TECHNICAL PROPOSAL

for

SIX MONTHS PILOT PROJECT

ON

IN-SITU TREATMENT OF TANNERIES POLLUTION
ODOR, EFFLUENT AND SLUDGE
IN SIALKOT
USING EM TECHNOLOGY

EM RESEARCH ORGANIZATION

for

Middle East & Central Asia

Lahore, Pakistan.

Tel: 042-5303861

Email: dr.ali@emro.co.jp

URL:http://www.embiotech.org

TABLE OF CONTENTS

SIX MONTHS PILOT PROJECT
ON
IN-SITU TREATMENT OF TANNERIES POLLUTION
ODOR, EFFLUENT AND SLUDGE
IN SIALKOT
USING EM TECHNOLOGY

1. Introduction

In Pakistan the leather industry is the 3rd largest export-earning sector with an export income of over US $ 700 million and contributes about 35 million to the national economy. This is achieved from the production of more than 750 tanneries, located in clusters of Korangi (160), Kasur (237), Sialkot (235) and Lahore and Multan (130). For the availability of raw material Pakistan being an agricultural country possesses a well-established system of cattle breeding, have large livestock population and produces about 6.1 million hides (2.1 million cow hides and 4.0 million buffalo hides) and 36.5 million skins (22.7 million goat skins and 13.8 million sheep skins) per year.

The leather processing industry utilizes considerable quantities of organic and inorganic chemicals (may be toxic and/or harmful) and over and above large amounts of water. Thus, the leather production generates considerable quantities of effluent, sludge and solid wastes. Depending upon the 'production type' of tanneries (raw to finish, raw to crust, raw to wet blue, wet blue to crust and wet blue to finish) per one ton of raw skin/hide on an average about 50 to 100 m^3 of waste water and 45 to 150 Kg dried sludge are produced. Tannery effluent exhibits high values of the environmental pollution parameters i.e. BOD, COD, TSS, TDS, Sulfate, Chloride and Chromium etc. This very effluent is discharged into natural water bodies without any treatment, which causes severe degradation of environment and pollution of river water as well as ground water. Presently from 230 tanneries in Sialkot cluster about 9388-m^3/day effluents is being discharged into different drains and 50 tons/day sludge are dumped in the suburbs of tanneries indiscriminately.

The magnitude of pollution problems is increasing at an alarming rate. The pollution caused by 237 tanneries in Kasur cluster has been eliminated to a large extent with the implementation of Kasur Tannery Pollution Control

Project (KTPCP) with all its components but there still exists not only odor problems in the tanneries and at Common Effluent Pretreatment Plant (CEPTP) but also NEQS are not met in the effluent being discharged. The sludge since the operation (Oct, 2001) of CEPTP is being accumulated in the lagoons and the problem of its disposal is going to arise in the near future. This means this method to control tanneries pollution still possesses some shortcomings which are beyond the control this method. Recently EM Technology, developed in Japan, has shown its worth to overcome the sewage and industrial pollution*. The concentration of pollutants has been diminish to such an extent that the effluent and sewage water are being used for various purposes. The odor was also eliminated. It is new technology, details are given in respective section. This is the reason that a six months pilot project to eliminate odor, diminishing effluent pollutants corresponding to NEQS and conversion of waste tanneries sludge into bio fertilizer useful in agriculture is being proposed to be undertaken at 10 different tanneries of various type of production.

The EM Technology can be applied **in–situ** in the premises of individual tannery to eliminate odor and to treat effluent and sludge at sludge station without undertaking a big project like that of Kasur, a net saving of initial investment of over Rs. 1250 million and reduced running expenditure with added benefits of good atmosphere, effluent concentration corresponding to NEQS and useful bio fertilizer made from waste tannery sludge.

---

* 1. Saadat City Sewage / industrial wastewater treatment with EM Technology, December, 1997: the heavy metals were reduced to the tune of Cd 40% , Pb 90%, Cu 20%, Zn 99.9%, Ni 80% and Cr 98%. The project is in working condition and is being run successfully by the Ministry of Agriculture and Environments, Government of Egypt.

2. Oily sludge of Attock Refinery Ltd., Rawalpindi was treated with EM Technology for 2 months. The experiment was carried out in collaboration with NCPC. Heavy metals were reduced to large extent and the oily sludge was converted to a bio sludge and finally after mixing with dried soil into a bio fertilizer. The bio fertilizer is being used to grow vegetables at ARL area. Now 600 tons oily sludge of ARL is to be treated at a large scale to get rid of the pollution and the waste oily sludge.
3. EM reduced Cr from 50 000 ppm to 450 ppm in the sludge of Eastern Leather Company, Muridkey. The experiment was carried out in collaboration with Pakistan Tanners Association (PTA). The ELC sludge was converted to a powdery form and the same has been applied to rice crops successfully.

The statistics** of all the tanneries with respect to location, type of production, installed capacity, present production, area occupied and covered area is available and the same is discussed to understand various aspects of tanning in Sialkot cluster.

2. Location of Tanneries

Presently there are 230 tanneries scattered all around the city and suburbs from the location point of view these can be grouped into 10 different clusters. The details are given in table-1. The maximum tanneries (22%)have been found to be located in Malkey Kalan Head Marala road cluster (C-1), followed by Pul aik and Sambrial clusters (C-2 & C-4, 16% & 15% respectively).

Table-1: Tannery Clusters in Sialkot Sector

Name of Cluster		No. Of Tanneries	Percentage
Malkey Kalan Head Marala Road	C-1	51	22.17
Pul Aik	C-2	36	15.65
Defense Road	C-3	25	10.87
Sambrial	C-4	34	14.78
Pasrur Road	C-5	15	6.52
Daska Road	C-6	17	7.39
Khadim Ali Road	C-7	23	10.0
Small Industrial Estate	C-8	15	6.52
Neka Pura	C-9	6	2.61
Said Pura Road	C-10	8	3.48
Total		**230**	**100**

** Source: Cleaner Production Center, Allama Iqbal Town, Defence road Sialkot, Pakistan.

2.1 Tanneries by Production Type

Tanneries can be classified by 'production type'. These are as follows:

A. Raw to wet blue
B. Raw to crust
C. Raw to finish
D. Wet blue to crust
E. Wet blue to finish

The statistics with respect to production type is enumerated in table-2.

Table-2: Tanneries by production type

Type	No. of Tanneries	Type	No. of Tanneries
A	23	C	2
A-B-E	1	D	83
A-D	1	D-E	31
A-D-E	2	E	78
A-E	9	**Total**	**230**

The perusal of the data indicates that production type of wet blue to crust and wet blue to finish dominate (83%) in Sialkot cluster. It is followed by production type of raw to wet blue (10%). It is worth mentioning here that more than 90% tanned hides and skins are purchased from the tanneries of Kasur cluster to augment the production type industry in Sialkot cluster. The tanning industrialists of Sialkot cluster have the advantage of dry port for export purposes over the Kasur cluster.

3. Tanneries Production

The available data on production capacities of each cluster reveals that the annual present production of 230 tanneries comes to 29147 tons, thus the daily average production of all 230 tanneries is estimated to be about 127 tons. The production of all the industries can be increased if these are run according to their installed capacity, thus the production of 297 tons/day can be achieved. The production capacities of each cluster are given in Table-3.

Table-3: Production capacities of each cluster

Name of Cluster	Annual Present Production (Tons)
C-1	5,806
C-2	2,709
C-3	2,580
C-4	10,037
C-5	2,113
C-6	1,820
C-7	1,646
C-8	934
C-9	556
C-10	946
Total	**29,147**

The data of table-3 further indicates that 34 tanneries in C-4 dominate the production and its share is about 35% of the total as compared to 51 tanneries of C-1, which produce about 20% of the total production.

3.1 Production by Type of Industry

The production by type of industry is enumerated in Table-4. The perusal of the data indicates that 'types' C, D and E dominate in production in general. Type –'A' tanneries produce 3696 tons annually with its share of about 13% of the total production.

Table-4: Production by Type of Industry

Type of Industry	Annual Production (Tons)
A	3,696
A-B-E	1
A-D	840
A-D-E	480
A-E	2,625
C	5,430
D	5,949
D-E	3,265
E	6,861
Total	**29,147**

4. Area Wise Classification of Tanneries

The present 230 tanneries occupy a total area of 19,400 marlas (approximately 121 acres). The total area along with covered area (marlas) of each cluster is given in Table-5. The perusal of the data reveals that 51 tanneries of C-1 occupy only 11% of the total area as compared to 34 tanneries of C-4, which occupy about 37.5% of the total area. It is interesting to note that 36 tanneries of C-2 occupy only about 6% of the total area.

Table-5: Area Wise Classification of Tanneries

Name of Cluster	Area in marlas		Percentage
	Total area	Covered area	
C-1	2,180	879	11.24
C-2	1,149	642	5.92
C-3	1,837	1,201	9.47
C-4	7,269	2,867	37.47
C-5	2,222	882	11.45
C-6	2,832	573	14.60
C-7	615	321	3.17
C-8	539	318	2.78
C-9	237	156	1.22
C-10	521	269	2.69
Total	**19,399**	**8,109**	**100.00**

4.1 Land utilization by each cluster

Basically the land utilization in the tanneries depends upon the type of the operation being carried out and the volume of production. The land utilization in 10 clusters of Sialkot tanneries is tabulated in Table-6. The land, if available in excess, in each tannery can be used for in house treatments and Cleaner Production Techniques, which have come into force recently in order to reduce and minimize the parameters contributing towards pollution of water and land. Unfortunately the tanning industry of Sialkot is not practicing the techniques for cleaner production. It may take some period to make the industrialists more realistic and friendly towards pollution. The data further indicates that 71 tanneries are utilizing the area size between 1 to 2 kanals. It is further noticed that 197 tanneries are utilizing the area measuring up to 4 kanals. There are only 33 tanneries, which utilize more than 4 kanals area.

Table-6: Land Utilization in tanneries

Cluster	Up to 10 Marla	10-20 Marla	1-2 Kanal	2-4 Kanal	4-8 Kanals	1-2 Acres	2-4 Acres	4-8 Acres	8-16 Acres	Total
C-1	8	11	17	12	1	1	1			**51**
C-2	3	10	16	7						**36**
C-3	1	9	6	5	1	2	1			**25**
C-4	0	0	6	11	6	5	5		1	**34**
C-5	1	1	6	4	1			2		**15**
C-6	2	2	5	4		2	1		1	**17**
C-7	5	5	10	3						**23**
C-8	5	8	2							**15**
C-9		2	2	1	1					**6**
C-10			1	6	1					**8**
Total	25	48	71	53	11	10	8	2	2	**230**

5. Production of effluent and sludge

5.1 Effluent production

The tanneries utilize large amounts of water in processing the leather. Thus leather industries are known as for generating huge quantity of highly polluted effluent. The leather industry utilizes considerable quantities of organic and inorganic chemicals, which are toxic as well as harmful. It utilizes mostly soda ash, fungicide, chromium Sulfide, sodium Sulfate and lime during tanning operations. The chromium is utilized during tanning process to produce 'wet blue' hides and skins. In the raw hide/skin processing of the offered quantity of chemicals (except chromium) about 15% are consumed and the remaining unconsumed chemicals (about 85%) are either discharged into tannery effluent or partly goes into the sludge. In case of chromium about 70% of the offered amount is taken up by the hides/skins and about 30% remains unconsumed and goes into the effluent or into the sludge. The presence of chromium in the effluent as well as in the sludge is dangerous for all living animals and human beings.

The volume of discharged effluent from an individual tannery fluctuates throughout the day depending on whether pits or drums have completed their cycle and are being emptied. The water consumption in 10 clusters of 230 tanneries is enumerated in Table-7. The data indicate that the maximum effluent flow from the existing 230 tanneries in Sialkot cluster is 9388 m^3/day and is being thrown into the open drain indiscriminately.

Table-7: Production of effluent by each cluster

Name of Cluster	Max. Estimated water consumption (M^3)
C-1	1,248
C-2	538
C-3	719
C-4	4,702
C-5	631
C-6	529
C-7	348
C-8	223
C-9	206
C-10	245
Total	9,388

The data of Table-7 indicate that 34 tanneries located in C-4 discharge more than 50% of the total effluent and 51 tanneries of C-1 producing about 13.3% of the total flow. Presently all the existing tanneries of Sialkot Cluster discharge their effluent into the unlined drains along road alignment or over the ground, which ultimately accumulates in the adjoining low lying areas forming different shapes of ponds of various dimensions. Some of the drains fall into the local sewerage system and the others fall into the main drains, which ultimately find their way into the river. In this way, the effluent containing high amounts of salts and heavy metals inclusive of Cr (very dangerous for human health) contaminate the ground water and the river water. The polluted river water either seeps into the ground water, thus polluting the good quality of ground water, or carries the polluted water along its course. The polluted water entering the river is not diluted because the rivers in the Punjab remain dry for about 11 months period due to the after affects of Indus Water Treaty 1960. The rivers only get water during Moon Soon season. This is the reason that most of the village people get serious diseases, which become the headlines of daily Newspapers. If this state of affairs continues no wonder the people will be in the grip of serious diseases, even more dangerous than Hepatitis and Cancer. Something shall have to be done to save the natural resources, land and water, and the poor people, which are already in the grip of high prices hike.

5.1.1. Effluent Production by type-wise industry

The production of effluent by type-wise industry has also been estimated by using the water consumption data. The water consumption for each type of leather industry varies and the same is given in table -8. The perusal of the data indicates that the maximum quantity of water 50 liters / kg of production is consumed by the raw to finish 'type of production'. It is followed by raw to crust (45 lit/kg) and raw to wet (30 lit/kg).

Table-8 Production of effluent by each 'type of production'

Type of production	Process	Water consumption lit/kg of production
A	Raw to Wet	30
B	Raw to Crust	45
C	Raw to Finish	50
D	Wet Blue to Crust	15
E	Wet Blue to Finish	20

5.2 Sludge Production

The leather industry not only produces highly polluted effluent but also generates considerable quantity of solid wastes. On an average about 150 kg of dried sludge per 1 ton raw hide is produced, being maximum (180 kg) in the 'type of production' of raw to crust and minimum (45 kg) in the wet blue to crust type of production. The quantity of sludge generated by 'type wise production' is enumerated in table-9.

Table –9: Generation of Sludge by type wise Production

Type of Production	Sludge production (kg/1000 kg hide /skin)	
	Wet	Dried
A: Raw to Wet Blue	445	160
B: Raw to Crust	495	180
C: Raw to Finish	500	150
D: Wet Blue to Crust	145	45
E: Wet Blue to Finish	160	50

In the leather industry about 25% of the weight of rawhide results in the finished leather whereas the remaining 75% becomes a solid waste. Of the total solid waste being generated by the tanneries about 50% is utilize by the down stream users for extracting by products such as fats for the manufacture of soap, glue, gelatin, chicken feed and fish meal, and the remaining 50% of the total is dumped indiscriminately outside the tanneries in the nearby waste lands or vacant plots. Thus, polluting the environments and ultimately land and water resources.

National Environmental Quality Standards (NEQS) have been formulated for the effluent of leather industry but the same are under consideration for the sludge. The leather industry is already facing problems for the disposal of sludge as uptill now no arrangements either from the Govt. or from the leather industrialists / Pakistan Tanners Association have been made. The problem is expected to grow further and complicated with the enforcement of NEQS for the sludge.

Keeping in view the present production and the installed capacity of the tanneries the estimation of sludge generation according to the 'type of production' is given in table–10. The perusal of the data reveals that about 21,966 tons per year of sludge (≈ 80 tons of sludge / day) will be produced at maximum installed capacity as compared to 7,083 tons present production (≈ 26 tons of sludge / day). This means that about 80 tons per day of sludge will have to be handled and arrangements for its disposal shall have to be made in future in the suburbs of tanneries of Sialkot cluster as compared to the present dumping of about 26 tons of sludge / day. This situation warrants a wise decision on disposal of sludge as such with all its pollutants or on disposal / reuse after bio remediation using EM Technology with which heavy metals are eliminated /diminished to an acceptable extent, which if used as bio fertilizer for raising crops or as soil amendment to improve salt affected lands in such quantities, which are not dangerous and harmful to the animals as well as to the human beings if the crops or food is consumed by them, but such quantity are to be found out by experiments under various conditions.

Table-10 **Type wise production of sludge at present & at installed capacity**

Type of Production	Present production (Tons)	Sludge produced / tons production capacity (ton)	Estimate of sludge production at present rate (ton)	Installed capacity (ton)	Max. possible annual production (ton)*	Estimate of annual sludge production of max. rate (tons)	Overall estimate of annual production (tons)
A	3696	0.445	1645	74	20345	9054	5349
A-B-E	1	0.545	1	3	825	450	225
A-D	840	0.490	412	4	1100	539	475
A-E	2625	0.495	1299	31	8651	4282	2791
C	5430	0.500	2715	32	8800	4400	3558
D	5949	0.045	268	65	17758	799	533
D-E	3265	0.050	163	32	8764	438	301
E	6861	0.050	343	67	18312	916	629
Total	29147		7083	315	86755	21966	14525

- based on 275 working days

---

6. Effluent composition

The effluent carries a number of salts. The nature and composition of offered amount of various salts in processing the raw leather to its finishing stage is partly consumed by the leather and the remaining unconsumed salts / chemicals form solvate and are found in the effluent or in the sludge. The contribution towards pollution of the environments, land and water depends upon the load of harmful salts / heavy metals in the effluent and sludge. The chemical composition of pollutants in a typical tannery effluent is enumerated in table-11. For comparison purposes NEQS values are also given. The perusal of the data especially on Cr indicates that it is really in high quantity. Its removal is evident and necessary from viewpoint of health of animals and human beings.

Table-11 Chemical Composition of Tannery Effluent and NEQS Values

Parameters	Effluent	NEQS
pH	7-9	6-10
Total suspended solids, TSS (mg/l)	2700-3000	150
Total dissolved solids, TDS (mg/l)	6000-7000	3500
Sulphate, SO_4 (mg/l)	800-1000	600
Chloride, Cl (mg/l)	3000-3200	1000
Chromium, Cr (mg/l)	10-30	1.0
Biological Oxygen Demand,BOD_5 (mg/l)	1200-1350	80
Chemical Oxygen Demand, COD (mg/l)	3500-4000	150

7. Sludge Composition

The wastewater coming out of a tannery is loaded with different types of salts along with various sizes of solid particles, which finally are to form the sludge. The majority of the tanneries throw the effluent containing sludge particles into the open drains without considering any degradation of environment and pollution of air, land and water. With the passage of time these drains are blocked due to the settling of sludge particles and the effluent creates havoc all around. Thus, there exits no systematic practical method of sludge disposal. The situation is worsened day by day. Perhaps the time has come to think upon the proper and scientific disposal of not only sludge but also effluent. In order to understand the contribution of sludge towards pollution the chemical composition of tannery sludge is given in table -12. The contents of Cr are very high. The Cr is dangerous for men & animals. Cr is absorbed through both the respiratory and gastrointestinal tracts. Water and serum soluble chromates are absorbed into the blood system.

Table-12 **Chemical composition of tannery sludge from sedimentation tank.**

Parameters		**Quantity**
N	% by weight	5
Sulfide	-do-	Nil
Sulfate	-do-	2.3
Calcium	-do-	4.63
Lime	-do-	11.60
Cl	-do-	22.62
P	-do-	0.2
K	-do-	0.063
Organic matter	-do-	57
Cr	-do-	5
C/N ratio	-do-	6
Zn	ppm	190-220
Fe	ppm	9000-9500
Mn	ppm	240-280

8. Necessity of in-situ bio remediation of tanneries wastes with EM Technology

The existing 230 tanneries of Sialkot cluster are no doubt providing raw material for various items being used by the human beings and foreign exchange earnings to Pakistan but at the same time have become the source of environmental degradation as well as health hazards for the animals and human beings. Sialkot city with its suburbs is suffering from air, surface water, ground water, river water and fertile land pollution. One can very easily imagine and understand the pollution caused by about 9400 m^3 / day of heavily polluted tannery effluent. The problem of pollution of air and water and health hazards will be multiplied by more than 3 times if the tanneries are run at the maximum installed capacity. The problem must be solved on priority bases without losing any time. The population of Sialkot is already suffering from respiratory disorders, skin infection related diseases, diarrhea / dysentery and typhoid. Hepatitis is increasing at an alarming rate.

Presently there is no common effluent treatment plant and sludge disposal site in Sialkot cluster like that of Kasur. Further, in most of the tanneries the land is not available for the establishment of individual treatment plant, in house treatment facilities and implementation of cleaner production techniques. Therefore, very little improvement is possible as it is hard to acquire the required land adjacent to tanneries for establishment of treatment plants and implementation of cleaner production techniques.

This necessitates the importance of in-situ bio-remediation of tannery wastes and in each tannery possibilities of installation of equipments for the application of EM Technology are to be explored so that the problem of effluent and sludge is solved before it leaves the premises of a tannery.

In Punjab for the first time in the history, the huge pollution caused by the over 230 tanneries in the vicinity of Kasur city became the headlines of daily Newspapers and even the then Prime Minister of the Islamic Republic of Pakistan had to visit the polluted area spreading over 400 acres of land and addressed a gathering of over 3,00,000 people. The action taken was accelerated and Kasur Tannery Pollution Control Project with components of construction of Common Effluent Pretreatment Plant (CEPTP), civil works, equipments, purchase of land and technical assistance at a cost of Rs. 424.76 million was approved by ECNEC in February, 2002. The cost estimated for CEPTP was Rs. 263.3 million. In fact this project was the first

of its kind in Punjab. One year has been completed. The present running cost of one year comes to about Rs. 25 million. The NEQS requirements are still to be met in case of discharged effluent (sludge is being accumulated in sludge lagoons for the last one year). The parameters TDS (2.5 times), COD (6 to 7 times), Cl (4 times), SO_4 and BOD_5 (7.5 time) show higher concentrations as compared to the NEQS. The Cr and TSS values of outlet-effluent are within NEQS values (Table -13).

Table-13 Kasur Tannery Pollution Control Project*
Waste water Analysis Results**

Sampling point		pH	TSS mg/l	TDS mg/l	BOD5 mg/l	COD mg/l	Cl mg/l	S mg/l	SO_4 mg/l	Cr mg/l
at inlet	a	9.19	2733	12250	1440	3750	7076	192	2450	53
	b	9.16	2741	12750	1140	3683	5602	195	2283	47
after settling tank	a	7.98	708	8000	520	1583	4098	87	1809	6.4
	b	8.04	733	8166	442	1466	3588	79	1691	6.4
After treatment	a	8.29	72	9416	287	1000	4445	24	909	0.95
	b	8.28	73	9167	277	983	4071	30	894	1.05
NEQS		6 to 10	150	3500	80	150	1000	1.0	600	1.0

* Source: office of G.M. Kasur Tannery Waste Management Agency, Depalpur road, Kasur.

** The original table was too long and to show a trend an average of 6 days data was calculated and reproduced here.

a= the sample was collected at 08.45 am daily on 2nd, 3rd, 4th, 9th, 10th, & 11th December 2002. The data given in column 'a' is the average of 6 days data.

b= The sample was also taken at 08.45 am daily on 12nd, 13th, 14th, 16th, 17th, & 18th December, 2002. The data given in column 'b' is the average of 6 days data.

At inlet means effluent coming from the tanneries and it is without any treatment.

In simple words the pollution problem has been shifted from Kasur city to other areas where effluent carrying Pandoki drain falls into the river Sutlej that further contaminates the sweet ground water.

Cleaner Production Center (CPC), Sialkot is working almost on the same lines as of Kasur Pollution Control Project to handle the tanneries pollution. Not only this CPC, Sialkot has a proposal to shift 196 tanneries to Wazairabad-Sambrial Road Cluster already having 34 large tanneries located relatively away from the city center to form a tannery zone in order to establish common effluent treatment plant including effluent collection system. It may cost Rs. 1575 million* with same shortcomings being face at Kasur.

In both the projects of Kasur and Sialkot clusters it has been considered enough to establish solid waste disposal system and earmarking of an area for solid waste disposal. The solid wastes of tanneries are dumped in an earmarked space, compacting it with bulldozers and then covering it with soil. The sludge is still lying in lagoons in Kasur Project and the problem of its disposal is still to be faced at Kasur. The sludge in addition to other pollutants contain 5% Cr which is critical from the point of view of dumping or use in agriculture. This means that the pollution problem of effluent and sludge is still hanging and if examined critically remains unsolved, even after spending Rs. 425 million at Kasur. The same results may be expected after implementation of a project at Sialkot on similar lines of Kasur pollution project.

Now the question arises what to do? Twenty first century has started and it is the century of application of modern knowledge, inventions, findings and techniques achieved with science during 20th century. One method to control pollution caused by tanneries effluent and sludge is already under test at Kasur and shortcomings still exist. Another method is to control pollution with the help of effective microorganisms (EM), which are easy to apply and handle without any danger of any kind.

Thanks to Prof. Dr. Teruo Higa, University of the Ryukyus, Okinawa, Japan, who with diligent research invented effective microorganisms (EM) whose application was tested and found useful in agriculture, poultry, livestock, fisheries. Their effectiveness and efficacy for bio-remediation of sewage water and industrial wastes has recently been recognized and established.

8.1 What is EM !

EM is an abbreviation of effective microorganisms. EM is a combination of various beneficial, naturally occurring microorganisms mostly used for or found in foods. It contains beneficial organisms from 3 main genera: phototrophic bacteria, lactic acid bacteria and yeast. These effective microorganisms secrete beneficial substances such as vitamins, organic acids, chelated minerals and antioxidants when in contact with organic matter.
There are aerobic and anaerobic bacteria. The anaerobic microorganisms are lactobacillus bifidis and other various strains of intestinal bacteria, zymogens (zymogenic microorganisms or fermenting bacteria), sulfur / sulfate reducing bacteria, chlorobacteria and brown green photosynthetic bacteria. In the group of aerobic bacteria included are blue green algae, azotobacters, bacillus sp. (bacillus subtiles) acetobacters, methanogens and sulfur bacteria,
Lactobacilli and photosynthetic bacteria, which are important components in the EM formula, belong to the anaerobic group. They are now recognized as being effective in the control of diseases.
The EM Technology, with a combination of all the products of EM in proper proportions to be applied at definite times and intervals, is a tool with which desired results with respect to purity and decomposition of pollutants inclusive heavy metals are possible to be achieved through bio-remediation of the matter. EM controls the propagation of the harmful microorganisms that cause contamination and prevents oxidation effectively with the production of antioxidants. Actually two kinds of effective microorganisms coexist within EM: zymogenic microorganisms and synthesizing microorganisms. Decomposition achieved with Zymogenic microorganisms reduces organic matter to a soluble state. This is the best food for the bacteria in EM and they readily consume it. Large quantities and wide variety of both organic and amino acids as well as antioxidizing enzymes are produced. This makes for the EM easy to bring about break down and decomposition of chemical substances, which are a major cause of pollution.

Effective microorganisms were developed over many years in liquid form by Prof. Dr. Teruo Higa at the University of the Ryukyus, Okinawa, Japan. It is, however, stressed that EM is not a synthetic chemical or a medicine and it is neither genetically modified. Subsequently EM Research Organization was founded in 1994 in Okinawa, Japan. 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 research in different fields to uncover viable solutions for existing environmental and health problems in 23 countries inclusive of America, China, Korea, Thailand, Netherlands, Australia, Germany and many others.

8.2 Bio-remediation of tanneries effluent and sludge

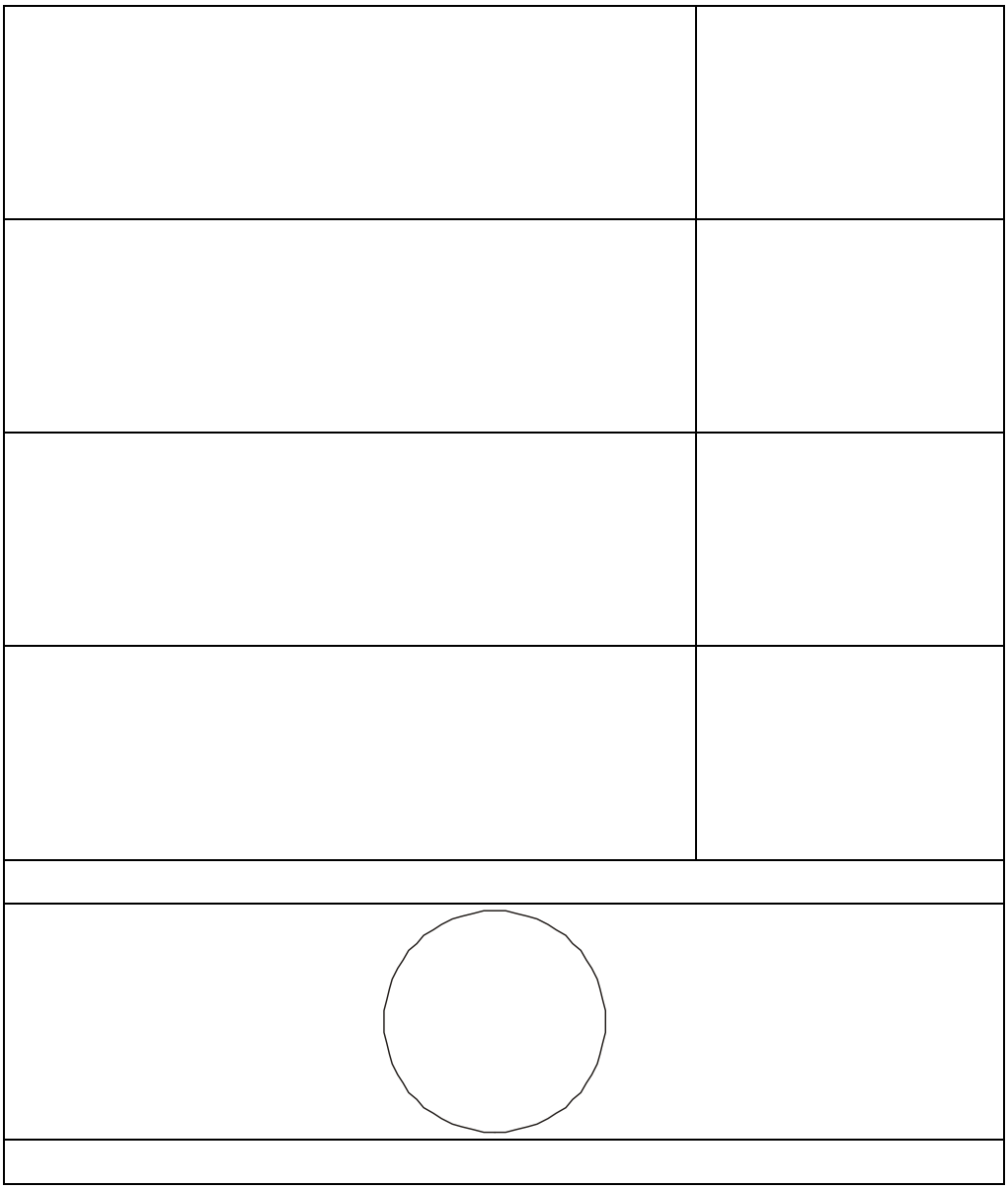
8.2.1 Deodorization of Tannery's unpleasant odor using EM Technology

EM possesses the capacity to effectively eliminate the unpleasant odor. An admixture of among other things ammonia, hydrogen sulfide, generally causes the offensive odor, trim ethylamine and methyl mercapton. These substances are happened to become the substances (substrate) for the microorganisms of EM. Thus, the microorganisms of EM gobble them up and the odor is eliminated because of non-existence of components of odor.

In Sialkot cluster each tannery drains its effluent containing sludge particles into the open drain. This means that there exits no equalization tank, sedimentation tank and sludge lagoons. In some of the tanneries no space is available for the construction of these tanks. Under these circumstances the plans to collect the effluent and its further treatments will vary accordingly. In such cases there is no other alternative except to construct few dug-in-tanks to collect effluent and its treatment with EM. The dug-in-tanks system will also have provision for small dug-in-tanks for sludge. A schematic diagram is given in figure –1. The sludge in the form of slurry will have to be pumped out with the help of sludge pumps and collected in tankers of suitable capacity for onward transportation to sludge station, where further treatment of sludge with EM Technology will be undertaken to convert a resource considered waste into a useful by product. Once dug-in-tanks system in a tannery is constructed, managed and found practicable from the point of view of reducing pollutants concentration corresponding to NEQS, pumping out of sludge-slurry into the tanker with sludge pump the problem of pollution will be controlled. The experience gained will be applied in other similar tanneries. According to the data given in table –6 there are 25 tanneries occupying up to 10 marlas land, 48 tanneries are having 10 – 20 marlas space and 71 tanneries possess 1 – 2 kanals. These 144 tanneries will

Fig.-1: **Schematic diagram of dug-in-tank system**

Effluent collectors **Sludge collectors**



be problematic from the point of view of construction of dug-in-tanks system. If it is not possible to construct dug-in-tank system for the in-situ bio-remediation of tannery wastes, then other practical solutions will have to be found out.

The tanneries having enough space will pose no problem of construction of equalization tank, sedimentation tank and sludge lagoons. In these tanneries the equipments needed for the application of EM Technology to treat effluent and sludge can be fixed easily. There will be no need of construction of dug-in-tanks system. The sludge from the such tanneries can be easily collected and transported to the sludge station for further treatment with EM Technology to convert into a useful by product. According to the data given in table –6 about 86 tanneries have areas of more than 2 Kanals.

For deodorization EM-extended has to be sprinkled on to the effluent collected in the tank with sprinkling and dozing units so that the area is fully covered. EM-extended will be dozed with dozing-units along with tap water connected with monoblock centrifugal pump to provide required pressure for sprinkling. The application of EM-extended with sprinklers will be a regular process and has to be carried out during the working hours of a tannery. This will eliminate the odor produced daily by the tannery effluent resulting in the betterment of the atmosphere or microclimate of the effluent tank, and its surroundings.

As sprinkling will become a part and parcel of the tannery the equipments have to be fixed permanently and are to be protected from damage. The EM-extended will have to be prepared well in time so that stock is available to feed the sprinklers system depending upon the volume of the effluent. The elimination of odor will certainly affect the working attitude of workers and bring a healthy change to all workers. At least lungs will inhale good air to prolong their life.

8.2.2 Tannery's Effluent Treatment with EM Technology

EM Technology with all its EM products is extremely effective to reduce the pollution load especially heavy metals inclusive of Cr. The Cr is used in tanning and unconsumed Cr forms the part of effluent and sludge. Its concentration varies from 10 – 30 mg/l in the effluent and it is almost 5% (50,000 mg/l) in the sludge as Cr. accumulates more in the solid wastes of the tannery as compared to the effluent.

To minimize the concentration of salts in the effluent and to bring the values within NEQS the application of EM products has to be undertaken just from the point where tannery effluent is allowed to drain either into the dug-in-tank system or equalization tank. EM is to be applied as EM extended in liquid form prepared from EM products and water. This EM-extended have to be stored in dark plastic tanks of suitable size and have to be prepared well in time so that effective microorganisms multiply tremendously (3 to 5 times of original number). Depending upon the load of salts in the effluent the application has to be regulated in such a way that it meets the requirements and warrants NEQS. As production of leather / effluent is a continuous process at least during working hours, it is therefore, necessary to continue the treatment of effluent with EM. The effluent carrying pollutants and reasonable quantity of EM now enters the dug-in-tanks system or equalization tank, where generally the effluent will remain for at least 8 –12 hours or even more under continuous mixing, equalization and aeration with aerators. This means the effective microorganisms have the same time for reaction with pollutants. It is the dug-in-tank system or equalization tank where the concentration of pollutants are to be minimized as per NEQS. One important point must be kept in mind i.e. it is not only the effluent but also the sludge particles. The quantity of EM to be used will, therefore, have to be correspondingly increased, although the possibility of further treatment of sludge at the sludge station exists to convert it into bio-sludge with bio-remediation using EM Technology.

9. Previous achievements of EM Research Organization

9.1. Trial on tanneries effluent

Siddique Leather Work (SLW) is situated at 13thKm Lahore-Sheikhupura road. This tannery is said to be one of the modern tannery where cleaner production techniques are applied. For this purpose 2 equalization tanks measuring 9.5m x 7.5m x 4.375m each having 250 – 260m^3 water storage capacity each, one primary settlement tank of 330m^3 capacity, effluent decanter of 75 m^3 capacity and 6 sludge drying beds of 40m^2 capacity each had been constructed and maintained well. 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 is cleared manually at regular intervals in order to let the effluent passed without any obstruction. The equalization tank is provided with aerators. 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 near by drain. The slurry from the sedimentation tank is pumped out mechanically into the effluent decanter. After some period the slurry is pumped into the sludge lagoons. The beds of these lagoons have been provided with coarse sand to drain extra water from the slurry. As soon as the water is drained out, the sludge flakes are formed and become handleable, these are removed from the lagoons manually and are disposed of indiscriminately in nearby places. SLW has qualified staff and it is equipped with a laboratory.

A trial on treatment of SLW effluent with EM products and elimination of odor in collaboration with Pakistan Tanners Association (PTA) Lahore was undertaken. It was completed during, 31st January 2003 to 07th February 2003. During this experiment a quantity of 15m^3 EM extended was applied to the effluent. It was prepared from EM -1, EM-3 and sugarcane molasses in installments as per requirements in plastic tanks made available by SLW. To start with 1m^3 EM extended was applied immediately to the effluent at a point, where it has just passed through the fine sieve before entry into the equalization tank, in order to provide basic doze of effective microorganisms to start and to boost bio remediation process. After which a suitable quantity

of EM extended was continued to be applied at the same point in the small drain carrying effluent from the SLW to the equalization tank. This helped to continue, maintain and to 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 point in the SLW. The aerators in the equalization tank are run for 16 hours a day (maximum reaction period between effective microorganisms and the pollutants in the effluents) and are closed for 8 hours at night.

The useful microorganisms propagated themselves and reacted with the pollutants in the equalization tank. 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, thus, had maximum period for reaction with the pollutants in the equalization tank although their working continues 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 drains out. In SLW this draining out effluent, still loaded with pollutants, finally finds its way into the nearby drain.

To increase the reaction period between EM and pollutants the draining out effluent from the sedimentation tank was collected in plastic tanks of $1m^3$ each. A definite doze of EM extended was also applied. These tanks were kept for 24 – 48 hours. The effluent was found to be more clear and the concentration of pollutants decreased to reasonable extent. This means that the reaction period between effective microorganisms and pollutants should not be less than 3 – 4 days. The adjustment of quantity of EM and of effluent are to be found out in each tannery in order to fulfill NEQS.

The experiment on deodorization of tannery's odor 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 sprinklers, dozing unit and rubber pipes. A new rubber pipe of ¾ inch size had to be purchased as the old rubber pipe was fully with algae and other contaminations, which blocked the fine holes of sprinklers. SLW dignitaries were kind enough to spare budget for all such accessories. Without their prompt and timely help it would have not possible to complete the experiment.

The sprinkling of EM helped in the elimination of odor in the micro atmosphere over the equalization tank and subsequently of the area of effluent accumulation. EM showed really its wonderful effect.

The success of sprinkling irrigation to eliminate odor can only be confirmed by smelling although equipments exist to examine various components of gasses causing odor. The success of EM to reduce pollutants in the effluent can only be judged with analysis of the treated effluent at various stages and at the final stage. For this purpose the sampling of the effluent was done by NEC and SLW at different stages of the experiment. The experiment was conducted for 8 days from 31st January, 2003 to 7th February, 2003.

The sampling was made by SLW 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 over flown from the sedimentation tank is allowed to enter into the outlet drain which finally falls into the main drain. The samples were analyzed by the Chemist of SLW. The results are given in table –15.

Table –15 EM efficacy in eliminating pollutants in SLW effluent

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

a = sample taken at the entry point into the equalization tank
b = sample taken from the point where over flown wastewater from the sedimentation tank is being drained out.

The perusal of the data shows that on 3rd & 6th February, TSS (33 to 50%), SO_4 (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. 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 ($32^{\%}$), SO_4 ($35^{\%}$), TDS ($70^{\%}$) but TSS & Cl concentration increased, it may be due to closing of aeration and equalization system. Cr was reduced from 178 mg/l to 0.346 mg/l.

This trial is the first of its kind, which has been carried out on tannery effluent. It was just to have rudimentary knowledge of effectiveness of EM products on the behavior of pollutants. This trial proved the effectiveness and efficacy of EM products meaning thereby that tannery effluent can be treated with EM to achieve the minimum concentration of pollutants. The knowledge gained from small-scale trial can be very easily applied on large scale. The adjustment with respects to quantities and combinations of various EM products coupled with increased reaction period between effective microorganisms and pollutants has to be made.

In Sialkot cluster of tanneries the effluent of each tannery can be converted into harmless wastewater corresponding NEQS values with the application of EM products. The quantity of EM products depends upon the production of effluent and concentration of pollutants. The quantity of EM products is for the time being difficult to be fixed giving a definite formula but within 2 to 4 months period definite conclusions can be made giving exact quantity of EM products and retention time at various stages of effluent in the equalization and sedimentation tank. If the retention time (reaction period between EM products and pollutants) is less in equalization tank then the over flown effluent from the sedimentation tank will have to be treated with EM to arrive at the range of parameters given by NEQS. Simply speaking it is only the EM Technology, at present, which can save from pollution of what so ever kind, quantity and quality. The pollution of odor and effluent can be eliminated / diminished certainly with EM Technology.

9.2. Conversion of waste tannery's sludge into useful bio sludge

This experiment was carried out on tannery sludge of Eastern Leather Company, Muridkey in collaboration with Pakistan Tanners Association. It is worth mentioning that Cr. contents were reduced from 50,000 ppm to 302 & 620 ppm (table –16).

Table-16 **Analysis of original sludge, crushed bio sludge and non crushed bio sludge**

Parameter	Original	Crushed bio-sludge	Non crushed bio-sludge
N %	4.6	0.68	0.76
P %	0.2	0.052	0.039
K %	0.063	0.39	0.35
C: N	4.8:1	12:1	10:1
Organic matter %	38.0	14.1	13.1
pH	8.3	7.6	7.4
EC ms/cm	14.2	13.9	13.0
CO_3me/l	Nil	Nil	Nil
HCO_3 me/l	4.4	60	50
Cl me/l	192.5	100	90
Na me/l	34.38	28.2	36.9
Ca %	4.63	0.64	0.23
So_4 %	2.30	0.23	0.26
Zn ppm	195	44	3.8
Cu ppm	---	8.8	3.8
Fe ppm	9400	9825	11563
Mn ppm	248	132	128
Cr	5%	620 ppm	312 ppm

The sludge, which was hard to break, was converted into a powdery form of material. The bio sludge was tested as a fertilizer. The rice crop was grown. The results were encouraging. It is interesting to note that the Cr has been found in the original soil (C-1, the plot which was kept as control and conventional fertilizers were applied in order to have comparison with the plot to which bio fertilizer was applied). It is 0.08ppm. The same quantity of Cr (0.08ppm) was found in C-2 plot to which original sludge without treatment with EM was applied. C-2 plot was introduced to have comparison with the bio sludge plots. The Cr was also found in the soil sample of plots of T-1 & T-2, although the concentration varies. The results are given in table -17.

Table-17 ANALYSIS OF SOIL BFORE AND AFTER THE APPLICATION OF BIO-SLUDGE AND EM-IRRIGATION

Parameters	Original	After the application of bio-sludge & EM-irrigation			
		C-1	C-2	T-1	T-2
N %	0.028	----	----	----	---
P (available) ppm	2.280	4.3	7.8	5.1	4.3
K ppm	67.25	173	133	140	158
So_4 ppm	88.00	7.4	32.4	26.1	2.1
Mg ppm	98.33	77	75	75	76
Zn ppm	2.33	0.61	6.0	0.25	4.0
Cr ppm	Nil	0.08	0.08	0.05	0.24
Cu ppm	ND	1.84	2.0	1.7	1.82
Fe ppm	14.25	32.5	38.6	27.2	29.5
Mn ppm	5.50	8.9	8.9	10.3	9.7
B ppm	0.933	1.45	Nil	1.16	2.0
Cd ppm		175	175	178	162
O.M %	0.473	0.28	1.1	1.1	1.1
Na mg/l	3.70	.6	.46	.49	.31
Ca mg/l	4.55	1.11	0.73	0.34	0.52
Co_3 mg/l	Nil	27.7	25.5	25.55	26.62
HCO_3 mg/l	7.167	2.9	3.4	2.8	2.7
Cl mg/l	1.833	.81	.75	.64	.79
EC ds/m	0.667	.6	.4	.4	.5
PH	7.900	8.1	8.1	8.1	8.1
Water Subtraction%	36.67	32	32	32	32
Textural class	Loam	Loam	Loam	Loam	Loam

C-1: conventional fertilization
C-2: non-crushed sludge
T-1: bio-crushed sludge and EM-extended irrigations
T-2: Bio-non-crushed sludge and EM-extend Irrigations

9.3 Experiment on conversion of SLW sludge

The experiment on fresh sludge (with 25 – 30% moisture) of Siddique Leather Works (SLW) was also completed in a period of 5 weeks starting from 4th February, to 11th March, 2003. One ton of sludge was removed from the sludge lagoon manually, placed on a plastic sheet on the floor, mixed well with 500 Kg sand, 80 liters EM extended solution and 70 Kg Bokashi, transformed into a heap and covered with a plastic sheet to create anaerobic conditions. The sludge was examined every week and the moisture contents were maintained at 30% with EM solution. In the 5th week the sludge was completely fermented giving a nice fermenting smell. The physical condition of the sludge was completely changed. It became powdery like. It is named as bio sludge / bio fertilizer.

The samples from the original sludge and bio sludge were taken for analysis especially to see the Cr concentration. The original sludge sample was taken by the Chemist of SLW for analysis. According to the SLW laboratory analysis Cr was 50,000ppm while analysis results from NEC are still awaited.

The bio-sludge will be rich in nutrients and almost free from Cr contents. Thus, it can be used in agriculture as a substitute of farmyard manure and as soil amendment for salt affected lands in Punjab.

This is a proper and effective measure to convert a resource, being considered waste, into a useful by product, which can be reused in agriculture. It may be given, to start with, free of cost to the farmers and later on cost price. It will be a great service to humanity by the tannery industrialist.

10. COST OF TREATMENT OF EFFLUENT AND SLUDGE WITH EM TECHNOLOGY

The existing 230 tanneries are scattered all around the Sialkot city. These have been grouped into 10 different clusters, the details of which are given in table -1 and in table -2. Presently about 127 tons / day of finished leather is produced by 230 tanneries. This results in the production of effluent (9388m^3 /day) and of sludge (80 tons / day).

The Chamber of Commerce and Industry, Sialkot has got prepared a report on "Feasibility study for establishment of tannery zone in Sialkot" from INCONSULTANT (Pvt) Ltd. The report was submitted on August 28, 2002. The overall cost has been estimated to Rs. 1575 million. The breakup of the costs is as under:

1.	Land	=	Accordingly
2.	Infrastructure	=	Accordingly
3.	Effluent treatment plant	=	Accordingly
4.	Solid waste disposal system	=	Accordingly
5.	Effluent collection and disposal system	=	Accordingly
6.	Facilities	=	Accordingly
7.	Shifting of tanneries	=	Accordingly
8.	Service charges & consultancy	=	Accordingly
	Total	**=**	**Accordingly**

In order to save the initial huge expenditure of Rs. 1305 millions to be incurred on the infrastructure, effluent treatment plant and shifting of tanneries it is proposed that EM Technology be applied in the premises of each tannery to treat odor, effluent and sludge. To start with a pilot project for 6 months can be undertaken at 10 tanneries, one from each cluster as there are 10 clusters. The 'type of production' will also be given due consideration while selecting a tannery for the application of EM Technology. The experience gained will easily be applicable to other type of production.

EM products are to be stored in plastic containers (water tanks of ½ ton to 1 ton), plastic drums (200 liters) and plastic cans (30 – 60 liters). Few plastic buckets and scoops will also be needed. The concentrates of different EM material will be transported from Lahore to Sialkot. It will be unloaded at

respective tannery according to its requirements. EM extended will be prepared from the EM concentrates at each tannery. It will be stored there and applied as and when required. The prepared EM extended will be used for the treatment of effluent and elimination of odor. The plastic containers, drums, cans and buckets can be stored in a room or near the treatment dug-in-tanks system or equalization tank. The space required for these can be easily found out in the tannery.

For deodorization sprinkling units, centrifugal mono block pump and dozing unit along with pvc pipes / rubber pipes are required. The sprinklers are to be fixed on to the dug-in-tank system / equalization tank. The centrifugal mono block pump is to be place near the water source to maintain required pressure for sprinkling. The dozing unit is to be placed nearby. All the units are small in size and can be placed without occupying much space near to the dug-in-tanks system / equalization tank.

As leather production is a continuous process. Some industries are run continuously for 24 hours and the others might be operating for 16 hours. The effluent being discharged by a tannery will have to be treated with various EM products in order to diminish the concentration of pollutants corresponding to NEQS. For this purpose the effective microorganisms have to be given enough time for reaction to gobble them up. The reaction period will have to be determined in each tannery as the quantity and quality of pollutant differ. This will not take much time and can be arrived at a conclusion within 2-3 months.

As there exists no provision for processing the effluent to sludge in Sialkot cluster it is therefore proposed to construct dug-in-tank system in tanneries having less space and an equalization tank in tanneries where enough space is available. Under these circumstances the slurry will have to be pumped out with sludge pump into a tanker at each tannery. The sludge pump along with electric motor will be fixed near the dug-in-tank system / equalization tank. The tanker will carry it to the sludge station. At the sludge station the slurry will be dewatered in suitable lagoons and the sludge will be treated with EM extended and Bokashi. A homogeneous mixture will be prepared and kept under anaerobic conditions to convert the waste sludge into bio sludge. This bio sludge / bio fertilizer can be applied in agriculture. The EM extended and Bokashi will be prepared at the sludge station from the concentrates of EM transported from Lahore to Sialkot.

For the transportation of EM concentrates from Lahore to Sialkot a truck will have to be purchased or hired for 6 months, the duration of the project. A tanker will be required to carry slurry from the tanneries to the sludge station. This will have to be purchased or hired for the project period.

For the mobility of technical officers from Lahore to Sialkot a land rover and for the supervisor at Sialkot motorcycles will be required.
The cost of the project consists of the followings:

1. Equipments needed at each tannery (annex –1).
2. Equipments required at the sludge station (annex –2).
3. Lease of EM manufacturing unit inclusive of EM manufacturing cost, electricity and water charges. The total cost will be Rs. 218000 per month.
4. a) Lease of transport for (annex –3):
   - Tanker for transportation of molasses from sugar mills to EM factory, Lahore.
   - Truck for transportation of EM seed from Lahore to Sialkot.
   - Tanker for collection of slurry from 10 tanneries and its transportation to sludge station.
   - Tractor for mixing EM products and Bokashi with tanneries sludge at the sludge station.

   b) Lease of transport (annex –3):
   - A land cruiser for supervisory technical officers.
   - A pickup small for local transportation of different materials to each tannery.
   - 2 motorcycles for supervisor at Sialkot.

5. Staff required at each tannery and at the sludge station (annex –4).
6. Service charges of supervisory technical officers @ Rs. 1 05 000/= per month.
7. EM material cost for use at Sialkot for the treatment of 5000m^3 effluent and 630 tons sludge of 10 tanneries (annex –5).

The estimated total cost for six months project to treat odor, effluent at 10 tanneries and sludge at the sludge station comes to Rs. 14.9 million inclusive of cost of hiring of 25 acres land for the sludge station. The breakup of the cost is given in table -18.

Table –18

Estimated total cost for six months project at 10 tanneries, Sialkot

Sr. Nos.	Description	Cost Rs.
1	Equipments needed at 10 tanneries.	Accordingly
2	Equipments required at sludge station.	Accordingly
3	Lease of manufacturing unit, EM manufacturing cost, electricity and water.	Accordingly
4	Lease of tankers, trucks, tractor, pickup, land cruiser and motorcycles.	Accordingly
7	Salaries of staff for 10 tanneries and of sludge station.	Accordingly
8	Service charges of supervisory technical officers @ Rs. 10 5000/= per month	Accordingly
9	EM material cost for 10 tanneries for 5000m^3 effluent treatment and conversion of 630 tons dried sludge into bio sludge / bio fertilizer.	Accordingly
10	Miscellaneous	Accordingly
	Sub Total	Accordingly
11	25 acres of land are required for the sludge station. These will be hired for the project period. Lagoons will also be constructed (subject to actual expenditure and if made available free of cost, this item can be elimenated).	Accordingly
	Grand Total	Accordingly

annex –1

Equipments needed at each tannery

Sr. Nos.	Description	Quantity	Rate Rs.	Cost Rs.
1	Plastic tanks 1m^3 each	10	Accordingly	Accordingly
2	Plastic drums 200 lit each	04	Accordingly	Accordingly
3	Steel buckets 020 lit each	04	Accordingly	Accordingly
4	Dozing unit with attachments	01	Accordingly	Accordingly
5	Sprinkling unit 6 pieces set	01	Accordingly	Accordingly
6	Scoop	04	Accordingly	Accordingly
7	Miscellaneous: pvc pipes, rubber pipes, nozzles, clips etc.		Accordingly	Accordingly
8	Mono block comprising of sludge pump, electric motor, special pipes and accessories etc.	01	Accordingly	Accordingly
Sub total			Accordingly	Accordingly
Cost for 10 tanneries			Accordingly	Accordingly

Annex –2

Equipment required at the sludge station

Sr. Nos.	Description	Quantity	Rate Rs.	Cost Rs.
1	Plastic tanks 1m^3 each	02	Accordingly	Accordingly
2	Plastic drums 200 lit each	02	Accordingly	Accordingly
3	Plastic cans 100 lit each	02	Accordingly	Accordingly
4	Steel bucket 20 lit each	02	Accordingly	Accordingly
5	Plastic sheet	200 kg	Accordingly	Accordingly
6	Injector 1HP	01	Accordingly	Accordingly
	Sub total		Accordingly	Accordingly
	Cost for 10 tanneries			Accordingly

Annex –3

Lease* of tankers, truck, tractor, pickup and land cruiser for six months

Sr. Nos.	Description	Cost Rs.
1	Tanker for molasses transportation from sugar mills to EM factory Lahore.	Accordingly
2	Trucks for EM seed transportation from Lahore to Sialkot and sludge collection at the sludge station from 10 tanneries.	Accordingly
3	Tractor for mixing EM & Bokashi with the sludge at the sludge station.	Accordingly
4	Pickup for local transportation of different material.	Accordingly
5	Land Cruiser for supervisory for technical officers.	Accordingly
6	Motorcycle	Accordingly
	Total	Accordingly

* Subject to actual verified cost.

Annex –4

Staff required at 10 tanneries and at the sludge station at Sialkot

Sr. Nos.	Description	Nos.	Salary / month Rs.	Total Rs.
1	Technicians for 10 tanneries and sludge station.	24	Accordingly	Accordingly
2	Supervisors for 10 tanneries and sludge station	03	Accordingly	Accordingly
3	Security guard at sludge station	04	Accordingly	Accordingly
4	Laborers	06	Accordingly	Accordingly
Sub total				Accordingly
Salaries for six months				Accordingly

Annex –5

Breakup of cost of EM material and Bokashi

Sr. Nos.	Description	Quantity	Rate Rs.	Cost Rs.
1	EM material: EM Env. A EM Env. B EM Env. M	 8 m^3 4.5 m^3 6.38 ton	 Accordingly Accordingly Accordingly	 Accordingly Accordingly Accordingly
Sub total				Accordingly
Cost of 10 tanneries				Accordingly
2	EM Env. P	70 kg	Accordingly	Accordingly
3	Bokashi	13.75 ton	Accordingly	Accordingly
Sub total for Sr. Nos. 2 & 3				Accordingly
Grand total				Accordingly