

PILOT STUDY

on

Safe Disposal

of

Effluent & sludge through Bio remediation

Using EM Technology

at

Siddiq Leather Works

**EMRO / PTA
COLLABORATION**



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Table of Contents

Sr. #	Description	Page
1.	Site description	01
2.	Bases for undertaking the experiment at SLW	01
3.	What is EM and its composition	02
3.1	Invention of EM	03
3.2	Foundation of Asia Pacific Natural Agriculture Network	03
3.3	Foundation of EM Research Organization	04
3.3.1	Establishment of EM Research Organization Regional Office for Middle East & Central Asia, Lahore, Pakistan	04
3.4	Areas of research and application	04
3.4.1	Agriculture	05
3.4.2	Animal husbandry	06
3.4.3	Environmental pollution	06
3.4.3.1	Deodorization at a waste treatment plant	06
3.4.3.2	Deodorization from kitchen garbage processing	07
3.4.3.3	Deodorization at a livestock farm	07
3.4.3.4	Conversion of petroleum sludge into bio fertilizer in Pakistan	07
3.4.3.5	Conversion of tannery sludge into bio fertilizer in Pakistan	08
3.4.3.6	Reduction in the concentration of pollutants in the tannery's effluent	08
3.4.4	The future / potential of EM	08
4.	Collaboration of EMRO / PTA / SLW for research	09
5.	Material and methods	09
5.1	Preparation of EM extended	10
5.2	Methodology of application of EM to the Effluent	10
5.2.1	Existing primary treatment facilities at SLW	10
5.2.1.1	Screening	10
5.2.1.2	Equalization, sedimentation and sludge lagoons	11
5.2.2	Application of EM to the effluent	12

5.3	Reaction place and period for EM	12
5.4	Deodorization	13
5.5	Treatment of tannery's sludge with EM	13
6.	Results and discussion	15
6.1	Effluent sampling and analysis by SLW laboratory	15
6.1.1	Shutdown of agitators and aeration system	16
6.2	Effluent sampling and analysis by PTA, Lahore	17
6.3	Effect of increased reaction period between EM & effluent on the reduction of pollutants	19
6.4	Results of deodorization	21
6.5	Results of raw sludge and EM treated sludge	21
6.5.1	Nutrients status of EM treated sludge (bio sludge / bio fertilizer)	22
7.	Shortcomings	23
8.	Conclusions	23
9.	Recommendations regarding use of bio sludge / bio fertilizer.	23

Siddiq Leather Works

Bio remediation of effluent & sludge

Using EM Technology

1. Site description.

Siddiq Leather Works (SLW) was established in 1947 at 13thKm Lahore-Sheikhupura road. Its annual production is estimated to be 15 – 18 million square feet finished leather. It has highly qualified staff of various disciplines. It has its own laboratory for analysis purposes. SLW is one of the modern tannery where latest leather production techniques are being used. SLW is fully cooperating with Pakistan Tanners Association (PTA), Lahore for the adaptation of cleaner production methods.

SLW is generating about 1000m³ effluent per day. At peak hours the effluent flow becomes 1500 m³ / day with a peak factor of 1.5. For this purpose 2 equalization tanks measuring 9.5m x 7.5m x 4.375m each having 250 – 260m³ water storage capacity each, one primary settlement tank of 330m³ capacity, effluent decanter of 75 m³ capacity and 6 sludge drying beds of 40m² capacity each had been constructed and maintained well.

2. Bases for undertaking the experiment at SLW

Mr. Syed Ali, Principal Officer, EM Research Organization Regional Office for Middle East & Central Asia, Lahore, Pakistan invited Prof. Dr. Teruo Higa, the founder of EM Technology, Okinawa, JAPAN during 13th to 18th December 2002 to examined the progress made by this office as recently few study trials were completed on

- Bio remediation of oily sludge at Attock Refinery Ltd, Rawalpindi in collaboration with UNIDO / NCPC and ARL.
- Safe disposal of tannery sludge of Eastern Leather Company, Muridkey in collaboration with Pakistan Tanners Association and ELC, and
- Bio degradation of heavy metals in Himont Chemicals, Raiwind.

To make the visit more useful, fruitful and beneficial for Pakistan the arrangements were also made for lectures at NCPC, Rawalpindi and PTA, Lahore on use of EM Technology to resolve environmental pollution problems caused by sewage and industrial effluents and solid wastes. Thus, the lecture given by Prof. Dr. Teruo Higa to the Tanning Industrialists and PTA experts in the morning of 18th December 2002 and followed by a visit to SLW in the evening made the bases for carrying out an experiment at SLW. The details are as under:

Prof. Dr. Teruo Higa, University of the Ryukyus, Okinawa, Japan, the inventor of EM Technology, visited Pakistan as per arrangements made by Mr. Syed Ali, Principal Officer EMRO, Pakistan, from 13th to 18th December 2002. On 16th he visited Kasur Tannery Pollution Project in the afternoon. The problems relating to the odor and higher concentration of pollutants still existing were discussed by the project manager Mr. Salman Akhtar Khan. The solutions were given at site.

On 18th Prof. Dr. Teruo Higa gave a comprehensive lecture on the application of EM Technology on the bio remediation of wastewaters and solid wastes to the tanning industrialist and experts of PTA at Lahore. In the afternoon he visited SLW. The owner and higher executive / technical staff discussed the problems relating to odor, reduction in the concentration of effluent and disposal of sludge with Prof. Dr. Higa. He was confident that these problems could be solved by using EM Technology.

Now the question arises what is EM! what constitutes EM, what is the mechanism of its working and in which areas it has shown its success. To understand the EM Technology fully its biography is given in detail.

3. What is EM and its composition

EM stands for Effective Microorganisms. EM is a combination of various beneficial, naturally occurring microorganisms mostly used for or found in foods. EM is a liquid concentrate. It is produced in vats from cultivations of over 80 varieties of microorganisms. The microorganisms are drawn from 10 genera belonging to 5 different families. The most outstanding characteristic of EM is this that it includes both aerobic and

anaerobic species coexisting symbiotically in a most beneficially productive manner. EM contains beneficial tiny anabiotic microorganisms from 3 main genera: phototrophic bacteria, photosynthetic bacteria, lactic acid bacteria, yeast, fungi and effective actinomycetes. A positive feature of effective microorganisms is that their secretions contain large amounts of nutrients such as amino acids, organic acids, chelated minerals, antioxidants, polysaccharides and vitamins. These are beneficial to both plants and animals.

3.1 Invention of EM

Prof. Dr. Teruo Higa, the University of the Ryukyus, Okinawa, Japan started his research on effective microorganisms in 1968. With sustained and diligent research he produced the first batch of effective microorganisms, which eventually called EM in 1980. EM is available in liquid form. EM is produced through a natural process of fermentation and not chemically synthesized or genetically engineered. Thus, EM is neither a synthetic chemical nor a medicine. EM Technology can be considered a natural technology with beneficial effects in all the areas and has shown no adverse effects on plants, animals, humans and environments after decades of application. EM is recognized and classified as safe material to be used in the field of agriculture, poultry, fisheries, animal husbandry and environments to treat polluted water, solid wastes such as kitchen garbage, city wastes, petroleum oily sludge, tannery's sludge and to eliminate odor in industries of tanning and waste processing plant. Recently it has been used to eliminate odor at animal farms, at zoo and in bathrooms.

3.2 Foundation of Asia Pacific Natural Agriculture Network

In the beginning EM was used to enhance productivity of crops under conventional organic farming. The results were remarkable and the expansion process of EM Technology began in 1989 at the international Kyusei Nature Farming conference held in Thailand. The Asia Pacific Natural Agriculture Network was formed in order to scientifically validate the technology of effective microorganisms and to enhance its use in the region. This network, which included 13 countries ranging from the west coast of the United States of America through Asia to Pakistan developed the mandate to establish an international program for promoting research, education and extension of nature farming with EM Technology.

3.3 Foundation of EM Research Organization

To demonstrate the amazing potential of EM and to assist in resolving problems relating to almost all the areas EM Research Organization was founded in 1994 in Okinawa, Japan. Since then EM Research Organization promotes and disseminates EM Technology all over the world through its regional branch / liaison offices, Joint venture companies, NGO, NPO, affiliates and local Governments. EM Research Organization has a team of over 100 researchers around the globe conducting EM research in different fields to uncover viable solutions for existing environmental and health problems.

3.3.1 Establishment of EM Research Organization Regional Office for Middle East & Central Asia, Lahore, Pakistan

EM Research Organization Inc., Okinawa, JAPAN established its Regional Office for Middle East & Central Asia at Lahore, Pakistan during June 2001. It is headed by Mr. Syed Ali as Principal Officer. The research activities are carried out with a team of qualified personnel having M.Sc and Ph.D degrees. EM Research Organization is responsible for:

- carrying out research using EM Technology in preparation of bio active organic manures to maintain the fertility of the land to increase yields of various crops,
- carrying out research to establish formulae to be applicable in the areas of agriculture, horticulture, floriculture, fisheries, poultry and animal husbandry,
- undertaking research to resolve problems relating to environmental pollution caused by sewage and all types of industrial effluent and solid wastes, and
- demonstrating the application of EM for deodorization especially in tanneries as well as of sewage water.

3.4 Areas of research and application

Today, EM Technology has extended its activities to over 116 countries, where it is being used in the field of agriculture, fisheries, poultry, animal husbandry and environments such as recycling of sewage water, city wastes and kitchen garbage. Of 116 countries EM is being manufactured in 45 countries.

Recently EM Technology has shown its potential to bio remediate the oily sludge of petroleum refineries and the waste sludge of tanneries converting these into bio sludge and finally into bio

fertilizer. EM Technology has proven its success to treat effluent of tanneries by reducing the concentration of pollutants and eliminating the pungent awful stench.

3.4.1 Agriculture

EM Technology has brought a major revolution in a number of seemingly diverse areas. EM Technology is effecting significant and on going changes in agriculture. It has increased not only the yield but also improved the quality of the produce. In Japan the average yield of rice has been increased from 540 kg to 840-9000 kg / 1000 m². The cucumber plant grown with EM produced 4 – 5 cucumber per node instead of one only. In South America, Brazil has been enthusiastically focusing on EM as a way of breaking free from the destructive slash-and-burn farming methods which have grown up there, and of simultaneously protecting the natural environment of the Amazon Basin. As a result Brazil is currently the world's largest consumer of EM. Brazil's monthly production capacity of EM is over 700 tons. USA, Canada, China France, Russia, Germany, Holland, Japan, Australia, Spain, Argentina, Malaysia, Kenya, Syria, Egypt, Pakistan, India, Sri Lanka, Colombia, Vietnam, Taiwan, Korea, Philippines, Denmark, Poland, South Africa, Sudan, Lebanon, Indonesia, Thailand, New Zealand, Peru are producing and using EM in various fields. On the other hand in 71 countries EM is being used but not manufactured, among these are Chili, Cambodia, Cuba, Sweden, Namibia, Angola, Mali, Portugal, Greece, Yugoslavia, Saudi Arabia, Nigeria, Afghanistan, Zimbabwe, UAE, Mexico, Hungary, Finland, Congo, Ghana, Morocco, Turkey, Iran, Qatar, Italy, Austria, Israel, and Venezuela, etc.

In Hawaii EM (1: 500) was sprayed on Macadamia Nuts trees at Cordoza farm weekly and EM Bokashi was applied around the base of each tree along with EM extended application. EM application improved the health of the trees. EM treatment increased not only the size of the flowers but also caused the formation of clusters of macadamia nuts on the branch instead of only single nut.

In Waliua, Oahu U.S.A. the Dole Food Corporation applied EM Bokashi around the base of 2 years old grape fruit trees and EM (1: 1000) was sprayed over the entire plants weekly. EM increased the

quality and quantity of grape fruits. It also prevented the insect attack.

3.4.2 Animal husbandry

A ranch in America experienced a high incidence of deformity among its cattle. Investigations showed that the deformities were related to the underground water supply on the ranch. The cattle were drinking this underground water, which was found to be loaded with heavy minerals. EM was introduced to the wells containing this very groundwater. In a short space of time it was noticed that the birth of deformed young dropped away surprisingly.

3.4.3 Environmental pollution

EM resolves problems of environmental pollutions with two types of microorganisms. Zymogenic EM produces antioxidants and certain synthesizing strains of anaerobic microorganisms love to consume contaminants and pollutants. The photosynthetic bacteria, which play central role in EM, are able to tolerate extremely high temperature, in certain cases temperatures in excess of 700°C. The use of EM has purified the wastewater in the public library in Gushikawa, a city in Okinawa, Japan. The effluent has been treated with EM, which has purified it to such a degree that it can safely be used for drinking purposes. The use of EM has caused a lot of savings. EM Technology is being used to banish odors in bathrooms and showers as well as to remove the contaminated and malodorous build-up inside pipes.

3.4.3.1 Deodorization at a waste treatment plant

In Switzerland, the Olfar Technology of Switzerland developed a plant with finer system for handling 5 - 20 tons of waste per hour. It is capable of disposing of discarded and waste items. This recycling operation was capable of dealing with a huge miscellany of items ranging from scrap metals like aluminum, iron and steel as well as plastics and vinyl's, waste paper and textiles of all kinds to kitchen waste, food scraps and other organic substances. The entire accumulated mishmash of waste was finely pulverized and then separated for recycling by means of a most advanced sorting and processing procedure. There was, however, one serious drawback to all of this: the sorted and processed waste gave off the most pungent and awful stench. Despite the fact that ozone sterilization was being used midway through the process to counteract the

smell. The stench itself was bad enough, but the ozone used in the sterilization process was downright dangerous. Ozone is a virulent carcinogen and as such potentially life-threatening. EM was introduced into the system at one of the earliest stages of the operation. EM was sprinkled on to the waste materials right at the start of the pulverization process before entry into the crusher. EM acted as a very powerful deodorant and eradicated the terrible stench completely as if by magic. EM further enabled the Swiss recycling operation to do away with the dangerous process of ozone sterilization and improved the running efficiency of the machinery.

3.4.3.2 Deodorization from kitchen garbage processing

Kani City, central western part of mainland Japan, has been exceptionally successful in its use of EM Technology to process kitchen garbage since 1992. The associated unpleasant smell produced by the saprogenic or putrefactive bacteria has been completely eliminated by the use of EM.

3.4.3.3 Deodorization at a livestock farm

The use of EM has banished the unpleasant odor coming from livestock farms. Offensive odors coming from livestock farms are generally caused by admixture of among other things ammonia, hydrogen sulfide, trim ethylamine and methylmercaptan. These substances just happened to provide substrate for the microorganisms in EM, who go to it and gobble them up, thereby effectively eradicating them.

3.4.3.4 Safe disposal of petroleum oily sludge as bio sludge / bio fertilizer in Pakistan

In Pakistan EM Research Organization, Lahore has carried out research in collaboration with NCPC on the bio remediation of oily sludge of Attock Refinery Ltd in October 2002. The oily sludge was converted to bio sludge with the use of various EM products and finally by mixing with equal quantity of dried soil it was converted to a bio fertilizer. Agricultural trials are under progress. The heavy metals in the sludge were diminished to a certain extent. Treatment of 600 tons of oily sludge at large scale with EM Technology is under consideration by the ARL dignitaries.

3.4.3.5 Safe disposal of tannery's sludge as bio sludge / bio fertilizer in Pakistan

EM Research Organization Lahore, Pakistan has completed research trial on effluent and sludge treatment with EM products in collaboration with Pakistan Tanner Association Lahore. The tannery sludge of Eastern Leather Company was changed to a powdery farm material, was named as bio sludge / bio fertilizer because of its richness in macro and micronutrients. It is worth mentioning that Cr was reduced from 50 000 ppm to 312 ppm in the sludge. The sludge of Siddiq Leather Works (SLW) was also treated and it changed into a powdery material. Cr was reduced to nil to 1.054% as per analysis of Soil and Water Laboratory, Agriculture Department, Government of Punjab and Environmental Sciences Laboratory, PTA, Lahore respectively. At ELC premises rice crop was grown with the application of bio sludge and EM irrigation and EM spraying. The results were satisfactory.

3.4.3.6 Reduction in the concentration of pollutants in the tannery's effluent

The effluent of SLW was also treated with sprinklers to eliminate odor and with EM extended to reduce the pollutants. The results were encouraging. On the same lines a project has been submitted to UN / UNIDO Islamabad to cater the problem still existing at the Kasur Tannery Pollution Control Project (KTPCP). The project is aimed to eliminate odor at the common effluent pretreatment plant, Kasur and to reduce the concentration of pollutants.

3.4.4 The future / potential of EM

In short application of EM Technology has the potential to contribute significantly to the general improvement of health and to sustain this in a number of ways by affording greater environmental protection and ensuring an economic food supply of safe, high-quality foods through its use in agriculture, and by solving problems of environmental pollution by means of large scale recycling operations, which would simultaneously reduce wanton use of precious natural resources.

The list of beneficial applications of EM is endless as what the human beings consider contaminated, offensive and malodorous is the food of the microorganisms in EM. Thus, there is no limit to

the potential applications of EM Technology. Hence the future of the world lies in the use of EM for controlling pollution problems.

4 Collaboration of EMRO / PTA / SLW for research

EM Research Organization, Lahore cooperated already with PTA in carrying out research on the sludge of Eastern Leather Company, Muridkey. The sludge changed into bio sludge / bio fertilizer, applied to the rice crop and satisfactory results were obtained.

For carrying out this piece of research at SLW a meeting was held in the office of Mr. Asif Mahmood (B.Sc Elec. Engg), Maintenance Engineer, SLW on the procedure and methods of the experiment. Mr. Syed Ali, Principal Officer and Dr. Mushtaq Ahmad, Tech. Officer, EM Research Organization, and Mr. Hasan Ahmad, Environmental Engineer, PTA, Lahore attended the meeting. It was decided that EMRO will arranged all the EM products and sprinkling and dozing units. PTA will help in carrying out the experiment, collect samples and get them analyzed. SLW will provide material such as plastic tanks, drums, buckets, labor and other facility needed at the site.

5. Material and methods

The team of EM Research Organization accompanied by Hasan Ahmad, Environmental Engineer, PTA visited SLW on 16th January 2003. A detailed survey of the area, where equalization tank, sedimentation tank, decanter and sludge lagoons are located, was carried out. An estimate for the material required for the preparation of EM solutions and equipments needed was prepared. The Maintenance Engineer, SLW agreed to provide plastic tanks of 1 ton capacity each, plastic buckets, water rubber pipe, clips and labor as per requirements.

5.1 Preparation of EM extended

On 31st January 2003 three plastic tanks of 1-ton capacity each were washed thoroughly by the labor of SLW. EM extended was prepared in these plastic tanks and were capped. About 72 hours were given to the effective microorganisms to propagate.



Preparation of EM

5.2 Methodology of application of EM to the effluent

The experiment on the effluent and deodorization started simultaneously.

The experiment on the effluent was conducted from 3rd to 11th February. It was started at about 09:00 hours and stopped at 18:00 hours daily. The officers of EM Research Organization, PTA and SLW worked continuously.

5.2.1 Existing primary treatment facilities at SLW

5.2.1.1 Screening

In SLW the effluent is collected in a network of small drains and finally it is allowed to flow into a medium size drain, which falls into the equalization tank. Before entry into the equalization tank the effluent is passed through a set of stainless steel sieves having different mesh openings. The solid wastes sticking to the sieves are cleared manually at regular intervals in order to let the effluent passed without any obstruction.

5.2.1.2. Equalization, Sedimentation tank and sludge lagoon

The equalization tank is provided with aerators and agitators. The effluent is kept for about 8 - 16 hours under constant mixing and aeration. The effluent is pumped out mechanically into the primary settlement tank (sedimentation tank), where it is kept at a relatively quiescent state. The settle able solids are allowed to settle. The supernatant effluent still loaded with contaminations is allowed to fall into the nearby open drain. The slurry from the sedimentation tank is pumped out mechanically into the decanter. From where after some period the slurry is pumped into the sludge lagoons. The beds of these lagoons have been provided with coarse sand to dewater the slurry. As soon as the water is drained out, the sludge flakes are formed and become handle able. These are removed from the lagoons manually and are disposed of indiscriminately in nearby places.



Sprinkling of EM in the equalization tank

5.2.2. Application of EM to the effluent

During this experiment (3rd to 11th Feb) a total quantity of 15m³ EM extended, prepared in installments as per requirements, was applied to the effluent.

To start with 1m³ EM extended was applied immediately to the effluent at a point in the medium size drain, where it has just reached after screening through the fine sieve, before entry into the equalization tank. After which a suitable quantity of EM extended was continued to be dripped daily from 09:00 to 22:00 hours at the same point in the medium size drain.



Application of EM

5.3 Reaction place and period for EM

The useful microorganisms were propagated in the EM extended prepared already 2 to 3 days before the application / dripping. The application of 1 m³ EM extended in the beginning provided basic doze of effective microorganisms to start and to boost bio remediation process. The continuous daily dripping of EM extended helped to continue, maintain and propagate the useful bacteria for the treatment of the effluent and to reduce the pollutants in the equalization tank because this is the first bio remediation place in the SLW. The aerators in the equalization tank are run for 16 hours a day. Thus, 16 hours is the maximum reaction period between effective microorganisms and the pollutants in the effluents and are closed for 8 hours at night.

The effluent containing solid particles had to be pumped into the sedimentation tank as and when its quantity increases in the equalization tank. The useful microorganisms not only reacted

with the pollutants in the equalization tank but also continued its working in the sedimentation tank, which retains slurry for maximum period. In the sedimentation tank the effluent remains at quiescent state. The sludge settles down slowly and the supernatant liquid still loaded with pollutants is continuously drained out and thrown into the nearby open drain, which carries it to the river Ravi.

To see the effect of increased reaction period between EM and pollutants the draining out effluent from the sedimentation tank was retained in 3 plastic tanks of 1m³ each. These tanks were kept for few days to anticipate the effect of working of EM and necessity of having a storage tank before the effluent is finally drained.

5.4 Deodorization

The experiment on deodorization of tannery's odor and effluent treatment was started simultaneously.

For this purpose EM extended was sprinkled on to the effluent of the equalization tank with the help of sprinkler and dozing units. These were run for about 9 – 10 hours daily. In the beginning a lot of problems were faced with respect to fixation of sprinkler, dozing unit and rubber pipes. A new rubber pipe of ³/₄ inch size had to be purchased, as the old rubber pipe was full with algae and other contaminations, which blocked the fine holes of the sprinkler. SLW Officers were very cooperative and rendered help to complete the experiment.

5.5 Treatment of tannery's sludge with EM

On 2nd February 100 liters EM extended solution was prepared in a plastic drum. It was made air tight and kept for the treatment of sludge.

On 4th February the weight of 1 square foot sludge was determined with electronic balance. Thus, the area required to weigh 1 ton of sludge was calculated. Accordingly one ton of sludge was removed from the sludge lagoon by four laborers. It was placed on a plastic sheet spread on the brick floor, mixed well with 500 Kg sand, 80 liters EM extended solution and 70 Kg Bokashi manually. A heap was made and it was covered with a plastic sheet to create anaerobic conditions. The EM treated sludge was examined every

week and the moisture contents were maintained at 30% with EM solution in order to provide sufficient moisture to the microorganisms for working.

On 14th March the sludge was thoroughly examined by the experts of EM and PTA. It was found that it has been completely fermented as it was giving a nice fermenting smell. The original cohesive nature of the sludge was changed to just powdery type. It was still not dry and was having about 10% moisture. The upper plastic sheet was removed and the sludge was allowed to dry in the natural sunshine.

The bio sludge was finally examined on 28th March by the PTA experts and a sample was taken for analysis. On 29th March the bio sludge was examined by the experts of EMRO. It was found that the sludge was converted into a bio fertilizer. The laborers were asked to store the bio sludge / bio fertilizer in the bags for further use in agriculture and floriculture.



Sludge lagoon



Mixing of EM



Anaerobic conditions



Activity of EM



Biosludge

6. Results and discussions

The success of EM to reduce pollutants in the effluent and in the sludge can only be judged with analysis of the treated effluent and sludge at various stages and at the final stage. For this purpose PTA and SLW did the sampling of the effluent and sludge at different stages of the experiment. The experiment on effluent was conducted from 31st January to 11th February 2003 and on sludge from 4th February to 29th March. The results on the treatment of effluent and sludge are discussed separately.

6.1 Results of EM treated effluent as reported by SLW

The sampling of the raw effluent and EM treated effluent was made by SLW-Chemist on 3rd, 4th, & 6th February from two points i.e. one from the point where effluent enters the equalization tank and the other from the point where clear effluent overflows from the sedimentation tank and enters into the main drain. The samples were analyzed by the Chemist of SLW laboratory. The results are given in table -1.

Table -1 **EM efficacy in eliminating pollutants in SLW effluent**
(Analysis carried out by SLW laboratory)

Sampling point & date		pH	TSS mg/l	TDS mg/l	Cl mg/l	S mg/l	SO ₄ mg/l	Cr mg/l
3.2.03	a	8.0	400	5600	142	92	1600	210
	b	7.5	200	5600	135	37	400	0.27
6.2.03	a	10.0	900	5900	57	320	1150	110
	b	9.0	300	4100	43	128	400	0.195
4.2.03	a	7.5	2400	4000	895	80	2000	178
	b	7.5	3600	2800	1065	26	700	0.346
10.2.03	a	7.5	100	1300	1200	---	288	38
	b	8.0	300	1800	750	17	493	13

a = sample taken at the entry point into the equalization tank (raw / untreated effluent)

b = sample taken from the point where the effluent overflows from the sedimentation tank and enters into the main drain (after treatment with EM)

The perusal of the data shows that on 3rd & 6th February, TSS (33 to 50%), SO₄ (25 to 35%), S (40%), Cl (75 to 95%) were reduced after treatment with EM products. Cr was minimized from 210 mg/l to 0.27mg/l on 3rd February and from 110mg/l to 0.195mg/l on 6th February.

6.1.1 Shutdown of agitators and aeration system

On 4th February there occurred a defect in the aeration system and aeration was blocked, thus the system had to be stopped at about 11:45 hours. The trial was continued to see the effectiveness of EM products under non-aeration. The data show that there was considerable decrease in the concentration of S (32%), SO₄ (35%), TDS (70%) but TSS & Cl concentration increased, it may be due to closing of aeration in the equalization tank. Cr was reduced from 178 mg/l to 0.346 mg/l.

On 10th February the results do not tally with the trend of effect of EM on the reduction of pollutants as shown on 3rd & 6th February. It may be due to some error either in the analysis or in reporting the results because it is simply unbelievable.

This trial is the first of its kind, which has been carried out on tannery effluent. It has provided rudimentary knowledge of effectiveness of EM products on the behavior of pollutants.

This trial does prove the effectiveness and efficacy of EM products meaning thereby that tannery effluent can be treated with EM to achieve the minimum concentration of pollutants with adjustment of quantity of EM corresponding to carrying load of pollutants in the effluents at various stages of production and increased reaction period between effective microorganisms and pollutants (provision of a new tank after the sedimentation tank for the effluent, which presently is being drained out).

As the total retention period (reaction period between EM products and pollutants) seems to be less in the equalization tank and sedimentation tank, it necessitates the provision of a new tank after the sedimentation tank for the draining out effluent for treatment with more EM to achieve the range of parameters given by NEQS.

6.2 Results of EM treated effluent as reported by PTA, Lahore

The PTA, Environmental Engineer, also made the sampling of the raw effluent and EM treated effluent on 6th and 9th February. A small quantity of the raw effluent from the medium size drain carrying SLW effluent before entry into the equalization tank was collected in a container after each 30 minutes during 24 hours starting from 09:00 to 09:00 hours. The effluent in the sampling container was mixed thoroughly and 1 lit of the effluent was taken in a plastic bottle for analysis. Similarly samples from the EM treated effluent at the point where it leaves the sedimentation tank were collected in a container after every 30 minutes. Having mixed the effluent of the container 1lit effluent was taken in a plastic bottle for analysis.

The raw effluent and EM treated effluent was analyzed by the laboratory of environmental sciences. The results are summarized in table -2.

Table –2 **EM efficacy in eliminating pollutants in SLW effluent**
 (Analysis carried by laboratory of environmental sciences)

Parameters	Date of sampling	Raw effluent	EM treated effluent	NEQS
COD mg/l	6.2.03	2664	1662	150
	9.2.03	1615	1151	
BOD** mg/l	6.2.03	1620	810	80
	9.2.03	1720	980	
TDS* mg/l	6.2.03	5480	7260	3500
	9.2.03	3180	4660	
TSS mg/l	6.2.03	920	380	150
	9.2.03	790	340	
SO ₄ * mg/l	6.2.03	684	606	600
	9.2.03	522	810	
S* mg/l	6.2.03	.224	2.48	1
	9.2.03	9.5	9.26	
Cr* mg/l	6.2.03	31	17.2	1
	9.2.03	19	25.8	
Cl* mg/l	6.2.03	2059	3499	1000
	9.2.03	100	2039	
Oil & grease mg/l	6.2.03	203	130	10
	9.2.03	297	53	
pH	6.2.03	7.94	7.98	6 - 10
	9.2.03	9.55	9.32	

* It is pointed out with great sorrow and pain that there is some serious error in carrying out analysis. The results given have put the results of previous experiments carried out in other countries and even in SLW in question. This necessitates that in future the samples must be got analyzed from at least three laboratories, though these are costly.

It is also worth mentioning that on 4th Feb the agitators and aeration system in the equalization tanks refuse to work. This also affected the results.

** BOD was determined by the Institute of Environmental Engineering and Research, University of Engineering & Technology, Lahore.

The perusal of the data reveals that the concentration of COD, BOD, TSS and oil & grease has decreased on 6th as well as on 9th February. On the other hand the concentration of TDS and Cl increased on both the dates while that of SO₄ and Cr increased on 9th Feb only. The effect of EM on S and pH is not visible.

The results do show a trend of the effect of EM on the reduction of pollutants in the effluent but the quantity of EM application is to be adjusted corresponding to the load of pollutants in the effluent.

Further research is needed at the laboratory of environmental sciences to verify the effect of different quantity of EM to minimize the known quantity of pollutants in the effluent to NEQS.

6.3 Results of increased reaction period between EM & effluent on the reduction of pollutants

During the experiments it was thought that enough time is not being provided to the effective microorganisms to react with the pollutants in the equalization tank as the effluent is to be pumped out into the sedimentation tank to accommodate the peak period effluent. To provide more time to EM for reaction with pollutants, two plastic tanks of 1 ton capacity each were placed near the sedimentation tank. These were filled with the effluent that was being thrown into the out going drain. The 1st tank was filled on 6th Feb and the 2nd tank was filled on 9th Feb. These were left open. On 12th Feb the supernatant liquid from the 2nd tank was transferred into the 3rd plastic tank and left open. It is pointed out that no EM was added into these tanks. The samples from these 3 tanks were taken on 17th and 22nd Feb and were analyzed in the laboratory of environmental sciences. The results are arranged in table -3.

Table –3. EM efficacy in eliminating pollutants in SLW effluent with increased reaction period

(Analysis carried by laboratory of environmental sciences)

Parameters	Date February	Tank –1	Tank –2	Tank –3	NEQS
BOD ₅ mg/l	17 th	300	525	465	80
	22 nd	225	480	457	
COD mg/l	17 th	1595	1662	1638	150
	22 nd	1388	1549	1536	
Cl mg/l	17 th	712	2295	2273	1000
	22 nd	696	2249	2329	
SO ₄ mg/l	17 th	970	866	804	600
	22 nd	920	728	710	
S mg/l	17 th	.24	3.5	6.0	1
	22 nd	.22	.32	7.74	
Cr mg/l	17 th	8.6	7.74	8.6	1
	22 nd	9.5	6.9	5.2	
TDS mg/l	17 th	3090	5810	6060	3500
	22 nd	2600	5660	5850	
TSS mg/l	17 th	360	20	50	200
	22 nd	310	80	50	
Oil & grease mg/l	17 th	167	143	77	10
	22 nd	70	130	113	
pH	17 th	8.1	8.5	8.5	6-10
	22 nd	8.3	8.6	8.7	

The perusal of the data show that the concentration of all the pollutants has decreased to various degrees when compared for 17th & 22nd in each tank and pH remained unaffected.

This gives the idea that EM must have been added to the 2 tanks where out going effluent was collected to increase the reaction period between EM and effluent, as it was not done in the present experiment. It must be noted for future experiments while dealing with such type of effluents.

It is imperative that the research must be continued to treat such types of effluents to arrive at a formula covering the combination of EM products and effluent.

6.4 Results of deodorization

The sprinkling of EM did helped in the elimination of odor partially in the micro atmosphere over the equalization tank as only one sprinkler was placed on to the effluent in the equalization tank. The sprinkler had to be fixed reverse. It did not show its working as per design although it was made in USA. The area covered by the sprinkling EM was about 1 meter in diameter, which was not sufficient at all as the total area of the equalization tank is 71.25 m². This was the first experiment of this kind. It provided rudimentary knowledge with respect to elimination of odor. It does show its positive effect. The experts of EM were confident that if proper and suitable sprinkling of EM were done the odor would have been eliminated completely.

6.5 Results of raw sludge and EM treated sludge

The samples from the raw sludge and from the bio sludge were taken by the SLW laboratory in-charge and by the PTA experts on 4th Feb and 14th & 28th March respectively. The samples were analyzed in the SLW Laboratory, Soil and Water Testing Laboratory, Agriculture Department and in the Environmental Sciences Laboratory. The results are given in table -4.

Table -4. **EM efficacy in eliminating Cr in sludge**

Sr. No	Analyzed by	Cr concentration (%)	
		raw sludge	EM treated sludge
1	SLW laboratory	5	3
2	Environmental Sciences laboratory	*	1.054
3	Soil & water testing laboratory	*	Nil

* The results are awaited.

The effectiveness of EM to reduce Cr concentration varies as per analysis data given by the respective laboratory. Cr concentration in the EM treated sludge varies from nil to 3.0%. This indicates the authenticity of the results of the laboratory and with that the efficacy of EM.

6.5.1 Nutrients status of EM treated sludge (bio sludge / bio fertilizer)

Soil and Water Testing Laboratory, Agriculture Department, Government of the Punjab provided complete analysis covering all the nutrients in the bio sludge. The results are tabulated in table-5.

Table -5. Nutrients status of EM treated sludge (bio sludge / bio fertilizer)

pH	EC mS/cm	CO₃ Ppm	HCO₃ ppm	Cl ppm	Fe ppm	Zn ppm	Mn ppm	Cu Ppm
7.7	14.6	Nil	73	305	70	1200	60	Nil

Ca %	N %	P %	K %	Cr %	OM %	C %	SO₄ %
0.12	0.11	0.07	0.20	Nil	12.1	7.0	17.4

The perusal of the data shows that the bio sludge / bio fertilizer is rich in micronutrients (Fe, Zn, Mn & Cu), which are essential for plant growth. The macronutrients (NPK) are almost equal to the concentration of these in the farmyard manure. The SO₄ contents are enough to react with Na to reduce sodicity of the land. HCO₃ contents will help to reduce pH of the soil with which up take of nutrients will be enhanced. Organic matter is sufficient to maintain the release of nutrients as per requirements of the crop.

The most dangerous constituent of sludge of the leather industry is Cr, which is dangerous for human as well as animal health. World Health Organization has prescribed limits of various heavy metals in the drinking water. According to the WHO standards for drinking water Cr is 0.05ppm. At least 5-10 liters / day of drinking water is the requirement of each person. This means it will add 0.25 to 0.5 mg of Cr daily to the human body. Now if 500 kg of bio sludge is applied to 1 acre of land and mixed with the upper 9 inches soil, the concentration of sludge will be 11gm / ft² (1 acre = 220 ft x 198 ft = 43560 ft²) meaning thereby that Cr contents, if 3% Cr concentration is taken in the sludge as given in table -4, will be 0.33gm / ft² or 0.33gm of Cr will be mixed with 27kg of soil (weight of ft² ploughed land). The crop grown will take up the nutrients along with Cr from 12mg Cr mixed with one kg soil. In this way the Cr contents in the eatable part will be the least and

will have almost no effect on the human health. This needs long-term experiments on various types of soils and crops.

7. Shortcomings

- It was found that the use of chemicals at various stages of leather production at a tannery always varies. Thus, the effluent being generated by a tannery from time to time differs in the concentration of chemicals and hence the pollutants. The concentration varies within short period and depends upon the quantum of production. It needs diligent research.
- The analysis must be carried out by the responsible personnel.
- EM products are imported from Japan. These become expensive with the payment of freight charges, taxes, duty and local transport charges etc. EM products can become cheaper if these are manufactured in Pakistan. The manufacturing plant is available with EM Research Organization and can be put into operation with heavy investment.

8. Conclusions

- The trial does prove the effectiveness and efficacy of EM in reducing the concentration of pollutants in the tannery's effluent.
- The reaction period has to be increased between EM and pollutants either in the equalization tank or in a tank constructed after the sedimentation tank.
- Research on the treatment of tannery's effluent with EM is proposed to be conducted at the micro level in the laboratory of environmental sciences under the supervision of PTA.

9. Recommendations regarding use of bio sludge / bio fertilizer.

On treatment with EM products the tannery sludge changes into a powdery material. It is named as bio sludge / bio fertilizer because of its richness in macro and micronutrients (see section 6.5.1). It is

also biologically active. It can be used in floriculture for growing various types of flowers. It can be applied in a ratio of 1:10 (one part of bio fertilizer and 10 parts of normal soil). The bio fertilizer be mixed thoroughly with the soil before filling the pots for growing flowers.

It can also be used to reclaim salt affected lands due to its fertility status. It can also be used for growing agriculture crop and in horticulture but long term experiment are needed to see its effects on the uptake of heavy metals by the eatable / consumable parts and their toxicity to humans and animals.