Desalination and Water Treatment
www.deswater.com
doi:10.5004/dwt.2018.22829

125 (2018) 285–289
September

Experimental study on car washing wastewater treatment by coagulation and nano filtration method

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Received 6 March 2018; Accepted 22 July 2018

ABSTRACT

With the increase of car ownership in China, the number of car-wash has increased. This directly causes the increase of water consumption and vehicle washing wastewater. China is facing not only the shortage of water resources, but also the serious pollution of water resources. Therefore, the recovery and treatment of car washing wastewater is imminent. The existing handing) of wastewater include coagulation treatment, membrane biological reaction method, membrane filtration physical treatment and air float filtration method. In this research the coagulation treatment is used as the pre-treatment, the nano filtration membrane is used to treat the wastewater, and the concentrated water after nano filtration enters into the municipal sewage. Using this method, the removal rate of turbidity, COD and LAS reach the expected levels. The test shows that the car wash wastewater treated by our method has reached the discharge standard.

Keywords: Car-wash; Coagulation; Nano filtration; Wastewater treatment

1. Introduction

According to the statistics of the Ministry of public security, by the end of 2016, the number of motor vehicles in the country reached 290 million, of which 194 million cars which means that the increase of car ownership will promote the development of the car-wash, so that the washing wastewater will increase and thus increase the waste water of car washing. The traditional sewage treatment methods cannot meet the increasingly stringent quality requirements, meanwhile, China is facing water shortages and serious water pollution. The regeneration treatment of wastewater reuse is one of the effective ways to reduce the pressure of urban water environment [1]. Traditional sewage treatment methods include coagulation treatment, membrane biological reaction method, membrane filtration physical treatment method and air float filtration method. Compared with other wastewater treatment technologies, membrane technology has been widely used in water treatment and reuse in recent years due to its good and stable separation effect [2]. Nano filtration is a membrane filtration technology between ultra filtration and reverse osmosis, it can effectively intercept the multivalent salt and organic pollutants in the water, and has good stalling characteristics for the monovalent, multivalent ion mixing system. In recent years, the softening of drinking water, deep treatment and reuse of sewage and concentration separation of industrial process have been obtained in recent years for a wide range of applications [3,4]. Nano filtration (NF) is considered to as a promising technique for removing micro pollutants from wastewater (MPs) [5]. Nano filtration in wastewater treatment has

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Presented at the 4th Annual Science and Technology Conference (Tesseract'17) at the School of Petroleum Technology, Pandit Deen Dayal Petroleum University, 10–12 November 2017, Gandhinagar, India

1944-3994 / 1944-3986

a considerable amount of researches, Erkan Sahinkaya combined activated sludge process with nano filtration membrane which was on the basis of biochemical treatment in addition to the further the COD in the water, the chromaticity and salinity, to increase the water quality and reuse standard [6]. Li Kun et al. used the combined process of MBR-NF to treat textile wastewater. The whole system has a stable and efficient removal effect on the pollutants in the textile waste water. Among them, the removal rate of the sodium filter is lower than 4 mg/L, turbidity and chromaticity removal rate is up to 99.64% and 96.41% [7]. PMIA TFC NF membrane (A new type of nano filtration membrane) has great potential in the treatment of simulated textile wastewater [8,9]. Nano filtration membrane is widely used in food and beverage industry, mainly used in concentration, desalination and environment related to water treatment, such as soft albumin concentration and desalination, glucose syrup purification as well as to the process fluid, ion exchange resin regeneration recycling [10–13]. There are a lot of researches on the reuse of car wash wastewater. They adopt ultra filtration and reverse osmosis membrane, but there are few studies on the application of nano filtration membrane. The most prominent advantage of nano filtration membrane is its low energy consumption due to low operating pressure.

The common pollutants in car-wash wastewater are oil, sediment, automotive cleaning agent, some viruses and bacteria. The nano filtration membrane can greatly filter out organic salts, viruses and bacteria.

The method used in this paper is similar to that of traditional car washing wastewater treatment. The difference is that the nano filtration membrane is treated as a deepening process. Coagulation treatment is used as pre-treatment, organic salt, virus, bacteria and advanced treatment of wastewater is treated with nano filtration membrane. The concentrated water after nano filtration is discharged into the wastewater of the city, and the municipal sewage is treated uniformly by the government.

The rest of the paper is organized as follows. The second part is the method and the third part is the result and discussion. In the fourth part, we give the conclusion of this paper. The washing wastewater treated by our method has reached the standard for the water quality of urban sewage recycling urban waste water (GB18920-2002).

2. Methodology

Our experimental samples are taken from a car wash factory in Xi'an. In order to obtain the representative samples of waste water, we collected water according to the washing process and returned to the laboratory. After that, the water samples were fully mixed for later use. The processing road map is shown in Fig. 1.

2.1. Determination of raw water quality

As can be seen from Table 1, solid suspension, chromaticity, turbidity, COD and anionic detergent in car wash wastewater is seriously exceeding the standard. In order to make the recycled wastewater reach the standard, these excess amounts of elements must be handled properly. Solid suspension not only increases the turbidity of water, but also provides a growing environment for bacteria and algae. The oily substance in the waste water covers the water surface, which obstructs the natural purification and oxidation of water. Linear alkylbenzene sulfonates are the main component of car (automotive) cleaning agent. It is easy to form foam which can hinder water purification and reduce the dissolution and transmission speed of oxygen in water. E. coli in the environment is harmful to human health. In

Table 1
Water quality comparison table

Project	Wastewater	Water quality standards for car wash
pH	7.65	6.0–9.0
Suspended solids (mg/L)	63	5
Chromaticity	55–65	30
Turbidity (NTU)	47–96	5
COD (mg/L)	70–189	50
LAS (mg/L)	2.4–5.6	0.5
Total E. coli. (A/L)	4–7	3
Smell	Pungent smell	Without exception
Ammonia nitrogen (mg/L)	6.67–.75	10

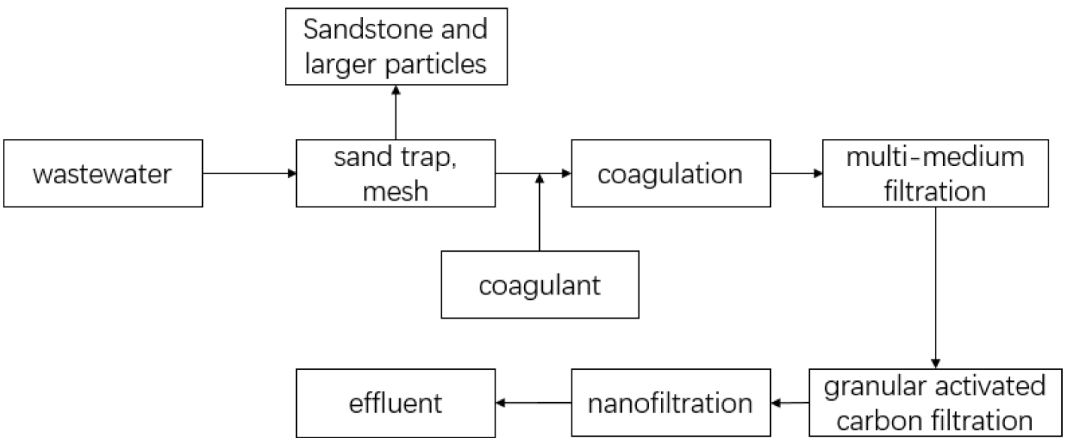

Fig. 1. Processing map.

waste water the virus and bacteria must be treated to avoid its harm.

For the pollutants in Table 1, the method in Table 2 is taken [14].

2.2. Numerical calculation

The determination of organic content by potassium dichromate method is calculated as follows [15]:

$$COD\,(mg/L) = C * V_1 - V_2 * 8000 / V_0 \quad (1)$$

where C is the concentration of $Fe_2(NH_4)_2(SO_4)_3$ (mol/L); V_0 is the water volume (ml); V_1 is the dosage of titrated waste water (ml); $Fe_2(NH_4)_2(SO_4)_3$ V_2 is the titrate the amount of blank sample $Fe_2(NH_4)_2(SO_4)_3$ (ml)

Nessler's reagent spectrophotometry determination of ammonia nitrogen content and its working principle is that the free ammonia or ammonium ion ammonia reacts with type reagent to generate a reddish brown complex the complex of the absorbance is proportional to the ammonia nitrogen content. The principle of methylene blue spectrophotometric determination of LAS content is similar to that of naldrin's reagent spectrophotometry. The difference is that the former is measured at the wavelength of 420 nm, while the absorbance methylene blue spectrophotometry has a wavelength of 652 nm.

First, draw the scatter diagram of absorbance and ammonia nitrogen and LAS according to the measured data and match the equation:

$$Y = b + aX \quad (2)$$

where Y is the ammonia nitrogen and LAS content of the sample to be measured (mg/L); X is the absorbance of the sample to be measured; a, b are the coefficients

Determine the coefficient a and b, determine the content of ammonia nitrogen and LAS in the original water.

3. Results and discussion

3.1. Coagulation treatment

Coagulation is a chemical method which includes coagulation and flocculation. The addition of coagulants to waste water can make the pollutants and suspended matter together in the water, form a flocculent, which can be precipitated under the action of gravity, and some toxic substances in the waste water can also be removed [16,17]. The coagulant is divided into inorganic salts and macromolecule mixtures.

Common macromolecules include polyaluminium chloride (PAC) and polyacrylamide (PAM). These coagulants are widely used in industrial wastewater treatment. By referring to the relevant literature and sorting out, we chose polyaluminium chloride (PAC) as coagulant and polyacrylamide (PAM) as a coagulant [18,19].

In the process of determining the best test PH value, the optimum test temperature, the best PAC dosage and the best PAM dosage, seven groups of parallel tests are designed in each project by using the control variate method. In each test, we determine the turbidity of solution and the rest of the COD and LAS. Then we do the independent variable PH, temperature, dosage of PAC and PAM dosage, pollutants removal rate curve drawing. Finally the independent variables of the optimal threshold are determined. Fig. 2 shows the removal effect of PH on pollutants. Fig. 3 shows the removal effect of temperature on pollutants. Fig. 4 shows the removal effect of PAC on pollutants. Fig. 5 shows the removal effect of PAM on pollutants.

It can be seen from Fig. 2 that turbidity and residual COD decrease with the change of PH first. When pH = 7, turbidity and COD removal rates are 56.71% and 26.30% respectively, and both of them have reached the best state of treatment.

It can be seen from Fig. 3, when the reaction temperature is 25°C, turbidity and COD removal rates are 57.32% and 27.10% respectively, and both of them have reached the best state of treatment.

It can be seen from Fig. 4 that washing waste water turbidity, residual COD and LAS keep steady decline with the increase of PAC inputs, and each of their removal rate increases with the increase of PAC inventory. When the PAC mass is greater than 24 mg/L, the removal rates of COD and turbidity growth are slowing down. The removal rate of LAS has not changed much. Therefore, we conclude that the optimal dosage of PAC is 24 mg/L.

Fig. 5 shows that when the PAC dosing quantity is 24 mg/L, PH value of 7, the temperature is 25°C, the PAM dosing quantity is greater than 1.2 mg/L, the turbidity of washing wastewater and residual values will change

Table 2
Analytical projects and methods

Project	Method
COD	Dichromate method
Turbidity	TB-2000 portable turbidimeter
Chromaticity	Platinum cobalt standard colorimetry
LAS	Methylene blue spectrophotometry

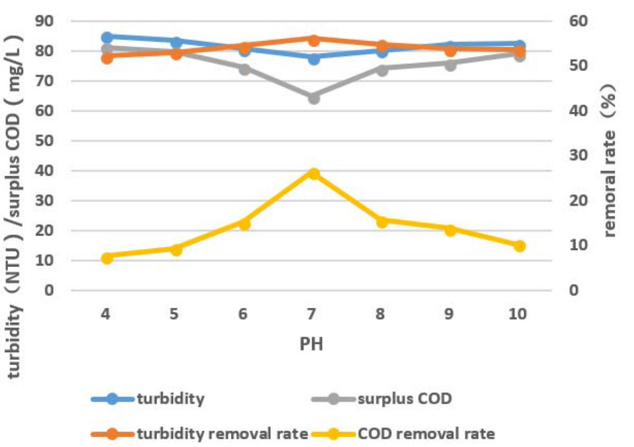

Fig. 2. PH for removal of pollutants.

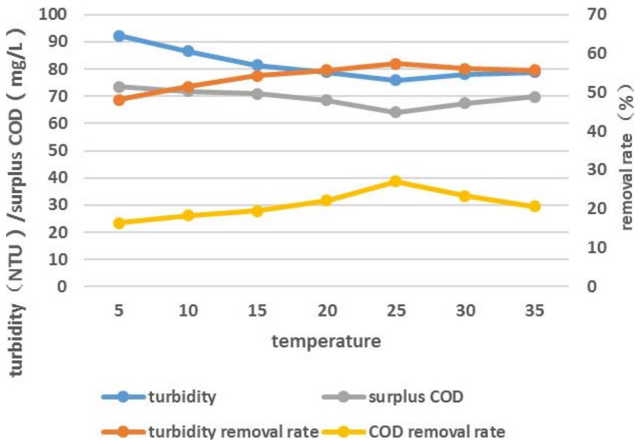

Fig. 3. Effect of temperature on removal of pollutants.

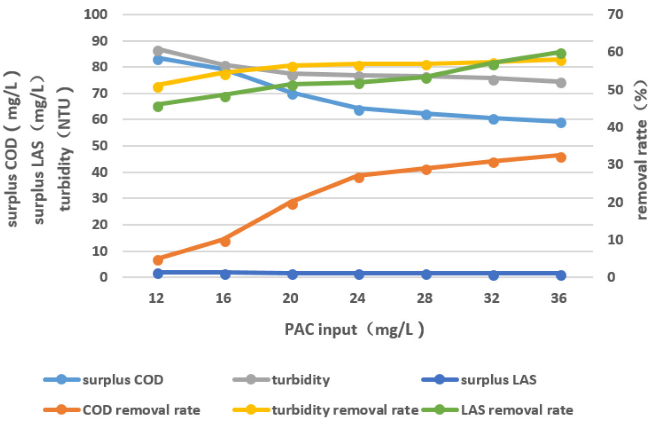

Fig. 4. Removal effect of PAC on pollutants.

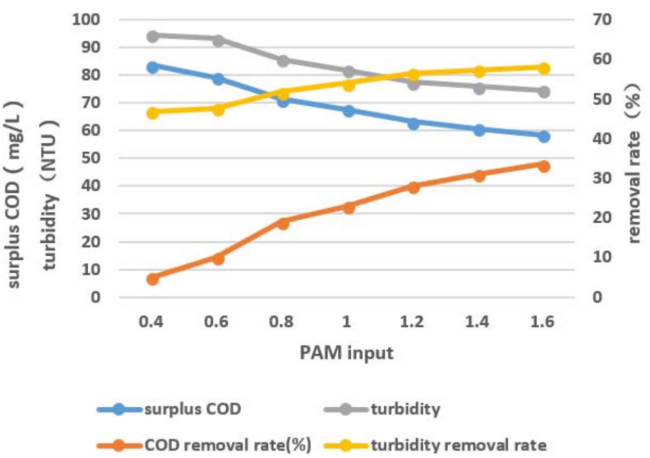

Fig. 5. The removal effect of PAM on pollutants.

slowly. Therefore, we conclude that the optimal delivery amount of PAM is 1.2 mg/L.

Comprehensive analysis of the factors for car washing wastewater in the amount of residual turbidity, COD and LAS, the influence of the best reaction conditions are as follows: coagulation reaction temperature of 25°C, pH value of 7, PAC dosing quantity of 24 mg/L, PAM dosing quantity is 1.2 mg/L. By coagulation and precipitation, the turbidity and COD concentration of wastewater can be greatly reduced, providing reliable guarantee for the stable operation of the follow-up processing unit.

Table 3
Performance table of Cori positive membrane nano filtration membrane

Membrane name	SG-NF1-4040-G
Component size(mm)	φ101.6*1016
Membrane composition	Eurelon
Effective membrane area (ft^2)	75
Water yield (gpd, 70 psi, 25°C)	1600
Minimum desalination rate (%)	97
Stable desalination rate (%)	>97
Continuous operation pH range (25°C)	2–11
Operating temperature range (°C)	2–45
Recommended operating pressure (psi)	40–200

3.2. Nano filtration treatment

Nano filtration can effectively remove all kinds of large organic molecules and achieve high permeability, antifouling ability and good selectivity [20]. Nano filtration membrane was first called "loose reverse osmosis membrane" or "dense ultra filtration membrane", but later renamed Schafer et al. [21,22]. In fact, the nano filtration membrane originated from the nano scale particle size of 1 nm, corresponding to a molecular weight range of 150–200 dags, not because the membrane structure (such as membrane pore size) is a nanometer level [23–25].

The nano filtration membrane selected in this experiment is a domestic medium Zhongyang membrane, SG-NF1-4040-G. Its performance is as shown in Table 3.

The wastewater from the previous step is filtered by multi-media and granular activated carbon, and then the filter is processed. Condensed water after filtration is discharged into the municipal wastewater, the purified water flows into the reservoir for reusing.

3.3. Discussion

In 3.1, it is determined that the coagulant can reach the best coagulating state when the dosage of PAC is 24 mg/L, the dosage of PAM is 1.2 mg/L, the test temperature is 25°C and the pH value of wastewater is 7. Under the optimum experimental conditions, the removal rates of turbidity, COD, LAS and chroma are 57.47%, 27.27%, 52.78% and 30% respectively. From Table 4, it can be seen that through the process of coagulation-medium filter-granular activated carbon filter-nano filtration, the removal rates of turbidity, COD, LAS and chromaticity in car washing wastewater are 99.89% (1–0.2/178), 87.73% (1–10.8/88), 87.5% (1–0.45/3.6)and 79.43% (1–14.4/70) respectively, which meet the discharge standard.

4. Conclusion

This paper studies the car washing wastewater of a car wash in xi 'an. Coagulation and nano filtration were used to

Table 4
Effect chart of wastewater treatment by unit

	Raw water	Coagulation	Multi-medium filtration	Granular activated carbon filtration	Nano filtration
Turbidity (NTU)	178	75.7	41.6	35	0.2
COD (mg/L)	88	64	53	16.9	10.8
LAS (mg/L)	3.6	1.7	1.6	0.48	0.45
Chroma	70	49	42	16.7	14.4
Taste	strong	yes	yes	No	no

treat automobile washing wastewater and realize the recycling of automobile washing wastewater. The conclusions are as follows:

1) In the process of coagulation, when 24 mg/L polyaluminum chloride (PAC) and 1.2 mg/L polyacrylamide (PAM) are added to the wastewater, the coagulation treatment can effectively remove the pollutants in the wastewater. The removal rates of turbidity, COD, LAS and chroma are 57.47%, 27.27%, 52.78% and 30%, respectively.
2) Activated carbon is critical to the removal of smell, chroma, COD and LAS and the removal rates of COD, chroma and LAS are 68.11 %, 60.23% and 70% respectively.
3) The removal rates of turbidity, COD, LAS and chroma reach 99.89%, 87.73%, 87.5% and 79.43% respectively, after coagulation multi medium filtration, granular activated carbon filtration and nanofiltration.

The water quality of the wastewater treated by combined process has reached the standard of reuse.

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