FEASIBILITY STUDY ON TREATMENT PLAN OF SCOURING WASTEWATER IN THE PRINTING AND DYEING WASTEWATER

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Abstract

With the rapid development of printing and dyeing industry, the total emissions of printing and dyeing wastewater growing day by day, the components are more and more complex. At present, comprehensive treatment method to sewage treatment is used primarily in printing and dyeing wastewater. This not only increases the area, but also increases the processing cost. In this article, scouring wastewater in the printing and dyeing wastewater is treated separately. Meanwhile, compared the two kinds of processing methods in terms of economy and technology， demonstrated the feasibility of scouring wastewater treated separately, provided theoretical basis for diversified treatment of printing and dyeing wastewater.

Keywords: *Comprehensive treatment, economic comparison, feasibility study, individual treatment, printing and dyeing wastewater, scouring wastewater.*

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1. INTRODUCTION

Emissions of printing and dyeing wastewater are large, which are the main source of industrial wastewater. According to statistics, daily emission of printing and dyeing wastewater is 3×10^6～$4\times10^6 m^3$. The components are complex，containing unreacted dyes, organic compounds and heavy metals. The current processing method has shortages such as large area occupied, more investment, high cost of governance and high production costs. In recent years, due to the development of chemical fiber fabrics , the rise of emulation silk , and the progress of printing and dyeing finishing technology, which make the difficult to biochemical degradation of organic matter into printing and dyeing wastewater, such as chemical pulp, rayon alkaline hydrolysis, new additives and so on[1,2]. It contributes to a lower ratio of B/C, and increases the difficulty of sewage treatment greatly.

Printing and dyeing process need to go through several stages, including preprocessing stage(singeing, desizing, scouring, bleaching and mercerizing process)，dyeing stage，printing and finishing stage. Scouring process is to use high temperature alkali steaming fabric, so as to remove residual impurities on the fabric, and make the fabric has superior water imbibition and the dye easy to absorb and diffuse in the process of dyeing and printing. The water quantity of scouring wastewater is large and concentration of pollutants is high, which contains caustic soda, surfactants, cellulose, acid, grease, wax, and so on. The wastewater is strongly alkaline, pH will reach 11 to 12, oxygen consumption is 20,000 ~ 25,000 mg/L, BOD_5 is 17，000 mg/L. If it's discharged directly, it will cause serious pollution [3]. Therefore, treating scouring wastewater is imminent.

The traditional method is mainly treating the wastewater together at each stage of the printing and dyeing processing, but this method covers an area of large and has a high operation cost. Various pollutants concentration of scouring wastewater are high, individual treatment can reduce operation cost of the printing and dyeing wastewater, and treatment effect will be better.

This article takes a printing and dyeing treatment plant as an example, introducing traditional treatment technology of printing and dyeing wastewater. Comparing printing and dyeing wastewater comprehensive treatment with scouring wastewater individual treatment, in terms of technological process and treatment effect and construction costs and so on. Thus it concluded that the feasibility of scouring wastewater treated separately, and provided a theoretical basis in the aspect of diversity, high efficiency and economy for future printing and dyeing wastewater treatment.

2. THE MAIN TREATMENT PROCESS

At present, the treatment methods of printing and dyeing wastewater mainly are physical, chemical, biological, biochemical, physical chemical method and so on[4-7]. Combining with the characteristics of China's national conditions, meanwhile，absorbing foreign technology experiences, sewage treatment technology of our country improved gradually, and formed some applicable technical route. Such as conventional activated sludge process, artificial biological purification technology, diffused emissions based and supplemented processing technology, to target the reuse wastewater treatment technology. Meanwhile, under the specific circumstances of combined sewage treatment，formed some traditional processing techniques, such as conventional activated sludge process, oxidation ditch, biological contact oxidation method, A/O method.

Conventional activated sludge process is a typical process of activated sludge sewage, its characteristic is aerobic microorganisms appear in the form of activated sludge in the aeration pool，and providing sufficient oxygen to microbes by air blower aeration, promoting microbial survival and reproduction so as to break down organic matter in the wastewater. After precipitation separation of the mixed liquids, activated sludge flooded back into the aeration pool. The sludge load rate is 0.2-0.4 $KgBOD_5$ / KgMLSS · d, aeration pool residence time is about four to six hours, the gas-water ratio is 8：1. This method has many advantages such as sewage treatment effect is good , the removal rate of BOD_5 can reach 90% ; be suitable for processing large amounts of wastewater ; performing reliably and stabilizing water quality. Also, it has many shortages such as high running cost; large area occupied; poor adaptability to the external environment; the N and P removal rate is low [8].

Oxidation ditch is also named circular aeration pool, is a closed ditch aeration pool. Sewage and activated sludge mixture keep on circulating，the hydraulic retention time is about 15~16h, sludge age up to 15~30 days, is extended aeration method. Due to the shallow depth（about three meter） of oxidation ditch, the process is long, the way of anoxia before aerators and oxygen-rich after aerators is designed to run, providing facultative aerobe and aerobic bacteria alternation conditions. This method has many advantages such as strong ability to withstand shock loads and hardly degradable organic matter also has a good treatment effect; treatment effect is stable and reliable; hydraulic retention time and SRT are very long, suspended solids and organic matter get more thorough degradation in the groove; capital and operating costs are lower than the general activated sludge; adaptability of water quality, water quantity, water temperature is strong; effluent water quality is well. Also, it has many shortages such as high operating and administrative expenses; large area is occupied [9].

Biological contact oxidation method is a kind of wastewater biological treatment methods derived from biological membrane method, it fills a certain quantity of filler into the biological contact oxidation pool, with the help of biological membrane sitting on the filler and sufficient oxygen， oxidation and decomposed of organic matter in wastewater by the effect of biological oxidation, to achieve the purpose of purifying. This method has many advantages such as strong adaptability to sharp change of BOD_5 load; processing time is short and small area occupied; difficult to produce sludge expansion; bacteria culture domesticated easily; less excess sludge. Also, it has many shortages such as cannot arbitrarily adjust biomass and device efficiency by the change of operation conditions; amount of biological membrane increased with the load and easy to plug the filler; producing a large number of metazoan (rotifers) and easy to influence water quality; contact filler of combined type can influence uniform aeration and mixing [10].

A/O process contact the front anoxic period with the back aerobic period, the DO（Dissolved Oxygen）of A section is not more than 0.2 mg/L, and the DO of O section is 2 to 4 mg/L. In the anoxic period, heterotrophic bacteria can hydrolyze these matters into organic acid such as starch in the wastewater, fiber, carbohydrate and some suspended pollutant and dissolved organic matter, make the macromolecular organic matter decomposed into small molecule organic matter, and make the insoluble organic matter into soluble organic matter. When these products flowed into aerobic pool after anoxic hydrolysis, then conducting aerobic treatment, it will improve wastewater biodegradability and efficiency of oxygen. In the anoxic period, protein, fat and other pollutant dissociated ammonia (NH_3、NH_4^+) by ammoniation of heterotrophic bacteria. Under the condition of sufficient oxygen, NH_3-N（NH_4^+） oxidizes into NO_3^- by nitrification of autotrophic bacteria, then back to A pool by reflux control. Under the condition of hypoxia，NO_3^- is restored to molecular nitrogen（N_2） by denitrification of heterotrophic bacteria, completing ecological cycle between the C, N and O, then innocuous treatment of wastewater came true. This method has many advantages such as removal rate of BOD and COD and SS reach 80% to 90%; process is simple and operating costs is low; pollutants degradation efficiency is high in denitrification process of anoxic period; volume load is high; strong ability resistance to shock load in anoxic and aerobic process. Also, it has many shortages such as degradation efficiency of difficult degradable substances is low; operating cost will increase when nitrogen removal efficiency improved [11].

Based on above analysis，printing and dyeing wastewater comprehensive treatment adopts biological contact oxidation method and scouring wastewater individual treatment adopts A/O process in this engineering example.

3. PRINTING AND DYEING WASTEWATER COMPREHENSIVE TREATMENT TECHNOLOGICAL PROCESS AND THE STRUCTURE FEATURES

3.1.Process Flow Diagram (Fig. 1)

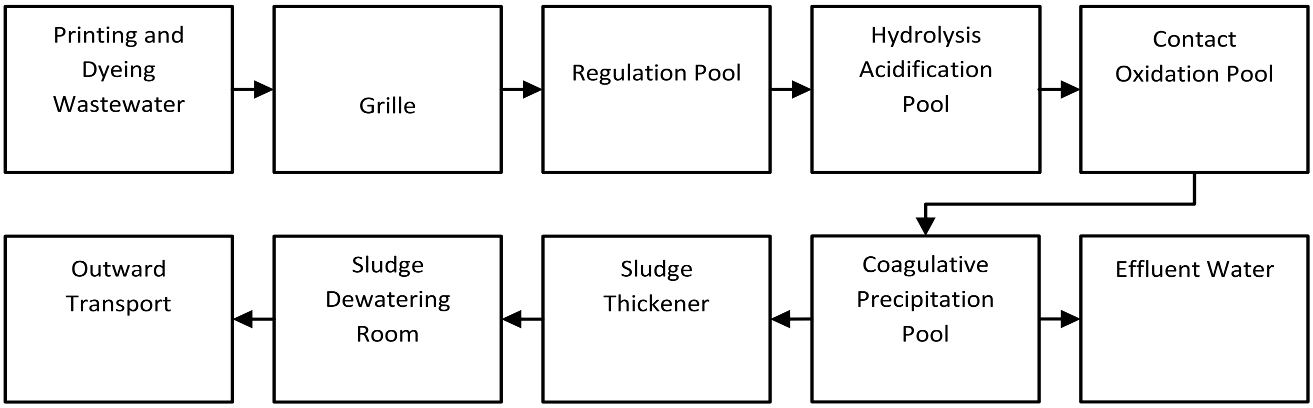

Fig. (1). The process flow diagram of printing and dyeing wastewater comprehensive treatment

3.2.Main Structure Features

1) Regulation pool [12]: It can adjust water quantity and quality, temperature, and wastewater pH, also it has the role of pre-aeration. It's reinforced concrete structure. The pool size: L×B×H =20m×12m×6m. The hydraulic retention time is 10 h. The effective depth is 5m. Regulation pool filling oxygen by two roots blower with the speed of $10m^3$/ min. The mud ditch setting at the bottom of regulation pool, which consists of mud tubes. Adopting the method of hydrostatic pressure to remove mud. In addition, the treated water was discharged into hydrolytic acidification pool with three (two - work- one - standby) sewage pumps (4PW) with a speed of $160m^3$/h.

2) Hydrolysis acidification pool [13]: It can reduce the molecular weight of organic matter and produce product of incomplete oxidation which it's advantage to subsequent aerobic treatment, also it has the function of biochemical treatment and sludge volume reduction and stabilization. It's reinforced concrete structure. The pool size: L×B×H =12m×8m×8m.Hydrolysis acidification pool surface load is 1.3 m^3/ (m^2·h).The hydraulic retention time is 6h. The effective depth is 7.8m. Adopting uniform water distribution at the bottom of the pool. The elastic filler, whose thickness is 1m, is filled in the area of clearwater of hydrolysis pool [14].

3) Contact oxidation pool: Wastewater to be treated with a speed through filler after filling oxygen, contact with biofilm, under the joint action of biofilm and suspended activated sludge, to achieve the role of purifying wastewater [15]. It's reinforced concrete structure, the two pools takes on rectangular in the plane. The pool size: L×B×H= 10m×10m×7m. The hydraulic retention time is 6h. The total height of filter layer is 4m. Filter pool is divided into four parts, and effective volume is $185m^3$. The pools adopting three-dimensional elastic filler of YCDT type, equipping with perforated tubes at the bottom. In addition, there are three (two - work- one - standby) roots blower. The Gas-water ratio is 15：1. Effluent water flow to well from braiding channel, then flow to sedimentation pool by power of gravity.

4) Coagulative precipitation pool: It's reinforced concrete structure, including coagulation pool and sedimentation pool. The coagulation pool size: L×B×H =4 m×4 m×5m.The reaction time is 30mim. The effective depth is 4m. The vertical sedimentation pool size: L×B×H =15 m×3 m×10m. The hydraulic retention time is 2h.The effective depth is 6m. Coagulant addition adopting wet method, it's easy to mix with water. This design makes PAC as coagulant [16]. Colloid and tiny suspended solids in the wastewater condensed into flocculation body under the effect of coagulants, so as to reduce the turbidity and chromaticity of wastewater and other water quality of sensory indicators, also remove toxic and hazardous pollutants. In addition, there is a truss-car suction dredge of GMN - 8000 type, suction dredge with a running speed of 1.0m/min, discharging sludge into sludge thickener.

3.3.The Quality and Processing Efficiency of Printing and Dyeing Wastewater (Table1)

Table 1. The quality and processing efficiency of influent water and effluent water in dyeing and printing wastewater (3000 t/d) comprehensive treatment

Item	BOD（mg/L）	CODcr（mg/L）	SS（mg/L）	Chroma	pH
Influent Water	300	1200	600	400	9-11
Effluent Water	25	100	80	42	6-9
Processing Efficiency	91.7%	91.7%	86.7%	89.5%	——

4. SCOURING WASTEWATER INDIVIDUAL TREATMENT TECHNOLOGICAL PROCESS AND THE STRUCTURE FEATURES

4.1.Process Flow Diagram (Fig.2)

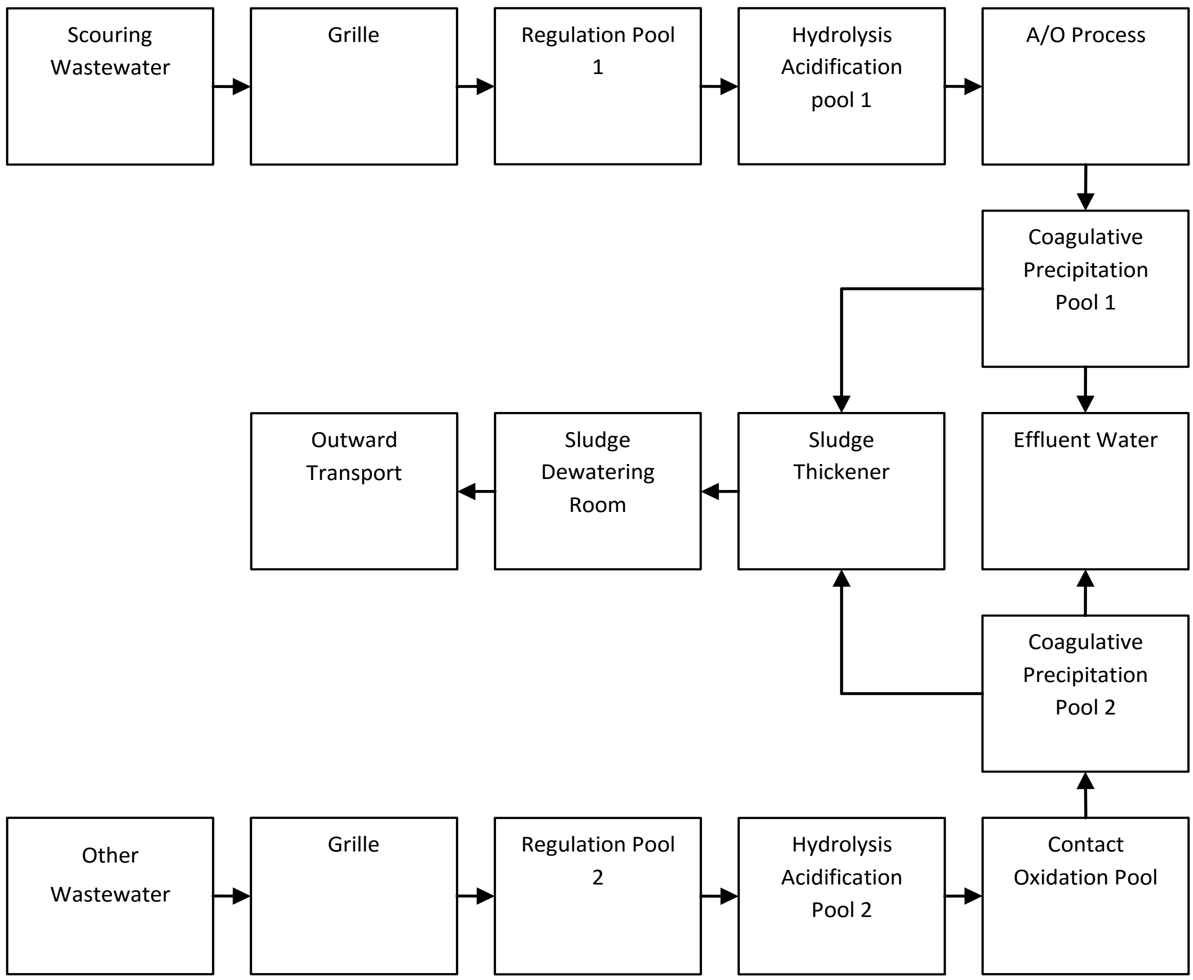

Fig. (2). The process flow diagram of scouring wastewater individual treatment

4.2.Main Structure Features

1) Regulation pool [12] 1: It's reinforced concrete structure. The pool size: L×B×H =8m×5m×4.5m. The hydraulic retention time is 12h. The effective depth is 4m. The Gas-water ratio is 4：1. Regulation pool filling oxygen by two roots blower with the speed of 8 m^3 / min. The mud ditch setting at the bottom of regulation pool, which consists of mud tubes. Adopting the method of hydrostatic pressure to remove mud. In addition, the treated water was discharged into hydrolytic acidification pool with two (one - work- one - standby) sewage pumps (4PW).

Regulation pool [12] 2: It's reinforced concrete structure. The pool size: L×B×H =12.5m×10m×4.5m. The hydraulic retention time is 10h. The effective depth is 4m. The Gas-water ratio is 5：1. Regulation pool filling oxygen by two roots blower with the speed of $10m^3$ / min. The mud ditch setting at the bottom of regulation pool, which consists of mud tubes. Adopting the method of hydrostatic pressure to remove mud. In addition, the treated water was discharged into hydrolytic acidification pool with three (two - work- one - standby) sewage pumps (4PW).

2) Hydrolysis acidification pool [13] 1: It's reinforced concrete structure. Setting an acidification pool. The pool size: L×B×H =12m×8m×8m. Hydrolysis acidification pool surface load is $1.1m^3/(m^2 \cdot h)$. The hydraulic retention time is 8h. The effective depth is 4.5 m. Adopting uniform water distribution at the bottom of the pool. Filling clearwater area of hydrolysis pool with 1 m elastic filler [14].

Hydrolysis acidification pool [13] 2: It's reinforced concrete structure. The pool size: L×B×H =12.5m×8m×10m. Hydrolysis acidification pool surface load is 1.2 m^3/ (m^2·h). The hydraulic retention time is 10h. The effective depth is 10m. Adopting uniform water distribution at the bottom of the pool. The elastic filler, whose thickness is 1m, is filled in the area of clearwater of hydrolysis pool [14].

3) A/O process: It's reinforced concrete structure, including anaerobic pool and aerobic pool. Anaerobic pool in the front of the structure, because of the effect of denitrification consumed part of carbon source organic matter, it can reduce aerobic pool load. Aerobic pool in the back of the structure, it can further remove the organic matter. The hydraulic retention time of anaerobic pool is 8h. The volume of anaerobic pool is 200m^3. The effective depth is 4m. The anaerobic pool size: L×B×H =12m×4m×4.5m; the hydraulic retention time of aerobic pool is 20h. The volume of aerobic pool is 500m^3. The effective depth is 4m. The aerobic pool size: L×B×H =12m×5m×4.5m.

4) Coagulative precipitation pool 1: It's reinforced concrete structure, including coagulation pool and sedimentation pool. The coagulation pool size: L×B×H =2m×2 m×4m. The reaction time is 30mim. The effective depth is 3.5m. The sedimentation pool size: L×B×H =3m×3 m×8m. The hydraulic retention time is 2h.The effective depth is 6m. This design makes PAC as coagulant [16]. Coagulant addition adopting wet method. In addition, there is a truss-car suction dredge of GMN - 8000 type, suction dredge with a running speed of 1.0m/mim, discharging sludge into sludge thickener after the pump sucking up sludge.

Coagulative precipitation pool 2: It's reinforced concrete structure, including coagulation pool and sedimentation pool. The coagulation pool size: L×B×H =4m×3m×4.5m. The reaction time is 30mim. The effective depth is 4.0m. The sedimentation pool size: L×B×H =7m×5m×10m. The hydraulic retention time is 2h. The effective depth is 6m. This design makes PAC as coagulant [16]. Coagulant addition adopting wet method. In addition, there is a truss-car suction dredge of GMN - 8000 type, suction dredge with a running speed of 1.0m/min, discharging sludge into sludge thickener after the pump sucking up sludge.

5) Contact oxidation pool: It's reinforced concrete structure, the two pools takes on rectangular in the plane. The pool size: L×B×H= 10m×8m×7m. The hydraulic retention time is 5h.The total height of filter layer is 4m. Filter pool is divided into four parts, and effective volume is 175 m^3. The pools adopting three-dimensional elastic filler of YCDT type, equipping with perforated tubes at the bottom. In addition, there are three (two - work- one - standby) roots blower. The Gas-water ratio is 14：1. Effluent water flow to well from braiding channel, then flow to sedimentation pool by power of gravity.

4.3.The Quality and Processing Efficiency of Scouring Wastewater and other Wastewater (Table 2 .and Table 3.)

Table 2. The quality and processing efficiency of influent water and effluent water in scouring wastewater (600 t/d) individual treatment

Item	**BOD（mg/L）**	**COD_{cr}（mg/L）**	**SS（mg/L）**	**Chroma**	**pH**
Influent Water	600	2000	800	800	11-12
Effluent Water	19	73	23	36	7-9
Processing Efficiency	96.8%	96.4%	97.1%	95.5%	——

Table 3. The quality and processing efficiency of influent water and effluent water in other wastewater (2400 t/d) treatment

Item	**BOD（mg/L）**	**COD_{cr}（mg/L）**	**SS（mg/L）**	**Chroma**	**pH**
Influent Water	400	1600	700	600	10-11
Effluent Water	36	120	77	57	6-9
Processing Efficiency	91.0%	92.5%	89.0%	90.5%	——

5. THE ECONOMIC ANALYSIS OF COMPREHENSIVE AND INDIVIDUAL TREATMENT

5.1.The Engineering Quotation of Comprehensive and Individual Treatment (Table 4.)

Table 4. The engineering quotation of comprehensive individual treatment

No.	Comprehensive Treatment		Individual Treatment	
1	Equipment and Structures	Price (10,000 Yuan)	Equipment and Structures	Price (10,000Yuan)
2	Regulation Pool	90	Regulation Pool 1	10
3	Hydrolysis Acidification Pool	50	Regulation Pool 2	30
4	Contact Oxidation Pool	90	Hydrolysis Acidification Pool 1	12
5	Coagulation Pool	10	Hydrolysis Acidification Pool 2	60
6	Sedimentation Pool	30	Contact Oxidation Pool	65
7	Master-Control Room	8	Anaerobic Pool	12
8	Equipment Room	10	Aerobic Pool	15
9	Blower Room	10	Coagulation and Sedimentation Pool 1	5
10	Sewage Pump	4	Coagulation and Sedimentation Pool 2	20
11	Aeration Perforated Pipe	6	Master-Control Room	8
12	Hydrolysis Water Distributor	5	Equipment Room	10
13	Hydrolysis Set Sinks	4.5	Blower Room	10
14	Elastic Filler	6.5	Sewage Pump	3
15	Roots Blower	15	Aeration Perforated Pipe	9
16	Efficient Aeration System	10	Hydrolysis Water Distributor	8
17	Adding Medicine System	6	Hydrolysis Set Sinks	8
18	Truss-Car Suction Dredge	5	Elastic Filler	9
19			Roots Blower	9
20			Efficient Aeration System	15
21			Adding Medicine System	6
22			Truss-Car Suction Dredge	10
Total		360		334

5.2.The Analysis of Comprehensive Treatment Cost

There are eight normal workers in this waste water plant. If the average wage of every worker is 20,000 yuan per year, the total cost of labor should be 160,000 yuan per year. So the cost of everyday is 449.44 yuan, which means that the price of water is 0.15 yuan per ton. The installed capacity of this plant reached 127.5 kW, and the operational consumed power per day is 5,849 kWh. The operational direct electric costs per day should be 3,536.4 yuan if the per kilowatt hour electricity was 0.6 yuan, which means that the price of water is 1.179 yuan per ton. The cost of chemical includes the cost of coagulant and decolouriser, besides, the price of coagulant is 0.35 yuan per cubic metre, and the price of decolouriser is 0.20 per cubic metre. So the direct operational cost is the following: 0.150+1.179+0.55=1.879 yuan. So the cost of water per day is 1.879. The annual cost is the following: 1.879×365×3,000=2,057,500 yuan.

5.3.The Analysis of Individual Treatment Cost

There are eight normal workers in this waste water plant. If the average wage of every worker is 20,000 yuan per year, the total cost of labor should be 160,000 yuan per year. So the cost of everyday is 449.44 yuan, which means that the price of water is 0.15 yuan per ton. The installed capacity of this plant reached 122.5 kW, and the operational consumed power per day is 4,048 kWh. The operational direct electric costs per day should be 2,428.8 yuan if the per kilowatt hour electricity was 0.6 yuan, which means that the price of water is 0.810 yuan per ton. The cost of chemical includes the cost of coagulant and decolouriser, besides, the price of coagulant is 0.35 yuan per cubic metre, and the price of decolouriser is 0.20 per cubic metre. So the direct operational cost is the following: 0.150+0.810+0.55=1.510 yuan. So the cost of water per day is 1.510. The annual cost is the following: 1.510×365×3000=1,653,500 yuan.

6. CONCLUSIONS

The traditional treatment methods of printing and dyeing wastewater have developed maturely in china. And it is difficult for us to make some improvement in economy and technology of the traditional treatment methods of printing and dyeing wastewater, so this article puts forward an idea for scouring wastewater individual treatment. From the viewpoint of treatment effect, the process of A/O, which is used in scouring wastewater individual treatment, also can achieve the treatment effect got by the biological contact oxidation that used in printing and dyeing wastewater comprehensive treatment. From the viewpoint of total project cost, the total cost for individual treatment structures is 3,340,000 yuan, which is below the cost of comprehensive treatment. The cost of comprehensive treatment is 3,600,000 Yuan, so the cost is more cost-efficient. From the viewpoint of annual running cost, the total cost for individual treatment structures is 1,653,500 yuan, which is below the cost of comprehensive treatment, the cost of comprehensive treatment is 2,057,500 yuan. So we can get the feasibility of scouring wastewater individual treatment by the method of comparison and analysis from the viewpoint of economy and technology.

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