Engineering practices of deodorization for odor in urban sewage treatment plants in China

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Abstract. As to the publishing of "13th Five-Year" Environmental Planning whose core is improving the quality of the environment. So the deodorization of odor in urban sewage treatment plants has become an important part of their comprehensive upgrading and transformation in China. It can be seen that the technology of biological deodorization technology and its combination technology which base on biological method have become the mainline of deodorization in Chinese urban sewage treatment plant from the induction of the source control technology, terminal control technology and the combination of the two technologies in the engineering practices of urban sewage treatment plant which have been built in recent years.

1 Introduction

The odor of Sewage treatment plant comes from the pretreatment of sewage, anaerobic and anoxic processes and sludge treatment(Jia-Zhen Luo, 2003), such as grating room, anaerobic tank, anoxic tank, digester and sludge extraction machine room, etc. In fact, the concentration of odor in grating room and sludge extraction machine room is more concentrated. The odor of Sewage treatment plant containing sulfur compounds, such as H_2S, thiols, Sulfur ethers and nitrogenous compounds, such as amines, acid amides, indoles(Chen Qin, 2009). The quantity and concentration of ammonia in odor is maximum and the hydrogen sulfide, dimethyl sulfide are next to them. In terms of the felling degree of odor, the methanethiol is most likely to cause people's sense of smell, and followed by Hydrogen sulfide, dimethyl sulfide and ammonia (Ai-Jie Wang et al., 2005, Li-Ping Xu, 2009). With the development of urbanization, many suburbs of the city which had built the sewage treatment plant has now become the city. The odor produced by sewage treatment plant has threatened the physical and mental health of the residents, and seriously affected the quality of people's living environment. Great progress has been made in the upgrading and reconstruction of Chinese sewage treatment process since 2008, but the progress of odor treatment is relatively slow. The basic idea of "13th Five-Year" national environmental protection planning has clear requirements that improving the quality of environment is the core. It will vigorously promote the implementation of the "air pollution prevention action plan" and "water pollution prevention action plan". The treatment of odor is putting on the environmental protection agenda. Therefore, it is of practical significance to explore and share the useful experience in the construction of the odor treatment technology and its engineering progress of the urban sewage treatment plant in China.

2 Odor Control Methods and Engineering Practices of Terminal Control Technology in Sewage Treatment Plant

Odor control technology can be divided into source control technology, terminal control technology and the combination of the two technologies(Jia Zhu et al., 2006). The treatment of odor in the sewage treatment plant is mainly based on the terminal treatment in China. Terminal control technology is to collect and deal with the generated odor and mainly includes physical method, chemical method, biological method and ionic method.

2.1 *Physical method*

Physical methods mainly include dilution method, masking method, water washing method with water and adsorption method. Among them, the first three physical methods are used less in engineering applications. Adsorption method is mainly used the adsorbent as activated carbon, silica gel and ion exchange resin, etc. to finish the adsorption of odor substances. Active carbon adsorption is the most commonly used method of physical treatment, because the adsorption capacity of activated carbon is generous and it's equipment is simple and easy to operate. For example, Liede sewage treatment plant in Guangzhou used catalytic activated carbon deodorizing device to purify odor in sewage pumping station. The concentrations of H_2S and NH_3 in the boundary of sewage treatment plant can meet the first class emission standard of *urban sewage treatment plant pollutant discharge standards*(GB 18918-2002)(Yun-Jin Chen et al., 2007).

2.2 *Chemical method*

Chemical deodorization method mainly includes chemical absorption, chemical oxidation and masking agent method and so on. Chemical absorption is a method that uses NaOH, NaClO and H_2SO_4, etc. to react with the odor substances to dissolve into the liquid phase and remove them. The absorption of NH_3 and H_2S in chemical absorption method is relatively fast and thorough. However, it is difficult to remove the thiol, volatile fatty acids or other volatile organic compounds. Chemical absorption method is generally used as a pre- treatment method for the combined treatment process of high concentration odor. Such as the North of the city sewage treatment plant in Nanjing used a large-scale concentrated chemical deodorization technology for the first time in China to remove the odor. After purification, odor removal rate up to 99.2%(Hua-Ming Wu et al., 2004). Binhe sewage treatment plant in Shenzhen used treatment with acid and alkali tower to make the odor concentration meet the first class emission standard of GB 18918-2002 (Hua-Ming Wu, 2007).

Chemical oxidation is refers to the using of ozone and other strong oxidizing agent to oxidize odor and make it become odorless or low odor. This method has high efficiency of purification, disinfection and sterilization. And it needs small occupation area. Photocatalytic oxidation method has been being more used in then applications of deodorization projects. Sanshui Anjie sewage treatment plant in Guangdong used a UV catalytic oxidation equipment (UVCY series)which was created by independent research and development for the deodorization. And the odor concentration met the second class emission standards of GB 18918-2002(Fei Zhong et al., 2011).

The most common method of masking agent method is plant extract technology. The plant extract which contains a large number of polysaccharides, active peptides, enzymes and other metabolic products is sprayed in space by using the atomization equipment. And the function of adsorption, catalytic oxidation, etc. will make sure the effect of the deodorization for odor. The plant extract technology is suitable to be used in small and enclosed spaces. Generally the technology is used for the structures with high concentration of odor such as pumping station, biological reaction tank and sludge extraction machine room. Process for spraying plant extracts was used to be the Odor control engineering for Zhuyuan No.1 sewage treatment plant in Shanghai. And the concentration of H_2S and NH_3 met the second class emission standard of GB 18918-2002. But the odor concentration was slightly over-proof(Yi-Cheng Lu et al., 2007). The process of plant extract were also applied to the odor treatment of sewage treatment plant in Tongxiang City, Zhejiang Province (Yi-Cheng Lu et al., 2005) and sludge wharf which under the first and second phase of the project of Liede sewage treatment plant(Liang Li et al., 2007), and the odor concentration met the second class emission standard of GB 18918-2002.

2.3 *Biological method*

Biological deodorization technology has the ad- vantages of high treatment efficiency, no secondary pollution, simple equipment, easy operation, low cost, convenient management and maintenance, and so on. However, the growth of microorganisms is affected by temperature, pH and other environmental factors. The stability of biological deodorization needs to be further improved. Biological deodorization technology mainly includes biological filter method, biological trickling filter method, soil filter method, etc.

The biological filter method is the technology that using the humidification, dust elimination and other ways to make pretreatment for collected odor, and then odor is passed through a deodorization tower which has a large number of organic solid fillers with a large number of deodorization micro-organisms, finally odor substances are adsorbed by microorganisms, and are degraded into CO_2, H_2O or small molecule organic compounds which are harmless and odorless. Organic solid filler can pro- vide the need for microbial growth and reproduction, such as attached site, nutrition and pH and so on, without additional nutrients. But the filler is easy to be degraded corrosion and it needs to be replaced regularly. At present, the biological filter method is the most mature technology and widely used in China, and it has a good effect on the removal of odor. Xiamen Jiutian Lake sewage treatment plant (Chong-cheng Huang, 2014)and a city sewage treatment in southern China(Fei-Long Yang, 2014) used biofilter system for deodorization and made strict control of their operation process. Their odor concentration all met the first class emission standard of GB 18918-2002. The Yangjiapu and South of city sewage treatment plants in Taiyuan (Jin-Rong Ren, 2015)and Huludao sewage treatment plant in High tech Zone of Liaoning Province(Ying Mu, 2015) all used biological filter for their deodorization. They made a significant effect that met the first class emission standard of GB 18918-2002. In addition, the first and second phase project of Ling'an sewage treatment plant in Zhejiang(Jin Song et al., 2015) and the expansion project of Jida water purification plant in Zhuhai(Hou-Bo He et al., 2006) also used biological filter for their deodorization, and the effect met GB 18918-2002 second class emission standard.

The biological trickling filter is similar with the biological filter. But the filler of biological trickling filter is inorganic, and it requires extra spraying of soluble inorganic nutrients. Biological trickling filter is more efficient and needs smaller floor area because the control of the operating conditions are so accurate that it can provide the appropriate concentration of nutrients, suitable pH value and temperature. The three stage project of Qige wastewater treatment plant in Hangzhou used biological trickling filter for odor control, and the core of the filter is SK compound biological deodorization technology. The effect of deodorization met the first class emission standard of GB 18918-2002(Xu-Dong Rui et al., 2012). The upgrade pumping station of one sewage treatment plant in Shenzhen used two-stage biological filter process for deodorization, and the concentration of H_2S and NH_3 met the first class emission standard of GB 18918-2002 after treatment(Yi-Qing Chen et al., 2013).

The soil filter is composed of the soil matrix, air distribution system, humidification system, the bio- logical community in the substrate, and the surface plants and so on. The odor of sewage treatment plant is collected by the wind turbine, and then is pushed into the soil matrix of soil filter. It will be adsorbed and degraded by microorganisms in the soil matrix. The soil filter is generally used in places where the landscape is demanding. However, the soil filter occupies a large space and it is easily affected by the weather. So the stability of soil filter is poor that the soil filter only suitable for warm and rainless place in the South of China. In order to finish the important deodorization of biological reaction tank, Fuxing sewage treatment plant in center district of Suzhou built a soil filter in renovation project. And the effect of deodorization met the first class emission standard of GB 18918-2002(Lin-Zhong Sun, 2014). Suzhou East sewage treatment plant also built a soil filter in the renovation project. The effect of the deodorization is obvious(Wei-Gang Wu & Fei Xu, 2012).

2.4 *Ion method*

Ion technology includes plasma technology, high energy ion technology and reactive oxygen techno- logy, etc. The equipment is complicated, and has high manufacturing cost and short service life, and is generally used in sewage lifting pumping station, the grating room, sludge dewatering workshop, and other places which has limited area and small scale odor.

Plasma technology is a new technology which produce plasma by high voltage pulsed corona dis- charge, and using the energy of electrons and active particles in the plasma to directly decompose the odor. Datansha sewage treatment plant in Guangzhou finished the deodorization by using plasma sterilization deodorization process. And the concentration of H_2S and NH_3 met the first class emission standard of GB 18918-2002(Yan-Ni Zhang, 2008).

High-energy ion technology is such a technology that using ion generator to emits high energy positive and negative ions under the action of electric field, and opening the chemical bonds of

VOC molecules, H_2S and NH_3, etc. by the high energy ions. Finally, the odorant is broken down into CO_2 and H_2O and other odorless and harmless substances. High energy ion technology was used to remove odor in one sewage treatment plant in Zhejiang Province. And the odor concentration met the second class emission standard of *emission standards for odor pollutants* (GB 14554-1993) (Xin-Ling Xu & San-San Li, 2015).

Reactive oxygen technology is a technology using high voltage electrostatic device to make the air produce oxygen ion group. At room temperature and atmospheric pressure, the odorant is decomposed into CO_2, H_2O and H_2SO_4 or partially oxidized compound by reactive oxygen species. Zhuyuan second wastewater treatment plant in Shanghai used the reactive oxygen species to carry on the centralized deodorization. The effect of deodorization met the second class emission standard of GB 18918-2002 (Hai-Long Bai et al., 2009). The biological deodorization of five city sewage treatment plants in Guilin is also intended to use reactive oxygen technology.

3 Source Control Technology and Engineering Practices of Sewage Treatment Plant

The source control is a technology that by adding chemicals, adjusting the control parameters of the operation, improving the micro environment and the dominant species, and adding deodorizing micro- organism to adjust and optimize the sewage treat- ment process and satisfy the requirement of the water quality. And source control can restrain the odor substances from the source at the same time. The source control technology mainly includes the liquid phase control technology and the technology of odorless sewage treatment(Jia Zhu et al., 2006).

Liquid phase control technology is a technology that avoiding anaerobic reaction to control the production of odor by adding chemical agents such as oxidizing agents, precipitants, biological inhibit- ors or pH modulators into the places where the anaerobic reaction is easy to occur. The places include sewage collection system as city sewers and fall wells and inlets and lifting pump stations of sewage treatment plants. The key to this technology is to see the city sewer and sewage treatment plants as a whole. Designers should optimize the slope and flow rate of the sewer and choose smooth and durable pipes, etc. to avoid the production of odor when the organic pollutant is deposited and an- aerobic reaction occurs .They should also set up air permeability well legitimately to avoid commercial and residential areas. In general, the whole design has to do best to prevent the formation of anoxic conditions in the drainage pipe(Jia-Zhen Luo, 2003). Although investments in infrastructure of liquid phase control technology are small and additional processing facilities and structures are not required, and liquid phase control technology relies on a large number of agents or power such as aeration, requires high operating costs, and produces secondary pollution. At present, there is no use in China.

Odorless sewage treatment technology is a technology that restraining or degrading the by-product of odor in sewage treatment process by optimizing microbial strains and adjusting process-ing technology under the premise of not affecting the quality of water. The technology does not need to add additional deodorant structures. So it can save construction cost and operate easily, but it is difficult to grasp the proper quantity of reflux of activated sludge. Xianyang Road sewage treatment plant in Tianjin used the CYYF whole process deodorization technology to make the effect of deodorization met the second class emission standard of local emission standards for odor pollutants DB 12/-059-95(Hui Wang, 2014). Jizhuangzi sewage treatment plant also used the whole process deodorization techno- logy to purify the odor. The dissolved oxygen of the incubator is controlled in the range of 0.15-0.50 mg/L. And the sludge dosing volume ratio for deodorization is within the range of 2.0%-10.0% of the influent volume. All indicators met the second class emission standard of GB 18918-2002(Er-Jun Xue et al., 2011).

4 Combination Deodorization Technology and Engineering Practices of Sewage Treatment Plant

In view of the difference of water quality, sewage treatment technology, the quantity, component and concentration and collection methods of odor in different treatment structures, sewage treatment plants all over China make pointed references to develop a variety of sewage treatment deodorization combination technology by according to local conditions and avoiding weaknesses(Li-Rong Jiang et al., 2010, Li-Rong Jiang, 2008). For example, a sewage treatment in

Harbin used chemical absorption and activated carbon adsorption federated technology for deodorization process, and the effect of deodorization met the first class emission standard of GB 18918-2002(Zuo-Feng Geng et al., 2008). Northern suburbs of Baotou water purification plant used the whole process biological deodorization technology and activated carbon adsorption process to purify the odor. The odor sensory indicators of whole plant met the first class emission standard of GB 18918-2002(Xue-Min Bao et al., 2015). Center sewage treatment plants in Wenzhou used the biological filter and plant extract technology for deodorization. In addition to the odor concentration slightly exceed the standard, the remaining indicators met the second class emission standard of GB 14554-93(Xu-Lei Wu et al., 2015). A sewage treatment plant in Suzhou changed original odor control project which used biological filtration and plant extract technology for the deodorization into the one that used plasma deodorization and soil filter technology and the another one which used plasma deodorization and soil filter technology. The effect of deodorization met the first class emission standard GB 14554-93(Jian-Han Ying et al., 2015).

5 Conclusion

The main deodorization engineering practices of urban sewage treatment plant in China shows that the main technologies for the engineering are biological method and the combination technology which bases on biological method. Biological method has the advantages of simple equipment, low operating cost, no secondary pollution, and so on. The biological method is worth popularizing because it has a good effect on deodorization. How- ever biological method is limited by high concentration and large amount of odor. The development of new type of filling material, screening of highly efficient deodorant bacteria, researches and developments of microbial deodorization bacteria and studies on kinetics of biological treatment, etc. should be strengthened. The choices of the deodorization technology of the sewage treatment plant should be combined with the processes of sewage treatment, characteristics of the odor, site requirements, and controls of cost and so on. In a few words, the choices should be adapted to local conditions to screen out the appropriate technology. The deodorization engineering in urban sewage treatment plant should give priority to the use of biological deodorant technology. But at the same time considering the structure characteristics and spatial characteristics of odor is necessary ,and the using of the combination deodorization techno- logy will cut the cost and make better effect to deodorization.

References

[1] Ai-Jie Wang, Xiao-Wen Xu, Nan Qi Ren, et al. 2005. Application and developing trend in bio-deodorization in sewage plant. *J . China biogas (03).*
[2] Chen Qin. 2009. Pollution of fetor from sewage disposal to vicinal environment and its treatment. *J . Environment Engineering (S1)*: 291-293.
[3] Chong-cheng Huang. 2014. Process planning of biological deodorization to buried sewage treatment plant. *J . Energy and Environment (02)*: 87-88,90.
[4] En-Jian Deng. 2008. Present state and future of wastewater treatment plant deodorization. *J . Industrial Safety and Environ- mental Protection (04).*
[5] Er-Jun Xue, Yu-Qing Li, Ying-Jing Nie, et al. 2011. Application of the whole process of odor removal technology in upgrading and reconstruction project of sewage treatment plant. *J . Tianjin Construction Science and Technology (03)*: 55-57.
[6] Fei Zhong, Jin Yang, Zhou-Xiang Cai. 2011. Application of ultraviolet catalytic oxidation for odor treatment in wastewater treatment plant. *J . Environment Engineering (06)*: 79-81.
[7] Fei-Long Yang. 2014. Application of biological filtration and deodorization in a municipal wastewater treatment plant in South China. *J . Chemical Engineering and Equipment (07)*: 196-200.
[8] Hai-Long Bai, Xiao-Jie Ma, Yu Zhang. 2009. On deodorization project design of Shanghai Zhuyuan No.2 sewage treatment works. *J . China Municipal Engineering (06)*: 38-40,79-80.
[9] Hou-Bo He, Jin-Wei Zheng, Tong Jin, et al. 2006. Bio- filtration technology for removing odor from a wastewater treatment plant. *J . Environmental Science And Technology 29(6)*: 86-88.
[10] Hua-Ming Wu, Xing-Hong Gu, Feng Li. 2004. Design of Chengbei wastewater treatment plant in Nanjing. *J . Water & Wastewater Engineering 30(4)*: 23-6.
[11] Hui Wang. 2014. Environmental impact assessment of CYYF. *J . Environ- ment and Development (04)*: 144-147.
[12] Jia Zhu, Wen-Yi Dong, Hong Du. 2006. Progress in odor control techniques for wastewater treatment plant. *J . Water Treatment Technology (02).*
[13] Jian-HanYing, Chun-Hwa Li, Ruo-Hong Li. 2015. Application of soil filter and plasma technology in sewage treatment plant. *J . Environmental Science and Technology (03)*: 35-37.

[14] Jia-Zhen Luo. 2003. On Generation of Source of Foul Smell in Urban Drainage Facilities and the Control Measures. *J . China Municipal Engineering (3)*: 50-52.
[15] Jin Song, Qin-Qin Zheng, Ting-Hua Li. 2015. Design of odor control system in sewage treatment plant. *J . Southwest Water & Wastewater (06)*: 6-9.
[16] Jin-Rong Ren. 2015. On selection and comparison of deodorization at sewage treatment plants in Taiyuan. *J . Shanxi Architecture (36)*: 133-134.
[17] Liang Li, Zhong-Fu hao, Ming-Jie Zhang, et al. 2007. Design of the first and second stage mud system in Liede Wastewater Treatment Plant. *J . Southwest Water & Waste- water (04)*: 6-9.
[18] Lin-Zhong Sun. 2014. Suzhou downtown Fuxing wastewater treatment plant upgrading reconstruction project. *J. Urban Roads Bridges & Flood Control (08)*: 161-164,115.
[19] Li-Ping Xu. 2009. Discussion of odor removal techniques using in sewage treatment plants and pump station. *J . Environmental Science and Management 34(1)*: 98-100.
[20] Li-Rong Jiang, Bo-Duo Wang, Yu Xiong, et al. 2010. Comparison of several odor removals technology in municipal wastewater treatment plant. *J . Ground Water (01)*.
[21] Sheng-Dong Wang, Feng Qin, Yi Yu, et al. 2005. Deodorization design for wastewater treatment plant. *J . Water & Wastewater Engineering (09)*: 20-23.
[22] Wei-Fa Xu. 2007. Design of odor control system for the third stage project in Binhe wastewater treatment plant. *J . China Water & Wastewater (18)*: 52-54.
[23] Wei-Gang Wu, Fei Xu. 2012. Design and operation of the upgrading project of the municipal sewage treatment plant in east Suzhou. *J . Pollution Prevention Technique (04)*: 71-75.
[24] Xin-Ling Xu, San-San Li. 2015. Design and application of high-energy ion deodorization engineering in urban sewage treatment plant. *J. Value Engineerin*g (30): 165-166.
[25] Xu-Dong Rui, Chen Dan, Wen-Jin Gong. 2012. Application and development of deodorization process in urban sewage treatment plants. *J . China Water & Wastewater (06)*: 21-23.
[26] Xue-Min Bao, Zuo-Yi Xiao, Chun-Li Zheng, et al. 2015. Practice of deodorization process for Baotou northern suburban water purification plant. *J . Modern Chemical Industry (12)*: 128-130,132.
[27] Xu-Lei Wu, Miao Gu, Zhi-li Sun, et al. 2015. Application of biotrickling bed to odor treatment in Wenzhou central district wastewater treatment plant. *J . China Water & Wastewater (16)*: 98-101.
[28] Yan-Ni Zhang. 2008. The applicability of the deodorization process of Datansha sewage treatment plant in Guangzhou City. *J . Environment (S1)*: 28-29,31.
[29] Yi-Cheng Lu, Can-Hua Xu, Tian-Qi Li, et al. 2007. Designs of odor removal project for Zhuyuan first WWPT. *J . China Water & Wastewater (16)*: 46-48.
[30] Ying Mu. 2015. Application of biological fitration and deodorization in the design of sewage treatment plant inhigh-tech district of huludao. *J . Value Engineering (04)*: 310-311.
[31] Yi-Qing Chen, Juan Yin, Jian-Guo Meng, et al. 2013. Design and operation of biological deodorization engineering in a sewage pumping station in Shenzhen. *J . China Water & Wastewater (18)*: 103-106.
[32] Yun-Jin Chen, Hua Huang, Yuan-Hong Wen, et al. 2007. Purification effect of odorous gases in sewage pumping station by catalytic activated carbon deodorizing system. *J . China Water & Wastewater 23(15)*: 76-78.
[33] Zuo-Feng Geng, Rui-Xing Liu, Jian Sun, et al. 2008. Odor treatment technology and its application in sewage treatment. *J . Energy Conservation & Environmental Protection (6)*: 40-41.