanometer level, the physicochemical properties of the material also change significantly [7-8]. Compared with bulk materials, nanomaterials have great differences in optics, mechanics, and magnetism. It can emit or quench fluorescence, generate SPR, be magnetic (Fe_3O_4 nanoparticles), enhance hardness, and change color (gold). Nanoparticles) and so on, this series of changes should be attributed to the small size effect of nanomaterials. As the particle size of the material decreases, the electronic energy level of the material also changes significantly. The silver nanocluster material is precisely because its size is too small (close to the Fermi wavelength), which leads to the breakage of electronic energy levels and finally emits fluorescence [9-10]. Although silver nanoclusters have been widely used, the luminescence mechanism of silver nanoclusters is still not well understood. Silver nanoclusters have been developed for more than ten years and are widely used in the detection of various molecules or ions by virtue of their advantages [11]. Compared with nucleic acid probes and quantum dots, silver nanoclusters have many obvious advantages when used in fluorescence analysis. Silver nanoclusters are simple to synthesize, do not require labeling, are nontoxic, and have high biocompatibility [12]. At present, there are some related reports using silver nanoclusters to detect mercury ions. For example, using DNA-synthesized silver nanoclusters to detect mercury ions and silver clusters synthesized with polymers as templates to detect mercury ions. Although these detection methods have achieved relatively ideal sensitivity, the detection of mercury ions using silver nanoclusters is based on the "turn-off" mode, which can easily lead to false positive results [13].

α-Fe_2O_3 nanomaterials: Different nanomaterials have different properties, and it is always difficult to use a single material in the design of electrochemical biosensors to give full play to its performance. Therefore, more and more researchers integrate various nanomaterials into Together, nanocomposites integrating multiple properties were synthesized [14–15]. Iron oxide-based nanomaterials have important characteristics such as small size and good magnetic properties, so they are widely used to remove heavy metal pollutants in water. The magnetic properties of iron oxide nanoparticles make the adsorbent easy to separate from the system, and iron oxide nanomaterials can be regenerated., can be reused. This enables iron oxide-based nanomaterials to serve as excellent and economical heavy metal adsorbents in water [16]. Some researchers have synthesized α-Fe_2O_3 nanoparticles with an average size of about 5nm, aggregated into a porous structure, and covered with high-affinity hydroxyl groups by a solvothermal method. The specific surface area is as high as 162m2/g. The adsorption capacities for As(II) and As(V) in water samples reached 95 mg/g and 47 mg/g, respectively, and in the presence of competing ions in the water samples, the selection of α-Fe_2O_3 nanoparticles for arsenic Sex is also particularly good [17-18].

Nano-bubble technology: It is a new type of aeration technology that can generate nano-level bubbles. Due to its small bubble diameter and high oxygen mass transfer rate, adsorption capacity and oxidation capacity, it is gradually used in the field of water treatment, but it is rarely used in the process of lake and river treatment [19-20].

3. Experimental Research

3.1. Research Objects

This article takes a river as an example. There are many large and small sewage outlets around the river. Due to eutrophication, the river water produces a large amount of duckweed and oily substances every day. Several obvious sewage outlets were found around the river, and the water quality discharged from these sewage outlets was also tested, and it was found that the river water body COD, nitrogen, phosphorus and other pollutants obviously exceeded the surface water class V water standard, which belongs to the state of heavy pollution.

3.2. Research Methods

In order to fully reflect the changes in the water quality of the river, according to the river topography and the location of the nanobubble machine, it was decided to select 6 points as the water sample collection points. Due to the large number of sampling points and slow changes in water quality, the sampling frequency is set to be once a week. In order to determine the representative adoption time, the variation law of river water quality in one day was investigated, and sampling was carried out at the sampling point every three hours. The results are shown in Table 1.

Table 1. Sampling water quality at different times in one day

	6 o'clock	9 o'clock	12 o'clock	15 o'clock	18 o'clock	21 o'clock	24 o'clock
COD	39	46.3	55	44.1	42	40	48.7
NH_4^+-N	27	31.8	34.2	25	26.3	33.6	35
TP	4.3	4.7	5.2	4.1	3.8	3.4	3.3

Since there are no factories around the river, almost no industrial wastewater flows in, and there is no leakage of industrial wastewater. The wastewater entering the river is mainly domestic sewage, and a large amount of domestic sewage is removed in the morning, resulting in a peak period of pollutants. The water sample at 12:00 is the most polluted time of the day, so the final choice was taken at 12:00.

The mass transfer efficiency of oxygen is an important factor affecting the DO value in water. In this experiment, the oxygen mass transfer efficiency of the nanobubble machine was also studied. The oxygen mass transfer efficiency of the bubbles generated by the nanobubble machine was characterized by measuring the oxygen mass transfer rate K_{La}. The higher the K_{La}, the higher the oxygen mass transfer efficiency. high.

$$dC/dt = K_{La}(C_1 - C_2) \quad (1)$$

Among them, dC/dt is the rate of change of dissolved oxygen concentration, C_1 is the saturated dissolved oxygen concentration in water, C is the dissolved oxygen concentration in water at time t, and $C_1 - C_2$ is the driving force of oxygen mass transfer.

Integrate equation (1) to get:

$$Ln(C_1 - C_2) - Ln(C_1 - C_0) = K_{La} \times \Delta t + \alpha \quad (2)$$

Among them, Δt is the aeration time, the dissolved oxygen concentration in the initial water, and α is a constant.

4. Application of Nanotechnology in Water Pollution Control

4.1. Removal Effect of Organic Pollutants in Water

The surface energy of nanobubbles itself can provide a certain oxidizing ability, which can oxidize some organic pollutants in the water; by increasing oxygen, the growth and reproduction of aquatic animals and plants and the growth and metabolism of aerobic microorganisms are enhanced, and the removal efficiency of CODcr is also improved accordingly. As shown in Figure 1, the average CODcr of the river before the treatment was about 38.5mg/L, and the CODcr of No. 1 and No. 2 sampling points were high, with an average of about 43mg/L. After the implementation of the nanobubble water body restoration technology, the water body The concentration of CODcr decreased significantly. After 30 days of treatment, the average CODcr in the water body decreased by 22.09% to 33.5mg/L. After 90 days of treatment, the average CODcr in the water body dropped to 21mg/L, which was 22mg/L lower than that before treatment. And in the process of treatment from 60 days to 90 days, the CODcr of the water body is kept below 25mg/L stably, and the CODcr index reaches the Class IV water standard in the surface water quality standard (CODcr≤30mg/L). The CODcr of No. 3 and No. 4 sampling points was the lowest, and the CODcr reached 15.8 mg/L after 90 days of treatment, and the removal rate was 55.11%.

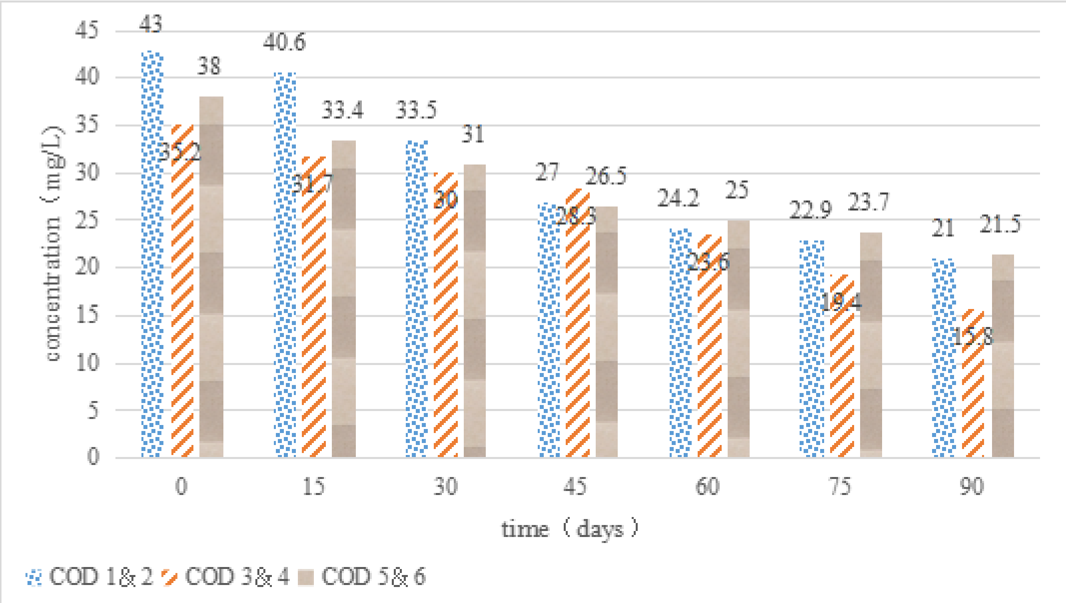

Figure 1. Changes in CODcr

4.2. Removal Effect of Nitrogen in Water

Nitrogen is an important element for phytoplankton to synthesize protein and chlorophyll, and a large amount of nitrogen enters the water body, which is an important cause of water eutrophication. The river is in a state of severe eutrophication. The average concentration of ammonia nitrogen in the water body reaches 23.5mg/L, and the average total nitrogen concentration is about 27.4mg/L, far exceeding the surface water class V standard (ammonia nitrogen≤2mg/L, total nitrogen≤ 2mg/L L). After the comprehensive treatment of nano-bubble water body restoration technology, the ammonia nitrogen and total nitrogen in the river water body have dropped significantly. According to the data of the 6 sampling points, the river water is mainly composed of inorganic nitrogen, and organic nitrogen accounts for a small part. This is because the main pollution source of the river is domestic sewage and a large amount of septic tank wastewater is discharged.

Table 2. Changes in ammonia nitrogen

	0	15	30	45	60	75	90
NH_4^+-N 1&2	26	25	22.8	18.5	16.2	15.4	13.3
NH_4^+-N 3&4	24.7	26.3	24	21.9	20	18.8	16
NH_4^+-N 5&6	23	22.6	18.7	15	14.2	13	11.5

From the data in Table 2, it can be seen that due to the different pollutant components of the pollution sources around the river, the ammonia nitrogen in the sampling points No. 5 and No. 6 is lower, but the change trend of ammonia nitrogen at the sampling points is roughly the same. Ammonia nitrogen is the main body of nitrogen in lake water. With the treatment of nanobubble water body restoration technology, ammonia nitrogen at sampling points 5 and 6 did not change much in the first 15 days, but began to decline on the 30th day, with an average concentration of 18.7 mg. /L, and with the passage of time, the ammonia nitrogen concentration in the water continued to decrease, and it dropped to 11.5 mg/L on the 90th day, a relative decrease of 50%. Although the nanobubble machine can increase the dissolved oxygen in the water in a short time, the microbial system does not change rapidly, so the early concentration of ammonia nitrogen does not decrease significantly. Since the river has not implemented any pollution interception measures, coupled with the accumulation of high pollution loads for a long time, there is a large amount of endogenous nitrogen pollution in the sediment, so it is difficult for the ammonia nitrogen to eventually be reduced to the V-class water standard.

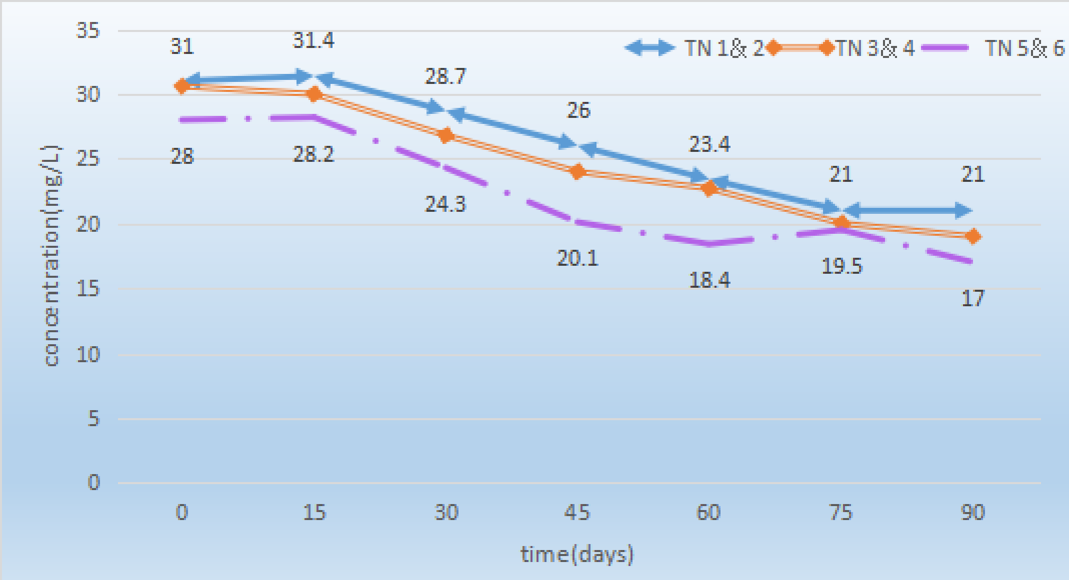

Figure 2. Changes in total nitrogen

It can be seen from the data in Figure 2 that the overall nitrogen showed a downward trend. However, the total nitrogen concentration of No. 1 and No. 2, No. 5 and No. 6 sampling points increased slightly in the first 15 days of treatment, and began to decline after 15 days. Compared with the first treatment, the relative decrease was 32.26% and 39.29%.

4.3. Removal Effect of Phosphorus in Water

Phosphorus in river water mainly enters the river through domestic sewage and farmland wastewater containing pesticides through pipelines or surface runoff, and when excessive phosphorus enters the water body, it will cause the water body to be over-trophic and lead to pollution.

Table 3. Changes in total phosphorus

	0	15	30	45	60	75	90
TP 1&2	4.2	3.8	3.5	3.1	2.7	2.4	2
TP 3&4	3.9	3.8	3.2	2.8	2.7	2.1	1.7
TP 5&6	3.5	3.4	2.9	2.4	2.15	1.5	1.45

Because the river contains almost all the surrounding domestic sewage, the total phosphorus concentration is seriously exceeding the standard. As shown in Table 3, the total phosphorus of No. 1 and No. 2 sampling points is as high as 4.2 mg/L. The total phosphorus concentration of No. 5 and No. 6 sampling points is lower than that of other sampling points, and the total phosphorus concentration and change trend of each sampling point are not much different as a whole. After three months of treatment, the total phosphorus concentration has been obtained. Significant decrease, the final average dropped to about 1.7mg/L, and the average removal rate of total phosphorus in the whole process was 55.65%. It is proved that the nanobubble water remediation technology has obvious ability to remove phosphorus in river water.

5. Conclusion

This paper mainly studies the response of river water quality to the nanobubble water remediation technology. Within three months of the implementation of the technology, the river water quality has been significantly improved. The concentrations of ammonia nitrogen, total nitrogen and total phosphorus in the water body all showed a downward trend, and the removal ability of organic pollutants, nitrogen and phosphorus in the water body was very high. In short, the nanobubble technology has a good treatment effect on eutrophic river water, and greatly improves the water quality.

Funding

This article is not supported by any foundation.

Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

References

[1] Vvtp A, Sw A, Me A, et al. Tree gum-based renewable materials: Sustainable applications in nanotechnology, biomedical and environmental fields - ScienceDirect. Biotechnology Advances, 2018, 36(7):1984-2016. https://doi.org/10.1016/j.biotechadv.2018.08.008

[2] Lefebvre X, Palmeri J, David P. Nanofiltration Theory: An Analytic Approach for Single Salts. Journal of Physical Chemistry B, 2018, 108(43):16811-16824. https://doi.org/10.1021/jp048631t

[3] Schwarz-Plaschg C. Nanotechnology is like ... The rhetorical roles of analogies in public engagement. Public understanding of science, 2018, 27(2):153-167.

[4] Zarrintaj P, Ahmadi Z, Hosseinnezhad M, et al. Photosensitizers in medicine: Does nanotechnology make a difference?. Materials Today: Proceedings, 2018, 5(7):15836-15844.

[5] Mnif I, Ellouz-Chaabouni S, Ghribi D. Glycolipid Biosurfactants, Main Classes, Functional Properties and Related Potential Applications in Environmental Biotechnology. Journal of Polymers and the Environment, 2018, 26(5):2192-2206.

[6] Kulikowska D, Gusiatin Z M. Effect Of Temperature Conditions On Cu, Ni, Zn And Fe Complexation By Humic Substances During Sewage Sludge Composting. Environmental Engineering & Management Journal, 2019, 18(1):213-223. https://doi.org/10.30638/eemj.2019.021

[7] Guest J, Novak P, Wang A. Anaerobic technology. Environmental Science: Water Research &

Technology, 2018, 4(11):1720-1720. https://doi.org/10.1039/C8EW90040J

[8] Pandiyan, Rajesh, Ayyaru, et al. Non-toxic properties of TiO2 and STiO2 nanocomposite PES ultrafiltration membranes for application in membrane-based environmental biotechnology. Ecotoxicology and Environmental Safety, 2018, 158(Aug.):248-255.

[9] Akhtar N, Gupta K, Goyal D, et al. Lignocellulosic Biomass Characteristics For Bioenergy Application: An Overview. Environmental engineering and management journal, 2019, 18(2):367-383. https://doi.org/10.30638/eemj.2019.035

[10] Setyawati M I, Leong D T, Zheng K, et al. Antimicrobial silver nanomaterials. Coordination Chemistry Reviews, 2018, 357(FEB.):1-17. https://doi.org/10.1016/j.ccr.2017.11.019

[11] Astruc D, Lu F. Nanomaterials for removal of toxic elements from water. Coordination Chemistry Reviews, 2018, 356(feb.):147-164.

[12] Ovid'Ko I A, Valiev R Z, Zhu Y T. Review on superior strength and enhanced ductility of metallic nanomaterials. Progress in Materials Science, 2018, 94(MAY):462-540.

[13] Ali M, Peng F, Younus H A, et al. Fuel economy in gasoline engines using Al2O3/TiO2 nanomaterials as nanolubricant additives. Applied Energy, 2018, 211(FEB.1):461-478.

[14] Rodela R, Swartling A G. Environmental governance in an increasingly complex world: Reflections on transdisciplinary collaborations for knowledge coproduction and learning. European environment, 2019, 29(2):83-86. https://doi.org/10.1002/eet.1842

[15] Khosravi M R, Samadi S. BL-ALM: A Blind Scalable Edge-Guided Reconstruction Filter for Smart Environmental Monitoring Through Green IoMT-UAV Networks. IEEE Transactions on Cognitive Communicatios and Networking, 2020, 5(2):727-736.

[16] Yoon S J, Nam Y S, Lee Y, et al. A dual colorimetric probe for rapid environmental monitoring of Hg 2+ and As 3+ using gold nanoparticles functionalized with d -penicillamine. RSC Advances, 2020, 11(10):5456-5465. https://doi.org/10.1039/D0RA08525A

[17] Vieira L R, Morgado F, Nogueira A, et al. Integrated multivariate approach of ecological and ecotoxicological parameters in coastal environmental monitoring studies. Ecological Indicators, 2018, 95P2(DEC.):1128-1142.

[18] Holland, Robert C. Sandia National Laboratories, California Environmental Monitoring Program annual report for 2011.. Archives of Disease in Childhood, 2018, 100(Suppl 3):A236-A237.

[19] Martin-Garin A, Millan-Garcia J A, Bairi A, et al. Environmental monitoring system based on an open source platform and the internet of things. Automation in Construction, 2018, 87(MAR.):201-214. https://doi.org/10.1016/j.autcon.2017.12.017

[20] Ahmadzada S, Ende J A, Alvarado R, et al. Responses of Well-differentiated Human Sinonasal Epithelial Cells to Allergen Exposure and Environmental Pollution in Chronic Rhinosinusitis. American Journal of Rhinology & Allergy, 2019, 33(6):624-633. https://doi.org/10.1177/1945892419853103