Exploration on the technology for ozone reduction in urban sewage treatment

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Abstract. With the rapid development of China's economy, urban water consumption is increasing. However, sewage treatment plants will produce large amounts of sludge after treatment of sewage. Generally, and the sludge treatment costs are relatively high. Therefore, the problem about how to deal with the sewage sludge becomes the hot issues. Municipal waste water treatment plant produces a lot of sludge. This paper summarized the abroad study of ozonation minimization technology. Introduction and discussion were made on the principle of ozonated efficiency of sludge minimization, the efficiency of sludge minimization and the relationship between efficiency and ozone dosage, as well the effect of return sludge ozonated on waste water treatment running and the sludge setting and the dewatering characteristic. The economic estimation was also made on this technology. It's showed that sludge minimization technology exhibits extensive application foreground.

1. Introduction
With the rapid development of China's economy, urban water consumption is increasing. However, sewage treatment plants will produce large amounts of sludge after treatment of sewage. Generally, and the sludge treatment costs are relatively high. Therefore, the problem about how to deal with the sewage sludge becomes the hot issues. The relevant technical staff should strengthen the research on the sludge deodorization technology of urban sewage treatment plant, reducing the sludge generated by sewage treatment plants. This paper mainly studies the sludge ozone reduction technology in urban sewage treatment plant, which is analyzed and discussed from the ozone sludge reduction principle, the relationship between the sludge reduction and the ozone dose and the the impact of ozone sludge treatment technology on sewage treatment plant. This can enhance the technical level of China's sewage plant [8].

In general, ozone is a potent oxidant that can do the relevant ozone treatment on sludge. First, ozone causes the cell wall of the sludge microbial to crack, causing the organic matter in the cell to be released. When the sludge flows to the biochemical pool, the organic material matrix is metabolized, resulting in $\text{H}_2\text{O}$, $\text{CO}_2$, $\text{NH}_3$ and other substances, thus contributing to the reduction of sludge. Second, ozone can produce oxidation on the sludge, making the protein, fat, carbohydrates and other substances oxidizing to carbon dioxide or water, so as to achieve the purpose of reducing sludge.

2. The relationship between sludge reduction and ozone dose
In general, there are a large number of bacteria in the sludge. First of all, the ozone is used as the relevant oxidant entering into the sludge, which can damage and dissolve the cell wall of sludge microbial. After this, the organic matter of microorganisms will be released. These organic matter becomes nutrients of
the treatment. Second, in the process of ozone using, ozone will cause another oxidation in the internal sludge. Therefore, the related chemical reaction between the carbohydrates and protein is promoted, which will become nitric oxide and carbon monoxide. In the ozone-related role, the sludge is decomposed into valuable elements, thereby promoting the decrease of the sludge in the sludge treatment plant. Finally, the ozone has a high efficiency on sludge treatment. Generally, the efficiency of the ozone treatment on sludge is related to the ozone dose and the amount of sludge entering the ozone reactor [1]. The relevant studies show that when the ozone-returning sludge is 3.3 times than the total amount of residual sludge and the ozone emission is 0.15kg, it can achieve zero emissions of residual sludge. In addition, the ozone can completely remove the sludge from the sludge pool of sewage treatment plant when it rises to a certain extent. Therefore, the effects of ozonized sludge technology on sludge treatment is very obvious. The sludge reduction efficiency is closely related to the ozone dose. When the ozone dose is as small as the standard dose, the sludge reduction efficiency is positively correlated with the ozone dose. When the ozone dose exceeds the standard dose, the sludge reduction efficiency will not increase significantly after adding the ozone dose [2].

3. Effect of Ozone Sludge Reduction Technology on Sewage Treatment Plant

(1) The impact on water quality

In general, the reduction of the sludge content of the sewage treatment plant should ensure the quality of the effluent from the WWTP. If the quality of the effluent from the sewage treatment plant is deteriorated after the relevant ozone sludge reduction treatment, the meaning of the ozone sludge reduction technology will be lost. According to the relevant reports, the effluent quality after the ozone sludge reduction treatment is basically the same as that of the water after the technical treatment, and the BOD removal efficiency after the ozone treatment is better. Although the SS concentration will increase occasionally with seasonal variation, BOD also increases due to the increase of SS concentration. In addition, BOD and SS basically meet the requirements of local water discharge [3].

(2) The relevant impact on nitrogen and phosphorus removal

Through the biological technology on nitrogen and phosphorus removal, the organic pollutants can be effectively removed, and the plant nutrients such as nitrogen and phosphorus are also removed. Some staff worry that the technology on ozone sludge reduction can affect the effect of nitrogen and phosphorus removal. According to the experiment, it shows that the effluent ammonia nitrogen has no significant change after ozone treatment [4]. The concentration of effluent ammonia nitrogen maintains a relatively low value, which generally is about 4 mg per liter. Therefore, the impact of ozone treatment on nitrogen and phosphorus removal is not worried.

(3) The relevant impact on sludge setting and dehydration performance

After the ozone treatment, whether the sludge sedimentation and dehydration performance caused by a negative impact is also concerned from the relevant issues. The research shows that ozone sludge reduction technology is beneficial for sludge sedimentation and dehydration. First, in general, the sludge will become a small floccule after ozone treatment, and then it will back to the biochemical pool, so as to promote the sludge particles homogenized. In addition, it can promote the sludge settling performance. Second, after the ozone treatment, the volume index of sludge decreased significantly. According to microbiological examination, it showed that the filamentous bacteria significantly reduced after the ozone treatment of sludge [5].

(4) The economic value of ozone sludge reduction technology

After finishing the sewage treatment, it is necessary for us to deal with the sludge in the sewage pool. The sludge treatment costs will be reduced through the ozone sludge reduction technology and the economic benefits of the sewage treatment plant will be enhanced. First, the amount of residual sludge is reduced, and the sludge treatment costs is also reduced. Second, although the ozone and related facilities and electricity is provided in sludge reduction technology to increase the operating costs and investment costs, its high efficiency and processing effect is obvious. After considering the comprehensive effects, ozone technology still has a significant investment value and economic benefits in sewage treatment [6].
4. The methods and results

4.1. Experiment of Sludge ozone treatment

The sludge used in the experiment was taken from the re-fluxing sludge of the secondary sedimentation tank of Beijing Qinghe Sewage Treatment Plant A/A/O. In addition, the MLSS and MLVSS were 8603 and 6185 mg·L\(^{-1}\), respectively. Meanwhile, 1400 mL sludge was taken with aeration for 24 h before each experiment and then diluted to 3500 mL with deionized water. The sludge treatment was carried out using a semi-continuous reaction, which means that sludge was continuously fed into the reactor, and two batches of ozone treatment were completed. The volume of the sludge sample was 500 mL and the flow rate of the ozone gas was 0.2 L·Min\(^{-1}\) by using sand core aeration. In the first batch of experiments, the initial pH is 6.8, and the oxidation time is 10 min. The ozone dosage was 0, 26, 63, 154, 227, and 268 mg·g\(^{-1}\) (in SS dollars). In the second batch, the ozone concentration was 50 mg·L\(^{-1}\), and the oxidation time was 9 min. In addition, the initial pH was adjusted to 3.0, 5.0, 7.0, 9.0 and 11.0 [7].

The ozone concentration was measured by the iodine method, and the residual ozone in the system was purged with nitrogen and collected with 1% KI solution. The ozone actually consumed was calculated by the formula (1).

\[
M_{O_{cons}} = C_{O_{gas}} \times Q_{O_{gas}} \times T - M_{O_{gasout}}
\]

(1)

In the formula, \(M_{O_{cons}}\) is the ozone consumption (mg), and \(C\) is the ozone concentration in the entrance of the reactor. \(Q\) is the flow rate of ozone gas. Measured by gas flow meter, we can obtained that \(T\) is ozone oxidation time of activated sludge (min), and \(M\) is the amount of ozone that did not participate in the reaction (mg).

The sludge dissolution rate \(R\) is used to characterize its lysis degree, and the calculation formula is shown in the follow:

\[
R = \frac{[\text{MISS}]_o - [\text{MISS}]_t}{[\text{MISS}]_o} \times 100\%
\]

(2)

In the formula, \([\text{MISS}]_o\) and \([\text{MISS}]_t\) represents the sludge MISS (mg L\(^{-1}\)) with ozone treatment and without ozone treatment.

4.2. Results and discuss

In the process of sludge ozone treatment, the initial dosage of ozone and the initial pH of activated sludge will affect the dissolution rate of sludge and the dissolution of organic matter, nitrogen and phosphorus, which will affect the effect of sludge reduction. Ozone dosage and sludge initial pH are not only beneficial for sludge reduction, but also to improve the economics of the process. In this experiment, the effect of different ozone dosage on the sludge dissolution rate was investigated. As shown in Fig. 1, the sludge MLSS and MLVSS decreased with the increase of ozone dosage, and the sludge dissolution rate increased gradually.
After the zone treatment, the effect of sludge reduction is more obvious. With the increase of ozone dosage, the MLSS and MLVSS of the sludge gradually decrease, and the sludge dissolving rate gradually increases. Meanwhile, the organic matter, nitrogen, phosphorus and other substances in the microbial cells are released to the sludge liquid. It is suggested that the reasonable ozone dosage is about 150 mg·g⁻¹, and the sludge dissolving rate can reach about 26%. The initial pH is alkaline, and the sludge dissolving rate is high. In addition, the organic matter is favorable to the dissolution of nitrogen, while the acidic conditions are conducive to the dissolution of phosphorus. Considering the initial pH effect, sludge ozone treatment should be in the condition of neutral or weak alkaline of initial pH.

After the sludge was returned to the biological treatment system, the effect of microbial activity, COD and nitrogen removal was not significantly affected. As the system had no excess sludge discharge, the phosphorus was gradually accumulated in the system, resulting in the decrease of phosphorus removal effect. Therefore, the phosphorus removal process needs to be added.

5. Conclusion
In summary, the technology of ozone sludge reduction can not only effectively deal with the sludge produced by the city's waste water treatment, prompting a significant reduction in the total sludge, but also can promote the oxidation of sludge into organic matter, which is conducive to ecological construction. The relevant technical personnel should strengthen the research on ozone sludge reduction technology. In addition, the technology should be widely used in China's sewage treatment plant, so as to improve the capacity for sewage treatment.

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