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MORTALITY RATE OF TILAPIA ZILLII GERV. EXPOSED TO RAW AND TREATED TANNERY WASTEWATER.

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ABSTRACT

The waste water from tanneries at Max industrial complex are discharged directly without pretreatment to Western Harbour (Mediterranean Sea).

Laboratory experiments using **Tilapia zillii** Gerv and tannery waste water and its dilutions (0% (control), 3%, 5%, 10%, 20%, 30%, 40%, 60%, 80% and 100%) had proved the high toxicity of such waste water and its dilutions.

The high lethality of tannery waste water is attributed mainly to its high content of ammonia, suspended organic matter, sulphides and heavy metals.

Treatment of tannery waste water by plain sedimentation decreased its lethality to fishes, i.e. 96 h - LC_{50} for **Tilapia zillii** became 40% tannery waste water, which was probably due to moderate removal of suspended organic matter and heavy metals mainly Cr.

Insignificant improvement of mortality rate was achieved by chemical coagulation using alum $(Al_2 (SO_4)_3 . 18 H_2O)$, inspite of the improvement in chemical characteristics of the raw waste.

The 96 h-LC_{50} for **Tilapia zillii** exposed to tannery waste water with activated sludge and sand filtration was 80%, which was attributed to effective removal of ammonia, suspended organic matter and heavy metals.

INTRODUCTION

Tanning industry is the process of converting animal skin into leather. Process operations of leather tanning and finishing industry is more or less similar all over the World (Younis, 1982).
Al-El-Max,

The tannery wastes are collected in public sewers and discharged directly to the western Harbour of Alexandria (Mediterranean Sea) without any treatment.

This study is an attempt to estimate lethality or 96 h-LC_{50} for **Tilapia zillii** exposed to tannery waste water and its dilutions as raw waste or after being treated, with different methods, to show the efficiency of each treatment. Kinne (1980) explained that although the mortality is a crude criterion, it facilitates a quick general assessement of pollutant toxicity, i.e. mortality tests operate under extreme conditions which permit survival only for minutes, hours, and days. The advantage of such conditions may enable the investigator to pin-point the source of trouble.

MATERIAL AND METHODS

Samples of tannery waste water were collected and send to the laboratory in plastic containers.

Determination of physical and chemical characterstics of tannery waste water were carried out according to the standard methods for examination of water and waste water (1975).

Treatment of tannery wastewater was performed as follows:

A. Preliminary Treatment :
Steel scrapers (5 mm wide) and fine wire mesh screens (1.5 mm mesh size) were used to remove the coarse floating substances and fine particles.

B. Primary Treatment :
a) Plain Sedimentation :
Circular plastic basin (50 cm in diameter and 90 cm in depth) was used for this purpose, during which scum and other floating substances were skimmed off manually. The supernatent was then withdrawn continuously by suction.

b) Coagulation Sedimentation :
Coagaulation sedimentation was carried by using Alum, $Al_2 (SO_4)_3.18 H_2O$, the dose was mg/l at pH 6.5 - 7.0.

c) Biological Treatment:
The activated sludge unit used in this study is shown in Figure 1. The pretreated tannery effluent was pumped at hydraulic rate (2l/h).

d) Tertiary Treatment:
The sand filter used in the test was plexiglass column of 12 cm diameter and 180 cm in length, containing a 90 cm bed of sand, with 60 cm of space above the bed for bed expansion. The sand filter was rested over an adjustable plexiglass perforated plate over which a 13 cm fiber glass wool was inserted to catch up the fine suspended particles. Another 17 cm was left beneath the perforated plate for effluent precollection.

After each run, the sand was backwashed with clean tap water.

1. Pretreated wastewater.
2. Primary Clarifier.
3. Domonitor.
4. Aeration Compartment.
5. Secondary Clarification.
6. Final Effluent.
7. Sludge Wasting.
8. Return Sludge.
9. Recirculation Pump.
10. Air Diffusers.
11. Sediments Outlet.

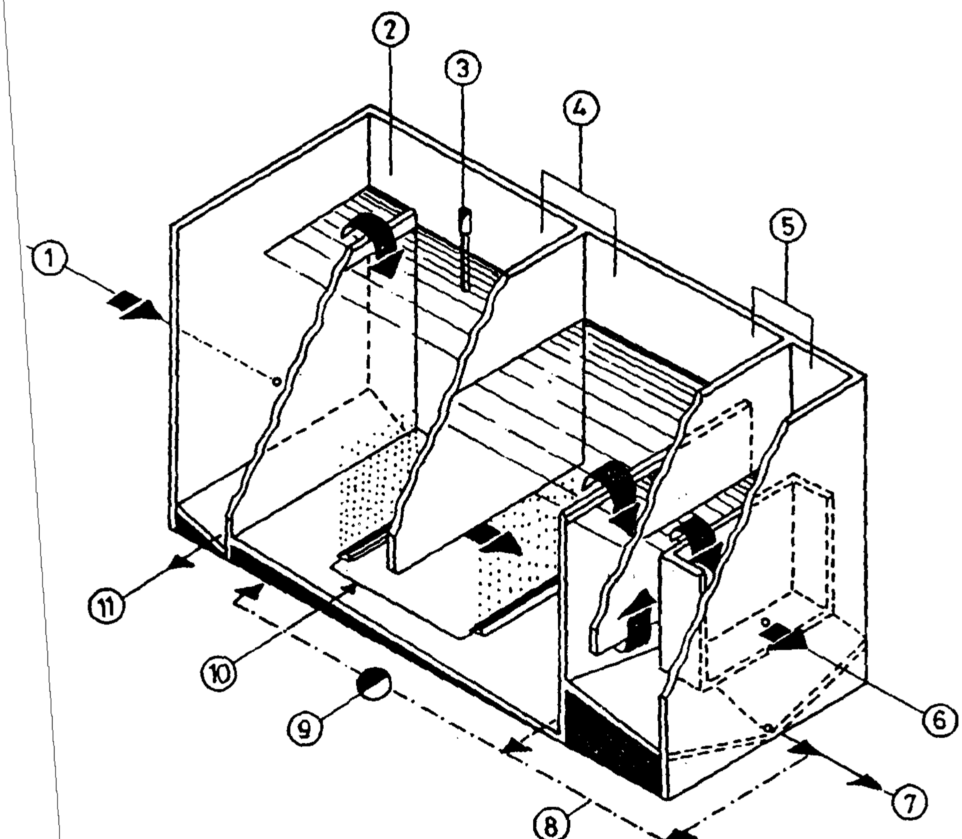

Fig. 1. Schematic of Bench-Scale Multicompartment Activated Sludge Unit. (Younis, 1982).

Ten aquaria were used to test the lethality of tannery waste water as reaw and after its treatment with different methods. Each aquarium contained 100 liters water and 12 **Tilapia zillii** Gerv of average TL=11 $\pm$ 1.2 cm. After fish acclimatized, different dilutions (0% as blank, 1%, 3%, 5%, 10%, 20%, 40%, 60%, 80% and 100% waste water) took place. Fish mortality was recorded in each aquarium during 96 hours, for calculation of 96 h LC_{50} (Portmann, 1972).

The aquaria were slowly aerated by air pump.

RESULTS AND DISCUSSION

The physicochemical analysis of tannery waste water indicates its high content of suspended organic matter, ammonia sulphates, sulphides and heavy metals e.g. Cr, Fe, Cu and Zn. Its biological oxygen demand and chemical oxygen demand are considerably high which led to significant low dissolved oxygen content (Table 1).

Plain sedimentation of such waste reveals a considerable decrease of suspended matter, turbidity and moderate reduction of biological oxygen demand and chemical oxygen demand. A significant reduction of chromium was achieved by plain sedimentation due to the high coagulation capacity of chromium (Table 1). Sproul et al. (1966) reported that chrome liquores in excess of 1% of the total flow proved to be an effective coagulant from composite waste containing 2000 mg/l suspended solids.

Alum (Al_2 $(SO_4)_3$. $18H_2O$) could be considered as the best coagulant for treatment of tanning effluent (Tesarik, 1972) i.e. it was effective in removing more suspended organic matter and achieved moderate reduction in biological oxygen demand and chemical oxygen demand (Table 1).

Results of the activated sludge unit for treating the tannery waste water, based on the results of preliminary investigation, indicated appreciable reduction of biological oxygen demand and chemical oxygen demand, and low removal of heavy metals and ammonia. (Table 1).

Sand filtration was applied after biological treatment. The characteristics of the filtered effluent indicated significant removal of major pollutants (BOD 92%, COD 91%, ammonia 86%, turbidity97%) as shown in table 1.

However, chemical examination alone of complex industrial wastes does not provide a sufficient information on their effects on aquatic biota for protection of the water environments.

Toxicity of such waste water must be evaluated directly through bioassay studies for prediction of what would happen in the field when such waste water are to be disposed of into water environment (Olla et al., 1980).

Laboratory experiments using aquaria containing **Tilapia zillii** and tannery waste water with different dilutions showed the high toxicity of such waste water and its dilutions, i.e. more than 50% of **Tilapia zillii** exposed to tannery waste water and its dilutions (up to 5% tannery waste water) died during 96 hours. This probably means that tannery waste water and its dilutions up to 5% are lethal to fishes.

TABLE 1

Physicochemical characteristics of the tannery waste water (raw), after plain sedimentation, after alum coagulation; after activated sludge, and after sand filtration.

Parameters mg/L	Tanner waste water (raw)	After plain sedimentation		After alum coagulation		After activated sludge		After sand filtration	
		Effluent	% of removal	Effluent	% of removal	Effluent	% of removal	Effluent	% of removal
pH	9.4	9.4	-	6.5	30.9%	7.4	21.3%	7	5.4%
Turbidity	160	90	43.8%	40	55.6%	78	13.3%	10	87 %
Cl^-	3700	3500	5.4%	3200	8.6%	2850	18.6%	1320	53.7%
Hardness	1120	970	13.4%	950	2.1%	960	1 %	680	29.2%
Nitrite	0.08	0.06	25 %	0.04	33.3%	0.05	16.7%	0.03	40 %
Nitrate	10	6	40 %	4	33.3%	6	-	2	67 %
Ammonia	200	190	5 %	160	15.8%	148	7.5%	20	86.5%
Sulphate	2500	2250	10 %	2300	-	2200	2.2%	1250	43.2%
Phosphate	125	125	-	125	-	150	-	100	33.3%
Total solids	15766	9507	39.7%	7510	21 %	8811	7.3%	7028	19.9%
Suspendes solids	10319	2167	71.1%	810	62.6%	1687	22.2%	473	72 %
Dissolved oxygen	ND	ND	-	ND	-	ND	-	ND	-
Biological oxygen demand	4500	3200	28.9%	2410	24.7%	660	79.4%	48	92.7%
Chemical oxygen demand	7040	4600	34.7%	3450	25 %	1120	75.7%	96	91.4%
Zn	0.120	0.06	50 %	0.05	16.7%	0.040	33.3%	0.030	25 %
Cu	0.075	0.028	62.7%	0.023	18 %	0.016	42.9%	0.010	37.5%
Fe	1.00	0.504	49.6%	0.494	2 %	0.318	37 %	0.123	61.4%
Cr	2.00	0.290	85.5%	0.283	2.4%	0.221	23.8%	0.040	81.9%
Ni	0.028	0.011	60 %	0.011	-	ND	-	ND	-
Pb	ND	ND	-	ND	-	ND	-	ND	-
Cd	ND	ND	-	ND	-	ND	-	ND	-
Mn	ND	ND	-	ND	-	ND	-	ND	-

The high toxicity of tannery waste water and its dilutions was attributed to multiple factors and this synergistic effects e.g. high content of ammonia, suspended matter, heavy metals, low oxygen, and high pH. Esvelt et al. (1973) measured the 96 h-LC_{50} of municipal wastes discharged to San Francisco Bay in 43 tests using golden shiner (Nortemigonus Crysoleucas) and found an average value of 2.2 TU of which only 0.74 TU was not attributable, from statistical correlation, to ammonia. It has been proposed that one possible mechanism of ammonia toxicity is suffocation due to destruction of the respiratory surface (Mitchel and Cech Jr, 1983). The toxicity of ammonia further increased due to high pH (Downing and Merkins, 1955) and low oxygen content (Lloyd, 1961). Also, the high content of suspended organic matters caused fauling of the gills (Saleh, 1982). However, it was found that the accumulation of heavy metals on the gills of the dead **Tilapia zillii** was nearly similar to that living in the blank aquarium (Table 3). This probably means that the heavy metals in such waste water play a minor role in mortality of the fish. Ramoorthy and Blumhagen (1984) explained that the organic matter decreased the uptake of Hg and Zn but enhanced that of Cd.

Mortality rate of **Tilapia zillii** exposed to tannery waste water after its treatment by plain sedimentation considerably decreased, i.e. The 96 h-LC_{50} for **Tilapia zillii** became about 40% treated waste water, which was probably due to high removal of suspended matters (Tables 1 and 2). On the other hand, the 96 h-LC_{50} for **Tilapia zillii** exposed to treated tannery waste water by activated sludge and filtered with sand became 80%, which could be explained by the effective removal of ammonia and suspended matters (Tables 1 and 2).

However, treatment of tannery waste water by Alum coagulation showed significant improvement by chemical analysis, while the results of bioassay studies showed comparatively slight improvement to aquatic biota (Tables 1 and 2).

SUMMARY AND CONCLUSION

Tannery waste water is highly toxic to aquatic biota e.g. fishes. Its lethality is attributed mainly to its high content of ammonia and suspended matter as well as H_2S which caused suffocation of the fish. However, the heavy metals in such waste water play a minor role in mortality of the fish.

Plain sedimentation was effective in removing most of suspended matter, while tertiary treatment was effective in removing high concentrations of ammonia and suspended matter.

Although treatment of tannery waste water by alum coagulation showed good improvement by chemical analysis, the results of bioassay studies did not encourage such kind of treatment alone as for as toxicity elimination.

TABLE 2

Mortality rate of **Tilapia zillii** Gerv. inhabiting different dilutions of tannery wastewater (raw); after plain sedimentation, after alum coagulation, after activated sludge and after sand filtration during 96 hours.

Each aquarium contained 100 liters water and 12 **Tilapia zillii** Gerv. of average TL = 11 cm. ± 1.2.

% of waster water in water aquarium	Tannery waste water (raw)		After plain sedimentation		After alum coagulation		After activated sludge		After sand filtration	
	Numbers of fish died	%of fish mortality	Numbers of fish died	%of fish mortality	Numbers of fish died	% of fish mortality	Numbers of fish died	% of fish - mortality	Number of fish died	of fish mortality
0 % waste water (blank)	NO	0 %	NO	0 %	No	0 %	NO	0 %	NO	0 %
1 % waste water	NO	0 %	NO	0 %	NO	0 %	NO	0 %	NO	0 %
3 % waste water	1	8.3 %	NO	0 %	NO	0 %	NO	0 %	NO	0 %
5 % waste water	12	100 %	NO	0 %	NO	0 %	NO	0 %	NO	0 %
10 % waste water	12	100 %	NO	0 %	6	50 %	NO	0 %	NO	0 %
20 % waste water	12	100 %	5	41.7 %	12	100 %	1	8.3 %	NO	0 %
40 % waste water	12	100 %	12	100 %	12	100 %	4	33.3 %	NO	0 %
60 % waste water	12	100 %	12	100 %	12	100 %	12	100 %	2	16.68 %
80 % waste water	12	100 %	12	100 %	12	100 %	12	100 %	8	66.6 %
100 % waste water	12	100 %	12	100 %	12	100 %	12	100 %	12	100 %

TABLE 3
Heavy metals content in the gills and flesh of *Tilapia zillii* Gerv. died during 96 hours when inhabiting contaminated water with tannery waste (raw), and in blank fish. (mg. element / kilogram tissue).

% of tannery waste water in water aqurium	Organ	Cu	Fe	Cr
0 % waste water (blank)	Gills	ND	33.2	ND
	Flesh	ND	12	ND
5 % waste water	Gills	ND	34.4	ND
	Flesh	ND	13.2	ND
10 % waste water	Gills	ND	33.8	Nd
	Flesh	ND	13.0	ND

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