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Environmental geochemistry evaluation of wastewater in different paper factory units by factor analysis method (case study)

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Abstract

Ahvaz paper industry is one of the most important polluting industries in Khuzestan, which causes many problems, if it is not treated and discharged into the environment. The high intensity of pollution in the pulp and chemical units of Ahvaz factory has produced brown to black wastewater, which has complicated the treatment process. In order to determine the quality of Ahvaz paper in pollutant units and the role of pollutant variables in the final wastewater of the plant, it calculated 13 physical, chemical and biological pollutant variables in 26 samples of wastewater of different units. The final wastewater were compared with agricultural water quality standard in Iran. Variables such as soluble solids, suspended solids, alkalinity, COD, BOD and turbidity with values of 1630, 820, 343, 2452, 316 and 106 mg / L, respectively, were more than from the agricultural water standard in the final wastewater. The paper machine unit and the chemical production unit were effective in increasing the soluble, suspended solids, alkalinity and turbidity of the solids. Pulp unite and baggase dewatering unit were effective in increasing the chemical and BOD in the final wastewater compound. Therefore, it is necessary to build a combined physical, chemical and biological treatment plant in order to remove the final wastewater pollutants and to modify and standardize agricultural water in Ahvaz paper factory.

Introduction

Ahvaz Paper Industries Group was established in 1968 in the north of Khuzestan with the aim of using bagasse produced in the Haft Tepe sugarcane factory to produce pulp and then produce paper. In paper factories, including Paper Ahvaz, water is the agent of transferring and moving the mass of cellulose from the beginning to the end of the production line. In addition, water is used for purposes such as cooling, pulping making, pulping washing, steam generation and transfer. Ahvaz paper threatens the environment by producing a large amount of industrial waste containing organic and chemical loads, especially organochlorine compounds, and discharging it into the Dez and finally Karun River. Considering the water consumption of the Karun River for drinking in the cities of Khuzestan province, it is necessary to treat the wastewater of this factory (Tolainejad et al., 2010). Water of Dez River in addition to water distribution among industries, is constantly in contact with polluting sources, sewage and return water from these industries. Wastewater in addition to polluting the environment, produces ugly sights, unpleasant odors, algae growth, and finally the accumulation of insects. The raw material of Ahvaz paper is sugarcane bagasse that 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. This factory uses colored chemical substances and compounds for dyeing paper pulp, and casese dark and light brown color of wastewater. Since most of the materials used in the paper industry are organic materials and mainly in the form of suspended solids in the wastewater, it is necessary to reduce or digest the solids (Khodadadi, 2015). For this purpose, multi-unit physical, chemical and biological treatment is necessary to reduce the pollution load (Babaei et al., 2011; Jafari, 2000). Ahvaz paper factory with a water consumption of 790 L/s has wastewater of 740 L/s (Khodadadi, 2015).

Ghahramani et al. (2014) determined that the pulp and paper industry is one of the industries where the amount of pollutants in their wastewater is high. Most of the wastewater of the paper industry come from the pulping process, which contains pollutants of suspended solids, color and colloidal substances. Khodadadi (2015) considered the paper industry as one of the most important causes of pollution in the world, which consumes between 76-230 m^3 of water per ton of product, which indicates high water consumption and large volume of wastewater production. Takdestan et al. (2015) studied the quantitative and qualitative characteristics of paper industry wastewater and management strategies including the integration of chemical, biological and anaerobic combined methods to remove pollutants. Ghazizadeh et al. (2015) investigated the recycling process of paper and waste from the operation of Kahrizak factory. They found that polluting factors such as high organic load, relatively abundant foam, suspended solids, chemical and biological oxygen demand and high turbidity and as well as complexity in the chemical structure of pollutants is one of the quality characteristics of wastewater. Rudi and Keshavarz (2016) considered the paper industry to be one of the biggest polluting industries. Wastewater of the paper factory, due to the presence of various compounds such as lignin and toxic substances, strongly changed the color of the water and led to a decrease in the photosynthesis activities of plants and aquatic organisms. Franta and Wilderer (1997) evaluated and proposed the biological treatment of paper pulp wastewater using a sequential integration method. Ammary (2004) proposed sequential anaerobic and aerobic combined methods in 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 for the treatment of industrial wastewater. 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).

The purpose of this article is to investigate the pollution sources of different Ahvaz paper factory units, wastewater pollution indicators and determined the chemical quality and pollution load of incoming and outgoing wastewater from the factory units in accordance with the Iran environmental standards.

Materials and methods

Location of Ahvaz paper factory

Ahvaz paper factory with an area of 80 hectares is located in the vicinity of Haft-Tepe sugarcane factory in Khuzestan province (Figure 1). Haft Tepe region is in a hot and dry region and includes vast plains. The average temperature in Haft-Tepe is 25 degrees Celsius, Dez River is the important part of Karun River in Khuzestan province, and enters the plain of Khuzestan in the north of Dezful and flows into Karun at Qir Dam. The consumping water of Ahvaz factory is supplied from the sub-channel of Dez River, which belongs to Haft-Tepe sugarcane factory (Tolainejad et al., 2010).

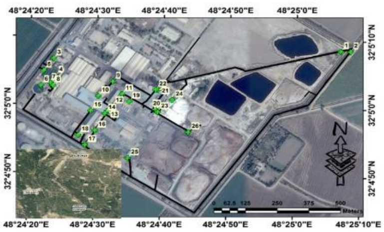

Fig.1. Geographical location and sampling locations of the wastewater in different units of Ahvaz Factory

Study method

The production line of paper factory consists of different units with different functions. The physical, chemical and biological of wastewater was measured in 13 main units and 13 sub-units (Figure 1 and Table 1). Sampling was done in plastic and glass containers depending on the investigated variable in a period of 6 months, and the tests were performed according to ASTM water and wastewater standard methods in the accredited laboratory of Ahvaz Water and Sewerage Company. The measured variables are: temperature, acidity, electrical conductivity, total dissolved solids, suspended solids, alkalinity, chlorine, chemical oxygen demand (COD) and biochemical (BOD), turbidity, lignin and sulfate. Chemical and biochemical oxygen demand are measured based on St.Method 5220, 5210B and the acidity, TDS and EC are measured respectively by digital PH meter, METTLER model TOLEDO device, and ASTM D1293 conductivity meter (Woodard, 2001).

Table 1. Water and wastewater collected from different units of Ahvaz paper factory

Sample No.	Wastewater production unit	Sample No.	Wastewater production unit
1	Wastewater of the canal unit next to the old pilot	14	Car wastewater 2
2	Wastewater of the canal unit next to the new pilot	15	Car wastewater 3
3	Semi-deep well of the guest house	16	Wastewater of the pulping unit 2
4	Semi-deep well of the physical treatment plant	17	Pulp, machine and pitting wastewater
5	Factory inlet water	18	Wastewater of pulping unit 2
6	Clarifier outlet water	19	Wastewater of chemicals unit
7	Wastewater of physical treatment	20	Wastewater from the treatment plant
8	Wastewater of the media filter	21	Wastewater recovery thickener unit
9	Wastewater of additive preparation unit	22	Pulping wastewater 1 and chemical recovery
10	Wastewater of reverse osmosis treatment	23	Wastewater recovery and chemical treatment unit
11	Wastewater of pulping 1 on channel 1	24	Lime kiln wastewater
12	Wastewater of pulping 1 on channel 2	25	Wastewater of bagasse pulping unit
13	Wastewater of pulp preparation part 1	26	Wastewater recovery and chemical treatment unit

Statistical analysis

Changes in temperature, acidity, electrical conductivity, dissolved solids, total suspended solids, alkalinity, chlorine, chemical and biological oxygen demand, turbidity, lignin and sulfate were investigated in multivariate statistical analysis. Since these changes are not symmetrically distributed and the variables have different units, logratio data were used to standardize. Relationships between variables and different units determined by factor analysis. The analysis was done with the statistical program STATISTICA. The factor of analysis was using the principal components method, instead of the original data and examines the dependence between the available variables from the covariance matrix and the correlation coefficient (Li et al., 2015). Varimax rotation was used to strengthen the factors.

Results and discussion

Evaluation of physical, chemical and biological variables of wastewater

In 26 samples of wastewater from different units of Ahvaz factory, it was investigated the variables of temperature, acidity, electrical conductivity, total dissolved and suspended solids, alkalinity, chlorine, chemical and biochemical oxygen demand, turbidity, lignin and sulfate (Sharikhani et al., 2019a)(Tables 2 and 3).

Temperature: The temperature of different units varied from 18 to 57 degrees Celsius. In 54% of the units, the temperature was more than 25 degrees Celsius and higher than the agricultural water standard. The average temperature in the recovery unit was the highest and equal to 57 degrees Celsius, and the lowest in the chemical preparation unit was equal to 18 degrees Celsius and in the final wastewater was 23 degrees Celsius.

Acidity: In different units of the factory, acidity varied from 5 to 13 with an average of 8 (Table 2). The wastewater acidity of some units was acidic (reiter unit or bagasse preparation and material preparation unit), alkaline (chemical preparation unit) and neutral in some units (bagasse pulping and paper machines unit). The highest average value of acidity in the chemical preparation unit was equal to 13.00 and the lowest value was 5.00 in the Ritter unit. In the final wastewater of the factory, it varied from 8.30 to 11.7 with an average of 8.3. The acidity in the chemical preparation unit varied from 11.53 to 13.80. The acidity for the use of wastewater in agriculture was 6.00-8.5. Due to the use of chemicals such as brine, phosphate, chlorine and caustic in soda, as well as the possible seepage of the black liquid is highly alkaline wastewater in pulp decolorization, preparation of chemicals, bagasse washing, recovery and preparation units. The material and retort unites had acidic acidity due to using cyanide and sulfuric acid (Sharikhani et al., 2019b).

Electrical conductivity: Electrical conductivity in different units varied from 340 to 2854 microsiemens/cm (Table 2). The minimum electrical conductivity was 340 in the lime kiln unit and maximum was in the wastewater of the chemical production unit with 2800 microsiemens/cm. Electrical conductivity with 9450 and 8910 microsiemens/cm was also recorded in pulp making units 2 and preparation of chemicals. In 85% of the units, the electrical conductivity was higher than the agricultural water standard (700 microsiemens/cm).

Total Dissolved Solids (TDS): The amount of dissolved solids of the wastewater varied from 349 to 11313 mg/L (Table 2). In 92% of the factory units, the amount of solids was higher than the standard of agricultural water (500 mg/L). Its average value in lime kiln with 380 mg/liter was lower than the standard of agricultural water and the highest value with 2253 mg/liter in pulping unit 2. Due to the use of caustic, brine, gum, starch, porcelain soil and waste materials, dissolved solids in chemical preparation unit was the most important unit with more than 10,000 mg/L. Dissolved solids were high in the wastewater of the material preparation, pulp making, outlet channel and machine wastewater, respectively. Paper machine units also caused an increase in soluble solids in the factory wastewater due to the sudden discharge of waste materials and the overflow of the pulp tanks. The average amount of dissolved solids in the wastewater of the factory is 1630 mg/L and the highest amount is 4700 mg/L.

Total suspended solids (TSS): The concentration of suspended solids in different units of the paper plant ranged from 18 to 1872 with an average of 488 mg/L. The highest amount of suspended solids in the bagasse dewatering unit varied from 300 to 3900 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 with an average of 820 mg/L. In 77% of the wastewater of the units, the amount of suspended matter was higher than the standard amount of agricultural water (100 mg/L). The large amount of suspended material in the wastewater of various factory units is caused by floating materials, silica from the output of dewatered bagasse, lime and sodium carbonate (emptied from white washers) and the rubbish of outlet channel wall. The large volume of suspended solid particles in the wastewater of paper machine units and paper recycling unit has an effect on the concentration of the wastewater of the units. The 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.

Alkalinity: Alkalinity in different units varied from 24 to 5990 with an average of 560 mg/L. The maximum amount of alkalinity with 18,440 mg/L was related to the wastewater of the chemical preparation unit. The average alkalinity in the final wastewater was 343 mg/L and its maximum was 1200 mg/L. Alkalinity was higher than the agricultural water standard (200 mg/L) in 38% of the wastewater of units such as preparation of chemicals, pulping and final wastewater. In the wastewater of the chemical preparation unit, porcelain soil and lime are associated with increased acidity and alkalinity.

Chlorine: The average concentration of chlorine varied from 30 to 341 mg/L in different units (Table 2). The maximum concentration of chlorine was 550 mg/L in units such as pulping, preparation of chemicals and dewatering, and in the final wastewater was 300 mg/L. The average concentration of chlorine in 15% of the wastewater of units (pulping and dewatering units) was higher than the agricultural water standard (200 mg/L). The use of soda in baking pulp and dyeing using sodium hypochlorite in the pulping unit was the reason for the increase in chlorine.

Chemical oxygen demand (COD): Chemical oxygen demand ranged from 20 to 2452 with a mean of 1037 mg/L (Table 2). 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 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. In more than 92% of the wastewater of different units (except for the chemical preparation unit), the amount of COD was higher than the agricultural water standard (200 mg/L).

Biological oxygen demand (BOD): In different units, BOD varied from 10 to 740 with an average of 248 mg/L. The amount of biological oxygen (BOD) in the bagasse pulping unit (SPM) was the highest with 740 mg/L, and the lowest was related to the chemical preparation, recovery and lime kiln units. In the final wastewater, BOD ranged from 68 to 700 with an average of 316 mg/L. Also, the maximum amount of BOD in pulp unit 1 and 2 was 720 and 400 mg/L, respectively. Bagasse is de-pitted in the preparation units before being delivered to the cooking pot and transferred to the drainage systems. Washing and draining bagasse is associated with an increase in the BOD of the wastewater of the units. In 45% of the wastewater of the units such as bagasse kerning, pulping, dewatering, reiter and final wastewater, the amount of BOD was higher than the agricultural water standard (100 mg/L).

Turbidity: The turbidity in the wastewater of different units varies from 3 to 475 NTU. Its highest values are in the factory wastewater (633 NTU) and paper machine 3 (475 NTU) and the lowest value is in the recovery unit (10 NTU). The increase of this parameter in the recovery units is equal to the defect in the wastewater of this unit. The average turbidity in the final wastewater is 135 NTU. In more than 77% of the factory wastewater, the turbidity is higher than the agricultural water standard (50 NTU).

Lignin and tannin: The average amount of lignin and tannin in the wastewater of different units varied from 2 to 200 mg/L. In pulp mill wastewater (especially pulp mill 1), the highest amount was 512 mg/L, in pulp mill 2 it was 396 mg/L, and in paper machine and lime kiln it was the least. Lignin and tannin in the final wastewater of the factory was 96.6 mg/L. Lignin and tannin must be transported through the installed pipes before being discharged to the sewage canals and to the anaerobic lagoons outside the production area. Energy consumption is high with the production of lignin and tannin into the aerobic treatment system.

Sulfate: The average concentration of sulfate in all units ranged from 41 to 2758 mg/L (Sharikhani et al., 2019c) (Table 2). Sulfate was the lowest in the wastewater of the lime unit (42 mg/L) and the highest in the wastewater of the chemical preparation unit (2758 mg/L). Sulfate in the final wastewater was minimum 80 and maximum 3950 and on average 472 mg/L. The wastewater of the chemical production unit contains a large amount of alum. Alum is used in paper machine units to increase paper strength and reduce the acidity of that unit. The maximum amount of sulfate in chemical preparation units was 3580 mg/L and in the final wastewater was 3950 mg/L. Sulfate concentration in 46% of the units, such as the machine unit, the preparation of chemicals and the final wastewater, was higher than the agricultural water standard (250 mg/L).

Table 2 .Statistical summary of physical, chemical and biological variables of different units in Ahvaz paper factory (electrical conductivity in ms/cm, temperature in degree centigrade, turbidity in NTU and other variables in mg/L).

Variables	mean	minimum	maximum	Sd.deviation	skewness	kurtisis	standard
Temperature	26	18	57	7.27	3.39	14	25
Acidity	8	5	13	1.90	0.24	0.01	6.00-8.5
Electrical conductivity	1132	340	2854	609	1.26	1.35	700
Total Dissolved Solids	1198	349	11313	2123	4.67	22	500
Total suspended solids	488	18	1872	558	1.06	0.20	100
Alkalinity	560	24	5990	1230	3.92	16	200
Chlorine	99	30	341	95	1.24	0.71	600
COD	1037	20	2452	786	0.14	-1.31	200
BOD	248	10	740	276	0.77	-1.11	100
Turbidity	100	3	475	107	1.90	4.99	50
Lignin and tannin	44	2	200	62	1.33	0.42	-
Sulfate	281	41	2758	538	4.16	19	500

Table 3 .Average values of physical, chemical and biological variables of different units in Ahvaz paper factory

	Final wastewater	Rater	Lime klin	Dehydration	Material preparation	Recovery	Chemical material	Machin3	Machin2	Machin1	Pulping2	Pulping1	Bagasse piling
Temperature	23	21	30	18	23	57	19	28	26	30	26	24	25
Acidity	8	5	10	7	6	10	13	7	6	6	10	9	7
Electrical conductivity	1200	560	340	740	840	1340	2800	1200	1090	900	2300	1310	730
Total Dissolved Solids	1630	838	380	1655	6611	650	10285	1084	1139	950	2253	2022	782
Total suspended solids	820	30	530	1348	694	18	213	1332	1185	1100	704	511	54
Alkalinity	343	76	60	143	24	380	5990	77	70	117	1057	720	174
Chlorine	178	0	40	220	110	46	135	192	165	172	197	322	46
COD	2452	2017	400	1945	957	658	20	1061	1255	1119	2291	2032	717
BOD	316	539	-	245	60	-	-	10	75	61	400	633	740
Turbidity	106	45	130	146	204	10	67	475	275	221	78	148	35
Lignin and tannin	97	450	0	38	9	60	8	0	0	2	140	150	34
Sulfate	472	42	41	115	375	181	2757	457	390	400	226	189	76

Factor Analysis

Factor analysis in order to determine the source of qualitative variables of wastewater indicated four factors with 78.87% of variance in different units (Tabel 4). Factors 1 to 4 have 43.00, 15.60, 10.70 and 9.50% variance respectively. In the first factor, the variables of suspended solids, turbidity, sulfate and chlorine, in the second factor, the variables of alkalinity, acidity, dissolved solids, in the third factor, the temperature variable, and in the fourth factor, the variables of BOD, COD, lignin-tannin had high correlations, respectively (Table 4 and Figure 2).

Table 4. Factor loadings of qualitative variables in Ahvaz paper wastewater by factor analysis

	Factor1	Factor2	Factor3	Factor4
Temperature	-0.14	-0.02	-0.79	0.12
Acidity	-0.13	0.86	-0.29	0.04
Electrical conductivity	0.05	0.36	-0.39	0.59
Total Dissolved Solids	0.39	0.72	0.43	0.16
Total suspended solids	0.92	0.11	-0.10	0.24
Alkalinity	0.26	0.88	0.01	0.22
Chlorine	0.77	0.14	0.13	0.14
COD	0.52	-0.14	0.08	0.78
BOD	0.34	0.14	0.14	0.81
Turbidity	0.91	-0.02	-0.04	0.26
Lignin and tannin	0.27	0.41	-0.04	0.74
Sulfate	0.78	0.26	0.00	0.39
Eigenvalue	0.59	2.03	1.39	1.23
Variance%	43.04	15.65	10.69	4.49
Cumulative varianc%	43.04	58.69	69.38	78.87

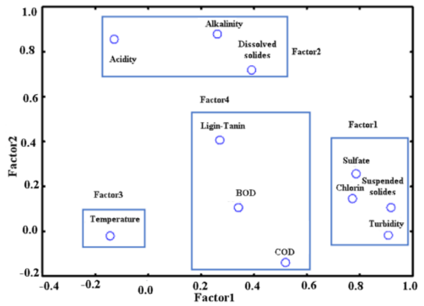

Fig 2. The effect of variables on the graph of factor 1 and factor 2

The amount of factor load is the criterion for choosing the main qualitative variables, which varies depending on the research conditions and the complexity and extent of the studied area. The absolute value of the factor load resulting from the implementation of strong, medium and weak factor analysis is greater than 0.75, 0.50 - 0.75 and smaller than 0.5, respectively (Li et al., 2015). Factor 1 deserves attention in units 20 (outlet of the chemical refinery of the recovery unit), unit 15 (machine 3), unit 13 (machine 1), unit 14 (machine 2) and unit 9 (additives preparation unit) (Figure 3). Examining the first factor in units with medium and high pollution shows the greater contribution of pollution variables in this factor, which is consistent with the results of Razmkhah et al., 2010 and Al-Badaii et al., 2013.

The recovery unit consists of five parts: water purification, evaporators, boilers, lime kiln, caustic, as well as the recovery of chemicals (caustic). The output of chemical treatment is alum and polyelectrolytes. The paper machine unit is also divided into five major parts: pulp preparation, machine, dryer, twister, cutting and packaging. In the wastewater of the paper machine unit, there were large amounts of very fine fibers, fillers and dyes, which is known as white water because of its color. Used water and other chemicals are mixed in the bottom part of the paper machine. Additives to paper, such as starch, calcium carbonate, are prepared in the additive part and transferred to the relevant tanks. The waste of pulp in the storage tanks of the machine and the presence of impurities and recycled materials in the wastewater of this unit lead to an increase in suspended matter and turbidity in the wastewater of these units. The average suspended solids in the wastewater of paper industries in Canada, Finland, Norway, France and the United States are 14.5, 15, 5, 10, 4 mg/L, respectively, and in Iran, equal to 480 mg/L has been reported, which shows a minimum difference in Iran. It is 12 times the standard level of EPA and Iran Environmental Protection Organization (APHA, 1995; Pokhrel and Viraraghavan, 2004). The use of soda in baking pulp and dyeing using sodium hypochlorite from the pulping unit to the machine is the reason for the increase in chlorine. The wastewater of the chemical production unit contains a large amount of alum (aluminum sulfate), which is associated with an increase in sulfate.

The second factor was observed in units 19 (wastewater of chemicals unit), unit 1 (final sewage channel), unit 16 (pulp 3). In the chemical unit, the chemicals used in baking operations are prepared. Chlorine gas capsules are discharged and in a process with a combination of chlorine gas and liquid caustic, water (sodium hypochlorite) is prepared for pulp dyeing and bleaching. In this unit, a substance called Hypo is made for decolorizing pulp, which consists of chlorine gas and 5% caustic. Carbonate materials, porcelain and lime in the wastewater increase pH and alkalinity. The use of caustic, brine, gum, starch, porcelain clay in the chemical preparation unit is by increasing the soluble solids in the wastewater of this unit. The use of cyanide and sulfuric acid for preservation and preliminary dyeing is the final acidification of the wastewater. The third factor plays an important role in units 23 (mixing of recovery wastewater and chemical treatment unit) and unit 21 (output of recovery unit evaporators). The temperature is high in the wastewater of two units of evaporators (effects) and recovery boiler.

The fourth factor is considerable in units 22 (mixing of wastewater from pulping units 1, recovery of chemical dilution and sometimes sanitary wastewater), unit 17 (intersection of wastewater of pulping units and machines and dry and wet pitting units), unit 16 (outlet of pulp 2), unit 26 (wastewater from bagasse warehouse), units 11 and 12 (outlet of pulp 1), units 1 and 2 (final wastewater channel), unit 25 (wastewater from bagasse core unit) and unit 18 (dewatering wastewater in pulping unit 2), respectively. The organic materials obtained from the units in question become BOD, COD and also lignin (Qazizadeh et al., 2015), in order to remove and reduce organic compounds in the final wastewater treatment, it is necessary to know the unit producing organic materials in Ahvaz paper factory (Cadet et al., 2007). The organic material producing units in the factory are follwing:

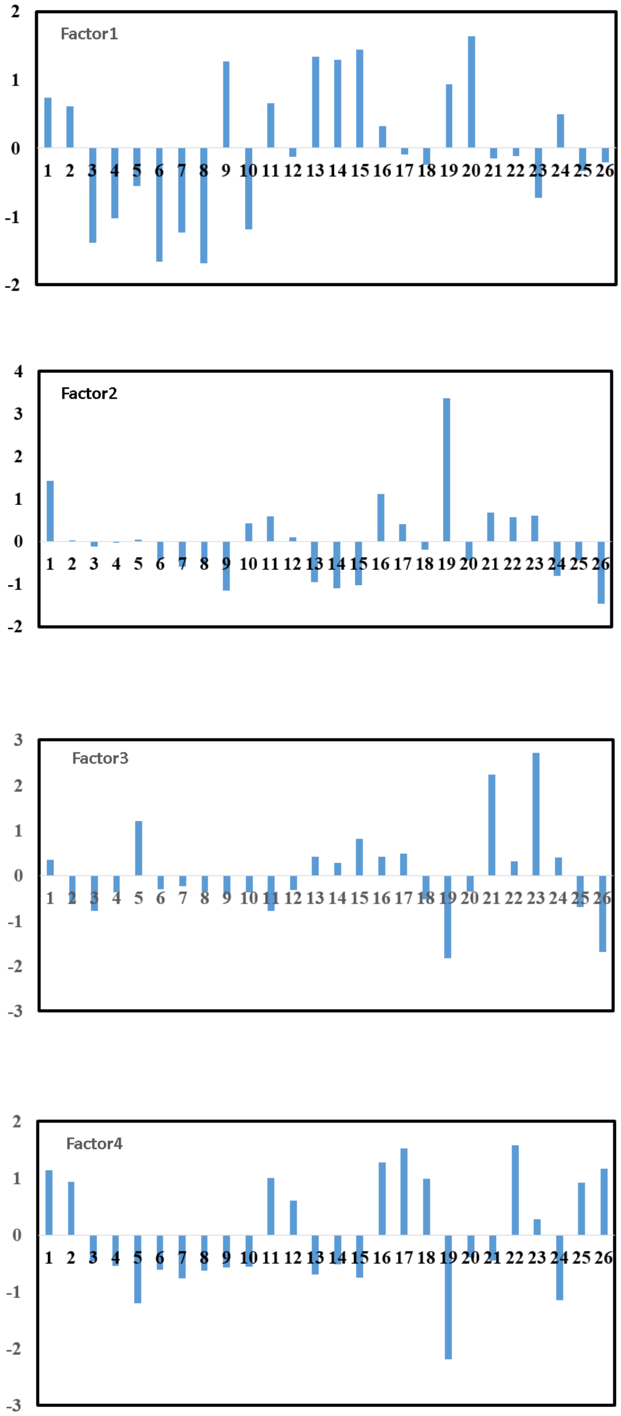

Fig. 3. Factor load value of different factors in 26 factory wastewater units

1) Bagasse preparation area: Transferring bagasse from Haft-Tepe Sugarcane Factory, carrying out the preparation stage and sending this material to the pulping part or the bagasse storage area are among the duties of this unit. After transferring the bagasse to the factory, the bagasse enters the bagasse kerning section or separation of useful fibers. After pulping, bagasse is mixed with water by a pulper and sent to pulp mills. It should be noted that during the exploitation seasons, the transfer is done by a pulper and in other seasons by a conveyor belt. On the other hand, the produced wastewater is discharged in a channel near the pulpers. Before delivering the de-pitted bagasse to the cooking pot, the bagasse is transferred to the dewatering or core removal systems. Here, the kernels remaining in the fibers are removed from the bagasse along with water. Then the useful fibers are guided to the cooking pot by the conveyor belt. This area produces a lot of sewage.

2) Bagasse storage: pulping operations are carried out throughout the year, while sugarcane harvesting takes six to seven months at most. During the harvesting season, the excess bagasse used by the pulp mills is sent to the bagasse storage area and stored in the four hills after de-seeding (pitting) along with water. Bagasse is flammable due to the presence of alcohol, so bagasse is constantly kept wet with water.

3) Pulping: Pulping consists of 2 units and each unit includes four parts of bagasse washing and dewatering, cooking, detergents and decolorization. In the washing and dewatering unit, after de-seeding and transferring the bagasse to the pulping units 1 and 2, bagasse is mixed with 3% water and sugar syrup is produced, which is washed along with the fibers and transported with a pump. After washing the bagasse and de-seeding, the useful fibers along with the water are directed to the pulp mills and the cooking pot by the pump. In this unit, a large amount of water is removed from the washed bagasse as wastewater before the bagasse enters the pulping section. In the cooking unit, the cooking device is a closed environment like a pressure cooker, where lignin is dissolved along with cellulose and fibers. The purpose of cooking is to convert the useful fibers of bagasse into pulp and to dissolve the lignin along with the fibers and finally the free fibers. In addition to bagasse, caustic soda (NaOH) 10% is used in the boiler. This stage is associated with the production of wastewater with a large amount of lignin (Rudi and Keshavarz, 2016). In the pulp washing unit and during the cooking stage, a black liquid (black liquor) is obtained, which contains organic compounds and mineral salts that must be separated from the pulp. (Mahmoudabadi, 2016). Wastewater from pulp washing (black liquid) is collected and sent to the recovery unit to recover chemicals (lignin and soda).

Caustic soda recycling and lignin burning is the goal of building a recovery unit and is a member of the wastewater treatment unit. When the recovery system has problems, the black liquor is transferred to the anaerobic lagoon. In the pulp sieving unit, sieves are used to purify the pulp in order to separate coarse fibers from the pulp. Coarse fibers and mineral grains separated from the pulp are discharged into the wastewater channel. In the pulp concentration unit, after the refining process, the pulp is sent to the thickeners and its concentration reaches 12%. In order to store the pulp, excess water is taken from the pulp and then it is stored. The water taken from the pulp is directed to the sewage system. In the bleaching or decolorization unit, brown pulp is decolorized and whitened in three stages using chlorine gas, caustic soda, and sodium hypochlorite. The wastewater created at this stage is highly toxic. After these steps, white pulp is stored in white pulp tanks to be sent to paper machines.

Industrial Towns Organization of Iran (1390) not complying with the permissible limits of wastewater discharge in the main and producing industries with COD value above 2000 mg/L, BOD above 1000 mg/L and suspended solids amount above 300 mg/L is mentioned as one of the most important problems of disturbance in the process of recovery and purification in industrial towns. The average BOD standard of discharged wastewater in developed countries is between 41.2 and 41 mg/L compared to Iran, which is 300-700 mg/L, and is 11 times higher than the standard for discharge into water (Pokhrel and Viraraghavan, 2004).

Conclusion

Ahvaz factory pollutes the environment by producing a large amount of industrial wastewater containing organic and chemical load of organic chlorine compounds and discharging into Dez River and finally Karun River as a result of worn-out equipment and old technology. Paper factory enters wastewater on average 65,000 m^3/day to the Dez River. The daily load entering the Karun River is 159,380 kg with a COD of about 2452 mg/L. The values of the physical and chemical variables of the factory wastewater are higher than the agricultural standards in all cases. The color of the wastewater is dark and brown in different conditions and has a foamy appearance. The acidity of the wastewater is more alkaline and the COD of the wastewater is 16 times higher than the agricultural standards. Wastewater turbidity is high due to the release of dissolved and suspended solids additives resulting from the washing, decolorizing and pulping process. The results of the analysis of the samples indicate the spatial changes of the pollutant variables, and the pulping and chemical preparation units have very high levels of pollution. Therefore, it is necessary to install industrial wastewater treatment plants to treat Ahvas Factory's wastewater.

References

Adhikari, J.R. Lohani, S.P., 2019. Design, installation, operation and experimentation of septic tank – UASB wastewater treatment system, Renewable Energy, 143: 1406-1415.

Al-Badaii, F., Shuhaimi-Othman, M., Gasim, M.B., 2013.Water quality assessment of the Semenyih river, Selangor, Malaysia. Journal of Chemistry, 1-10.

Ammary, B.Y., 2004. Nutrients requirements in biological industrial wastewater treatment", Water and Environmental Engineering Department, African Journal of Biotechnology 3 (4): 236-238.

APHA, WPCF, AWWA., 1995. Standard methods for the examination of water and wastewater." APHA NWT, 19th ed. 2-56,2-57-4-65,4-70,5-1,5-10,9-45,9-53.

Babaei, F., Foursquare Amin, H., Farajpour, A., Maleki, A., 2011. Characteristics of the Paper Evaluation of Quantitative and Qualitative Characteristics of Industrial Wastewater of Cellulose and Pulp Industries and Different Methods of Purification, Second Specialized Conference on Environmental Engineering,Tehran University,Iran. https://www.civilica.com/Paper-CEE02-CEE02-581.html. (In Persian)

Cadet, C., N. Lucas, J.F., Beteau, A., Guillet, M., 2007. Aurousseau and N. Simonin. Modelling of wastewater treatment of a pulp and paper mill for monitoring. Environmental. Engineering and Management Journal. 2(3), 163-174.

El-Naas, M.H., Surkatti, R., Al-Zuhair, S., 2016. Petroleum refinery wastewater treatment: A pilot scale study, Journal of Water Process Engineering, 14: 71-76.

Franta, J.R., Wilderer P.A., 1997. Biological treatment of papermill wastewater by sequencing batch reactor technology to reduce residual organics, Water Science and Technology, 35(1): 129-136.

Ghahramani, P., Hejazi, S., Shirazi, M. And Taghavi, S., 2014. New Approaches to Pollution and Sewage Pollution in Pulp and Paper Factory, Second National Conference on Architecture, Restoration, Urban Development and Environment-Sustainable Development, Hamadan Faculty of Martyr Muftah, https://www.civilica.com/Paper-ARUES02-ARUES02_108.html (In Persian)

Ghazizadeh, Sh., Kardar, Sh. And Alipour, P., 2015.Quantitative and Qualitative Assessment of Waste Paper Recycling Factories, Case Study of Kahrizak Paper Mill, National Conference on Water, Wastewater and Waste, https://www.civilica.com/Paper-PASAB06-PASAB06_024.html. (In Persian)

Industrial Towns Organization of Iran., 1390. Law and Regulations of Small Industries and Industrial Towns Organization of Iran and Subsidiaries, Published by Industrial Towns Organization of Iran, 121-122. (In Persian)

Jafari, A., 2000. Study and study of industrial wastewater treatment plant of paper factory and presenting a solution for its optimization", Tarbiat Moallem University, Tehran, Faculty of Engineering. (In Persian)

Khodadadi, F., 2015. A Review on Wastewater Treatment Methods for Pulp and Paper Industries Based on Biological Methods and Membrane Filtration, National Conference on Environmental Engineering and Management, Tehran, Mazandaran Environmental Research Center, https://www.civilica.com/Paper-EEMCONF01-EEMCONF01_047.html (in Persian)

Li, D., Huang, D., Gue, C., Gue. X., 2015. Multivariate statistical analysis of temporal-spatial variations in water quality of a construces wetland purification system in a typical park in Beijing, China." Environmental monitoring and assessment, 187(1): 1-14.

Mahmoodabadi, M., 2016. Determination of Pollution Indices for the Design of Wastewater Refinery Systems of Small Communities; Case Study villages around Zarand, Kerman Province,Journal of Irrigation Iran Water 6(4):138-152. (In Persian)

Phuong, N., Tien,T., Hoa,P., Van Nam,T., Le Luu,T., 2018.Treatment of cake shop wastewater by pilot-scale Submerged Membrane Bioreactor (SMBR), Bioresource Technology Reports, 4: 101-105.

Pokhrel, D., Viraraghavan T., 2004. Treatment of pulp and paper mill wastewater-a review. Science of the Total Environment, 333:37–58.

Razmkhah, H., Abrishamchi A., Torkkian, A., 2010. Evaluation of spatial and temporal variation in water quality by pattern recognition techniques: A case study on Jajrood River (Tehran, Iran). Journal of Environmental Management, 91: 52-860.

Rudy, H. And Keshavarz, R., 2016. Environmental Concerns with the Effluent of the Dough and Paper Industry", 3rd International Conference on Green Economy, Babolsar, Taroud-e-North Industrial Research Company,https://www.civilica.com/Paper-GETOROUD03-GETOROUD03_070.html. (In Persian)

Samriyeh, A., 2009. Chemical analysis of bagasse used by pars paper factory, National Conference on Chemical Engineering, Islamshahr, Islamic Azad University, Islamshahr Branch,https://www.civilica.com/Paper-NCCEESLAMSHAR01-NCCEESLAMSHAR01_122.html. (In Persian)

Sharikhani, M., Ghadimi, F., Hajati, A., 21019a. Investigation of the impact of bagasse on water resources pollution of Haft Tapeh paper factory, Fourth International Congress on Agricultural Development, Natural Resources and Environment in Iran, Tabriz, https://www.civilica.com/Paper-ICSDA04-ICSDA04_1144.html. (In Persian)

Sarykhani, M., Ghadimi, F., Hajati, A., 2019b. Evaluation and Analysis of Current and Modern Solutions for Water Treatment of Urban and Industrial Wastewater, 4th International Conference on Modern Research in Civil, Architecture, Urban Management and Environment, Karaj, Iran,https://www.civilica.com/Paper-ENGIN04-ENGIN04_020.html. (In Persian)

Sarikhani, M., Hajati, A., Ghadimi, F., 2019c. Quantitative and qualitative evaluation of pasteurizing plant wastewater Case study of Haft-Tapeh paper mill, 4th International Conference on Modern Research in Civil, Architecture, Urban and Environmental

Management, Karaj, Iran. https://www.civilica.com/Paper-ENGIN04-ENGIN04_021.html. (In Persian)

Shen,L., Wang,W., Li,T., Cui,Y., Wang,B., Yu,G., Wang,X., Wei,D., Xiao,J., Deng, Sh.,2019. Powdered activated coke for COD removal in the advanced treatment of mixed chemical wastewaters and regeneration by Fenton oxidation, Chemical Engineering Journal, 371: 631-638.

Takedestan, A., Kurdani, M., Jenadale, H. And Hosseini Panah, A., 2015.Quantitative and Qualitative Characteristics of Waste Paper, Paper pulp and Management Solutions for its Pollutants Removal, International Conference on Environment,https://www.civilica.com/Paper-CESET01-CESET01-172.html. (In Persian)

TOULAINEJAD, M., MAKVANDI, A., MOHAMMADPOUR ZANGANEH,GH., LAVAFIAN NEJAD, B., 2010. AN OVERVIEW ON THE STATUS OF WATER RESOURCES AND CONSUMPTION IN KHUZESTAN PROVINCE, SECOND NATIONAL WATER CONFERENCE, BEHBAHAN, ISLAMIC AZAD UNIVVERSITY, HTTPS://WWW.CIVILICA.COM/PAPER-WATER02-WATER02_092.HTML. (IN PERSIAN)

Woodard, F., 2001. Industrial Waste Treatment Handbook, Butterworth-Heinemann, USA.

Yang, B., Xu, H., Yang, Sh., Bi, Sh., Li, F., Shen, Ch., Maa, Ch., Tian,Q., Liu, J., Song, X., Sand,W., Liu,Y., 2018. Treatment of industrial dyeing wastewater with a pilot-scale strengthened circulation anaerobic reactor, Bioresource Technology, 264: 154-162.

Zheng, D., Cai, W., Wang, T., Qin, L., Zhang Z., Ren, X., Li, J., Yanga, Z., 2015. Pilot-scale integrated membrane system for the treatment of acrylonitrile wastewater, Desalination, 357(2): 215-224.