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Advanced Treatment of Urban Sewage Sludge by Upflow Aerated Biological Filter

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Abstract: In today's world, due to industrial and agricultural development, population explosion, water abuse and pollution, the water crisis caused by water shortage and water pollution has become a complex problem faced by most countries in terms of policy, economy and society. As a new type of wastewater treatment process, biological filter has been widely used at home and abroad. The purpose of this work is to study the characteristics of starting the hanging film culture after the advanced treatment of urban sewage sludge by aerated biological up-flow filter. By changing the ammonia nitrogen concentration, hydraulic retention time and filter material filling height, the treatment efficiency of the aerated biological filter was studied, and the optimal process operating conditions were determined and optimized. Using aerated biological up-flow filter to treat sewage sludge in M city, the COD removal rate is the lowest 30%, the highest removal rate is 47%; the turbidity removal results show that the highest removal rate is 92%, and the lower removal rate is 71%.

1. Introduction

With the rapid development of urbanization and industrialization in our country, our demand for water resources has also become larger and larger. This background makes sewage treatment begin to be paid attention to, and its status is equal to that of production and supply of tap water [1]. In recent years, in the sewage treatment industry, my country's development momentum is very strong. The specific performance is that the ability to treat sewage has become stronger and stronger, and the most intuitive sewage treatment rate has become higher and higher. The volume of treated sewage has also become larger. Therefore, how to protect water resources and prevent water pollution is an urgent task for all countries in the world to solve the problem of water shortage [2].

Reclaimed water reuse technology has been widely used overseas since the 1960s. Varma V S studied the correlation between the aeration effect and the mixing effect of compost materials during the composting process of water hyacinth under different aeration conditions. Trial 1 was run in agitation mode, Trial 2 was run in passive mode, and Trials 3 and 4 were performed with forced aeration conditions at different aeration intervals. Composts were run for 30 days, and changes in temperature and pH patterns, volatile solids reduction, and nitrogen conversion were associated with different composts. Due to the proper combination of waste and proper composting, a higher degradation rate of water hyacinth was observed in Trial 2. Nitrogen and phosphorus levels were observed to increase at the end of composting. Furthermore, we observed lower OUR and CO2 release rates due to higher organic matter degradation rates, indicating the stability of the compost over 30 days [3]. Nguyen A T Q investigated the dissolution properties of phytolithic ash obtained by dry ashing of straw at 400, 600 and 800 ℃. Nutrient (K, P, Ca, Mg) release was highly dependent on the overall dissolution of phytolith ash over a 6-day time span. CO2 significantly reduced the dissolution rate of phytolith ash, but increased the release rate of cationic and anionic nutrients. Aeration with CO2 shifts the carbonate balance (H2CO3, HCO3- and CO32-) towards H2CO3, lowering the pH of the solution and thus reducing the rate of phytolith dissolution. After this, enhanced H+ exchange promoted the release of nutrients from the phytolith ash. This indicates the different responses of phytoliths and the nutrients they absorb to CO2, and provides better insights into the fate of soil phytoliths and trends in the nutrient budget of straw phytoliths in soils [4]. Porte H evaluated process performance and determined the microbial community structure of two laboratory-scale, thermophilic trickle-flow biofilter reactors for the biomethanation of hydrogen and carbon dioxide for a total of 94 days. Stable and stable operation is achieved with a single pass of airflow. The quality of the output gas (>97%) is comparable to the methane purity achieved by a commercial biogas purification system that meets the specifications for alternative natural gas. At a hydrogen loading rate of 7.2 L-H2/(L-R center point d), the methane productivity of the reactor reached >1.7 L-CH4/(L-R center point d) [5]. These studies provide a theoretical basis for the research and application of biological aerated filters.

In this paper, the up-flow aerated biological filter is applied to the advanced treatment of urban sewage sludge. The aerated biological filter is easy to manage and has the characteristics of strong load and vibration resistance. This paper studies the characteristics of advanced treatment of urban sewage sludge by aerated biological anode filter, finds a suitable sewage treatment technology, and realizes a large number of renewable resources. It will play an important role in maintaining sustainable economic development, with far-reaching social and economic benefits.

2. Research on Upflow Aerated Biological Filter

2.1. Advanced Sewage Treatment Technology

(1) Activated carbon adsorption technology

Activated carbon adsorption technology is often used in advanced treatment of domestic sewage, because the removal rate of activated carbon reaches more than 70%, which can effectively reduce the odor, color, chlorinated organic compounds, heavy metals and other pollution indicators in sewage at low cost, and it is easy to control. However, the activated carbon adsorption technology has high construction and maintenance costs [6-7].

(2) Membrane separation technology membrane

Separation technology is a water treatment method that uses a semi-permeable membrane to intercept impurities in domestic sewage and remove various pollutants. Its characteristic is that there is no phase change in the process of mechanical screening, and the driving force can be obtained under a certain pressure, and a higher removal effect can be obtained. With the development of membrane treatment technology, the commonly used methods are microfiltration, reverse osmosis, ultrafiltration and nanofiltration [8-9].

(3) Aerated biological filter process

Gas biological filter process is a new type of biofilm treatment process developed on the basis of biological contact oxidation and submerged biological filter process. This technology combines the biodegradability of biofilms and the physical retention of the packaging layer, because of its high efficiency and economy, small footprint, and high removal efficiency of SS, ammonia nitrogen, COD and BOD [10-11].

2.2. The Principle of Biological Aerated Filter to Purify Organic Wastewater

When filtration and aeration work, the first layer of microorganisms is attached to the surface of the carrier, the wastewater flows through the surface of the carrier through the adsorption of organic elements, and oxygen diffuses into the biofilm and undergoes oxidation. In the film, the destruction of waste. In the biofilter, impurities, dissolved oxygen and many important elements first diffuse to the surface of the biofilm through the water layer, and then penetrate into the interior of the biofilm, which not only maintains the growth of organisms in the membrane, but also diffuses. and spread widely. Diffusion in biofilms. Alternatively, soil contamination can also be digested and transformed by biofilms, eventually producing many metabolites [12-13]. In the outer layer of the biofilm, the biofilm layer is formed by aerobic microorganisms. Organic matter, often forming a facultative anaerobic environment. Here, bacteria are permanently present, have poor adhesion to the material, and are easily released [14-15].

2.3. Properties of Major Pollutants

(1) Organic pollutants

Some toxic and harmful substances are not only difficult to reduce, but also have bioaccumulation, and the three main factors (carcinogenic, teratogenic, and mutagenic) are very harmful to public health. It most commonly reacts with liquid chlorine to form trihalomethanes (THM), haloacetic acids (HAA) and other halogenated pesticide products, many of which have been shown to cause cancer in laboratory animals. The main reason is that the humic acid, fulvic acid and other trihalomethane precursors in the raw water will produce trihalomethanes during the chlorination process of water [16-17].

(2) Nitrogen

Nitrogen exists in water in the form of organic nitrogen, ammonia, nitrite and salt, and when iron salts are used as filters, the removal rate of ammonia nitrogen is very low. Allowing nitrifying bacteria to grow, nitrifying bacteria and the organics released by ammonia can cause odor problems. The production of chloramines from ammonia also consumes chlorine to remove odors, reducing the effectiveness of disinfectants. Drinking water with high concentrations of nitrates and nitrites can cause two harms to the human body: the accumulation of nitrites replaces oxygen in red blood cells, which eventually leads to respiration; ingestion of high concentrations of nitrates can lead to toxicity, i.e. cancer [18].

(3) Iron, manganese:

Water with high iron and manganese content has an odor and can produce reddish-brown or even sediment that discolors washed clothes.

3. Experimental Design of Advanced Treatment of Municipal Sewage Sludge

3.1. Test Water

The research object of this experiment is M city sewage sludge. In the pilot test, the prepared water body was used for research, and the influent water mainly simulated the nitrogen and phosphorus pollution in the urban sewage sludge, and other water quality factors were not considered in the pilot test. During the membrane culture stage of the aerated biological filter, ammonium chloride was added to the dechlorinated tap water, and the pH was adjusted with sodium bicarbonate and dilute hydrochloric acid. The influent water with ammonia nitrogen concentration of 25mg/L, pH of 6 to 8 and alkalinity of about 200mg/L was prepared.

3.2. Selection of Filter Media

The filter material is at the core of the aerated biological filter. In this paper, 2~4mm zeolite and 2~4mm volcanic rock are used as the filling filter material in this experiment, and the filter material is washed repeatedly before filling. By setting up three groups of experiments of single-layer zeolite BAF, single-layer volcanic rock BAF and zeolite-volcanic double-layer BAF, the operation effects of the three groups of experiments were investigated respectively. The performance parameters of the two filter media are shown in Table 1:

Table 1. Performance parameters of filter media

Filter name	Filter particle size (mm)	Porosity (%)	Bulk density (kg/m^3)
Volcanic rock	2~4	53.41	740
Zeolite	2~4	52.14	950

3.3.V Detection Indicators and Analysis Methods

The test analysis indicators are: CODCr, NH3-N and turbidity. The detection methods used are potassium dichromate method, titration method and turbidimeter method respectively. The experimental instruments used mainly include reflux device, distillation device, WG-71 electric heating Blast drying furnace and WGZ-200 turbidity meter, etc. When sewage flows through the filter tank, the rate of decrease of pollutant concentration, that is, the amount of pollutants removed per unit of filter bed height (measured by concentration) is proportional to the concentration of the pollutant. points:

$$\ln \frac{\rho_s}{\rho_{s0}} = -K\rho_S \tag{1}$$

Where h represents the depth from the surface of the filter bed; K represents the coefficient of the treatment efficiency of the BAF filter.

The K value is the same as the nature of sewage, and can be obtained from the following formula:

$$K = K'\rho_{S0}{}^{m}(Q/A)^{n} \tag{2}$$

In the formula, m represents the coefficient related to the influent water quality.

4. Analysis and Research on Sewage Sludge Treatment by Up-flow Aerated Biological Filter

4.1. The Effect of Removing COD

Although COD is not an identification indicator of sewage sludge, excessive COD concentration will lead to black odor phenomenon in rivers, and reducing the concentration of organic matter can eliminate the black odor phenomenon well. The removal effect of COD on urban sewage sludge is shown in Table 2.

Table 2. COD removal effect

Time/d	10	20	30	40	50
Water intake (mg/L)	15	11	30	20	10
Out of water (mg/L)	7	5	15	12	7
Removal rate (%)	40	47	30	33	35

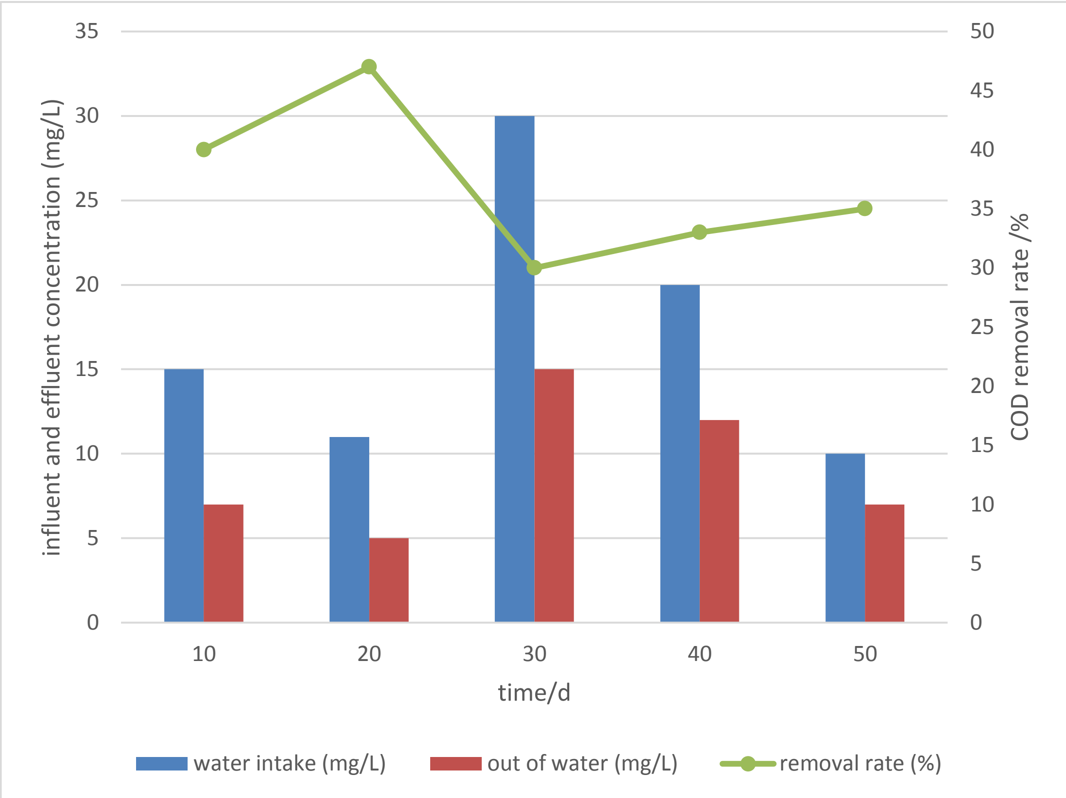

Figure 1. COD removal effect diagram

As shown in Figure 2, the overall operation effect of the integrated equipment is good, the minimum COD removal rate is 30%, and the maximum removal rate is 47%. In the early stage of operation, due to the large fluctuation of water quality, the COD removal rate also fluctuated to a certain extent. At the same time, it can be found that when the COD influent concentration is high, the removal rate will not decrease. The reason is that the organic concentration in the water body increases, and the microorganisms in the equipment have sufficient nutrient sources and proliferate in large quantities, which can effectively remove the sewage sludge. Based on the above analysis, the integrated equipment has a stable COD removal capacity. Although the influent concentration fluctuates greatly, the effluent value meets the standard of surface IV water. In order to further improve the COD removal capacity of the equipment, it is necessary to prolong the hydraulic retention time, which cannot achieve the expectation of quickly alleviating the black and odor phenomenon. From an engineering point of view, the treatment effect of the equipment can meet the requirements.

4.2. The Effect of Removing Turbidity

Turbidity, as one of the sensory indicators of water, reflects the number and size of suspended particles in the water. In the case of high turbidity, on the one hand, it is easy to cause the water body to turn black, and on the other hand, it is not conducive to the removal of ammonia nitrogen in the water by microorganisms. Therefore, turbidity is also an important monitoring indicator in the process of sewage sludge treatment. The removal effect of the combined process on the turbidity of urban sewage sludge is shown in Table 3.

Table 3. Turbidity removal effect

Time/d	10	20	30	40	50
Water intake (NTU)	17	27	45	28	27
Out of water (NTU)	3	5	2	6	5
Removal rate (%)	91	92	71	83	90

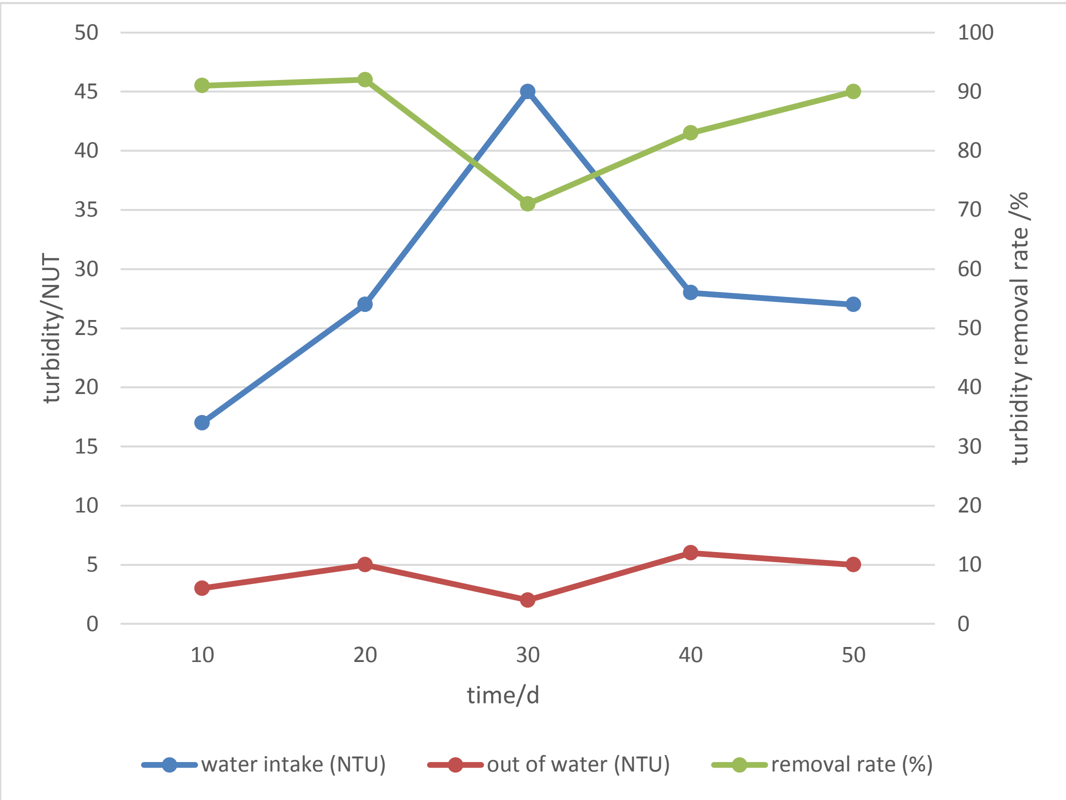

Figure 2. Turbidity removal effect diagram

It can be seen from Figure 2 that the turbidity value of the water body fluctuates greatly, the turbidity range of the influent is 17~45NTU, the turbidity range of the effluent is 2~6NTU, the highest removal rate is 92%, and the lowest removal rate is 71%. In most cases, the turbidity removal rate was maintained around 90%. The reason for the occasional lower removal rate is that the backwash of the equipment is not carried out in time, so the turbidity value of the effluent will be high. Based on the above analysis, the integrated equipment relies on physical filtration and biological adsorption, which can play a better role in removing turbidity.

5. Conclusion

Based on the analysis of the characteristics of the advanced treatment of urban sewage sludge in the up-flow aerated biological filter, this paper designs the COD and turbidity removal effect experiments of the sewage sludge. The results show that the up-flow aerated biological filter can play a better role. Good turbidity removal effect. Aeration process is one of the most effective and economical treatment methods to solve these problems. It can overcome some shortcomings of the traditional activated sludge process, such as: large investment, low production load, frequent sludge bulking, slow start-up, slow response to shock loads, etc. Therefore, it is very important to study the aerated biological filter as a high-performance, low-energy water treatment technology with low energy consumption and low floor space.

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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] Weaver J E, Himmel W J . Relation Of Increased Water Content And Decreased Aeration To Root Development In Hydrophytes. Plant Physiology, 2019, 5(1):69-92. https://doi.org/10.1104/pp.5.1.69

[2] Treesubsuntorn C, Thiravetyan P . Botanical Biofilter for Indoor Toluene Removal and Reduction of Carbon dioxide Emission under Low Light Intensity by Using Mixed C3 and CAM Plants. Journal of Cleaner Production, 2018, 194(SEP.1):94-100.

[3] Varma V S, Prasad R, Deb S, et al. Effects of Aeration During Pile Composting of Water Hyacinth Operated at Agitated, Passive and Forced Aerated Condition. Waste and Biomass Valorization, 2018, 9(8):1339-1347. https://doi.org/10.1007/s12649-017-9876-2

[4] Nguyen A T Q, Nguyen A M, Nguyen M T, et al. The regulatory role of CO2on nutrient releases from ashed rice straw phytoliths. Biogeochemistry, 2021, 160(1):35-47.

[5] Porte H, Kougias P G, Alfaro N, et al. Process performance and microbial community structure

in thermophilic trickling biofilter reactors for biogas upgrading. The Science of the Total Environment, 2019, 655(MAR.10):529-538.

[6] Valdez-Castillo M, Saucedo-Lucero J O, Villalobos-Romero K L, et al. Steady-state operation of a biofilter coupled with photocatalytic control of bacterial bioaerosol emissions. Environmental Science and Pollution Research, 2021, 28(3):1-11.

[7] Mckie M J, Ziv-El M C, Taylor-Edmonds L, et al. Biofilter scaling procedures for organics removal: A potential alternative to piloting. Water Research, 2019, 151(MAR.15):87-97. https://doi.org/10.1016/j.watres.2018.12.006

[8] Saucedo-Lucero J O, Revah S . Monitoring key organic indoor pollutants and their elimination in a biotrickling biofilter. Environmental Science and Pollution Research, 2018, 25(10):9806-9816.

[9] Subari F, Kamaruzzaman M A, Abdullah S S, et al. Simultaneous Removal of Ammonium and Manganese in Slow Sand Biofilter (SSB) by Naturally Grown Bacteria from Lake Water and Its Diverse Microbial Community. Journal of Environmental Chemical Engineering, 2018, 6(5):6351-6358. https://doi.org/10.1016/j.jece.2018.09.053

[10] Terry, Leigh, G, et al. Biodegradable organic matter and rapid-rate biofilter performance: A review. Water research: A journal of the international water association, 2018, 128(Jan.1):234-245.

[11] Khorsandi H, Gholizadeh M, Aghapour A A . Catechol biodegradation by a novel hybrid anoxic biofilter (HAB). Environmental Technology, 2018, 41(7):1-21.

[12] Salini N G, Antony R . The heterostructured nanocomposite of EPS/PVA/Ag-TiO2 for sewage treatment by COD removal. Emergent Materials, 2021, 5(2):369-379.

[13] Yamane T, Yoshida N, Sugioka M . Estimation of total energy requirement for sewage treatment by a microbial fuel cell with a one-meter air-cathode assuming Michaelis–Menten COD degradation. RSC Advances, 2021, 11(33):20036-20045. https://doi.org/10.1039/D1RA03061B

[14] Perkins R, Whitehead M, Goulson D . Dead in the water: comment on "Development of an aquatic exposure assessment model for imidacloprid in sewage treatment plant discharges arising from use of veterinary medicinal products". Environmental Sciences Europe, 2021, 33(1):1-6.

[15] Valdez-Castillo M, Saucedo-Lucero J O, Villalobos-Romero K L, et al. Steady-state operation of a biofilter coupled with photocatalytic control of bacterial bioaerosol emissions. Environmental Science and Pollution Research, 2021, 28(3):1-11.

[16] Devault D A, Amalric L, Bristeau S, et al. Removal efficiency of emerging micropollutants in biofilter wastewater treatment plants in tropical areas. Environmental Science and Pollution Research, 2021, 28(15):1-27. https://doi.org/10.1007/s11356-020-10868-z

[17] Siswanto D, Permana B H, Treesubsuntorn C, et al. Sansevieria trifasciata and Chlorophytum comosum botanical biofilter for cigarette smoke phytoremediation in a pilot-scale experiment—evaluation of multi-pollutant removal efficiency and CO2 emission. Air Quality, Atmosphere & Health, 2020, 13(1):109-117. https://doi.org/10.1007/s11869-019-00775-9

[18] Elikten H, Kuzu S L, Saral A, et al. Performance evaluation of a full-scale open bed biolter through on-site measurements and CFD analyses. Process Safety and Environmental Protection, 2021, 152(22):692-700. https://doi.org/10.1016/j.psep.2021.06.047