

Application of DbaF Technique for Tannery Industry Wastewater Treatment



El Nadi, M.H., El Sergany, F.A.R., El Hosseiny, O.M.

ABSTRACT: *With the interest in environmental protection the interest in industrial wastewater treatment had increased especially with enlargement in industry and the increase of the treatment cost that affect the products prices. This study aimed to investigate the suitability of applying the Dual Biological Aerated Filter (DBAF) as new low cost technique system for biological treatment preceded by a chemical precipitation to treat industrial wastewater of tannery industry. This new technology decreases construction costs, O&M costs and safe land required with high efficiency. The research made on a plant erected in Shahien tannery in Alexandria operated for five months. Where studied the factors affect the plant efficiency under all operation conditions due to operation program, chemicals used, rates and the effects on plant loads to obtain its suitability for such type of wastewater. The study proved the applicability of the system for such wastewater. The removal ratios for BOD, COD & Cr were 88.05%, 85.5%, 98.85% respectively. Which are high values for treatment efficiency of such type of wastewater and a good efficiency for TSS removal achieved. Also the system did not affected by sudden variations in loads or the non uniformity in tannery operation. The economic comparison with other treatments previously used approved the economy of this system.*

Key Words: *Industrial wastewater, Tannery industry wastewater treatment, Biological treatment, DBAF technique.*

I. INTRODUCTION

The tanning industry is one of the leading economic sector in many countries generates large quantities of heavily polluted wastewater containing ammonia, sulfides & organic substances including tannins, these substances are derived from hides, skins and from the addition of reagent during processing of these materials [1].

The uncontrolled release of tannery effluents in natural water bodies increases the environmental pollution & the health risks. Tannery wastewater treatment represents a serious environmental & technology problem [2]. Also the disposal in the domestic sewerage system caused a lot of troubles with the sewers age and with the treatment due to the high loads of pollutants. Leather industry is one of the major sources of hard currency in many centuries, in Egypt leather industry is an old one and goes back to the ancient Egyptians. The present production is at old Cairo city, The remaining are located in Alexandria, at Max district, it holds about 19 tanneries, other areas are distributed among Egypt, mainly in Damanhour & Assiut.

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The characteristics of tannery wastewater depend on the tanning process adopted, the amount of water used, and the process of hide preservation. Tannery industry use a big amount of water between 15-20 m³ per ton of raw skin. Their effluents are characterized by COD & BOD [6] from tannery industry. The expected pollution loads of a typical Egyptian Tannery are estimated per ton of products as 52m³ of water, 49kg of BOD, 258kg of COD, 138kg of TCS, 489kg of TSS 3.5kg of chrome and 15 kg of total nitrogen with average pH value 10 [14].

The waste average is 8000 ppm total solids, 1500 ppm volatile (organic) solids, 1000 ppm protein, 300 ppm NaCl, 1600 ppm total hardness, 1000 ppm sulfide, 40 ppm chromium, 60 ppm ammonium nitrogen, 1000 ppm BOD, it has pH value between 11 and 12 and normally produces at 10 percent sludge concentration because of the lime and sodium sulfide contents. Wide fluctuation in the nature of tannery wastes due to intermittent dump, discharge, make these wastes difficult to treat. Especially when combination with municipal sewage, protein and other material extracted from the hides are estimated to produce 50 to 70% of the BOD load and process chemicals are estimated to reduce from 30 -50% [6]. The discharge of tannery wastewater can cause severe environmental problems due to its high chemical oxygen demand, high chromium concentration & deep color content [4]. The leather industry is one of the strategic sectors as a major source of hard currency it can even compete with the petroleum sector for many countries there is Italy, North Korea, Hong Kong, Brazil, Portugal, Spain, China Germany, Indonesia, France, Britain, Pakistan, India, Ethiopia, Nigeria & USA. A new technique was applied in Madjo tannery, Ethiopia, using ponds system for treatment of tannery waste, the system was comprised of advanced facultative pond, secondary facultative pond & maturation pond all arranged in series [11]. Wastewater ponds are natural systems whose biochemical & hydrodynamic processes are influenced by meteorological factors such as sunshine, wind, temperature, rainfall, & evaporation. Pretreatment was provided by passing the raw combined tannery wastewater through successive bar screen & detaining the screened wastewater for one day into two horizontal settling tank. The system achieved a high pollutant removal, the highest, removal of BOD₅, COD, S.S (50-90%) & can adequately treat now combined wastewater [12]. In India as a part of an action to reduce the pollution of the river Ganga to reduce the output of chromium by tanneries treatment plant consisting of two up flow anaerobic sludge bed (UASB) reactor followed by a post treatment reduces the wastewater pollution by 80% of BOD, COD, TSS but sulfide is still high [12].



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Tannery industry wastewater collected from a local leather industry in Pakistan, was subjected to D.

C electrolysis in a simple cell having two static sheet of electrodes & stirring of assembly after proper dilution & adjustment to desire conditions 1% of HNO₃ & 1% of NAHCO₃ were used as electrolytes & PH adjusters [13]. Various combination of electrodes were tested & conditions optimized for best electrode couple with increased recovery & removal of chromium. the recovery of 99% chromium removal was achieved such treatment not only minimize the environmental water pollution ,but results in the formation of useful products employed for recycling purpose in tannery or other related industry to make the process economical [13].

A new technique for tannery wastewater treatment is applied in a common wastewater treatment plant of an organized tannery industry region at Turkey. Treatment procedure is characterized by COD reduction in wastewater by using Electro –Fenton process. Treatment of wastewater carried out by an electro-chemical batch reactor equipped with two electrodes that connected parallel to each other in this process. COD is reduced by 60 to 70 % within 10 minutes by taking into consideration the local sewerage discharge unit .The applicability of this process will increase since there are organics & toxics inorganic substances present in the tannery wastewater & these substances have high resistance to biological degradation [13].

At the city of Leon in France, Soils have been irrigated with water from the river Turbio for over 25 years but nothing is known about how this has affected its characteristics & biological functionary considering the discharge of untreated tannery effluents to the river, the characteristics of the irrigated soils might have changed during that time. Although irrigation with water from the Turbio in which wastewater from the city of Leon has increased the increase of **cr** & **cu** in the soil further irrigation will increase the solidity & the salinity which may deteriorate soil [4].

In Canada, to decrease the pollution at the source & reduce the amount of water used. The in laboratory work demonstrated the effectiveness of the Media-Flex filter on column tests & provided an opportunity to explore ways of recovering chrome & sulfur compounds in the filter material. Unfortunately, because of fire, which completely, destroyed the tannery, the field work initially planned could not be completed [3].

The Egyptian tanned leather suffers from industrial over crowding, lack of water, treatment facilities, the use of antiquated technologies, production processes & suffers from complex associated in poor applied technique in tanning process, lack of environmental awareness & untrained workers.

The Egyptian tanned leather industry wish to be competitive in the new world economy, producers will need to adjust their production methods to new environmental health & safety standers being imposed or preferred by foreign markets .However , to do so they first need to come into compliance with Egyptian environmental regulations, particularly those involving waste water influent standards [2].

The tanning industry constitutes the 5th largest industry sector in Egypt employing more than 250,000 people. Italy is the main importer of Egyptian tanned leather importing average 7million LE other importers include Greece, Jordan & Libya.

Most tanneries are located in a run down densely populated section of Misr el kadima in southern Cairo, also known as “Tannery District” .The district supplies 85% of Egyptian tanned leather [2].

Drainage systems in the district have mostly collapsed leaving tanning effluent to run through the streets, although some tanneries have built above ground channels that carry effluent to municipal sewers .decayed infrastructure makes it difficult to establish individual treatment units or centralized in the tanner’s district the only other notable tanning district is in Alexandria although it is much smaller than in Cairo . Another problem facing the tanning industry is that poor environmental standards encourage the over use of chemicals ,wich tends to make the level of residue in Egyptian tanned leather high this prevent finished leather from exporters from sometimes meeting the environmental health & safety requirements of foreign markets.

In 1994, Egypt passed the law of the environmental (law 4 of 1994) & subsequent executive regulations .In 1995 protecting land, air & water resources. However given that no Egyptians tanneries have on site waste water treatment facilities it can be safely said that tanning industry is in violation of all applicable articles of these laws [14].

Treatment of tannery wastes by neutralization & sedimentation by coagulation is effective & secured removal of turbidity, suspended solids, BOD, COD. Additional of cement, kaolin prior to treatment with alum is very effective in saving alum if it is use alone kaolin is effective in the removal of suspended solids & COD [15].

The recent used treatment among the world is very costly to be applied in private factories especially with the shortage of the required area for the treatment.

II. MATERIALS & METHODS

The aim of this study is to apply a new technique for treating tannery industrial wastewater that achieve the least required area, the highest efficiency & the lowest possible cost. The system is consisted of chemical precipitation followed by new biological unit called DBAF produced By Egyptian Team [17 & 18].

The continuous flow pilot plant was erected in *Shahien* factory consists of Screen followed by chemical precipitator (figure (1)) followed by dual biological aerated tower filter (DBAF) (figure(2)) with air blowers followed by two final sedimentation tanks.

The plant’s components are made of steel structure & reinforced concrete and plastic parts as shown below.



Figure (1) Chemical precipitator tank

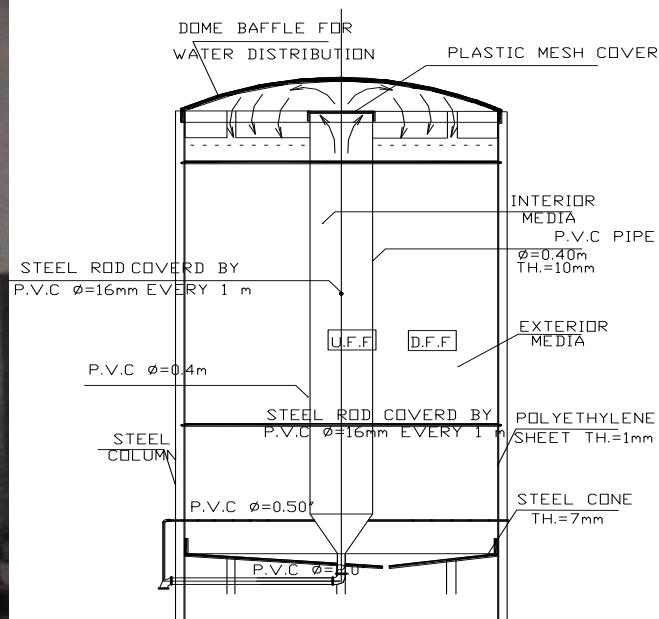


Figure (2) DBAF Unit in Shahein factory

Samples were weekly measured for all parameters with the coverage of all operation conditions & loads in the influent & the effluent & also after the precipitator tank but not every week and measuring the BOD, COD, TSS, total Cr, Total N and pH-value.

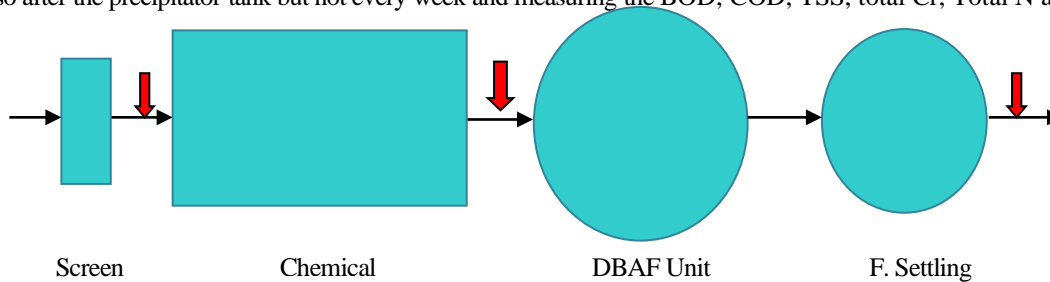


Figure (3) Samples Locations on Plant Flow Line

III. RESULTS & DISCUSSIONS

The plant erection in *Shahein* tannery factory in el Max Alexandria took one month then two weeks for start up then four months operation to determine the study results. Figures (4) & (5) illustrated the measured parameters removal ratios during the study period through the applied treatment units.

It can be seen from figure (4) that the chemical precipitation was succeeded in the removal of Cr from wastewater to give the chance for the bacterial action to take place in the biological unit. The chemical precipitation succeeded in achieving Cr Removal ratio 98.85% even what is the value of Cr Load in the influent that keep the effluent concentration always below the bacterial effective limit that achieve the requirements from this treatment step.

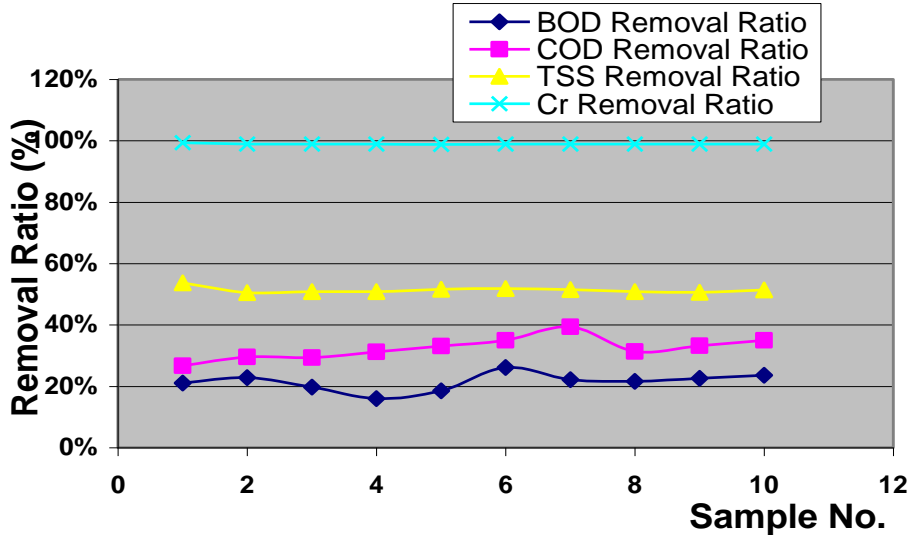


Figure (4) Removal Ratios by Chemical Precipitation.

On the other hand the chemical precipitation succeeded in decreasing the BOD & COD loads on the biological unit by ratios varied between 16.0 & 23.6 % for BOD and 26.7 & 39.4% for COD that ease the role of DBAF system as

biological unit and help its success as new biological treatment procedure for tannery wastewater.

Also, the TSS load was decreased by chemical precipitation to about 50% that improve the influent quality that enters to the biological unit and decrease its problems in this unit.

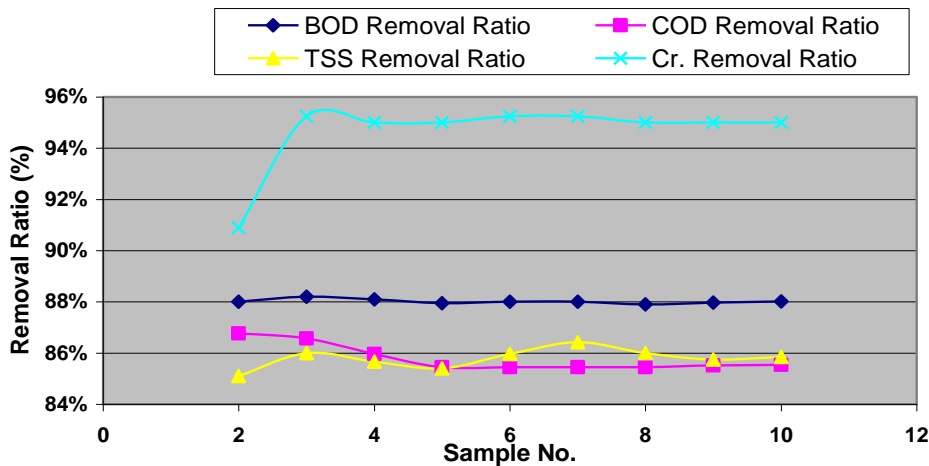


Figure (5) Removal Ratios by DBAF Unit.

The results for biological treatment using DBAF system shows that this treatment was very effective in BOD, COD, TSS Removal that achieves the target from the study. In general the DBAF treatment unit decreased the parameters loads that enter to it resulting very good removal efficiencies that meet the law limits for the disposal in the municipal sewerage system. **Figure (5)** shows the removal efficiencies for BOD, COD, TSS & Cr (chrome) by the DBAF system during the study period. Even the BOD & COD loads were high than domestic sewage but the DBAF unit had succeeded in removing it by

average removal ratios 88.05% for BOD that gives effluent concentration average 89 ppm and 85.50% for COD that gives effluent concentration average 160 ppm and both values are less than the permissible limits to dispose to the sewerage network of the city.

Also, it can be noticed that the BOD & COD effluent concentrations have small variations even the influent has big variations which resulted that the DBAF system can meet high organic loads with no effect on its efficiency. The same achievement had been made with the TSS that also resulted good removal efficiencies in the DBAF system and produced effluent concentrations below the law limits. Even the TSS removal ratios seems to be affected badly with the increase of its influent concentration but it still with in limits and this mainly due to the pretreatment efficiency. The DBAF system succeeded also in Cr. removal due to the formation of flocs in the biological unit that collect all the rest Cr. impurities and also the produced salts due to the biological action that could act with the rest dissolved Cr. that easy their settling in the final sedimentation tank. These results prove the technical success of the DBAF system application for such type of industrial wastewater. This leads to a comparison with the traditional applied wastewater treatment for such type of industrial wastewater to illustrate the DBAF system suitability, reliability and its economy with comparison with other systems of treatment. For economical aspects, the DBAF system needs area for the study factory with all the preceding and followed units equal to 0.54 m²/m³/day the initial cost was 1000 L.E./m³/day of plant design flow. And the running cost

during the study period was varied between 0.90 – 1.20 L.E. /m³/day of the plant flow [17, 18]. The application of activated sludge process for such wastewater type need an area for the plant 2.0 m²/m³/day at least [16] with initial cost between 3500-4000 L.E./m³/day from plant design flow [16]. The daily running cost that covered the operating labors salaries, power consumption, spare parts & fuel and oils varied between 3.6 – 4.0 L.E. /m³/day [11]. The application of sequence batch reactor for such wastewater type need an area for the plant 1.0 m² / m³/day at least [10] with initial cost between 3000 L.E./m³/day from plant design flow. The daily running cost that covered the operating labors salaries, power consumption, spare parts & fuel and oils varied between 3.0 L.E./m³/day [11]. The application of trickling filter process for such wastewater type need an area for the plant 3.0 m² / m³/day at least [10] with initial cost between 4000 L.E./m³/day from plant design flow [16]. The daily running cost that covered the operating labors salaries, power consumption, spare parts & fuel and oils varied between 2.0 L.E./m³/day [16]. Figure (6) shows the comparison results between the DBAF system and the applied previously three technologies which used for tannery industrial wastewater treatment and

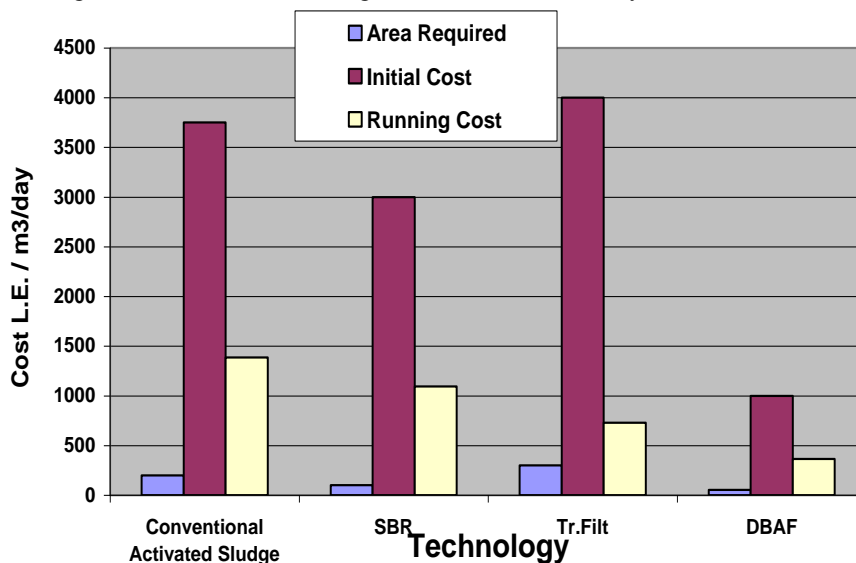


Figure (6) Cost Comparison with Old Used Technologies.

IV. CONCLUSIONS

The study concluded the following:

1. The success of DBAF system for treating such industry wastewater type with suitable removal efficiencies.
2. The DBAF unit reducing the required area to about 20% and reducing the required power supply to about 10% of the activated sludge system and minimizing the control needs to its minimal value.
3. The DBAF achieved less cost in initial by 50% and in running 60% with reducing 53% in total cost compared with activated sludge system which applied in this industrial wastewater treatment.
4. The results for chemical treatment using sodium sulphate addition followed by precipitation in settling tank shows

that this treatment was effective in achieving Cr removal ratio by 98.85%.

5. The chemical precipitation succeeded in decreasing the BOD & COD loads on the biological unit by ratios varied between 16.0 & 23.6 % for BOD and 26.7 & 39.4% for COD.
6. The TSS load was decreased by chemical precipitation to about 50%.
7. The DBAF system achieves high removal efficiency for BOD, COD, TSS & Cr ;the BOD & COD loads were high than domestic sewage but the DBAF unit had succeeded in removing it by average removal ratios 88.05% for BOD and 85.50% for COD.

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8. The TSS and Cr resulted good removal efficiencies in the DBAF system and produced good effluent concentrations.

REFERENCES

1. PACER consultants, "Environmental impact assessment for the Relocation of Tanneries To Robeiky. ", EEAA, Egypt, February 1999.
2. Assomac Serviizi Srl with Egitatlec Consultants," Master Plan & Conceptual Projections, New Leather District, Badr City- Egypt.", Ministry of Industry & Mineral Wealth, Cairo, Egypt, 2000.
3. Szyrkowicz, L., Kelsall, G.H. & De Faveri, M. "Performance of electrochemical reactor for treatment of tannery waste waters", <http://www.ovid.com>, USA, April 2007.
4. Kurt, U., Apaydin, O. & Gonullu, M. T., "Reduction of COD in wastewater from an organized tannery industrial region by electro-fenton process", <http://www.sciencedirect.com/> journal of hazduos materiel, USA, September 2006.
5. Bernal, A., Tapia, T., "Effects of tanneries wastewater on chemical and biological soil characteristics.", www.sciencedirect.com/www.elsevier.com/locate/apsoil , USA, January 2006.
6. Calheiros, C. S.C, "Constructed wetland systems vegetated with different plants applied to the treatment of tannery wastewater". www.sciencedirect.com, Journal homepage, www.elsevier.com/locate/watres, USA, February 2005.
7. Nemerow, N. L., "Industrial water pollution origins & characteristics", JAWWA, USA, fr p.334-340, USA, April 2002.
8. Mont, C., Costa, S., Williams, J. & Tamburghittp, E., "Phytoremediation of chromium by model constructed wetland ", www.sciencedirect.com, Biosiurce report, USA, October 2005.
9. Mont, C., Costa, S., "Reuse of tannery wastewater by combination of ultra-filtration & reverse osmosis after a conventional physical – chemical treatment". <http://www.sciencedirect.com/www.elsevier.com/locate/desalination>, USA, February 2006.
10. Roger, F., Mendoza, J.A., Roca, M.V. & Aleixandr, G., " Industrial wastewater treatment plants self monitoring", <http://www.ovid.com>, USA, January 2002.
11. Tadesse, L., Green, F.B., & Puhakka, J.A., "Seasonal & diurnal variations of temperature, PH & dissolved oxygen in advanced integrated wastewater pond system treating tannery effluent", <http://www.ovid.com>, USA, March 2003.
12. Wiegant, W.M. & JkALKER, T.J., "Full scale experience with tannery water management: an integrated approach", <http://www.ovid.com>, Italy, June 1999.
13. Juddin, S., Lutfullah, Kakakhel, Iqbal M. & Shah, A., " Electrolytic recovery of chromium salts from tannery wastewater ", www.sciencedirect.com, Journal of hazardous materiel, Turkey, March 2007.
14. Rashed, I., "Treatibility study for tannery wastewater by using cement dust & kaolin dust", Ain Shams University, Faculty of Eng. Journal, No. 3, Coiro Egypt, 2008.
15. EEAA Report, "Industrial wastewater plants for tannery industry.", <http://www.leather-egypt.com/profile.htm>, Egypt, December 2003.
16. AWWA Organization Manuals, "Industrial wastewater plants self – Monitoring Mannual.", AWWPCF, USA, fr p.5-62., 2002.
17. El Nadi, M. H., Nasr, N. A. H. & Sameh, S. M., " Simplified Equation For DBAF System In Wastewater Treatment", Ain Shams Univ., Faculty of Eng., Scientific Bulletin, vol. 38, No. 2, Egypt, June 2003.
18. El Nadi, M. H., El Sergany, F. A. & Sameh, S. M. M., "Performance of Dual Biological Aerated Filter (DBAF) as a Domestic Sewage Treatment Plant", Ain Shams Univ., Faculty of Eng., 1st Intr. Conf. for Environmental Engineering, Egypt, April 2005.

Fields of interest:-

Biological filtration, stabilization ponds, Anaerobic treatment, low cost technologies for sanitation, sludge dewatering and reuse, pollution control for water streams, sea water desalination, water flotation, Dynamic filtration, leak detection in water networks, fire fighting techniques, groundwater contamination & air pollution control.



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