Research Trial

Tannery Sludge Bioremediation *and* its reuse in Agriculture *using* EM Technology

EMRO / PTA COLLABORATION

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Tannery sludge bio-remediation using EM-Technology

Introduction

In Punjab, at present, leather manufacturing industries (Tanneries) are 516, of which 130 are large, 176 are medium and 210 are small and for classification purpose are said to be mainly located in Lahore cluster, Sahiwal cluster, Multan cluster, Gujranwala cluster and Sialkot cluster. The raw material for these tanneries is cow/buffalo hide and goat/sheep/skins. The industry utilizes considerable quantities of inorganic and organic chemicals (may be toxic and/or harmful) and over and above large amounts of water. In the process of leather production considerable quantities of waste water and solid waste are generated, depending upon the type of industry (raw to finish, raw to wet blue and wet blue to finish) for one ton of raw hide/skin, about 50 to 100m³ of waste water and 150 to 45kg solid waste (dried sludge) are produced on an average (Table-6.1).

Table 6.1 Average waste water and sludge production

Type of industry	Hides/Skin (Kg)	Production of effluent water and solid waste	
		Waste water m^3	Dried sludge (kg)
Raw to finish	10000	1000	1500
Raw to wet blue	10000	600	1600
Wet blue to finish	10000	500	450

In the tanning industry about 25% of the weight of raw hide results in the finished leather where as the remaining 75% becomes a solid waste; of the solid waste about 50% is utilized by the manufactures of poultry feed, gelatin, glue, fish meal and soap, and the remaining 50% is dumped indiscriminately. In the raw hides/skins processing of the offered quantity of chemicals (except chromium) about 15% are consumed and the unconsumed chemicals are either discharged into tannery effluent or as solid waste. In case of chromium about 70% of the offered amount is taken up by the hides/skins and about 30% remains unexhausted and goes into effluent waste water as well as into solid waste.

The tanneries, being high water consumption industry, generate huge quantity of waste water high in BOD, COD, TDS, TSS, Cl, Sulfides, and Chromium and is discharged untreated into drains which ultimately find their way into adjoining river.

Table: 6.2 PREVAILING RANGE IN TANNERIES EFFLUENT AND OF NEQS

Parameter mg/l	Prevailing Range	NEQS
pH	3.5 – 9.4	6 – 10
TDS	1,520 – 15,850	3,500
TSS	1,000 – 1,240	150
BOD	800 – 1,200	80
COD	1,800 – 2,700	150
Sulfate	1,000 – 1,300	600
Sulfide	35 – 100	1.0
Chloride	1,200 – 6,500	1,000
Chromium	20 – 100	1.0

The disposal of solid waste (sludge) is a burning problem due to increasing demand of leather. The leather industry is the second most important sector of Pakistan with regard to exports amounting to us $600 million in 2000. Pakistan major leather exports are to Australia, Japan, Germany, Italy, UK and USA. The situation of disposal of sludge will further aggravate in the near future when the environmental quality standards for the solid waste will come into force. The presence of chromium in sludge is dangerous for health if it is utilized in agriculture. It is, therefore, essential to remove it during the leather production process within the industry. A number of leather industries have installed "chrome recovery plant" and are recovering chromium up to 100%. The recovered chromium can be used for tanning with out any compromise on the quality of leather. The investment made payback period is less than one year.

Presently there is no proper sludge disposal system in the tanneries. The dried sludge is removed from the sludge drying beds and disposed of in the tannery surroundings indiscriminately without any environmental consideration. This method of sludge disposal is so far been considered as low-cost-solution.

Actually, it is the approach with which a problem is to be solved. To day the application of latest science inventions have made it easy to find a workable cost effective method of solving a problem, only one must have the knowledge. We in Pakistan do not know the utility/effectiveness of many new inventions, even if we are happened to know, we hesitate or have no belief/courage to adopt such technologies. We take a lot of time to accept or to change our approach towards right direction. Disposal of sludge is not a big problem if it is converted into a useful by-product. The EM is a miracle and can be used to transform sludge of leather industry into a useful by-product (bio-fertilizer) to use in agriculture. Under the supreme sustained guidance of Prof. Dr. Teruo Higa. of Japan, EM Research Organization Pakistan is engaged in research with the motto that "a waste is a resource rather than a waste".

EM Research Organization (EMRO) in collaboration with Pakistan Tanneries Association (PTA) initiated research on "Tannery Sludge Bio-remediation using EM Technology" during February 2002. The bio-remediation

anaerobic tannery sludge is one of the cheapest, convenient to handle practicable and workable method with which its safe disposal as a by-product (Bio-fertilizer for use in agriculture, orchards, house hold gardening and pot-flowering) is possible.

Treatment Methodology

EM stands for effective microorganisms. EM is a combination of various beneficial, naturally occurring microorganisms mostly used or found in foods. It contains beneficial organisms from 3 main genera: phototrophic bacteria, lactic acid bacteria and yeast. These effective microorganisms work and show their impact by secreting beneficial and effective substances such as vitamins, organic acids, chelated minerals and antioxidants when these are provided proper food (organic matter and molasses etc). They also change the media of disease inducing pathogens into disease suppressing media and increase the colonies of effective microorganisms. Thus, they increase the humus content of the media treated with EM. It is, however, stressed here that EM is not a synthetic chemical and can be used safely.

The experiment was conducted in the premises of Eastern Leather Company (ELC), located on Muridkey-Sheikhupura road near Muridkey. ELC is not equipped with chromium removal plant, therefore, produced tannery sludge containing 5% (50000ppm) chromium. The sludge is just like flakes of 1.0 to 1.5cm in thickness, very hard to break with hands, can be broken with hammer into small pieces of various dimensions. Before the start of experiment this original sludge was got analyzed (Table-6.3).

Table 6.3. 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 %	22.0	8.2	7.6
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_3 me/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	33
Cu ppm	----	8.8	3.8
Fe ppm	9400	9825	11563
Mn ppm	248	132	128
Cr	5 %	620 ppm	312 ppm

EM-Technology comprised of preparation of EM extended and Bokashi in addition to other EM extended and Bokashi in addition to other EM-products. EM extended was prepared with the following ingredients.

EM-1	=	1lit
Molasses	=	3lit
Water	=	18lit

The mixture was kept in plastic drums and stored in a dark place. The EM extended was ready for use in 7–10 days.
Bokashi is a type of organic matter rich in nutrients and effective microorganisms. It was prepared with the following ingredients:

Rice bran	=	100kg
EM-extended	=	10lit
Molasses	=	30lit
Water	=	300lit

The rice bran was spread over a plastic sheet. The solution containing water, EM extended and molasses was sprinkled evenly in installments. Each time homogeneous mixture was made manually till the total amount of solution was finished and desired results of maintenance of moisture contents and cohesiveness of rice bran were obtained. The mixture was packed in plastic bags and stored in a dark place for 15–20 days. Then it is ready for use.

Two tons of ELC sludge was weighted one ton was crushed into pieces (named crushed sludge) and the other ton of sludge was left as such (named non-crushed sludge).
Following treatments were given to both the sludges:

a) Crushed Sludge

One ton original sludge was got manually crushed, spread evenly over a plastic sheet, mixed well with 100kg Bokashi (EM product) and EM extended solution containing EM extended 2lit, molasses 6lit and water 300lit, transformed into a heap covered with a plastic sheet to create anaerobic condition, and left for 40–45 days to complete fermentation within which EM worked to achieve a desired results. First of all odor was completely eliminated within 10 days and fermentation was completed within 40 days. The crushed sludge fermented completely giving a nice fermenting smell and physically was changed to a powdery type of material, which was easy to handle and transport elsewhere.

b) Non-crushed sludge

One ton of non-crushed sludge was taken, spread evenly over a plastic sheet, mixed well with 100kg green leaves and farmyard manure and EM extended solution containing EM extended 2lit, molasses 6lit and water 300lit, transformed in to a heap, covered with a plastic sheet to ferment it an aerobically and left for 40–45 days to complete the fermentation period. The bad odor vanished within 10 days period. The non-crushed sludge fermented completely and the hard flakes of non-crushed sludge changed into a powdery like material giving a nice fermenting smell. The powdery material was easy to handle and transport elsewhere.

The first phase of the bio-remediation of tannery sludge was completed within a period of 2 month.

CONCLUSIONS

From the successful trial it can be safely concluded that the original sludge, crushed and non-crushed (a resource being considered a waste material to be dumped or disposed of with cost indiscriminately) was got bio-remediate an aerobically into a bio-fertilizer (a useful bio-by-product, need not to be disposed of indiscriminately but at the factory gate can be soled out at cost price or can be given a free of cost to get benefit in agriculture, a great service to humanity by the industrialists of the leather industry).

SECOND PHASE OF THE EXPERIMENT USING BIO-SLUDGE IN AGRICULTURE

The tannery sludge crushed and non-crushed changed into a powdery form of bio-sludge or bio-fertilizer through bio-remediation using EM Technology.

Both the bio-sludges obtained from crushed as well as non-crushed sludge had been got analyses (Table-6.3). A perusal of the table6.3 reveals that contents of chromium considered to be dangerous for human health have been reduced drastically from 5% (50000 ppm,) to 312/520 ppm.

It was thought that this very “bio-by-product” be tried in agriculture. A pieces of land about one acre was lying waste at one corner of the premises boundary of ELC. A lot of building material was lying in one corner of this acre. Anyhow experiment was designed using ELC Laborers which leather was manufacturing minded not agricultural minded, meaning thereby having no experience of such type of experiments. Beside this no canal or tube well was available directly for irrigation purposes. The irrigation was given with

the ground water stored in a fish farm earthen dug-in-tank with over flow from the tank when it is full with water. It is certain that fish farm earthen tank might also be receiving some food for fish rearing.

The agronomical factors were also not kept in view such as number of plants (nursery plantation). Even at the time of maturity it was observed that the irrigation water applied to T2 plot was going to C2 plot because the earthen bund separating the two plots were found broken at two places. The T-1 plot was unluckily having broken pieces of bricks and uneven land surface. It was observed that the condition of rice crop receiving uneven irrigation had poor growth. Moreover in the north western corner a lot of earth in the shape of a heap was lying and remained as such till the harvesting. From the point of view of agriculture it is still a matter of appreciation that the growth in T1 and T2 plots receiving bio-sludge, Bokashi and EM extended irrigations was satisfactory. (Table 6.4)

Table 6.4. YIELD OF RICE CROP

Treatments		**Yield / acre Kg**	**Remarks**
T1	bio-crushed sludge irrigate with EM-extd EM-sprays	607	scattered growth, uneven land and uneven irrigation
T2	bio-non-crushed sludge irrigate with EM-extd EM-spray	1000	Irrigation water was going from T-2 to C-2 via broken earthen bund.
C1	synthetic chemical fertilizer irrigate & pesticides sprays	1345	already cultivated area
C2	Non-crushed-sludge irrigations	808	was receiving irrigation water inclusive of EM from T-2 plot

EM Compost

EM Bokashi

EM Spray

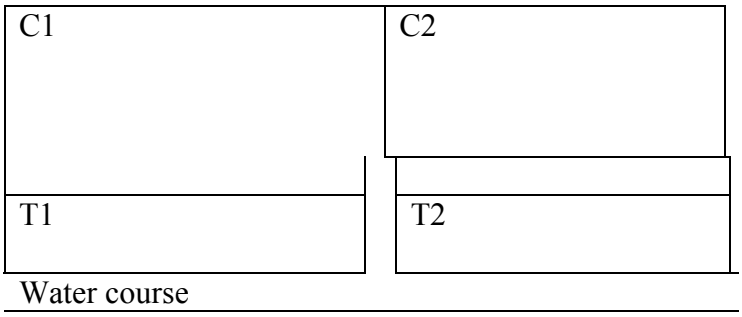
EM Irrigation

(A) Control Difference

(B) EM Treated

It can be established with further research on agriculture land under farmer's conditions that the application of bio-sludge and EM products (Bokashi or compost prepared with rice husk, rice bran, FYM) combined with EM extended irrigations will show better yields as compared to conventional fertilization (NPK fertilizers). The layout plan is given in figure-6.1.

LAYOUT PLAN FOR RICE CROP AT ELC



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-extd. Irrigations

Yield results are given in Table-6.4.
Pakistan Tanners Association (PTA) engineers-cum-experts of environments took a great pain in carrying out this very experiment and learned a lot about agricultural experiments.

The soil samples from 0~15cm (plough layer) were taken before the start of the experiment on 14th May 2002 and on 23rd Oct 2002 at earring stage i.e. three weeks before the harvesting (13-14th Nov 2002). It was got analyzed (Table 6.5). It is worth mentioning here that the chromium concentration ranged 0.24 to 0.05, maximum (0.24 in T2) and minimum in T1. Thus, it can be authenticated that the chromium was brought to less than expected standards NEQS (Table 6.2) by EM Technology. The scientific explanation is still to be found out, what was the fate of chromium!

Plants samples from all the treatments were also taken at the time of harvesting on 13-14th Nov 2002. These were got analyzed (Table 6.6). The concentration of chromium ranged from Nil to 0.02, much less than the values of NEQS. The plants, therefore, can be used for animal consumption as these are feed to animals in Pakistan. The analysis of Rice grains is still under process.

Table 6.5: Analysis of soil before 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
SO4 ppm	88.00	7.4	32.4	26.1	2.1
Mg ppm	98.3	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	0.6	0.46	0.49	0.31
Ca+Mg mg/l	4.55	1.11	0.73	0.34	0.52
CO3 mg/l	Nil	27.7	25.5	25.55	26.2
HCO3 mg/l	0.167	2.9	3.4	2.8	2.7
Cl mg/l	1.833	0.81	0.75	0.64	0.79
EC ds/m	0.667	0.6	0.4	0.4	0.5
pH	7.900	8.1	8.1	8.1	8.1
Water saturation %	36.67	32	32	32	32
Textural class	Loam	Loam	Loam	Loam	Loam

Table 6.6.

Plant Analysis

Parameters	Concentrations of Nutrients			
	C-1	C-2	T-1	T-2
N %	1.1	1.1	1.1	1.8
P2O5 %	.2	0.14	.22	0.23
K %	0.63	0.62	0.64	0.56
Ca %	0.27	0.18	0.25	0.24
Mg %	0.29	0.26	0.27	0.26
Na %	0.69	0.90	0.60	1.01
Zn ppm	39.0	33.0	94.0	58.0
Cu ppm	7.9	17.9	11.1	4.8
Fe ppm	154	101	217	194
B ppm	2.9	13.1	21.8	6.5
Mn ppm	129	332	99	206
Cr ppm	Nil	0.01	0.02	0.01

Overall

Benefits/advantages of using
EM Technology in Leather Industry

In EM Technology effective microorganisms provide service and work for the benefit of human beings. Main benefits can be summarized as under:

1 EM to be used (EM-1) is the cheapest (Rs. 20/= 1 Liter) and available in abundant quantity.

2 The further multiplication of EM-1 into EM extended and Bokashi can be made at site with no transportation cost. It is easy to understand and to make both the EM products. EM Extended is prepared with EM-1, molasses and water and Bokashi with rice bran, EM extended, molasses and water. All the ingredients are environments friendly and not dangerous for health.

3 The storage of EM extended is in plastic drums is easy and handy. Application in small as well a large quantity as per requirements can be regulated.

4 EM can safely and effectively be used in Leather industry at specific points/sites as per requirements to treat the waste water carrying solid waste also just at the start. Thus helps in elimination odor of the industry in improving the micro-climate/atmosphere and in rendering of the environments friendly for all the employees, thus increased more output. EM starts working at the beginning, continues working on wastewater and solid waste during further processes and with proper dozing converts wastes into useful bio-by-product rich in nutrients and useable in agriculture.

5 Saving of cost involved in disposing of bad sludge or bad water, rather the bio-by-product can be disposed of at factory gate at cost price or free of cost to the users to start with. It will be great service to humanity as well as to the nation.

EM-Technology helps to control environments and pollutions of every kind, converts waste water and waste solids to useful & beneficial bio-by-products useable in agriculture, even reduced chromium from 5% (50,000 ppm) to 466 ppm (parts per million).