Alexandria Engineering Journal

Gelatin industry wastewater treatment

Hamdy Seif
Sanitary Eng., Dept., Faculty of Eng., Alexandria University, Alexandria, Egypt

El-Nasr Tanning Company is one of the affiliated companies of the chemical industries as holding company. This research was completed to serve the project is to be implemented at the Gelatin Factory in Alexandria to treat the wastewater discharge into the sewerage system. A treatability study of gelatin wastewater using bio-chemical treatment method by primary sedimentation adding poly electrolytes polymers as a coagulant at pH (7.5 – 8.5), followed by extended aeration and final settling and then finally filtration gave a good results . COD decreased from 2614 to 350 ppm, BOD decrease from 1345 to 206 and SS decreased from 2023 to 0 ppm. The characteristics of the treated wastewater could be recycled in the same industry and satisfying the Egyptian law 93/1962 and 44/2000 requirements.

تم هذا البحث على المخلفات السائله الناتجه من صناعة الجيلاتين لدراسة قابلية هذا النوع من المخلفات للمعالجه البيولوجيه بنظام التهويه المطوله, ويتكون الجهاز المعملى من وحدة ضبط الـ pH بتخفيضها من ١٢،٢٠ الى ٨،٠٠ واضافة البوليمر(بولى اليكتروليت) كمروب. ثم تجهيز وحدة المعالجه البيولوجيه بمستحضر مماثل لمخلفات الجيلاتين وتلقيحه ببكتريا من وحدة تخمير وبعد انتظام الوحده فى المعالجه تم تشغيلها بالمخلفات السائله الحقيقيه من المصنع على مدى ٤٥ يوما بمدة مكث ثابته عند ١٦ ساعه فى درجة حرارة المعمل. وتم قياس تركيز كل من القياسات التاليه بشكل منتظم: TSS, TDS, BOD5, COD, oil and grease, NH3, Cl, SO4, Cr, and P2O5. وكانت النتائج ازالة المواد العالقه والزيوت والشحوم بنسبة ١٠٠% وبنسبة حوالى ٨٥% لكل من BOD5, COD وازالة كل من NH3, P2O بنسب ٥٩،٣% و ٨٨،١% على التوالى. واوضحت النتائج ان جميع القياسات تلبى مانصت عليه القوانين ٩٣ لسنة ١٩٦٣ و ٤٤ لسنة ٢٠٠٠ فيما يتعلق بمعالجة الصرف الصناعى, علاوه على ان خواص المياه الناتجه يجعل من الممكن اعادة استخدامها فى نفس الموقع مما ينتج عنه عائد استثمارى من توفير استهلاك المياه.

Keywords: Gelatin wastewater, Neutralization, Polyelectrolyte polymers, Biological treatment, Fine filtration

1. Introduction

Applied microbiology techniques are used in wastewater treatment plants to improve the biodegradation processes that occur in the environment [1]. In this case, these techniques were used to adjust the biochemical processes of a wastewater treatment plant of a gelatin industry, which has a biological treatment. The main features of the effluent from gelatin industries are the high organic load, sulfides and fatty material in reasonable amounts. Gelatin is a colloidal protein, obtained from collagen purification, main compound of the skin, bones and tissues taken from slaughtered animals. Well- known for its adhesive, protector and coagulant properties [2]. The gelatin industry has experienced high growth in recent years. As an aftermath the wastewater generation rate increased to a level higher than the wastewater treatment plant facilities. So the treatment efficiency decreased. The new techniques were based on the analytical monitoring, through microbiological and physical-chemical analysis. Thus developing of different phases in the same process was essential to grow aerobic or anaerobic microorganisms to icrease the removal efficiency of the process [3-4].

The influence of temperature and pH on the acidification of a synthetic gelatin based wastewater was investigated [5]. Gelatin degradation efficiency and rate, degree of acidification, and formation rate of volatile fatty acids and alcohols, all slightly increased with temperature. The effect of increasing pH on the treatability of gelatin wastewater was studied to find that gelatin degradation efficiency substantially increased from 60.0% to 97.5% with increasing pH from 4.0 to 7.0. The degree of acidification increased from 32.0% at pH 4.0 to 71.6% at pH 6.5, but dropped to 66.8% when pH increased to 7.0.

The optimum pH for the overall acidogenic activity was found close to 5.9, the optimum pH calculated using a semi-empirical model. The region between pH 5.0 and 6.0 was the transition zone [5-6]. On the other hand studying the effect of decreasing pH was not studied. The aim of this work is to investigate the treatability of gelatin wastewater containing sucrose as carbohydrate and gelatin as proteins in bench scale reactor . The focus is mainly on the evaluation of the substrate utilization and pH evolution with different parameters at mesophilic temperature in a lab-scale bioreactor.

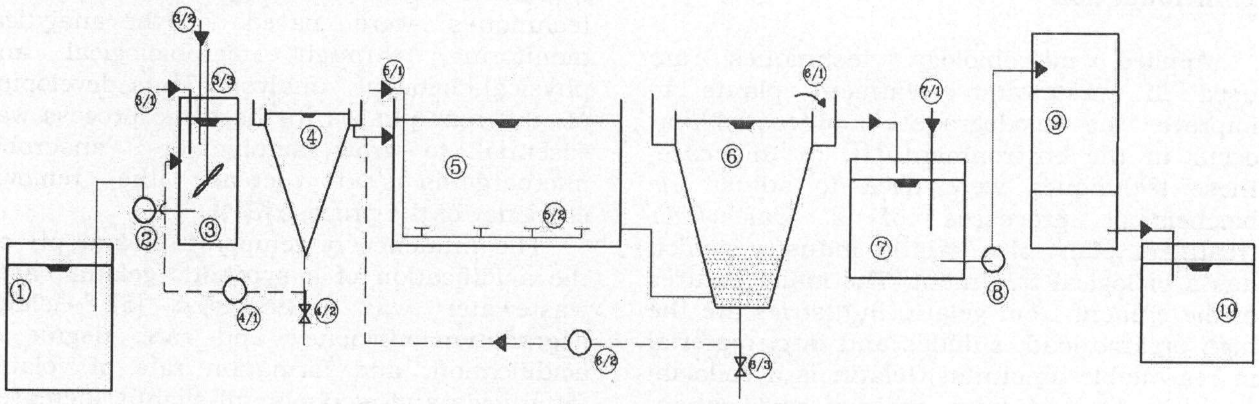
2. Materials and methods

The project is to be implemented at the Gelatin Factory in Alexandria (El-Nasr Tanning Company) to treat the wastewater discharge of this factory. Lab-scale aerobic reactor was used to carry out the experiments. Different wastewater samples was collected regularly from Gelatin factory at different dates, 100 liters each time from that Company. The analysis of samples were recorded before starting the treatability study. The steps of bench scale of this treatability study is shown in fig. 1. The physical and chemical parameters analyzed were: Settleable solids, pH, TSS, TDS, BOD5, COD, oil and grease, NH3, Cl, SO4, Cr, and P2O5. The chemical oxygen demand (COD) was measured according to the HACH potassium dichromate method approved by USEPA (Cat. 21259-15, 0-3000 ppm). The pH was measured using a digital pH meter (Horiba D-12). The other parameters were measured according to standard methods for examination of water and wastewater, 20th eddition [8].

3. Experimental protocol

Neutralization by sulphuric acid to reduce pH from 12.2 to 8.0 was the first stage of this study, followed by coagulation with polyelectrolyte polymer. Primary settler was used to collect the settleables before the biological unit. Then the start-up of the treatability study was the next stage using a soluble substrate based on glucose and acetate.

Bioreactor was fed with a mixture of gelatin and sucrose . The feed input, the effluent discharge, and the recycle suction point were also placed. The operation temperature was the ambient temperature which was in the range of 15-30C throughout this study.



1-Feed tank. 2-Feeding Pump. 3-PH adjustment, 3/1-Neutralization, 3/2-Coagulation.
4-Settler, 4/1-pump, 4/2-Excess of sediments.
5-Biological Reactor 5/1-Air tube 5/2-Areation system (diffusers)
6-Settler 6/1-Outlet weir, 6/2-pump (recycling), 6/3-Excess sludge
7-Treated wastewater, 7/1-Disinfection.
8-Pump for filters. 9-Fine filter. 10-Treated water to be reused.

Fig. 1. Schematic diagram of bench scale set-up.

Fractions of both solid and liquid phases taken from an industrial reactor processing gelatin-rich wastewater were used for inoculation of reactor. The substrate consisted initially of a mixture of milk powder, acetate and glucose (10%, 20% and 70% of the total COD, respectively) plus 0.1 g L-1 of NH4Cl and 0.66 g L-1 of NaHCO3, in order to provide the micro and macro-nutrients and adequate environmental conditions for microbial growth. The bioreactor start-up procedure consisted of stepped increases in COD loading rate. The Organic Loading Rate (OLR) was gradually increased from 500 to 3000 mg COD/L/d along a 45 days experimentation period. The feed flow rate was kept constant at 4 L /d for retention time of about 24 houres. Finally, the feed flow rates increased to 6.0 L/d, keeping the same range of inlet concentration for fixed retention time of about 16 houres.

During this acclimatization stage, the influent COD concentration was increased from 0.50 to 3.00 g L-1 containing around 5% of insoluble substrates. After acclimatization stage, when 85% total COD removal efficiencies was reached, the feed was replaced gradually by using actual wastewater was trasefered from the company weekly throughout the research time for about one and half month. Sodium hypoclorite was used as adisinfectant before filtration to protect the fine filter from biomass growing and then colging.

4. Results and discussion

When the treatability study worked as an aerobic reactor, simulating an extended aeration system, the DO rates was increased from 4.5 mg/L by aeration and mainained rest of the time at saturated level according to the ambient temperature as showen in table 1, according standard of DO saturation [6].

The results of analysis of influent and effluent are showing in table 2. Influent COD and BOD concentrations varied in the range of (2105-2730mg/L) and (1241-1611mg/L) respictively with ratio of (1.7: 1.00) in average. The COD and BOD concentrations in the influent and effluent are illustrated in figs. 2 and 3. The COD concentration decreased from 2730 to 410mg/L and BOD decreased from 1611 to 241mg/L with average removal efficiency of 85% for both.

Table 1
Saturated DO related to the ambient temperature

T (C°)	DO(mg/L)	T (C°)	DO(mg/L)
15	10.2	25	8.4
16	10.0	26	8.2
17	9.7	27	8.1
18	9.5	28	7.9
19	9.4	29	7.8
20	9.2	30	7.6
21	9.0	31	7.5
22	8.8	32	7.4
23	8.7	33	7.3
24	8.5	34	7.2

Fig. 4 shows that the TDS concentration decreased from 2274 to 1972 mg/L, TSS and oil&grease were removed completely because of using filteration after settling. Fig. 5 shows that decreasing the concentration of NH3 was from 49.22 to 5.85mg/L with removal of 88.1% while CL decreased only from 472 to 444mg/L.

The concentration of SO4 increased in the effluent because H2SO4 was used with raw wastewater to decrease the pH from about 12.20 to be about 8.00.

Also as shown in fig. 5 concentration of P2O5 decreased from 1.4 to 0.57mg/L with removal of 59.3%.

The treatment efficiency was calculated comparing the analytical results obtained at inlet of the biological unit and outlet of secondary setller in terms of BOD5 and COD or any other parameter in table of analyses, as expressed by the following equation and results are shown in table 3:

Eff(%) = [(X – X0)/X0] x 100 ....Where:

Eff = treatment efficiency [%]

X = Analyzed Parameter – output value (effluent) [mg/L]

X0 = Analyzed Parameter – input value (influent) [mg/L]

The quality of final treated wastewater was obtained are recommended to recycle the

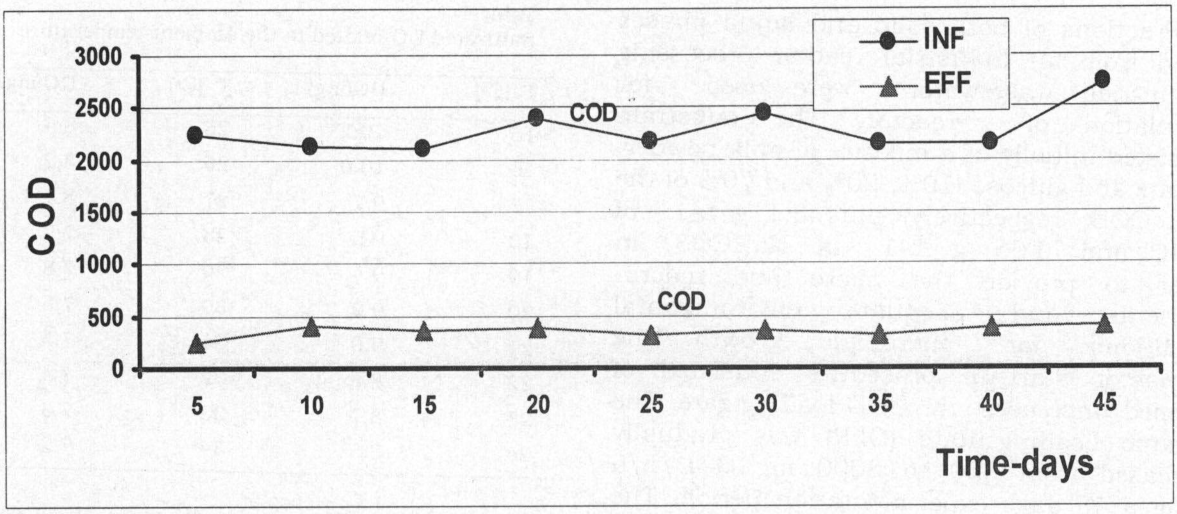


Fig. 2. Concentration of COD in influent and effluent compared with law limits.

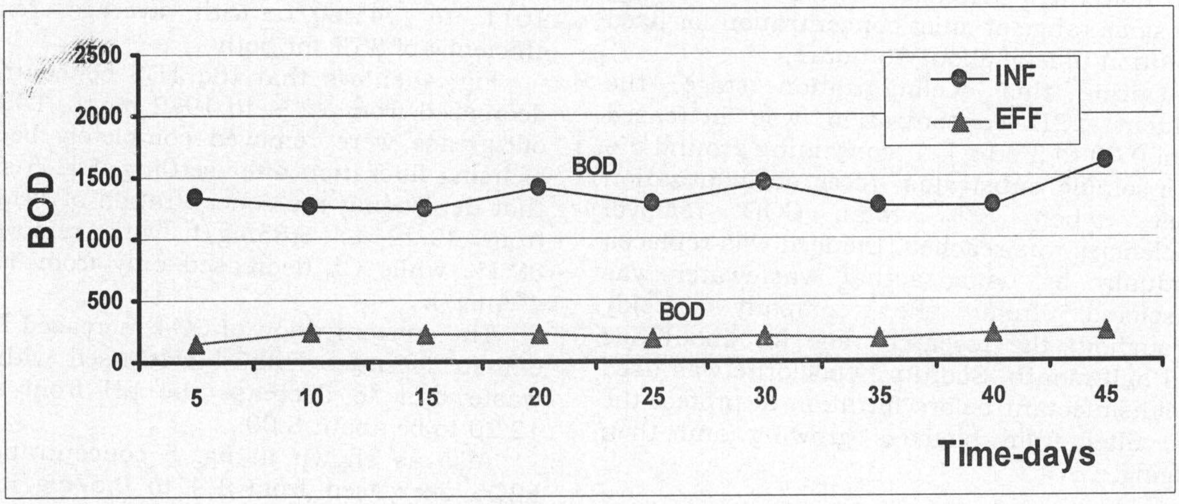


Fig. 3. Concentration of BOD in influent and effluent compared with law limits.

wastewater after treatment to be reused in the same industrial processes to safe about 80 % of the coasts of water bill.

5. Conclusions

1. This research was conducted on the development of applicable method of gelatin wastewater treatment of satisfy Law 93/1962.
2. The bio-chemical treatment under aerobic conditions in combination with the use of filtration a significant results for different parameters.
3. SS and O and G were removed completely.
4. BOD, COD, NH3 and P2O5 removal efficiency were 84.6 %, 84.6 %, 88.10% and 59.3 % respectively.
5. Using Bio-chemical method followed by filtration is essential to get treated gelatin wastewater to be reused.
6. The quality of final treated wastewater was obtained are recommended to be reused in the same industrial processes to safe about 80 % of the coasts of water bill.

Table 2
Influent and effluent values of different parameters

Parameters		Inf=Analysis of raw wastewater before adjustment of pH									Aver
Sample duration days		5	10	15	20	25	30	35	40	45	
PH	Inf	12.31	12.5	12.2	11.9	12.8	12.1	11.5	11.8	12.4	12.16
	Eff	7.9	8.1	8	7.7	8	8.1	8	8.2	8.3	8.03
Settled solid (10 min)	Inf	16.9	14.1	11.8	9.2	15.3	12.8	10.1	7.2	12.1	12.16
	Eff	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Settled solid (30 min)	Inf	19.2	16.3	14.1	13.1	18.8	18.9	15.4	9.8	19.3	16.1
	Eff	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
T.D.S. mg/L	In	2950	1958	2150	2110	2580	2980	2115	1950	2180	2274
	Eff	2100	1850	1950	1980	2000	2100	1990	1800	1980	1972
T.S.S. mg/L	Inf	1880	1900	1950	2000	2100	2300	1980	2030	2100	2023
	Eff	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
BOD_5 mg/L	Inf	1611	1268	1263	1446	1286	1416	1241	1251	1327	1345
	Eff	241	224	182	212	184	218	217	232	147.5	206
COD mg/L	Inf	2730	2150	2142	2450	2180	2400	2105	2121	2250	2280
	Eff	410	380	310	360	312	370	369	394	250	350
O&G mg/L	Inf	134	125	119	130	128	111	95	120	118	120
	Eff	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
NH_3 mg/L	Inf	45	58	46	41	56	59	48	41	49	49.22
	Eff	6	7	6	8	7.1	3.9	4	5.1	5.6	5.85
CL mg/L	Inf	450	430	475	435	480	418	510	460	595	472
	Eff	458	450	470	428	412	430	510	420	418	444
SO_4 mg/L	Inf	94	82	68	75	84	59	64	58	71	72.77
	Eff	150	185	160	145	157	131	128	125	127	145
Cr mg/L	Inf	0.01	0.01	N.D	N.D	0.011	0.02	N.D	0.01	0.01	0.008
	Eff	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
P_2O_5 mg/L	Inf	1.5	1.5	1.1	1.2	1.3	1.5	2	1.3	1.2	1.4
	Eff	0.7	0.6	0.5	0.5	0.3	0.5	0.6	0.8	0.7	0.57

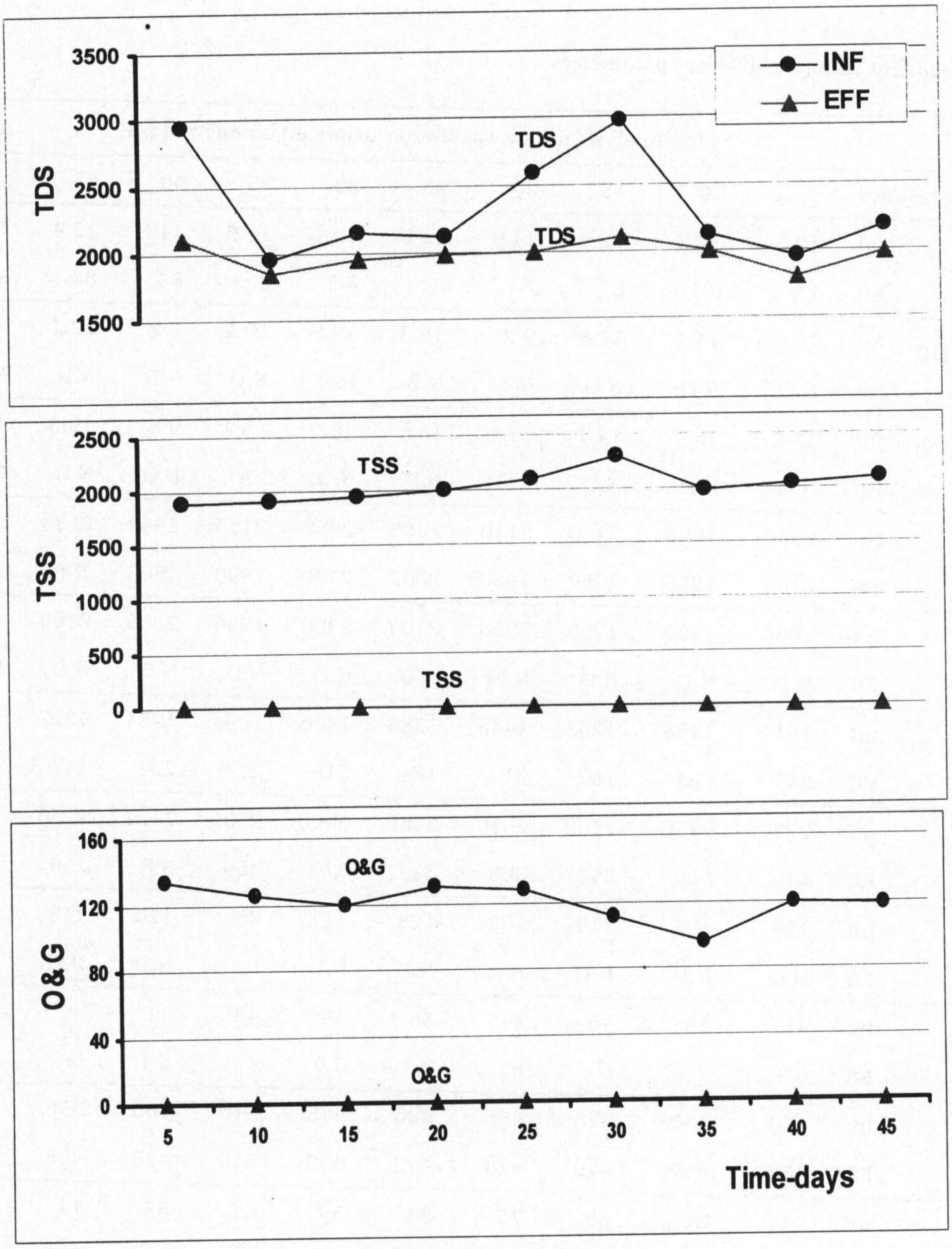


Fig. 4. Influent and Effluent concentrations.

Table 3
Average concentration of influent and effluent and removal efficiency %

Parameters	Average of influent	Average of effluent	Removal efficiency %
T.D.S. (mg/L)	2274	1972	5.1
T.S.S. (mg/L)	2023	N.D	100
BOD_5 (mg/L)	1345	206	84.6
COD (mg/L)	2280	350	84.6
O &G (mg/L)	120	N.D	100
NH_3 (mg/L)	49.22	5.85	88.1
P_2O_5 (mg/L)	1.4	0.57	59.3

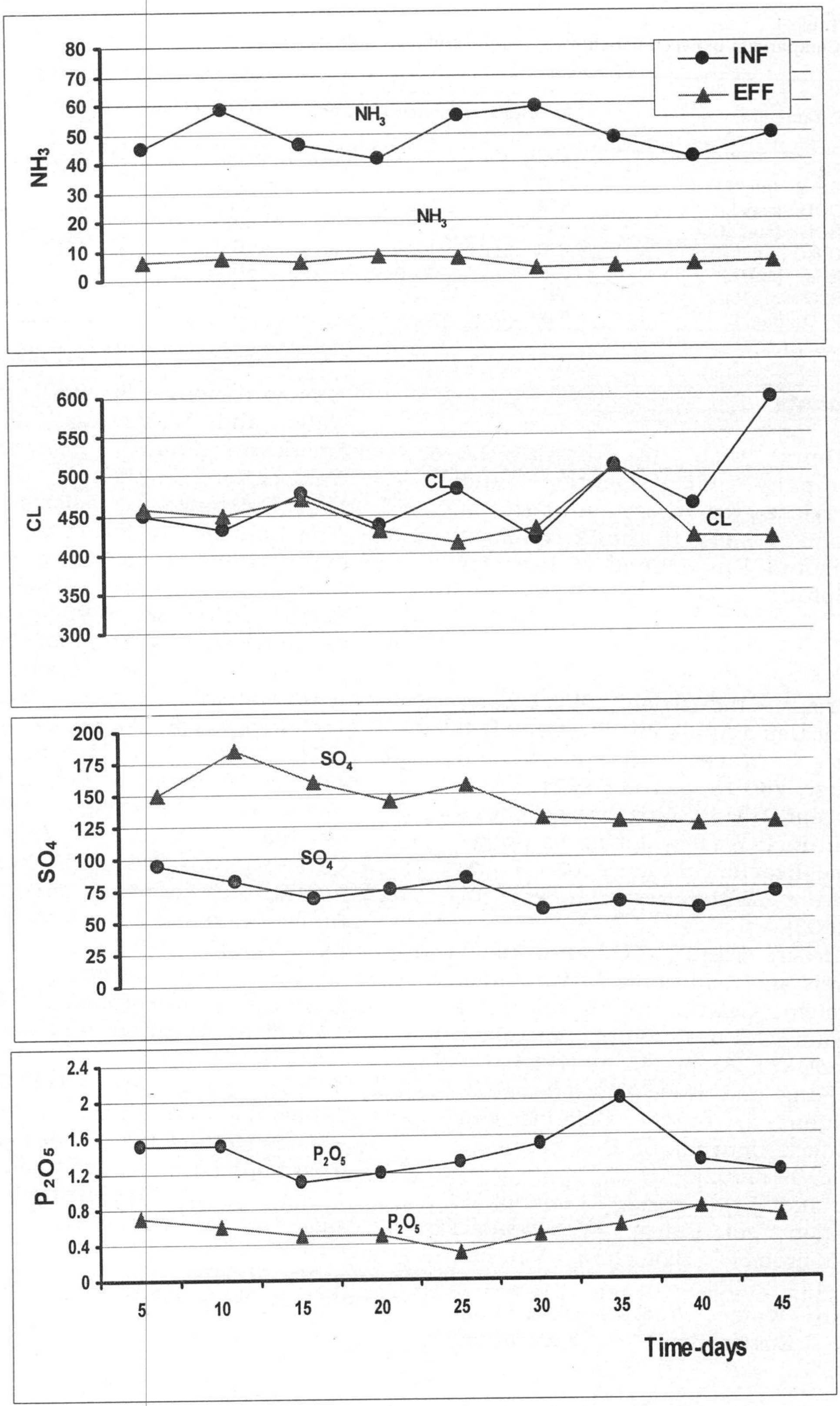


Fig. 5. Influent and effluent concentrations of NH_3, CL, SO_4, and P_2O_4 mg/L.

Table 4
Comparison between bench scale results and allowable limits by law

Parameters	Results from bench scale exp.	Allowable limits by law
pH	6-9.5	8.03
T.S.S. (mg/L)	N.D	<800
COD (mg/L)	350	<1100
BOD_5 (mg/L)	206	<600
O &G (mg/L)	N.D	<100
NH_3 (mg/L)	0.3	<100
S2O4 (mg/L)	145	<400
P_2O_5 (mg/L)	5.8	<25

Acknowledgments

The authors wish to thank the Chemix company for scientific and industrial services for there support of this study, and wishes to thank chimest Samir Rafaeil and Eng Moheb Malak for the there helpful.

References

[1] J. Jeris, "Industrial Wastewater Treatment Using Anaerobic Fluidised Bed Reactors". Water Science and Technology, Vol. 15, p. 169 (1983).

[2] H.Q. Yu and H.H.P. Fang, "Acidogenesis of Gelatin-Rich Wastewater in an Upflow Anaerobic Reactor Influence of pH and Temperature". Water Research, Vol. 37, p. 55, (2003).

[3] A.M. Breure and J.G.Van Andel, "Hydrolysis and Acidogenic Fermentation of a Protein, Gelatin, in an Anaerobic Continuous Culture". Appl. Microbiol. Biotechnol, Vol. 20, pp. 45–49 (1984).

[4] H.H.P. Fang and H.Q. Yu, "Mesophilic Acidification of Gelatinaceous Wastewater". Journal of Biotechnology, Vol. 93, p. 99 (2002).

[5] H.Q. Yu and H.H.P. Fang, "Thermophilic Acidification of Dairy Wastewater". Appl. Microbiol. Biotechnol, Vol. 54, pp. 439–444 (2000).

[6] American Water Works Association, Water Environment Federation: "Standard method for the Examination of Water and Wastewatet", 20th edition American Public HealthAssociation, Washington DC (2000).

[7] D.J. Batstone, J. Keller, L. Blackall, "The Influence of Substrate Kinetics on the Microbial Community Structure in Granular Anaerobic Biomass". Water Research, Vol. 38, 1390 (2004).

[8] G. Lettinga, L.W. Hulshoff Pol, "UASB-Process Design for Various Types of Wastewaters". Water Science and Technology, Vol. 24, pp. 87–107(1991).

[9] A.M. Breure, K.A. Mooijman, J.g. Van Andel, "Protein Degradation in Anaerobic Digestion: Influence of Volatile Fatty Acids and Carbohydrates on Hydrolysis and Acidogenic Fermentation of Gelatin". Appl. Microbiol. Bio-technol, Vol. 24, pp. 426–431 (1986).

[10] George Techobanoglous, L. Franklin Burton, "Wastewater Engineering Treatment Disposal and Reuse", third Edition (1991).

[11] H.H.P. Fang and D.W.C. Chung, "Anaerobic Treatment of Proteinaceous Wastewater Under Mesophilic and Thermophilic Conditions". Water Science and Technology. Vol. 40, pp. 77–84 (1999).

Received May 7, 2007
Accepted September 2, 2007