Textile Dyeing Wastewater Treatment

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Textile Dyeing Wastewater Treatment

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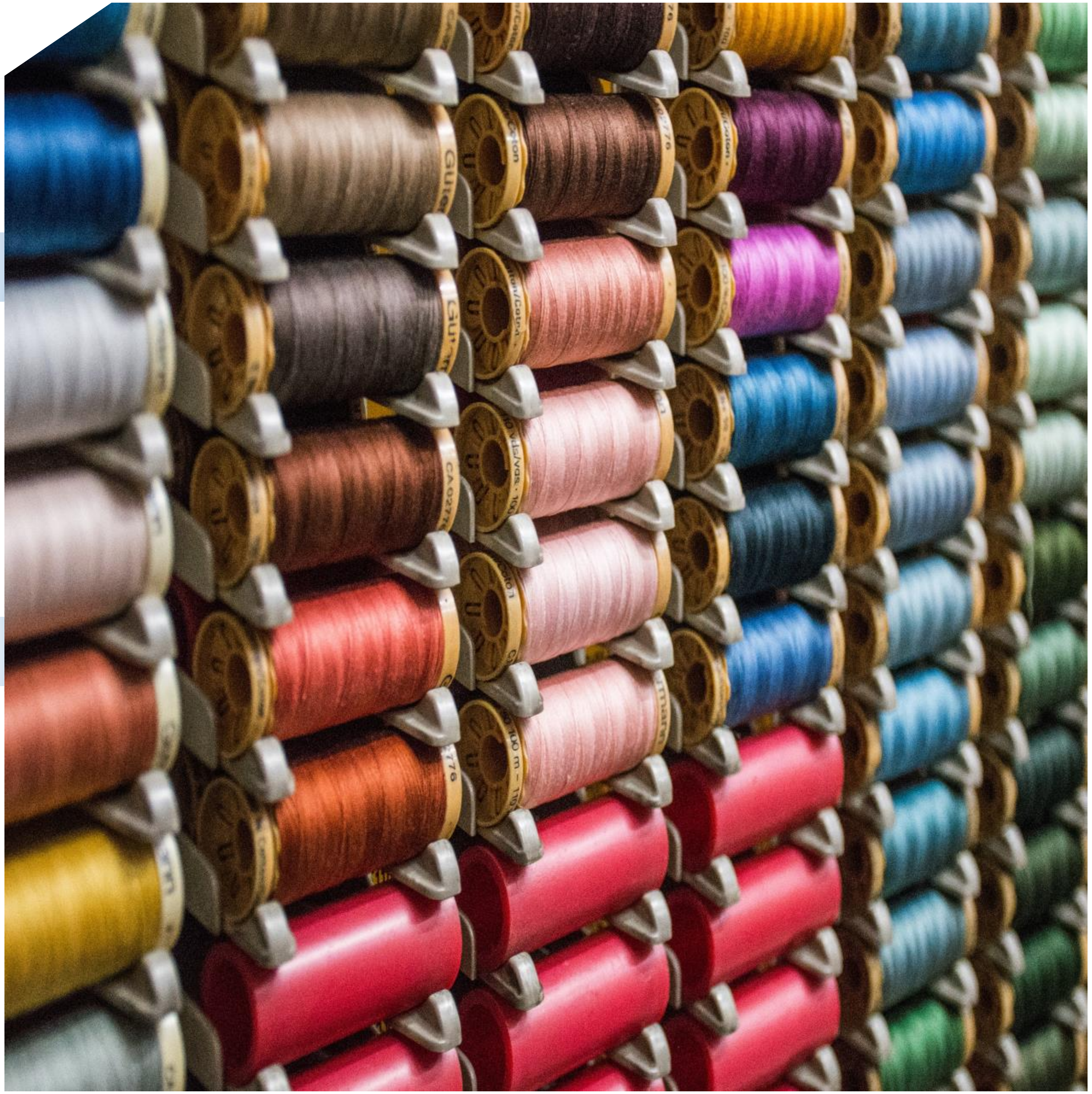

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1. Introduction

1.1 Textile printing and dyeing process

The variety of fiber	The commonly used dyes
Cellulose fiber	Direct dyes, Reactive dyes,Vat dyes, Sulfide dyes, Azo dyes
Wool	Acid dyes
Silk	Direct dyes,Acid dyes
Polyester	Azo dyes,Disperse dyes
Polyester-cotton	Disperse / Vat dyes,Disperse / Insoluble dye
polyacrylonitrile fiber	Cationic dyes, Disperse dyes
polyacrylonitrile fiber -wool	Cationic dyes,Acid dyes
vinylon	Direct dyes,Vat dyes,Sulfur dyes,Acid dyes,

Table 1. The varieties of common used fiber

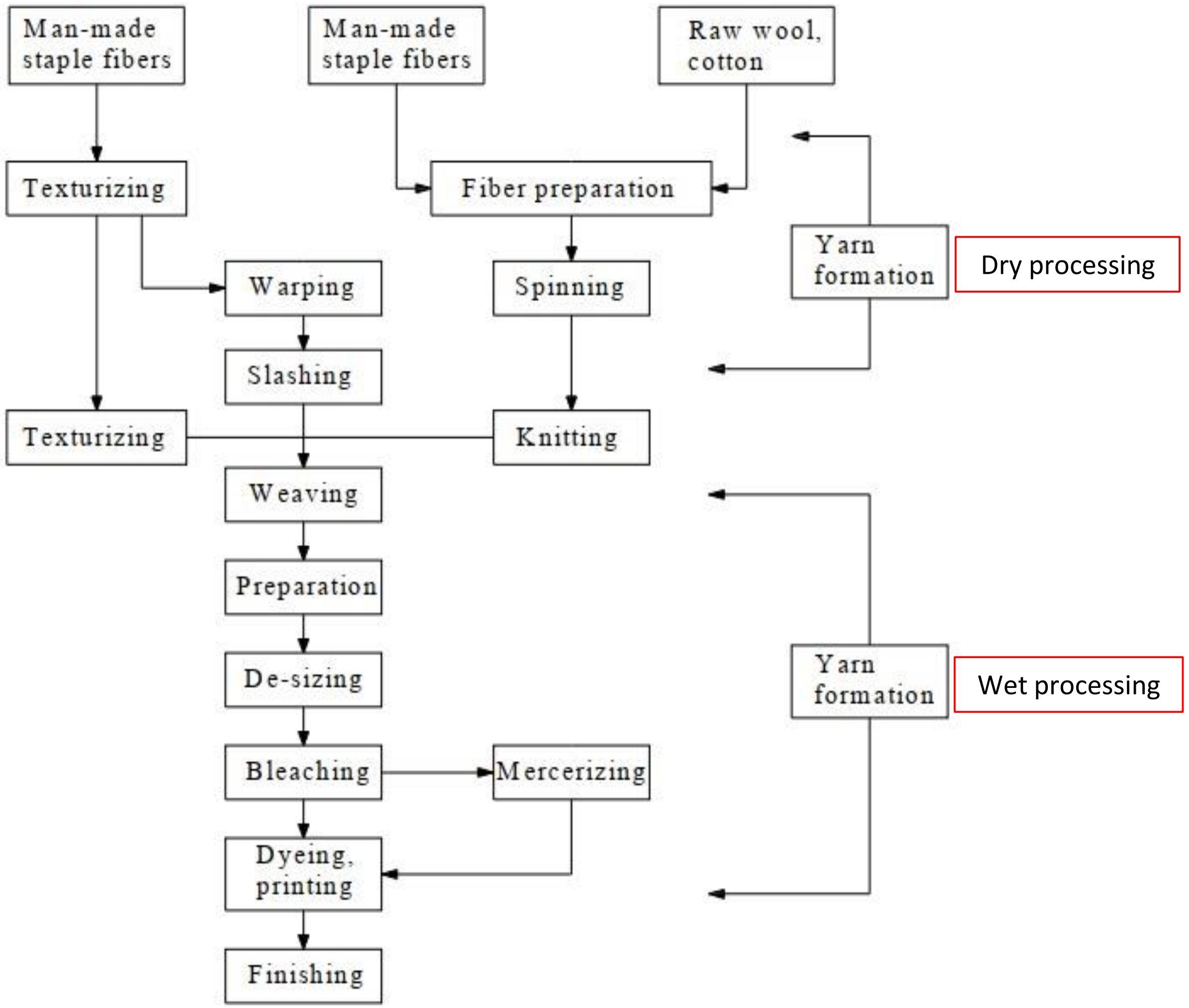
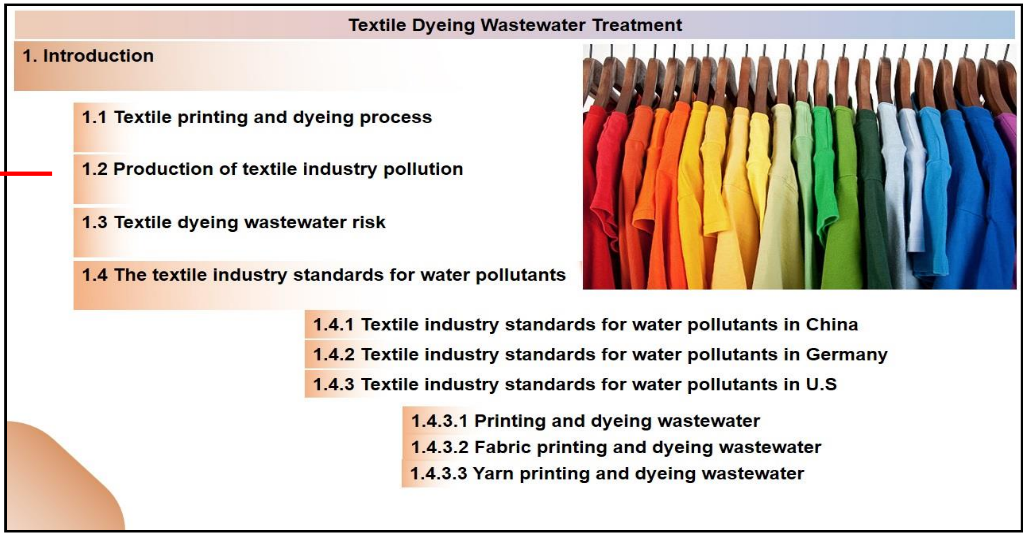


Fig. 1. Various steps involved in processing textile in a cotton mill (B. Ramesh Babu et al.,2007).

The typical printing and dyeing process is shown in Fig. 1 and the main used fiber dyes at present have been shown in Table 1

1.2 Production of textile industry pollution



Process	Compounds
Desizing	Sizes, enzymes, starch, waxes, ammonia.
Scouring	Disinfectants and insecticides residues, NaOH, surfactants, soaps, fats, waxes, pectin, oils, sizes, anti-static agents, spent solvents, enzymes.
Bleaching	H_2O_2, AOX, sodium silicate or organic stabiliser, high pH.
Mercerizing	High pH, NaOH
Dyeing	Colour, metals, salts, surfactants, organic processing assistants, sulphide, acidity/alkalinity, formaldehyde.
Printing	Urea, solvents, colour, metals.
Finishing	Resins, waxes, chlorinated compounds, acetate, stearate, spent solvents, softeners.

Table 2. Specific pollutants from textile and dyeing processing operations

1.3 Textile dyeing wastewater risk

If a textile mill discharges the wastewater into the local environment without any treatment, it will has a serious impact on natural water bodies and land in the surrounding area.

High values of COD and BOD5 presence of particulate matter and sediments, and oil and grease in the effluent causes depletion of dissolved oxygen, which has an adverse effect on the aquatic ecological system.

Effluent from textile mills also contains chromium, which has a cumulative effect, and higher possibilities for entering into the food chain.

1.4 The textile industry standards for water pollutants

As the wastewater is harmful to the environment and people, there are strict requirements for the emission of the wastewater

Textile Dyeing Wastewater Treatment

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1.1 Textile printing and dyeing process

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1.4.3.1 Printing and dyeing wastewater

1.4.3.2 Fabric printing and dyeing wastewater

1.4.3.3 Yarn printing and dyeing wastewater

1.4.1 Textile industry standards for water pollutants in China

Serial number	Parameters	The Limits of Discharged Concentration	The Limits of Discharged Concentration for new Factory	The Special Limits of Discharged Concentration
1	COD	100mg/L	80 mg/L	60 mg/L
2	BOD	25 mg/L	20 mg/L	15 mg/L
3	pH	6~9	6~9	6~9
4	SS	70 mg/L	60 mg/L	20 mg/L
5	Chrominance	80	60	40
6	TN	20 mg/L	15 mg/L	12 mg/L
7	NH3-N	15 mg/L	12 mg/L	10 mg/L
8	TP	1.0 mg/L	0.5 mg/L	0.5 mg/L
9	S	1.0 mg/L	Can not be detected	Can not be detected
10	ClO2	0.5 mg/L	0.5 mg/L	0.5 mg/L
11	Cr6+	0.5 mg/L	Can not be detected	Can not be detected
12	Aniline	1.0 mg/L	Can not be detected	Can not be detected

Table 3. "Textile industry standards for water pollutants"

due to the difference in the raw materials, products, dyes, technology and equipment,

the standards of the wastewater emission have too much items.

Serial number	Parameters	The Limits of Discharged Concentration
1	COD	160mg/L
2	BOD	25 mg/L
3	TP	2.0 mg/L
4	TN	20 mg/L
5	NH_3-N	10 mg/L
6	Nitrite	1.0 mg/L

Table 4. Textile industry standards for water pollutants

1.4.2 Textile industry standards for water pollutants in Germany

1.4.3 Textile industry standards for water pollutants in U.S

Printing and dyeing wastewater

Fabric printing and dyeing wastewater

Yarn printing and dyeing wastewater

Serial number	Parameters	BPT	
		Maximum	Average of 30 days
		Kg/t(Fabric)	
1	BOD_5	22.4	11.2
2	COD	163.0	81.5
3	TSS	35.2	17.6
4	S	0.28	0.14
5	Phenol	0.14	0.07
6	Cr	0.14	0.07
7	pH	6.0~9.0	6.0~9.0

Table 5. Emission standards for gross printing and dyeing wastewater

Serial number	Parameters	BPT	
		Maximum	Average of 30 days
		Kg/t(Fabric)	
1	BOD_5	6.8	3.4
2	COD	84.6	42.3
3	TSS	17.4	8.7
4	S	0.24	0.12
5	Phenol	0.12	0.06
6	Cr	0.12	0.06
7	pH	6.0~9.0	6.0~9.0

Table 7. Emission standards for yarn printing and dyeing wastewater

It is adjusted for the Yarn printing and dyeing wastewater, including washing, mercerization, resin processing, dyeing and special finishing The requirements using BPT (best practical control tech.)

Serial number	Parameters	BPT	
		Maximum	Average of 30 days
		Kg/t(Fabric)	
1	BOD_5	5.0	2.5
2	COD	60	30
3	TSS	21.8	10.9
4	S	0.20	0.10
5	Phenol	0.10	0.05
6	Cr	0.10	0.05
7	pH	6.0~9.0	6.0~9.0

Table 6. Emission standards for fabric printing and dyeing wastewater

2. Textile dyeing wastewater treatment processes

In the past several decades, many techniques have been developed to find an **economic** and **efficient way** to treat the textile dyeing wastewater, including physicochemical, biochemical, combined treatment processes and other technologies.
These technologies are usually highly efficient for the textile dyeing wastewater.

The textile dyeing wastewater has a large amount of complex components with high concentrations of organic, high-color and changing greatly characteristics. Owing to their high BOD/COD, their coloration and their salt load, the wastewater resulting from dyeing cotton with reactive dyes are seriously polluted.

2. Textile dyeing wastewater treatment processes

Textile Dyeing Wastewater Treatment

- 2.1 Physicochemical wastewater treatment
  - 2.1.1 Equalization and homogenization
  - 2.1.2 Floatation
  - 2.1.3 Coagulation flocculation sedimentation
  - 2.1.4 Chemical oxidation
    - 2.1.4.1 Fenton reaction
    - 2.1.4.2 Ozone oxidation
  - 2.1.5 Adsorption
  - 2.1.6 Membrane separation process
    - 2.1.6.1 Reverse osmosis
    - 2.1.6.2 Nanofiltration
    - 2.1.6.3 Ultrafiltration
    - 2.1.6.4 Microfiltration

2. Textile dyeing wastewater treatment processes

2.1 Physicochemical wastewater treatment

high removal of chroma and suspended substances, while it has a low removal of COD

2.1.1 Equalization and homogenization

the regulating tank is set to treat the wastewater

it's usually mixed the wastewater with air or mechanical mixing equipment in the tank.

2.1.2 Floatation

2.1.3 Coagulation flocculation sedimentation

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2.1.4.2 Ozone oxidation

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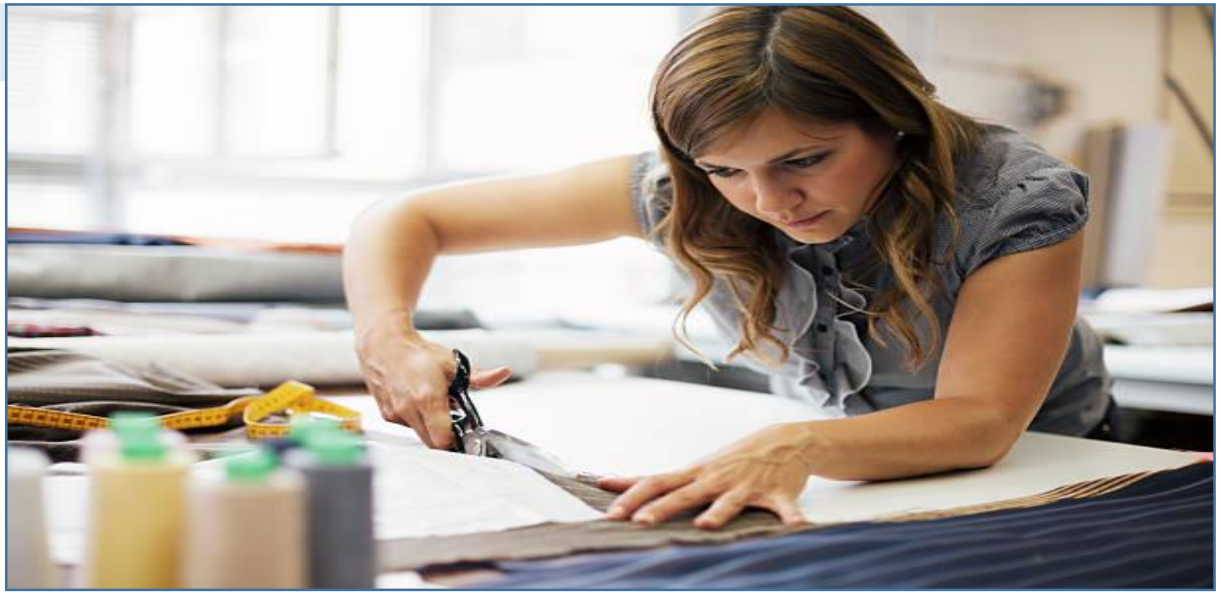

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  - 2.1.6.4 Microfiltration

The floatation produces a large number of micro-bubbles in order to form the three-phase substances of water, gas, and solid

oil particles are separated from the water

eliminate the **surface electrical charges of the colloids.**
This effect is named coagulation

2. Textile dyeing wastewater treatment processes

2.1 Physicochemical wastewater treatment

2.1.1 Equalization and homogenization

2.1.2 Floatation

2.1.3 Coagulation flocculation sedimentation

<u>2.1.4 Chemical oxidation</u>

Chemical operations can **oxidize the pigment in the printing and dyeing wastewater** as well as bleaching the effluent

<u>2.1.4.1 Fenton reaction</u>

the main chemical is hydrogen peroxide **(H_2O_2)**

able to decolorise a wide range of dyes

<u>2.1.4.2 Ozone oxidation</u>

very effective and fast decolorising treatment, which can easily break the double bonds present in most of the dyes

2.1.5 Adsorption

2.1.6 Membrane separation process

2.1.6.1 Reverse osmosis

2.1.6.2 Nano filtration

2.1.6.3 Ultrafiltration

2.1.6.4 Microfiltration

2. Textile dyeing wastewater treatment processes

2.1 Physicochemical wastewater treatment

Adsorption is the most used method in physicochemical wastewater treatment

2.1.1 Equalization and homogenization

2.1.2 Floatation

Commonly used adsorbents are activated carbon, silicon polymers and kaolin.

2.1.3 Coagulation flocculation sedimentation

2.1.4 Chemical oxidation

2.1.4.1 Fenton reaction

2.1.4.2 Ozone oxidation

2.1.5 Adsorption

activated carbon is still the best adsorbent of dye wastewater. The chroma can be removed 92.17% and COD can be reduced 91.15% in series adsorption reactors, which meet the wastewater standard in the textile industry and can be reused as the washing water.

2.1.6 Membrane separation process

2.1.6.1 Reverse osmosis

2.1.6.2 Nano filtration

2.1.6.3 Ultrafiltration

2.1.6.4 Microfiltration

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2.1.6.1 Reverse osmosis

2.1.6.2 Nano filtration

2.1.6.3 Ultrafiltration

2.1.6.4 Microfiltration

use of membrane's selective permeability separate certain substances in wastewater.

Membrane separation process is a new separation technology, with high separation efficiency, low energy consumption, easy operation, no pollution and so on. However, this technology is still not large-scale promoted

2. Textile dyeing wastewater treatment processes

2.1 Physicochemical wastewater treatment

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2.1.2 Floatation

2.1.3 Coagulation flocculation sedimentation

2.1.4 Chemical oxidation

2.1.4.1 Fenton reaction

2.1.4.2 Ozone oxidation

2.1.5 Adsorption

2.1.6 Membrane separation process

2.1.6.1 Reverse osmosis -

have a retention rate of 90% or more for most types of ionic compounds and produce a high quality of permeate.

It must be noted that higher the concentration of dissolved salt,the more important the osmotic pressure becomes

2.1.6.2 Nano filtration-

this sequence decreases concentration polarization during the filtration process, which increases the process output.

2.1.6.3 Ultrafiltration-

1nm-0.05μ m, enables elimination of macromolecules and particles, but the elimination of polluting substances, such as dyes, is never complete.

2.1.6.4 Microfiltration-

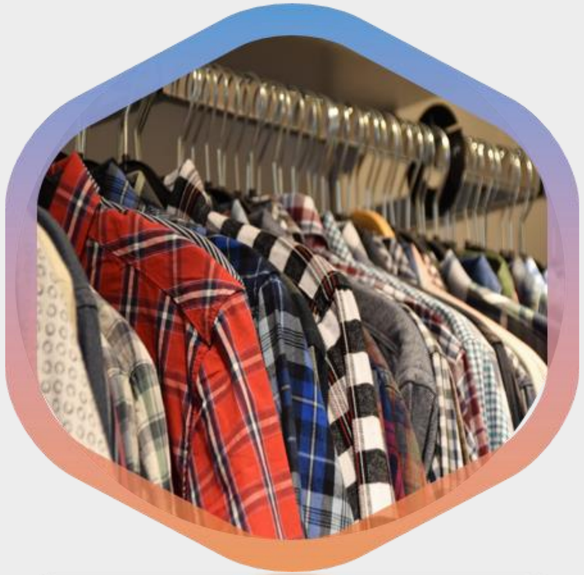
0.1-1μ m is suitable for treating dye baths containing pigment dyes, as well as for subsequent rinsing baths.

Microfiltration can also be used as a pretreatment for nanofiltration or reverse osmosis

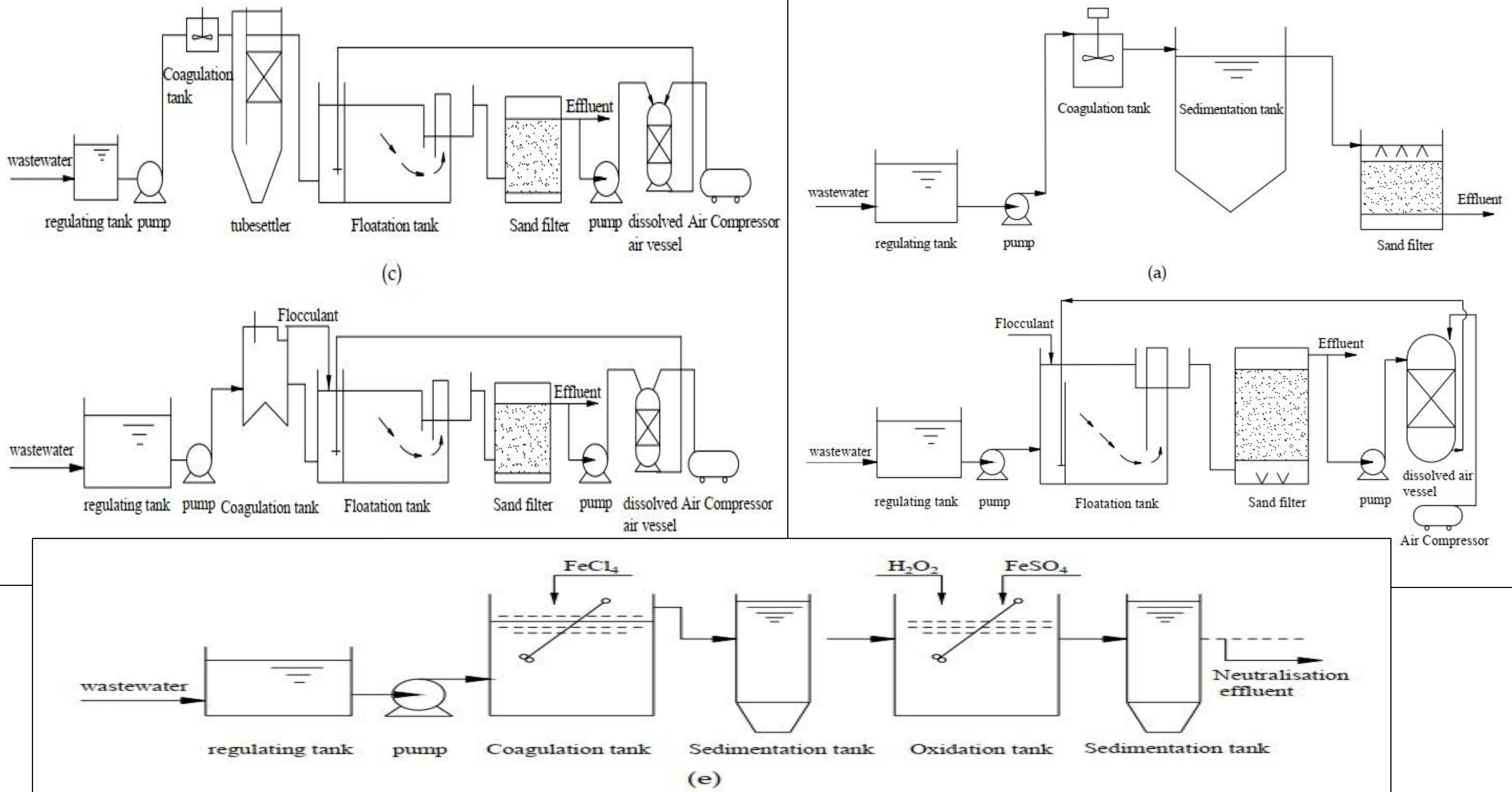
Some typical physicochemical treatment process is shown in Table 8

Name	Dyes and Additives in sewage	Water Quantity (t/d)	Main Process	Amount of Coagulant (mg/L)	Water Qualify		Treatment Efficiency	
					Color (times)	COD (mg/L)	Color (%)	COD (%)
A Knitting Mill in Kunming Yunnan	Naphthol, Direct dye, Acidic dye, Reactive dye	1000	wastewater → pump → (PAC) mixed reaction tank effluent ← sedimentation tank	60-80	70-120	267	>90	60
A Printing and Dyeing Mill in Shanghai	Vat dye, Naphthol, Dope	Pilot scale test	wastewater → regulating tank → pump → dissoved vessel → floatation tank → effluent	400	400	600-800	80-90	60
A Printing and Dyeing Mill in Beijing	Acidic dye, Disperse dye, Reactive dye Sulfide dye	120	wastewater → regulating tank → coagulatio tube sedimentation tank → floatation tank → sand filter tank → effluent	–	174-347	228-352	97.41	74.69
A Silk and Dyeing Mill in Shaoxing, zhejiang	Disperse dye, Reactive dye, Direct dye, Sulfide dye, Acidic dye	500	wastewater → regulating tank → reaction tank → coagulation tank → tube sedimentation tank ↓ effluent tank	$FeSO_4$: 0.7kg/t sewage, Lime: 0.38kg/t sewage.	720-830	1114-1153	92	55-59

Table 8. Physicochemical treatment instance of textile dyeing wastewater



The physicochemical treatment process in textile dyeing wastewater



2.2 Biological wastewater treatment method

The biological process removes dissolved matter in a way similar to the self depuration but in a further and more efficient way than clariflocculation. The removal efficiency depends upon the ratio between organic load and the bio mass present in the oxidation tank, its temperature, and oxygen concentration

The bio mass concentration can increase, by aeration the suspension effect but it is important not to reach a mixing energy that can destroy the flocks, because it can inhibit the following settling.

According to the different oxygen demand, biological treatment methods can be divided into aerobic and anaerobic treatment. Because of high efficiency and wide application of the aerobic biological treatment, it naturally becomes the mainstream of biological treatment.

2.2 Biological wastewater treatment method

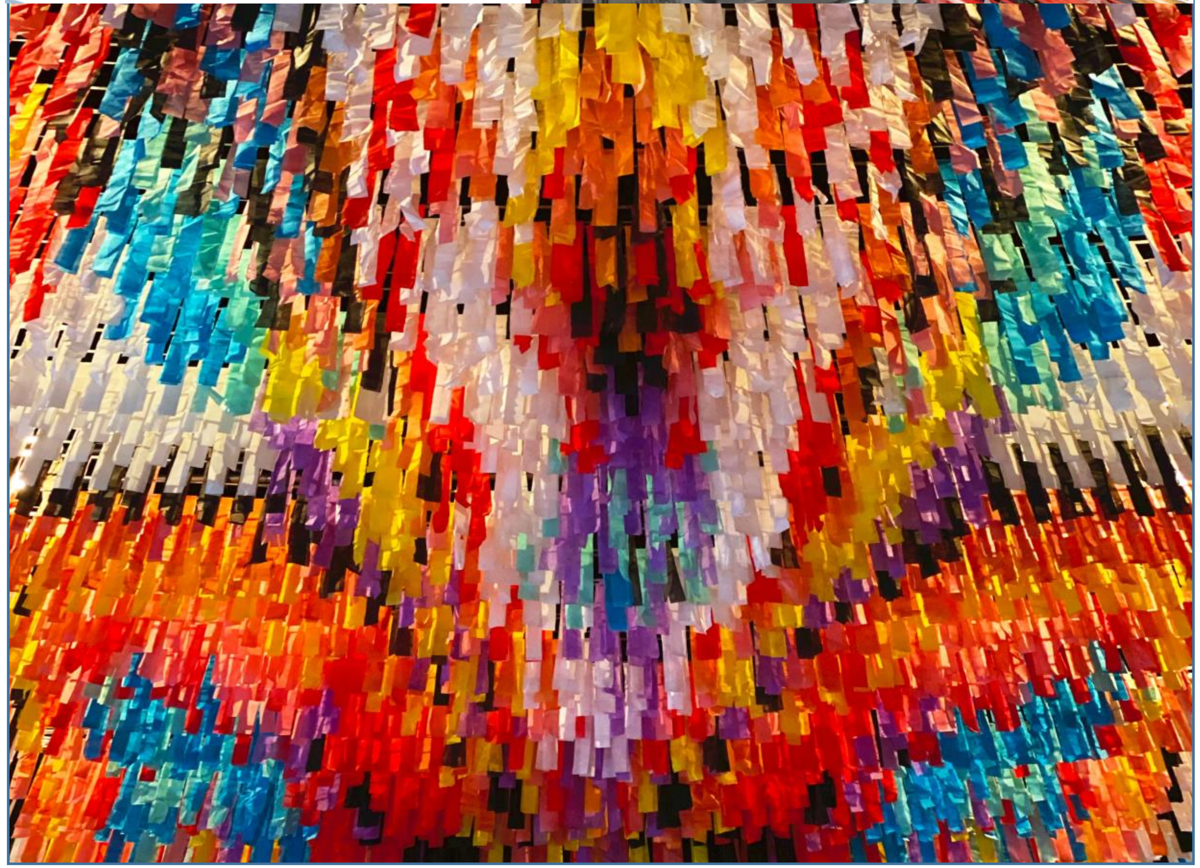
2.2.1.1 Activated sludge process

2.2.1.2 Biofilm

2.2.1.2.1 Biological contact oxidation

2.2.1.2.2 Rotating Biological Contactor

2.2.1.2.3 Biological fluidized bed



2. Textile dyeing wastewater treatment processes

2.2 Biological wastewater treatment method

2.2.1.1 Activated sludge process

Activated sludge is a kind of floc which is mainly comprised of many microorganisms, which has strong decomposition and adsorption of the organics, so it is called "activated sludge".

Oxidation ditch It is a variant of activated sludge, which is a special form of extended aeration.

2.2.1.2 Biofilm

biofilm process is a kind of biological treatment that making the numerous microorganisms to attach to some fixed object surface, while letting the wastewater flow on its surface to purify it by contact.

2.2.1.2.1 Biological contact oxidation

The main feature of the process is to set fillers in the aeration tanks, so that it has the characteristics of activated sludge and biofilm.

2.2.1.2.2 Rotating Biological Contactor

Rotating Biological Contactor is an efficient sewage treatment plant developed on the basis of the original biological filter. It is constituted by a series of closed disks which are fixed on a horizontal axis

2.3 Biochemical and physicochemical combination processes

In recent years, as the application of new technologies in textile and dyeing industry, a large number of difficult biodegradable organic matter such as PVA slurry, surface active agents and new additives enter into the dyeing wastewater, which result in the high concentration of the organic matter, complex and changeable composition and the obvious reduction of the biodegradability.

quite a number of sewage treatment facilities can't normally operate even stop running. Therefore, the biochemical and physicochemical combination processes has been gradually developed.

2.3 Biochemical and physicochemical combination processes

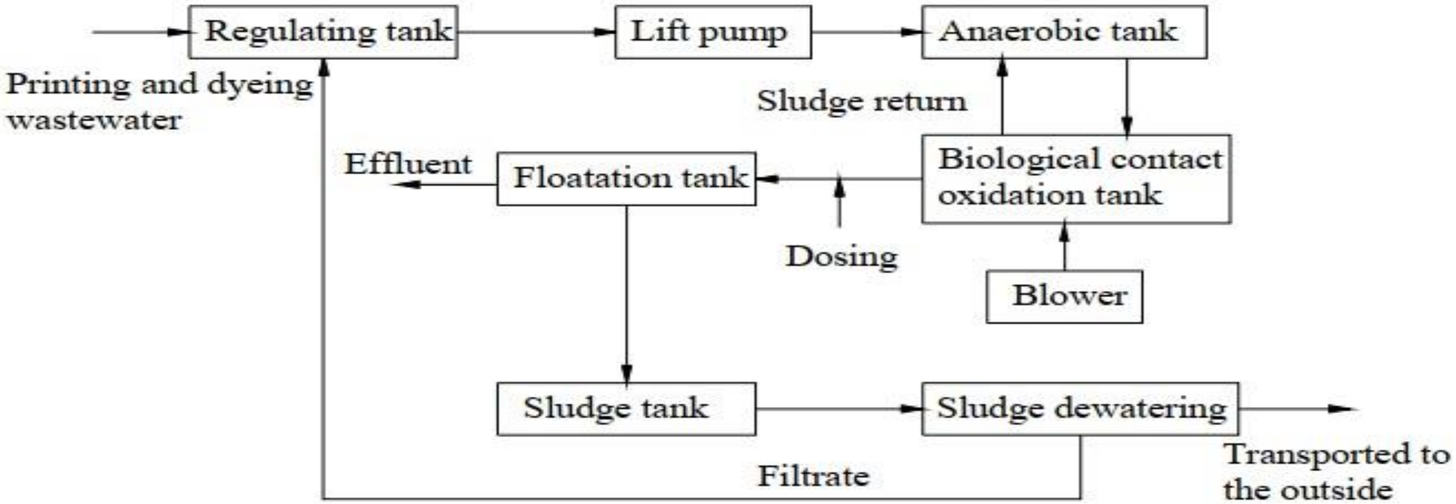
2.3.1 Hydrolytic acidification-contact oxidation-air floatation process

2.3.2 Anaerobic-aerobic-biological carbon contacts

2.3.3 Coagulation-ABR-oxidation ditch process

2.3.4 UASB-aerobic-physicochemical treatment process

After the treatment of this process, the COD removal rate can be up to 95% or more. The actual effluent quality is about: pH=6~9, color<100times, SS<100mg/L,BOD5<50mg/L , COD<150mg/L.



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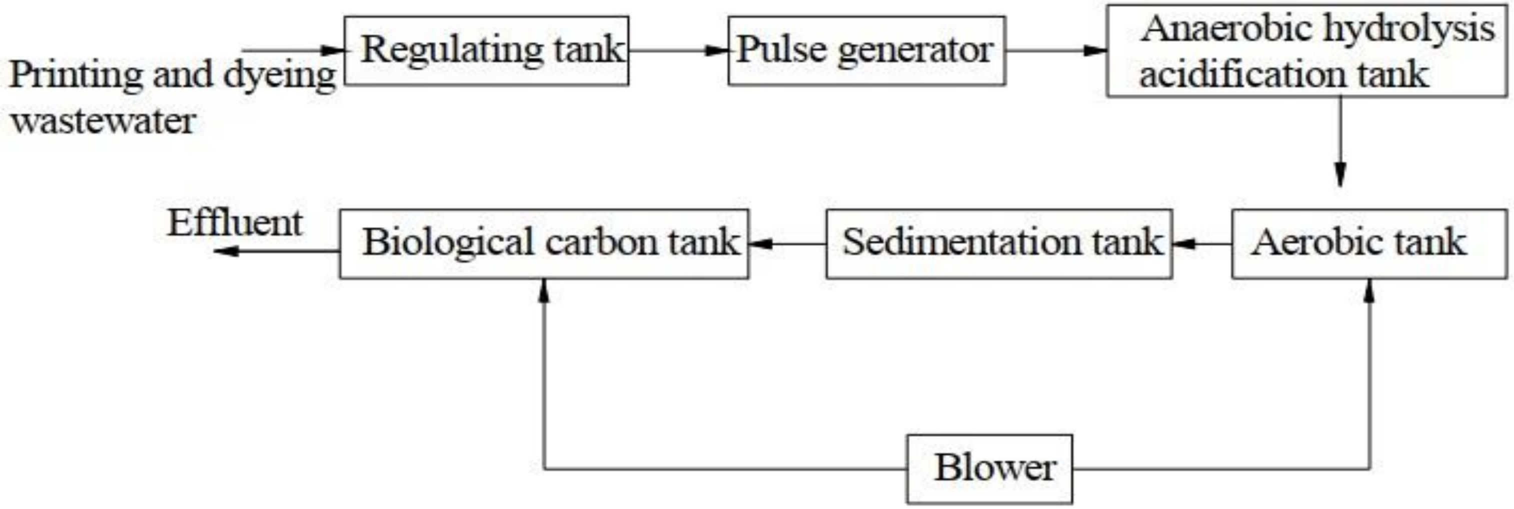

2.3.2 Anaerobic-aerobic-biological carbon contacts

The purpose is aiming at degrading some poorly biodegradable polymer materials and insoluble material in textile dyeing wastewater to small molecules and soluble substances by hydrolysis andacidification, meanwhile, improving the biodegradability and BOD5/CODCr value of thewastewater in order to create a good condition for thesubsequent aerobic biological treatment.

2.3 Biochemical and physicochemical combination processes

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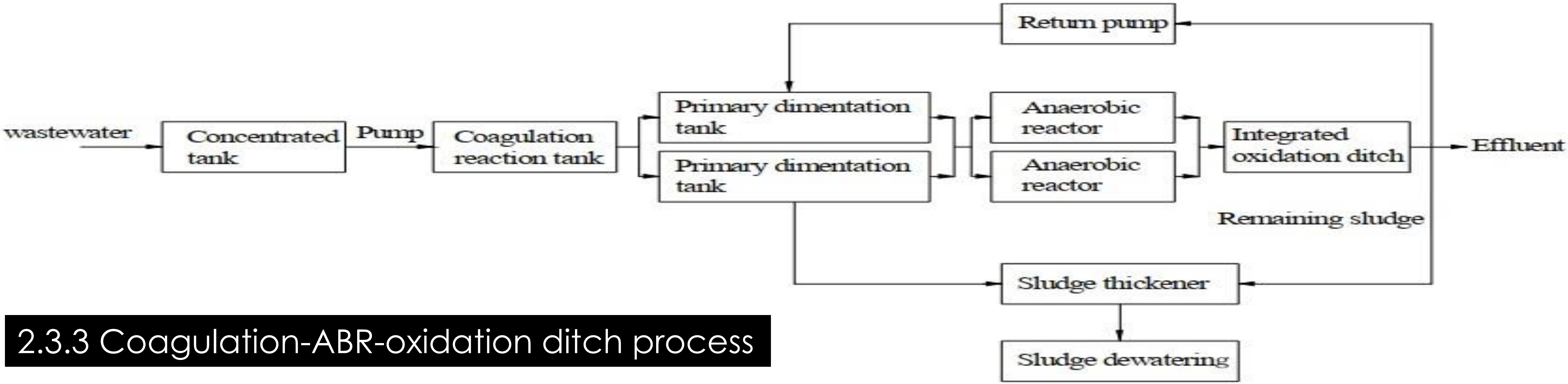
2.3.4 UASB-aerobic-physicochemical treatment process

Process	PH	CODcr (mg/L)	BOD_5 (mg/L)	SS (mg/L)	Color (times)
Wastewater	9-13	1800-2000	400-500	250-350	500
Coagulation effluent	6-9	1327	344	157	102
ABR effluent	6-9	532	292	94	48
Aerobic secondly sedimentation effluent	6-9	80	15	14	30

Table 10. Average Quality of Each Process Effluent



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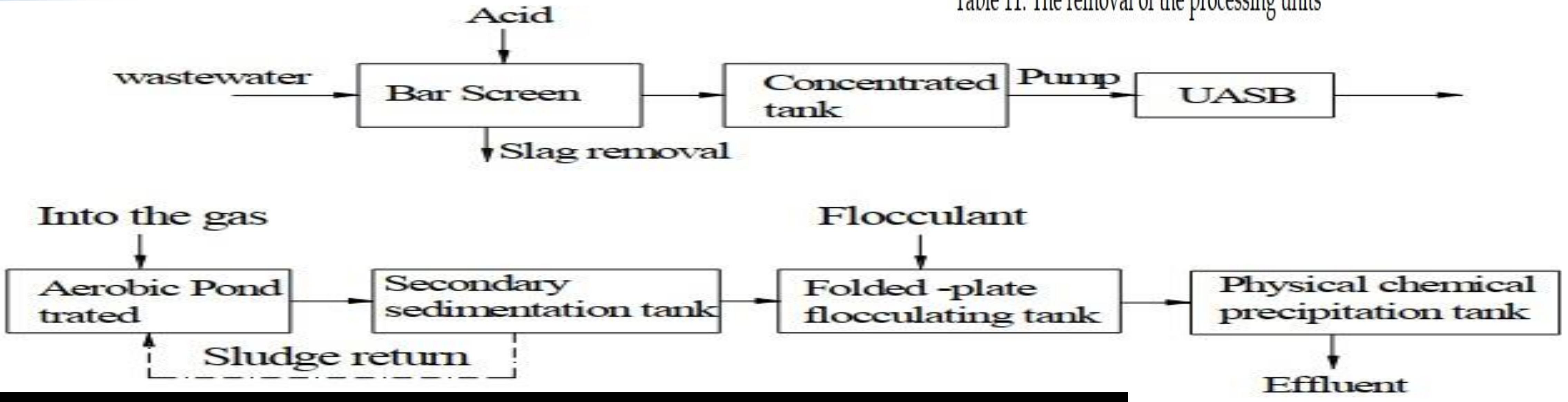
2.3.3 Coagulation-ABR-oxidation ditch process

2.3.4 UASB-aerobic-physicochemical treatment process

Items	(raw water) regulating tank	Biochemical treatment system		Physicochemical treatment system	
		Effluent	Removal rate	Effluent	Removal rate
PH	8-12	7-8		6-9	
CODcr(mg/L)	1000-2000	100-200	90	≤100	50
BOD_5(mg/L)	300-600	15-30	95	≤30	
Color(times)	100-600	60	80	≤40	35

Table 11. The removal of the processing units



2.3.4 UASB-aerobic-physicochemical treatment process

2.4 Cutting-edge treatment process

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2.4.1 Photochemical oxidation

2.4.2 Electrochemical oxidation

2.4.3 Ultrasonic technology

2.4 Cutting-edge treatment process

2.4.1 Photochemical oxidation

2.4.2 Electrochemical oxidation

2.4.3 Ultrasonic technology

This technology can effectively destroy a lot of organic pollutants whose structure is stable and difficult to biologically degrade.

Photochemical oxidation has many advantages of the mild reaction conditions (ambient temperature and pressure), powerful oxidation ability and fast speed, etc. It can be divided into 4 kinds, which are light decomposition, photoactivate oxidation, optical excitation oxidation and photocatalysis oxidation. Among them, the photocatalysis oxidation has been more researched and applied currently.

2. Textile dyeing wastewater treatment processes

2.4 Cutting-edge treatment process

2.4.1 Photochemical oxidation

2.4.2 Electrochemical oxidation

2.4.3 Ultrasonic technology

The mechanism of the electrochemical process treating dyeing wastewater is making use of electrolytic oxidation, electrolytic reduction, electrocoagulation or electrolytic floating destruct the structure or the existence state to make it bleached.

Under normal temperature and pressure, it can produce hydroxyl radicals directly or indirectly through the reactions in the catalytic activity electrode, thus thedegradation of the difficultly biodegradable pollutants is effective. It is one of the maindirections in future research.

2. Textile dyeing wastewater treatment processes

2.4 Cutting-edge treatment process

2.4.1 Photochemical oxidation

2.4.2 Electrochemical oxidation

2.4.3 Ultrasonic technology

Using ultrasonic technology can degrade chemical pollutants, especially the refractory organic pollutants in water. It combines the characteristics of advanced oxidation technology, incineration, supercritical water oxidation and other wastewater treatment technologies. Besides the degradation conditions are mild, degradation speed is fast and application widely, it can also use individually or combined with other water treatment technologies.

At present, the ultrasonic technology in the research of water treatment has achieved great achievements, but most of them are still confined to laboratory research level

Conclusions and recommendations

Current, the textile dyeing wastewater is one of the most important source of pollution. The type of this wastewater has the characteristics of higher value of color, BOD and COD,Complex composition, large emission, widely distributed and difficult degradation. If being directly discharged without being treated, it will bring serious harm to the ecological environment. Because of the dangers of dyeing wastewater, many countries have enacted strict emissions standards, but There is no uniform standard currently.

Waste minimization is of great importance in decreasing pollution load and production costs. Various methods can be applied to treat cotton textile effluents and to minimize pollution load. Traditional technologies to treat textile wastewater include various combinations of biological, physical, and chemical methods, but these methods require high capital and operating costs. Technologies based on membrane systems are among the best alternative methods that can be adopted for large-scale ecologically friendly treatment processes. A combination methods involving adsorption followed by nanofiltration has also been advocated, although a major drawback in direct nanofiltration is a substantial reduction in pollutants, which causes permeation through flux.

The treated water at this stage may be used for rinsing and washing purposes; however, an ion-exchange step may be introduced if the water is desired to be used for industrial processing.

Conclusions and recommendations

As the improvement of the environmental protection laws and the raise of the awareness of environmental protection, the pollution of printing and dyeing enterprises has caught a lot of attention and the treatment of dyeing wastewater has become a focus.
Recently, except the oxidation, filtration and other single method research, it has been introduced a large number of electric, magnetic, optical and thermal method to treat the refractory materials.

Prevention and treatment of dyeing wastewater pollution are complementary.
We can both use preventive measures as well as a variety of methods to control the wastes and make use of treated water.

This will not only reduce water consumption, but also effectively reduce the pollution of the printing and dyeing wastewater and achieve sustainable development of society.

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The treatment of textile wet processing effluent to meet stringent governmental regulations is a complex and continually evolving process. Treatment methods that were perfectly acceptable in the past may not be suitable today or in the future. This book provides new ideas and processes to assist the textile industry in meeting the challenging requirements of treating textile effluent.

How to reference

In order to correctly reference this scholarly work, feel free to copy and paste the following:

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Thank you for your attention