Common problem thinking and technical innovation elaboration
Based on the status quo of urban sewage treatment in China

Zuojun Liu¹, a, Yang Qiao², b, Zhexian Li³, c, Yi Gong⁴, d, Xiangkai Wang⁵, e
¹North China University of Water Resources and Electric Power, Zhengzhou, Henan
²Zhengzhou University of Light Industry, Zhengzhou, Henan
³Baoding University of Technology, Hebei, Baoding
⁴North China University of Science and Technology Tangshan, Hebei
⁵Tangshan University Tangshan, Hebei
¹qwe135134138@163.com
²22251909618@qq.com
³952767756@qq.com
⁴2145949267@qq.com
⁵1766629151@qq.com

Abstract—China's urban sewage treatment developed rapidly, but there are many common problems. In the form of online questionnaire, 1100 people were randomly selected as sample data for description analysis. Based on quantitative research methods on China's drainage and sewage treatment from 1978 to 2019 and the literature research and information integration of related books and materials, this article discusses the commonalities in urban sewage discharge standards, sewage treatment, and effective sludge treatment and recycling. Descriptive research is carried out on the problem, and due to the current main contradiction in sewage treatment, it is converted to the effective removal of nitrogen and phosphorus organic matter. Then, anaerobic ammonia oxidation is introduced and its scientific and technological prospects are prospected, hoping to provide supportive reference for related research researchers.

1. INTRODUCTION
China's urban sewage is composed of 42% industrial wastewater, 35% domestic water and 23% public service water. Sewage treatment plays a vital role for China, where the process of urbanization is accelerating [1]. In 2015, the Chinese government issued the "Water Pollution Prevention and Control Action Plan". In 2017, the detailed rules for various sub-fields of water treatment were gradually released. In 2020, the National Development and Reform Commission and the Ministry of Housing and Urban-Rural Development issued the "Implementation Plan for Strengthening and Weaknesses of Urban Domestic Sewage Treatment Facilities", etc. That policy has promoted its diversified and standardized development. Although rapid promotion was achieved in Chinese urban sewage treatment capacity and a certain number of equipment and processes were developed to form a mature and complete industrial chain, there is a large gap between China and developed countries as a whole. On
the one hand, there are deficiencies in the urban sewage discharge standards and the actual discharge process. On the other hand, the amount of urban sludge in China is large while the quality is poor, since the existing theories and technical means cannot effectively solve the problem. In addition to above two problems, the problem of eutrophication as a "difficult and miscellaneous disease" needs to be rectified in China. Focusing on overcoming the difficulties of sewage recycling, the innovative technology shall be adopted to solve the above problems.

2. ANALYSIS OF PUBLIC SURVEY ON SEWAGE TREATMENT
A total of 1,100 results were collected, including 53.09% for men, 46.91% for women, and 85.81% of people aged 10-40 years. The results on sewage treatment are shown in Table 1. As can be seen in Table 1, 24.36% of people who know the current situation of Chinese water resources, 36.55%, and 31% and 8.09% respectively. It shows that everyone’s understanding of China’s water resources still has a certain understanding and attention. At present, 17.18% understand China’s sewage treatment, 18%, 34.18%, 36.45% and 12.18% respectively, indicating that our understanding of China’s sewage treatment still needs to be improved.

The cognitive understanding of different groups of sewage treatment is shown in Table 2. Table 2 shows that sewage treatment is very influential for 28.73%, 42.09% of people think that it affects life, and only 20.18% of people think that sewage treatment does not affect life, indicating that people care more about the level of sewage treatment. 34.64 per cent believed that sewage treatment policies were lacking and it was necessary to improve relevant sewage treatment policies. In the understanding of the capacity of local sewage treatment plants, 62.18% of people do not pay much attention to this information, indicating that the policy on sewage treatment is imperfect and people have fewer channels to receive relevant information.

| TABLE 1 UNDERSTANDING OF SEWAGE TREATMENT AMONG DIFFERENT POPULATION GROUPS |
|-----------------------------------------------|--------|----------|
| Independent variable                      | Condition | Number | Proportion |
| Gender                                      | man     | 584     | 53.09%     |
|                                             | women   | 516     | 46.91%     |
| Age                                         | 10-20 year | 310     | 28.18%     |
|                                             | 20-30 year | 367     | 33.36%     |
|                                             | 30-40 year | 259     | 23.55%     |
|                                             | 40-50 year | 164     | 14.19%     |
|                                             | Know well | 568     | 24.36%     |
| Knowledge of current water resources         | Know    | 402     | 36.55%     |
|                                             | Do not know much | 341     | 31%        |
|                                             | Do not now | 89      | 8.09%      |
|                                             | Know well | 189     | 17.18%     |
| Knowledge of sewage treatment                | Know    | 376     | 34.18%     |
|                                             | Do not know much | 401     | 36.45%     |
|                                             | Do not now | 134     | 12.18%     |

| TABLE 2 COGNITIVE UNDERSTANDING OF SEWAGE TREATMENT AMONG DIFFERENT POPULATION GROUPS |
|-----------------------------------------------|--------|----------|
| Independent variable                      | Condition | Number | Proportion |
| The level of sewage treatment affects the level of living | Very affected | 316     | 28.73%     |
|                                             | Affected | 463     | 42.09%     |
|                                             | Not Affected | 222     | 20.18%     |
|                                             | Indifferent attitude | 99      | 9%         |
|                                             | Very perfect | 207     | 18.82%     |
| The degree of perfection of sewage treatment policies | Perfect | 328     | 29.82%     |
|                                             | Deficient | 381     | 34.64%     |
|                                             | Do not pay attention | 184     | 16.73%     |
| Awareness of the                           | Know a lot about | 356     | 32.36%     |
The impact of sewage treatment on various industries is shown in Figure 1. As can be seen from Figure 1, 49.55% of people believe that sewage treatment has a great impact on the catering industry. For people's healthy food, it is necessary to strengthen the treatment of sewage. 53.18% per cent believe that sewage treatment agriculture has a great impact, because the food people daily eat comes from agriculture. If sewage is not effectively treated effectively, it is more harmful to their health. 50 per cent believe that sewage treatment seriously affects energy, and 61 per cent believe that sewage treatment is closely related to environmental protection.

The importance of sewage treatment capacity is shown in Figure 2. 67.55% think that the support of the government policy is the primary reason for improving sewage treatment capacity, 66.45% believe that the enhancement of environmental awareness can improve sewage treatment capacity, 63.09% think that high-tech research and development contributes to sewage treatment, thus shows the support of government policy, the enhancement of environmental awareness and new technology research and development, is the key to improve sewage treatment capacity.
process, the annual discharge of sewage continues to increase. It can be seen from Figure 3 that China's sewage treatment rate has continued to increase over the years, the number of sewage treatment plants has increased significantly, their treatment capacity has been continuously strengthened, the sewage treatment rate has steadily increased, and organic pollution has also been curbed. Local governments in economically developed areas such as the eastern coast of China have relatively strong financial strength and strong economic population gathering functions, which are more suitable for the construction and operation of large-scale sewage treatment facilities. The construction of sewage treatment facilities in the above-mentioned areas is relatively sound, and the sewage treatment industry is developing relatively fast, nevertheless, there are significant differences in the amount of sewage discharge, treatment level, and sludge treatment and disposal rate at the regional level. This is obvious in Figures 4. At the same time, as a worldwide problem, the phenomenon of excessive nitrogen and phosphorus emissions has appeared in 66.2% of the main water bodies in China, and 67 of the 131 major lakes in China have a high degree of eutrophication, accounting for 51.2%. Nitrogen and phosphorus removal has become the current situation, as well as a major issue in the field of sewage treatment.

FIGURE 3. SUMMARY OF CHINA'S SEWAGE TREATMENT LEVEL OVER THE YEARS

FIGURE 4. COMPARISON OF SLUDGE AND SEWAGE LEVELS IN CHINA
3.2. The issue of sewage discharge standards
The current sewage discharge standards are too uniform and lack local standards that are both strict and lenient. Each sewage treatment plant should have different discharge standards. Different sewage discharge standards are expected to be adopted by the sewage plants in the different area. Taking sewage denitrification and phosphorus removal as an example, the total nitrogen concentration of urban sewage is distinct in northern and southern China, and there is a big problem in the implementation of the level A discharge standard with the requirement of "uniformity and uniformity". For fragile water bodies such as lakes and bays, even if the first-level A discharge standard is met, serious harm will be caused. For example, the low-temperature northeast inland water body is very difficult to remove nitrogen and phosphorus from sewage biologically. Enormous manpower and financial resources will be consumed to implement the first-level discharge A emission standards. Whereas, Australia [2] The three major sewage treatment plants in Sydney can be directly discharged into the deep sea after primary treatment such as sedimentation, which greatly saves the operation cost of sewage treatment plants. Whereas, discharging directly into the deep sea after primary treatment greatly saves the operation costs of sewage treatment plants in three sewage treatment plants in Sydney, Australia.

3.3. Problems of urban sewage treatment system

3.3.1. Serious leakage of river quality pipe network and drainage pipes
The large flow of urban sewage source water, extremely low BOD concentration, low biological treatment efficiency, and low energy consumption sludge have low organic components, which brings serious difficulties to the anaerobic digestion of sludge.

3.3.2. Excessive application of denitrification filter
The biological denitrification process can be carried out in the mainstream process of the sewage treatment plant. The existing process is difficult to accurately control the carbon source dosage, which makes the effect unstable, high construction and operating costs, and covers a large area.

4. Sludge treatment and disposal technology

4.1. Status of sludge treatment
It is estimated that the annual growth rate of sludge production in China is greater than 10% [3], but it does not match with the relatively backward sludge treatment and disposal capacity that has just started, since there is a stable sludge in the existing sewage treatment facilities. Less than 1/4 of the processing facilities, less than 10% of the processing technology and supporting equipment are more complete. The phenomenon of “heavy mud and light water” is common in the evaluation of sewage treatment in China. Low effectiveness have been seen in sewage treatment, disposal rate of municipal sludge and energy recovery rate, and the treatment rate of municipal sludge is even lower that of sewage treatment. Although more than 80% of sewage treatment plants can carry out sludge thickening and dewatering to achieve preliminary reduction, the annual discharge of sludge with 80% moisture content reaches 40 million tons, and the direct landfill treatment accounts for more than 60%. A large part of the sludge Landfill without stabilization has caused serious secondary pollution.

At present, the main methods of sludge treatment and disposal in China are agricultural and landfill, of which sludge accounts for about 46.43% for agricultural purposes, about 32.14% for landfills, 3.57% for mixed landfills with municipal solid waste, and 3.57% for landscaping. No disposal accounted for approximately 14.28%. Because of the rapidly developed social and economic situation and obviously increased urban population, many cities formed the phenomenon of "sludge besieged cities". As a consequence of the lack of strict sludge discharge supervision in the early sewage treatment plants, the sewage and sludge treatment units were generally separated. In order to pursue a simple sewage treatment rate, the sludge treatment and treatment units were simplified as much as possible, or even ignored. In order to save operating costs, some sewage plants have left the built
sludge treatment facilities idle for a long time, and even transported the untreated dewatered sludge at will, simply landfilled or piled it up, bringing hidden dangers to the ecological environment.

Facing the severe challenges of environmental pollution and resource shortage, equal emphasis on mud-water treatment has become one of the principles of water pollution prevention and control.

4.2. Technical difficulties of sludge disposal
Each stage of sewage treatment produces sludge with different internal components, and the nature of the sludge greatly increases the difficulty of disposal [4]. First of all, as a solid with low bioavailability, it is difficult to use biological treatment technology to degrade and repair its internal pollutants, and the use of physical and chemical technology is expensive and ineffective. Secondly, the high water content of the sludge makes its volume too large, which increases the processing burden. General mechanical dehydration can only reduce the moisture content to about 80%. Deep dehydration requires the use of energy-intensive drying dehydration or other dehydration technologies.

4.3. Progress in sludge treatment and disposal technology
China has carried out research on a variety of sludge treatment and disposal processes, such as ultrasonic pretreatment, sludge combustion, and thermal hydrolysis. These methods have better realized the cell damage of microorganisms in the sludge, the release of organic matter in organisms, and the conversion of large molecules such as proteins and fats to small molecules. This type of technology improves the efficiency of sludge dewatering and optimizes the biodegradation process.

4.3.1. Uncoupling technology
Uncoupling metabolism technology is the application of uncoupling agents to destroy the coupling state of anabolism and catabolism in microbial life activities, making it difficult for the energy produced by catabolism to supply itself for the anabolism process, and the original microorganisms are difficult to multiply quickly. The new "offspring". The difficulty of sludge treatment and disposal was reduced fundamentally from the source as the number of microorganisms decays. At present, China's uncoupling technology mainly relies on two types of chemical coupling agents, natural and artificial. Natural uncoupling agents are synthesized by the organism itself, such as brown fat and uncoupling proteins synthesized by the organism, while artificial coupling agents are chemical substances with uncoupling effect synthesized in a man-made controllable environment, such as 2, 4-Dinitrogen basic points (DNP), etc. [4].

4.3.2. Sludge fueling technology
Compared with other technologies, the application value of sludge fuelization technology can be seen on the aspect of converting the sludge into energy when the treatment is completed. For example, the treated sludge can use its biomass energy for power generation and oil production. This technology requires high organic content in the sludge, and the process equipment is complex, so the degree of promotion is low.

4.3.3. Thermal hydrolysis technology
A high-pressure reactor to heat the hydrolyzed sludge was used in this technology, causing the microbial cell membrane to break to form a hydrolysate with high organic content, and finally as a result that the hydrolysate is treated by anaerobic digestion. The main purpose of thermal hydrolysis technology to treat sludge is to improve the dewatering performance and anaerobic digestion performance of sludge and enhance its biodegradability. The principle of thermal hydrolysis technology is relatively simple, that is, high temperature and high pressure are used in the high pressure reactor to destroy the microbial cells and promote the hydrolysis of organic matter, which not only alleviates the biological pollution in the activated sludge, but also enhances the dehydration and oxidation of the sludge. Sex.
4.4. Prospect analysis of sludge resource utilization

The utilization of sludge resources is the long-term technical direction of sludge treatment in developed countries in Europe and the United States [5]. For example, according to the national conditions, Japan mainly uses building materials and uses landfills and landfills as a supplement. Central and Eastern Europe mainly uses anaerobic digestion. The sludge is mainly used for agriculture, and the United States uses anaerobic digestion for agriculture and incineration. As a valuable resource, sludge can be used after stabilization and harmless treatment, which can not only avoid secondary pollution, but also develop new resources to meet the requirements of sustainable development. At this stage, reduction and harmlessness are the primary goals of sludge treatment and disposal, and the above primary goals must comply with the principles of safety and environmental protection. In the future, the resource utilization of sludge will become the development direction of sludge treatment and disposal.

5. BRIEF INTRODUCTION OF ANAEROBIC AMMONIA OXIDATION

The main contradiction of China's urban sewage treatment plants has shifted from the removal of organic matter to the removal of nutrients such as nitrogen and phosphorus. With the large-scale construction, operation and commissioning of urban sewage treatment plants in China, the organic matter treatment rate and compliance rate are both significantly high, whereas the removal rate of nitrogen and phosphorus is generally low, which has become an urgent problem for urban sewage treatment plants today.

5.1. Process brief

In the traditional biological denitrification process, denitrification is achieved by nitrification and denitrification. Under aerobic conditions, there are denitrification phenomena in various biological treatment systems and some phenomena that are completely different from the traditional denitrification theory [6]. For example, heterotrophic bacteria can participate in the nitrification process, and the denitrification process can be in good condition. Under oxygen conditions, NH₄ can be converted to N₂ under anaerobic conditions. The anammox process was developed in 1990 by the Kluyver Biotechnology Laboratory of Delft University of Technology in the Netherlands. This process breaks through the basic theory of the traditional process: under anaerobic conditions, ammonia is used as the electron donor, nitrate or nitrite is the electron acceptor, and the ammonia is oxidized to nitrogen. This is the same as the full nitrification (ammonia oxidation to nitrate) Compared with saving more than 60% of oxygen supply, it can also save the carbon source required by traditional biological denitrification process. At the same time, because the cell yield of anammox bacteria is much lower than that of denitrifying bacteria, the sludge output of the anammox process is only about 15% of that of the traditional process.

The reaction process is as follows:

\[ \text{NH}_2\text{OH} + \text{NH}_3 \rightarrow \text{N}_2\text{H}_4 + \text{H}_2\text{O} \]
\[ \text{NH}_3 + \text{HNO}_2 \rightarrow \text{N}_2 + 2\text{H}_2\text{O} \]
\[ \text{HNO}_2 + \text{H}_2\text{O} + \text{NAD} \rightarrow \text{HNO}_3 + \text{NADH}_2 \]

5.2. Advanced technology

Compared with the traditional nitrification and denitrification technology, the anammox process has many advantages:

Since ammonia can be directly used as the electron donor for the denitrification reaction, there is no need to add organic matter as the electron donor, which not only saves costs, but also prevents secondary pollution.

In the nitrification reaction, 2 mol of oxygen is consumed for every 1 mol of ammonia ion to be oxidized, while in the anammox reaction, only 0.75 mol of oxygen is needed for every 1 mol of ammonium ion to be oxidized, and the oxygen consumption is reduced by 62.5%.
Traditional nitrification can generate 2 mol of hydrogen ions by oxidizing 1 mol of ammonium ions, while denitrification can generate 1 mol of hydroxyl ions by reducing 1 mol of nitrate ions or nitrite ions. However, the acid production of anammox is greatly reduced, and the alkali production is reduced to zero, which can save a lot of neutralizing reagents and prevent possible secondary pollution.

6. TO SUM UP
With reference to current reality, this article comprehensively analyzes the current status of wastewater treatment in China through data and literature, summarizes its common problems, points out its development direction, and draws the following conclusions:

1. The overall progress of sewage treatment is great, but there is a gap with the world's advanced level.
2. The level of sludge treatment and sewage treatment is extremely mismatched. The “large amount of sludge” should be controlled from the source, the “poor sludge quality” should be solved from the technical method level, and the prospects for its resource utilization should be actively explored.
3. The serious eutrophication status of domestic water bodies and the improvement of nitrogen and phosphorus removal rate must rely on the upgrading and innovation of denitrification and deoxygenation technology. Some anaerobic ammonia oxidation in mainstream cities is the main direction in the future.
4. The government should improve support policies, establish a sound regulatory system, and promote the multi-dimensional coordinated development of industrial specialization and socialization.

REFERENCES
[1] Shiyu Huang. Analysis of the status quo and development of urban sewage treatment in China [J]. Resource Conservation and Environmental Protection, 2013(12): 173.
[2] Xingwang Sun, Youhua Ma, Guiling Wang, et al. Status and technology research on rural domestic sewage treatment in key river basins in China [J]. Chinese Agricultural Science Bulletin, 2010, 26(18): 384-388.
[3] Yayong Liu. Treatment technology and process analysis of municipal sewage sludge [D]. South China University of Technology, 2010.
[4] Gangfeng Ren. Comprehensive evaluation of sludge treatment and disposal methods in municipal sewage treatment plants [J]. Environment and Development, 2020(12): 16-17.
[5] Hefei Zhang, Yan Xu, Zhengzhong Zeng, et al. Research on foreign urban sludge treatment and disposal methods and its enlightenment to my country [J]. Environmental Engineering, 2010(S1): 434-438.
[6] Huihuang Shao, Xianjin Fang, Yihui Wu, et al. Research on the carbon source of denitrification biological denitrification of urban domestic sewage[J]. Water supply and drainage, 2014 (40): 92-95.