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Study on Industrial Wastewater Characteristics in New Borg El-Arab City, Alexandria, Egypt

M.H. Ramadan, O.D. El-Sebaie, F.M. El-Sharkawy
A.H. Mahmoud and R.A. Hussein
Environmental Health Department,
High Institute of Public Health, Alexandria University, Egypt

Abstract. Over the past 20 years, the new industrial cities were considered as the main solution to most of the problems facing the metropolitan industrial areas and to assist in the national industrial development. In these new communities, industrial and domestic activities result in the production of vast quantities of wastewater; the improper disposal of which may cause serious environmental hazards. New Borg El-Arab Industrial City (NBA) includes 9 residential areas and 4 industrial zones. The four industrial zones are occupied by 266 running factories belonging to different industrial sectors. All the domestic sewage as well as the industrial wastewater are treated at an oxidation pond treatment plant and the plant effluent is used in irrigation of silviculture areas. The general objective of the present study was to assess the industrial wastewater characteristics. The pre-assessment phase revealed that 64 factories were discharging industrial wastewater. They could be classified into 9 textile plants, 11 fabricated metal plants, 7 paper and cardboard plants, 12 chemical plants, 23 food industrial plants, and 2 glue plants. The results revealed that out of the 64 wastewater-generating industrial plants in NBA city, 39 were violating the law 93/62 of the wastewater discharge into the sewerage system for one parameter or more. These were 8 textile companies, 5 fabricated metal companies, 4 paper and allied products companies, 7 chemical companies, 12 food processing companies, the studied 2 edible oil refinery companies, and 1 glue production company. The frequency of violation was found to be 59%, 44%, 10%, 56%, 56%, 36%, 10%, and 2.6% as regards pH, SS, settleable solids, BOD, COD, O&G, PO_4^{3-}, and NH_3 respectively among the violating plants. The study proposed some recommendations for the violating companies to comply with the law limits. These were pollution reduction, pre-treatment, loans and grants, and awareness and training programmes.

Introduction

Industry, in its modern sense, has been known in Egypt since the early 19th century. Following World War I, industrial activities based on natural resources began to increase. The concentration of these industries in the metropolitan areas of Cairo, Delta, and Alexandria has put services such as transport, communications, water supply as well as wastewater disposal under special strain. Furthermore, it has led to an imbalance in ecological conditions and a widespread deterioration of environmental quality (Hamza and Gallup, 1982). As a result, new industrial cities (NICs) were represented as the main distinct solution to stop environmental deterioration in the cities of metropolitan areas (World Bank, 1997).

Industries make up about 80% of the entire pollution load in wastewater. Industrial and domestic activities result in the production of vast quantities of wastewater. Industries often send their untreated wastewater directly to a municipal facility, paying it to treat them along with municipal wastewater. But industrial effluents sometimes have components that interfere with proper functioning of the municipal plant, or the plant may be unable to remove noxious pollutants and pass them into receiving waters. Also, municipalities often want to use biosolids for beneficial purposes; and the presence of certain industrial pollutants may make these applications impossible or more difficult (Hill, 1977).

The New Borg El-Arab (NBA) City is one of the industrial cities in Egypt. It is a part of the Northwestern coastal region of Egypt. It is located at 60 kms from Alexandria and 14 kms from the Mediterranean Sea. The city includes nine residential areas and 4 industrial zones. The 4 industrial zones (I, II, III, and IV) are occupied by 510 factories of different industrial sectors. Most of the residential and industrial zones wastewater in NBA City is served by a network of collecting pipes that carry wastewater to a Waste Stabilization Pond (WSP) treatment plant (Council of NBA, 2002). The study aims at assessing the industrial wastewater characteristics in NBA City.

Materials and Methods

Within the 4 industrial zones of NBA City, an inventory of the different industrial plants was prepared. A preliminary evaluation visit to each plant was performed in order to prepare an inventory of the wastewater generating companies. These companies constituted the study samples.

Samples were collected from the wastewater discharged out of the industrial plants. Sampling was performed six times for each plant. Whenever possible, composite samples were taken. The samples were analyzed physically and chemically according to the Standard Methods for the Examination of Water and Wastewater (Clesceri, *et al*., 1995).

Results of analyses were compared to the standards mentioned in the decree No. 44/2000, executive decree of law 93/62, for the discharge of industrial waste into the sewerage system (Ministry of Housing and Utilities, 2000).

Results and Discussion

Results of the Wastewater Audit

As a result of the survey, it was found that 266 factories were actually operating. It has been found that 64 factories were producing considerable amounts of wastewater. They are distributed as follows: 16, 31, 16, and 1 factories, in the industrial zones, I, II, III, and IV, respectively. Among the wastewater generating industries, 23 food plants, 12 chemical plants, 11 metal plants, 9 textile plants, 7 paper and allied products plants, and 2 tanning and glue plants.

Wastewater Characterization

Textile industrial sector

From the results presented in Table 1, it is clear that the pH of the wastewater discharged was mostly in the alkaline range, probably from the desizing and bleaching processes. This was in agreement with Snowden-Swan who deduced that the major pollution issue in peroxide bleaching is the high pH (Snowden-Swan, 1995). As for cotton preparation in company [9], no alkali was used and consequently the effluent was almost neutral.

Although TDS has no standard value in the decree 44/2002, it could be compared with its corresponding value stated in the previous executive decree No. 9/89 (2000 mg/l). Hence, most companies were found to discharge higher concentrations than that stated in the latter decree. These high TDS contents would not be removed by the present WSP treatment plant. Therefore, they would appear in the final effluent of the ponds thus jeopardizing its suitability for reuse in irrigation, since the Egyptian law No. 92/63 and its executive decree No. 44/2000 specify a TDS value of 2000 mg/l. According to the EPA, a typical cotton batch dyeing uses quantities of salt that range from 20% to 80% of the weight of goods dyed, and the usual salt concentration in such wastewater is 2000 to 3000 ppm, with a pH over 10 (USEPA, 1997). This was in accordance with the results of the study since TDS had a mean of 2140 mg/l.

The highest BOD_5 value was encountered with company [9] (715 mg/l). In addition, COD value was also found to violate the law in the same aforementioned company (1785 mg/l) resulting from the cotton particles reaching the waste stream from raw material washing. Similarly, a COD of 1432 mg/l was determined in the effluent from the raw material storage area in Company [7] where there was very much spillage of dyes and chemicals on the floor.

TABLE 1. Physico-chemical analysis of the wastewater discharged from textile companies located in NBA city (1999-2000).

Activity	pH	TDS mg/l	TSS mg/l	Settleable solids ml/l		BOD_5 mg/l	COD mg/l	NH_3 mg/l	NO_3^- mg/l	PO_4^{3-} mg/l	O&G mg/l
				10 min	30 min						
1 – Dyeing cotton fabrics	6-9.7	2352	664	0.2	0.3	420	1022	1	0	2.8	86.5
2 – Dyeing polyester fabrics	9.6 - 10.7	1147	97	0	0	575	945	13	9.5	0.9	23
3 – Dyeing cotton fabrics – Cloth making	7.6 - 10	3841	420	0	0	347	703	9	2	3	35
4 – Bleached fabrics	7.5	405	14	0	0	32.5	87	8.5	0	0.75	8
5 – Dyeing cotton fabrics	10-10.7	4390	1481	7.5	11	440	680	0	0.3	0.75	0
6 – Dyeing fabrics	8.3-9.8	1045	179	0	0	230	349	0.2	0.24	0.5	8.5
7 – Dyeing fabrics – Clothes making	7.6-9.4 7.6	3538 1287	32 2267	0 0.2	0 13	530 116	1432 280	4 4.5	0 0	115 38	120 24
8 – Dyeing fabrics	9.4-10.5	2360	213	0	0	427	871	2.5	0.3	2.6	62
9 – Production of absorbent cotton	8.7	1030	250	5	8	715	1785	3	0	15	87
Mean		2140	250	1.3	3.2	383	815	3.8	1.2	18	45.4
Range	6-10.7	405-3841	32-2267	0-7.5	0-13	32.5-715	87-1785	0-13	0-9.5	0.5-115	0-120

The average values of BOD_5 and COD were calculated to be 383 and 815 mg/l, respectively for all surveyed textile mills. This was in accordance with previous results obtained from a study on the textile industries in El-Seouf area in Alexandria (350 and 754 mg/l in El-Seouf Company and 405 and 676 mg/l, in El-Motahida Company, respectively) (Sohail, 1978). On the contrary, lower BOD_5 and COD values were determined from Kafr El-Dawar textile companies. They were found to be 282 and 417 mg/l respectively in the Italian Factory, and 347 and 534 mg/l, respectively in El-Beida Dyers Company (Attia, 1981). Moreover, much higher values were obtained from the characterization of the effluent from Misr Amereya Company as well as United Arab Company where BOD values were 750 and 760 mg/l, respectively, and COD were 1200 and 1728 mg/l, respectively (El-Sharkawy, *et al*., 1999). This variability might be due to the difference in the processes applied, raw material, and chemicals used in addition to the management philosophy regarding water and wastewater within each factory.

Comparing the characteristics of the effluents from different textile mills in NBA City with the limits stated in decree 44/2002 for the discharge of publicly-owned treatment plants, it was obvious that all of them (except Company [4]) need source reduction measures followed by installation of pre-treatment units to be able to discharge their wastewater into the sewerage system.

Fabricated metal industrial sector

The results of the analysis of the waste streams discharged from fabricated metal industrial plants are presented in Table 2. Regarding pH, it is obvious to be strongly acidic in the 3 surveyed galvanizing shops (1.8 in both companies [1&2] and 4.2 in company [3]). This results from the use of concentrated H_2SO_4 for degreasing the workpiece prior to dipping in the Zn bath. Nevertheless, this acidic pH was not found to be in agreement with the 6.7-7.6 reported by Rodenkirchen (1973). Such neutral range could be attributed to that in some companies, NaOH is added to the galvanization tank.

TABLE 2. Physico-chemical analysis of the wastewater discharged from fabricated metal companies located in NBA city (1999-2000).

Activity	pH	TDS mg/l	TSS mg/l	Settleable solids mg/l		BOD_5 mg/l	COD mg/l	NH_3 mg/l	NO_3^- mg/l	PO_4^{3-} mg/l	O&G mg/l
				10 min	30 min						
1 – Galvanization	1.8	2947	663	0.5	0.6	230	614	12	0.6	0.7	32
2 – Galvanization	1.8	1200	500	0	5.3	30	40	8.4	0	0.1	0
3 – Galvanization	4.2	1228	366	0	0	200	300	2.4	0	1.4	0
4 – Painting	9.3	1021	1442	0	0	800	2611	3	0.1	3.4	213
5 – Painting	7.2	664	50	0	0	30	60	12	0.4	0.2	0
6 – Painting	8.5	1340	648	0	0.1	315	980	1.12	0.24	1.85	21
7 – Painting, galvanizing, and anodizing	6.6	916	674	2	2	330	1108	5	1	1	53
8 – Plating	7	436	60	0	0	60	115	0.8	0.6	0.4	31
9 – Plating	7.2	516	60	0	0	120	200	2.5	12.5	0.7	2
10 – Plating	7.7	480	99	0	0.1	150	184	1.12	0.24	2	0
11 – Plating and painting	7.4	637	59	0.4	0.4	18	40	1.1	0.4	0.1	0
Mean		1035	420	0.3	0.6	208	568	4.5	1.5	1	32
Range	1.8-9.3	436-2947	50-1442	0-2	0-5.3	18-800	40-2611	0.8-12	0-12.5	0.1-3.4	0-213

TDS were high in the wastewater of company [1] (2947 mg/l) owing to the high ionization and dissolution capacity of the strong acid.

Otherwise, and after excluding these galvanizing enterprises, pH range in the effluents of the other companies was 6.6 to 9.3 which complied with the decree 44/2000 of the Egyptian law.

Concerning SS, they were below 800 mg/l limit stated in decree 44/2000 except in waste effluent from company [4]. BOD_5, COD, and O&G were also violating the law in waste stream from the same company, whose metal finishing process consists of painting. They were recorded to be 800, 2611, and 213 mg/l, respectively. This was in agreement with USEPA who stated that inorganic metal finishing had little effect on BOD_5 and on the other hand, organic finishing wastes (from painting processes) consist of compounds that contribute to organic load in the waste stream (USEPA, 1995).

Company [6] was also using painting process. It has been used to discharge its waste stream into a septic tank that was periodically evacuated and cleaned. However, its COD value (980 mg/l) was still much higher than the other factories. Slightly higher COD value of 1108 mg/l was similarly encountered in wastewater discharged from company [7] performing anodizing, galvanizing, and painting. The combination of these processes resulted in a waste effluent characterized by 674, 330, 1108, and 53 mg/l for TSS, BOD, COD, and O&G, respectively.

Regarding wastewater generated from electroplating companies, they were all complying with the said decree. According to Steward (1986), the BOD_5 of metal electroplating wastewater is generally below 25 to 30 mg/l and COD is high depending on the amount of O&G removed from the processed metal surfaces. Similarly, results of another study carried out in an electroplating shop in Alexandria revealed that all the parameters in the final effluent were within the limits stated in the Egyptian law. Exceptions were the heavy metal concentrations including Cr (40 mg/l), Ni (5 mg/l), Cu (2.2 mg/l), and Fe (9 mg/l) (Abd El-Salam, 2002). On the contrary, heavy metals determined in wastewater discharged from NBA electroplating companies were analyzed and found to range from 0.32-0.37 mg/l for Ni and from 0.06-0.07 mg/l for Cr.

Paper industrial sector

Table 3 presents the results of the characteristics of wastewater generated from paper industry. With the exception of facilities [3&6] that used to recycle their treated wastewater, the other factories were discharging heavily polluted effluents with means of 2015 mg/l TDS, 3676 mg/l SS, 20 and 16 ml/l settleable solids after 10 and 30 minutes, respectively, 2615 mg/l BOD_5, 4062 mg/l COD and pH range of 2.6-11. All these values are violating the law.

TABLE 3. Physico-chemical analysis of the wastewater discharged from paper industrial plants located in NBA city (1999-2000).

Activity	pH	TDS mg/l	TSS mg/l	Settleable solids ml		BOD_5 mg/l	COD mg/l	NH_3 mg/l	NO_3^- mg/l	PO_4^{3-} mg/l	O&G mg/l
				10 min	30 min						
Cardboard manufacturing											
1 – Paper sheet → corrugated cardboard	7.-11	2303	18157	0.6	1	11150	15230	3.6	0	0.75	14
2 – Paper sheet → corrugated cardboard	6.7-7.9	1299	945	5	6.3	765	1192	7	2	0.3	27.5
Paper manufacturing											
3 – Waste paper → paper rolls and sheets	7	1073	282	0.7	5.5	180	300	0.2	0.1	2.9	3
4 – Waste paper → paper rolls and sheets	2.6-7	2508	391	18	15	698	1884	3.5	1	0.6	27
5 – Waste paper → paper rolls	6.5	4018	2245	94	68.5	2800	5560	1.4	0.5	0.7	10
6 – Bagasse and waste paper → Paper jumbo, rolls, sanitary towels, napkins, diapers	7.1	890	36	0	0	94	226	2.6	0	0.5	25
Mean		2015	3676	20	16	2615	4062	3	0.6	1	18
Range	2.6-11	890-2508	36-1817	0-94	0-68.5	94-2800	266-15230	0.2-7	0-2	0.3-2.9	3-27.5

The pH value of 2.6 was observed once in company [4] and might be from washing the wire screen with dilute H_2SO_4. On the other hand, the alkaline pH value (11) was encountered in the waste stream of company [1] and might be from the leakage of the adhesive solution used to prepare the corrugated cardboard.

The major source of the extremely high values of BOD_5, COD, and TSS (11,150, 15,230 and 18,157 mg/l, respectively) in the waste stream for the same company [1] was the presence of starch. Improperly managed starch at Georgia-Pacific City corrugated packaging plant resulted in BOD_5 and TSS levels as high as 2600 mg/l per each (Berens and Johnson, 1998).

On the contrary, factory [2] was slightly exceeding the limits for discharge since it was discharging wastewater loaded with 945, 765, and 1192 mg/l for SS, BOD5, and COD, respectively.

Despite companies [4&5] had in-plant wastewater treatment units, their wastewater was characterized with high solids content either in terms of TDS, SS, or settleable solids being 2508 mg/l, 391 mg/l, and 18 ml/l at 10 minutes respectively for company [4] and 4018 mg/l, 2245 mg/l, 94 ml/l and 69 ml/l at 10 and 30 minutes respectively, for company [5]. These high values are attributed to the large amount of cellulosic fibers escaping from the treatment unit. Furthermore, such fibers were the cause of the high organic load in the effluents. COD was highly recorded as 1884 and 5560 mg/l, respectively for the same aforementioned factories. Such solid contents, BOD_5, and COD values were lower than those reported by a chemothermomechanical pulping mill in Canada (9600, 1200, 4000, and 12000 mg/l for TDS, SS BOD, COD, respectively) probably resulting from the chemicals used in the pulping process (Dufresne, *et al.*, 1998).

On the other hand, the values recorded in the present study were very high compared with those reported in the effluents of Varta paper factory and National Paper Company. Both are paper reprocessing plants with TDS means of 1428 and 819 mg/l respectively, BOD_5 of 355 and 630 mg/l, and COD of 1264 and 1650 mg/l, respectively (Ahmed, 1999). Moreover, the results obtained from NBA paper manufacturing wastewater were even higher than those recorded from Rakta Paper Company in which rice straw and bagasse were used for pulp production. The effluent from Rakta had BOD_5 range of 800-1725 mg/l and COD range of 1104-2428 mg/l (Salib, 1979). This could be attributed to the absence of any wastewater recycling in Rakta Company causing the pollution load to be diluted by the large amount of wastewater discharged. In addition, the housekeeping in both companies [4&5] was poor, besides the poor operation of the treatment units.

Chemical industrial sector

The chemical industrial sector is presented in Table 4, showing a great variability in the results obtained. Regarding compliance, 5 companies were complying with law 93/62. These were companies [1,7,9,10,11].

In company [1], the acidic effluent from sulphonic acid preparation was neutralized.

The cooling water used to reduce the temperature of the mold in company [7] was used to dilute the wastewater resulting from equipment cleaning. Such dilution resulted in a waste stream with minor pollutants concentrations.

TABLE 4. Physico-chemical analysis of the wastewater discharged from chemical and glue industrial plants located in NBA city (1999-2000).

Activity	pH	TDS mg/l	TSS mg/l	Settleable solids ml/l		BOD_5 mg/l	COD mg/l	NH_3 mg/l	NO_3^- mg/l	PO_4^{3-} mg/l	O&G mg/l
				10 min	30 min						
Chemical industrial plants											
1 – Dodecyl-benzene sulphonic acid, detergents	8.8	455	421	0	0	540	825	0.6	5	2.4	12
2 – Plastic containers, detergents	6.3-11.7	3455	2774	0	0	205	465	23.4	0.8	1.1	20
3 – Soap	11.4	37197	14832	0	0	1500	23000	114	0	2.5	290
4 – Construction chemicals	7.1-	3589	1598	0.7	1.4	2550	14008	6	6	0.7	5
5 – Plastic paint, insulating material	7.3-7.7	1090	53	0	0	745	1615	13	0.25	0.2	9
6 – Soft gelatin capsules	2.5-6.3	623	643	0	0	597	1333	3.6	0.6	5.5	23
7 – Plastic containers – Chemicals for textile industries	7.1-7.4	1346	288	0.8	1.4	145	343	11	0.15	2	39
8 – Painting pastes	7.2	930	482	0.5	1	860	1136	4	0.5	9	103
9 – Car paints, industrial paints and other chemicals	6.1-6.9	782	300	2.5	3.5	373	680	30	0	4.7	100
10 – Cosmetics	6.5-7.5	673	112	0	0	323	454	0.4	0.5	1.1	4
11 – Cosmetics	6-6.1	834	170	0.3	0.5	91	181	1.5	0.5	0.8	30
12 – Sodium silicate	10.8	14989	38531	0.1	0.3	150	400	7	0.1	6.5	30
Mean		5497	5017	0.4	0.7	673	3703	17.9	1.2	3	55.4
Range	2.5-11.7	455-37197	53-38531	0-2.5	0-3.5	91-2550	181-23000	0.4-114	0.6	0.2-9	4-103
Glue industrial plants											
1 – Glue, fat, phosphate powder	7.5-8.7	207	34	0	0	146	215	55	1	1.3	24
2 – Glue, fat, phosphate powder	6-6.5	1862	1953	4	7	2100	3877	340	0.9	31	160
Mean		1035	994	2	3.5	1123	2046	198	1	16	92
Range	6-8.7	207-1862	34-1953	0-4	0-7	146-2100	215-3877	55-340	0.9-1	1.3-31	24-160

Company [9] produces solvent-based paints. Hazardous wastes result when the mixing vessels and let-down tanks are cleaned. Instead of disposing this waste solvent, a solvent recovery system based on equipment and floor cleaning. Besides, it seems that the factory had neutralized some of the effluent acidity.

Finally, the production of printing pastes used in the textile industry within company [8] resulted in a polluted waste stream loaded with 860 mg/l BOD_5, 1136 mg/l COD, and 103 mg/l O&G. This was in accordance with the World Bank study that revealed that liquid effluents resulting from equipment cleaning after batch operation in dye manufacturing contain high BOD_5, COD, SS, and O&G (World Bank, 1997).

Glue industrial sector

Characterization of the effluents from both glue manufacturing plants is presented in Table 4. The huge contrast between the treated and the untreated effluents is clearly illustrated. The wastewater of company [1] is complying with the Egyptian law 93/62 in all items. On the other hand, company [2] is discharging a heavily polluted stream containing 1953, 2100, 3877, 340, 31, and 160 mg/l for SS, BOD_5, COD, NH_3, PO_4^{3-}, and O&G, respectively. All these parameters were laying within the ranges determined by Hassan and Ramadan (1999) who found that the final effluents of 5 glue plants had the range of 1400-51,000, 3520-116,000, 553-52,210, and 25-20,600 mg/l for BOD, COD, SS, and O&G, respectively. They attributed the high organic load in glue wastewater to the steps of bone washing, fat extraction, and fat dehydration with H_2SO_4. In addition, they interpreted the high SS content to the dust and foreign matter that were adhering to the processed bones.

Food industrial sector

Food processing is the largest wastewater generating industrial sector in NBA City. This sector includes 7 meat and poultry processing plants, 5 vegetable and fruit processing plants, 6 bakery and confectionery production plants, 3 dairy industrial plants, and 2 edible oil refineries. Due to the large variety of the processes encountered in this sector, the results of every industrial subdivision will be presented and discussed separately. The results of analysis of the effluents of the plants of this sector are presented in Table 5.

Meat and poultry processing industry

The results of a study carried out by EPA revealed that only 25% of the brine used in meat cooking remained in the product and the pH of meat processing wastewater was typically in the 6.5-8.5 range (UNEP, 2002). This was in accordance with the results obtained from the present study. With the exception of

TABLE 5. Physico-chemical analysis of the wastewater discharged from meat and poultry processing industrial plants located in NBA city (1999-2000).

Products	pH	TDS mg/l	TSS mg/l	Settleable solids ml/l		BOD_5 mg/l	COD mg/l	NH_3-H mg/l	NH_3^- mg/l	PO_4^{3-} mg/l	O&G mg/l
				10 min	30 min						
Meat and poultry processing industrial plants											
1 – Meat products	6.1-6.7 6.1-6.5	1377 1253	978 652	3 0.8	4 1.5	930 600	1275 980	3.5 6	0 0	2.5 0.2	156 92
2 – Meat products – Tomato concentrate	4.7-7.3	780	537	0	0	350	530	2.7	0.16	2.6	115
3 – Meat products	6.4	1954	140	0.1	0.2	370	680	24	0	0	42
4 – Meat products	7	790	450	2	2.5	300	600	4	0	1.7	25
5 – Frozen poultry	6.7-7.8	779	608	4	6	557	1018	4.1	0.3	3.5	105
6 – Frozen poultry	6.5-6.7	850	1188	0.1	1	560	9026	7.2	0.25	4.8	140
7 – Chicken stock	6.7	750	212	0.5	0.7	380	885	4.5	0.2	2.9	84
Mean		1014	470	1.3	4.8	464	792	7.1	0.2	2.6	95
Range	4.7-7.8	594-1954	140-978	0-4	0-4.8	300-930	530-1275	2.7-24	0-0.3	0-4.8	25-156
Fruit and vegetable industrial plants											
1 – Frozen vegetables	6.9	1000	120	0.4	0.6	600	1060	0	0.5	2.5	68.5
2 – Juice	6.7	1200	150	6.5	7	600	1010	0.1	0.4	3.5	25
3 – Dried vegetables	6.9	5200	420	30	30	5000	8000	12	72	2.7	50
4 – Tomato concentrate	5.3-5.4	1411	448	50	51	690	873	2	0.2	2	5
5 – Frozen vegetables	6.8	980	130	0.5	1	450	870	0	0	1	10
Mean		1958	254	17.5	17.9	1469	2403	2.8	14.6	2.3	32
Range	5.3-6.9	980-5200	120-448	0.4-50	0.6-51	450-5000	870-8000	0-12	0-72	1-3.5	5-68.5
Bakery industrial plants											
1 – Bread – Pastries	9.3	1200	180	0.01	0.01	320	480	2.5	0	3	94
2 – Tehina and halawa	4.7-5.2	1987	10149	260	200	5934	10165	17.5	0.5	6.2	175
3 – Biscuits and chocolates	6.5-7.7	2367	335	2.5	4	190	336	5	0	1.3	70

Table 5. Contd.

Products	pH	TDS mg/l	TSS mg/l	Settleable solids ml/l 10 min	Settleable solids ml/l 30 min	BOD_5 mg/l	COD mg/l	NH_3-H mg/l	NH_3^- mg/l	PO_4^{3-} mg/l	O&G mg/l
4 – Powder jelly or crème caramel	6.3-6.8	952	473	4	5	475	655	3.8	0	0.6	41
5 – Wafers	6.2	1534	76	4.5	5.3	660	950	5.2	0	0	140
6 – Chocolate – Biscuits sticks	5.2-7	2446	258	0.1	0.5	2015	4120	3.1	0.25	3.3	644
Range		1748	1911	45.2	35.9	1599	2784	6.2	0.1	2.4	194
Range	4.7-9.3	952-2446	76-10149	0.01-260	0.01-200	190-5934	336-10165	2.5-17.5	0-0.5	0-6.2	70-664
Dairy industrial plants											
1 – Processed cheese	5.5	2038	1048	100	56	3450	5500	1	0.3	1.4	75
2 – Processed cheese – Butter	4.5	20486	7800	0.6	4	12490	17328	6.5	0	253	380
3 – Butter – Processed cheese	6.1-6.4	1038	407	9	9	690	1450	6	0	2.7	33
Mean		7854	3085	36.5	23	5489	8093	4.5	0.1	85.7	163
Range	4.5-6.4	1038-20486	407-7800	0.6-100	4-56	690-12490	1450-17328	1-6.5	0-0.3	1.4-253	33-380
Edible oil refineries industrial plants											
1 –	9.9-11.8	4614	2682	0	0	4750	8310	6.8	0	4.6	475
2 –	7.2-12.2	2813	1903	7	7	7190	11736	10.5	0	91	493
Mean		3714	2293	3.5	3.5	5970	10023	8.65	0	47.8	484
Range	7.2	2813-4614	1903-2682	0-7	0-7	4750-7190	8310-11736	6.8-	0-0	4.6-91	475-493

company [2] wastewater, the pH of all plant effluents ranged from 6.1 to 7.8. As for the exception company, the acidic effluent (pH = 4.7) could be contributed to the tomato concentrate production line discharging acidic wastewater during equipment washing.

Wastewater generated from company [1] was overloaded with 978, 930, 1275, and 156 mg/l for SS, BOD_5, COD, and O&G, respectively. This might be due to the segregation of the polluted waste stream. This company was found to have 2 separate sewer networks. The first outlet was highly polluted while the second was not. Generally, when an in-plant wastewater treatment plant is installed, the concept of waste segregation appears as the way to reduce the cost of treating clean wastewater. However, in the absence of this pre-treatment unit, combining both polluted and unpolluted effluents would be beneficial since this would dilute the strength of the discharged constituents. This could explain why the other 3 meat processing plants were complying with law 93/62 as concerns their effluent characteristics.

Regarding poultry processing plants [5&6], both were discharging O&G levels (105 mg/l and 140 mg/l) higher than the limit stated by the law. The other parameters were all found to comply with the law and were much lower than those recorded from an EPA study of poultry processing wastewater (ranges of BOD, SS, and O&G of 948-2166, 510-1040, and 243-1501 mg/l, respectively) (USEPA, 2002). The obvious contrast between the EPA study and the present study might be due to the larger amount of water consumed and discharged from NBA abattoirs leading to dilution.

Fruit and vegetable processing industry

It encompassed 5 companies of which 2 were producing frozen packaged vegetables [companies 1&5], 2 were producing concentrates [companies 2&4], and the fifth company was producing dehydrated vegetables [company 3].

As regards pH, it was in the range of 5.3 to 6.9. The acidic value was recorded in the effluent from company [4] for the production of tomato concentrate. This was in accordance with EPA results (5.3-7.4) (Sohail, 1978). The same factory had higher BOD_5 level (690 mg/l) than the limit stated by law 93/62, probably from the tomato residue washed with wastewater during equipment cleaning.

Concerning TDS, very high levels reaching up to 5200 mg/l were encountered with company [3] and this resulted in subsequent high BOD_5 (5000 mg/l) and COD (8000 mg/l). This could be due to the raw material processed on the sampling day (*e.g.*, beets or sweet potatoes generating BOD levels of 4000 mg/l and 7500 mg/l, respectively). As a matter of fact, wastewater characteristics are highly dependant on the type of product being processed (Economopoulos, 1993).

Generally, the average values obtained from the analysis of wastewater generated from vegetable processing plants were 1958, 254, 1469, 2403, and 32 mg/l for TDS, SS, BOD_5, COD, and O&G, respectively. They were falling within the ranges determined for Kaha Company (between 440-2587, 84-923, 200-2160, 271-3500, and 10-36 mg/l for TDS, SS, BOD, COD, and O&G, respectively) (Attia, 1981).

Bakery industrial sector

The mean BOD_5, COD, and O&G of the plants of this sector were 1599, 2784, and 194 mg/l, respectively. By comparing these averages with wastewater discharged from Bisco Misr Company and loaded with 1165 mg/l BOD_5, 2360 mg/l COD, and 70 mg/l O&G (Sohail, 1978), NBA bakeries wastewater was found to be more polluted, probably due to the strong industrial effluent generated from company [2].

This company was found to discharge highly polluted waste stream with an acidic pH resulting from the wastage of citric acid and maleic acid. In addition, the settleable solids were determined to be 260 and 200ml/l after 10 and 30 minutes respectively due to the presence of sesame seed husks that were also the cause of the high SS content (10149 mg/l) and the high COD level (10,165 mg/l). Furthermore, the oil content of sesame seeds was found to reach wastewater from the seeds soaking, washing steps, and from the ultimate equipment cleaning. This oil content led to a BOD_5 value of 5934 mg/l, and an O&G value of 175 mg/l.

Company [6] was found to discharge high organic load (BOD_5 of 2015 mg/l and COD of 4120 mg/l) and high O&G content up to 644 mg/l. This was in agreement with the wastewater discharged from Tom's Foods confectionery in Georgia (2,380, 4560, and 66 mg/l for BOD_5, COD, and O&G, respectively) (Givens and Cable, 1988). This might be due to the sweet ingredients flowing on the floor during processing and carried to the drains during cleaning. The high values reported from company [6] wastewater analysis illustrated the necessity to start a pollution prevention program besides installing a wastewater treatment unit. This was the situation in company [5] using lime/NaOH to treat the plant discharge. However, slightly high BOD_5 (660 mg/l) and O&G (140 mg/l) values were determined in the effluent from this company.

Dairy industrial sector

The pH was always in the acidic range (4.5-6.4). This was in accordance with the Misr Dairy plant effluent characteristics showing pH range of 5.2-6.9 (Salem, *et al*., 1995). This could be attributed to the fermentation of milk sugar lactose into lactic acid.

Total dissolved solids were recorded to have a range of 1038 to 20,486 mg/l. Such high value might be due to the large amounts of salts incorporated in cheese making. As regards SS, they ranged between 407 and 7800 mg/l.

As far as the organic load was concerned, the UNEP put a COD range for dairy effluent from 180 to 23,000 mg/l. Low values were associated with milk-receiving operations and high values were due to the presence of whey from cheese production. In addition, the World Bank determined that COD was normally about 1.5 times the BOD level in dairy wastewater (World Bank, 2001). This was in agreement with the results of the present study where mean BOD_5 and COD were 5489 and 8093 mg/l, respectively. These values were also concordant with those reported in Misr Dairy effluents (5580 and 7860 mg/l, respectively) (Salem, *et al*., 1995).

Moreover, total phosphates concentration was found to be very high (253 mg/l) in company [2] and caused the mean concentration to be 85.7 mg/l. Nonetheless, this average was still lower than that recorded in a Kafr El-Dawar cheese production plant (144 mg/l). These phosphates might be owed to the detergents used in cleansing procedure (Ramadan, *et al*., 1998).

Finally, O&G were also violating the Egyptian law in the same aforementioned factory and were probably a result of butter and cheese lost into the drains.

As a whole, the 3 surveyed companies were violating the law for the discharge into the sewerage system.

Edible oil refinery industrial sector

The alkaline pH range (7.2-12.2) was obvious and could be attributed to the excess NaOH used in fatty acid removal. Similarly, the high phosphorus concentration especially in company [2] might be due to the H_3PO_4 used in degumming process.

The recorded mean values of BOD_5, COD, S.S., and O&G were 5970, 10023, 2293, and 484 mg/l, respectively. They were all falling within the ranges prescribed by an oil refinery pollution control centre in India. These ranges were 1,375-6500, 2,500-10,500, 100-5,800, and 150-1,900 mg/l for BOD_5, COD, SS, and O&G, respectively (APPCB, 2001).

However, these values were much higher than those recorded for Alexandria Oil and Soap Company whose final effluent was loaded with 2000, 500, 700, 400, and 100 mg/l for TDS, SS, COD, BOD_5, and O&G, respectively. This could be explained by the in-plant wastewater treatment in Alexandria Oil and Soap Company (El-Shal, 1994).

On the other hand, the results recorded from the present study were lower than those determined by the World Bank for edible oil processing wastewater (20,000-35,000, 30,000-60,000, 10,000, and 5,000-10,000 mg/l for BOD_5, COD, TDS, and O&G, respectively). These high concentrations were probably determined from integrated oil refineries performing both the extraction and the processing of oil from a variety of fruits, seeds, and nuts. The extraction processes might be mechanical or involving the use of solvent followed by boiling. All these processes generate high organic loads in the waste stream (World Bank, 1997).

Conclusions and Recommendations

Based on the findings, it can be concluded that only 25 out of 64 companies complied with the Egyptian law 93/62. Those violating the law were distributed as follows: 14 food, 8 textile, 7 chemical, 5 fabricated metal, 4 paper and 1 glue industrial companies. The frequency of violation was found to be 59%, 44%, 10%, 56%, 56%, 36 %, 10%, and 2.6% as regards pH, SS, settleable solids, BOD, COD, O&G, PO_4^{3-}, and NH_3, respectively among the violating plants.

The following are some proposed recommendations to achieve environmental compliance as regards wastewater management in NBA City:

1 – Industrial plants are required to implement the possible pollution prevention methods prior to treatment.
2 – Following prevention measures, industrial wastewater violating the law 93/62 prior to its discharge should be treated.
3 – Loans and grants should be offered to the violating companies to help them with the programmes of pollution control.
4 – Awareness and training programmes on pollution prevention and control should be arranged among industry personnel.

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دراسة عن خصائص الصرف الصناعي بمدينة برج العرب الصناعية الجديدة – الإسكندرية – مصر

محمد حسن رمضان ، و ألفت دسوقي السباعي ، و فهمي محمود الشرقاوى ، و علية حنفي محمود ، و ريم عبد الحميد حسين

قسم صحة البيئة ، المعهد العالي للصحة العامة ، جامعة الإسكندرية – جمهورية مصر العربية

المستخلص. على امتداد العشرين عاما الماضية، اعتبرت المدن الصناعية الجديدة هي الحل الأمثل للمشاكل التي تواجه المناطق الصناعية داخل المدن بالإضافة إلى دورها في التنمية الصناعية. وينتج عن الأنشطة السكانية والصناعية في تلك المجتمعات الجديدة كميات كبيرة من المخلفات السائلة التي يمكن أن يؤدي عدم التخلص منها بالطرق الآمنة إلى بعض المخاطر البيئية. تشتمل مدينة برج العرب الصناعية الجديدة على ٩ مناطق سكنية و ٤ مناطق صناعية تم إشغالها بحوالي ٢٢٦ مصنعا تنتمي للقطاعات الصناعية المختلفة. ويتم تجميع الصرف الصحي و الصناعي الناتج من المدينة ليعالج في محطة برك أكسدة ويستخدم السائل الخارج من المحطة في ري الأشجار الخشبية. وتهدف الدراسة إلى تقييم خصائص الصرف الصناعي للمدينة. وقد أظهرت مرحلة التقييم المبدئي أنه يوجد ٦٤ مصنعا فقط لديها صرفا صناعيا، وقد تم تقسيم هذه المصانع تبعا للقطاعات الصناعية التي تتبعها إلى: ٩ مصانع نسيج، ١١ مصنعا للمعادن، ٧ مصانع ورق وكرتون، ١٢ مصنعا كيماويا، ٢٣ مصنعا للمواد الغذائية ومصنعين للغراء. وقد بينت نتائج الدراسة أنه يوجد من بين المصانع التي لها صرف صناعي في مدينة برج العرب ٣٩ مصنعا مخالفا لمؤشر أو لعدد من المؤشرات طبقا للقانون المصري ٩٣/ ٦٢ الذي يتحكم في الصرف إلى شبكة المجاري. وقد تبين أن هذه المصانع هي: ٨ مصانع نسيج، ٥ مصانع لتشكيل المعادن، ٤ مصانع ورق وكرتون، ٧ مصانع

كيماوية، ١٢ مصنعا للمواد الغذائية ومصنعين لإنتاج الزيوت ومصنع لإنتاج الغراء. وقد تبين أن نسب التعدي كانت ٥٩٪، ٤٤٪، ١٠٪، ٥٦٪، ٥٦٪، ٣٦٪، ١٠٪، ٦و٢٪ لمؤشرات الرقم الهيدروجيني، الجوامد العالقة، الجوامد العالقة القابلة للترسيب، الأكسجين الحيوي الممتص، الأكسجين الكيماوي المستهلك، الزيوت والشحوم، الفوسفات، الأمونيا على الترتيب. وقد أوصت الدراسة ببعض الاقتراحات للمصانع المخالفة حتى تتطابق مع معايير القانون، ومن هذه الاقتراحات تطبيق طرق الحد من التلوث والمعالجة عند مصدر توالد المخلفات وعلى توفير التمويل اللازم للمصانع و على تدريب الكوادر المسئولة وزيادة التوعية.