

Research to Control the Pollution of Membrane Bioreactor by Activated Silica Filler

Delgersaikhan*, Yongfeng Zhang^a

College of Chemical Engineering, Inner Mongolia University of Technology, Hohhot 010051, China

*Corresponding author e-mail: 2362907514@qq.com, ^a1976864688@qq.com

Abstract. For the purpose of re-purification of domestic sewage, a new type of active silica packing was used to control the pollution of membrane bioreactors. The change law of membrane flux and its influencing factors during the long-term operation were investigated. In this paper will show the main filler to the membrane flux decay, as well as further study on the effect of domestic sewage treatment. After 42 days of continuous testing, the average membrane flux was designed at 84L/m²·h, the membrane bioreactor cleaning cycle increased by 30% to 40%, the membrane life expectancy increased by 30% to 40% and the sewage treatment speed increased by 25% to 35%. The treated reclaimed water has a COD of 11.7-18.1 mg/L, a BOD₅ of 3.2-5.6 mg/L, an ammonia nitrogen of 8.54-9.10 mg/L, a hardness of 2.5 mmol/L, a turbidity of 1.91NTU, a chroma of 4, a suspended matter of 0.0001 mg/L, pH value of 7.20, a salt content of 0.07%, a conductivity of 960μs/cm and a TDS of 734mg/L, meeting the first-class requirements of the urban sewage treatment plant pollutant discharge standard and the integrated waste water discharge standard.

1. Introduction

In recent years, membrane bioreactors have been widely used in the field of sewage treatment. It has a small footprint, leaves the remaining sludge and effluent quality good, and can achieve the standard features of reuse. However, the problem of membrane pollution control has always been a challenge in the application of this method. This paper describes the use of activated silica filler to control waste water reuse, membrane of hollow fiber membrane fouling research and the initial results obtained.

Municipal sewage contains high levels of organic compounds, inorganic pollutants and various pathogenic micro, organisms. If discharged directly without effective treatment, it may cause the pollution of the entire water body and cause serious ecological damage [1-4]. There is a need to find a way to deal with urban domestic waste water. So for the membrane bioreactor treatment of domestic sewage research is particularly important.

The purpose of this paper is to study the bioreactor control by bioreactor with activated silica and the bioreactor treatment of domestic sewage, how to better prevent membrane pollution, improve membrane flux, and thereby enhancing the organic and inorganic removal rate. Membrane fouling results in decreased membrane flux, reduced water production capacity, shortened membrane life, and increased membrane bioreactor operating costs [5, 6]. Therefore, it is necessary to reduce and control the membrane fouling and to obtain larger membrane flux under the conditions of low energy consumption.



In this experiment, the water quality was measured to meet the requirements of washing water on the basis of effectively improving the flux of the membrane, thus giving the application prospect of membrane bioreactor a bright future.

2. Experimental part

2.1. Test the water

1.86t domestic sewage and activated sludge were collected from Chunhua Waterworks Sewage Treatment Plant in Saihan District, Hohhot city, Inner Mongolia Autonomous Region. COD of each waste water sample was 288.7-596.2mg/L, BOD 103.4-125.8 mg/L, ammonia nitrogen 30.54-47.82mg/L, turbidity 11.88NTU, suspended solids 22.58mg/L, color 256, pH 7.91, salt content Was 0.11%, conductivity was 1543 μ S/cm, TDS was 985 mg/L and hardness was 3.8 mmol/L.

2.2. Analytical methods

Routine analysis and determination projects include the treatment of water COD, $\text{NH}_3\text{-N}$, turbidity, suspended solids, color, pH, hardness, salt content, conductivity and so on. Determination of GB18918-2002 and GB8978-1996 method.

2.3. The experimental method

In this study, the experiment did not repeat with active silica filler and sewage, nor mud, to maintain a certain pressure and continuous aeration, while the membrane flux was significantly reduced by physical and chemical cleaning methods. In the cases of sludge is still there in the membrane after physical and chemical washing methods are used or complete washing is impossible, the sludge in the membrane is cleaned with the support of sucker pipe using the water in itself and reverse flush from side of outlet by adjusting the appropriate water flow. The experiment ran for 42 days (4 times in total) with 1L of distilled water in the opposite direction for a duration of about 5 minutes each time. Sludge remaining in the membrane module and clogged in the voids is flushed out with distilled water, greatly improving membrane flux.

The experimental membrane module from East China University of Science - Membrane Science and Engineering Center. MBR mainly consists of bioreactor and membrane module in two parts. Its characteristics are self-contained membrane components, easy to clean, replace and add aeration devices, and so on. An aeration pipe is arranged below the membrane module, an aeration pipe is connected with an air pump, a water outlet pipe is connected with the upper surface of the hollow fiber membrane, and the water outlet pipe is connected with a water pump.

2.4. Active silica filler

The preparation of activated silica filler is divided into six stages: water, mixing, extrusion granulation, drying, roasting and cooling. Mixing, extrusion granulation: This experiment is done in laboratory. The powder raw materials and adhesives are taken in accordance with the appropriate ratio. These are added into the mixer, mixed evenly, water is added and the mixture is stirred into sticky and hand-held ball. And then granulated by rotating in an extrusion granulator until the particles are become oval shaped and separate small parts. Drying: The purpose is to remove moisture from the raw material portion to prevent cracking during sintering. Roasting: The dried particles are placed into the crucible, the resistance furnace temperature is set to the design temperature, calcined at a constant temperature within the design time. After the specified time the filler is removed and cooled to room temperature.

In this paper, the control of membrane flux attenuation makes use of active silicon as the main raw material, adding a binder granulation made of filler. Filler added to the reaction pool plays a role in adsorption and retention of organic macro molecules [7]. This then plays a role in retarding the attenuation of membrane flux and removal of sewage chroma. It has a wide range of sources, low prices, is economic, and has strong adsorption, making it quite suitable for sewage treatment. Its physical and

chemical properties and economic performance makes the use of membrane bioreactor treatment of domestic sewage an excellent choice [8].

3. Test results and discussion

3.1. Membrane flux and membrane fouling

In the experiment, the membrane bioreactor membrane assembly is easy to plug, resulting in decreased membrane flux. In this experiment, with the combination of chemical and physical methods to clean the membrane module and the timing of backwashing, the experimental results are guaranteed. During the experiment, the highest flux of membrane flux was $98.2\text{L}/\text{m}^2\cdot\text{h}$ and the lowest flux was $69\text{L}/\text{m}^2\cdot\text{h}$ with an average of $84\text{L}/\text{m}^2\cdot\text{h}$.

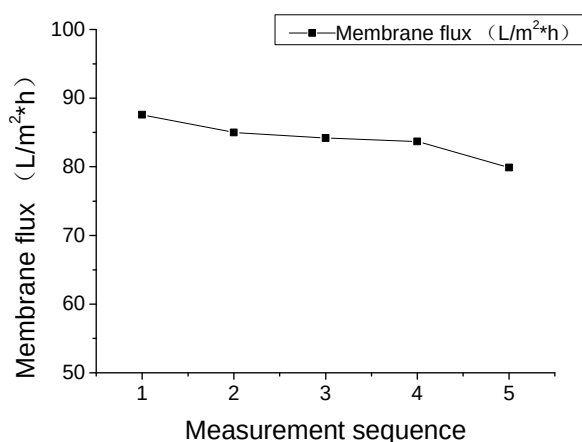


Figure 1. Measurement sequence membrane flux

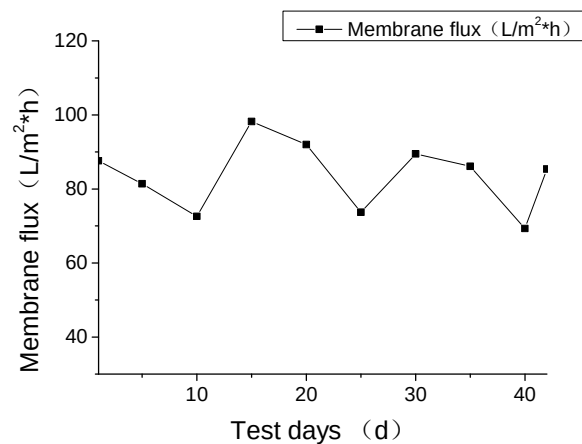


Figure 2. Membrane flux

It can be seen from the above data that the membrane flux of the membrane module used in this paper under the given pressure (8MPa) shows a downward trend with the passing of time. During a short period of operation there is an average membrane flux of $84\text{L}/\text{m}^2\cdot\text{h}$.

Membrane bioreactor clogging was reduced in this experiment because of the active silica packing. Therefore, the membrane bioreactor cleaning cycle increased by 30% to 40%, the membrane life expectancy increased by 30% to 40%.

In order to reduce the membrane pollution and prolong the service life of the membrane, this experiment mainly uses the combination of physical and chemical cleaning methods to clean the membrane module. In this experiment, the combination of chemical and physical methods to clean the exterior of the membrane module, and regular backwash to solve the clogging of the membrane module led to the experimental weakening of the membrane flux.

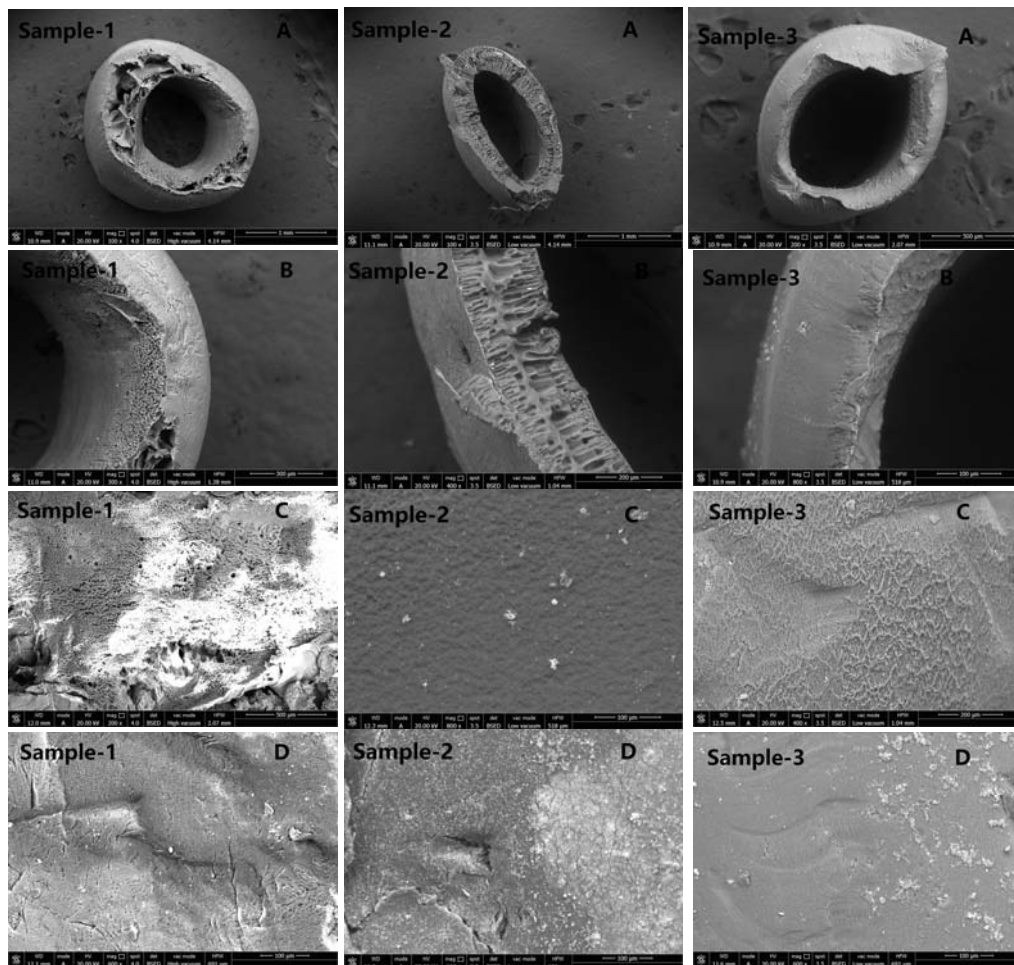


Figure 3. Hollow fiber membrane electron microscopy (SEM) image
(A - Section overall picture, B - section partially enlarged, C- inner surface, D - outer surface)

Inner and outer surface magnification 600 times, section of the whole and partial section pictures enlarged 800 times. Sample-1 is new hollow fiber membrane, no sewage treatment before, we can see that the surface has many gaps. Sample-2 is hollow fiber membrane after backwashing, it can be seen that some of the voids have become clogged, but most of the hollow fiber membranes gap have returned to original shape. Sample-3 is plugged hollow fiber membrane, under severe pollution, section enlarged to 600-800 times, still cannot see the gap in Fig.3.

3.2. Domestic sewage treatment effect analysis

Raw water was added into the regulation of the pool to complete the membrane bioreactor sludge cultivation and domestication. This indicates that in the process of this experiment one of the domestic sewage and sludge microorganisms in the process of experiment has always been active due to the continuous aeration of the membrane bioreactor. COD/BOD₅ was treated 3 times greater in result of the experiment. During the test, the temperature of the sewage remained between 13°C and 20°C.

The raw water has a chromaticity of 256 times and the treated water has a chroma of 4. Experimental results show that the water quality of SS is 0, pH value of 7.20, turbidity of 1.91mg/L, the water quality is good, in full compliance with the State Environmental Protection Administration released <<Domestic sewage treatment plant pollutant discharge standards>> and <<Sewage integrated Emission standards>>. The salt content of influent was 0.11%, the salinity of treated effluent was 0.07%,

the influent hardness was 3.8 mmol/L, the effluent was 2.5 mmol/L, the conductivity decreased from 1543 μ S/cm to 960 μ S/cm, influent TDS was 985 mg/L and 734 mg/L after treatment.

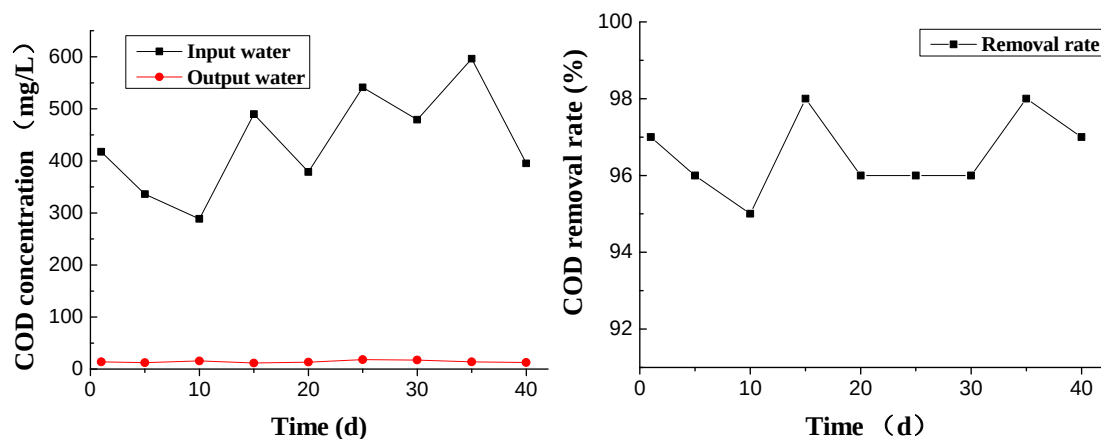


Figure 4. COD Remove result

Figure 4 shows the changes of the COD concentration at the outlet of the membrane bioreactor with the lapse of time during the operation from the first day to the 42nd day after the domestic sewage is added to the membrane bioreactor. Figure 6 also indirectly reflects the COD removal efficiency over time. This is the result of the combined effect of membrane fouling, aeration and sludge concentration. On the 40th day from the beginning of detection, COD removal efficiency was relatively large and basically stabilized. From the 35th day to the 42nd day, the removal efficiency decreased, finally reaching 0. Because there is not a large amount of clogging at the beginning of the hollow fiber membrane, and aeration has been maintained at about 8MPa, which is more suitable for the growth of microorganisms in the sludge, so the water treatment effect is very good. From the initial influent COD of 288.7-596.2mg/L, the treated effluent COD concentration is 11.7-18.1mg/L, which shows that the membrane bioreactor has COD removal efficiency of more than 95% and good COD removing effect.

Research on pollution of membrane bioreactor controlled by activated silica filler showed complete treatment sewage within 42 days, with sewage treatment sped up 25% to 35%.

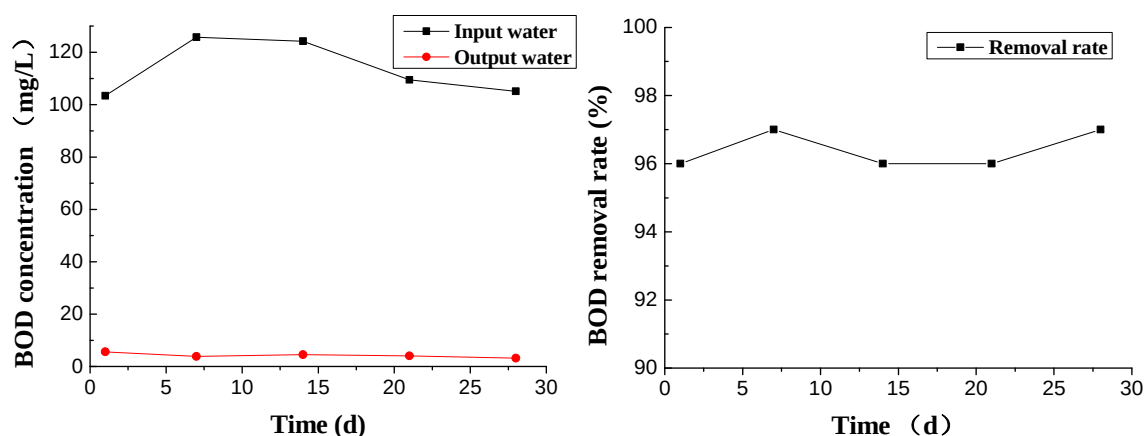


Figure 5. BOD Remove result

Figures 5 show water entered with BOD₅ at 103.4mg/L, treatment effluent BOD₅ concentration of 4mg/L, Over 96% of BOD₅ removal capacity. BOD₅ removal efficiency from fast to slow and then stabilized, due to membrane fouling and selective interaction of activated silica filler results. From the

figure we can see the first day to 14 days results significantly decreased, which is due to the treatment of water samples when a hollow fiber membrane short tube caused by the treatment effect after the 14th day tends to be stable. This is coupled with serious membrane fouling microorganisms, which tends to be the inevitable result of stability.

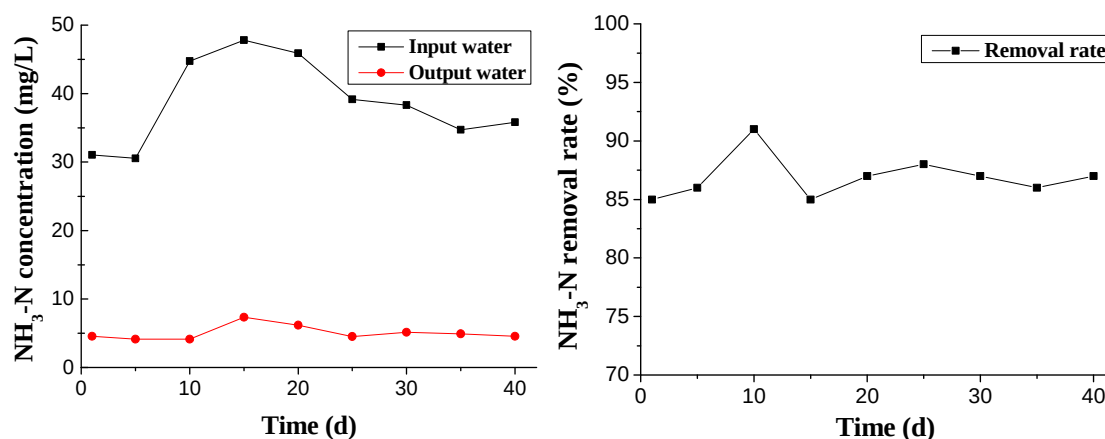


Figure 6. Ammonia nitrogen remove result

Figure 6 shows an ammonia nitrogen intake 30.54-47.82mg/L, and an effluent ammonia nitrogen content of 4.14-7.32mg/L. This is because the membrane bioreactor's effective retention can retain a longer era of microorganisms. Bacteria in the system effects to water purification and concentration of sewage purification. The nitrification effect is obvious, resulting in a high ammonia nitrogen removal rate. It can be seen from Figure 6 that the membrane bioreactor has an ammonia-nitrogen removal efficiency of over 85%. When the domestic sewage treatment is conducted, the removal effect of ammonia nitrogen on the 15th day is obvious and the removal efficiency is relatively stable, which is due to the membrane flux stability combined with the inevitable result of the huge number of nitrobacteria. The removal rate is slowed down after being affected by the membrane fouling. The ammonia nitrogen removal effect is obviously enhanced after the membrane module is cleaned. The effluent quality of ammonia nitrogen index of 4mg/L, in full compliance with the State Environmental Protection Administration promulgated the <<Domestic sewage treatment plant pollutant discharge standards>> and <<Integrated waste water discharge standard>> first level standard for domestic sewage treatment, can be directly used for non-drinking water.

4. Conclusion

Membrane bioreactor cleaning cycle increased by 30-40%, the membrane life expectancy increased by 30-40%, the sewage treatment speed up 25-35%.

In this paper, hollow fiber membrane bioreactor integrated membrane technology was applied to treat domestic sewage in Chunhua Sewage Treatment Plant of Saihan District of Hohhot city. The average membrane flux was designed to be 84L/m²•h. The experimental determination of the project is divided into oxygen-consuming organic pollutants, eutrophic pollutants, solid pollutants, sensory pollutants, inorganic non-toxic substances to analyze its indicators. Membrane bioreactor treatment of domestic sewage test results show that: After the treatment of domestic sewage test results for the COD of 11.7-18.1mg/L, BOD₅ 3.2-5.6mg/L, ammonia nitrogen is 4.14-7.32 mg/L, turbidity of 1.91NTU, the hardness of 2.5 mmol/L, Chroma 4, 0.0001 mg/L Suspension, pH 7.20, salinity 0.07%, conductivity 960 $\mu\text{s/cm}$ and TDS 734 mg/L. According to the environmental functions and protection goals of domestic sewage treatment plants discharged into surface waters, the experimental results reached the level of a standard promulgated by the State Environmental Protection Administration for Discharge Standards of <<Pollutants for Domestic Sewage Treatment Plants>> and <<Grade I of Integrated waste water

discharge standards>> This technology hollow fiber membrane bioreactor treatment of domestic sewage, the results can reach the basic requirements for reuse. Through this test method, the membrane flux of the membrane bioreactor is determined again, the active silica filler controls the membrane fouling, and the physical and chemical membrane cleaning methods and the membrane preservation method are used to treat domestic sewage. The study shows that the hollow fiber membrane bioreactor is an extremely efficient treatment of sewage, operation and management of water treatment equipment.

References

- [1] Zhiwei Wang et al. Research and applications of membrane bioreactors in China: Progress and prospect. *Separation and Purification Technology* 2008, 62: 249 - 263.
- [2] Jan Hoinkis et al. Membrane Bioreactor (MBR) Technology – a Promising Approach for Industrial Water Reuse. *Procedia Engineering [J]*. 2012, 33: 234 - 241.
- [3] Miura Y, Watanabe Y, Okabe S. Membrane biofouling in pilotscale membrane bioreactors (MBRs) treating municipal waste water: impact of biofilm formation [J]. *Environmental Science and technology*, 2006, 41 (2): 632 - 638.
- [4] Qianwen Sui, Jiang Chao, Dawei Yu et al. Research to control the pollution of membrane bioreactor by activated silica filler[J].*Journal of hazardous materials*. 2017, 342: 210 - 219.
- [5] Shaohua Chen, Xiang Zheng, Junxin Liu. Permeate Flux and Membrane Fouling Controlling of a Membrane Bioreactor with Gravity Flow to Treat Domestic Sewage and Landfill Leachate. *Environmental Science*. 2006. 27 (12): 2518 - 2524
- [6] Yanjia Wei, Guoyi Li. Membrane fouling behavior and microbial community succession in a submerged membrane bioreactor treating harbor oily wastewater. *Zhejiang Univ-Sci A (Appl Phys and Eng)* 2016. 17(9): 745 – 757.
- [7] Yu Jiang, Yongfeng Zhang, Jie Bai, Zhaoifei Ma, Jingdong Cui. Facile Synthesis via Electrospinning of a Tetraethoxysilane/Polyvinylpyrrolidone Sol and Characterization of Ultrafine Crystalline SiO₂ Nanofibers. *Journal of Macromolecular Science [J]*, 2014, 53 (B): 383 - 390.
- [8] Jiangong Wang. Design Optimization of MBR System for Oily Waste water Treatment in Port. *AER Advances in Engineering Research [J]*. 2017, 143: 525 - 529.