Journal of Earth & Statistics
Journal homepage: http://www.Jes.arakut.ac.ir
Doi: 10.22034/jes.2024.2031010.1048

Construction of modern integrated pilot and determining the efficiency of physical, chemical and biological treatment of paper factory wastewater (Case Study)

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Article Info

Keywords:
Wastewater, Integrated pilot, Removal efficiency, Treatment plant, Paper factory

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Abstract

The values of physical, chemical and biological variables in the paper factory wastewater are higher than the environmental standards in all cases. The color of the wastewater is dark and brown and has a foamy appearance in different conditions. The wastewater COD is 16 times higher than the existing standards in agriculture. Dissolved and suspended solids are high in the wastewater resulting from the process of washing, decolorization and pulping. Pulping and chemical production units are overloaded. Therefore, it is necessary to install industrial wastewater treatment plants to treat the wastewater of Ahvaz paper factory. Before the construction of the main wastewater treatment plant, a new integrated continuous pilot system was established at the factory site and next to the wastewater transfer channel, and was determined the removal efficiency of physical, chemical, and biological substances such as suspended solids, soluble solids, and COD. The average total suspended solids dropped from 2314 mg/L in the inlet wastewater to 7 mg/L in the outlet wastewater and removal efficiency was 99.7% in the pilot combined treatment system. The average total dissolved solids dropped from 6256 mg/L in the inlet wastewater to 623 mg/liter in the outlet wastewater and removal efficiency was 90%. The average COD decreased from 1533 mg/L in the input wastewater to 354 mg/L in the output wastewater and removal efficiency was 80%. Therefore, a new integrated filtration system is proposed in Ahvaz paper factory.

1. Introduction

Ahvaz group's paper production process is such that sugarcane bagasse is used to produce paper pulp. The organic compounds in the pulp enter the wastewater. Sometimes the amount of chemical oxygen demand (COD) of the wastewater has reached 3000 mg/L, which is five times that of urban sewage. Also, this company uses colored chemical substances and compounds for dyeing paper pulp, and the color of the resulting wastewater is dark and light brown, depending on what substances and when it entered the wastewater (Samriyeh, 2009). It is necessary to reduce or digest the solids, since most of the materials used in the paper industry are organic materials and mainly in the form of suspended solids in the wastewater (Khodadadi, 2015). For this purpose, multi-unit physical, chemical and biological treatment is necessary to reduce the pollution load (Babaei et al., 2008; Jafari, 2000). Ghahramani et al. (2014) represent the pulp and paper industry is one of the industries where the amount of pollutants is high in their wastewater. Most of the wastewater of the paper industry come from the pulping process, which contains suspended solids pollutants.Takdestan et al. (2015) proposed the quantitative and qualitative characteristics of paper industry wastewater, management problems including the integration of chemical, biological and anaerobic and combined methods to remove pollutants. Ghazizadeh et al. (2015) investigated the recycling process of paper and wastewater from the operation of Kahrizak factory and found that polluting factors is one of the quality characteristics of wastewater such as high organic load, relatively abundant foam, suspended solids, chemical and biological oxygen demand and high turbidity as well as complexity in the chemical structure of pollutants. Franta and Wilderer (1997) evaluated and proposed the biological treatment of paper pulp wastewater using a sequential integration method. Ammary (2004) proposed sequential combined anaerobic and aerobic methods in a laboratory scale to investigate the efficiency of removal of chemical oxygen demand in order to treat the wastewater of paper pulping unit. Cadet et al. (2007) emphasized on the wastewater treatment of the paper industry, especially the pulping unit. Zheng et al. (2015), El-naas et al. (2016), Phuong et al. (2018) and yang et al. (2018) found the construction of a pilot treatment plant to be effective in order to treat the final effluent of industries. Adhikari and Lohani (2019) and Shen et al. (2019) referred to wastewater treatment using a combined biological and chemical method to remove suspended solids (TSS) and chemical oxygen demand (COD). Takdestan et al. (2014) evaluated the quantitative and qualitative characteristics of wastewater from paper and pulp industries and management strategies to remove its pollutants. The amount of TSS suspended in the air was 75-150 kg/ton and 20-25 m^3/ton of dry paper pulp output wastewater was measured by Kraft method, and COD whit 20-200 kg, and in the end, were suggested to treat the available wastewater by integrating chemical and biological methods, combined anaerobic methods. Franta and Wilderer (1997) eliminated biological treatment of paper pulp wastewater using sequential combination method (RBC) and the remaining organisms, in this research. Sequence experiments (SBR) have been carried out in the laboratory pilot to determine the factors affecting the composition. They investigated the concentration of the remaining organism in the wastewater of biological sewage treatment plants. Wastewater discharged by a paper mill was used to feed four consecutive SBR reactors. The influence of process conditions was investigated the duration of the fill step or the duration of the reaction. The results showed that the amount of removal depends on the age of the sludge and the optimal process strategy. The highest COD removal rate and the best sludge regulation characteristics for pulping wastewater were obtained at a sludge age of 20 days (more than 15 days) in a reaction period of 6-12 hours. Cadet et al. (2007) worked on the wastewater treatment of the pulp industry, designing and validating the treatment pilot model. Experiments on a semi-industrial plant have evaluated using real wastewater, the design of a pulping wastewater treatment system model. They modeled the inlet flow rate of 0.28 m^3/ day, the amount of current circulating in the system is 2.35 times the internal flow with COD equivalent to 770 mg/L in a reactor with a volume of 250 liters. The main goal was to obtain a model that predicts the behavior of the dynamic process. Ammary (2004) a simple formula to calculate the nutrients required for the treatment of paper industry wastewater using sequential anaerobic and aerobic reactors on a laboratory scale to check the removal efficiency and the observed biomass yield coefficient was presented. Therefore, with extensive aeration to treat pulp and paper wastewater with a COD: N: P ratio of about 170.0:5:5, it is able to achieve more than 75% of COD. In paper factories, including Ahvaz Paper, from the beginning to the end of the production line, water is the agent of transferring and moving the cellulose mass. (Sharikhani et al., 2019a) In addition, water is also used for purposes such as cooling, dough making, dough washing, steam production, and condensation agent (Zheng et al., 2015). Ahvaz paper threatens the environment by producing a large amount of industrial wastewater containing organic and chemical loads, especially organochlorine compounds, and discharging it into the Dez River and Karun. Considering the water consumption of the Karun River in the downstream for the drinking purposes of the major cities of Khuzestan province, it becomes the importance of wastewater treatment of this factory more apparent. Considering that one of the major paper production projects in Iran is limited to Khuzestan province and the use of bagasse (sugarcane bagasse) as the raw material for paper shredders, and the main center of life of the Karun River is also due to the discharge wastewater and are on the decline industrial, agricultural, and health wastewater (Tolainejad et al., 2009). The importance of preservation and survival of this valuable source of life becomes more obvious. Considering the existing problems regarding the wastewater of the factory, it is inevitable to install the industrial and sanitary wastewater treatment plant of this factory. On the other hand, it is necessary to have a uniform composition of wastewater in the pilot project, so the composition of produced wastewater in the process should be known. Therefore, it is necessary to specify each wastewater production process in terms of quantity and quality. In other words, the combined shock is one of the issues that can severely affect the wastewater treatment pilot.

Considering the current conditions and the lack of water in the future years, for the construction of a sewage treatment system and its installation, a problem should be thought of first to solve these issues. In the implementation of this project, there are two discussions, one is the design and construction and continuous operation of a combined multi-purpose purification device to reduce physical, chemical and biological pollution, and the other is a set of tests that are carried out in this purification system device, which efficiency improve the work to the desired extent. The meaning of efficiency here is to reduce as much pollution as possible in wastewater, shorten the treatment time and flow rate with higher input. In other words, the aim is to evaluate the performance of the new pilot system of amphibian treatment under the aerobic-anaerobic chemical-biological mechanism to control the wastewater pollution of Ahvaz paper factory.

2. Materials and methods

The pilot used in this research is made of steel and has a volume of about 80 m^3. This pilot includes various units. In general, the pilot system consists of a main steel part and a smaller part. Figure 1 shows a view from the design process to the construction of pilot. In order to prevent rust, the surface of the pilot is completely covered with epoxy paint. The concrete foundation is designed and implemented to bear the weight of the pilot. The thickness of the footing is 70 cm and it consists of two grids of 16 and 20 rebar at the top and bottom. The distances of the rebars in the upper and lower grids are close to 20 cm. Also, in order to strengthen the pilot body, two steel belts have been welded around the body using stud profile 12. The pilot system of Ahvaze paper amphibian wastewater treatment includes different parts such as primary sedimentation unit, wastewater mixing unit with return sludge, amphibian chemical-biological simultaneous treatment unit, aerobic chemical-biological simultaneous treatment unit, secondary sedimentation unit, coagulation unit, flocculation, sand filter and ozonation unit (Yang et al., 2018; Adhikari and Lohani, 2019) (Figs. 1 and 2).

In recent years, the use of packing media is expanding day by day due to its high contact surface with small volume and as a result of increasing the efficiency of wastewater treatment, especially in the biological methods of attached growth. These packings are produced from the best materials and mainly in the form of light blocks with a very resistant structure in various designs in the form of honeycomb and egg comb with vertical, cross and diagonal channels. High specific surface area per unit of low volume, low weight, high strength, ease of transportation, degreasing and removal of flow shocks in sedimentation tanks, removal of nitrates from waste water and so on are some of the advantages of this type of media (Fig. 3).). The specifications of the media used in the pilot amphibian system to optimize the purification operation are presented in Table 1.

Fig.1. Physical and chemical purification units in pilot

Fig.2. Amphibian biological filter tank

Fig. 3. The use of new generation media packing in the composite biological treatment method

Table 1. Specifications of the new generation media used in the amphibious pilot system

Characteristics	Unit	Value
The level of nominal media influence	m^2/m^3	500+30
Special impact level	m^2/m^3	390
Bulk factor	Kg/m^3	0.92-0.97
Weight per m^3 media	Kg	100-110
Approximate diameter of each media	mm	13-18
Approximate length of each media	mm	10-15
Material	-	polyethylene (polymer)

The pilot system of continuous integrated wastewater treatment includes various parts such as primary sedimentation unit, wastewater mixing unit with return sludge, secondary sedimentation unit, coagulation and flocculation unit, sand filter, ozonation unit and purification unit. Simultaneous chemical-biological and simultaneous chemical-biological purification unit is aerobic (Fig. 4). The wastewater entering the treatment pilot is of two types: black water and brown water (Fig. 5).

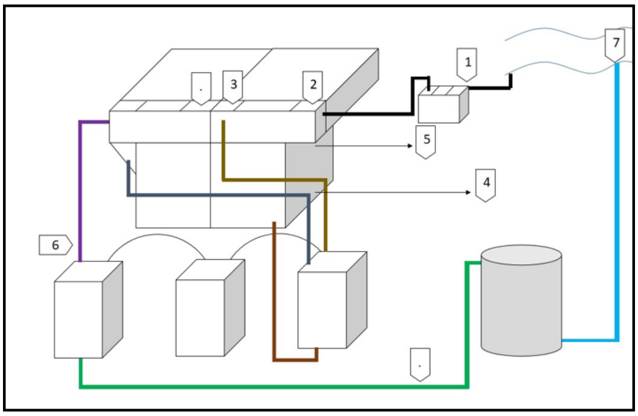

Figure 4. Different sampling stations of the purification pilot (S1=wastewater, S2=primary sedimentation, S3=aerobic amphibia, S4=anaerobic amphibia, S5=aerobic, S6=secondary sedimentation, S7=outflow)

Fig. 5. Black and brown wastewater from the paper factory

In order to determine the removal efficiency, COD variables, total suspended solids (TSS) and total dissolved solids (TDS) of different pilot units are presented in table 2 after the uniformity of the pilot in 5 time periods of sampling.

Table2. Total suspended, dissolved solids and COD values at different times in Treatment pilot

	Time	1	2	3	4	5
	S1	5400	1410	1030	2940	790
	S2	1210	500	312	1000	175
	S3	220	150	107	170	170
TSS	S4	115	120	49	30	175
(mg/L)	S5	105	90	52	50	48
	S6	33	25	10	8	12
	S7	10	5	6	8	6
	S1	17290	3345	4430	3720	2495
	S2	10766	2250	2122	1720	1270
	S3	1725	1835	1580	1450	1620
TDS	S4	1020	1150	1082	1265	1125
(mg/L)	S5	825	1080	1118	1370	1235
	S6	630	630	756	786	750
	S7	525	530	712	650	700
COD (mg/L)	S1	2150	2270	835	875	-
	S7	600	250	115	450	-

It is necessary to explain that on the first date, the input flow rate was 0.43 m^3/h. It was added 250 g phosphorus fertilizer to the system and the blower worked for 5 minutes. On the second date, the input flow was 0.103 m^3/h and 250 g phosphorus fertilizer was added to the system. On the third date, the input flow was 0.1 m^3/h and 300 g phosphorus fertilizer was added to the system.

On the fourth day, the flow rate was 0.15 m^3/h and 250 grams of phosphorus fertilizer and 300 g urea (nitrogen) fertilizer have been added to the system and the blower has been on for one hour.

It have been added 250 g phosphorus fertilizer and 300 g urea (nitrogen) fertilizer to the system and the blower has been on for an hour. On the fifth day, the input flow rate was 0.1 m^3/h and were added 250 g phosphorus fertilizer and 300 g urea (nitrogen) fertilizer to the system and the blower was on for one hour.

3. Results and discussion

3.1. Examination of removal efficiency in different units

Primary sedimentation unit (S2): After passing through the pre-settling unit, the primary wastewater (station S1) enters the primary settling unit (station S2). The total amount of suspended solids dropped from an average of 2314 mg/kg in the primary wastewater to 639 mg/kg in the secondary sedimentation unit and the average removal efficiency is 72%. Also, the average amount of total dissolved solids dropped from an average of 6256 mg/kg in the primary wastewater to 3626 mg/kg in the secondary sedimentation unit and the average removal efficiency was 42% (Table 3).

Amphibian Aerobic Unit (S3): In this unit, the purified wastewater from the primary sedimentation unit (S2) enters to the aerobic unit (aerobic bacteria) (S3). The total amount of suspended solids dropped from an average of 639 mg/kg in the primary sedimentation to 163 mg/kg in the aerobic unit and the average removal efficiency is 74%. Also, the average amount of total dissolved solids dropped from an average of 3626 mg/kg in the initial sedimentation to 1642 mg/kg in the aerobic unit and the average removal efficiency was 55% (Table 4).

Amphibian Anaerobic Unit (S4): In this unit, the purified wastewater from the aerobic unit (S3) enters the anaerobic unit (anaerobic bacteria) (S4). The total amount of suspended solids dropped from an average of 163 mg/kg in the amphibian aerobic unit to 98 mg/kg in the amphibian anaerobic unit and the average removal efficiency was 40%. Also, the average amount of total dissolved solids dropped from an average of 1642 mg/kg in amphibian aerobic to 1128 mg/kg in amphibian anaerobic unit and the average removal efficiency was 31% (Table 5).

Aerobic unit (S5): In this unit, the purified wastewater from the amphibian aerobic unit (S3) enters the aerobic unit (aerobic bacteria) (S5). The total amount of suspended solids decreased from an average of 163 mg/kg in amphibian aerobic to 69 mg/kg in aerobic unit and the average removal efficiency was 58%. Also, the average amount of total dissolved solids dropped from an average of 1642 mg/kg in amphibian aerobic to 1326 mg/kg in aerobic unit and the average removal efficiency was 19% (Table 6).

Secondary sedimentation unit (S6): In this unit, the purified wastewater from the aerobic unit (S5) enters the secondary sedimentation unit (S6). The amount of total suspended solids dropped from an average of 69 mg/kg in aerobic to 15 mg/kg in secondary sedimentation unit and the average removal efficiency was 78%. Also, the average amount of total dissolved solids dropped from an average of 1326 mg/kg in aerobic to 710 mg/kg in secondary sedimentation unit and the average removal efficiency was 46% (Table 7**).**

Outflow unit (S7): In this unit, the treated wastewater of the secondary sedimentation unit enters the wastewater outlet unit (S7) after passing through the coagulating chemical unit and sand filter (S6). The amount of total suspended solids dropped from an average of 15 mg/kg in secondary sedimentation to 7 mg/kg in the wastewater and the average removal efficiency was 53%. Also, the average amount of total dissolved solids dropped from an average of 710 mg/kg in secondary sedimentation to 623 mg/kg in the output wastewater unit, and the average removal efficiency was 12% (Table 8).

Table 3. Removal wastewater of total suspended and dissolved solids in the primary sedimentation unit

TDS				TSS			
Descriptive Statistics	**Primary wastewater (S1)**	**Primary settling (S2)**	**Removal efficiency%**	**Descriptive Statistics**	**Primary wastewater (S1)**	**Primary settling (S2)**	**Removal efficiency%**
Average	**639**	**163**	**74**	**Average**	**2314**	**639**	**72**
Minimum	**175**	**107**	**39**	**Minimum**	**790**	**175**	**78**
Maximum	**1210**	**220**	**82**	**Maximum**	**5400**	**1210**	**78**

Table 4. Removal efficiency of total suspended and dissolved solids in the aerobic unit

TDS				TSS			
Descriptive Statistics	**Primary wastewater (S2)**	**Amphibian aerobics (S3)**	**Removal efficiency%**	**Descriptive Statistics**	**Primary wastewater (S2)**	**Amphibian aerobics (S3)**	**Removal efficiency%**
Average	**3626**	**1642**	**55**	**Average**	**639**	**163**	**74**
Minimum	**1370**	**1450**	**14**	**Minimum**	**175**	**107**	**39**
Maximum	**10766**	**1835**	**83**	**Maximum**	**1210**	**220**	**82**

Table 5. Removal efficiency of total suspended and dissolved solids in the anaerobic amphibian unit

TDS				TSS			
Descriptive Statistics	**Amphibian aerobics (S3)**	**Amphibian anaerobes (S4)**	**Removal efficiency%**	**Descriptive Statistics**	**Amphibian aerobics (S3)**	**Amphibian anaerobes (S4)**	**Removal efficiency%**
Average	**1642**	**1128**	**31**	**Average**	**163**	**98**	**40**
Minimum	**1450**	**1020**	**30**	**Minimum**	**107**	**30**	**72**
Maximum	**1835**	**1265**	**31**	**Maximum**	**220**	**175**	**20**

Table 6. Removal efficiency of total suspended and dissolved solids in aerobic unit

TDS				TSS			
Descriptive Statistics	**Amphibian aerobics (S3)**	**aerobes (S5)**	**Removal efficiency%**	**Descriptive Statistics**	**Amphibian aerobics (S3)**	**aerobes (S5)**	**Removal efficiency%**
Average	**1642**	**1326**	**19**	**Average**	**163**	**69**	**58**
Minimum	**1450**	**825**	**43**	**Minimum**	**107**	**48**	**55**
Maximum	**1835**	**1370**	**25**	**Maximum**	**220**	**105**	**53**

Table 7. Removal efficiency of total suspended and dissolved solids in the secondary sedimentation unit

	TDS				TSS		
Descriptive Statistics	**aerobes (S5)**	**secondary sedimentation (S6)**	**Removal efficiency%**	**Descriptive Statistics**	**aerobes (S5)**	**secondary sedimentation (S6)**	**Removal efficiency%**
Average	**1326**	**710**	**46**	**Average**	**69**	**15**	**78**
Minimum	**825**	**525**	**36**	**Minimum**	**48**	**8**	**83**
Maximum	**1370**	**750**	**45**	**Maximum**	**105**	**33**	**69**

Table 8. Removal efficiency of total suspended and dissolved solids in the secondary sedimentation unit

	TDS				TSS		
Descriptive Statistics	secondary sedimentation (S6)	Outflow (S7)	Removal efficiency%	Descriptive Statistics	secondary sedimentation (S6)	Outflow (S7)	Removal efficiency%
Average	710	623	12	Average	15	7	53
Minimum	525	525	0	Minimum	8	5	38
Maximum	750	712	5	Maximum	33	10	70

3.2. Evaluation of pilot wastewater

In this part, It has been evaluated the efficiency of removing pollutants such as total suspended solids, total dissolved solids and COD in the inlet wastewater and the outlet treated wastewater. In Fig.6, the inlet wastewater with code 1 has been removed from the pilot system after passing through various physical and biological filters and treated as wastewater with code 7. In the treatment operation, it is seen a sharp drop in total suspended solids, total dissolved solids and COD.

Fig.6. Removal of pollutants in the pilot purification system

Total suspended solids (TSS): In the pilot system, the average total suspended solids decreased from 2314 mg/L in the inlet wastewater to 7 mg/L in the outlet wastewater and is removal efficiency 99.7% (Table 9 and Figs. 7 and 8).

Total dissolved solids (TDS): In the pilot system, the average total dissolved solids decreased from 6256 mg/L in the inlet wastewater to 623 mg/L in the outlet wastewater, and is removal efficiency 90% (Table 10 and Figs.9 and 10).

Table 9. Percentage of total suspended solids removal efficiency

Descriptive Statistics	Total suspended solids of inlet wastewater (S1)	Total suspended solids of outlet wastewater (S7)	Removal efficiency % (St)
Average	2314	7	99.7
Minimum	790	5	99.4
Maximum	5400	10	99.8

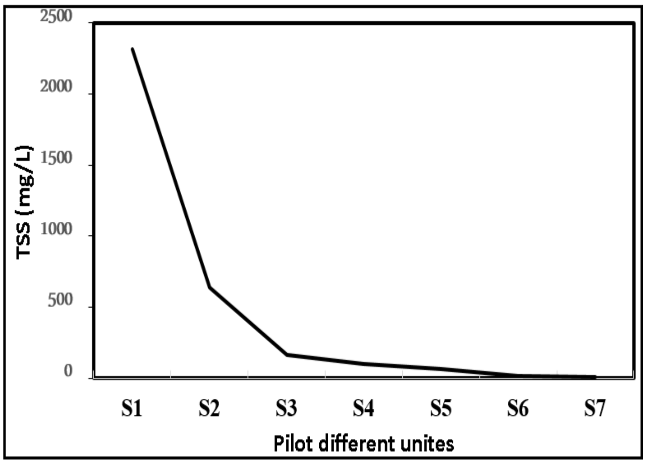

Fig.7. Total concentration of suspended solids in different pilot treatment units.
(S1=wastewater, S2=primary sedimentation, S3=aerobic amphibia, S4=anaerobic amphibia, S5=aerobic, S6=secondary sedimentation, S7=outflow)

Fig. 9. Total concentration of dissolved solids in different pilot treatment units.
(S1= wastewater, S2=primary sedimentation, S3=aerobic amphibia, S4=anaerobic amphibia, S5=aerobic, S6=secondary sedimentation, S7=outflow).

Fig.8. Removal efficiency of total suspended solids in pilot treatment (St = total treatment efficiency)

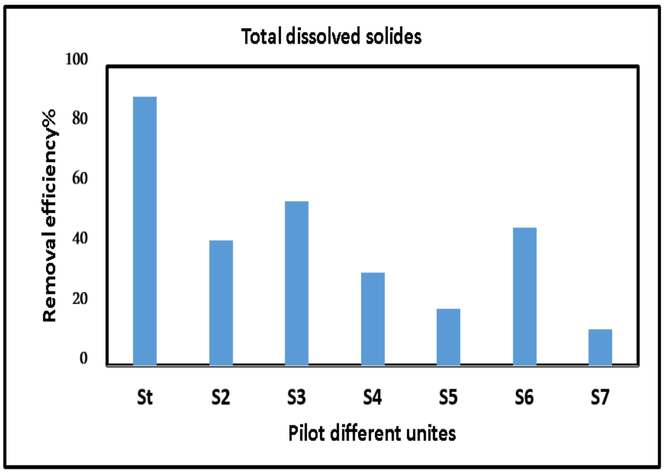

Fig. 10. Removal efficiency of total suspended solids in pilot treatment (St = total treatment efficiency

Table 9.Percentage removal efficiency of total dissolvedsolids

Descriptive Statistics	Total dissolved solids of inlet wastewater (S1)	Total dissolved of outlet wastewater (S7)	Removal efficiency% (St)
Average	6256	623	90
Minimum	2495	525	79
Maximum	17290	712	96

Chemical oxygen demand (COD): In the pilot system, the average COD has dropped from 1533 mg/L in the inlet wastewater to 354 mg/L in the outlet wastewater, and is removal efficiency 80%. (Table 10).

Table 10. COD removal efficiency percentage

Descriptive Statistics	COD inlet wastewater (S1)	COD wastewater (S7)	Removal efficiency % (St)
Average	1533	354	80
Minimum	835	115	86
Maximum	2270	600	-

This study showed that the average removal efficiency by combined method (physical, chemical and biological) in Ahvaz paper purification pilot was 99.7% for suspended load, 90% for soluble load and 80% for COD. Liang et al. (2023) using the combined method of papermaking purification in China determined the efficiency of decomposition of suspended solid at 80%, dissolved load at 50% and COD at 75%. The concentration of suspended solid in different units of Ahvaz paper factory varied from 18 to 1872 mg/L with an average of 488 mg/L. The highest amount of suspended solids in the bagasse dewatering unit varied from 300 to 3900 mg/L with an average of 1348 mg/L. The amount of suspended solids was the lowest in bagasse recovery, reiter and coring units. The amount of suspended solids in the final wastewater varied from 193 to 3900 mg/L with an average of 820 mg/L. In 77% of the wastewater in units, the amount of suspended solid was higher than the standard amount of agricultural water (100 mg/L). The large amount of suspended solids in the wastewater of different factory units is caused by floating materials, silica from the output of dewatered bagasse, lime and sodium carbonate (emptied from white washers) (Sarykhani, et al., 2019b). The large volume of suspended solid particles in the wastewater of the paper machine units and the paper recycling unit has an effect on the concentration of the effluent of the units (Ghahrmani et al., 2014). Waste of pulp in the storage tanks of the machine and the presence of impurities and recycled materials in the wastewater of these units have led to the increase of suspended substances in the wastewater (Ghadimi et al., 2024a). The amount of dissolved solids in the wastewater from Ahvaz paper factory varied from 349 to 11313 mg/L. In 92 percent of the factory units, the amount of dissolved solids was higher than the agricultural water standard (500 mg/L). Its average value in the lime kiln was 380 mg/L lower than the agricultural water standard and the highest value was 2253 mg/L in the pulping unit. The chemical production unit was the most important unit with more than 10,000 mg/L of dissolved solids due to the use of caustic, brine, gum, starch, porcelain soil and waste materials. Dissolved solids after the wastewater of the chemical unit were high in the wastewater of the material preparation, pulping, outlet channel and machine wastewater, respectively. Paper machine units also cause an increase in soluble solids in the factory wastewater due to the sudden discharge of waste materials (power cut) and the overflow of the pulp tanks. The average amount of dissolved solids in the wastewater of the factory was 1630 mg/L, and the highest amount was 4700 mg/L (Ghadimi et al., 2024a). COD ranged from 20 to 2452 mg/L with an average of 1037 mg/L. The highest amount of COD was in pulping 1 and 2 and the final wastewater (more than 4500 mg/L) and the lowest was related to the wastewater of chemical preparation (40 mg/L). In the final wastewater, the amount of COD varied from 500 to 4200 mg/L with an average of 2452 mg/L. The high amount of COD in the final wastewater is caused by the mixture of wastewater from recovery units, pulping 1, reiter and lime kiln units. Leakage of black leachate with large amounts of caustic is associated with increased alkalinity, color and turbidity (Sarikhani et al., 2019c). In more than 92% of wastewater in different factory units, the COD value was higher than the agricultural water standard (200 mg/L) (except for the chemical production unit) (Ghadimi et al., 2024a). In cluster analysis and differential analysis of pollutant variables in different units of Ahvaz paper factory were found to have high values of soluble solids, suspended solids in the final wastewater related to the process units of paper machine and preparation of chemicals, and COD related to the units of pulping and pulping of bagasse and dewatering of bagasse. This study showed that the share of main compounds such as soluble solids, suspended solids and COD in the final wastewater of Ahvaz paper factory was 31%, 16% and 47%, respectively, where the share of the pulping unit in the production of COD was 28% and the share of the machine unit in the production of COD was 22%. The share of bagasse preparation unit (coring, dewatering and retort) of COD is 36%, machine in suspended matter is 46% and the share of soluble matter in chemical production unit is 59%. The highest COD value measured is related to pulping units 1 and 2. Therefore, bagasse, pulp and paper machine preparation units are the most important sources of COD in the final wastewater with a total of 86% respectively. Therefore, the wastewater treatment steps for the paper factory were presented in Fig.11 based on the efficiency of physical, chemical and biological removal in different treatment units.

4. Conclusion

Pulp and paper factories are one of the biggest sources of pollution all over the world and is associated with the production of a huge volume of wastewater. Ahvaz paper factory produces a large amount of industrial wastewater due to worn-out

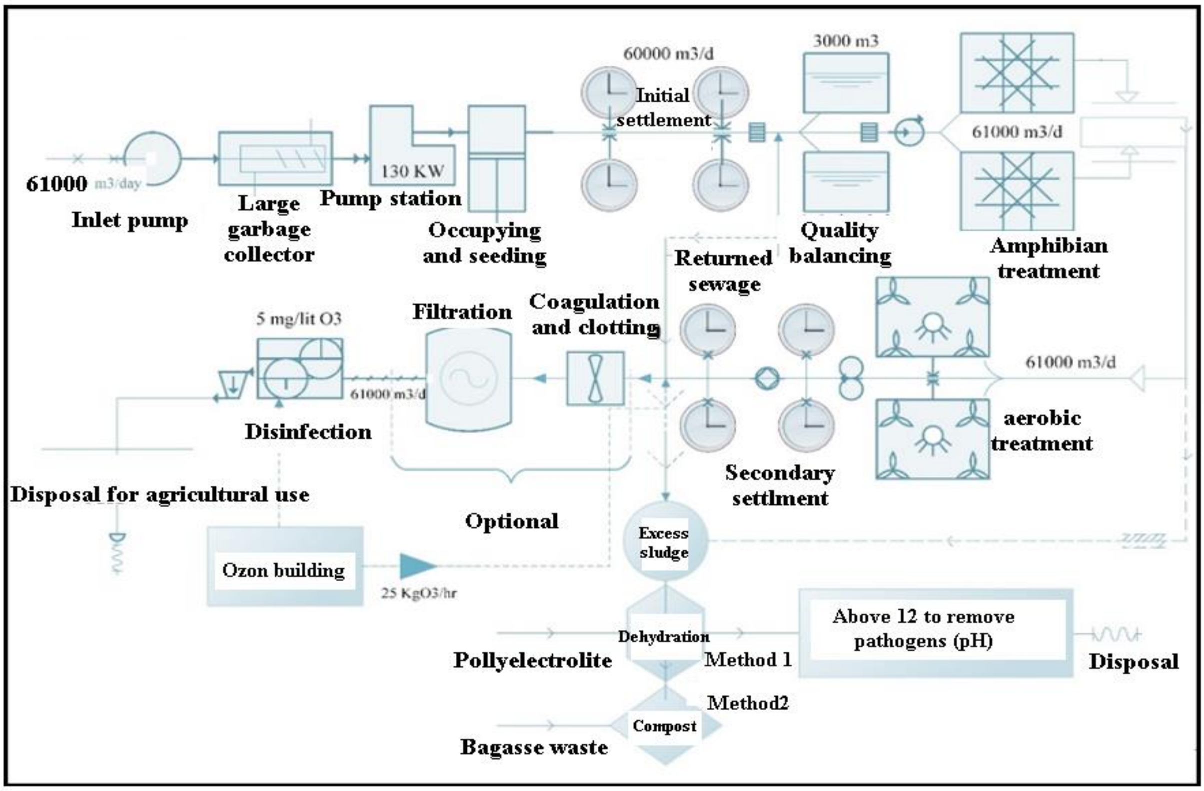

Fig. 11. Diagram of different units of the proposed papermaking treatment plant system with a capacity of 61,000 m^3/day.

devices and old technology, containing organic load and the chemistry of organic chlorine compounds and its discharge into Dez River. Ahvaz paper factory discharges an average of 65,000 m^3 of wastewater per day into the Dez River and finally the Karun River. With a COD of about 2452 mg/L, the daily load entering the Karun River is 159,380 kg. The paper machine unit and the chemical production unit were effective in increasing the dissolved and suspended solids, and the pulping and bagasse dewatering units were effective in increasing the COD in the final wastewater composition. Since a major part of the paper industry consists of organic materials in solid form suspended in the final wastewater, therefore, it is necessary to reduce or digest the desired materials, and for this purpose, it propsed multi-unit physical, chemical and biological purification. Therefore, the construction of a new integrated pilot unit or combined physical, chemical and biological treatment of amphibians was considered in order to remove final wastewater pollutants and to standardize water for agriculture or to recirculate water to the Ahvaz paper factory and determine the efficiency of removing physical, chemical and biological waste materials**.**

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