



PRETREATMENT REQUIREMENTS AND STATUS OF INDUSTRIAL EFFLUENTS IN THE GREATER ISTANBUL AREA

H. Z. Sarikaya, V. Eroglu, M. F. Sevimli and I. Öztürk

Istanbul Technical University, Civil Engineering Faculty, Environmental Engineering Department, 80626 Maslak, Istanbul, Turkey

ABSTRACT

Evaluation of the industrial pretreatment plants in Istanbul Metropolitan area is presented. Out of 7899 industries located in Istanbul, 1420 of them require pretreatment to meet the discharge criteria. Currently, there are 532 pretreatment works which treat 82.6 percent of the industrial wastewaters. Discharge standards and the compliance monitoring system for the industrial wastewater discharges into the public sewers as applied by the Istanbul Water and Sewerage Administration are discussed. The performance data of the pretreatment plants are given based on the percent non-compliance and percent removal efficiency figures determined for different categories of industry. Problem areas in terms of industrial sector and in terms of quality parameters are identified. © 1997 IAWQ. Published by Elsevier Science Ltd

KEYWORDS

Discharge standards; industrial pretreatment; industrial wastewater; performance of pretreatment plants; sewer ordinances.

INTRODUCTION

The City of Istanbul with a population of about 12 million is not only the center of tourism and trade, but is also a center of industry. Approximately one half of the country's industry is located in the Istanbul Metropolitan Area. The number of industries registered by the Istanbul's Chamber of Industry is 7899, over a wide range of size and category (Data Processing Center, 1996).

The number of industries which require pretreatment in accordance with the "Discharge Regulations into the Public Sewers" of Istanbul Water and Sewerage Administration (ISKI) is 1420 (Department of Wastewater Treatment, 1996). Most of these industries (921) are located on the European side and the rest (499) are located on the Asian side.

The aim of this paper is to introduce the current regulations and the monitoring system for industrial effluents, to present data on industrial pretreatment works of different categories of industries and to evaluate the compliance or non-compliance data.

LEGISLATION AND MONITORING

Discharge of the industrial wastewaters into the public sewers or into the receiving waters must comply with the pertinent regulations of ISKI which have been revised (The Regulation of the Discharge of Wastewaters into the Sanitary Sewer Network, 1995). Any industry located in the Istanbul metropolitan area must obtain the "Discharge Permit" from ISKI to be able to discharge its wastewater. The need for pretreatment or full treatment is decided on the basis of the comparison of the discharge limits with the mean concentration of the relevant quality parameters measured in at least two consecutive 2-hour composite samples. If treatment is needed, the industry has to build its treatment works within 12 months, during this period industry is given "Temporary Discharge Permit". Following the construction of the treatment plant, if the effluents meet the ISKI discharge standards, a discharge permit valid for a period of three years is issued.

The discharge limits currently in effect are presented in Table 1.

Table 1. Limits for the discharge of industrial wastewater into the public sewers (The Regulation of the Discharge of Wastewaters into the Sanitary Sewer Network, 1995)

PARAMETERS	Max. Allowable Concentration (Two hours composite sample)
Chemical Oxygen Demand (COD)	800 mg/l
Total Suspended Solid (TSS)	350 mg/l
Total Kjeldahl Nitrogen (TKN)	40 mg/l
Total Phosphorus (P)	10 mg/l
Oil and Grease	100 mg/l
Anionic Surface Active Substances	Discharge of nonbiodegradable detergent is not allowable.
Arsenic (As)	10 mg/l
Antimony (Sb)	3 mg/l
Tin (Sn)	5 mg/l
Boron (B)	3 mg/l
Cadmium (Cd)	2 mg/l
Total Chromium (Cr)	3 mg/l
Copper (Cu)	5 mg/l
Lead (Pb)	3 mg/l
Nickel (Ni)	5 mg/l
Zinc (Zn)	10 mg/l
Mercury (Hg)	0.2 mg/l
Silver (Ag)	5 mg/l
Total Cyanide (Cn)	10 mg/l
Phenol	10 mg/l
Total Sulphur	2 mg/l
Bioassay Test (TL 50)	100 %
Sulphate (SO ₄ ²⁻)	1700 mg/l

Industries which do not comply with the limits given in Table 1 must pay the fine called "Pollution Prevention Share" (PPS) proportional to the exceedence of the limits. There are some other limits which are used as the control parameters and regardless of the willingness to pay PPS, an industry must satisfy them. These are:

- pH = 6~10
- Surface Active Substances ≤ 400 mg/l
- Oil and Grease ≤ 1000 mg/l
- Total Suspended Solids ≤ 2000 mg/l

Pretreatment is required in case the limits are exceeded and the flow is more than 1 m³/day. Pretreatment is not compulsory for COD values up to 4000 mg/l provided that public sewers drain into a biological treatment plant. However, PPS is collected for the part of COD above the limit (800 mg/l). Dilution in order to meet the standards is prohibited.

ISKI has two directorates to monitor the industrial effluents; one for the European and the other one for the Asian side of Istanbul city. Industries are visited regularly and the samples are analysed at the laboratories of ISKI. At present the sampling and analysis capacity of ISKI is not enough to take samples to achieve proper statistical evaluation of the results of an industry. However, measures are being taken to improve the capacity and to have a fair judgement of an industry with respect to the regulation and legislation.

Industries discharging directly into the receiving water bodies must comply with the discharge regulations of the Turkish Ministry of Environment.

EVALUATION OF THE PRETREATMENT WORKS

The status of the existing pretreatment works with respect to the total required pretreatment is summarized in Table 2 for different categories of industries. While the number of industries requiring pretreatment is 1420, the number of industries with pretreatment is 532 which is 37.5 percent of the total. Since ISKI's policy was to emphasize the potential polluters, the industries with high flowrates were at the top of the list to build the treatment plants. Therefore, though 37.5% of the industries have pretreatment works, 82.6% of the industrial wastewater is pretreated before discharge into the public sewers. As can be seen from Table 2, on the basis of treated flowrate the leather and leather products has the highest, and paper and paper products industry has the lowest treated wastewater percentage.

The overall non-compliance percentages of different categories of industries are calculated as follows:

$$p(\%) = \frac{\sum [p_i(\%) \times Q_i]}{\sum Q_i} \quad (1)$$

in which; p: overall non-compliance percentage
 p_i : non-compliance percentage of i^{th} industry
 Q_i : the flowrate of i^{th} industry

The compliance percentage may be calculated as:

$$\text{Percent compliance} = 100 - p(\%) \quad (2)$$

Similarly, the overall removal efficiency of a pollutant for a given industrial category is calculated as:

$$\eta(\%) = \frac{\sum [\eta_i(\%) \times Q_i]}{\sum Q_i} \quad (3)$$

where; η : overall removal efficiency
 η_i : removal efficiency of i^{th} industry.

The calculated overall non-compliance and removal efficiencies are presented in Table 3. The data presented in this table are used to identify the problem areas in terms of industrial sector and in terms of the quality parameter. For instance, TKN is the problem parameter for food and beverage industry. Similarly sulphate is a problem parameter for textile, metal and non-metal industry. The reason for high SO_4^{2-} concentration in the effluents of the metal industry is the use of H_2SO_4 for surface cleaning and polishing. The use of Na_2SO_4 in dyeing process of the textile industry is causing high SO_4^{2-} problem. Chemical and non-metal industries have problems with COD.

The range of the removal efficiencies for different parameters and for different industrial sectors are presented in Table 4. The wide range of efficiencies indicates that the performance of the pretreatment plants is highly variable.

Table 2. Status of the pretreatment works in Istanbul (Department of Wastewater Treatment, 1996)

TYPE OF INDUSTRY	Pretreatment Plants		Industries Need To Build Pretreatment Plant		Total		Percent Treatment	
	Number	Flowrate (m ³ /day)	Number	Flowrate (m ³ /day)	Number	Flowrate (m ³ /day)	Based on Number	Based on Flowrate
AGRICULTURE, FORESTRY AND FISHING								
Beef Cattle	-	-	2	22	2	22	-	-
Chicken	-	-	10	100	10	100	-	-
SUB TOTAL	-	-	12	122	12	122	-	-
MANUFACTURE OF FOOD AND BEVERAGE INDUSTRY								
Manufacturing of Dairy Products	1	30	2	5	3	35	33.3	85.7
Grain Mill Products	1	250	7	54	8	304	12.5	82.2
Canning, Preserving and Processing of Fish, Crustacean and Similar Food	2	210	-	-	2	210	100	100
Canning, Preserving and Processing of Fruits and Vegetables	-	-	1	2	1	2	-	-
Confectionery	7	200	3	12	10	212	70.0	94.3
Manufacture of Vegetables and Animal Oils and Fats	2	152	1	2	3	154	66.7	98.7
Beverage Industry	3	260	3	5	6	265	50.0	98.1
Manufacture of Food Products not Elsewhere classified	4	45	3	4	7	49	57.1	91.8
Slaughtering, Preparing and Preserving Meat	11	1118	9	141	20	1259	55.0	88.8
SUB TOTAL	31	2265	29	225	60	2490	51.7	91.0
TEXTILE INDUSTRY								
Integrated Textile Industry	7	3500	2	10	9	3510	77.8	99.7
Wool Scouring	1	28	2	69	3	97	33.3	28.9
Wool Processing	2	44	-	-	2	44	100	100
Dry processes	2	50	18	87	20	137	10.0	36.5
Woven Fabric Finishing	63	10050	134	3747	197	13797	32.0	72.8
Knit Finishing	5	400	3	17	8	417	62.5	95.9
Stock and Yarn Finishing	27	2500	9	537	36	3037	75.0	82.3
Nonwoven Fabric Manufacturing	2	269	1	5	3	274	66.7	98.2
Clothing	7	702	7	61	14	763	50.0	92.0
Not Elsewhere Classified	-	-	2	3	2	3	-	-
SUB TOTAL	116	17543	178	4536	294	22079	39.5	79.5
LEATHER AND LEATHER PRODUCTS								
Integrated Leather Industry	1*	10000	5	807	6	10807	16.7	92.5
Tanneries and Leather Finishing	-	-	3	10	3	10	-	-
Leather Dying	-	-	1	1	1	1	-	-
SUB TOTAL	1	10000	9	818	10	10818	10.0	92.4
PAPER AND PAPER PRODUCT, PRINTING AND PUBLISHING								
Manufacture of Paper and Paper Products	6	18	11	67	17	85	35.3	21.2
Printing and Publishing	10	44	6	6	16	50	62.5	88.0
SUB TOTAL	16	62	17	73	33	135	48.5	45.9
PETROLEUM AND PETROLEUM PRODUCTS								
Manufacture of Petroleum Products	1	2	3	4	4	6	25.0	33.3
Petroleum Stations	150	356	132	238	282	594	53.2	59.9
SUB TOTAL	151	358	135	242	286	600	52.8	59.7

* Organized leather industry estate which houses 110 leather factories

Table 2. contd.

TYPE OF INDUSTRY	Pretreatment Plant		Industries Need To Build Pretreatment Plant		Total		Percent Treatment	
	Number	Flowrate (m ³ /day)	Number	Flowrate (m ³ /day)	Number	Flowrate (m ³ /day)	Based on Number	Based on Flowrate
	WOOD AND WOOD PRODUCTS							
Plywood Manufacturing	-	-	1	2	1	2	-	-
CHEMICAL INDUSTRY								
Manufacture of Inorganic Chemicals	4	24	7	5	11	29	36.4	82.8
Manufacture of Basic Organic Chemicals	10	330	4	71	14	401	71.4	82.3
Manufacture of Fertilisers and Pesticides	2	7	2	3	4	10	50.0	70.0
Manufacture of Synthetic Resins and Plastic Materials	4	43	8	18	12	61	33.3	70.5
Manufacture of Dyestuff, Pigments and Printing Ink	16	47	22	36	38	83	42.1	56.6
Manufacture of Adhesives and Sealants	1	4	2	6	3	10	33.3	40.0
Manufacture of Pharmaceutical Products	27	410	12	35	39	445	69.2	92.1
Manufacture of Soap and Detergents	5	316	5	27	10	343	50.0	92.1
Manufacture of Perfumes and Cosmetics	1	3	4	37	5	40	20.0	7.5
Not Elsewhere Classified	2	5	5	7	7	12	28.6	41.7
Manufacture of Rubber Products	1	3	6	13	7	16	14.3	18.8
SUB TOTAL	73	1192	77	258	150	1450	48.7	82.2
MANUFACTURE OF NON-METALLIC MINERAL INDUSTRY								
Manufacture of Cement, Lime and Plaster	-	-	5	188	5	188	-	-
Manufacture of Glass and Glassware	10	432	7	71	17	503	58.8	85.9
Manufacture of Refractory and Ceramic Goods	8	239	96	181	104	420	7.7	56.9
SUB TOTAL	18	671	108	440	126	1111	14.3	60.4
BASIC METAL INDUSTRY								
Iron and Steel Industry	16	76	43	41	59	117	27.1	65.0
Manufacture of Iron Alloy Products	-	-	2	2	2	2	-	-
Metal Foundries	8	27	19	12	27	39	29.6	69.2
Enamelling Industry	-	-	11	8	11	8	-	-
Metal Finishing	65	977	185	200	250	1177	26.0	83.0
Copper Forming Industry	-	-	8	8	8	8	-	-
Aluminium Forming Industry	10	198	19	83	29	281	34.5	70.5
Manufacture of Batteries Accumulators	4	120	2	13	6	133	66.7	90.2
Manufacture of Electrical and Electronically Equipment Industry	14	537	12	12	26	549	53.8	97.8
Shipbuilding and Repairing	1	12	6	48	7	60	14.3	20.0
Not elsewhere classified	8	39	15	15	23	54	34.8	72.2
SUB TOTAL	126	1986	322	442	448	2428	28.1	81.8
GRAND TOTAL	532	34077	888	7158	1420	41235	37.5	82.6

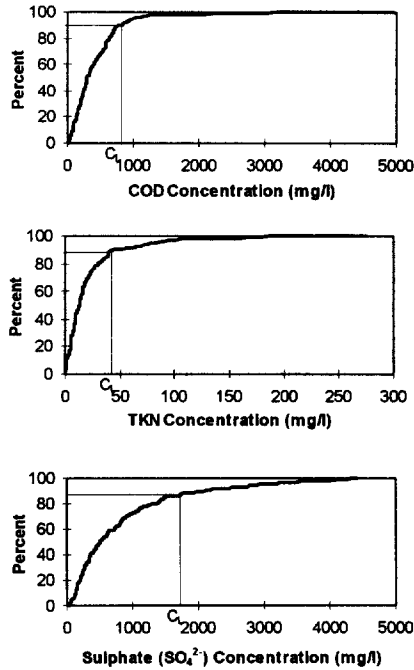
In order to have closer look at the textile industry, Fig. 1 is prepared. In 1995, 227 samples were taken from 116 pretreatment plants of the textile industry. The cumulative distribution of COD, TKN and SO₄²⁻ values are shown in Fig. 1. The vertical axis denotes the percent of the samples with equal or smaller concentrations than the values stated on the horizontal axis. The maximum concentration limits (CL) permitted by the regulation are also marked on the figure. As it is evident from Fig. 1, 10%, 12%, 14%, of the samples taken in 1995 exceeded the limits of COD, TKN and SO₄²⁻ respectively.

Table 3. Overall non-compliance and removal efficiencies

TYPE OF INDUSTRY	Food and Beverages		Textile		Petroleum and Petroleum Pro.		Chemical		Non-metal		Metal	
	P	η	P	η	P	η	P	η	P	η	P	η
pH	-	-	0.5	-	-	-	-	-	-	-	-	0.3
COD	3.7	90.4	3.4	91.8	6.5	-	20	90.0	38.7	67.4	7.3	78.0
TSS	1.3	95.9	2.1	88.9	3.0	-	1.3	82.6	7.5	99.0	0.4	74.7
TKN	26.2	58.8	6.6	89.8	-	-	5.6	60.0	7.5	72.0	6.6	49.6
Total P	1.4	73.8	-	76.7	-	-	0.2	-	-	-	2.7	98.2
Oil and Grease	-	81.4	-	76.2	2.4	-	2.4	87.6	-	89.0	-	44.0
Sulphate (SO_4^{2-})	-	-	13.4	-	-	-	7.3	-	22.6	-	24	-
S^{2-}	-	-	1.8	-	-	-	-	-	-	-	-	-
Cr	-	-	-	-	-	-	-	-	-	-	3	-
Cu	-	-	-	-	-	-	-	-	-	-	12.2	-
Pb	-	-	-	-	-	-	-	-	0.2	-	-	-
Ni	-	-	-	-	-	-	-	-	-	-	4.6	-
Zn	-	-	-	-	-	-	1	-	4.0	-	1.1	-

Table 4. Ranges of removal efficiencies

TYPE OF INDUSTRY	Efficiency Range (%)				
	COD	TSS	TKN	Total P	Oil and Grease
Food And Beverages Industry	42-99	64-99	36-96	25-81	70-99
Textile Industry	21-99	17-99	10-96	41-96	50-99
Chemical Industry	56-96	69-99	43-92	-	63-89
Non-metal Industry	54-82	99	72	-	89
Metal Industry	10-92	14-99	42-67	98-99	38-84

Figure 1. Cumulative frequency distribution of COD, TKN and SO_4^{2-} concentration in the effluents of the pretreatment plants of the textile industry.

CONCLUSION

There are 7899 industries in Istanbul Metropolitan area. The number of the industries which have liquid wastes requiring pretreatment before discharge into the public sewers is 1420 of which 532 of them have already built pretreatment plants. 82.6 percent of the industrial wastewaters is pretreated before discharge. Istanbul Water and Sewerage Administration is in charge of the control of the industrial discharges. Industries must comply with regulations set by ISKI. Otherwise, they may either be prohibited to discharge or given a penalty to pay the fines proportional to the exceedence of the limits. Following the evaluation of the performance of the plants in 1995, percent compliance and percent removal efficiency figures are calculated and are presented. Percent non-compliance data are used to identify parameters of discharge criteria with which industries have problems to satisfy. It was found that most industrial sectors had difficulties in meeting the TKN limit. Non-compliance of TKN limit was as high as 26.2% in food and beverage industrial sector. Textile, metal and non-metal sector had problems with SO_4 with non-compliance percentages ranging from 13.4 to 24. In non-metal and chemical industry COD limits were exceeded in 38.7 and 20 percent of the samples respectively.

REFERENCES

- Data Processing Center (1996). *The Annual Report*, Data Processing Center, Istanbul Su ve Kanalizasyon Idaresi, Istanbul, Turkey.
- Department of Wastewater Treatment (1996). *Archive notes of the wastewater treatment studies in Istanbul*, Department of Wastewater Treatment, Istanbul Su ve Kanalizasyon Idaresi, Istanbul, Turkey.
- The Regulation of the Discharge of Wastewaters into the Sanitary Sewer Network* (1995). Istanbul Su ve Kanalizasyon Idaresi, Istanbul, Turkey.