Application of MBR Technology in Schoolyard Domestic Sewage Treatment

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Abstract. This paper discusses the special features of campus sewage, and chooses more suitable sewage treatment for campus sewage. At the same time, it expounds the advantages and disadvantages of it. Compared with city sewage from industry and agriculture, campus sewage has much more characteristic content of pollutants with higher COD, SS and tiny toxic pollutants[5]. Therefore rather than using the traditional activated sludge process, MBR is more appropriate for schoolyard domestic sewage treatment for small area, stable effluent quality, good removal efficiency and little residual sludge production. Additionally, new campuses of universities are always built far away from the city centre, and the water transportation cost can be saved with a sewage treatment system in the campus. The treated water has the quality to be used as gray water for campus watering, cleaning and so on, which can also help the universities to save money. Undeniably, it also has the disadvantages of high energy consumption and cost, for it needs to update the active membrane regularly. If it is used in cities, it will be a huge financial burden for governments. But when it is used in campuses, less sewage will need less membranes, and the polluted membranes can also be used for students’ research.

1. Introduction
With the development and popularization of higher education, colleges and universities have built new campuses to expand their scale, leading to a situation where the amount of sewage discharged from colleges and universities has also increased. At the same time, with the characteristics of centralization and high output, the centralized treatment and on-site reuse of the campus domestic sewage will make sense, and save the transportation and other related expenses. The main sources of the schoolyard sewage include the students cleaning in daily life, the canteen sewage, the toilet water, feces and urine sewage in the bathroom, and so on[2]. By trying out the MBR technologies, it is hoped to achieve a convenient and efficient sewage treatment result in the campus. Through the in-depth treatment of school sewage to achieve the standard of reclaimed water quality, people have achieved on-site resources and harmlessness of domestic sewage and reuse the reclaimed water for sanitary flushing, campus greening irrigation and so on.

2. Methods and Analysis

2.1. Selecting different membranes
2.1.1. Different time. It can be clearly seen from Table 1 that the main pollution index of campus sewage varies in different periods of time, which proves that the composition of sewage will change over time in a day for the different function of the place where the sewage is discharged and the place where the water is used. Therefore, the choice of membrane should be changed along with these changes, as membrane plays an important treatment role in this technology.

Table 1. Mean Value of Sewage Quality Indexes in Different Research Periods

| Time  | PH   | ρ(DO)/mg·L⁻¹ | CODCr/mg·L⁻¹ | ρ(TN)/mg·L⁻¹ | ρ(NH₃-N)/mg·L⁻¹ | ρ(TP)/mg·L⁻¹ |
|-------|------|--------------|--------------|--------------|----------------|--------------|
| 6:00  | 7.58 | 10.24        | 17.55        | 10.82        | 0.558          | 0.55         |
| 8:00  | 7.67 | 8.83         | 26.84        | 8.39         | 0.47           | 0.24         |
| 10:00 | 7.24 | 7.92         | 20.39        | 23.49        | 0.58           | 0.37         |
| 12:00 | 7.48 | 5.88         | 19.45        | 37.22        | 0.769          | 0.24         |
| 14:00 | 7.42 | 5.7          | 21.84        | 25.34        | 0.676          | 0.23         |
| 16:00 | 7.35 | 6.83         | 18.44        | 16.73        | 0.558          | 0.2          |
| 18:00 | 7.69 | 7.36         | 23.94        | 12.83        | 0.594          | 0.45         |
| 20:00 | 7.59 | 8.49         | 26.83        | 18.47        | 0.676          | 0.58         |
| 22:00 | 7.47 | 8.4          | 29.1         | 23.93        | 0.594          | 0.64         |
| 0:00  | 7.65 | 7.94         | 21.48        | 27.05        | 0.635          | 0.55         |

COD is a measure index reflecting the degree of organic pollution in water body. The CODCr in college sewage reached a maximum at 8:00 a.m. and 20:00 at night as shown in figure 1. This is mainly because that most of the students choose to do some washing on these two points[1].

![Figure 1. CODCr Content Variation Curve of Sewage Water for Schoolyard.](image)

Figure 2 shows that the TN and NH₃-N content in the sewage both reach the maximum at the midday and the TN and NH₃-N levels are in a rising trend after 18:00 p.m. Besides, the TP content reached the maximum at 22:00 and the minimum at 16:00. Phosphorus pollution is often derived from the household detergent, so once the laundry or cafeteria cleaning peak in colleges and universities, the TP content of sewage will increase significantly[1].
Figure 2. ITN and NH3-N Content Variation Curve of Sewage Water for Schoolyard.

In a word, the quality of sewage will change with time in colleges and universities, especially, the pollutants of organic, nitrogen and phosphorus, and they will have higher content in noon and evening. Therefore, the content and components of the pollutants through the membranes can be controlled by selecting different membranes to save energy, reduce consumption of membranes and improve the treatment efficiency of the pollutants in sewage. For example, the removal efficiency of pollutants in water can be improved by selecting specific membranes that only allow organics to pass through at noon and after 18:00 p.m.

2.1.2. Different source. The content and component of pollutants in water are well known to be closely related to the source of sewage. In campus, there are several such sites for the centralized discharge of sewage, including dormitory, canteen, laboratory, and so on. The sewage can be classified in the same way as garbage to control the pollutants through different kinds of membrane in equipment to improve the efficiency of domestic sewage treatment.

2.2. High Efficiency of MBR Technology

2.2.1. High quality of effluent.

Table 2. Effect of Treating Various Organic Industrial Sewage

| sewage          | inflow BOD | inflow SS | outflow BOD | outflow SS |
|-----------------|------------|-----------|-------------|------------|
| mariculture sewage | 800        | 250       | 10          | 1          |
| mariculture sewage | 8000       | 700       | 20          | 5          |
| mariculture sewage | 2000       | 50        | 20          | 1          |
| noodle factory sewage | 700        | 150       | 5           | 1          |
| cosmetic sewage     | 2000       | 600       | 10          | 5          |
| egg processing      | 2500       | 1550      | 10          | 2          |
| pork processing     | 3000       | 800       | 20          | 5          |

As can be seen in table 2, the MBR technology can greatly remove pollutants, especially organic pollutants from the sewage.
Additionally, for the new campus of the university far away from the city center, the on-site treatment and on-site reuse of sewage is very necessary, and BBR technology can completely meet the needs of the standard for grey water reuse as can be seen in table 3.

Table 3. Comparison of Reuse Standard of Membrane Effluent and China's Grey Water

| MBR effluent | Flushing toilets | Washing cars | Urban greening | Landscape environment | Recreational landscape |
|--------------|------------------|--------------|----------------|-----------------------|-----------------------|
| PH           | 7-8              |              |                | 6-9                   |                       |
| Color(Hazen) | <30              | 30           | 30             | 30(30)                | 30                    |
| Turbidity    | <1               | 5            | 5              | 10                    | 5(5)                  |
| SS           | Undetected       | -            | -              | 20(10)                | -                     |
| BOD5         | <5               | 10           | 10             | 20                    | 10(6)                 |
| CODCr        | <30              | -            | -              | -                     | -                     |
| NH3-N        | <1               | 10           | 10             | 20                    | 5(5)                  |
| Anionic surfactant | <0.1        | 1.0          | 0.5            | 1.0                   | 0.5(0.5)              |
| TN           | <15              | -            | -              | 15(15)                | 15(15)                |
| TP           | <1               | -            | -              | 1.0(0.5)              | 1.0(0.5)              |

Obviously, the effluent water quality can meet the grey water standard, and the grey water can be used for many water-consuming activities, such as sanitary flushing, campus cleaning, campus greening irrigation.

2.2.2. Less land occupation. Several related data shows that the traditional sewage treatment process requires more plant equipment, but the MBR technology has greatly improved in this respect[6]. It simplifies the sewage treatment process and device, thus reducing the system occupied area and improving the wastewater treatment efficiency in limited space with membranes’ characteristics at the same time.

2.3. Reasons of MBR technology better suited to small range of domestic sewage treatment

2.3.1. High cost for energy. MBR technology needs energy to keep up pressure and people have to update the membranes frequently, therefore, it may not be able to afford for massive sewage treatment.
Figure 4 above shows that the DO concentration has great influence on the removal efficiency of organic matter. When DO is 1.0mg/L, the removal efficiency of COD and NH3-N was 83.79% and 66.2% respectively. The removal rate of COD and NH3-N increased obviously with the increase of DO. Therefore, to improve the removal efficiency of organic matter, people usually choose to force the transfer of oxygen into sewage using external forces, which requires a large amount of energy consumption.

Additionally, the technology also requires additional energy consumption to create external pressure and accelerate pollutant transfer in order to speed up pollutant passing through membrane gaps, and thus contacting widely with the relevant treating substances such as microorganisms, to increase sewage treatment speed.

2.3.2. Research value for university. The campus MBR system itself can be used as on-the-spot investigation and research places for the related professional students. Meanwhile, the membranes in the device has a limited life, and the damage of membranes is divided into reversible and irreversible categories. The reversible damage is valuable to the students majoring in material science, chemistry, environment and so on in colleges and universities. The students can make full use of the campus sewage treatment system to study the relevant content and may bring further improvements to the technology.

2.4. Cost for domestic sewage, cleaning water and excess sludge treatment

2.4.1. The troubles sludge caused in the system. The excess sludge cannot be treated on campus, so it needs to be transported to other treatment plants, which needs transportation costs and wastes traffic resources.

According to statistics, in the operation of activated sludge plant, 90% is caused by sludge bulking. A German task force has investigated hundreds of sewage plants and found that about 50 percent of them have sludge bulking problems. The activated sludge is the ecosystem of many microbial populations. The direct cause of sludge bulking is the overgrowth of filamentous bacteria. Once the sludge bulking problem occurs in sewage treatment system, the pollutants in the water can not settle down well in the sedimentation tank, which will affect the effluent quality of activated sludge process.

Besides, the excess sludge in the traditional activated sludge method is also difficult to preserve and dispose in campus, which is likely to contain a large number of bacteria and toxic and harmful substances, which will endanger students’ health. If it is transported to specialized treatment plants, the school have to pay a certain amount of transportation and handling costs, which is not worthy for the school.
2.4.2. Extra cost of campus water. The schoolyard domestic sewage has to go to the municipal water treatment center and it also needs the extra cost of purchasing clean water. The above cost can be significantly reduced if separate water treatment systems are built on campus.

Table 4. Campus water structure

| site/use            | Teaching area sink | Water for washing in the dining hall | Water for bath | Water used in waterroom of dormitory | Water for building cleaning |
|---------------------|--------------------|--------------------------------------|----------------|--------------------------------------|-----------------------------|
| the yield of water (t/Y) | 16000              | 34700                                | 87800          | 186800                               | 57800                       |
| site/use            | Water for toilet   | Water for fire fighting pool         | Water for greenig | Artificial pool water                |                             |
| the yield of water (t/Y) | 410400             | 4200                                 | 22700          | 10400                                |                             |

Table 4 above shows how much water the campus uses in all aspects.[2] The amount of water available to replace it with grey water is 447700 tons, and the total annual water consumption is 830800 tons. The amount of alternative water is about 53.89% and it is a great saving if a specific water treatment system can be built in the campus.

3. Discussion

3.1. Advantages of MBR technology
MBR technology has the advantages of small footprint, high efficiency of sewage treatment, good effluent quality, stable effluent quality and so on. Besides, its effluent quality can reach the level of grey water with the standard, thus suitable for use in the campus, to save the purchase of clean water and transport of sewage and water purification costs.

3.2. Disadvantages of MBR technology
MBR technology also has its disadvantages. Compared with the traditional process, it has a higher technological requirement and needs more cost investment. But the total amount of campus sewage is not so large that the universities can afford it, and the MBR system can also create conditions for students to study and research.

3.3. Suggestions
Different types of membranes can be tried in school wastewater treatment systems. It is known that the waste water on campus contains some laboratory wastewater which is usually of high toxicity and difficult to treat. If the campus sewage treatment system can be divided into different zones and different membranes are used to treat different domestic sewage with different sources, compositions and toxicity, the effect of campus sewage treatment can be greatly improved.

Furthermore, the universities are supposed to try combining the MBR technology with the SBR technology or other sewage treatment systems, benefiting from all their advantages and keeping the campus from being influenced by polluted water and bad water treatment system. For example, the biological pool in the activated sludge treatment method can be improved by the MBR technology.
Through the use of the membranes, the bacteria or effective treatment substances are kept at a higher concentration to enhance the treatment effect and speed up the treatment.

4. Conclusion
Based on the statements mentioned above, including land occupation, treatment efficiency and extra cost, the MBR technology is more suitable for campus sewage treatment. The MBR technology can guarantee the quality of effluent, which can be directly recycled in campus, saving a lot of extra costs. However, this paper has some refinements to be made and the recommendations will be tested later. In follow-up studies, the advantages of MBR, the more proper treatment of campus sewage, as well as the collaboration between MBR and other technologies will continue to be explored.

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