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Textile industry wastes, a real threat to agricultural environment in Egypt

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ABSTRACT

The problems associated with the discharge of textile dyes into the environment are of growing public concern. This study was conducted to identify the magnitude of the problem in relation to environment pollution. A questionnaire was submitted to several textile plants in the major industrial sites in Egypt: Shubra El Khima, Mehella Kubra, Kafr El-Dawar and New Borg El-Arab regions. The questionnaire intended to seek information regarding textile wastewater disposal, effluent volumes discharged, dyes used, and percent of dyes loss into the effluent discharge. Soils close to the textile plants were analyzed to assess the potential for soil degradation. Soil biological activity using dehydrogenase enzyme activity, total microbial counts as effected by three commonly textile dyes used (Dis-azo brown, Acid red, and Reactive) and their mixture were evaluated. The effect of these dyes on beneficial soil microorganisms; *Rhizobium*, *Azotobacter*, yeast, and fungi, was appraised. The main findings were as follows:- The COD of the effluent wastewater was generally high reaching up to 3918 mg/l. On the other hand, the BOD which involves measuring the dissolved oxygen used by microorganism to biodegrade organic compounds was generally low and did not exceed 350 mg/l. Such low BOD values relative to COD can be attributed to the dyes toxic effect on microbial activity. The pH of the tested wastewaters ranged from 3.8 to as high as 11.9. The salinity measurement as EC ranged from 0.4 to 19.6/ dS/m. Such wide range in pH and EC is likely to be attributed to the use of different chemical including the dyes. The textile plants had a detrimental effect on the quality of adjacent soils expressed by chemo-physical properties such as pH and EC of the soil as well as the biological activity of the soil. The dyes showed devastating effect on beneficial soil microorganisms such as *Rhizobium*, *Azotobacter* and yeast. On contrary fungi showed a strong resistance to the dye toxicity. This strengthens the ideas of studying the fungal strains to identify the potential fungal candidates for dyes removal and biodegradation.

INTRODUCTION

Textile dyes wastes are among the most difficult wastes to treat. This is due to their synthetic origin and complex aromatic molecular structures which make them more difficult to biodegrade in the environment. The conventional waste treatment systems were found to be unefficient in dye biodegradation. The lack of remediation technologies in the industrial plants results in discharging of dyes containing wastewaters in the nearby lagoons as the only available approach for waste disposal. These wastes find their way eventually to the water streams, which are used for land irrigation of agricultural.

The textile dye particularly Azo dyes are reported to be toxic[8]. In this work studies on the carcinogenicity and toxicity of Direct, Acid and Basic textile dyes, were conducted using Ames test[2]. The results showed that the studied dyes have mutagenic effect on the test organisms used in these studies.

In previous work[27] studied the toxicity of dyes widely used in Egyptian textile industry. The studies showed the hazardous nature of these dyes.

The ability of microorganisms to decolorize and metabolize dyes has long been a matter of research, and the use of bioremediation based technologies for treating textile wastewater has attracted the interest of scientists[23]. Aretxaga et al., (2001) documented the removal of the dye Gris Lanaset G from aqueous solutions by fungal pellets and determined adsorption of the dye by dead biomass pellets of *Trametes versicolor*. Several other authors studied the decolorization of textile dyes by fungal strains. Kirby et al., (2000) found that *Phlebia tremellosa* fungal strains were able to decolorize eight synthetic textile dyes, Yesilada et al., (2002) studied the decolorization of the textile dye Astrazon Red FBL by the biomass of Funalia trogii fungi and Meehan et al.[14], used a thermotolerant yeast, Kluyveromyces to decolorize the Remazol Black-B dye.

Removal of textile dyes from industrial effluent was done by several methods including nonliving agricultural wastes[22], alum sludge[4], yeast biomass[14], anaerobic bacteria[20], bacterial biomass[25], Fungi[3,12] and/or ozonation and electroflocculation[5].

Azo dyes are the largest class of dyes with the greatest variety of colors. At least 3000 different varieties of azo dyes are extensively used in textile, paper, food, cosmetics and pharmaceuticals industries. Individual bacterial strain cannot degrade azo dyes completely and the intermediate products are carcinogenic aromatic amines, which need to be further decomposed[6]. Removal of the azo dyes was studied based on reductive cleavage of the dyes azo linkages through anaerobic treatment[26] or through employing zerovalent iron[18].

MATERIALS AND METHODS

Chemo physical analyses

Wastewater quality assessment was based on the conventional parameters: Chemical oxygen demand (COD), biochemical oxygen demand (BOD), and total solids (TS); employing the standard Methods[1]. COD was measured using (Hach) spectrophotometer test kit, whereas BOD was measured by OXI Top BOD meter (WTW, Co). The EC values were determined using digital YSIEC meter (model 35), and the pH was measured by digital Orion pH meter (model 420A). Specific absorption of dye solutions was assayed by LBK spectrophotometer (model 4054) for the Dis-azo brown, Acid red, and Reactive blue at 342, 542, and 562nm wavelength, respectively.

Microbiological analyses

Total counts were enumerated in soil samples employing the plate count technique using nutrient agar. Plates were incubated at 28°C and the total microflora was counted after 7 days. Counts are presented as colony forming units (CFU) per gram oven dry soil.

The dyes toxic effect was tested on rhizobium, azotobacter, yeast and fungi Microbial strains isolated from Egyptian soils; except the rhizobium strain (*R.etli*) was obtained from the Italian culture collection IIGB recommended as inoculant strain for bean. Three dyes were employed, in addition to their mix. The Dis-azo brown dye was obtained as pure chemical from the Textile Industries Division, National Research Center. The Acid red and Reactive blue dyes were obtained from Dyetex Company at Borg El-Arab. Specific media was used for each microorganism: yeast mannitol extract (YMA) for rhizobium, Ashby medium for Azotobacter, and malt extract for yeast and fungal strains. One ml from 48 hrs liquid cultures of each strain was spread on the surface of agar media amended with 300 or 600μg/ml dye concentration. Three replicates were conducted and the plates were incubated at 30°C for five days. Results are reported as relative growth.

Dye effect on soil dehydrogenase activity

The dehydrogenase assay is based on using the 2,3,5-triphenyl tetrazolium chioride (TTC) to replace atmospheric O_2 as H acceptor during the oxidation process. Five grams soil sample were placed in a stoppered 50ml Erlenmeyer flasks then mixed with 0.1% $CaCO_3$ and 1ml of 3% aqueous solution of TTC and 2.5ml of distilled water. This amount of liquid should be sufficient for small amount of free liquid to appear over the surface of the soil after mixing. Flasks were stoppered and incubated at 30°C for 24 hours. The triphenyl formazan (TPF) produced was extracted with methanol. The contents of the flasks were filtered, the soil was re-extracted and the filtrate made to 50ml volume with methanol. The intensity of the reddish colour was measured using a spectrophotometer at a wavelength of 485nm with 1ml cuvette and methanol as a blank[25]. The test was conducted on natural soils as well as on soils amended with 600 ppm dye. The amount of produced TPF was calculated against reference calibration graph prepared from TPF standards (Formation of mg formazan requires 150.35µl of H_2). The dehydrogenase activity of the soil was expressed as µl H_2g^{-1} soil day^{-1}.

RESULTS AND DISCUSSION

Problem identification

Questionnaires were submitted to 24 textile companies. But only 15 responded and allowed the project team to visits their factories. A total of 43 wastewater samples were obtained from the respective disposal sites shown in TABLE 1. The amount of wastewater discharged from each factory (Q) ranged from 2.5 to 5000m^3/day. (TABLE 1). The main dyes used are Reactive in several plants, Direct in 7 plants, Disperse in 6 plants, Vat in 2 plants, Sulfur in 2 plants, and Acid in one plant. Currently, there are approximately 3000 types of dyes in the world market. More than 60000 tons of dyes are released into the environment through industrial wastewater from two major sources, the textile and dyestuff industries[13,17]. In a survey of over 4000 dyes, the Ecological and Toucological Association of the Dyestuff Manufacturing Industry (ETAD) reported that 90% were found to be toxic, with the highest toxicities found in the Dis-azo direct and basic dyes[23]. Wastewater is the main route by which dyes enter the environment[27].

TABLE 2 indicates that for the visited textile plants, percentage of dyes lost to the environment ranged from 0.01 to 95%, and similar losses were reported by Peter[1,19]. Source of the dye and manufacturing technique affect the efficiency of dye fixation on the fabrics. Advances in the dye industry play an important role in the dye fixation efficiency. The survey revealed that around 50% of the dyes used are produced locally (TABLE 2), which may account for the high dye release into the

TABLE 1: Textile wastewater discharged (Q) and samples obtained from disposal sites

Region	Company Q m^3/day	Qm^3/day	Sample	Sampling site
New Borg	Seif El Din Co for industry and trade	50	1,2	Drainage outlet.
	Egyptian Int'l Co for knitting and dyeing(Dyetex)	650	3,4, 5,6	Drainage water from the dyehouse basin. Dyehouse drainage. Drainage outlet.
	Egyptian Industries Co. (Sougic)	NA	7,8,9, 10,11	Drainage water from the dyehouse basin. drainage outlet.
Cairo	Nouno textile factory and dye-house 2.5	2.5	12,13	Drainage outlet. Wastewater sample was collected from inside drainage.
	El mukatem dyehouse	25	14,15, 16, 17,20,21	Drainage water from the dyehouse. Dyehouse drainage. Ddrainage outlet.
	Shams company	10	18,19, 22	Drainage water from the dyehouse basin. Drainage outlet. Dyehouse drainage.
Mehalla Kubra	El-Nasr textile and dyeing Co.	5000	23,25,26	Drainage water from the dyehourse basin. Drainage water from the dyehouse basin. From dyes factory after treatment
	El Salam textile and dyeing Co.	NA	24	Drainage canal.
	El belkiny dyehouse 7	7	27	Drainage water from the dyehouse basin.
Shubra El Khima	El-Salam dyeing and finishing Co.	40	28,29,30	Drainage canal. Drainage water from the dyehouse basin.
	Asco factory	40	31	Drainage canal.
	The egyptian Co. for dyeing, printing and finishing (Misrtex)	60	32,33,34	Drainage water from the dyehouse basin.
	El fanneya dyeing, printing and finishing Co.	50	35, 36	Drianage water from the dyehouse basin.
Kafr El-Dawar	Ixmadye company	NA	38,39,40	Drainage outlet before treatment
	Misr El beida dyers	NA	37,41,42	Small Defshu drainage canal. Big Defshu drainage canal. Drainage outlet.
	Societe Misr Pour La, Rayonne S.S. Akafrel	NA	43	Drainage outlet.

Q : Wastewater discharge in m^3/day; NA: Data not available

TABLE 2: Source of dyes used in textile industries, % of the excess dyes lost in the waste effluents and and waste treatment methods

Samples location	Company name	% of dyes lost	Treatment methods	Source of dyes Local imported	Source of dyes Countries
New Borg	Self El Din Co for industrial and trade	0.1-8	Mechanical	Local imported	NA
	Egyptian Int'l Co for Knitting and Dyeing (Dyetex)	0.5-5	Mechanical	imported	Germany
	Egyptian Industries Co.(Sougic)	0.1-9	Mechanical	imported	Germany, east Assian countries
Cairo	Nouno Textile Factory and Dye- House	85-95	Mechanical	Local	NA
	El Mukatem Dyehouse	0-55	None	Local imported	Asma dye Co. Chaina, Coria, India.
	Shams Company	0.01-3	None	Local imported	Cibia Co., Japan
Mehalla Kubra	El-Nasr Textile and Dyeing Co.	0.1-6	Mechanical and chemical	imported	German, Tewon, Chaina, India
	El Salam Textile and Dyeing Co.	0.5-9	Chemical	Imported	All countries
	El Belkiny Dyshouse	0.5-3	None	Local imported	Asma dye Co. Chaina, India
Shurba Khima	El-Salam Dyeing and Finishing Co.	NA	None	imported	Germany, Coria, India
	The Egyptian Co. for Dyeing, Printing and Finishing (Misrtex)	NA	None	Local	NA
	El Fanneya Dyeing, Printing and Finishing Co.	NA*	None	ND	NA
Kafr El-Dawar	Ixmadye company	50	Mechanical and chemical	Local	Asma dye Co.
	Misr El Beida Dyers S.A.E	NA	Mechanical and chemical	Local imported	NA
	Societe Misr Pour La Rayonne S.S. Akafrel	NA	Mechanical and chemical	Local imported	NA

***NA: Data not available**

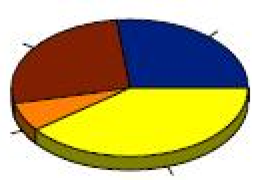

Figure 1: Treatment techniques applied for remediation of effluents among all sites examined in the tested sites

textile wastewater. The dyeing machinery used are mainly of the Jogers and Jet type, and in some cases are of the Haspol and overflow types. Figure 1 and TABLE 2 also shows that around 27% of the surveyed plants employ mechanical treatment, another 27% employ both mechanical and chemical treatment, and only one plant employs chemical treatment. The remaining 40% of the visited textile plants did not employ any treatment process.

Characteristics of the textile wastewaters

Main parameters data for the tested wastewater are given in TABLE 3. The chemical oxygen demand (COD) is a measure of the organic matter in industrial and municipal wastes that contain compounds that are toxic to biological life; employing a strong chemical oxidizing agent such as potassium dichromate[15]. The maximum COD value obtained was 3918mg/l for sample 36 of shubra Elkhima where no treatment was applied (TABLE 2). Most of the COD values are relatively high, and only few are below 100mg/l. The biochemical oxygen demand (BOD) is the most widely used parameter of organic pollution, as it involves measuring the dissolved oxygen used by microorganisms. Presence of toxic compounds such as dyes are likely to have a devastating effect on satisfactory operation of the biological degradation process. The BOD values reported in TABLE 3 are generally low and did not exceed 350mg/l, which can be attributed to the dyes toxic effect. For many types of wastewater it is possible to correlate

TABLE 3: Biological and chemical constituents in wastewater obtained from different textile plants

Area	Sample number	Parameter				
		COD mg/l	BOD mg/l	Total solids (TS)mg/l	pH	EC (dS/m)
	1	2280	150	6152	11.58	4.65
	2	1380	50	4408	11.71	4.01
	3	450	100	1568	7.01	1.3
	4	370	15	872	6.61	0.71
New	5	780	250	6574	9.27	8.12
Borg	6	190	50	488	5.82	0.73
El Arab	7	170	35	3552	9.41	4.86
	8	100	40	988	8.81	0.96
	9	200	NA*	1092	8.39	1.18
	10	60	36	844	8.8	0.87
	11	90	180	1308	7.22	1.32
	12	470	15	56	8.5	0.71
	13	80	15	388	8.55	0.4
	14	160	45	1500	9.18	1.97
	15	3130	350	5255	10	8.35
	16	NA*	20	968	9.15	2.3
Cairo	17	1260	40	2828	10.66	2.34
	18	3130	250	4944	11.67	4.71
	19	156	90	756	8.77	0.35
	20	268	35	2080	9.73	2.24
	21	NA*	55	2016	9.77	3.18
	22	688	45	580	9.46	0.54
	23	2938	60	11836	10.8	19.55
Mehalla	24	664	120	1968	7.26	2.93
El-	25	862	20	2196	9	2.9
Kubra	26	134	15	1388	7.79	2.36
	27	1274	60	2624	9.51	3.03
	28	834	60	912	3.69	1.2
	29	1384	100	1084	6.05	1.4
	30	778	60	2244	3.65	0.2
Shubra	31	52	4	576	7.55	1
ElKhima	32	1750	200	2088	4.26	0.91
	33	1088	40	1440	9.35	1.6
	34	110	20	860	7	1.5
	35	3455	300	71888	7.84	70
	36	3918	50	1588	4.81	0.9
	37	228	50	980	3.8	1.56
	38	771	-	1328	3.66	1.65
Kafr	39	872	50	1980	2.48	3.44
ElDawar	40	400	750	5910	11.85	7.84
	41	92	4	888	7.5	1.04
	42	70	4	925	6.76	1.22
	43	NA	10	576	7.08	0.82

***Data not available**

TABLE 4: Heavy metals content of textile wastewater

Area	Sample no.	Heavy metals Values (mg/l)						
		Fe	Mn	Zn	Cu	Cr	Co	Ni
	1	0.51	0.154	0.198	0.189	-	0.304	0.029
	2	0.408	0.098	0.138	0.054	-	0.114	-
	3	0.051	0.084	0.018	-	-	0.038	-
New	4	0.042	0.048	0.324	-	0.076	-	-
Borg El	5	2.142	0.098	0.312	-	-	0.076	-
Arab	6	0.102	0.042	0.03	-	-	0.038	-
factory	7	-	0.112	0.216	-	-	0.038	-
sites	8	-	0.042	0.024	-	-	-	-
	9	0.051	0.056	0.036	-	-	-	-
	10	-	0.014	-	-	-	-	-
	11	0.255	0.042	0.06	-	-	-	0.029
	12	-	0.056	0.048	0.027	0.544	-	0.029
	13	-	0.014	0.018	0.027	-	-	-
	14	-	0.084	0.048	4.077	-	-	-
	15	0.255	0.084	0.06	76.28	-	0.304	0.406
	16	-	0.07	0.036	-	-	-	-
Cairo	17	-	0.042	0.048	0.162	-	0.038	-
	18	0.408	0.056	0.039	-	-	-	-
	19	-	0.028	0.09	0.027	-	-	-
	20	-	0.042	0.03	0.027	-	-	-
	21	-	0.042	0.24	0.27	-	-	-
	22	-	0.07	0.222	-	-	-	-
	23	-	-	-	0.999	-	0.076	-
	24	0.102	0.098	0.018	-	-	0.038	-
Mehalla	25	-	0.028	0.018	-	-	-	-
	26	0.051	0.028	-	-	-	-	-
	27	0.051	0.07	0.102	-	-	-	-
	28	0.816	0.546	1.53	0.0270	-	-	-
	29	0.918	0.574	0.024	-	-	-	-
	30	0.663	0.63	0.192	-	-	-	-
	31	-	0.042	-	-	-	-	-
Shubra El-Khima	32	0.612	2.198	0.66	0.81	-	-	-
	33	-	0.462	0.108	-	-	-	-
	34	-	0.098	-	-	-	-	-
	35	0.459	0.084	0.048	8.397	0.408	0.304	0.348
	36	0.459	2.212	0.168	-	-	-	-

COD with BOD. This can be very useful because the COD can be determined in 3h, compared with 5 days for BOD. Once the correlation has been established, COD measurement can be used to good advantage for treatment-plant control and operation. However, checking the COD/BOD data in TABLE 3 suggests that such correlation may not exist for textile wastewater, presumably due to the confounding effect of dye toxicity on microbial activity.

Total solids (TS) content of wastewater is defined as all the matter that remains as residue upon evaporation at 103-105°C. It is usually classified into dissolved, total (TDS) and suspended solids (SS). As shown in TABLE 3, the TS values are generally high and reached as much as 11836 mg/l for sample No 23 from Mehalla Kubra. The pH in tested wastewaters ranged from 3.8 (highly acidic) for sample 37 to as high as 11.85 for sample 40, both from Kafr El-Dawar (TABLE 3) The electrical conductivity (EC) also ranged considerably from 0.4 dS/m (sample 13) to 19.55 dS/m (Sample 23). Such wide range in pH and EC may be attributed to the use of sodium hydroxide and sodium chloride in the textile bleaching and sizing process.

Heavy metals content of textile wastewater is given in TABLE 4; because of their potential toxicity in the treatment and disposal of wastewaters. For instance copper (Cu) and chromium (Cr) are toxic in varying degrees to microorganisms and therefore must be taken into consideration in the design of a biological treatment plant; as the microorganisms may be killed and treatment ceases. Copper is toxic in sludge digesters at concentration of 100mg/l where as chromium is toxic at concentrations of 500mg/l[15]. Such high concentrations are not noted in the textile wastewaters(TABLE 4).

Compliance of textile wastewaters with law 48/82

TABLE 5 gives the maximum limits allowed for discharging industrial and municipal wastewaters into non-fresh water bodies (Law 48/82, article 61). This TABLE shows that the permissible pH range is between 6 to 8, whereas several wastewater samples in TABLE 3 were outside this range. Most of the COD values for the textile wastewater samples (TABLE 3) exceeded the standard 100mg/l (TABLE 5). On the other hand, several BOD values are below the 60mg/l standard (TABLE 5); but undoubtedly this is due to the dye toxicity effect on microbial activity stated earlier. The TDS limit is 2000mg/l (TABLE 5), which is equivalent to EC around 3; and was exceeded in many wastewater samples (TABLE 3). With respect to heavy metals, their sum should not exceed 1mg/l, and as shown in TABLE 4, few of the tested wastewater samples exceeded this limit. It may be concluded that the tested textile wastewater samples did not comply with the regulations; while for protecting public health and the environment we should insist on strict compliance with regulations.

TABLE 5: Law No. 48/1982 regulatory limits for municipal and industrial wastewater discharge into non-fresh water

Parameter	Maximum limits, allowed, mg/L	
	Municipal	Industrial
Temperature	35 °C	35 °C
pH	6-9	6-9
BOD	60	60
OD (dichromate)	80	100
DO(dissolved oxygen)	not less than 4	-
Dissolved solids	2000	2000
Suspended solids(SS)	50	60
Color	Free of colored material	
Heavy metals (Sum)	1 (mg/l)	
Fecal coliform (MPN)	5000/100ml	

Assessing quality of soils adjacent to textile plants

Eighteen soil samples were collected from soils adjacent to the textile plants (TABLE 6). As expected, texture of Mehalla Kubra, Shubra El Khima, and Kar El-Dawar soils is clay (TABLE 7); and their calcium carbonate ($CaCO_3$) content ranged from 1.3 to 5.8% (TABLE 8). Only soil No. 47 from Borg El-Arab tended to be sandy (TABLE 7), with relatively higher $CaCO_3$ content of 9.3% (TABLE 8). Soil salinity varied considerably as the EC ranged from 1.09 dS/m to 22.4 dS/m to 22.4 dS/m (TABLE 8). Soil No. 47 had a high EC of 21.7 dS/m accompanied by a relatively

TABLE 6: Soil sampling adjacent to the textile plants

Samples location	Company/factory name	Soil sample number	Sampling site
New Borg El-Arab	Egyptian Industries Co. (Sougic)	47	Soil exposed to the dye residues inside the company premises.
Mehalla Kubra	El Salam Textile and Dyeing Co.	48	Soil sample adjacent to drainage canal.
Shubra El Khima	Asco factory 2	53,	Fallow soil sample, 50 meter away from the factory drainage.
		54,	Fallow soil sample, 100 meter away from the factory drainage
		55,	Fallow soil sample, 200 meter away from the factory drainage
	Asco drain	56, 57, 58	Soil sample adjucant to drain.
	Asco factory 1.	59,	Agric. Soil sample, 50 meter away from the factory drainage.
		60,	Agric. Soil sample, 100 meter away from the factory drainage
		61,	Agric. Soil sample, 200 meter away from the factory drainage.
Kafr El-Dawar	Imadye factory	44,	Fallow soil sample, 50 meter away from the factory drainage
		45,	Fallow soil sample, 100 meter away from the factory drainage
		46	Fallow soil sample, 200 meter away from the factory drainage
	Small Dafshu El Beida drain	51,	Fallow soil sample beside small Dafshu El Beida drain.
		49,	Fallow soil sample, 50 meter away from small Dafshu El Beida drain.
		50	Fallow soil sample, 100 meter away from small Dafshu El Beida drain.
	Big Dafshu drain	52	Soil sample adjacent to big Dafshu drain.

high pH of 8.35. (TABLE 8). It may be noted from TABLE 6 that this Borg El-Arab sample was taken from soil exposed to the dye residues inside the company premises.

The healthy Delta soils normally gives a total microbial count around 10^9-10^{10} CFU per gram soil. In comparison, CFU of soils adjacent to the textile plants were much lower; with CFU around 10^7 for 7 samples (TABLE 9) and around 10^8 for only 2 samples. (Nos. 48 and 53, TABLE 9). Such reduction in microbial CFU suggests a detrimental effect of textile plants on adjacent soils. The soil enzyme activity is recommended an indicator to soil fertility. Among these enzymes, dehydrogenase enzyme is a successful candidate for this type of studies as it proves reliable test. The results showed that the dehydrogenase activity was different from soil to another being very high in soil from near Asco factory II, Asco drain, Asco factory I at Shubra El Khima and Ixmadye factory and Small Dafshu El Beida drain at Kafr El-Dawar as compared to another soils. Effect of adding 600 ppm dye to 8 soils (adjacent to textile

TABLE 7: Mechanical analysis of sampled soils

No	Sand %		Silt %		Clay		Texture class
	Coarse	Fine	Coarse	Fine	Coarse	Fine	
44	8.0	7.2	8.5	19.0	7.0	50.3	Clay
45	10.4	2.0	11.0	25.9	8.2	42.4	Clay
46	3.9	0.9	10.6	29.8	10.0	44.9	Clay loam
47	18.0	19.8	28.0	24.7	4.3	5.3	Sandy
48	0.2	-	14.6	26.4	14.2	44.6	Clay
49	0.8	0.1	13.4	39.6	8.4	37.6	Clay
50	2.0	0.4	27.6	25.3	7.0	37.8	Clay
51	2.7	0.4	23.7	27.1	9.4	36.8	Clay
52	20.1	21.1	2.7	0.4	12.4	43.3	Sandy clay loam
53	1.2	0.1	21.6	25.6	15.7	35.8	Clay
54	1.3	0.4	20.7	26.5	4.8	46.3	Clay
55	1.4	0.5	21.3	27.9	6.7	42.2	Clay
56	4.6	1.3	16.4	24.1	7.7	46.0	Clay
57	2.1	0.6	20.3	28.4	11.3	37.4	Clay
58	2.5	0.7	20.7	34.3	9.3	32.6	Clay
59	3.3	0.5	9.6	28.2	12.2	46.2	Clay
60	3.6	0.7	12.0	28.4	8.9	46.6	Clay
61	3.4	0.7	11.0	18.4	12.8	53.6	Clay

TABLE 9: Microbial counts in soils affected by continuous discharge of textile industrial effluence

Company name	Sample number	Total counts	Enzyme activity $\mu l/g^{-1}/24hrs$	
			Natural soil	Soil receiving
El-Salam Texttile and Dyeing Co. at El-Mehalla Kubra	48	1.6×10^8	-	-
Asco factory II at Shubra El Khima	53	1.1×10^8	183.77	128.64
Asco drain at Shubra El Khima	56	4.0×10^7	67.25	41.69
Asco factory I at Shubra El Khima	59	6.0×10^7	25.18	30.87
Ixmadye factory at Kafr El-Dawar	44	1.9×10^7	58.72	114.43
Small Dafashu El Beida drain at Kafr El-Dawar	51	3.8×10^7	30.29	66.68
Small Dafshu El Beida drain at Kafr El-Dawar	49	5.9×10^7	51.33	35.41
Small Dafshu El Beida drain at Kafr El-Dawar	50	1.7×10^7	75.77	98.51
Big Dafshu drain at Kafr El-Dawar	52	6.0×10^7	18.36	26.32

TABLE 8: Chemical analysis of sampled soils

No.	ECe	pH	$CaCO_3$%	Gypsum%	O.M.%	Ca^{++}	Mg^{++}	Na^+	K^+	$HCO_3^- + CO_3^{--}$	Cl^{--}	SO_4^{--}
44	2.9	6.41	1.3	10.4	8.7	8.5	5.3	14.0	1.2	0.7	18.8	9.5
45	1.43	6.61	2.8	0.0	7.5	4.1	2.9	6.8	0.5	0.6	8.8	4.9
46	1.22	6.65	1.3	0.0	1.4	3.8	2.5	5.9	0.3	0.3	8.2	3.7
47	21.7	8.35	9.3	0.0	4.9	-	-	-	-	-	-	-
48	5.4	6.79	3.3	14.6	14.5	14.3	10.0	25.6	4.1	1.5	38.2	14.3
49	4.6	6.68	0.8	12.8	7.7	13.8	9.1	20.2	3.9	10	31.8	13.2
50	3.18	6.76	1.5	4.9	5.8	9.5	7.1	13.7	1.5	1.1	17.6	13.1
51	5.00	6.10	1.3	16.4	18.8	13.5	9.5	24.5	2.5	1.3	26.8	21.9
52	22.4	6.44	5.8	14.5	14.7	55.5	39.8	114.1	7.3	1.3	158.0	64.7
53	4.88	6.83	4.0	0.0	8.9	15.1	9.4	22.5	1.8	1.5	31.2	16.1
54	2.45	6.81	4.8	0.0	5.7	7.6	4.2	11.5	1.2	0.8	15.3	8.4
55	10.59	6.74	4.3	6.6	6.7	23.2	18.2	60.0	3.9	2.4	69.3	34.2
56	17.35	6.45	5.3	16.7	16.6	51.3	32.8	83.4	6.0	1.5	111.3	60.7
57	1.99	6.86	2.5	4.8	3.7	4.8	2.8	10.9	1.4	1.0	11.6	7.3
58	4.82	7.72	2.8	6.7	7.4	14.9	9.3	22.1	1.9	1.4	30.7	16.1
59	1.09	6.92	1.0	0.0	3.7	3.3	2.1	4.5	1.0	0.6	6.8	3.5
60	1.41	6.95	2.3	0.0	6.4	4.0	2.8	6.7	0.6	0.5	8.6	5.0
61	1.26	6.94	4.3	0.0	2.5	3.4	2.5	6.3	0.4	0.3	8.3	4.0

TABLE 10: Effect of three textile dyes on the growth of four soil microorganisms

Microorganisms	Specific media without dye	Disazo brown (Conc. ppm)		Acid red (Conc. ppm)		Reactive blue (Conc. ppm)		Mix of dyes (Conc. ppm)	
		300	600	300	600	300	600	300	600
R. etli EC3	+++	-	-	+	-	-	-	+	-
Azotobacter sp	+++	-	-	++	-	-	-	-	-
Yeast	+++	+	-	+	-	-	-	+	-
Fungal	+++	+++	+++	++	++	++	++	+++	+++

Relative growth: +++=heavy growth, ++=growth, +=slight growth, - =no growth

plants) on soil dehydrogenase activity is shown in the last two columns of TABLE 9. Enzyme activity was 183.8μl/g for soil No. 53 (CFU 10^8) and was reduced to 128.6μl/g on adding 600 ppm dye (TABLE 9). The direct effect of the dye on dehydrogenase activity did not show specific pattern. With the addition of the dye, the activity either increased or decreased. This shows the direct effect of dyes on enzyme function. Dehydrogenase activity did not decrease which indicate that the soil and its microbial inhabitants are healthy and continue to handle the pollutants by oxidation. In comparison, enzyme activity of the other 7 soils having only CFU 10^7 ranged from 18.4 to 75.8l/g; and the response to dye addition was erratic (TABLE 9). Undoubtedly, reduction in CFU reflects changes in soil microbial diversity induced by dye poisoning; resulting in negative effects on microbial function and soil enzymatic activity.

Effect of three dyes and their mixture on rhizobium, azotobacter, yeast and fungi is shown in TABLE 10. Results are given as relative growth obtained by enumeration on the appropriate media for each microorganism. Dyes were added at 300 ppm and 600 ppm concentrations, and practically fungi growth was not affected; indicating its strong resistance to dye poisoning. On the other hand, rhizobium, azotobacter and yeast did not grow at the 600 ppm concentration; and their growth was slight and rather erratic at the 300 ppm dye concentration. Such results dramatize the devastating effect of dyes on these soil microorganisms.

CONCLUSION

Wastewater of several textile plants were investigated as well as the soils adjacent to these textile plants. The main findings are as follows:

- The COD which may contain organic compounds that are toxic to biological life was generally high; with values ranging up to 3918 mg/l. On the other hand, the BOD which involves measuring the dissolved oxygen used by microorganism to biodegrade organic compounds was generally low and did not exceed 350mg/l. Such low BOD values relative to COD can be attributed to the dyes toxic effect on microbial activity.
- The pH of tested wastewaters ranged from 3.8 (highly acidic) to as high as 11.9. Also, wastewater EC ranged considerably from 0.4 dS/m to 19.6/m. Such wide range in pH and EC may be attributed to the use of sodium hydroxide and sodium chloride in the textile bleaching and sizing process.
- The textile plants had a detrimental effect on the quality of adjacent soils expressed by chemo-physical properties such as pH and EC or biological properties such as soil enzymatic activity or microorganisms.
- The dyes has a devastating effect on beneficial soil microorganisms such as rhizobium, azotobacter and yeast. Among soil microorganisms, fungi showed a strong resistance to dye toxicity.
- Most of the tested textile wastewaters exceeded the regulatory limits stated by law 48/82. For protecting public health and the environment we should insist on strict compliance with regulations.

In view of our financial constraints, dye pollution control requires developing a cost-effective treatment technology. Results given in this work show the strong resistance of soil fungi to dye toxicity. Several fungi strains have been isolated, and their dye removal capacity is currently investigated. As stated earlier, main objective of the future work is to develop a bioremediation technology for cost-effective removal of dyes from textile wastewaters.

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