Chapter 6

Hydrolytic Acidification-Two Stage EGSB-A/O Combined Process for Pesticide Wastewater Treatment

Yongjun Sun*, Shengbao Zhou, Kinjal J. Shah*, Xuefeng Xiao

College of Urban Construction, Nanjing Tech University, Nanjing, 211816, China

Yongjun Sun: sunyongjun@njtech.edu.cn, Kinjal J. Shah: kjshah@njtech.edu.cn

Abstract

The wastewater produced by a chemical enterprise in Ningxia has the characteristics of high COD, high salt content, and high ammoniacal nitrogen. The biodegradability of the wastewater is poor due to presence of higher concentration of pollutant. The scale of first stage of treatment was 400m³/d. The wastewater of different characteristic was collected and treated separately. The combined process of "micro electrolysis + Fenton oxidation + coagulation precipitation + evaporation crystallization" was used to pretreat the wastewater containing high salt and high COD. The main process was "hydrolytic acidification + two-stage Expanded Granular Sludge Bed (EGSB) + two-stage advance Fenton oxidation (A/O)". The final concentrations of effluent COD, NH₃-N and TDS are 376 mg/L, 34.74 mg/L, and 442 mg/L, and the removal rates are 99.9%, 81.3%, and 99.9%, respectively. The environmental, engineering and economical (3E) practices showed that the combined process has stable operation, strong impact resistance, and high reduction of COD in the effluent.

Keywords

Pesticide Wastewater, Pretreatment, Two-Staged EGSB, Advance Oxidation, Fenton Oxidation

Contents

Hydrolytic Acidification-Two Stage EGSB-A/O Combined Process for Pesticide Wastewater Treatment.....	168
1. Introduction.....	169

2.	Treatment process selection.....	172
2.1	Pretreatment process selection.....	172
2.2	Biochemical treatment process selection.....	173
2.3	Advanced treatment process selection.....	173
2.4	Wastewater treatment process	174
3	Main processing unit and design parameters	175
3.1	Pretreatment system.....	175
3.2	Biochemical treatment system.....	177
3.3	Advanced processing system.....	178
4.	3E analysis of each operation units.....	178
	Conclusion.....	180
	References	180

1. Introduction

Pesticides are important chemical substances used in the prevention and control of plant diseases and insect pests in agricultural production. [1]. In recent years, through the advancement of science and technology and the rapid development of the green agricultural practices, China has started their move towards major producer of pesticides [2]. Therefore, the pesticide industry has become one of the important industries in China's industrial system [2]. According to the available statistics, there are currently more than 2,500 pesticide manufacturing units/industries in China. While comparing those with developed countries, there is still a big gap in the overall level of China's pesticide industry, mainly manifested in more outdated and less ultra-efficient varieties, irrational product structure, environmental hazards, and toxicity [3]. Among them, many manufacturers are reluctant to invest much in research and development, and thus they are practicing with old or expired manufacturing methods [4]. On the other hand, some products have been eliminated in the international production process or even banned due to implementing green chemical and hazardous free production practices. Now these low-end products are not only harmful to the environment and toxic but also cause fierce market competition, leading to a bleak market for new products, which leads to a vicious cycle [5].

While considering the environmental impacts, the total amount of wastewater discharged from the pesticide production process is about 300 million tons per year [6]. These wastewaters have high pollutant concentration, deep color, high salt content, complex

ingredients, and high toxicity, and poor biodegradability. If it is directly discharged without effective treatment, it will not only pollute surface water but also pollute the ground water. Moreover, eutrophication effects also will be found after discharging polluted water to other water system, which cause great harm to various animals and plants in the water body [7]. It is very difficult to set up protocols for chemical waste in water system because the raw materials and production processes are different for variety of pesticides. This will lead to generates complex wastewater composition. In ordered to identify it and categorized it, few generalized features have been listed below:

- a) The concentration of organic pollutants is quite high: far exceeding the national takeover standards allowed. The value of chemical oxygen demand can reach tens of thousands of mg/L, and the concentration of organic matter that is difficult to degrade is beyond the range that the sewage plant can take over [8].
- b) The biological toxicity is very high: the wastewater contains not only some pesticides, pesticide intermediates, and difficult-to-degrade substances, but also high concentrations of toxic and harmful substances such as phenol, arsenic, and mercury [9].
- c) It has a strong pungent odor: it has severe irritation and damage to the respiratory organs of the human body and has a certain impact on the surrounding ecological environment [10].
- d) The composition and content of wastewater and the amount of wastewater are not easy to control: the time and type of products production are related to market demand and seasonal changes [11].

Pesticide wastewater contains a large amount of toxic and hazardous substances such as nitrobenzene, chloronitrobenzene, chlorobenzene, etc. Thus, the complex types of pesticide have complex composition of wastewater and a single treatment method to achieve pure water is very expensive [12]. Meanwhile, the high concentration of refractory organic substances in it increases the treatment complexity, increase the treatment cost, and greatly increase the risk of the sewage treatment plant exceeding the standard [14]. If the concentration of polluted water is not controlled upon time, it will damage to the soil and which leads to enter into food chain system to affect human health. Meanwhile, the untreated pesticide water directly enters the sewage treatment plant, and the toxic and harmful substances have a destructive effect on the activated sludge in the biological reaction tank, reducing its activity and processing capacity which causes a large number of deaths of microorganisms in activated sludge. [13].

There are many processes for treating pesticide wastewater or high-salt and high-concentration organic wastewater, but it is very difficult to achieve the desired treatment effect by using a certain physical and chemical method or biochemical method alone.

Therefore, according to the characteristics of wastewater and the advantages and disadvantages of various treatment methods, many studies have been carried out with a variety of physicochemical and biochemical combined processes to treat wastewater. Generally, the beginning of the processes has been carried out by physical and chemical methods where suspended matter and colloid in the wastewater are removed. If the salt content of the wastewater is too high, it needs to be desalted. Followed by advance oxidation technology to reduce the toxicity of wastewater. Additionally, the biodegradability of wastewater was carried out by biochemical treatment processes to meet the influent requirements. Finally, through biodegradation, the organic matter in the wastewater is degraded to ensure that the final effluent quality meets the discharge requirements. If the standard cannot be reached after biochemical treatment, the wastewater needs to be further treated. In such case, the combined process has been widely used in the field of industrial wastewater treatment, but for China's pesticide wastewater, due to the complexity and variety of products and processes, the types of pollutants in wastewater are often very different. Different combination of processes should be used according to the characteristics of wastewater to achieve the best treatment effect.

This research was carried out on wastewater samples of fine chemical manufacturing company, Ningxia, producer of pesticides such as propachlor, metalaxyl, difenoconazole, and pesticide intermediates such as dimethalone and toluene. The wastewater is collected as per different segment of the plants namely, liquor wastewater, toluene wastewater, alkaline wastewater, neutralization wastewater, and domestic sewage in the plant. The compositions of those wastewater plants are complex, the concentration of organic matter is high, the content of COD and $\text{NH}_3\text{-N}$ is high, and the salt content is high (See Table 1). Thus, it is difficult to achieve the expected results with only applying biochemical treatment methods. But, after applying pretreatment process, biochemical treatment, and advanced treatment process of the wastewater jointly, the effluent meets the Class B standard of "Water Quality Standards for Wastewater Discharge into Urban Sewers" [GBT 31962-2015] and meets the requirements for access to the sewage pipe network of the park. The specific water quality of the inlet and outlet is shown in Table 1.

Table. 1 Design influent and effluent water quality.

Wastewater name	Water volume [m ³ /d]	COD [mg/L]	NH ₃ -N[mg/L]	TN [mg/L]	TP [mg/L]	pH	Salt content [mg/L]
Heptenone acid water	44.2	477500	129.03	212.89	0.713	7.32	89600
Synthetic acid water	7.8	243500	1146.75	1651.32	10.746	1.11	9550
Hypochlorous toluene wash	14.4	487750	127.63	243.77	0.19	10.29	70360
Liquid alkaline washing with toluene	39.8	188000	79.03	126.37	0.19	11.55	62320
Acetochloric acid water	63.8	2	28.38	54.77	0.143	1.28	52975
Clethodim one wash	32.4	2000	6.81	10.87	0.095	5.25	149
Decarboxylated water	77.2	41600	738.06	1320.18	1.664	0.75	941
Decarboxylation once washed	24.5	88500	32.44	57.61	0.285	1.77	2380
Synthetic one wash	26.2	3740	258.75	387.6	0.333	2.72	2200
Synthetic secondary washing	25.4	7890	254.85	389.21	0.095	4.78	248
Wash toluene once	21.5	22280	32.75	59.28	0.095	6.67	647
Washing toluene twice	12.6	2300	39	74.5	0.024	3.78	194
Heptenone wash once	9.6	74200	171.84	307.25	0.38	4.91	3730
Design effluent quality	400	500	45	70	8	6~9	—

2. Treatment process selection

2.1 Pretreatment process selection

It can be seen from Table 1 that multiple streams of wastewater belong to high-salt and high-COD wastewater category. As discussed before, multi component wastewater require

specific pretreatment. In case of high-salt and high-COD category, Fe/C micro-electrolysis coupled Fenton redox-oxidation of wastewater can be used which can degrade macromolecular organics to make small and simpler molecules for improving the wastewater biodegradability. However, it has a limitation of controlling the amount of Fe^{2+} and Fe^{3+} , the large amount of Fe^{2+} and Fe^{3+} remaining in the wastewater is not conducive to the subsequent biochemical treatment. Thus, this technique needed follow-up techniques. In that case, coagulation and precipitation techniques can be implemented where Fe^{2+} and Fe^{3+} of the solution converted to form of $\text{Fe}[\text{OH}]_2$ and $\text{Fe}[\text{OH}]_3$. However, the salinity in the wastewater is high, which is not good for the microorganisms in the subsequent biochemical unit. Thus, the evaporative salt precipitation is used to treat high-salt wastewater.

2.2 Biochemical treatment process selection

The wastewater after pretreatment still has a high concentration of organic matter. Therefore, the biochemical treatment adopts the process of "hydrolytic acidification two-stage Expanded Granular Sludge Bed (EGSB) +A/O". Studies have shown that hydrolytic acidification can convert difficult-to-biodegradable macromolecular substances into easily biodegradable substances, further improving the wastewater biodegradability. The EGSB anaerobic treatment process is an anaerobic biological treatment process specially designed for high-concentration organic industrial wastewater. It has a high volume load and impact resistance, and can effectively resist fluctuations in water quality, and it is simple to operate and very practical treatment process. In addition, the combination of hydrolytic acidification and EGSB provides short-term denitrification conditions for anaerobic ammonia oxidation, which can effectively reduce the ammoniacal nitrogen load, reduce the need for external carbon sources due to deamination, and achieve the system's requirements for the ammoniacal nitrogen index. Due to the low TP index in the wastewater and the high concentration of ammoniacal nitrogen and COD, after the load is greatly reduced by EGSB, the denitrifying bacteria in the anoxic tank will be used as the carbon source for the COD reduction in the wastewater to bring the aerobic tank back into the mixture. $\text{NO}_3\text{-N}$ and $\text{NO}_2\text{-N}$ are converted into N_2 by denitrification, and the concentration of BOD_5 and $\text{NO}_3\text{-N}$ are reduced. Finally, the biodegradable COD and ammoniacal nitrogen are completely degraded.

2.3 Advanced treatment process selection

The Fenton oxidation process is selected as the advanced treatment process, which can not only increase the impact load caused by the change in water volume but also achieve efficient precipitation in the sedimentation tank. In summary, the process flow of the wastewater treatment scheme is shown in Figure 1.

Figure. 1 Flow chart of the Wastewater Treatment Process.

2.4 Wastewater treatment process

The wastewater treatment process flow is shown in Fig. 1. Wherein, 106 m³/d high-salt and high-COD wastewater and 230 m³/d other wastewater are pretreated in two ways. As shown in Fig. 1, the wastewater first enters the regulating tanks 1 and 2 to regulate the water quality and quantity where the pH is adjusted to 3-4. Followed by, the wastewater flows into the Fe/C micro electrolysis reactors 1 and 2 to reduce and degrade the organic pollutants in the wastewater. Subsequently, the wastewater flows into the Fenton reactors 1 and 2 by gravity. Here, the hydroxyl radicals oxidize and degrade pollutants to improve the biodegradability of organic pollutants. The active groups of wastewater are decomposed completely. After Fenton process, effluent is passed to stabilization tank 1 and 2, where pH is adjusted to 8-9 by the pH-adjusting reactor. Now the effluent flows into the coagulation sedimentation tanks 1 and 2 to complete the flocculation reaction where separation is taking place into sludge and water. The remaining sludge is pumped into the chemical sludge tank for further treatment. The effluent having 64 m³/d of high-salt and low-COD flow into the regulating tank 3 for the evaporation kettle. Here, the concentrated liquid enters the evaporator and evaporates most of the wastewater. Finally, it is cooled and crystallized there. The wastewater from the coagulation sedimentation tank 2 enters the hydrolysis and acidification tank where degradation of macromolecular organic matter taking place into small-molecule organic matter to improve biodegradability. The effluent from the hydrolysis and acidification tank flows into the precipitation tank 3 to prevent the growth of micro-organisms in the subsequent biochemical treatment unit. The effluent from the precipitation tank 3 enters the two-stage EGSB reactor. Subsequently, the wastewater enters the biochemical reaction tank, degrades the BOD of the wastewater and

then the wastewater flows into the secondary precipitation tank to realize the separation of sludge and water. Part of the sludge in the precipitation tank 3 and the secondary sedimentation tank is returned to the hydrolysis acidification tank and the anoxic/aerobic biochemical reaction tank, and the excess sludge is sent to the biochemical sludge tank for treatment. The treated wastewater from the secondary precipitation tank enters the pH-adjusting reaction kettle by gravity-flow, and the pH is adjusted to 3-4 by dosing the concentrated H_2SO_4 , and the effluent is pumped to the Fenton reactor 3 for advanced treatment of wastewater. In the final stage, the sludge in the biochemical sludge tank and the chemical sludge tank is conditioned by the sludge adjustment tank, and then filtered by a plate and frame filter press to produce sludge cake which is transported out, and the filtered water returns to the adjustment tank.

3 Main processing unit and design parameters

3.1 Pretreatment system

[1] Adjusting tank 1. Two seats, design flow $Q_1 = 106 \text{ m}^3/\text{d}$, size $\Phi 3.0 \text{ m} \times 3.0 \text{ m}$ [including 0.5 m super high], effective volume 35.33 m^3 , HRT = 8 h. Adopt carbon steel lining plastic anti-corrosion structure. Supporting equipment: 2 pH online instruments, 2 flow meters; 2 submersible mixers, power $N = 0.35 \text{ kW}$.

[2] Fe/C micro-electrolysis reactor 1. Two seats, size $\Phi 3.0 \text{ m} \times 2.0 \text{ m}$ [including 0.5 m super high], effective volume 17.67 m^3 , HRT = 4 h. Adopt carbon steel lining plastic anti-corrosion structure. Supporting equipment: 2 sets of aeration device iron carbon filler 9 m^3 .

[3] Fenton reactor 1. Two seats, size $\Phi 3.0 \text{ m} \times 2.0 \text{ m}$ [including 0.5 m super high], effective volume 17.67 m^3 , HRT = 4 h. Adopt carbon steel lining plastic anti-corrosion structure. Supporting equipment: 2 pulp mixers, model JBJ-800 [D = 800 mm, $N = 1.0 \text{ kW}$].

[4] 1.2 stable pools, size $\Phi 3.0 \text{ m} \times 2.0 \text{ m}$ [including 0.5 m super high], effective volume 17.67 m^3 , HRT = 4 h. Adopt carbon steel lining plastic anti-corrosion structure. Supporting equipment: 2 pulp mixers, model JBJ-800 [D = 800 mm, $N = 1.0 \text{ kW}$].

[5] Coagulation tank 1. One, with a size of $2.0 \text{ m} \times 1.2 \text{ m} \times 1.7 \text{ m}$ [including an ultra-high 0.5 m], an effective volume of 2.95 m^3 , and HRT = 40 min. Adopt steel concrete anti-corrosion semi-underground structure. Supporting equipment: one set of gas stirring device, one tube static mixer, model SK-25 / 50 [DN = 50, $Q = 3.5 \sim 7.0 \text{ m}^3/\text{h}$].

[6] Settling tank 1. One, with a size of $2.8 \text{ m} \times 2.0 \text{ m} \times 2.8 \text{ m}$ [including an ultra-high 0.5 m], an effective volume of 13.25 m^3 , HRT = 3 h, and a surface load $q = 0.8 \text{ m}^3/[\text{m}^2\text{h}]$. Adopt steel concrete anti-corrosion semi-underground structure. Supporting equipment: 1 set of

scraper and 2 sets of sludge pumps ($Q=3.0 \text{ m}^3/\text{h}$, $H=10 \text{ m}$, $N=0.55 \text{ kW}$), One used, one spare.

[7] Adjusting tank 2. Two, design flow $Q_2 = 170 \text{ m}^3/\text{d}$, size $\Phi 3.0 \text{ m} \times 4.3 \text{ m}$ [including 0.3 m super high], effective volume 56.67 m^3 , $\text{HRT} = 8 \text{ h}$. Adopt carbon steel lining plastic anti-corrosion structure. Supporting equipment: 2 pH online instruments, 2 flow meters; 2 submersible mixers, power $N = 0.35 \text{ kW}$.

[8] Evaporation kettle. One, design flow $Q = 7.0 \text{ m}^3/\text{h}$. supporting equipment: 1 set of evaporation kettle equipment.

[9] Regulating tank 3. Two seats, design flow $Q_3 = 230 \text{ m}^3 / \text{d}$, size $\Phi 3.0 \text{ m} \times 5.7 \text{ m}$ [including 0.3 m super high], effective volume 76.67 m^3 , $\text{HRT} = 8 \text{ h}$. Adopt carbon steel lining plastic anti-corrosion structure. Supporting equipment: 2 pH online instruments, 2 flow meters; 2 submersible mixers, power $N = 0.35 \text{ kW}$.

[10] Fe / C micro-electrolysis reactor 2. Two seats, size $\Phi 3.0 \text{ m} \times 3.2 \text{ m}$ [including 0.5 m super high], effective volume 38.33 m^3 , $\text{HRT} = 4 \text{ h}$. Adopt carbon steel lining plastic anti-corrosion structure. Supporting equipment: 2 sets of aeration devices iron carbon filler 19 m^3 .

[11] Fenton reactor 2. Two seats, size $\Phi 3.0 \text{ m} \times 3.2 \text{ m}$ [including 0.5 m super high], effective volume 38.33 m^3 , $\text{HRT} = 4 \text{ h}$. Adopt carbon steel lining plastic anti-corrosion structure. Supporting equipment: 2 pulp mixers, model JBJ-800 [$D = 800 \text{ mm}$, $N = 1.0 \text{ kW}$].

[12] 2 stable tanks, size $\Phi 3.0 \text{ m} \times 3.2 \text{ m}$ [including 0.5 m super high], effective volume 38.33 m^3 , $\text{HRT} = 4 \text{ h}$. Adopt carbon steel lining plastic anti-corrosion structure. Supporting equipment: 2 pulp mixers, model JBJ-800 [$D = 800 \text{ mm}$, $N = 1.0 \text{ kW}$].

[13] Coagulation tank 2. One, with a size of $2.5 \text{ m} \times 1.5 \text{ m} \times 2.2 \text{ m}$ [including an ultra-high 0.5 m], an effective volume of 6.39 m^3 , and $\text{HRT} = 40 \text{ min}$. Adopt steel concrete anti-corrosion semi-underground structure. Supporting equipment: one set of gas stirring device, one tube static mixer, model SK-25 / 50 [$\text{DN} = 50$, $Q = 3.5 \sim 7.0 \text{ m}^3/\text{h}$].

[14] Settling tank 2. One, with a size of $4.0 \text{ m} \times 3.0 \text{ m} \times 2.9 \text{ m}$ [including an ultra-high 0.5 m], an effective volume of 28.75 m^3 , $\text{HRT} = 3 \text{ h}$, and a surface load $q = 0.8 \text{ m}^3 / [\text{m}^2 \cdot \text{h}]$. Adopt steel concrete anti-corrosion semi-underground structure. Supporting equipment: 1 set of scraper and 2 sets of sludge pumps [$Q = 3.0 \text{ m}^3/\text{h}$, $H = 10 \text{ m}$, $N = 0.55 \text{ kW}$], one for each use.

3.2 Biochemical treatment system

[1] Hydrolysis acidification tank. One, with a design flow of 400 m³/d, a size of 20.0 m × 8.0 m × 6.0 m [including an ultra-high 0.5 m], volumetric load $N_v = 3.0 \text{ kg}/[\text{m}^3 \cdot \text{d}]$, and an effective volume of 856.4 m³. Adopt steel concrete anti-corrosion semi-underground structure. Auxiliary equipment: 1 pH online instrument, 1 ORP online instrument; 2 push flow stirring devices, power $N = 3 \text{ kw}$. There are 4 front tanks in the hydrolytic acidification tank, with a size of 10.0 m × 5.0 m × 4.5m [including ultra-high 0.5 m], an effective volume of 800 m³, and HRT = 48 h. Adopt steel concrete anti-corrosion semi-underground structure. Supporting equipment: one pH online meter, one flow meter; eight submersible mixers, power $N = 1.0 \text{ kw}$; eight lift pumps, model KQL40-100 [I] [$Q = 16.3 \text{ m}^3/\text{h}$, $H = 11.3 \text{ m}$, $N = 1.1 \text{ kW}$], 4 uses 4 spares.

[2] Settling tank 3. One, with a size of 5.5 m × 3.8 m × 3.7 m [including an ultra-high 0.5 m], an effective volume of 66.67 m³, HRT = 4 h, and a surface load $q = 0.8 \text{ m}^3/[\text{m}^2 \cdot \text{h}]$. Adopt steel concrete anti-corrosion semi-underground structure. Supporting equipment: 1 set of scraper and 2 sets of sludge pumps [$Q = 5.0 \text{ m}^3/\text{h}$, $H = 15 \text{ m}$, $N = 0.75 \text{ kW}$], one for each use.

[3] EGSB reactor. 2 sets of 4 units, design flow $Q = 400 \text{ m}^3 / \text{d}$, size $\Phi 8.0 \text{ m} \times 24.0 \text{ m}$. Adopt carbon steel lining plastic anti-corrosion structure. Supporting equipment: 4 sets of pulse water replenisher, 8 sets of biogas slurry separator.

[4] Anoxic pool. One, with a size of 8.0 m × 5.5 m × 4.2 m [including an ultra-high 0.5 m], an effective volume of 164.27 m³, and a volumetric load $N_v = 1.50 \text{ kg}/[\text{m}^3 \cdot \text{d}]$. Adopt steel concrete anti-corrosion semi-underground structure. Auxiliary equipment: 1 pH online instrument, 1 DO online instrument; 2 push flow stirring devices, power $N = 1.50 \text{ kw}$.

[5] Aerobic pool. Two, size 20.0 m × 8.0 m × 5.2 m [including ultra-high 0.5 m], effective volume of 1485 m³, volume load $N_v = 0.8 \text{ kg}/[\text{m}^3 \cdot \text{d}]$. Adopt steel concrete anti-corrosion semi-underground structure. Auxiliary equipment: 2 pH online instruments, 2 DO online instruments, 2 micro porous aeration systems; 4 push flow stirring devices, power $N = 3.0 \text{ kw}$; 4 internal reflux pumps, $Q = 60 \text{ m}^3/\text{h}$, $H = 15 \text{ m}$, $N = 5.5 \text{ kW}$, 2 for 2 and 2; MBBR filler 700 m³.

[6] Second sink pool. One, with a size of $\Phi 5.0 \text{ m} \times 2.7 \text{ m}$ [including ultra-high 0.5 m], effective volume of 41.67 m³, HRT = 2.5 h, and surface load $q = 0.85 \text{ m}^3/[\text{m}^2 \cdot \text{h}]$. Adopt steel concrete anti-corrosion semi-underground structure. Auxiliary equipment: 1 set of mud scraper, 2 sets of sludge pump, $Q = 5.0 \text{ m}^3/\text{h}$, $H = 15 \text{ m}$, $N = 0.75 \text{ kW}$, 1 for 1 spare.

3.3 Advanced processing system

[1] Fenton reactor 3. Two seats, size $\Phi 3.0 \text{ m} \times 5.2 \text{ m}$ [including 0.5 m super high], effective volume 66.67 m^3 , HRT = 4h. Adopt carbon steel lining plastic anti-corrosion structure. Supporting equipment: 2 pulp mixers, model JBJ-800 [D = 800 mm, N = 1.0 kW].

[2] Stable pool 2. Two seats, size $\Phi 3.0 \text{ m} \times 5.2 \text{ m}$ [including 0.5 m super high], effective volume 66.67 m^3 , HRT = 4 h. Adopt carbon steel lining plastic anti-corrosion structure. Supporting equipment: 2 pulp mixers, model JBJ-800 [D = 800 mm, N = 1.0 kW].

4. 3E analysis of each operation units

After about 60 days of commissioning and operation, each reactor was successfully started, and the effluent water quality of some treatment structures is shown in Table 2.

Table 2 Effluent water quality of water treatment structure

Reactors	COD [mg/L]	NH ₄ -N [mg/L]	Salt content [mg/L]	TP [mg/L]	pH
Regulating tank 1	358386	184.85	70888	1.18	8.85
Regulating tank 2	130103	176.94	42200	0.74	5.49
Evaporation kettle	65051	159.24	1688	0.65	7.24
Regulating tank 3	30080	322.98	1098	0.68	3.06
Coagulation sedimentation tank 2	17386	465.09	553	0.45	7.82
Hydrolysis acidification tank	30115	268.08	673	0.28	7.56
Two-stage EGSB reactors	3689	96.51	545	0.36	7.34
A/O Biochemical reaction tank	470	38.60	491	0.15	7.55
Fenton Reactor 3	376	34.74	442	0.03	2.78

It can be seen from Table 2 that the combined process of pretreatment + biochemical treatment + in-depth treatment finally stabilizes the COD, NH₃-N, TN, TP values. While comparing table 1 and table 2, it can be seen that there is significant difference in the values of COD of the effluent at about 400 mg /L, the ammonia nitrogen at about 35 mg / L, and the TP does not detect. By the time, they all meet the Class B standard of “Water Quality Standards for Wastewater Discharge into Cities and Towns” [GBT 31962-2015]. The effluent water quality has a small fluctuation range and the process can be operated stably. So it can be concluded that the above designed process of pretreatment + biochemical

treatment + in-depth treatment works more effectively and efficiently. However, it is mandatory to consider 3E benefits, environmental, engineering and economical. Above mentioned benefits for environmental where we can found significant improvement of wastewater quality where COD was found to be 376 mg/L with 99.9% removal rate, whereas NH₃-N and TDS were found to be 34.74 mg/L and 442 mg/L with 81.3 and 99.9% removal rates, respectively. Similarly, the engineering practice shows that the combined process has stable operation, strong impact resistance, and high reduction of COD in the effluent. There are 3 major engineering drawbacks which support this combined process, i.e.

[1] If we treat wastewater separately, it will not be advisable for the prospects of material safety as it has to pass from unit to unit and each pollutants have different characteristics. However, in this kind of combined process, water quality is treated in different treatment sections in a targeted manner to resist impact load and ensure the safe and stable operation of the overall process.

[2] The evaporative crystallization process is used to efficiently remove salts, which solves the effect of high-salinity wastewater on active micro-organisms in the biochemical treatment process.

[3] The Fe/C micro-electrolysis coupled Fenton oxidation method is used to retreat the wastewater. The micro-electrolysis reaction causes large molecular organics to open and break the chain while generating a large amount of Fe²⁺, which greatly reduces the dose of Fenton reaction and effectively reduces wastewater treatment costs.

After considering environmental and engineering aspects, finally, economical aspects need to be considered. In this combined process, the operating expenses include electricity, flocculant, and labor. The total installed capacity of the station is 123.85 kW, the operating power is 104.75 kW, and the power consumption is 1165.40 kW·h / d. The electricity cost is calculated at 0.80 yuan/[kW · h], then the electricity fee is 2.33 yuan / m³. The reagents include H₂SO₄, NaOH, PAM, PAC, and H₂O₂. Under normal circumstances, the reagent fee is equivalent to 2.0 yuan/m³. 3 wastewater stations need to be arranged. The staff adopts a three-shift system, and the salary is calculated at 2,000 yuan/[month person], equivalent to a labor cost of 0.5 yuan/m³. The total operating cost is 4.96 RMB/m³. In common, above mentioned combine process is 3E advisable which can satisfy environmental, engineering and economical aspects of the process.

Conclusion

Fine chemical manufacturing company, Ningxia producing fenfluramine, metalaxyl, difenoconazole, and other chemical synthetic pesticides and pesticide intermediates. In China, every enterprise need to meet the effluent water quality [GBT 31962-2015] Class B standard. In wastewater samples of Nangxia industry, high COD, high salt content, and high ammoniacal nitrogen were found. The biodegradability of wastewater is poor due to presence of higher concentration of pollutant. In this research, wastewater treatment process were combined by a mass pretreatment + biochemical treatment + advanced treatment process for further treatment. Biochemical treatment is based on hydrolysis and acidification, two-stage EGSB, and A/O process. The combined process has a good treatment effect, strong impact load resistance, and a high degree of automation as well. The final concentrations of effluent COD, NH₃-N and TDS were 376 mg / L, 34.74 mg / L, and 442 mg / L, and the removal rates were 99.9%, 81.3%, and 99.9%, respectively. Finally, the effluent water quality fluctuation range is small, and also it meets 3E analysis. This result meets the requirements of the enterprise to access the sewage pipe network of the park.

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