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Pilot-plant Testing of a CEPT System Application for the Largest Industrial Complex in Iran

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Abstract: In this study, the technological strategies for discharging the industrial complex waste into the MWTP have been reviewed. There are more than 200 industrial complexes in Iran and among these, Toos Industrial Complex of Mashhad City at the north part of the Country is one of the largest and is also considered to be the most active one. Nearly all types of industries have been gathered and put into operation at this Complex (totally 488 industrial plants, 154 of which are now under operation). According to the results, the mean volume of the industrial wastewater produced and the overall conversion factor were determined to be 2691.8 m^3d^{-1} and 73%, respectively. The study has continued after organizing a pilot plant in the vicinity of the complex for accomplishing the centralized pretreatment of the wastes with the aid of various chemicals (lime and FeO_3). Inspecting the work of the pilot plant has revealed that the removal rates of pollutants were 27 to 53% for BODS' 25 to 59% for COD and 46 to 94% for TSS. These removal levels were enough to make the remained load of industrial wastes qualified for discharge into MWTP. The final conclusion was that all the problems could be solved by taking advantage of CEPT for Toos industrial wastewaters.

Key words: Industrial wastewater, MWTP (municipal wastewater treatment plant), joint treatment, CEPT (chemically-enhanced primary treatment)

INTRODUCTION

The objective of every wastewater pretreatment program is proper management of industrial wastewater in such a way that the required regulations are respected and the most cost-effective options are adopted. The key factors for this management are[1-3]:

1-in plant control 2-water conservation and recycling, 3-safety considerations, 4-expenditure analysis and 5-pretreatment regulations.

Pretreatment is often necessary before industrial wastewater discharge into the MWTP and nearly all industries are urged to comply with local or national standards of pretreatment otherwise they introduce contaminants into the sewers which may damage the networks or inhibit the treatment processes in MWTPs. In recent decades the pretreatment regulations have become more restrictive[4-6].

Industrial wastewater pretreatment may be accomplished by various operations and processes and selection of any option is dependant on wastewater characteristics, regulations and variations incidental to industrial production. Especially of more significance a sound pretreatment program has the following objectives[1,7,8]:

1. Controlling contaminants discharge into sewers in such amounts that they can not produce adverse effects on MWTP and residual sludge utilization.
2. Controlling contaminants that can pass unchanged and/or producing incompatibility in treatment train.
3. Improving conditions for combined treatment of industrial and municipal wastewaters, reclamation and reuse of total effluents.

Chemically enhanced primary treatment (CEPT) is a single-stage pretreatment process that would result in a high level of contaminants removal and would thereby produce an effluent that would have no adverse effect on MWTPs[9-11].

While it is true that many cities lack sewerage system, some urban areas in Iran have extensive systems which are often overloaded by industrial wastes discharges that can cause shock loads in MWTP as well. But upgrading

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these existing facilities often costs too much. By centralized waste treatment trials all the obstructive industrial plants have been gathered from some of these cities and located in adjacent areas called industrial complexes. Again, the wastewater discharges from these complexes have created many problems for sewerage systems and MWTPs. Time has come to seriously consider the pretreatment of industrial wastewaters wherever the joint treatment of industrial and municipal wastes has to be continued. Therefore the study aims to test CEPT as a process for pre-treating the wastewater of a typical industrial complex in Iran.

MATERIALS AND METHODS

For this study, Toos Industrial Complex of Mashhad City which is one of the largest complexes in Iran has been chosen and the established plants of this Complex have been examined for determination of quantity and quality of wastes produced in both quality and quantity.

Toos Industrial Complex is located in 18 km of Cento Road (Mashhad-Ghoochan Road). Establishment of this Complex had been conducted for gathering the dispersed industrial plants in a unique position parallel to Cento-Road, thereupon the development of urban areas became possible without further contact to industry and its pollution.

Wastewater flow has been measured by applying different procedures described in literature and for each plant the more appropriate of them has been chosen.

The major uses of industrial water consumption are process water, landscape irrigation, cleansing and drinking. By specifying these fractions, total wastewater flow of an industrial plant can be determined after considering water loss and defining the water conservation factors. In this respect, the wastewater originated from any industrial process can be determined using the following statement:

Process wastewater = Water consumed for processing-Water loss

Table 1 shows the data obtained from estimating the wastewater flows of established plants of Toos Complex.

Based on water consumption rate in different seasons and by using other statistical data, the yearly average maximum coefficient is determined to be about 1.9 and the average ratio of maximum flow to minimum flow is 3.7, indicating a broad range of yearly flow variations especially for food processing industries.

With respect to diversity of existing plants in Toos Complex, dominant plants having much more contributions in wastewater generation have been chosen at the first step of this study and their wastewaters have been sampled individually. Besides, the final wastewater of the whole Complex has been sampled and analyzed separately. Table 2 shows the information about qualitative characteristics of Toos wastewater.

The pretreatment systems are very different namely from a plain screening to advanced chemical and biological processes and the primary goal of this study was selection of a flexible system; we adopt CEPT as a specific technology was adapted for Toos wastewater pretreatment after conventional preliminary stages of screening, equalization and optional neutralization. The pretreatment stages are shown in Fig. 1. Table 3 shows the characteristics of the constructed pilot plant in detail.

For determining the performance of described pretreatment system, two samples of 100 L volume were taken from the final manhole of the Complex and transferred to the site of pilot plant for performing pretreatment. This work has been continued everyday for two months. Large and floatable solids were first separated by a manual screening device and then the wastewater was sent to an equalization tank. pH was determined in site by a portable pH meter. Then a detention time of 1 h was regarded for wastewater treatment with lime (250 mg L^{-1} as CaO) and after accomplishing sedimentation the supernatant was transferred to the laboratory.

At the second stage, lime plus a coagulant (ferric chloride, 5 mg L^{-1} as Fe) was used for pretreatment.

Table 1: Different industrial groups of Toos Industrial Complex and quantitative characteristics of their wastewaters

Industrial group	Food	None. primary metals	Textile	Chemicals	Minerals	Cellulose	Power/electronic	Total
Average wastewater production-m^3/day	2031.3	169.8	76.6	268.2	83.9	13.2	48.8	2691.8

Table 2: Qualitative characteristics of the final effluent of toos industrial complex

Parameter	BODS mg L^{-1}		COD mg L^{-1}		TSS	TDS	VSS	EC		PO_4	NO_3	Cr^{6+}
sample	Soluble	Total	Soluble	Total	mg L^{-1}	mg L^{-1}	mg L^{-1}	µS cm^{-1}	pH	mg L^{-1}	mg L^{-1}	mg L^{-1}
1	861	1761	1631	2352	1816	1785	912	2090	5.10	10.25	11.6	0.1
2	590	1015	1080	1780	320	1760	180	1995	6.69	5.79	2.9	-
3	1078	2203	3140	4960	520	960	360	1419	5.68	13.43	11.6	0.6
4	847	1971	1465	2465	1874	2500	1304	2663	4.46	14.21	10.0	0.2
5	810	1726	1541	2405	1617	1596	1160	1981	5.78	12.13	11.2	-
Average	837	1737	1771	27918	1229	1720	783	2029	5.54	11.16	9.5	0.3

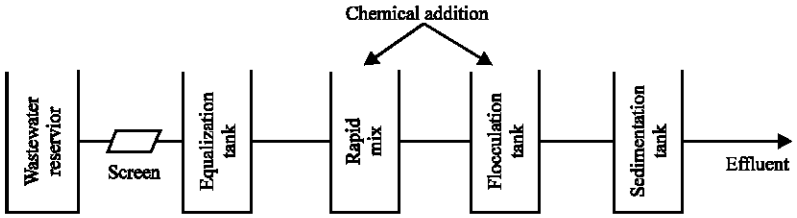

Fig. 1: Flow diagram of toos industrial complex's CEPT pilot plant

Table 3: Characteristics of the constituted pilot-plant

reservoir for wastewater	100 L capacity
manual screening	openings of 3.35 mm
equalization tank	100 L effective volume-metallic
Dimensions	50x50x40 cm
detention time	10 h
flow regulation pump	0-25 L h^{-1}-Jesco
rapid mix chamber	2L-effective volume
Dimensions	12x12x15 cm
detention time	60 s
mechanical mixers	3
sedimentation tank	20 L-effective volume-metallic
Dimensions	30x30x23 cm
total detention time	2 h

The optimum doses of chemicals were determined according to the required amounts of pollutants' removal (COD) and by Jar tests. The treat-ability of wastewater was at first determined using high doses of chemicals (250 mg L^{-1} lime and 10 mg L^{-1} $FeCl_3$).

RESULTS AND DISCUSSION

The major results obtained from this study are given in Table 4-6. These results are relating to the estimated efficiencies of the pretreatment system in removing some important pollutants from the final wastewater of Toos Complex.

As the most important industries of Toos Complex are food, non-primary metals and textile, the wastewater of each was first examined separately and then a mixed sample was prepared and analyzed in laboratory. All these wastes were then pretreated in the pilot system (Fig. 2-5).

Table 2 and 4 show that the removal of all contaminants has improved as the pH increased to 10 or more. But this matter is important to say that lime addition has not improved the BOD reduction noticeably as the same 20 to 30% reduction is achievable in conventional primary sedimentation mostly because of removing settable organic compounds. But by taking into account all the conditions of biological treatment and reaction velocities, it can be conclude that even this low removal may be accepted to be enough for reduction of excess industrial loadings to MWTPs.

At the second phase of the study, ferric chloride was added to the pretreatment system at low dose of 5 mg L^{-1}.

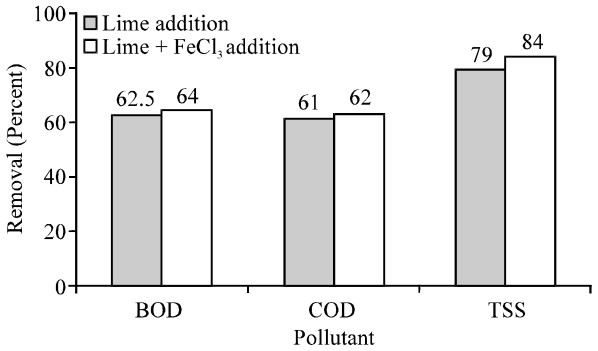

Fig. 2: Performance of CEPT pilot plant for pollutants removal from the wastewater of food industry

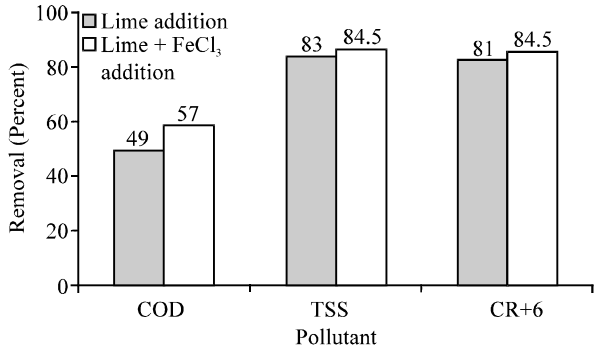

Fig. 3: Performance of CEPT pilot plant for pollutants removal from the wastewater of non-primary metals industry

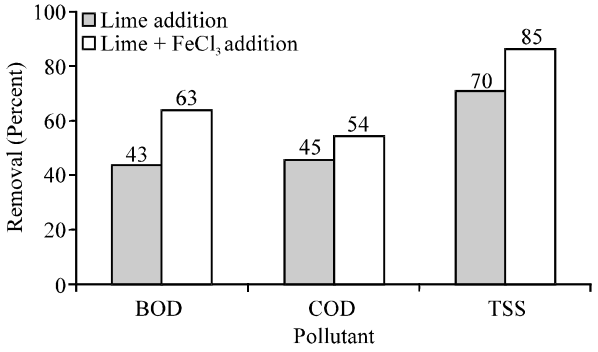

Fig. 4: Performance of CEPT pilot plant for pollutants removal from the wastewater of textile industry

Table 4: Results obtained from lime treatment of toos industrial state's effluent

Wastewater sample	Inf. BOD_5 mg L^{-1}	Eff. BOD_5 mg L^{-1}	BOD_5 reduction (%)	Inf. COD mg L^{-1}	Eff. COD mg L^{-1}	COD reduction (%)	Inf. TSS mg L^{-1}	Eff. TSS mg L^{-1}	TSS reduction (%)	initial pH	final pH
1	1761	1127	36	2352	1528	35	1861	781	57	5.1	10.1
2	1025	615	40	1780	997	44	320	77	76	6.7	10.8
3	2203	1256	43	4960	2579	48	520	146	72	5.7	10.5
4	1971	1439	27	2462	1847	25	1874	1012	46	4.5	9.9
5	1726	1070	38	2405	1371	40	1617	420	74	5.8	10.2

Table 5: Results obtained from pretreatment of toos industrial complexes' effluent by lime and ferric chloride (low dose)

Wastewater sample	Inf. BOD_5 mg L^{-1}	Eff. BOD_5 mg L^{-1}	BOD_5 reduction (%)	Inf. COD mg L^{-1}	Eff. COD mg L^{-1}	COD reduction (%)	Inf. TSS mg L^{-1}	Eff. TSS mg L^{-1}	TSS reduction (%)	initial pH	final pH
1	1761	1109	37	2352	1505	36	1860	671	63	5.5	10.3
2	1025	615	40	1780	1032	42	320	48	85	6.7	10.6
3	2203	1343	39	4960	2827	43	250	125	76	5.8	10.2
4	1971	1261	36	2462	1477	40	1874	806	57	5.0	10.0
5	1726	1087	37	2450	1347	44	1617	178	89	5.8	10.4

Table 6: Results obtained from pretreatment of toos industrial complexes' effluent by lime and ferric chloride (high dose)

Wastewater sample	Inf. BOD_5 mg L^{-1}	Eff. BOD_5 mg L^{-1}	BOD_5 reduction (%)	Inf. COD mg L^{-1}	Eff. COD mg L^{-1}	COD reduction (%)	Inf. TSS mg L^{-1}	Eff. TSS mg L^{-1}	TSS reduction (%)	initial pH	final pH
5	1726	811	53	2450	990	59	1617	97	94	5.8	10.4

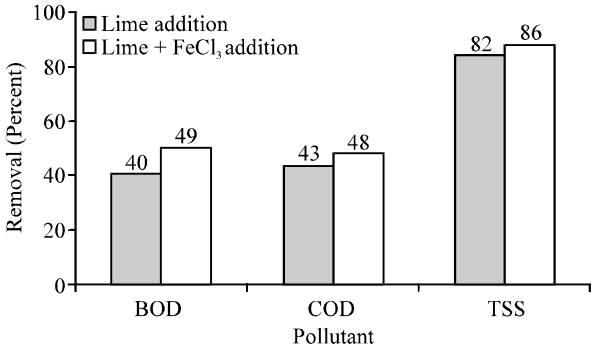

Fig. 5: Performance of CEPT pilot plant for pollutants removal from the mixture of industry wastewaters

of coarse the optimum coagulant doses for wastewater treatment is much more than for water but applying high doses may produce a considerable amount of sludge and makes the process uneconomical. So we did not use doses above 5 mg L^{-1} and it was interesting for us to see that good results were even gained by this low dose.

According to the results obtained it was concluded that wastewater treatment by FeO_3 had again improved by pH rising and the maximum efficiency obtained was at pH 10.6.

The BOD removal levels have varied from 36 to 40% and compared to similar reductions by single lime application it shows much improvement. This is obviously noticeable for sample no-4 that indicated an improvement of about 10% for BOD removal and accordingly this can lead to a considerable reduction of industrial influent loads. Similar to BOD, COD removal levels were about 36 to 44%.

In comparison to previous conditions, considerable changes have been considered for Total Suspended Solids (TSS) removal that were variable from 57 to 89%. Outstanding removal was achieved at pH= 10.4 which was regarded to be the optimum pH at these conditions. Much better TSS removal was observed after treating the final wastewater of Toos Complex by higher FeO_3 doses. But this practice has been recommended when a complete treatment is required whereas it is not the aim of pretreatment, instead the aim is to use chemicals in minimum amounts.

It should also cast a glance on existing MWTP located in Toos Complex. The domestic wastewater is treated by two aerated lagoons, with nominal capacity of 14000 m^3/day. Before this study, the system was overloaded by industrial wastes so the wastewater could not adequately be treated and the final effluent of the Complex was quite unpleasant. The explanation is clear: there were an additional daily BOD loading of 2690 kg and SS loadings of 1556 kg imposed by industrial wastewaters (without industrial wastes' the influent to MWTP was determined to be 14000 m^3/day and BODS and TSS were about 180 and 250 mg L^{-1} whereas by joint treatment they were all increased, the flow rate for example has become about 17000 m^3/day). The reader should conclude from this part of the study that as much as 940 kg of this load (as daily BODS) would be removable by CEPT of industrial wastes and with respect to the load imposed by TSS, the problem could be entirely removed by low lime treatment (pH> 10).

As the final effluent of the Complex is expected for irrigation use in agricultural lands, so there would be

no need to treat this effluent to BODS concentrations of as low as 20 mg L^{-1} and a limit of 100 mg L^{-1} or less would be enough for this purpose.

Overall, this report which is the result of a two-year study confidently rcomplexe the claim that CEPT (low dose application of $FeCl_3$ and/or lime as the primary chemicals) is a simple applicable and well-proven technology for effective first-stage treatment of industrial wastewaters which can have an outstanding effect on the reduction of suspended solids and organic loads of industrial wastes. It may also lead the reader to believe that CEPT would be a well-accepted technology for future projects of industrial complexes developments.

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