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Assessment of Automobile Industry Wastewater Treatment Units

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Industrial wastewater is one of the major sources of water pollution in Egypt. The principal hazard to public health caused by industrial wastes is pollution with toxic materials, which may enter a municipal water supply or may be harmful to people using the stream for recreational purposes. These wastes can damage aquatic life, sewer fabric and interfere with the operation of treatment plants and increase the cost and environmental risks of sludge treatment and disposal. Moreover, persistent untreated pollutants passing through these systems may contaminate receiving water bodies.

Metal finishing industry is related to many industries. It cuts across and is part of the transportation (especially automotive), electrical (appliance and electronic), and other industries. The liquid wastes discharged from these industries are not voluminous, but are extremely dangerous because of their toxic content (El-Gohary et al, 1996). These industries release process wastewater containing a variety of hazardous materials, such as heavy metals like chromium, zinc and nickel; organic micro pollutants like polycyclic aromatic hydrocarbons; solvent, paints and other chemicals (El-Gohary et al, 1989;van Baardwijk and Pols, 1990).

The major reason for categorizing heavy metals as the most dangerous pollutants is not simply because they are toxic. Once they have been discharged to waterways, they attach readily to sediment particles on the bottoms of drains and lakes, and are taken up by bottom dwelling organisms, which are in turn eaten by fish. At each stage they are concentrated, and fish can concentrate metals to extremely high levels (Abdel Wahaab, 1995). Chromium, which is commonly used in many industries, has been the most extensively investigated metal with respect to genetic and carcinogenic effects (De Flora et al, 1990; Nieboer and Shaw, 1988; WHO, 1988).
The aim of the present study was to evaluate and to assess the environmental situation of the largest automobile manufacturing company in Egypt (General Motors Egypt) and propose solutions to comply with environmental legislation.

MATERIALS AND METHODS

Wastewater from General Motors Egypt located at 6 October Industrial City provided the materials of this study (500 m^3/day). The 6 October Industrial City is the largest industrial city in Egypt, located at a distance of 38 km from Cairo. The industrial zone encompasses 850 factories, representing almost all industrial sectors.

Intensive monitoring program to GME was carried out over 10 weeks period. There are two pre-treatment units; one for painting department and the other for phosphating department. Chemical coagulation–sedimention procedures are used in both treatment schemes. The layout of the two treatment units is shown in Figure (1,2).

Chemical treatment using ferrous sulfate and lime are used in treating wastewater from the painting department. To accelerate sedimentation, a cationic polymer is usually added. In the phosphating treatment unit, sodium bisulfate is used to reduce chromium from hexavalent to trivalent at pH 2.0, followed by neutralization of the acidic wastewater using NaOH. Cationic polymer is used for precipitation purpose. Wastewater from the two pre-treatment units is mixed together and discharged to the city sewerage system.

To evaluate the performance of the treatment units and the current environmental situation of General Motors Egypt, composite wastewater samples from influent and effluent of the treatment units and the final industrial effluent were collected for analysis. Chemical treatment of painting and phosphating wastewater effluent was conducted at the Water Pollution Control Department of the National Research Centre following the same steps and using the same chemicals given in the operational manual of the GME treatment units. Physico-chemical characteristics of wastewater samples were determined in accordance with the American Standard Methods (1995).

RESULTS AND DISCUSSION

To identify the problem and evaluate the current situation, composite wastewater samples were collected over a 24-hour period from the influent and effluent of the treatment units as well as the final industrial effluent of the plant. Results of the analysis are presented in Table (1).

The results obtained showed that the wastewaters from the two production lines are strong in nature. COD and BOD values were 5905 mg/L and 2114 mg/L for painting production line, respectively. Corresponding COD and

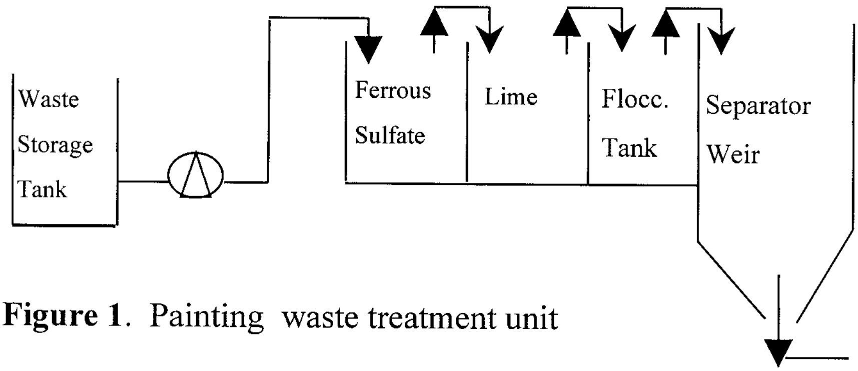

Figure 1. Painting waste treatment unit

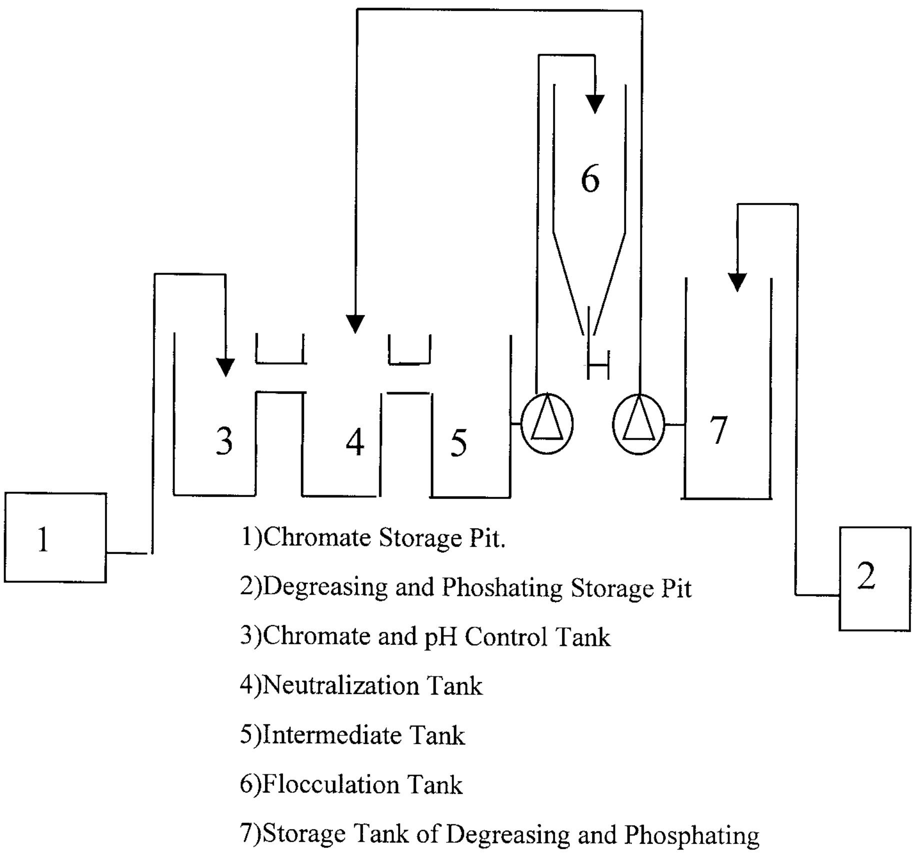

Figure 2. Phosphating waste treatment unit

BOD values in phosphating wastewater were 2970 mg/L and 1610 mg/L, respectively. The pH values ranged between 3.0 and 7.4 (painting wastewater) and between 5.5 and 9.0 (phosphating wastewater). High concentrations of total phosphorous and oil and grease in both cases were recorded. Total phosphorous concentration reached 24 mg/L and 220 mg/L in painting and phosphating wastewater, respectively. Oil and grease concentrations were 1470 mg/L and 430 mg/L in painting and phosphating wastewater, respectively. Total heavy metals reached 55 mg/L in phosphating wastewater.

Physico-chemical characteristics of samples collected from the industrial mixture varied widely, depending on the production processes and the treatment unit's performance (Table 1). The pH-values varied from 6 to 12. COD and BOD value were 3241 mg/L and 1102 mg/L, on-average respectively. Total suspended solids were 724 mg/L. Oil and grease reached 612 mg/L in the mixture. Total phosphorous was as high as 167 mg/L. High concentrations of total heavy metals were recorded (37.87 mg/L). The industrial effluent is not complying with the Egyptian Standards regulating discharge of wastewater's into the sewerage system (Law 93/62 and its Decree no 9/89).

It is worth mentioning however, that the treatment units are not operating properly. No significant removal was recorded in any of the pollution parameters listed in Table (1). The pH-values of the treated effluent fluctuated from 5 to 12 and from 6 to 12 for painting and phosphating wastewater treatment units, respectively. It is clear from the low/high pH-values of the effluent, which does not confirm the optimum pH of the treatment process that the problem with these treatment units is due mainly to improper operation and maintenance.

For the painting wastewater treatment unit (Figure 1), recommendations were given to the operators to check the electrical control system including pH-meter and the dosing equipment, and to replace or repair the out of order parts. It has been observed that, the pH-values of the influent and effluent wastewater are extremely acidic or alkaline. This confirms that only one coagulant is dosed at a time, which reduces the efficiency of the system. Therefore, the pumps should be regulated that required quantities of both coagulants are dosed. Laboratory experiments confirm that the optimum pH of the coagulant used should be 8.5±0.3. Moreover, to improve the efficiency, in the later stage, the sedimentation tank should be provided with inlet and outlet baffles to reduce the dead zones and ensure sufficient retention time in the sedimentation tank.

Table 1. Characteristics of wastewater discharged from the different departments as well as the final industrial effluent at General Motors Egypt.

† Parameters	Unit	Painting Wastewater Treatment Unit		Phosphating Wastewater Treatment Unit		Industr. Mixture	Law 93/62 and its Decree 9/89
		Inf.	Eff.	Inf.	Eff.		
PH (Range)	-	3-7.4	5-12	5.5-9	6-12	5-12	6-10
COD	mgO_2/L	5905	4120	2970	2650	3241	700
BOD	mgO_2/L	2114	1881	1610	1290	1102	400
TSS	mg/L	687	525	640	609	724	500
T-P	mgP/L	24	20.8	220	205	167	5
Oil & Grease	mg/L	1470	960	430	455	612	100
Settl. Solids *10 min.*	ml/L	1.5	1.0	0.5	1.0	15	5
Settl. Solids *30 min.*	ml/L	2.5	1.3	1.0	1.0	25	10
Heavy Metals							
Zinc(Zn)	mg/L	0.60	0.80	38.00	22.00	17.25	*0-10*
Chromium(Cr)	mg/L	0.05	0.05	8.70	0.30	7.09	for <50
Copper(Cu)	mg/L	0.05	0.05	0.05	1.05	1.30	m^3/day,
Cadmium(Cd)	mg/L	0.03	0.01	0.07	0.06	0.80	*0-5*
Nickel(Ni)	mg/L	0.34	0.07	7.80	8.20	10.68	for >50
Lead(Pb)	mg/L	0.06	0.02	0.02	0.025	0.75	m^3/day

†: Average of five composite samples collected over 8 weeks.

Based on the laboratory experiments, recommendations have been made to improve the efficiency of the phosphating treatment system. Installation of an additional tank with a regulated dosing pump was suggested to inject calcium chloride. Laboratory experiments confirm also that the optimum pH-value at this point should be 9.5 ± 0.3. This will not only maximize the precipitation processes of the residual soluble phosphates in the liquor and transfer it to an insoluble form of calcium phosphate, but also the precipitation of metals-hydroxide as well.

Following implementation of the recommended adjustments, composite samples were collected and analyzed to evaluate the performance of the treatment units.

The results obtained in Table (2) indicated marked improvement in both treatment units' performance.

Table 2. Characteristics of the upgraded treatment unit's effluent comparing to Egyptian Consent Standards to Sewerage System.

† Parameters	Unit	Painting Wastewater Treatment Unit		Phosphating Wastewater Treatmen Unit		Industr. Mixture	Law 93/62 and its Decree 9/89
		Inf.	Eff.	Inf.	Eff.		
pH (Range)	-	4-8.5	8.5±0.3	5.5-9	9.5±0.3	6.5-8.7	6-10
COD	mgO_2/L	4821	520	2330	270	625	700
BOD	mgO_2/L	2224	331	1310	98	237	400
TSS	mg/L	599	98	540	323	132	500
T-P	mgP/L	19	3.9	205	6.9	6.3	5
Oil & Grease	mg/L	1120	87	330	76	88	100
Settl. Solids *10 min.*	ml/L	1.9	nil	0.5	nil	0.5	5
Settl. Solids *30 min.*	ml/L	3.5	nil	1.0	nil	1.5	10
Heavy Metals							
Zinc(Zn)	mg/L	0.70	0.01	34.00	2.10	1.70	*0-10*
Chromium(Cr)	mg/L	<0.05	<0.05	8.00	0.30	0.150	for <50
Copper(Cu)	mg/L	<0.05	<0.05	0.05	<0.05	0.20	m^3/day,
Cadmium(Cd)	mg/L	0.03	0.01	0.07	0.06	0.06	*0-5*
Nickel(Ni)	mg/L	0.32	0.02	8.50	0.20	0.40	for >50
Lead(Pb)	mg/L	0.06	0.01	0.02	0.025	1.13	m^3/day

†: Average of six successive samples collected over 8 weeks.

Residual COD, BOD and TSS in the treated effluent of the painting treatment unit were 520 mg/l, 331 mg/L and 98 mg/L, respectively. Oil and grease concentration in the treated effluent was 87 mg/L, with a removal value of 92% (Table 2).

Effluent characteristics of the phosphating treatment unit indicated significant removal efficiency in all pollution parameters (Table 2).

Residual COD value was 270 mg/L, with a removal efficiency of 88%. BOD removal efficiency was 93%, with a residual concentration of only 98 mg/L.

Significant removal efficiency was achieved in total phosphorous concentration (97%). Only residual value of 6.3 mg P/L was recorded in the treated effluent. Total heavy metals concentrations were as low as 2.7 mg/l.

Summing up the previous results stated in Table (2), it can be concluded that, the industrial effluents are in compliance with the Egyptian Standards regulating discharge of wastewater into the sewerage system (Law 93/62 and its Decree no 9/89). Consequently, the treated effluent can be disposed of safely to sewers.

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