OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

FAIR USE POLICY

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

06587

UNITED NATIONS INDUSTRIAL
DEVELOPMENT ORGANIZATION

Distr.
RESTRICTED

UNIDO/ITD.337/Rev.1
14 October 1975

ENGLISH

06587

UNIDO PROJECT NO. EP/INT/73/001

UNEP PROJECT NO. 0402 - 73 - 001

DRAFT PROJECT FINAL REPORT (IN 2 VOLUMES)

VOLUME 1

ENVIRONMENTAL CONSIDERATIONS IN THE LEATHER PRODUCING INDUSTRY 1/

1/ The views and opinions expressed in this paper are those of the author and do not necessarily reflect the views of the secretariat of UNIDO. This document has been reproduced without formal editing.

id.75-7728

We regret that some of the pages in the microfiche copy of this report may not be up to the proper legibility standards even though the best possible copy was used for preparing the master fiche

CONTENTS VOLUME I

INTRODUCTION

Following the United Nations Conference on the Human Environment held at Stockholm in 1972, the General Assembly of the United Nations established the United Nations Environment Programme (U.N.E.P.). The United Nations Industrial Development Organisation (U.N.I.D.O.) with its special role in the field of industrial development has collaborated with the newly formed UNEP to form a joint work programme within the environment field. The project to which this report relates is a component of this joint study programme.

The major objective of this study within the leather sector, which from time immemorial has been universally recognised as having great pollution potential, is given in the project document as follows :-

"To study the leather industry in depth, in order to assess the environmental considerations which have an impact upon its operation and development. The study will be of a background and "stocktaking" nature which is necessary for formulation of an environmentally sound development in this branch of the industry".

Suggestions were sought at meetings from the representatives of several developing countries, in order to formulate a work plan to maximise the utility of the final report to the developing countries, especially where the leather industry is now, or potentially, is of significant economic or environmental impact.

D. Winters (United Kingdom) was appointed as Senior Consultant to co-ordinate the project and to edit the project report, and he was assisted in varying degrees by consultants, and the report owes much to the inputs of the following :-

Teferra Assrat	(Ethiopia)
D. A. Bailey	(U.K.)
W. Frendrup	(Denmark)
T. J. Johnson	(U.K.)
T. Mathews	(India)
J. A. Villa	(Argentine)
W. Weber	(Switzerland)

Due to the large mass of material accumulated, and the wide span covered in the different chapters, and the divergent areas of interest it has been felt expedient to report on the project in two volumes.

Thus Volume I deals with the more generalised situation, including the possible environmental impact of the industry, treated theoretically, and based on three area studies, as well as the financial implications of the introduction of control plant and equipment.

Volume II has a more technical treatment and aims at mitigating the harmful environmental effects of the leather industry, giving some detail as to means by which environmental impact may be lessened by employing "best environmental processes", and also outlining possible effluent treatment systems applicable in differing circumstances.

Thus Volume I is addressed to governmental and industrial decision makers, and Volume II is of more concern to the entrepreneur and technologists, as well as the planner. Both Volumes, however, are closely interrelated and need to be read in conjunction with each other by those who wish to implement any specific proposal.

In general the report is directed towards the developing countries where the tanning industry in many cases is undergoing expansion. However, much of the data is pertinent to the more developed nations although in these areas more sophisticated and costly treatment schemes may be employed.

The recommendations outlined in Volume II are given as general guides - treatment plants have not been operated under the exact conditions quoted but international authorities in this field agree that in most instances the proposed treatment plants should operate efficiently, subject to some minor local modifications.

The methodology employed in the area studies, and the terms of reference for the technical studies are not recorded here to avoid repetition, but may be found in the "Report of the Preparatory Study Group Meeting", Vienna, 19 - 23 August 1974, UNIDO/ITD.290.

CHAPTER I

ENVIRONMENTAL CONSIDERATIONS IN THE LEATHER INDUSTRY

THE PROJECT AND ITS CHALLENGES: SUMMARY AND CONCLUSIONS

A THE PROJECT

A summarised description of the project is given in the project document as follows :-

" 1. The study and identification of :

a. processing techniques and methods used.

b. the type and quantity (per unit of output or other appropriate unit) of materials discharged (waste and/or pollutants) for each type of major process.

c. types of damages resulting from the discharge of unused materials.

d. "best" available and most practicable environmentally beneficial technology - including technologies available for recovery and/or reuse of waste materials.

e. adaptability of the different technologies to varying types of local conditions.

2. The determination of trends within the industry; including the development and utilization of environmentally sound technologies.

3. The determination of the most rigorous environmental criteria and the highest standards which can be met (technically and economically).

4. The determination of the impact of environmental considerations on future development especially the investment implications, giving special consideration to harmful materials, adaptation of technologies, and a better utilization of resources. "

The initial work plan of the project document had envisaged the major emphasis of the study being based on detailed field work in at least three areas or countries with some supplementation from the literature. However, following the discussions at joint meetings of UNIDO staff members, consultants and representatives of two developing countries in Vienna (Ethiopia and India), it became apparent that, although much could be gained from the three area studies, there would be need for more technical desk studies to augment the area studies. This conclusion was reached when it was concluded that area studies may in themselves only yield somewhat generalized situation reports, lacking in quantitative data, showing the need for a technical background which would help to put the area studies into true perspective. Thus, in addition to area studies covering Argentine, Ethiopia and India (State of Tamil Nadu), it was decided to report separately on the following :-

Possible Ecological Impacts of the Leather Industry's Wastes.

The Leather Industry's Solid wastes.

Financial and Economic Effects caused by Pollution Mitigation.

Better Environmental Processes of Tanning.

Tannery Effluent Treatment and Disposal.

The need for these summarised technical desk studies was necessitated as there is a dearth of definitive works on the subject, although there is a mass of papers and publications covering the field at specialist levels. This project and its report is therefore an attempt to summarise the technical, ecological and financial fields of environmental nuisance mitigation in the Leather Industry so that an outline, at least, of all aspects will be available to all interested parties who otherwise would have to refer to a multitude of different publications to build up an overall picture.

Certainly in the developing countries, which more and more are involved in the leather industry, the need for a concise summary covering all the above aspects has been clearly shown in the area studies.

B. THE CHALLENGES

One of the major problems of a global study within the leather field is the large variation in the technology employed from area to area and country to country, and even within a country. These variations are partly attributable to the degree of mechanisation, but also to some extent to the type of technology employed, and the chemicals used therein. It is obvious that variations in mechanisation and technology may well yield vastly different environmental impacts, according to local circumstances. However, the variations are countless and could not easily be compressed within this project. Additionally, in most areas there had been no analysis of tannery effluents, and their impact. In order to overcome some part of this disability, it was felt expedient to adopt a basic typical tannery effluent. This is detailed in Annexes I and II. By use of such a typical tannery effluent one was enabled to quote possible theoretical financial and ecological impacts under varying circumstances. The acceptance of this typical tannery analysis was not an easy choice. The analysis accepted was that which has been found applicable in Western Europe. However, there was little reason to suggest that standard "conventional" methods of processing in the three areas studied would yield vastly differing effluents from the "typical", with regard to actual pollutants discharged.

Common usage of water in more conservative tanning practice requires over 50 litres water per kilogram (l/kg) of salted raw material being processed. However, modern techniques show that water usage could well be circa 15 l/kg salted raw material, and in the ecological studies and treatment methods one has employed the lower level of water usage. This is justified on several grounds, although it is commercially not universally adopted many newer tanneries were aiming towards these lower water usage levels, and one must expect them to become more accepted within the near future. It was also felt that by using this lower level of water the dilution effect was less, thus the pollutants in the effluent would appear at higher levels, having more significant effect. Equally the treatment systems detailed in Volume II and costed in Volume I would be more economic, and require less area. Current indications are that there is a rapid movement towards the use of even lesser quantities of water in tanning, catalysed by environmental and cost considerations in many countries, and availability in other countries.

Although technologies vary from country to country, there is little evidence to suggest that total pollutants available in tannery effluents vary greatly using conventional methods, however, there is a possibility that a new vogue of technology incorporating recycling of the major polluting processes is on the verge of commercial acceptance. These recycling processes which can have significant beneficial effects on pollutants discharged, and costs of leather production are discussed in Volume II under the general heading of "Best Environmental Processes". Although, as they are not yet fully accepted by industry, they have not formed a major part of the presentation, and the discussions in Volume II have referred in general to the best environmental processes currently accepted for commercial leather production. However, there is little doubt that when the work in this field, in several Institutes of the World, in due course, come to fruition, the treatment of tannery effluents may be much simplified, with the resultant lessening of costs. Indeed one may quote from a recent meeting at the Centre Technique du Cuir (C.T.C.), reported in LEATHER*(i) referring to two major recycling processes suggests that... "the use of these two modifications, plus

* (i) LEATHER (International Journal of the Industry, London, April 1975 No. 1774398 Page 59)

the use of counter-current washing was claimed to reduce total water consumption from 13·5 to 8·3 m^3/ton* (ii) in addition to bringing about a major reduction, perhaps as much as 80%, in the toxicity charge".

However, in the realisation that such new technologies are unlikely to be available in the mass of tanneries in the developing countries for many years, and even in newly installed tanneries such techniques may not be employed for 5 to 10 years; hence it is felt more appropriate to consider offering advice aimed at improving the more conservative conventional processes currently accepted by tanners, in an effort to improve their impact on the environment and/or treat the effluent so produced.

C. SUMMARY

There is little doubt that the tanning industry is a potential polluting industry of some significance. Indeed this has been recognised for several millennia and, accordingly, in several of the old established world religions the tanning industry confers with it and its associates some degree of second class citzenship, in recognition of the environmentally degrading nature of the industry. However with modern techniques and mechanisation much may be done to mitigate the effect of the industry on the environment, and today it is within the technical and economic competence of the majority of the world's tanners to reduce their impact to a much less significant level. It must be stated that in many developed and developing countries tanners have not yet accepted the challenge, and continue to pollute with little regard for their environs. Technologies for mitigation are available in the developed world, although in some areas the huge costs of capital equipment for mitigation, especially in smaller units, is not always to be found. In the developing world, the situation is not as clear cut. We have examined three areas in some detail, and one may summarise our findings as follows :-

I. In India (State of Tamil Nadu) a study of some 88 tanneries representing the 4 - 500 tanneries in the State revealed that little effluent treatment was being practised, and in most cases tannery effluents were discharged to river or agricultural land after minimal primary treatment. Evidence is supplied which shows quite clearly that in one River, The River Palar, tannery

---

* (ii) m^3/ton is equal to 1/kg

effluents have contributed to the heavy pollution and despoliation of the natural water qualities of over 20 kms of River, depriving the local population of their normal source of domestic and agricultural waters. Yet it must be realised that India has available the expertise and technologies to allow full mitigating effluent treatment. The Central Leather Research Institute in Madras (CLRI) in association with other Government bodies is in possession of all the necessary expertise to overcome the environmental impact caused by the tanning industry. Thus the problem prima facie appears to be dissemination of information and availability of capital. Although with the large number of tanneries involved the magnitude of the problem requires superhuman effort.

II In Ethiopia the situation is somewhat mixed. All new tanneries have reasonable effluent treatment facilities, and some of the older tanneries have also installed effluent treatment equipment. However, this applies to the area of Addis Ababa and some tanneries in the rural areas. In the City of Asmara, the tanners have not installed effluent treatment, as the municipal authorities have not exercised their authority in this field, and have adopted the policy of allowing the River Maibella to serve as an actual sewer for all municipal and industrial wastes. At the time of this study (late 1974) there appeared no plans to discourage this practice, especially as the municipality discharge their own wastes into the river, which flows into the Albara River en route to the Sudan. In such a circumstance, where tannery effluents are mixed with all other industrial and domestic effluents it is not possible to pinpoint the impact of tannery effluents. Although it is stated that the river concerned, for a large part of its course, is not useable for normal domestic purposes. But the apportionment of responsibility to the four Asmara tanneries has not been studied in relation to other industries in the area.

However, a significant local environmental effect is noted concerning one of the older Addis Ababa tanneries which does not operate control techniques, there, up to a distance of two to three km. down the small river, which the tannery uses for its tannery effluent disposal, (virtually untreated), the local inhabitants complain that the water is heavily contaminated. The number of tanneries that require mitigation control equipment is small.

III In the Argentine the current situation is that the majority of the tanneries are in the Greater Buenos Aires area, employing, with a few exceptions, little or no effluent treatment systems. Tanneries discharge their effluents into some 15 natural water conduits, which serve as sewers for all of the industries in the area, all of which flow directly or indirectly into the River Plate. Apparently no public indignation has been particularly aimed at the tanneries for their environmental impact, but the authorities are instituting a series of mitigating measures, the results of which are that tanneries will either have to install equipment for treating their effluent, or be relocated in more remote areas of the country, where they will have to treat their effluent to some extent, depending on the particular location. It appears that with regard to large and medium size tanneries no problem is expected. However the large number of smaller establishments are thought to pose a problem, and, as these smaller tanning establishments generate some 20% of the tanning industry's effluent their continued generation of untreated effluent will pose a long term pollution problem.

In the Argentine in general expertise is available to counsel the tanners, and it is understood the major problem will be of a financial nature - this affects the smaller units who are not as credit worthy or find difficulty in relocating.

IV During the evaluation of the possible theoretical ecological and environmental effects which could be related to the discharge of tannery wastes, the major point to emerge was the effect of stream flow of the recipient water course, thus for a normal chrome tannery operating so as to produce an effluent with characteristics as in Annexes I and II, discharging its effluent to a river, in order to support normal fish life the receiving stream should have at least a flow of 6 m^3/day stream flow per kg. of hide processed/day. Whereas with a flow of 4 m^3/day/kg of hide processed/day the stream will not be able to support fish life in some of its lower reaches. At a still lower flow of 2 m^3/day/kg of hide processed/day, the stream will be completely devoid of oxygen downstream of the waste outfall, and the consequential anerobic conditions may lead to the formation of floating sludge rafts, noxious gases, high turbidity etc., greatly lowering the aesthetic value of the receiving waters, thus in areas of high tanning activity with sluggish stream flow, the environmental impact may often be severe. (See Chapt.III of Vol.I)

V Financial consequences of the introduction of tannery effluent pollution control mitigation measures has received a fair measure of the efforts expended on this project, and the report attempts to quantify the actual costs of effluent treatment plants in developing countries. In the developed countries tanners have for long had the techniques available to implement mitigation measures, and have been restrained from doing so by the shortage of available capital, or so we are told. Many tanners in the developed world quote the figures suggested in the United States Environment Protection Agency documentation. As may be seen in Chapter V this data suggested high capital costs for mitigating plant, but to ease the situation for large units, huge economies of scale were available, and typical treatment plant capital costs are quoted with, in some cases, the cost of mitigating facilities exceeding current plant replacement values. Obviously under such conditions tanners would be reluctant to install treatment systems. However, the treatment schemes suggested in Volume II of this report have been costed in India, and significantly lower ratios of treatment costs to fixed capital of tanning units have been established, suggesting that the expected order would be that capital treatment costs for effluent treatment plant would represent some 5 to 11% of the fixed capital of a tanning unit of medium size, having less than a 1% effect on the production costs, whereas the U.S. E.P.A. figures suggest that percent change in price needed so that net income remains constant, varies from 1 to 9%.

V CONCLUSIONS

As the leather industry in most developing countries has an expectation of expansion of volume and an advance to further stages of processing, the leather industry assumes a significant position as a potential future pollutant. In many developing countries the leather industry is just emerging, with tremendous scope for future expansion, as these countries process their own raw materials instead of exporting them in the untreated state.

There is, without doubt, need of soundly balanced summarised data on the technical and financial aspects of tannery effluent control measures, and it is hoped that this report may be used as a discussion document in the necessary liaison between Governments and Industry. In the case of those countries where new industries are being installed, there is little reason to suggest that problems will be encountered, as in most cases such tanneries will be medium to large scale ventures, often with some foreign participation, thus the expertise and finance are usually available. Control may be exercised by the planning authorities as when licences to operate are granted they can quite easily be made conditional on suitable effluent treatment measures being employed.

Although Item 3 of the summarised project description asked for "the determination of the most rigorous environmental criteria and the highest standards which can be met (technically and economically)", the consultants felt that no rigid standards should be quoted, feeling that standards must relate to many local circumstances. However, in Volume II, when discussing effluent treatment techniques and plant, clear guide lines have been established, relating degree of effluent treatment and purity of final effluent with location of the tannery and conditions of the recipient. Likewise in Chapter III of Volume I when discussing "possible ecological effects of tanning effluents" guidance in this field has also been given. It is felt that sensible interpretation of the data in this report could provide a basis on which standards could be built for many different circumstances.

In those developing countries where the leather industry is based on a large number of medium or small tanneries already existing, the problem is not so easily overcome, such tanneries may not generally have the expertise or finance available and great social problems will be encountered if unachievable standards of effluent treatment were insisted upon. In Volume II of this report processes to mitigate the pollutant potential of the effluent are outlined which are suitable for large, medium or small tanneries, although for some suggested processes the internal plumbing requirements may not easily be available to the small units. A series of outline effluent treatment plant plans is also given with basic design data for varying locations for a large (circa 1,000 hides per day) and a medium to small (200 hides per day) tanning unit. The area studies have shown that in two specific cases there are not currently available proven economic effluent treatment plants, these deficiences refer to small tanning units (100 hides per day or less), where the published literature contains little suitable for either rural or urban situations. In this field it is felt that the present project report needs some amplification.

Whether or not a further study is commissioned to overcome the deficiences noted, it is felt that this report should be widely circulated to both Government and the Tanning Industry in the developing countries, as there exists a need for a comprehensive information source on the Leather Industry's environmental impact as well as mitigating techniques.*(i) This would partially fill the void, and make a contribution in the all important field of dissemination of technical "know-how", which must be considered the prime aim of any programme to improve the leather industry's environmental impact.

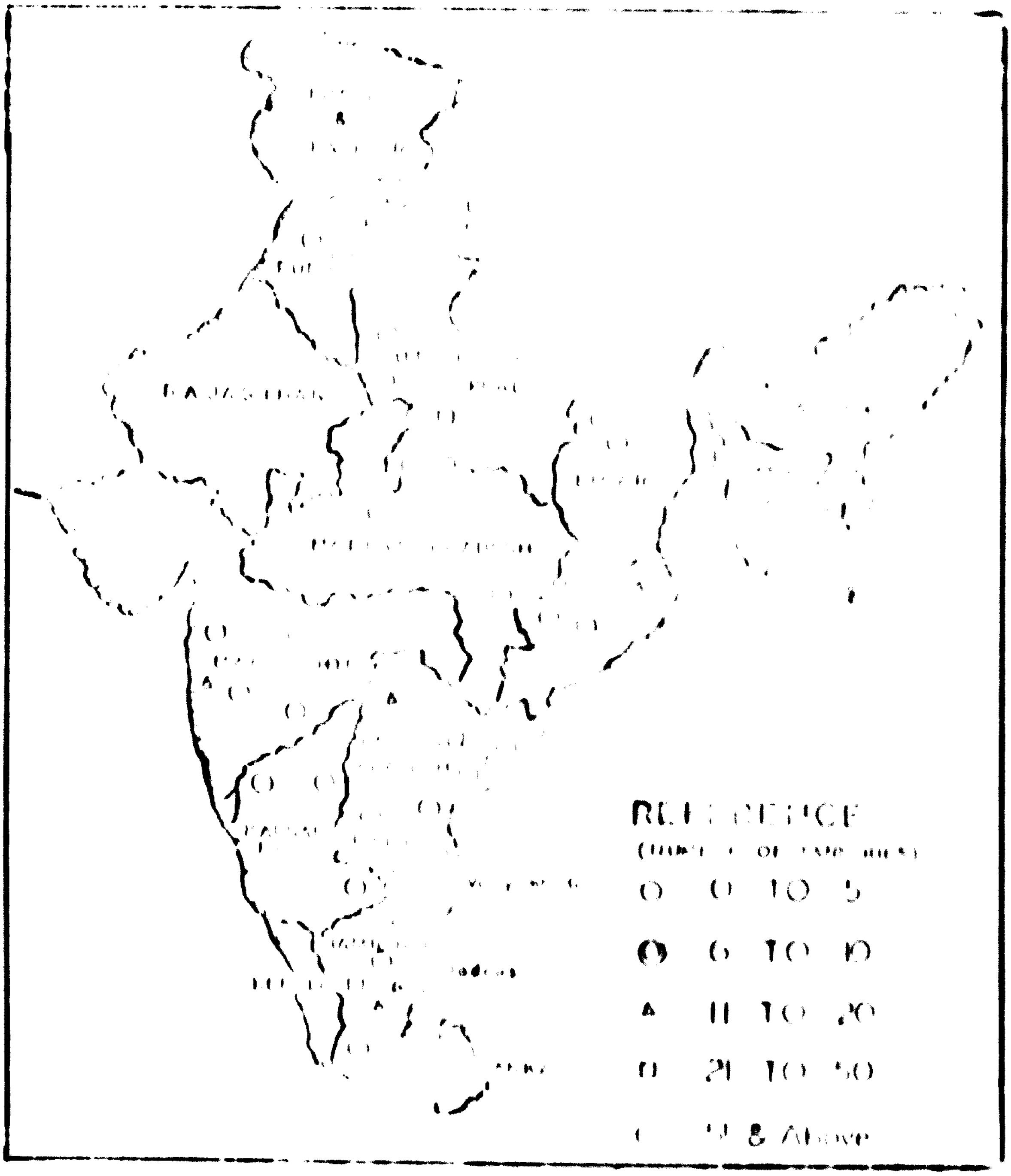
---

*(i) It is understood that a comprehensive technical book dealing with the leather industries' environmental effect and mitigating measures will shortly be published by the Centre Technique du Cuir, Lyon, France, at FF 160, which may prove too expensive for distribution to the many industrialists in the developing world who need guidance.

[illegible]

[illegible] industry that [illegible] unevenly [illegible] of [illegible] is given [illegible]

FIG. [illegible]



This survey attempts to generate a picture of the environmental impact of the leather producing industry in the State of Tamil Nadu (Madras). This industry with an old and interesting history has been a significant polluter of the environment. Though no comprehensive studies have yet been made of the damage done by the uncontrolled discharge of tannery effluents in this State, some work has been done by the Central Leather Research Institute (CLRI), Madras and the Madras Zonal Laboratory of the National Environmental Engineering Research Institute (NEERI). Earlier, the State Public Health Directorate had made some environmental studies in the North Arcot District. Abstracts of such data, together with representative data gathered from two of the tanneries visited in the present survey are presented in this report.

There are some [illegible] tanneries in the State of Tamil Nadu and during the course of the present survey [illegible] tanneries were visited and studied. These included small, medium and large scale manufacturers of both vegetable and chrome tanned leathers. Table [illegible] and Fig. [illegible] shows the distribution of the tanneries within Tamil Nadu, the tanneries visited and the types of product.

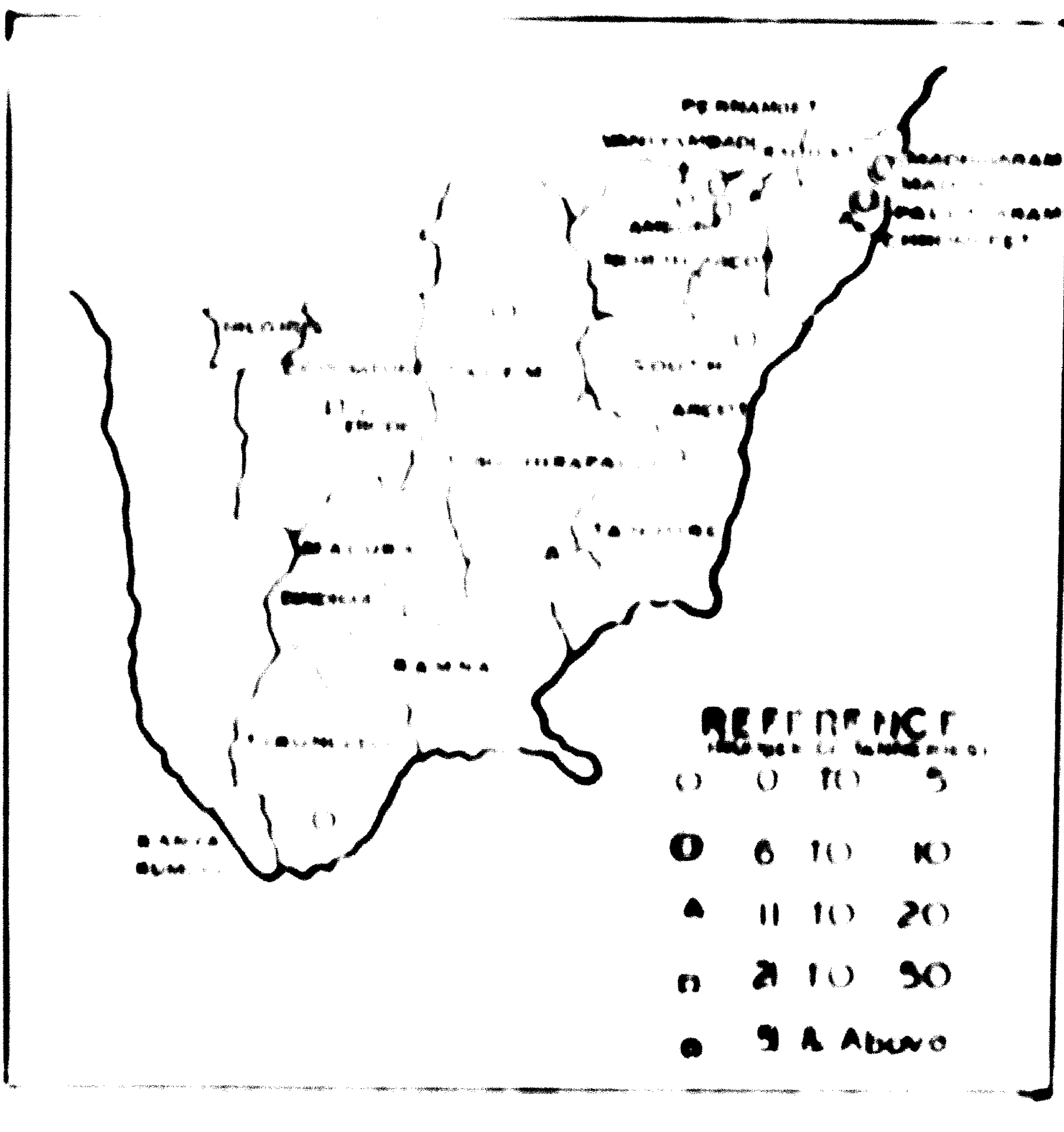
TABLE [illegible]

TANNERIES OF TAMIL NADU – EXISTING AND VISITED

PLACE	TOTAL NUMBER OF TANNERIES IN AREA	TANNERIES VISITED WITHIN AREA		
		No. of Tanneries Processing		
		Only Veg. Tanned Leathers	Only Chrome Tanned Leathers	Both Veg. & Chrome Tanned Leathers
Tiruchirapalli	[illegible]	1		
Dindigul	[illegible]	[illegible]		
Erode	30	[illegible]		
Vaniyambadi	100		[illegible]	
Ambur	50		[illegible]	1
Pernambut	50	[illegible]	4	[illegible]
Vellore	20	[illegible]	1	1
Ranipet	[illegible]	1	2	1
Pallavaram		[illegible]		1
Madhavaram	50	[illegible]	4	[illegible]
		1	2	

Many of the [illegible] tanneries are currently operating at reduced production levels, [illegible] are inoperative at present due to a variety of reasons. Among these reasons are the difficulty in obtaining credit due to the present [illegible] inflationary "credit squeeze" in the country, [illegible] power and water shortages coupled with the present official policy of [illegible] export of more finished leathers than semi-processed leather [illegible] for which is beyond the capacity of most tanners. Additionally, competition from some other developing countries [illegible] which have [illegible] out Indian exports.

FIG. II **[illegible] DISTRIBUTION OF TANNERIES IN TAMIL NADU STATE**



[illegible] GENERAL ENVIRONMENTAL EFFECTS

[illegible] situation where practically all tanneries have no access to sewage systems, the tanning industry in Tamil Nadu has had a significant adverse impact on the environment.

That water [illegible] aggravated by [illegible] water shortage, has assumed [illegible] proportions [illegible] more readily apparent [illegible] officials of the Tamil Nadu Water Supply and Drainage Board. It may be noted that ground water has been affected where tannery wastes have been dumped [illegible] spread [illegible] and [illegible] discharged into dry river beds making water unpalatable and unfit for irrigation. Extensive contamination of ground water has been observed in areas around Pallavaram, [illegible], Ambur, Ranipet, Pernambut and Vaniyambadi. At Ambur, wells have been found to be affected even at a distance of [illegible] from the tanneries. The Palar River has been considerably affected by tannery wastes. [illegible] relevant data and a map [illegible] showing [illegible] of tanneries on the banks of this river are presented [illegible] this report. The discharge of tannery wastes into surface waters [illegible] rendered [illegible] of cultivable area, causing much loss of irrigation potential.

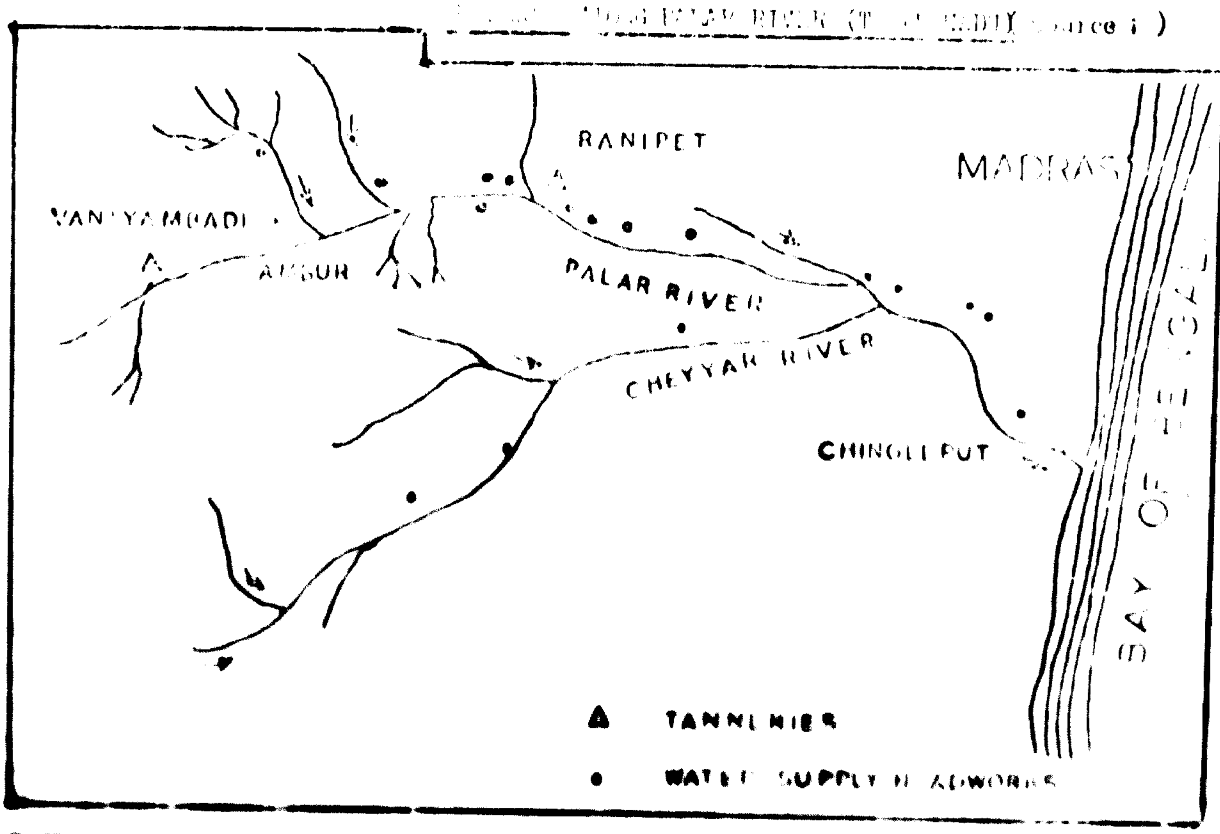
Apart from water pollution, inadequate methods of solid waste disposal, [illegible] and waste stagnation [illegible] accompanied by flies and scavenging vultures, [illegible]

[illegible]

The Palar River has been considerably affected by tannery wastes. Fig III is a spot plan showing tannery locations along the river. Table II shows water characteristics (dissolved solids and chlorides) at various places downstream of the river from Vaniyambadi. Fig IV is a graphical representation of the same data. It must be noted that seasonal variations in flow and dilution capacity considerably enhance the problem.

It is suggested that the evidence shown by Figs III and IV and Table II provides a clear prima facie case of tanneries and their effluents polluting the Palar [illegible] along a significant stretch of the river. This may be further appreciated when viewed against the effluent disposal methods shown in Case Studies 1 and 2.

FIG. III - RELATIVE LOCATIONS OF TANNERIES AND WATER SUPPLY [illegible] PALAR RIVER (T[illegible] NADU) (Source :)



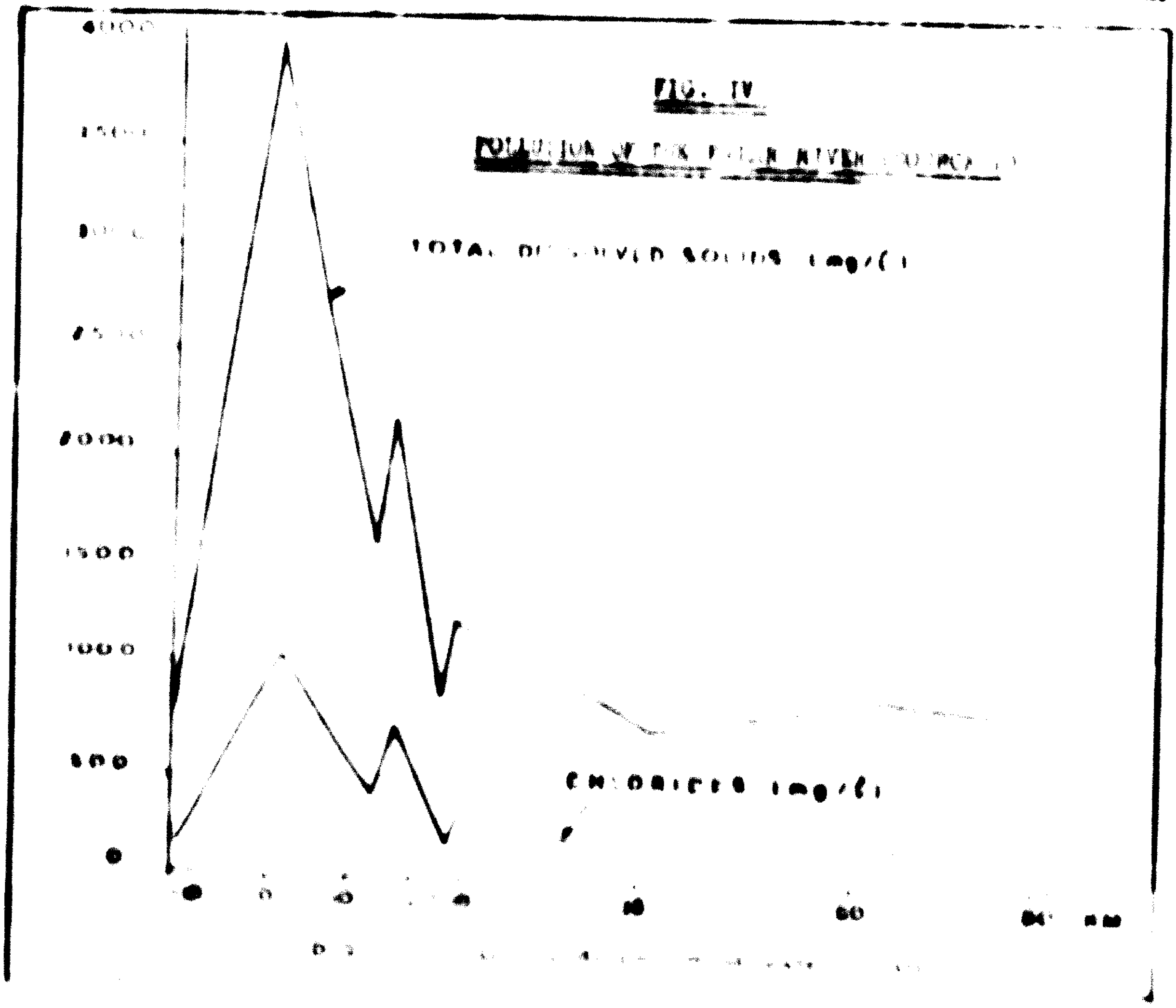


FIG. IV

POLLUTION OF THE PALAR RIVER [illegible]

TABLE II (Source 1)

SOME CHARACTERISTICS AT CERTAIN POINTS ON THE RIVER PALAR

Sl. No.	Distance along the River course with respect to the Vaniyambadi location	Pollutional Characteristics: Electrical Conductivity (indicative of dissolved solids).	Chlorides	Remarks
1.	10 Kms. upstream	700	80	Unpolluted natural water quality
2.	Near Vaniyambadi Town	4,000	1,000	Gross Pollution
3.	10 kms. downstream	1,400	300	Recovery incomplete
4.	12 kms. downstream (Ambur)	2,200	700	Second dose of gross pollution
5.	15 kms. downstream	1,100	350	Recovery incomplete
6.	1[illegible] kms. downstream	700	100	Recovery incomplete
7.	[illegible]8 kms. downstream (Ambur)	1,200	250	Third dose of Gross pollution
8.	30 kms. downstream	700	70	Recovery Complete
9.	60 kms. downstream (Ranipet)	850	140	Fourth dose of Gross Pollution
10.	[illegible]0 kms. downstream	750	70	Recovery Complete

IV. CASE STUDIES

Little purpose would be achieved by presenting detailed reports from all [illegible] tanneries visited in Tamil Nadu. The typical situation may be shown in abstracts of two case studies (a) and (b), and when one relates these typical cases to the 470 odd tanneries in the State, the enormity of the environmental impact may be accepted.

(a) CASE STUDY OF A TANNERY IN AMBUR

Tannery A is located in Ambur (about 200 km for Madras) in North Arcot district. Total population in this area is around 50,000.

There are some 22 tanneries in Ambur, most of them fairly large mechanised units processing both wet blue and finished leathers for export. A few process E.I. and chrome tanned leathers also for export. All these tanneries are situated outside municipal limits. The tanned goods are transported by road and all the tanneries except three have their own wells for water supply. Three tanneries get their water from the Palar River since their own well waters are highly saline and hard. The larger units have their own generators for power supply in addition to the State Electricity Board Supply.

The composite tannery wastes are highly coloured and give forth foul smells. Some of the tanneries have a number of earthen lagoons into which all the effluents are collected. Some tanners have acquired large areas of land around their tanneries which has been rendered useless for cultivation by continuous disposal of tan effluents. Another group of tanners whose tanneries are located on either bank of the Palar have constructed masonry settling tanks. But even here, the uncontrolled mixed wastes overflow and pollute the river. Some tanners do not even have these settling tanks, and allow the waste to flow directly into the dry river bed during summer. All the wells in the Ambur area have had their water rendered saline and hard. The adjoining agricultural lands have reportedly experienced significant drops in productivity.

The working environment tends to be less than satisfactory due to the high noise level in the mechanised tanneries. Some cases of complete whitening of hands are reported from workmen engaged in production of an assortment of white leathers - from use of titanium dioxide. There are a number of complaints of a lingering fleshy feeling that is not removed after use of ordinary soaps.

<u>Summary of Tannery A Data</u>

Tannery A is a chrome tannery with a capital investment of $ 5,600,000 and employing 600 workers. It is mechanised and uses 500,000 litres of water per day piped from the Palar River. The existing well water being highly saline, cannot be used. Power is drawn from the State Electricity Board Supply.

About 6,000 goatskins are being processed daily into finished leather. Unhairing is done by lime-sulphide painting for three hours. Reliming is done in drums for twenty-four hours followed by fleshing, deliming, washing and scudding. After pickling, the hides are chrome tanned in drums for six hours using 20% chrome liquor prepared in the tannery. Neutralisation, dyeing and fat liquoring are carried out in the usual manner and the leathers are finished into lining, upper leathers etc. for export.

There are no municipal sewers in the area. All waste liquors are allowed to flow through drains into seven earthen lagoons (size 10 m x 10 m x 3 m) and allowed to settle. Chromium hydroxide and other sludge is removed periodically and dumped. The overflow from the seventh lagoon is let out through an open masonry drain and collects in a well (size 3 m dia. and 10 m deep). From this well it is periodically pumped into a lagoon across the road and allowed to evaporate.

This tanner has plans to set up a treatment plant.

TABLE III

RESULTS OF ANALYSIS OF EFFLUENTS FROM TANNERY (a)

(All results except pH expressed as mg/l)

Tests	Major Processes					
	Soaking	Liming	Delime	Chrome Tanning	Retan & Dye	Composite *(1)
pH	7·5	11·0	8·2	3·1	5·5	7·0
Alkalinity ($CaCO_3$)	1,090	17,100	1,910	-	50	310
Chloride (Cl^-)	28,600	1,100	1,250	5,100	1,650	4,800
BOD	3,600	8,200	1,810	1,300	880	1,750
COD	9,590	13,390	5,280	6,700	2,700	3,400
Total Solids	48,830	39,250	18,720	34,360	6,200	14,800
Dissolved solids	43,000	22,670	13,980	28,110	5,100	12,000
Suspended solids	5,830	16,580	4,740	6,250	1,100	2,800
T. Nitrogen (N)	-	-	-	-	-	135·0
Phosphate (PO_4)	-	-	-	-	-	45·0
Total Chromium	-	-	-	-	-	125·0
Hexavalent chromium	-	-	-	-	-	Nil

*(1) As these analyses were on tannery scale, it may be noted that the "composite" will not be reconcilable to the sum of the major processes as washings and other processes were not analysed.

(b) CASE STUDY OF A TANNERY IN PALLAVARAM

Tannery B is located in Pallavaram (about 20 km. from Madras) in Chinglepet district. There are about 15 tanneries in the Pallavaram area processing both E.I. and finished leathers. The tanneries are outside Madras city limits and have been in existence for more than 30 years. The tanned goods are transported both by road and rail. Tanneries have their own wells as source of water supply. Some of the tanneries, whose well waters are saline, use municipal waters for finishing operations. There are no municipal sewers. Some tanneries have generators in addition to the State Electricity Board supply.

Semi-chrome and full chrome finished leathers are produced in a few tanneries. Vegetable tanned belting leather and other industrial leathers are produced in one of the tanneries. The remaining tanneries mostly produce E.I. tanned skins and kips.

The composite tannery wastes contain high amounts of suspended solids, dissolved organic impurities, salinity and alkalinity, apart from being highly coloured and emanating a foul smell. During the summer months one tannery reuses effluent for soaking and liming after primary sedimentation due to acute shortage of water. Some of the mechanised tanneries have either a series of masonry or earthen lagoons. All wastes are allowed to flow into these lagoons and the sludge is removed periodically and disposed of as manure or landfill. The supernatant is allowed to evaporate in the summer and overflows on to surrounding waste land during the monsoon.

Summary of Tannery B data

Tannery B is a vegetable tannery with 30 workers, processing 400 cow calf and 400 buff calf hides into E.I. for export. 50,000 litres per day of well water is used and power is drawn from the State Electricity Board Supply.

Unhairing is done by lime-sulphide painting for one day. The hides are then relimed for 6 days, after which they are fleshed, washed, delimed and pickled. Vegetable tanning is carried out in pits for 13 days using avaram bark, in combination with wattle extract. This is followed by myrabing, oiling and drying.

There are no municipal sewers. No effluent treatment is practised. The waste soak and lime liquors are run through separate drains and allowed to collect in earthen lagoons. Waste bark liquor flows through another drain to a separate earthen lagoon where it evaporates. The overflow is let out on open lands.

Fleshings are disposed of for glue manufacture and tanned trimmings are disposed of for manufacture of leather boards.

TABLE IV

CHARACTERISTICS OF INDIVIDUAL AND COMPOSITE WASTES FROM TANNERY (b)

Analysis	Major Processes					
	Soaking	Liming	Delime	Pickle	Veg. Tan.	Composite *(1)
pH	7·8	11·5	8·0	4·0	6·2	7·5
Alkalinity ($CaCO_3$ mg/l)	800	1,800	400	-	-	800
Chlorides (Cl^- mg/l)	11,200	300	100	2,350	1,200	1,685
Total solids (mg/l)	22,720	22,560	11,560	16,760	52,040	-
Suspended solids (mg/l)	2,500	6,600	200	600	17,320	-
BOD (mg/l)	1,100	1,920	630	620	3,300	720
COD (mg/l)	2,090	3,950	1,200	1,300	6,500	1,450
BOD load (kg/100 kg.hide)	0·409	1·87	0·528	0·334	0·340	2·4

*(1) See note on page 19

V. CAUSES OF PRESENT INADEQUACIES

There are a number of reasons why no effective precautions in the form of waste treatment and planned disposal are at present being taken to safeguard the environment. These include :-

1. Low economic status of the majority of tanners.
2. Availability of large areas of barren land not easily worked for agricultural purposes, allowing easy dumping of wastes with virtually no cost.
3. Ineffective enforcement of existing legislation by the concerned public health authorities.
4. Inadequate education and information dissemination among tanners regarding the costs/benefits of regard for the environment.

VI. MITIGATION OF ENVIRONMENTAL IMPACT OF TAMIL NADU TANNERIES

The situation is now changing gradually with increasing urbanisation. The C.L.R.I. in co-operation with N.E.E.R.I. are holding seminars and symposia where tanners are invited to present their views and, if possible, be convinced of the need for adequate effluent treatment and other environmental safeguards. One notable instance of such a "conversion" is a tannery in the Ranipet area for which the C.L.R.I. and N.E.E.R.I. are guiding the installation of a low cost waste treatment plant at a cost of US$ 60,000.

The present survey itself which involved inter alia discussions with numerous tanners and their associates, has made many of them realise the importance of the treatment of their effluents. Some have already intimated their interest in preventing further pollution of their own water sources, and of their desire to have better relations with the public, whose disenchantment with the foul smell and pollution of productive lands and water courses, is becoming increasingly vocal.

VII. GENERAL RECOMMENDATIONS

Based on the survey results it is suggested that the following basic recommendations could be implemented :-

1. Since all the tanneries in Tamil Nadu are situated in places where there are no municipal sewers, and keeping in mind the economic constraints of a majority of these establishments, a general basic method of handling effluents could be primary sedimentation followed by treatment in an anaerobic lagoon followed by an aerated lagoon before final disposal on land or into a water course. This could be on a group co-operative or individual basis. (See Vol.II)
2. The composite tannery wastes should always be screened to remove all solid matter (e.g. hair and fleshings) and the screened wastes should be subjected to sedimentation, preferably in masonry tanks. The sludge should be dried out and disposed of as manure as suggested by the Indian Standards Institution (IS : 5183 - 1969). This is being practised now by a few tanners, but not very systematically.
3. Effluents containing chromium should be mixed with waste lime liquor and the sludge allowed to settle in masonry tanks before disposal by landfill or incineration.
4. In areas such as Vaniyambadi, Ambur, Pernambet and Ranipet where there is a high degree of salinity in well waters, the soak and pickle waste liquors should be segregated and allowed to evaporate in solar evaporation ponds. Dusting salt should be disposed of in the dry state. Further, soaking the hides and skins in the minimum amount of water during the first soaking will ensure the minimum quantity of waste for disposal.

5. For tanneries located in one group, as in Kutchery Road at Vaniyambadi, or in V. Kota Road at Pernambet, a common treatment plant, e.g. a trickling filter or activated sludge, could be communally constructed and operated to reduce the cost of treatment by individual tanneries.

VIII LEGISLATION AND STANDARDS

Before remedial measures can be taken to improve the environmental degradation due to tannery effluents, and before legislation can be effectively implemented, there is a need for standards and criteria for such effluents, as well as those for water quality for various uses.

The Indian Parliament has enacted the Water (Prevention and Control of Pollution) Act, 1974. Water management is a State subject under the Indian Constitution. The various Indian States are now in the process of setting up their own Water Pollution Control Boards, and enacting similar legislation or adopting the central one. It will be some time before the beneficial effects of such actions are felt on the water pollution scene.

In the State of Tamil Nadu the disposal of liquid industrial effluent into rivers, tanks, municipal drains or sewers in governed by Rule 17 of the Tamil Nadu Factories Rules, 1950 and section 36 of the Tamil Nadu Public Health Act 1939 (as modified up to 8th January 1970). These laws seek to check the disposal of trade and municipal solid and liquid wastes into sewerage systems, water courses and in the neighbourhood of water courses. (See Annex III).

In this field Tamil Nadu has been a pioneer in the country, having set up an effluent control board many years ago. The basis thus exists for control of water pollution in this State.

The Indian Standards Institution (ISI) has evolved standards for permissible limits of all industrial effluents discharged into

(a) Inland surface waters (IS : 2490 - 1974)
(b) Public sewers (IS : 3306 - 1974)
(c) Land used for irrigation (IS : 3307 - 1965)
(See Annex IV)

Such data is being up-dated continuously in the light of advances in the field.

NOTE: (TAMIL NADU)

The average weights of the various raw materials processed in the tanneries visited are as follows :-

Cow Hide	10 to 15 kgs
Buff Hide	20 to 30 kgs
Cow calf hide	2 to 4 kgs
Buff calf hide	3 kgs
Goat or sheep skin	1 kg.

ENVIRONMENTAL IMPACT OF THE TANNING INDUSTRY - AREA STUDIES

B. ETHIOPIA

I Introduction

Ethiopia is a country with a large production of hides and skins but which has not yet fully developed its leather industry. Of the country's annual production of 7 million sheepskins, 7 million goatskins and 2·7 million cattle hides, the majority are still exported raw for processing elsewhere. There are currently four medium/large tanneries operating, and four smaller units. An ultra large tannery is due to start production in 1975, but even when this unit is in production some 75% of the available hides and skins will still be exported unprocessed. Thus there exists a large potential for the Ethiopian Tanning Industry to expand, and it is understood that long term Governmental plans visualize the exploitation of this potential.

Thus, the current environmental impact of the leather industry has great importance, as a guideline to the situation when the industry is expanded.

Until recently the tanning industry activity has been based at Addis Ababa and Asmara only, but recent developments have taken place in rural areas. Thus there are now :-

2 major tanneries and a pickling plant in Addis Ababa

4 tanneries in Asmara

1 medium size tannery and the, soon to be operational, ultra large tannery at Mojo and Edjesa (some 15 kms apart and 70 - 80 kms for Addis Ababa)

N.B. It should be noted that the survey reported on in this report was carried out in September/October 1974. Thus Governmental changes since that time are not incorporated.

II GENERAL ENVIRONMENTAL SITUATION

Responsibility for environmental matters is shared by several Ministries, Public Authorities and also municipalities have a voice in this important matter. The following are some of the major views, responsibilities and activities of various public bodies in Ethiopia as found during the survey :-

Ministry of Public Health

The Ministry are perturbed at the increasing use of rivers as a means of effluent disposal. A series of inspection sites have been introduced to check and analyse the water contamination; this step is to be followed by individual analysis of factory effluent discharges into the rivers. Legislation in draft form has been compiled and now awaits Governmental enactment. The draft specifies the maximum B.O.D. and suspended solids permissible prior to discharge into rivers or municipal sewers. No new licences will be granted to individual enterprises unless satisfactory effluent plants capable of meeting B.O.D. and SS specifications are built.

Ministry of Community Development

The Ministry welcomes any move to reduce the contamination of rivers which are used for potable purposes. They state however that any plans for effluent treatment must be designed to ensure that the cost of plant and its running costs must bear a realistic relationship to the production cost of the article manufactured.

Ministry of Commerce and Industry

The licensing of any future projects (including tanneries) should be conditional on the erection of effluent treatment plants to meet the standards now in the process of implementation. Existing tanneries should be compelled to conform with regulations provided that the cost of effluent treatment bears a reasonable relation to the production costs, (reasonable time being allowed).

Awash Valley Authority (A.V.A.)

From its study and survey of streams in Addis Ababa it had concluded that the majority of these which drain into the Little Akaki and Great Akaki Rivers, the main tributaries of the Awash River in the Upper Basin, and which flows through the urban centre of the city, are highly polluted. The main cause of pollution is attributed to animal and human excrements, septic tank effluents, trade and industrial wastes.

The [illegible] drinking, [illegible] the immediate and urgent attention [illegible]

Asmara Muni[illegible]

The muni[illegible] Maibella is within the muni[illegible] boundary and [illegible] used purely as a means of effluent [illegible] inclusive of industrial wastes. At present tannery [illegible] are allowed [illegible] into the river and it is understood there are no future plans to discourage this practice. No restrictions, [illegible] felt, can be imposed upon industrial waste discharges into the river while the municipality discharge their own untreated waste in a similar manner.

The river which is highly polluted flows into the Atbara River which in turn flows into the Sudan.

III SPECIFIC ENVIRONMENTAL IMPACT OF THE ETHIOPIAN LEATHER INDUSTRY

As may be seen from the abstracted case studies (see IV later) the situation is that in Asmara no tannery effluent control is practised, elsewhere the newer tanneries have good treatment facilities, whereas older plants may not be controlling effluents in any way. Thus one hears from the public as follows :-

> "Farmers alongside the River Maibella (Asmara) complain bitterly that water from the river cannot be used for irrigation or cattle watering, due to the heavy pollution. Complaints have been made to the municipality without success."
>
> Local inhabitants residing 3 kms below a tannery (ref. case study (a)) on the outskirts of Addis Ababa complain that the river water is contaminated and unsafe to drink.

There is little scientific evidence documented in Ethiopia to show actual tannery effluents impact on the environment. The Ethiopian "Public and Environmental Health Control Project" (A.V.A.) included a comprehensive survey of streams and rivers with analysis of samples taken at various points. However, although the project realised the pollution potential of the tanning industry the sampling points were not located above and below tannery outflows and thus could not yield actual examples of the tannery effluents' environmental impact.

As [illegible] tannery processing [illegible] ... [illegible] effluents [illegible] tannery effluents (see Annexes I and II) it may be clearly seen that discharge into a small stream, with a low rate of flow [illegible] have significant [illegible]. As the untreated tannery wastes in Asmara are combined with the industrial and domestic wastes, no apportionment of responsibility becomes possible.

IV ABSTRACTS OF CASE STUDIES OF TANNERIES VISITED

a. Medium/Large Tannery in Addis Ababa — No effluent treatment
b. Medium Large Tannery in Addis Ababa — Effluent Treatment
c. Large Prospective Tannery at [illegible] — Effluent Treatment
d. Medium Tannery in Asmara — Typical of all Asmara Tanneries; No effluent treatment

4.1 TANNERY CASE STUDY

Sited: Just outside Addis Ababa Municipality

Water supply: Treated River water

Effluent Disposal :- <u>Liquid</u> - <u>Untreated to branch of the Akaki River</u>

<u>Solids</u> - <u>Some buried, some deposited in River</u>

Condition of River below tannery :-

Highly polluted

Rate of flow dry season - 4 litres/sec

Colour varies with tannery discharge, blue to brown.

Present use of stream: - Laundry and cattle drinking 2/3 kms below tannery

Effluent treatment costs - Nil

Approx. Civil cost of tannery - U.S.$ 90,000

<u>Tannery Annual Production</u>

Hides - 50,400 pieces corrected grain bovine sides = 327,600 Kg. Air Dried

5,600 pieces Vegetable tanned sole leather = 36,400 Kg Air Dried

[illegible]

[illegible] — [illegible] Boundary

Date [illegible] — Water [illegible] date

Effluent [illegible] — Liquid via effluent plant to Little Akaki River

Liquid effluent is filtered and [illegible] to a holding tank settling for one day after which it passes to a coagulation tank where the liquid is treated with aluminium sulphate, [illegible] to coagulate [illegible]. After one day in the coagulation tank the liquid is aerated and passes into a settling tank for one day prior to passing through a [illegible] filter and chlorination tank to the river.

Solids Buried on tannery site

Condition of River below tannery site :

Highly polluted, BOD [illegible], SS [illegible]

Rate of flow dry season [illegible] litres/sec

Colour apparent unit [illegible]

N.B. This pollution is not necessarily due to tannery, as there is much other industry in the area, and if the tannery effluent plant is operated correctly, the effluent should not have a high pollution potential. In any case, the tannery could not on its own produce such a high level of pollution due to the dilution effect of the river.

Present use of River As garbage and excreta dumping site

Effluent treatment costs :- Capital U.S.$ 20,000

" " " Running Costs per annum U.S.$ 8,000

Running cost per kg Hide/Skin processed U.S.$ 0.0056

Effluent plant cost approx. 7.4% based on tannery civil building

Tannery Civil Building Cost approximately U.S.$ 280,000

__Tannery Annual production :--__

Hides - 14,000 pieces Sole Leather (Approx. 200 tons pelt)

8.,000 pieces Corrected grain sides

Skins - 960,000 pieces to pickled state

240,000 pieces to Chrome crust state.

(c) TANNERY CASE STUDY

Sited : Edjere - Approximately 80 km . r Addis Ababa - Rural Location.

__NOT YET OPERATIONAL__

Water supply - Treated River water

[illegible]

Effluent treatment costs [illegible]

[illegible] tanning [illegible]

Tanning [illegible]

Tannery [illegible]

Effluent Plant [illegible] approx [illegible] $ [illegible] on tannery [illegible] costs

Tannery Annual Production

Hides	[illegible] pieces	[illegible] M. Tons Air Dried
Sheepskins	[illegible] pieces	[illegible] M. Tons Air Dried
Goatskins	[illegible] pieces	[illegible] M. Tons Air Dried

[illegible]

Sited: [illegible] Township

Water supply: Municipal [illegible] bore hole [illegible]

Effluent disposal: **Liquid** — discharged via drain to [illegible] River
Solids — collected by Municipality and buried

Present use of River: Used solely as a means of effluent disposal. Flows into River [illegible] which in turn flows to the Sudan. Flow approx. [illegible] litres/sec in dry season

Effluent treatment costs: Nil.

Tannery Civil Building costs approximately U.S. $ [illegible]

Tannery Annual Production :

Hides [illegible] pieces finished leather - raw input [illegible] M. Tons Air Dried

Sheepskins [illegible] pieces to Wet Blue state for export - Raw input [illegible] M. Tons Air Dried

V. ANALYSIS OF THE CURRENT SITUATION WITH RESPECT TO ETHIOPIAN TANNERIES IMPACT ON THE ENVIRONMENT

It is clearly seen that the situation is confused, some tanneries not treating their effluents at all, obviously adding to the general industrial and domestic pollution. In Asmara this has been endorsed by the Municipality and in 1974 no plans were under discussion to attempt to lessen the pollution in the River Maibella.

In other areas both new and existing tanneries have been compelled to install effluent treatment plants in order to obtain manufacturing licenses.

There exists a strong case to equalise the situation and make all conform to a "reasonable" standard discharge. There is little doubt that the tannery in case a is having a great effect, even noticeable to the naked eye, on the branch of the Akaki River, as the flow is so low in the dry season that the tannery effluent will not be effectively diluted. However, the exact effect has not been proven.

The reactions of tanners are divided and can be summed up as follows :-

(a) Tanners who operate treatment plants. The treatment of tannery effluents is long overdue and provided the proposed Public Health restrictions are not too severe they are satisfied. Tanners do feel however that minimum standards of B.O.D. [illegible] and SS [illegible] are too strict in view of the highly polluted state of the rivers into which the tanners discharge their treated liquors.

(b) Tanners who do not operate treatment plants. The increase in production costs would be damaging. One tannery in Addis Ababa would consider erecting a treatment plant providing that such a plant was of compact design. Asmara tanners do not see the need for any treatment plant, their views are based on the assurance from the Asmara Municipality that the present system is adequate.

VI STANDARDS FOR EFFLUENTS

Under the auspices of the Ethiopian Standards Institute, a Committee for liquid wastes has been formed. The composition of the Committee is as follows :-

Ministry of Public Health

Municipality, Department of the Ministry of Interior

Water Resources Commission

Addis Ababa Water and Sewerage Authority

Ministry of Commerce, Industry and Tourism

University Faculty of Medicine, and others

The immediate tasks of the Committee will be to prepare standard proposals on :-

Methods of Sampling Liquid waste

Methods of Physical and Biochemical analysis of hygienic requirements of liquid wastes.

The Ministry of Public Health (Div. of Environmental Health) have issued provisional effluent standards, see Table V, but as may be anticipated the most important factor is the implementation of any such standards which was, in [illegible], apparently variable, according to the effectiveness of the Local Authority.

TABLE V

PROVISIONAL EFFLUENT STANDARDS

Component of Quality	Unit	Maximum Permissible Concentration in discharged waste water before entering receiving watercourses.
BOD ([illegible] days, [illegible])	mg/l	30
COD	mg/l	90
Total dissolved solids	mg/l	1,000
Suspended solids	mg/l	40
Chromium (III)	mg/l	2·0
Chromium (VI)	mg/l	0·1
Iron	mg/l	1·0
Phenol	mg/l	0·2
Oil or Grease	mg/l	20
pH	-	6·5 - 8·5
Cyanide	mg/l	0·[illegible]
N (NH_4)	mg/l	5·0
H_2S	mg/l	0·5
Free chlorine	mg/l	0·[illegible]

ENVIRONMENTAL IMPACT OF THE TANNING INDUSTRY - AREA STUDIES

C. ARGENTINA

I Introduction:

There are some 300 tanneries in existence in Argentina, nearly [illegible]0% of which are located in the dense urban region of Greater Buenos Aires which has a population of 8 million inhabitants. The distribution of the major tanneries may be seen in Fig. V.

Of these 300 tanneries, 25 of them form the nucleus of the chief group made up of 15 firms each of which tan more than 1,000 hides per day, and the other 10 which each tan between 500 to 1,000 per day. In this report data relating to only the most important 200 tanneries is given.

The Greater Buenos Aires zone is the most thickly populated region in the country with 8,000 inhabitants/sq. km. in contrast to the average for the whole of Argentina (an area of 2,790,000 sq. km.) of 9 inhabitants/sq. km.

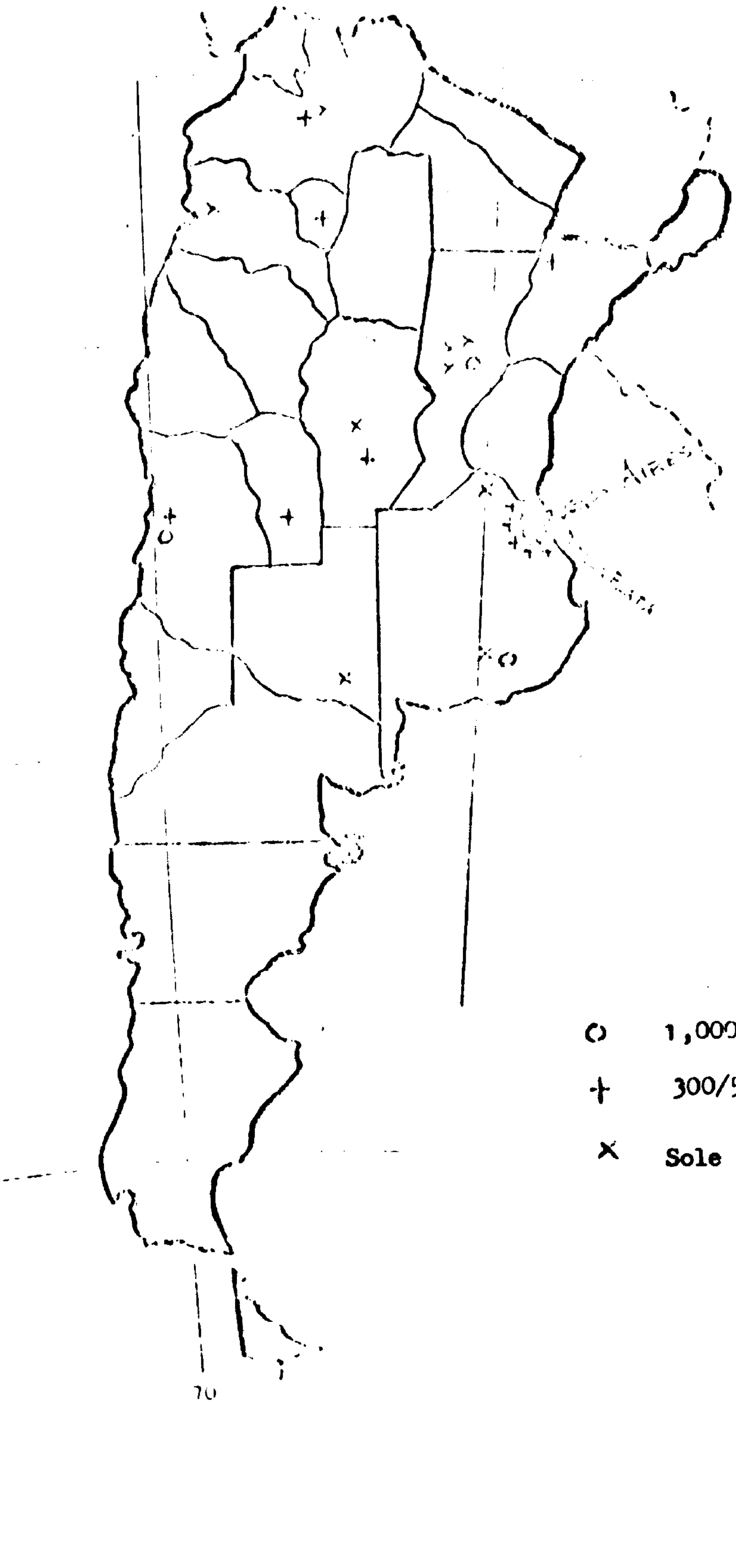
The Greater Buenos Aires zone supports the greatest concentration of industries of all kinds (food products, metallurgical, chemical etc.) and is the most urbanised area, serviced as it is by railways, communications (telephones, telegraphs, etc.) and paved roads, etc.

This particular zone has 15 water conduits and natural water courses which serve as sewers for the waste waters of the various industries set up within the area, and all of which flow directly or indirectly into the River Plate.

Owing to the River Plate's exceptional dimensions and particular characteristics (having a width of 70 km fronting the capital site of Buenos Aires and 200 km width at it's mouth), it is said to constitute a natural sewer for all effluent, with great natural advantages, as it has frequent tidal changes. Due to this fact all the industrial plants, including tanneries, have until now been indiscriminately discharging their waste water into the River Plate.

FIG. V.

DISTRIBUTION OF ARGENTINE TANNERIES



○ 1,000 or more Hides/day

+ 300/500 Hides/day

× Sole Leather Tanneries

II ENVIRONMENTAL IMPACT OF ARGENTINE TANNING INDUSTRY

As will be seen later in the vast majority of cases effluents from Buenos Aires tanneries enter conduits with other industrial wastes and flows by various routes to the River Plate. Thus no specific information is available as to the impact of the tanning industry's effluent.

Some 10 years ago fish mortality data and other evidence of contamination were made public, highlighting the very grave danger of these indiscriminate discharges. It is assumed that this reported fish mortality is the result of heavy pollution shown by a B.O.D. of the waste waters, greater than the maximum limits allowed. What part, if any, the tanning industry has played in this situation has not been evaluated.

Argentine tannery effluents, 1973/74 amounts to nearly 3 million m^3 a year. By far the greater number of these tanneries are located along the industrial belt surrounding Greater Buenos Aires, immediately outside the city, and primarily in the communities of Avellaneda and Lanus. The number of such establishments in the city itself is relatively small. With three exceptions, the tanneries located outside Greater Buenos Aires are of low production capacity, rarely more than 100 cattle hides a day. Considered by zones, the effluent volumes are as follows :-

Tanneries in	Avellaneda and Lanus	1,200,000 m^3/year	42·1%
"	" The Federal Capital	350,000 m^3/year	12·3%
"	" other parts of Greater Buenos Aires	400,000 m^3/year	14·0%
"	" the rest of the country	900,000 m^3/year	31·6%
	Total . . .	2,850,000 m^3/year	100%

These effluents flow into :

The Riachuelo 42·10% (tanneries in Avellaneda and Lanus)

The Riachuelo then flows to the River Plate and thus makes the total tannery effluent in :

The River Plate (Rio de la Plata) 68·4%

The rivers of the remainder of the country 31·6% (tanneries in the interior)

It is evident therefore that the major recipient of waste water from the tanneries is the River Plate, and especially its tributary, the Riachuelo, located centrally in the industrial belt of Greater Buenos Aires, in the zone between the capital city and the cities of Avellaneda and Lanus.

Clearly the Argentine Leather Industry has an environmental impact when it employs such large volumes of waste water.

By 1980 this impact will be 70 to 80% greater, because of the expected growth of the tanning industry during the next five years. By that year, therefore, the leather industry may be discharging an annual volume of 5 million m^3 of waste water (which contains some 0·003 per cent of solids and fatty residue) into the natural rivers and streams.

In Table VI may be seen the effluent treatment given in the majority of Argentinian Tanneries.

As is evident from the Table, despite the apparent heavy pollution of the River Plate and other waterways by the tanneries only one establishment out of 300 has a complete effluent treatment, and recycling system, and only four other tanneries have well developed treatment systems including oxidation tanks and systems for more than primary treatment. The rest of the group of 24 leading tanneries in the country only have primary treatment systems while the remaining 276 are operating primary treatment systems on a trial basis or not at all.

In addition to the liquid wastes produced by Argentinian tanners it is suggested (2) that the industry produces some 69,000 m. tons of solid waste annually, of which some 5 - 10,000 m. tons will be present in the effluents. (Perhaps 3,000 or more m. tons of fleshings and trimmings (5% of the total produced). Up to 3,000 tons of Hair and fat (majority of such waste) and some small part of the 1,000 m. tons of buffing dust produced annually.)

The balance of solid wastes are disposed :-

a) The fleshings are sold to cattle food factories and gelatine producers.

(b) The shavings are sold to brick factories and factories dealing with reconstituted leather and boards.

(c) Leather offcuts, trimmings and unusable splits are sold to factories for reconstituted leather.

TABLE VI

SANITATION SYSTEMS OF ARGENTINE TANNERIES

Tannery & Location	Effluent Treatment:	Drainage Site.
1. Moron (B.A.)	Primary treatment	Arroyo Moron = R. Plate
2. Lanus (B.A.)	Settling tanks; Primary treatment	Canal Sarandi = Riachuelo
3. Esperanza (Santa Fe)	Primary treatment	Arroyo Esperanza
4. Del Viso (B.A.)	Settling tanks; Oxidation tanks	Arroyo Pinasco = R. Plate
5. Lanus (B.A.)	Primary treatment	Canal Sarandi = Riachuelo
6. Lomas de Zamora (B.A.)	Complete purification plant (settling tanks, recycling, oxidation pond, etc.)	Riachuelo
7. Jauregui (B.A.)	Labyrinth type settling tanks & oxidation tanks	Rio Lujan = R. Plate
8. Avellaneda (B.A.)	Comprehensive treatment	Riachuelo
9. Maipu (Mendoza)	Primary treatment	Rio Mendoza
10. Lanus (B.A.)	Primary treatment	Canal Sarandi = Riachuelo
11. Azul (B.A.)	Primary treatment	Arroyo Azul
12. Bernal (B.A.)	Primary treatment	Arroyo St. Domingo = Riachuelo
13. Federal Capital	Primary treatment	Enclosed conduit = R. Plate
14. Federal Capital	Primary treatment	Municipal sewage system B.A.
15. Avellaneda (B.A.)	Primary treatment	Canal Sarandi = Riachuelo
16. Del Viso (B.A.)	Treatment including oxidation tanks	Arroyo Pinasco = R. Plate
17. Avellaneda (B.A)	Primary treatment	Arroyo St. Domingo = Riachuelo
18. Federal Capital	Primary treatment	Municipal sewage system B.A
19. Federal Capital	Primary treatment	Municipal sewage system B.A
20. Lanus (B.A.)	Primary treatment	Canal Sarandi = Riachuelo
21. Federal Capital	Primary treatment	Municipal sewage system B.A
22. Lanus (B.A.)	Primary treatment	Riachuelo
23. Federal Capital	Primary treatment	Enclosed conduit = R. Plate
24. Federal Capital	Primary treatment	Municipal sewage system B.A
100 Small Tanneries Lanus (B.A.)	No treatment	Riachuelo
50 Small Tanneries Avellaneda (B.A)	No treatment	Riachuelo
26 Sole leather tanneries at various locations throughout the interior of country.	No treatment	Various rivers and streams

200 Tanneries

(d) The buffing dust is collected and burned as it is not economically exploitable in the Argentine.

(e) The hairs, fats and grease, not being easily recovered are disposed of into the effluents. (Hair pulping usually adopted. As Argentina is such a large meat producer the economics do not allow recovery of fats from tanneries).

This method of disposal through the sale of wastage for different purposes works well in Greater Buenos Aires, and in other populous cities, e.g. Cordoba, Rosario and Mendoza, etc., and in places where commerce is active and where there are important and varied industries, but in the interior of the country greater difficulty is encountered in the sale of wastage, and therefore their accumulation in unsalubrious deposits is often the result.

In addition to the liquid and solid waste impact on the environment, it is often the case that the tanning industry has a potential to produce noxious odours.

The greatest efforts to combat this problem have been undertaken by the tanning community in Buenos Aires, a city which is completely developed and is heavily populated. It has been said:(2) "Despite the fact that certain of these tanneries are located in the midst of residential communities, they burden the neighbourhood with no odours, and one can move about in the vicinity of these establishments with the same sense of wellbeing as in any other business district, without perceiving any objectionable emanations". Even with tanneries located in other cities and regions there is no record of complaints by the public due to objectionable odours.

Although to date the Argentine industry has taken limited steps to examine and improve its environmental impact it is of comfort to note that research work regarding the industry's effluents and their environmental impact is now being carried out by a dedicated individual (3) (associated with a commercial tannery) as well as at the Leather Research Centre at La Plata (C.I.T.E.C.)

In Annex V may be found some characteristics of tannery effluents from various processes - these do not differ in any substantial way from the "Typical Tannery Effluent Analysis" shown in Annexes I and II, and, in the absence of other data, one may assume that the possible ecological effects discussed in Chapter III would apply to the Argentine.

III MITIGATION OF THE LEATHER INDUSTRY'S ENVIRONMENTAL IMPACT

The official agency responsible for pollution control is the National Sanitation Department (Obras Sanitarias de la Nacion), which inspects the tanneries periodically every 15 days to check for compliance with regulations. This Agency co-operates with:

The Ministry of Natural Resources and Human Environment and

The Directorate of Bromatology of the Province of Buenos Aires. Jointly, these bodies liaise with Trade and Research Institutes and Associations, and together they have recently proposed mitigating measures to alleviate pollution in three ways :-

(a) By setting limits to the quality of the waste water;

(b) By enforcing measures making mandatory the installation of complete waste water treatment plants;

(c) By enacting industrial promotion laws to encourage and assist in the relocation of tanneries to the interior of the country, especially to those areas with the smallest population and the greatest availability of natural streams.

(a) Limits: for quality of effluent.

Thus within Greater Buenos Aires there is a network of 15 enclosed conduits and natural watercourses, for each of which permissible limits have been set for the Biological Oxygen Demand (B.O.D.) and Consumed Oxygen (CO). The established limits are as follows :-

	B.O.D.	CO
White	50	18
Matanza	50	18
Luján	50	9
Tigre	50	23
Reconquista	100	25
Maciel	100	35
Riachuelo	100	30
Vega	100	20
Santo Domingo	150	100
Medrano	150	82
Moron	150	82
Del Rey	150	90
Maldonado	200	33
Cildanes	200	90
Sarandi	300	170

These limits apply to all industrial liquid waste.

(b) Enforcement of Effluent Treatment)
(c) Relocation of Tanneries)

In many cases tanneries are taking advantage of relocation assistance offered by Government promotion schemes in order to overcome the costs of effluent control.

There has been an immediate favourable response on the part of the leather industry to the provisions of the promotion plan for two basic reasons:

(a) Because the further away from Buenos Aires and the more underpopulated the proposed site, the more attractive are the incentives offered;

(b) Because all the tanneries of Greater Buenos Aires are faced with a very real threat of eviction because of the pollution situation.

As a result three large tanneries are already under construction in zones well removed from Greater Buenos Aires, 15 projects have been put forward to set up factories in the interior, and there are 10 cases of agreements and contracts for installation or the transferring of tannery sites. In most of the cases the construction includes totally equipped treatment plants. It is thought that this gradual removal to other zones is the right answer for the large scale establishments. However, it leaves the problem of the smaller tanneries still pending unsolved.

There are small tanneries (processing 5 to 20 hides a day) which perform no treatment at all, and discharge their waste water directly into the Greater Buenos Aires sewage system, which as already noted, empties into the River Plate. Because they are very numerous, these small tanning establishments generate some 20% of all the effluents produced by this industry, and unquestionably pose a pollution hazard. Most of them are located in Avellaneda and Lanus (60%), with the rest scattered over a wide area in the interior of the country.

This is probably the most serious problem with which Argentine environmental authorities will have to deal in connection with the tanneries. At the larger establishments strict measures are already being applied, and there is every reason to believe that within ten years all of these producers will either have relocated to the interior of the country where environmental conditions will be adequate, or will have installed complete systems for waste water treatment.

In the case of the small tanneries on the other hand neither of these two solutions is feasible, because of cost considerations. For the moment, there are no suitable solutions.

The expert who carried out the Argentine area study suggests that the Argentina tanning industry should adopt the following series of countermeasures to reduce the harmful effects of pollution :-

1. The better coordination of the actions of the official agencies among themselves and with associations and individuals engaged in private research.

2. The allocation, from the Government's official budget of amounts ten times larger than those presently set aside for pollution control and research.

3. The enactment of legislation requiring the tanneries to contribute a percentage of their turnover to work in the area of pollution control and research.

4. The required installation, as a minimum, of a primary waste water treatment plant at all existing tanneries.

5. The required installation of solid waste incinerators at tanneries located in the interior of the country. (Where recycling or utilization is not practised).

6. The required installation at tanneries processing 500 hides a day or more of a system for the complete treatment of effluent, or failing that, the relocation of these tanneries to remote regions.

7. The required performance by the group of 150 small tanneries located in Avellaneda and Lanus of :

(a) The oxidation or removal of sulphides from their effluent;

(b) The continuous balancing and pH control of their effluents.

8. The required installation of the following at all large and small tanneries (the majority of the large tanneries already have them) :-

(a) Pump action disposal systems for fleshings and their storage in external receptacles;

(b) Disposal systems for trimmings and their storage in external receptacles;

(c) Systems for the rapid delivery of these waste materials to other users.

IV ARGENTINA POLLUTION MITIGATION COSTS AND EXPENDITURE

The Government diverts a very small sum of the annual budget, just about U.S.$ 26,000 per year, towards research in the fight against pollution, and no financial support has been forthcoming from the tanneries for this purpose. Quite the contrary, they are opposed to investment of this type as being non-profitable, and have invested only in treatment plants on a rudimentary basis. Consequently the effect of these investments on the production costs of tanned leather is infinitesimal.

Up to the present only 1·53% of the total capital invested in the leather industry has been destined to setting up treatment plants of residual waters. This percentage represents 2·04% of the fixed investment and 9·52% of property and installations, and accounts for less than 0·5% of the cost of production.

In the new tanneries under construction, and those in the projected stage, the percentage allocated for effluent treatment plants reaches 4·44% of the total investment. It is suggested(2) that at this capital level, effluent treatment costs would account for 0·8 - 1·0% of the cost of production.

V CO-OPERATION WITH OTHER INDUSTRIES

It is obvious that there should be reciprocal co-operation between the tanneries on the one hand and the meat packers and slaughterhouses on the other, since both types of establishment produce waste material of animal origin, with similar characteristics, with the result that the problems they face are also similar.

To date, however, no such co-operation exists, for the reason that fundamental solutions have not been considered. Co-operation of this kind is found only at the integrated plants (meat packer - tannery), of which there are only a few in the interior of the country.

CHAPTER III

POSSIBLE ECOLOGICAL AND ENVIRONMENTAL EFFECTS WHICH COULD BE RELATED TO DISCHARGE OF TANNERY WASTES.

A. GENERAL

In the introductory notes in Chapter I mention was made of possible great variation in characteristics of tannery wastes. In order to obtain some measure of uniformity in the area studies and the technical sub-studies (forming the balance of the report Vols. I and II), it was felt expedient to accept "Typical Tannery Effluent Characteristics" - these may be fully seen in Annex I and II. The typical data accepted was based on the findings of studies in Western Europe. However, no evidence is available to suggest that such a "typical tannery effluent" dces not represent a reasonable mean of pollutants from the vast majority of mechanised conventional "non-environmentally sound" global leather production.

Only limited scientific work has been undertaken concerning the environmental and ecological effects of tannery wastes, and in this Chapter the use of the "typical analysis" allowed a widened discussion.

Tannery wastes are largely waterborne and characterised by high amounts of putrefactive organic materials, as well as possible toxic inorganic substances. These pollutants occur in the effluents both in the dissolved and suspended states. In addition, tannery effluents may be deeply coloured and can give rise to noxious smells. These features combine to make tannery wastes of relatively high "pollution potential".

The major characteristics of the accepted "typical tannery" effluent are as seen in Table VII .

TABLE VII

MAJOR CHARACTERISTICS OF THE "TYPICAL TANNERY EFFLUENT" ADOPTED.

		Chrome Tannery	Vegetable Tannery
Total Solids	mg/l	10,000	10,000
Suspended Solids	mg/l	2,500	1,500
$KMnO_4$ value	mg O_2/l	1,000	2,500
$B.O.D._5$	mg/l	900	1,700
Sulphide	mg/l	160	160
Chrome	mg/l	70	-
Chloride	mg/l	2,500	2,500

An effluent with such characteristics may give rise to various ecological and environmental effects. In general, the impact of tannery effluents on the environment will vary with a number of factors, among which are :

1) Unit operations and processes used in the tannery, i.e. hair pulping or hair retention, chrome or vegetable or "combination" tanning, use of hides green or cured, fleshed or unfleshed;

2) Segregation or combination of waste streams;

3) Place of discharge of final effluent, i.e. municipal sewer, waterway, land etc.

For instance, when discharged untreated into a water body it may impair the quality of the water and be detrimental to the well being of aquatic organisms. On land, under certain circumstances, it may result in a decrease in productivity of land and/or contamination of ground water. In sewers there is a possibility of interference with proper functioning of sewerage and waste water treatment systems.

B. DISCHARGE OF TANNERY WASTES INTO SURFACE WATER

The discharge of untreated tannery wastes into surface water bodies (probably the most common method of effluent disposal in developing countries) may bring about a deterioration of the desirable physical, chemical and biological qualities of the water. The water may become turbid and coloured due to non-settleable organic matter and the presence of tannins and colouring substances used in leather manufacture. It may give rise to noxious odours due to decomposition of unstable organic matter. This decomposition may also deplete the dissolved oxygen in the water body that is vital for aquatic life. The water may become saline and hard due to the presence of inorganic salts, and may acquire some measure of toxicity due to the presence of chromium, sulphides and ammonia in the waste. Pathogenic micro-organisms such as B. anthracis also may increase in water courses that receive tannery waste discharges. Further, due to turbidity and colour the process of photosynthesis may be restricted, thus affecting the primary link in the food chain. Sludge deposition at the bottom of the water course and the depletion of dissolved oxygen in water bodies can affect fish and other aquatic life.

In this Chapter the above factors are reviewed in relation to the water quality criteria for various beneficial uses of water, i.e. public, agricultural and industrial water supplies, cultivation of fish and other aquatic life, [illegible] and [illegible]. The [illegible] the degradation [illegible] the aquatic [illegible] situation [illegible] depending [illegible] among the [illegible] capacity of the receiving water. [illegible] reported in literature [illegible] water pollution [illegible] tannery waste [illegible] create [illegible] the dissolved [illegible] waste". Annexes [illegible] and [illegible] water body at [illegible] different degrees of dilution.

1. Dissolved Oxygen and Biochemical Oxygen Demand

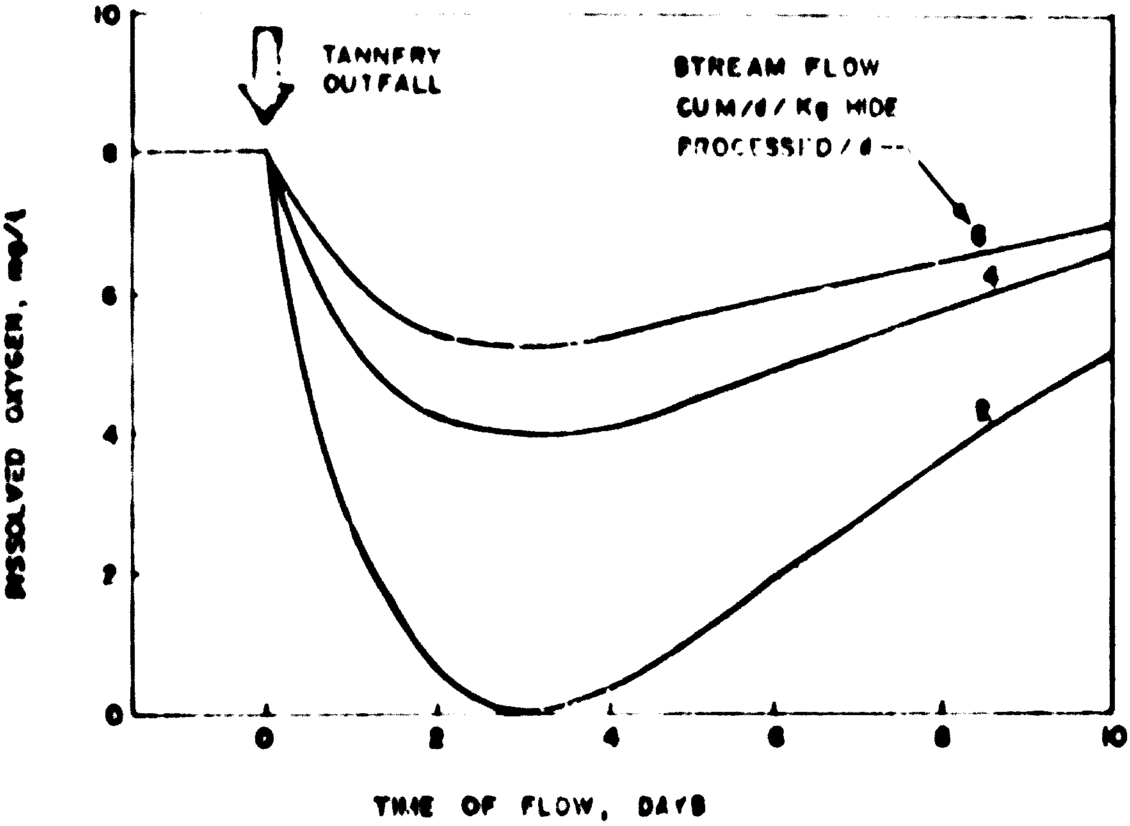
The maintenance of dissolved oxygen (DO) at an adequate level in a surface water body is important for most of its uses, as it is an indicator of the freshness of water, and is essential not only to keep aquatic organisms living, but also to maintain their healthy growth, development and reproduction. Reduced DO concentrations have been shown to interfere with fish populations through, among other ways, delayed hatching of eggs, reduced size and vigour of embryos, production of deformities in young, and decreased tolerance to certain toxicants. Organisms that form fish food may be similarly affected adversely under conditions of reduced DO. Addition of decomposable organic matter (present in tannery effluents) to a water body may deplete its DO content as oxygen is consumed by micro-organisms while decomposing the organic matter. Thus the biochemical oxygen demand (BOD) does not in itself cause direct harm to a water environment, but creates "oxygen stress" indirectly by lowering the DO content in water, which could [illegible] aerobic aquatic organisms.

No general statement can be made on the minimum DO level that should be maintained in a water body for cultivation of fish and other aquatic life. The requirement varies from specie to specie and with different stages of growth in any one specie. Minimum DO level is influenced by environmental factors such as temperature, wind intensity, depth of water and presence of impurities in water which may exert synergistic or antagonistic influences. There is significant variation in the threshold or limiting concentration of DO reported by various authors. The most often quoted work is of Ellis[5] who designated a DO range of 3 - 4.9 mg/l as unfavourably low but tolerated by many species for varying periods, and 5.0 mg/l and above as ample and favourable for fish life.

In order to have a quantitative idea of the effect of discharge of tannery wastes on the oxygen status of a stream, a hypothetical case of waste discharge from a chrome tannery has been calculated, and is shown in Fig. VI.

FIG. VI.

DISSOLVED OXYGEN PROFILE IN A HYPOTHETICAL STREAM RECEIVING TANNERY WASTE UNDER DIFFERENT FLOW CONDITIONS



The DO profiles are based on the Streeter Phelps formulation (6) for a waste with the characteristics shown in Annexes I and II. The calculations assume a sluggish stream, stream reaeration constant of 0·46 per day and BOD removal rate constant of 0·23 per day, at 20°C with a saturation DO value of 8 mg/l, and when there was no oxygen deficiency prior to discharge of the effluent. Fig. VI shows DO profiles for three flow conditions 2, 4 and 6 m^3/day stream flow/kg hide processed/day. It should be noted that for the three cases the same rates of stream reaeration and organic matter removal were assumed which may not be true. Further, the profiles may be modified due to sludge deposits and scouring if such conditions exist at different flows.

It is seen that to meet the water quality standard to support normal fish life a receiving stream should have at least a flow of 6 m^3/day stream flow per kg of hide processed/day. At a lower flow of 4 m^3/day/kg of hide processed/day the stream will not be able to support fish life in some of its reaches. At a still lower flow of 2 m^3/day/kg of hide processed/day, the stream will be completely devoid of oxygen downstream of the waste outfall and the consequential anaerobic conditions may lead to the formation of floating sludge rafts, noxious gases, high turbidity etc., lowering the aesthetic value of the receiving waters.

The corresponding values of stream flow for a vegetable tanning effluent are 11·4, 7·06 and 3·85 cu. m./day/kg. of hide processed/day respectively.

The above analysis, though based on realistic data, must be applied to field conditions with caution. The stream reaeration rate and the BOD removal rate should be determined for each particular case. Further, upon dilution in the stream the waste may exhibit a BOD value higher than what is assumed, on the basis of the analysis of raw waste, and therefore may deplete the DO to still lower levels.

The major constituents of tannery wastes that contribute to a high oxygen demand are proteins and vegetable tannins.

(a) Proteins

Tannery waste waters contain considerable amounts of protein, especially when a hair pulping unhairing system is used. These proteins are biologically degradable, and cause high oxygen demand together with the possible formation of large amounts of primary sludge during treatment of waste water.

(b) Vegetable tannins

Vegetable tannins and non-tannins present in waste waters increase the chemical oxygen demand considerably. Spent vegetable tan liquor contains a significant proportion of non-biodegradable materials which can persist in the final effluent.

2. Inorganic Pollutants

While organic substances added to a water body could become innocuous in due course by microbial action, inorganic pollutants are of a more permanent nature, unless they are in the suspended state or are precipitated from solution and settle down. Chlorides, chromium, nitrogen, sulphates and sulphides are the common inorganic pollutants present in significant quantities in tannery wastes.

Table VIII lists the water quality criteria with respect to the above parameters for various beneficial uses of water. The two references consulted in framing this Table are based on observations of a large number of researches. Wherever there were differences in the recommendations the more lenient value was selected. The values for water supporting fish life are arrived at on the basis of analysis of natural waters as well as in some cases on the basis of laboratory studies.

TABLE VIII

Water Quality Criteria for Various Uses of Water (mg/l)

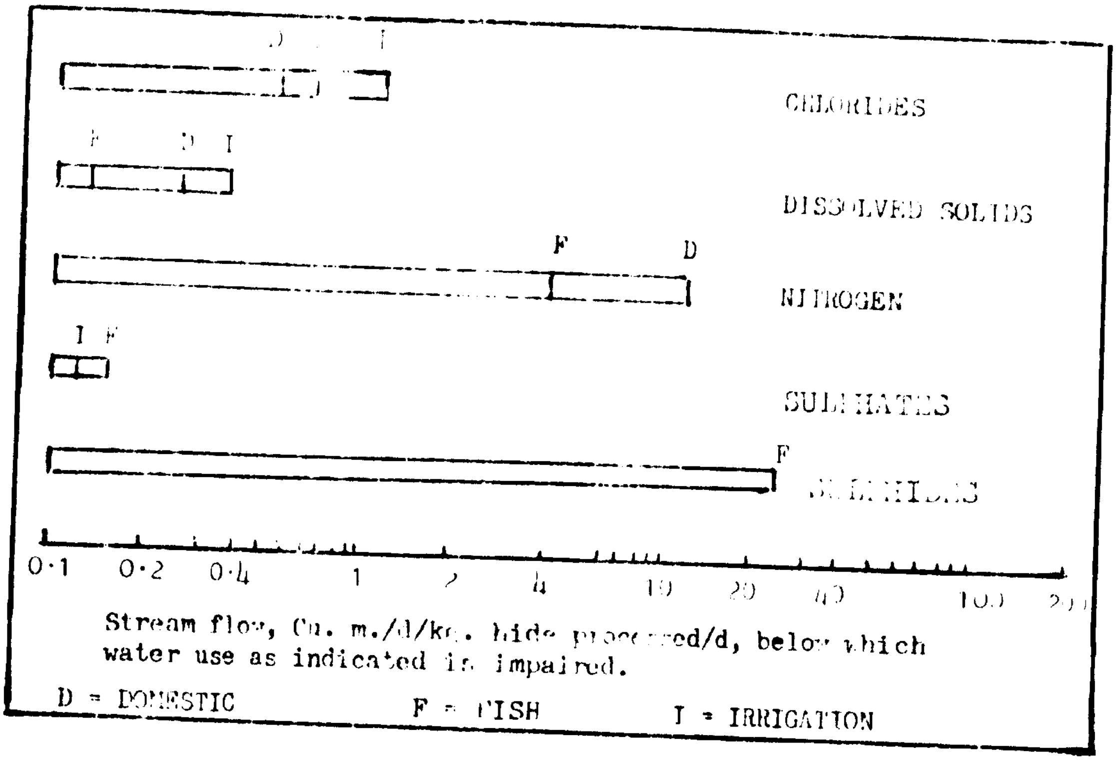
	Domestic Water	(Source)	Irrigation	Fish/Aquatic Life	(Source)
1, Chlorides	250	(8)	100	170	(8)
2, Dissolved Solids	1,000	([illegible])	700	2,000	(7)
3, Nitrogen (Ammonia)	0·4	(8)	-	1·5	(7)
4, Sulphates	500	([illegible])	200	90	(7)
5, Sulphides	-		-	0·3	(7)

High concentrations of inorganic constituents in domestic water supplies interfere mainly by imparting a brackish taste to the water. Sulphates may also have a laxative effect. The water quality cannot be brought to acceptable levels by conventional simple water treatment processes unless costly tertiary methods such as ion exchange, chemical softening etc. are utilized.

On the basis of Table VIII and the characteristics of tannery wastes in Annexes I and II, Fig. VII was prepared. It shows levels of stream flow or dilution below which various water uses are impaired due to discharge of tannery wastes.

It is seen that when the available dilution is about 1 cu.m/day per kg hide processed/day, chlorides, dissolved solids and sulphates in the waste are sufficiently diluted so as not to impair water quality for major uses of water sources. Nitrogen in tannery wastes is present in both organic and inorganic (ammonia) forms. Since the organic nitrogen in the waste is ultimately decomposed to yield ammonia, the total nitrogen in the waste is taken for calculating the dilution requirement. These assumptions provide a conservative requirement for effluent dilution.

FIG.VII - [illegible] FOR TANNERY [illegible] FOR [illegible] [illegible] OF [illegible] WATER



(e) Effect of Chromium

In general the toxicity of chromium salts towards aquatic life varies widely with the species, temperature, pH, valence of chromium as well as the complex synergistic and antagonistic effects due to other factors, e.g. hardness of water. Though fish are considered to be relatively tolerant of chromium salts fish food organisms and other lower forms of aquatic life are extremely sensitive. Chromium is known to inhibit the growth of algae.(9)

The effect of the chromium present in tannery waste is not clearly established. Using normal tanning techniques it may be expected that the chromium will be present in the trivalent form (reported to be less toxic), additionally the chromium will be precipitated in the mixed effluent at circa pH 10·0. The generally reported toxic effects of chromium refer to the hexavalent form. Such hexavalent chromium is only likely to be encountered in practice in effluents from tanneries using the now near obsolete "two bath chrome" tanning process. Calculations along the lines of thought employed in Fig.VII would suggest that in the rare cases where hexavalent chrome was discharged a flow of some 200 m^3/d/kg hide processed/day would be required to ensure a completely innocuous dilution. The actual environmental impact of the more normal trivalent, precipitated chrome from tannery wastes has not been established.

(b) Effect of Sulphides

In water, soluble sulphides (sodium sulphide used in tanneries) can result in unpleasant taste and odour problems. Sulphides can react with iron and other metals causing black precipitates. They can also react with oxygen causing a decrease in the DO content of the water. It has been observed that sulphide toxicity to fish increases as the pH value is lowered. One report[10] states that water containing 3·2 mg/l of sodium sulphide caused trout to overturn in 120 minutes at pH 9·0, in 10 minutes at pH 7·8 and in 4 minutes at pH 6·0. In another study [11] the toxicity of sodium sulphide containing effluents was determined specifically and the highest concentrations permissible for three species, i.e Daphnia magna, carp and gambusia affinis were found to be 1·9, 50 and 760 mg/l respectively. For industrial uses in general, even small traces of sulphide are sometimes considered detrimental.[7]

(c) Effects of Nitrogen and Phosphorous

Nitrogen and phosphorous from tannery effluents could enhance the problem of eutrophication in receiving waters. Being plant nutrients they may encourage the uncontrolled growth of algae and other plant life. This could eventually lead to the formation of blooms and depletion of dissolved oxygen, causing fish kills and the development of anaerobic zones where bacterial action produces noxious odours and a general lowering of water quality for aesthetic and recreational uses.

Such limiting nutrients and their critical concentrations are likely to differ in different bodies of water and have usually to be determined individually in each case. Analysis of the waters of 17 Wisconsin lakes led to the suggestion that annual average concentrations of 0·015 mg/l phosphorous and 0·3 mg/l of inorganic nitrogen were critical levels above which algal blooms can be expected. [11]

However it must be noted that the phosphorous levels in tannery effluent are seldom likely to exceed the 1 mg/l shown in Annex I and II and thus the dilution needed to avoid the critical levels is not high. Some modern tanneries employing polyphosphates as "conditioners" prior to tanning may well exceed the 1 mg/l and could thus have a potential for ecological disturbance unless greater dilutions are available.

(d) Effect of Chlorides

It is difficult to determine exactly what concentrations of sodium chloride (common salt) can cause toxicity in waters. Chloride concentration of 400 mg/l was reported[7] to be harmful to trout and 4000 mg/l to bass, pike and perch. It is nevertheless known that problems of corrosion, taste and quality of water necessary for industrial or agricultural purposes can occur at sodium chloride concentrations below those at which the above mentioned toxic effects are experienced.

(e) Effects of Suspended Solids

Suspended solids from tanneries include both organic and inorganic material. These solids may settle in part and could adversely affect fisheries by covering the bottom of the stream or lake and destroying fish food bottom fauna or the spawning grounds of fish. Waters normally containing 80 to 400 mg/l suspended solids are unlikely to support good fresh water fisheries[8]. Deposits containing organic material may deplete bottom oxygen supplies and produce hydrogen sulphide, carbon dioxide, methane and other noxious gases.

Suspended solids in water may interfere with many industrial processes and cause foaming in boilers, or encrustation on equipment exposed to water, especially as the temperature rises.

(f) Effect of colour, odour, turbidity and grease

The presence of colour, odour and turbidity most affects the use of water for domestic, industrial, recreational and aesthetic purposes. Water quality criteria for waters to be used for domestic and industrial water supply, limit colour to 75 and 3 to 9 units respectively [8]. In the specific case of tannery discharge, the water may remain unsuitable for domestic and industrial uses and the colour persist even after treatment.

One study[12] described the difficulty of removing the colour attributed to tannery waste at a water treatment plant located downstream of tannery outfalls. Raw water colour corresponding to [illegible]0 units on platinum-cobalt scale could be reduced to only 1[illegible] after coagulation, sedimentation, filtration and chlorination.

Turbidity of the water reduces light penetration and impairs photosynthetic activity of aquatic plants. It is usually difficult to assign numerical values for turbidity in water sources acceptable for water supplies, since even large concentrations may be removed by conventional water treatment processes. Likewise water quality criteria for recreation and aesthetic purposes vary greatly, and are difficult to define in numerical terms.

(g) Effect of Bacillus anthracis

Anthrax is primarily a disease of animals, but it can be transmitted to man. The bacillus can survive for long periods of time in the soil or on hides in the form of spores. It is reported that in 1958 out of 6,000 tons of dry hides handled at the Liverpool Docks one-quarter were contaminated with anthrax spores[13]. Moore[14] mentions cases on record where anthrax was transmitted to human beings through watercourses receiving tannery waste discharges.

C. DISPOSAL OF TANNERY WASTES ON LAND

Disposal of municipal and industrial waste water or sewage on land is an old practice. In developing countries with their predominantly agricultural economies this is a common method of disposing of such effluents. Disposal of wastes on land could not only eliminate pollution of surface water bodies, but is also an effective way of fulfilling the oft quoted twin objective of waste recycling and optimum utilisation of resources. In many instances industrial wastes have also been applied on land either for irrigation of crops or as a means of disposal through evaporation and infiltration. Tannery wastes when discharged on land, because of their high content of dissolved solids may affect soil fertility (beneficial and adverse effects have been reported), or may contaminate sub-surface water. Besides the liquid wastes, leachates from salt and dust dumpings may also contribute to this problem. Stagnation of wastes on land also creates considerable smell nuisance.

(1) Effect on Soil Productivity

According to a study in India[15] the productivity of the soil decreased when tannery wastes were applied on fields and some parts of the land became completely infertile, and germination of paddy seeds was not satisfactory. Another study[16] reported stunted growth of tomato plants when irrigated with tannery effluents. Germination of seeds was retarded and inhibited to some extent. They also reported that with continuous irrigation with the effluent there was an accumulation of sodium and chlorides in the soil. It has however been reported[17] that some New Zealand tanneries have been irrigating land with their effluent for many decades. This included chrome tannery effluent as well. Resistant types of grass appear to thrive.

It is well known that irrigation water may interfere with agricultural operations in three ways. Firstly, by changing the characteristics of the soil; secondly, by interfering with water uptake of plants; and thirdly, by the possible influence on the metabolic processes of plants through such substances as chromium. Tannery wastes have the potential for reacting in all the three ways. The presence of a high concentration of sodium in the waste results in deflocculation of soil (clay) particles, and thus destroys its structure which is essential for maintaining soil porosity and aeration. This is an important consideration since an adequate supply of oxygen is required in the soil for optimum plant growth. During utilization of water having a high BOD or COD (as in tannery effluent) lack of oxygen and reducing conditions may influence plant growth significantly.

Both trivalent and hexavalent chromium ions are toxic to plant life. Tolerance to the two ions varies with plant species, but more sensitive plants are adversely affected at about 5 mg/l for each ion[18].

As mentioned earlier in this report divergent views have been expressed as to the effect of chromium bearing tannery effluents and sludges on plant life and soil productivity. Much of the work undertaken by Research Institutes has been based on the use of sludges from tannery effluents. Whether these have greatly differing effects to the liquid effluent is unproven. In a later section the effect of sludges and other solid wastes is discussed, but recent studies in the U.K. using sludges may well have relevance also to liquid tannery wastes. A recent confidential report[19] quotes the following effect on plant life:-

"Some tannery sludges have been used as fertiliser on a local basis, mainly on account of their protein content, but also as a source of lime, without any reports of adverse effects on crops. In sewage works processes, chromium along with other heavy metals appears to concentrate in the sludge, and work at BIMRA [9] showed that quite high concentrations of chromium could be tolerated in sludge digestors. However, sewage works sludge finds a regular market as a fertiliser and for some years the Ministry of Agriculture has been investigating the effects of heavy metal constituents in sewage sludge on plant growth. Patterson [10] reports that Proctor barley suffered no visible effects when grown as a test crop in sandy loam at pH levels of 5.5-7.5 in the presence of up to 200 ppm Cr III. He also reports that a single application of 500 ppm Cr III on peat soil was stimulating to a range of crops but with repeated annual applications of 500 ppm Cr III toxic effects were noted, even though growth depression was slight. (500 ppm is equivalent to 1000 lb Cr/acre). Williams [11] has been conducting field trials on the effect of a range of heavy metals, Zn, Ni, Cu, Cr on red beet and celery. Chromium alone had no adverse effect after 4 years on either crop, irrespective of whether it had been applied once at the rate of 250 or 500 ppm in the soil or as 4 annual applications of 125 ppm in the soil. Arising from this work the Agricultural Development and Advisory Service had stated [12] that 'so far as is known at present chromium is not toxic to plants when present in cationic form (e.g. as a chromium salt such as chromium sulphate), unless present in very large amounts (over 500 ppm in the soil)'" (References in this abstract see below)

(2) Contamination of Sub-surface Water

Lagooning of tannery wastes or spreading on land for evaporation or irrigational purposes may lead to contamination of ground water. One study [20] reported deterioration of well water supply for a town when tannery wastes were disposed of by careless drainage. The problem was mitigated when the wastes were treated with the town municipal waste water. Another study [21] reported the effect of discharge of wastes from a group of tanneries into the dry bed of a

---

(9) Bailey, Dorrell & Robinson, J.Inst.Water Poll.Control, 1970 (1) 1

(10) Patterson, Min. of Ag. Fisheries & Food. Tech.Bull No. 21, 1971 page 193

(11) Williams, Private communication

(12) "Permissible levels of Toxic Metals in Sewage used on Agricultural Land" Ag. Dev. & Advisory Service, Advisory Paper 10 MAFF 1971

river. The river had a considerable amount of subsurface flow which was being tapped for domestic and irrigation water supplies. The survey showed that the background concentrations of total dissolved solids increased from between 640 and 740 mg/l to 1900 mg/l and chlorides from 88-180 mg/l to 820 mg/l in the area of the tannery effluent outfalls. The effect of contamination was observed up to a distance of 8 km.

D. DISCHARGE OF TANNERY WASTES INTO MUNICIPAL SEWERS

Discharge of tannery wastes to municipal sewers is a common practice where the area is covered by a sewerage system. Before disposal to sewers it is usual to remove specific contaminants depending upon the local municipal ordinances. Constituents of tannery wastes which may be regulated to suit the local municipal standards include suspended solids, alkalinity, pH, grease and sulphides. This is done mainly to prevent incrustation of sewers, sewer clogging and other forms of interference with the sewage system and operation of waste water treatment plants.

(1) Interference with Sewerage System

Table IX gives two typical standards for discharge of industrial wastes in sewers. It can easily be seen that the raw tannery wastes of Table VII will have to be pretreated to meet these standards.

TABLE IX

Limits for Industrial Effluents Discharged into Public Sewers

Characteristic		Sewage & Ind. Wastes Assoc. Washington D.C.	Indian Standards Institute
pH		5.5 - 9 [22]	5.5 - 9 [23]
BOD	mg/l	300	500
Suspended solids	mg/l	350	600
Oils and Grease	mg/l	100	100
Chromium	mg/l	-	2

Tannery effluents are known to cause deposition of calcium carbonate with the consequent choking of the receiving sewer. This is due to the conversion of calcium hydroxide to insoluble calcium carbonate by the carbon dioxide produced by decomposition of organic matter.[24] Sometimes the hair and fleshings help to form a binder with this calcium carbonate, causing the whole mass to adhere firmly and build up on the inside of the sewer surface. Necessity for frequent sewer cleaning where tannery wastes were discharged into sewers has been reported (25)(26)(27). It is noted that segregation of beamhouse and tanhouse wastes reduced scaling, as did the discharge of wastes into sewers carrying other wastes of low alkalinity or when the tannery wastes were sufficiently diluted.

Sulphide bearing wastes are objectionable from the point of view of safety of sewer workers and concentrations greater than 10 mg/l are considered objectionable (28). Mixing of tannery wastes with an acidic waste in a sewer may result in an excessive release of hydrogen sulphide. Concrete sewers are likely to suffer damage when they are made to carry sewage containing a high concentration of hydrogen sulphide due to admixture with tannery wastes. Hydrogen sulphide gas by itself is not injurious to portland cement concrete. Damage usually occurs after the gas is converted to sulphuric acid by dissolved oxygen or through the action of many species of aerobic bacteria. Both sulphides and sulphates in tannery waste effluents may cause corrosion due to production of sulphuric acid at the water line and crown of the sewer through the action of micro-organisms.

(2) Interference with Waste Treatment Operations

Treatment of tannery wastes with municipal sewage is now an accepted practice. The presence of tannery waste does not interfere with treatment operations if it does not exceed about 10% of total flow. Plants may be designed to accept the additional organic load and to handle heavy sludges when the volume of tannery effluents exceeds this value(24)(29). Other authorities quote much higher acceptable volumes of tannery effluent, Frendrup(30) has said that 20-30% of tannery effluent could be present in domestic sewage without necessitating special treatment. It has been suggested also that "The lime content of tannery effluents could be helpful in reducing the phosphorous content of sewage; on the other hand the excess phosphorous content of domestic sewage could also aid the treatment of the tannery wastes". (N.B. Tannery wastes may of course all be treated on their own with no admixture of domestic effluents.)

At small plants where no such precaution is taken and the tannery waste volume is more significant, interference with waste treatment operations could be due to one or more of the following factors:

(i) Excessive alkalinity/high pH resulting in interference with biological treatment processes e.g. activated sludge treatment.

(ii) Hair and fleshings which form scum on sedimentation tanks, clog sludge removal equipment or produce mats in digesters.

(iii) Lime sludges and adherent deposits which clog sewers or interfere with proper operation of sedimentation tanks.

(iv) Excessive loads of organic matter which overload the treatment units of the plant.

Chromium is known to be toxic to biological waste treatment processes. However, the toxicity of the trivalent form present in tannery wastes is relatively much lower[14]. One study[31] points out that bacteria can tolerate high concentrations of chromium where large amounts of organic matter are present. This could be one reason for the large range of toxic levels reported. Combined municipal and tannery wastes containing 5-7 mg/l chromium have been treated satisfactorily[32]. In the normal sequence of waste treatment operations, chromium is concentrated in sludge in primary sedimentation tanks. Concentrations of up to 300 mg/l of chromium in combined sludges did not interfere with operation of digesters having a minimum retention time of 21 days[32]. Therefore chromium of the levels in the "typical" tannery effluent (TableVII)is not expected to interfere with the operation of sewage treatment plants.

Sulphides up to a concentration of 200 mg/l are tolerated by the anaerobic digestion process[33]. During waste treatment operations sulphides may also be produced from reduction of sulphates. However, the above limit is not normally expected to be reached in tannery waste discharges to a municipal collection system, since a greater fraction of sulphides and sulphates would be in dissolved form and therefore would not be collected in the sludge which is fed to anaerobic digesters.

E. NOXIOUS SMELLS AND OTHER AIR POLLUTION

The leather industry is commonly associated with noxious smells arising from its raw materials, medieval methods of processing and effluent disposal. With the gradual expansion of the industry from its traditional village tannery setting to modern, highly centralised factories in urban areas, the problem has become more acute. The growing demand for a cleaner environment, especially in the context of increasing population growth and spreading human settlements, is forcing tanneries to reduce or completely eliminate all environment degrading "byproducts" not the least of which is the characteristic noxious smell.

Very little work has been carried out in tanneries to assess the intensity of smells generated during different operations of processing of skins and hides.

1. Origin of Smells in Tanneries

A tannery, like any other industry, can pollute the environment by its solid, liquid and airborne discharges. Into the latter category would fall the odour causing gases, smoke and dust. The main source of smells in a tannery are organic compounds, end-products of anaerobic decomposition or putrefaction of proteins include indole, skatole, mercaptans and miscellaneous aldehydes, all of which are odorous [34]. Smells in tanneries intensify from unhygienic practices in hide and skin processing, and delayed disposal of liquid and solid wastes. Different operations in tanneries which cause smells are briefly described below.

When the hide or skin is removed from an animal, the outside of the hide or skin is normally covered with dirt, while the inside of the skin contains micro-organisms held in control by the metabolic defenses of the animal. Therefore, immediately after the hide or skin is removed from the animal, decay starts unless the hide is properly cured. Least resistant in raw hide or skin to bacterial attack are mucoproteins, albumins, globulins and soft body fats, while more resistant to bacterial attack are the fibrous proteins, hair and collagen [35].

The beamhouse operations which include soaking, liming, deliming, bating etc. are the most disagreeable steps in leather manufacture from the point of view of potential smell production. These processes may produce putrescible organic matter, e.g. soak pit sludge, lime sludge, green fleshings, limed fleshing and trimmings which may all be responsible for noxious smells. During soaking the removal of curing salt and rehydration of the skin introduces the possibility of bacterial growth and protein putrefaction. Many unhairing systems in practical use are based on a balance of lime and sodium sulphide, sulphydrate or dimethyl amine sulphate to produce rapid efficient unhairing systems with controlled swelling [35]. These sulphides have the potential to liberate hydrogen sulphide when mixed with acids. Hydrogen sulphide is an extremely bad smelling gas which can be detected in concentrations as low as 0·1 ppm. Spent delime liquor, if not quickly disposed of, can give rise to putrefactive smells. During bating unwanted components, protein degradation products, epidermis, hair and the 'scud' on the surface of the skin and in the hair follicle and pores are removed by the enzyme action. Spent bate liquor may also be putrefactive. Pickling can not by itself give rise to noxious smells.

Vegetable tannins come from a wide variety of plants and may be found in wood, leaves, nuts, twigs and barks. The tannin extracts have their own peculiar smells.

Chrome tanning or mineral tanning operations do not give rise to any smells of an objectionable nature.

Some of the volatile solvents, lacquers etc. used in finishing may cause different odours.

The composite liquid wastes let out from a tannery are highly polluting in nature and contain large amounts of suspended matter which include hair, particles of flesh, lime, calcium carbonate etc. Although the relatively high pH tends to inhibit putrefaction for a time, the waste is inherently putrescible and may eventually become highly offensive [36]. Improper disposal of tannery effluents has been one of the major causes of noxious smells in tanneries. A Swedish tannery experienced difficulty due to evolution of hydrogen sulphide when treating raw sludge; the difficulty was overcome by a catalytic oxidation process [37].

II. Health Hazards Due to Noxious Smells and Hydrogen Sulphide

The effect of disagreeable odours on people is primarily a nuisance effect, and it is usually treated as such. There are cases, however, when secondary effects can be quite important. Certain intense odours may lead to nausea. Moreover, persistent odours that regularly interfere with sleep cannot help but interfere with ones wellbeing [30][38]. On the economic front, the loss of property values near poorly operated tanneries is partly a consequence of offensive odours.

Hydrogen sulphide which is liberated during some of the tanning operations is an irritant gas, and exposure to concentrations between 70 to 700 ppm may irritate the mucuous membranes of the eyes and the respiratory track. (The maximum allowable concentration for 8 hour exposure in working areas is 20 ppm). Pulmonary odema or bronchial pneumonia is likely to follow prolonged exposure to concentrations in the order of 250 to 660 ppm [39]. These levels of exposure may cause symptoms such as headache, dizziness, excitement, nausea or gastrointestinal disturbances, dryness and sensation of pain in the nose, throat and chest as well as bouts of coughing.

Numerous reports are presented by different workers on hazards of hydrogen sulphide in tanneries [40]. Knox and Schurmann [41] described cases of poisoning by hydrogen sulphide in a 3.5 m deep pit :- "The discharge valve for the sludge at the pit bottom in a tannery had a clamp and was normally opened from outside. When it broke a worker entered the pit to open the valve. This worker and three others who went to help him fell unconscious and ultimately died". Gupta et al [42] presented a report of a study of an Indian tannery of a similar disaster which yielded five fatalities. The hydrogen sulphide concentration at various levels in the pit were 0·84 mg/l at liquor surface and 0·46 mg/l at 1 meter above liquor surface. According to these authors hydrogen sulphide in concentrations of 0·38 mg/l will cause immediate unconsciousness and 0·78 mg/l may prove fatal.

Other dangers exist from chlorine and chlorine dioxides in oxidative unhairing, and when bleaching with chlorite.

Fire hazards may also be present when using nitrocellulose materials in finishing. Health hazards due to exposure to miscellaneous chemicals during finishing operations in a tannery are well documented [43] [44].

Dust problems normally arise in a tannery from buffing operations. The nature and magnitude of air pollution problems caused by dust depend on four factors :

i) the concentration of dust in the air
ii) size range of particles
iii) chemical composition and
iv) rate of settling

Leather dust of finer sizes are harmful to human health and comfort.

III. Control of Noxious Smells in a Tannery

Source control is the most effective means of abating odour. In many cases this requires only good sanitation practices, as the most persistent and offensive odours arise from putrefaction. Preventive measures are usually cheaper than control measures. Putrefactive odours may be greatly reduced by the proper use of disinfectants, spray systems and ventilation systems. Dust problems arising in tanneries during machine operations in general and buffing machines in particular, may be controlled by provision of suitable cyclone separators.

The smells caused by putrefaction of solid and liquid wastes generated during tannery operations can be reduced by rapid disposal without allowing time for putrefaction. Aeration in presence of manganese sulphate as catalyst seems to be the favoured method for removing sulphide from effluents. Aerobic biological methods of effluent treatment, dewatering of sludge by mechanical means, e.g. filter press, vacuum filters or on sand beds will considerably reduce the smells.

CHAPTER IV

TANNERY SOLID WASTES

PRODUCTION - DISPOSAL AND REUSE OR RECYCLING

Although in other sections of this report it has been felt expedient to discuss separately the production and environmental impacts of tanning activity and the mitigation of adverse environmental effects, it is felt that in dealing with tannery solid wastes such demarcation is not feasible and, therefore, here all major aspects of solid wastes produced by tanning activity are discussed, with the exception that solid wastes produced during treatment of effluent (e.g. sludges and cakes) need not be discussed here as they are referred to in Chapter III of this Volume, and also in Part II of Volume II of this report.

A. Production and Characteristics of Tannery Solid Wastes

I. Tannery Operations that Affect the Generation of Solid Wastes

Information regarding the production of solid wastes is somewhat meagre and contradictory. This may be indicative of the low economic valuation given such products. It may also be true that the relative lack of available data is due to the fact that tannery solid wastes have a somewhat low key impact on the environment, when compared with the tannery effluent which is reported to have much greater environmental impact.

Tannery solid wastes may be produced in varying quantities from the following processes: -

On receipt of the salted, "green" or dried hides the tanner will trim to remove irregular matter - this will produce raw trimmings in a "green" or cured state. Salted hides are then often dusted to remove the surface curing salt, or such salt may be dissolved in soak liquors, thus the possibility exists to produce salt dustings which may contain up to 25% of organic impurity due to the presence of blood and dung etc. Following soaking (rehydration of the hide or skin) it may be that the material is again trimmed, yielding an untanned trimming waste (potentially putrefactive, no longer cured). Lime and Sodium Sulphide are normally used to remove the hair, the method of unhairing will decide whether the hair will be recovered as a solid, or pulped into the effluent. At this stage it is normal to flesh the hide and skins, producing a waste of flesh and fat with a certain amount of hide pieces. Lime sludge may be produced in the lime pits, but in many cases, such sludge is allowed to enter the effluent rather than being collected and disposed of as a solid waste.

The dehaired, fleshed pelt is now passed through the deliming, bating, pickling and tanning processes. Tann[illegible] be completed using chromium or vegetable materials. Chrome tanning will produce no direct solid waste (ignoring the effect on the effluent), vegetable tannage may yield tan bark from leaching of equal or greater weight than the raw material being processed. Following tannage the leather is machined during shaving, splitting and buffing, and these processes all produce solid wastes in profusion, in addition to trimmings.

Table X outlines the major sources of production and possible applications for some tannery solid waste products.

TABLE X

SOURCES AND USES OF SOLID WASTES FROM TANNERIES IN HUNGARY

(Source 45)

Solid Waste By-Product	Place of Production	Possible Application
Non-proteinous By-products		
Used salt	Salt dusting & Store house	Regeneration (partly) for salting
Spent bark	Tannin Extraction	Carton Industry; As a fuel
Tan Liquor Sludge	Vegetable Tanning	Boiling, dispersing & Recycling to tanning
By-product fat	Mechanical or Chemical defatting of hides/Beamhouse	Soap Industry Currying of leather
Non-collagenous Protein		
Liming Protein	Lime Yard	Substitute for Casein Animal Food
Pig Bristle	Beamhouse	Brushes
Tail and Body Hair	Beamhouse	Carpet & Drugget Industry; Cushions
Untanned Collagen		
Shavings: Chrome Tanned	Chrome Tanning	Glue, Leather Board Synthetic Leather
" Veg. Tanned	Vegetable Tanning	Recovery of Tannin; Artificial Leather
Tanned splits	Splitting	Leather Board
By-products of Skiving, Levelling, fabrication etc.	Stitching & Cutting of Leather	Fibre Leather, Sole Patches; Mosaic Leather

II Characteristics and Quantities of Tannery Solid Wastes

It is impossible to generalize on the characteristics of solid tannery wastes. The untanned collagenous matters cited in Table and the fats are [illegible] easy to describe, as they are subject to putrefaction, and once this occurs rancid odours become noticeable. In many developing countries it is the foul odours which emanate from these putrescent solid wastes which account for much of the smell traditionally associated with tanneries. Whereas the majority of other solid products have no such noxious smells associated with them. This is not to suggest that tanned solid wastes have little environmental impact, as any visitor to the tanning quarters of Madras, Istanbul or Karachi (or indeed to any other major tanning centre) can testify to the disastrous environmental effect of the small mountains of solid tannery wastes which usually surround the tanneries. Aesthetically the solid wastes lower the whole quality of life, and in some cases encourage vermin as well as covering the locality with a miasma of malodorous vapours.

Individually, as one may see later, the solid wastes have little potential for ecological or environmental damage, but when accumulated they certainly have an environmental impact which is most easily noticed in a downgrading of the aesthetic picture.

It is perhaps the volume, not the characteristics or toxicity that make tannery solid wastes an important environmental subject. It is therefore self-evident that good housekeeping techniques could easily mitigate the environmental nuisance of tannery sites. Regular collection and disposal of solid wastes requires no great expenditure or high levels of technology. Thus in this sector few countries or tanning active areas should have problems due to economic ability or disability.

The mass of solid wastes produced in a tannery is great, it has been suggested (46) that 33% of the original protein material leaves the tannery in the form of effluent, sludge, fleshings, trimmings, shavings etc. -- of which the greater part would appear as solid wastes. Another authority shows that only 28% of the original protein content of the raw hide is used when processed into shoe uppers. Of the remaining 72% it is said that one-seventh is chrome leather waste. Admittedly much of this solid waste is generated at shoe factories, but even so the volumes produced within the tannery are great.

B. Disposal, Reuse, Recycling of Solid Tannery Wastes

The method adopted for disposal of tannery wastes vary greatly from area to area and country to country, depending on many factors. In general, where tanning industries have been long established there usually has been a simultaneous growth in industries which can utilize tannery wastes. This pattern, which held good until the last decade, was especially helpful to the tanning industry in the case of raw and limed fleshings, trimmings and splits, in this sector the presence of glue, gelatine and fat rendering units removed these most obnoxious solid wastes. Today, however, with the growth of synthetic adhesives, the demand, in most areas of the world, for raw or limed trimmings and splits has fallen rapidly and newer uses have not yet been fully established. Thus in many areas the tanner can no longer receive payment for these materials from the glue works, and is often forced to pay transport costs himself.

The subject of utilization of tannery by-products is too large to be treated comprehensively in this report, and for those requiring deeper insight into the subject two United Nations publications are available :-

1) A Food and Agricultural Organisation of the United Nations publication: "Processing and Utilization of Animal By-Products" (F.A.O. Agricultural Development Paper No. 75). This paper outlines many low level technology processes which may be used to economically reuse slaughterhouse and tannery by-products.

2) A paper presented at a 1971 United Nations Industrial Development Organisation Seminar : "The Proper Utilization of By-Products from Hides and Skins, Leather and Leather Products Industries" by Messrs. Halamek, Suchomel and Pektor (UNIDO ID/WG 79/10). This gives further details of possible means of utilizing various tannery wastes, generally employing higher levels of technology than the F.A.O. paper. In particular it outlines a method of utilizing various materials previously used in glue manufacture, and other solid wastes in the production of a semi-synthetic poromeric leatherlike material. Such a process environmentally is near perfect, as it allows scrap from the leather and leather shoe making operations to be recycled to form a substitute material for shoe components, including upper leather.

Such sophisticated recycling is of course re[illegible] capital intensive and could only be considered in areas with heavy concentrations of tanning activity, which would produce sufficient solid waste by-products to allow economic operation [illegible] such a process.

II The demand for tannery solid wastes has varied greatly during recent years, and generally the increasing cost of labour and the availability of substitute materials have been blamed for lack of demand. Halamek (47) tabulates the data relating price of tannery solid waste with price of finished recycled product in Czechoslovakia: -

TABLE XI

Waste	Product	Relative Price of Solid Waste	Relative Price of 1 kg. of Finished Product	Coefficient: Product Price / Waste Price
Chrome Tanned Shavings + Vegetable Tanned Clicking Waste	Fibrous Leather	0·03 0·06	11·15	124·2
Split Glue Stock	Photographic Gelatine	1·41	70·00	49·8
Split Glue Stock	Edible Gelatine	1·41	35·40	25·1
Chrome Tanned Clicking Waste	Hyrolyzate of Glutin	0·42	3·90	9·3
Split Glue Stock	Artificial Casings (ø 50 mm)	8·57	52·50	6·1
Hand Glue Stock	Glue	2·02	7·40	3·7
Machine Glue Stock	Hide Fat	2·42	6·00	2·5
Vegetable Tanned Clicking Waste	Used Instead of Coal	0·11	0·12	1·1

The data in Table XI is only illustrative of the situation at a given time and place and the co-efficient will vary from country to country.

III The possible uses of solid tannery wastes are countless, and mention may only be made of a few of major importance.

a) Glue Gelatine and Adhesive Manufacture.

One of the traditional uses of solid wastes (fleshings and shavings) is for the manufacture of glue and different grades of gelatine, including photographic and edible grades. The association between the tanning industry and the gelatine and glue industries has been lengthy and mutually beneficial. Association extends well outside the mere removal of hide pieces, fleshings and splits from the tannery, and their employment in gelatine and glue making. The use of common processes (e.g liming for gelatine making which is only the continuation of the liming which has been used as a preliminary for leather making) provides a strong technical link. The conversion of collagen to gelatine involves three stages; breaking of longitudinal bonds along the chains, breaking of lateral bonds between the chains and disruption of the hydrogen bonding system.

The widespread interest in processing fleshings and blue shavings into glue and gelatine is evidenced by the work carried out in different countries. According to Compte (48) the market for gelatine is expanding, particularly in the pharmaceutical industry (for encapsulation). Untanned collagen was preferred for this use. A medium quality glue has been produced commercially in Czechoslovakia (49) from chrome shavings and fleshings. A magnesium oxide process for making medium or low grade gelatine suitable for use in pharmaceutical preparations and food products from chrome shavings was developed in Germany.(50) A two stage process consisting of alkaline and acid treatment for the manufacture of animal glue has also been developed, utilizing different leather wastes (51) . Chrome tanned wastes were found to present a special problem because tanning makes hydrolysis of collagen difficult. According to IULCS Effluent Commission (48) the increased use of "wet blue" is leading in different countries to an increase in the amount of chrome tanned shavings and pieces. These are at present taken for detanning and subsequent manufacture of glue and gelatine.

Adhesives were prepared from vegetable tanned leather scrap and used as plywood adhesive in Pakistan(52). Leather scrap in this process is hydrolysed with sulphuric acid, dried and powdered. The powder either alone or in combination with rosin is best applied immediately after treatment with formalin. Adhesive compositions based on animal glue and trimethyl phenol are prepared in the U.S.A. (53).

b) Grease Recovery

The IULTCS Effluent Commission report(48) mentions that where previously all untanned wastes could be used for glue and gelatine manufacture, the advent of prefleshing, or fleshing after soaking, had resulted in an increase in green fleshings. The high water content of these materials (75-95%) has been a distinct disadvantage for the above purpose. The use of these materials in rendering had, on the other hand, become more possible. Soap making is a major market for the grease recovered in these rendering operations.

c) Conversion to Animal Feed Stuff and Proteins

Utilization of fleshings as an animal feed supplement has received considerable attention since it has potential for large scale adaptation. However there are cheaper and more efficient raw materials such as plant protein for the same purpose(54). Outlines of some of the processes used for converting fleshings and glue stock into animal feed supplements are described below. In a process developed in Japan(55) hide fleshings were mixed with carbohydrate residues, inocculated with fungi and fermented to produce a substance useful as a supplement to feeds for cattle and poultry. After conversion into a powder, limed fleshings have been found in Germany to be useful animal feed substitutes(56). It was noted that the minerals, higher pH and traces of sulphide present caused no disadvantage. Meals obtained from fleshings and glue stocks could be added for fattening in equal quantities in lieu of other animal foodstuffs (fish meal)(57). A formula for protein feed of 20-25% solids in which 60% glue stock is used for pigs and poultry was produced in East Germany in 1964.(58) The animal feeds made from fleshings were found lacking in some essential amino acids, and could not be used as sole rations. Feeding tests with rats and chickens in India also showed that delimed, defatted fleshings could not serve as the only source of protein in animal feed.

For making animal feeds, fleshings used should be free from toxic materials. When arsenic was used as an accelerator in the unhairing system (this is now discontinued) it contaminated lime fleshings and rendered them unfit for use. More recently another source of toxicity has surfaced, in the form of chlorinated products, used as bactericides in curing. There is evidence that spent chlorophenols used in treating raw hides are absorbed by the flesh and transmitted as toxic chlorodioxine in the rendered products added to animal feeds[59].

d) <u>Leather Substitutes from Leather Wastes</u>

An important outlet for tanned shavings, trimmings and dust is manufacture of leather substitutes. As early as 1938 Stather [60] used leather shavings to obtain products with properties similar to leather. Securing fibres long enough that could felt well with binders remained a problem. In Italy Salpa "Leather" consisting of 70% chrome shavings and 30% rubber latex was manufactured as early as 1928 [61]. In Czechoslovakia[62] chrome leather shavings were found suitable for production of "plastic leather" which can be used for slipper soles, middle soles and counters, as well as the poromeric materials previously mentioned [47]. The French Rubber Society [48] tested shoe soles made from a mixture of rubber and collagen, mixtures of 10 up to 100 parts of collagen to each 100 parts of rubber (latex) was used. In the presence of formaldehyde the use of untanned collagen lead to the formation of chemical bonds with rubber. The possibility of making water absorbent, semi-synthetic products by mixing collagen fibres was studied in Japan [63]. Shaving dust has also been incorporated into the manufacture of leather substitute material by applying the dust to the surface by means of electrical flocking [64]. A method of making reconstituted leather sheet involves refining chrome tanned leather pieces to provide an aqueous fibre stock, adding a plasticised polyvinyl acetate resin to the stock and precipitating it into fibres [65].

e) Leather Board from Leather Wastes

Leather Board mainly used as insoles, midsoles, stiffeners and heel lifts in the footwear industry, and in making cheap leather goods, are being produced in different countries out of shavings, trimmings, splits, buffings etc. A mixture of vegetable and chrome tanned shavings is also used in the manufacture of leather board.

In Japan attempts were made to manufacture leather board from the short fibres of chrome collagen recovered by disintegration of the fresh split from chrome leather for which there is no other use. Materials used for leather board were chrome collagen fibre, cotton, kraft pulp and chrome shavings[66]. Short length fibres which cannot be used for artificial leather manufacture could be utilized in leather board manufacture.

In India[67] very promising results were obtained in leather board manufacture using vegetable and chrome tanned shavings and rubber latex as the basic raw materials. In the manufacture of leather boards, chrome tanned shavings were found to require a special treatment for separation of fibre due to their greater resistance to tear. Condux type mills (wet grinding) have been used with satisfactory results.

f) Utilization of Leather Wastes as Fertilizer and Soil Conditioners

When there is no demand for glue and gelatine manufacture etc. fleshings are being used in some countries as manure. Vegetable tanned shavings, after digestion, are being used in India as fertilizers. Woodroffe[68] used thoroughly disintegrated vegetable tanned leather waste as a fertilizer successfully over a long period. Fertilizer may be the end use of untanned wastes, provided they are sulphide free. The soak liquor containing salt and proteins is used in India for irrigating coconut gardens[69]. Lime sludge obtained from lime pits is used as a soil conditioner in India. Effluent sludges obtained from vegetable tanneries are being used successfully as fertilizers[70]. The results of yield of "jowar" crop grown on plots using different fertilizers showed in India that tannery waste sludge helped the growth of the crops as good as the poultry manure. The disposal of

TABLE XII

ENVIRONMENTALLY SOUND AND UNSOUND PRACTICES OF SOLID WASTE DISPOSAL *(i)

Solid Waste	Environmentally Sound Utilization	Environmentally Unsound Utilization
Salt dust	Solar evaporation after dissolving in minimum amount of water and re-using in pickling etc.	Storing in heaps and allowing to be washed away during rains
Raw, Green Fleshings	Immediate disposal for glue manufacture, animal feed etc.	Piling in tannery yards and allowing to putrefy
Hair	Washing, drying and utilization for carpet, drugget industry etc.	Allowing it to choke effluent drains
Lime Sludge	Utilization for building construction, soil conditioning etc.	Allowing it to be disposed of into sewers or rivers thereby choking them.
Limed fleshings Splits and Trimmings	Utilization for glue and gelatine manufacture, animal feed, etc.	Piling in tannery yards and allowing to putrefy
Vegetable Tan Bark	Use as fuel and stable ground cover	Dumping inside tanneries
Vegetable tan sludge	Fertilizer, soil conditioner	Allowing entry into effluent flow
Vegetable and chrome tanned shavings and splits	Manufacture of leather boards, reducing chrome liquors etc. incineration along with sludge	Using for agriculture
Effluent sludges	Dewatering and incineration along with other solid wastes*(ii)	Drying in open yards, disposal into water course. lagooning indefinitely.

*(i) The information given in the above table is particularly relevant to developing countries.

*(ii) It has been reported that incineration of tannery sludge may cause Cr III to be oxidised to the Cr VI, hexavalent, form which is a much greater environmental hazard. Thus the location of any dump for ash is of great importance.

sludges containing chromium to agriculture is becoming increasingly difficult, and is discussed in Chapter III

IV It may be appreciated that the available techniques for solid waste utilization are legion, and each country must find acceptable methods within its economic reach. Many of the processes discussed earlier are capital intensive, and/or require large volumes of tannery by-products, not always available.

If one characterises "environmentally unsound" processes as those "which have higher water consumption, use excess chemicals and discharge wastes which allow little or no provision for recycling", one may then categorise as "environmentally sound" such processes which mitigate the above defects, see Table XII.

CHAPTER V

POSSIBLE FINANCIAL AND ECONOMIC EFFECTS WHICH COULD RESULT FROM THE INTRODUCTION OF TANNERY EFFLUENT POLLUTION CONTROL MITIGATION MEASURES

A. INTRODUCTION

Industrialists generally move slowly in implementing pollution mitigation measures, the usual reason given is that costs are beyond the financial resources of their sector of industry - tanners are no exception to the run of the mill industrialist. In many countries tannery effluent control is not practised on the grounds of inability to raise the necessary capital required to install effluent treatment units.

In other countries, especially the developed countries where control measures have been made obligatory, tanners complain that they must carry the burdens of effluent treatment, whereas their international competitors do not have this financial burden to bear. Thus global competitiveness is often quoted as a reason why industrialists in any country do not implement effluent control measures.

In this section of this report an attempt is made to outline possible capital costs for tannery effluent treatment schemes, and their effect on cost of production. It must be understood that there are great cost differences from country to country and within countries, and thus no firm figures are acceptable universally.

The costings covered in this Chapter refer only to the effluent schemes relating to the finished leathers -- chrome side leather and vegetable sole leather. Information is provided in Volume II Parts I and II on the effluent to be expected from "wet blue" and "ready to finish" leathers, and, using such data the costs quoted in this Chapter may be adapted to the differing levels of process. The Figure IX covers the effects of effluent treatment costs on Internal Rate of Return (IRR) for "ready to finish" and "wet blue" leathers, as well as finished.

This report has referred to "treatment of the effluent" from tanneries. This phrase is deliberately vague - it does not tell us to what standard or level tannery effluents could economically be treated. Realistically, it must be accepted that if industry is expected to expand and develop, and at the same time make a worthwhile improvement in its impact on the environment, expectations must be adjusted accordingly.

Generally there is no problem in producing demineralised water from trade effluent, but the price to be paid may be far higher than any economy could stand. Bailey(71) suggests that by treatment to a secondary stage (Biological) the cost would be some 20% of a full effluent treatment including reverse osmosis. Yet even this secondary stage may well achieve some 95% removal of B.O.D. This may not produce drinking water, or even the oft quoted standard of BOD/S.S. 25/30 mg/l., but certainly would make a drastic improvement in environmental conditions and would appear economically achievable in most countries.

The following histogram FIG. VIII shows some relationships between cost and levels of purification :-

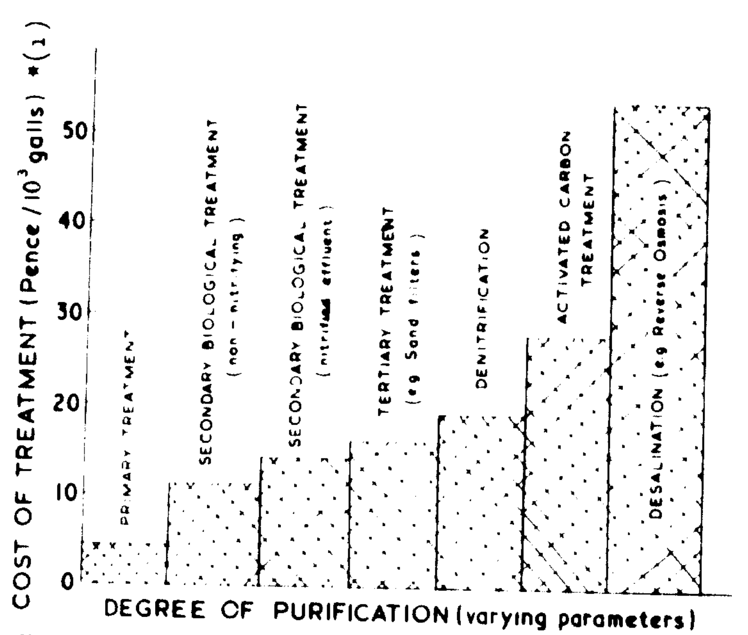


FIG. VIII The cost of treating domestic sewage to various standards of purification

In order to outline possible costs of effluent treatment, various previously published estimates of schemes proposed in the U.S.A. and India are quoted later. Additionally the costs of the major treatment schemes proposed in Volume II of this report have been costed in India Table XV(72)

Although this report recognises the need to improve tannery solid waste disposal methods, it has not attempted to give detailed costings as the disposal methods available are too variable, but in any case, the effluent treatment costs are far higher than solid waste disposal costs which are comparatively infinitesimal.

*(i) 10^3 galls = 4.546 m^3

B. FACTORS INFLUENCING COSTS OF TANNERY EFFLUENT TREATMENT UNITS

The factors which influence cost of treatment plants are many and only major topics may be reviewed here.

I. Degree of Purification

The histogram in A above quite clearly shows the relationship of costs to purification level.

II. Unit Size - Economy of Scale

Data published in the U.S.A.[73][74] shows great advantages due to economy of scale :-

Thus Treatment Plant Capital Costs for :-

A tannery with throughput of	2,200 Kg day	=	3238 US$ per 20Kg Hide per day
" " " "	" 6,800 " "	=	1391 " "
" " " "	" 15,876 " "	=	840 " "
" " " "	" 45,360 " "	=	512 " "

(See C later)

This suggests a six-fold reduction in capital cost per unit for a twenty-fold increase in plant size.

However, data published in India[75][76] shows lesser economies of scale :-

Thus Treatment Plant Capital Costs for :-

A tannery with throughput of	1,000 Kg daily	=	107·4 US$ per 20Kg Hide per day
" " " " "	2,000 " "	=	95·0 " "
" " " " "	4,000 " "	=	81·2 " "
" " " " "	8,000 " "	=	68·8 " "
" " " " "	10,000 " "	=	65·3 " "

This 1971/72 data from India, although not covering the same scale of operations does not show even a halving of capital costs per unit for a ten-fold increase in plant size.

It must be assumed that the reported high economies of scale in the U.S.A. are attributable to the relatively high percentage of sophisticated chemical engineering plant employed, which is subject to economies of scale.

Using "low cost" technologies, as in India, the economies of scale are greatly reduced as excavation and similar labour intensive activities are less subject to economies of scale.

Whether one employs sophisticated chemical engineering plant or "low cost" techniques, it does seem as if there are sufficient economies of scale available to justify tanners co-operating with each other, in areas of heavy tanning activity, to operate communal treatment plants.

Such [illegible] the major tanning areas of the world [illegible] of tanneries exist, e.g. Madras (India), [illegible] Karachi (Pakistan), Djakarta (Indonesia), Buenos Aires [illegible] and Istanbul (Turkey).

In areas where tanning [illegible] not large or not concentrated it may be that a unit [illegible] industry and domestic sewage would be socially advantageous [illegible] more economic, and most authorities suggest that up to 33% of [illegible] effluent can be mixed with domestic sewage without difficulty, [illegible] affecting the operation of the process. Such a joint plant [illegible] enable maximum advantage to be taken of economies of scale. [illegible] plants could be installed by tanners or municipalities, and the various parties charged according to volume and concentration.

III Local Conditions

All will appreciate that geographic situation will greatly influence cost of treatment plants. Land availability or otherwise will dictate to some extent the method of treatment that **may** be employed. Proximity to residential property can similarly influence choice of treatment system selected (see Volume II Part II). Such local conditions can be seen reflected in the estimated Indian tannery effluent treatment capital costs quoted in Chapter V - D, where the figure of U.S.$ 13,135 is quoted for a rural tannery compared with U.S. $ 138,500 for an urban unit of the same size. With such large variations within a country it is not surprising to find equally large variations from country to country. Major differences here are excavation and labour costs, these seem proportionately in line with actual capital costs for treatment schemes. It is interesting to compare excavation costs as these may account for up to 50% of the cost of rural type schemes, and even in more sophisticated schemes may represent some 20-30% of total capital cost [72].

Excavation costs are reported as [72] **:- (Normal soil, i.e.** clay, gravel, sand and some rock up to 2 m depth excavation)

Mean Excavation Costs - Per m^3 in U.S. $

Buenos Aires (Argentine)	U.S.$	3·87 per m^3
Ethiopia		0·80 " "
Europe - Denmark		2·00 " "
" Great Britain		1·75 " "
India		0·25 " "
U.S.A. (Central N.Y. State)		3.00 " "

Important differences in cost will result from the availability of cheap local steel supplies for tank fabrication (compared to costly imports for these bulky items), similarly rotors and air diffusers if available locally, even if somewhat cruder, may be produced at appreciably lower cost. "Low Cost" brick and clay linings to lagoons and tanks where available can be effective and far cheaper than concrete, and where available allow true "Low Cost" civil engineering works.

C. PUBLISHED DATA AS TO CAPITAL COSTS OF TANNERY EFFLUENT TREATMENT SCHEMES.

Limited data is available on this topic and such material as is published often seems conflicting. Isolated examples are available from many countries, but few comprehensive schemes have been publically costed. Data contained in United States, Environmental Protection Agency publications (73)(74) gives capital costs for two major levels of treatment:-

BPT = "Best Practicable Control Technology currently available" - basically pretreatment followed by activated sludge. (Pump, screen, equalize and primary clarification. Followed by an aeration basin, secondary clarifier, graded media filter and chlorination coupled with the necessary sludge handling plant).

BAT = "Best Available Technology Economically Achievable" suggests BPT treatment plus nitrification and denitrification.

These U.S. E.P.A. figures relate to 1970 costs, when abstracted and equated to a common unit value (a 20 kg salted hide has been assumed for simplicity, and as a mean of typical U.S. Packer hide and as a smaller Afro-Asian Hide) yield us Table XIII

TABLE XIII

CAPITAL COSTS OF TANNERY EFFLUENT TREATMENT PLANTS (U.S.$)

Tannery Production Capacity (Assuming Hides at 20 kg) DAILY:	Effluent Volume*: DAILY:	BPT Standard Capital Cost ($ 000)	BAT Standard Capital Cost ($ 000)	BPT Standard Capital Cost per 20 kg Hide per day
2,268 Kg. = 113 Hides	76 m³	366	527	3,238
6,804 Kg. = 340 "	227 m³	473	721	1,391
15,876 Kg. = 794 "	530 m³	667	1,065	840
45,360 Kg. = 2,268 "	1,514 m³	1,162	1,797	512

* The original data assumed an effluent of 4 U.S. gal. per lb. raw hide = circa 33·38 l/kg. hide.

The above costs were based on relatively sophisticated treatment systems and, at the other end of the scale, we have cost examples based on "Low Cost" technology. Figures quoted at a 1972 Madras Seminar based on three treatment stages may be seen in Table XIV

The three stages of treatment costed were:-

Treatment Stage I - Effluent mixed and settled. S. S. removed 75%

" " II - Above, plus anaerobic and aeration lagoons (B.O.D. less than 100 mg/l)

" " III - Pasveer oxidation ditch in place of aeration lagoons (B.O.D. [illegible] to 50 mg/l)

TABLE XIV

CAPITAL COST FOR VEGETABLE TANNERY EFFLUENT TREATMENT PLANT (Expressed in U.S.$ **)

Tannery Production Capacity	Capital Cost per Kg Hide Processed: Treatment Stages: 1	2	3	Stage Capital Cost per [illegible] Kg. Hide [illegible].d.
1,000 Kg. Daily - 50 Hides *	1·94	5·00	5·37	107·[illegible]
2,000 Kg. " - 100 "	1·84	4·[illegible]	[illegible]	[illegible]
[illegible],000 Kg. " - 200 "	1·50	3·[illegible]	[illegible]	[illegible]1·20
8,000 Kg. " - 400 "	1·36	3·03	3·[illegible]	[illegible]
10,000 Kg. " - 500 "	1·30	3·12	3·[illegible]	[illegible]·30

\# Hides at an average of [illegible] Kg.

** Rupee to U.S. $ Conversion at [illegible] Rs - 1 U.S.$

Assumed effluent produced = 3[illegible] l/Kg hide at BOD of [illegible],000 mg/l

Although the U.S.A. E.P.A. and Indian costs figures quoted above are not for the same process of treatment, one may compare the BPT level of the E.P.A. costs with Stage 3 of the Indian costs, as the resultant effluent will not be greatly different in character. It may be seen that at the 500 hides per day tannery level we find :-

Capital Cost for Tannery Effluent Treatment

U.S. BPT costs at 500 x circa U.S.$ 1100 = U.S.$ 550,000

Indian Stage 3 costs 500 at U.S.$ 65·3 = U.S.$ 32,650

Both the U.S.A. and Indian figures appear to be based on desk studies.

Thus U.S. treatment costs are some sixteen-fold those suggested in India, this is not an unacceptable difference if it is remembered that U.S. excavation costs (perhaps all labour costs?) are twelve-fold higher than in India. Between these extremes we find other effluent treatment costs quoted. Thus Centre Technique du Cuir in Lyon (72) quote figures for capital cost approximately 50% of the U.S.A. figures (based on actual projects) and capital costs from a new project in Ethiopia are some 25% of the U.S.A figures (1,200 hides per day). Much of the difference is attributable to vastly different labour costs, but much is also due to the use of "Low Cost" techniques. Obviously costs will vary from location to location even within a given country, as questions such as the production process employed, availability of land and the soil structure may have a large bearing on the actual cost.

Although discussion of capital costs may be of use, the major factor is the relationship of effluent treatment capital costs to tannery fixed assets. Here little information is available.

With such large deviations in capital cost estimates for effluent treatment it must be expected that cost of effluent treatment plant, compared with the existing capital value of the tanneries (replacement value) will vary tremendously. Thus we find the U.S.A. E.P.A. suggests that for an extra small U.S. Tannery (113 hides at 20 Kg. daily) the capital requirement for control facilities to BPT level is 149% of plant replacement value, but at a large U.S. tannery (twenty times greater capacity) the cost is down to 37% of plant replacement value.

Logic would suggest that the ratio of effluent treatment costs:fixed assets of tannery would be constant as in "Low Cost" effluent treatment areas the tannery building and civil engineering cost levels will be reduced pro rata. If that situation existed it would ensure some degree of global competitiveness, as all would have to shoulder a burden of a constant percentage to cover their control plant. However, during the "area studies" carried out within this project, it was found that effluent treatment costs in certain cases in Ethiopia were:

	Effluent Plant	as % Tannery Civil Engineering Costs
Case B (Circa 4-500 hides per day)	" "	= 7·14%
Case C (Over 1,200 hides per day)	" "	=3·47%

(Not included in the abstracts in Area Study) - Tannery Processing skins equivalent to 115 hides per day Effluent Plant 37%

D. STUDY ESTIMATES OF CAPITAL COSTS OF TANNERY EFFLUENT TREATMENT PLANT SCHEMES

Employing the expertise and contacts cemented during the course of this project, estimates of capital costs were obtained, from Indian sources, of the proposed effluent treatment schemes discussed in Volume II of this report. The estimates covered the following cases which have had capital costs suggested in UNIDO Working Papers:

CASE
A I Chrome Side Upper Leather Tannery

(Daily input 1,200 African hides at 5·2 kg daily = 17,472 kg. soaked, equivalent to 874 hides at 20 Kg.
Assume effluent at 250 m^3/day
B.O.D. 3,600 mg/l
Suspended Solids 10,000 mg/l)
(Ref. UNIDO Working Paper ID/WG 157/11 - SOME ECONOMIC ASPECTS CONCERNING THE ESTABLISHMENT OF TANNERIES IN DEVELOPING COUNTRIES)

Rural Location Treatment: Primary Sedimentation
Anaerobic Lagoon
Oxidation Ditch
Grass Plots

CASE
A II Chrome Side Upper Leather Tannery - Input and Effluent as A I
Urban Location - Limes Balancing only:
Treatment: Mix & Balance
High Rate Bio. Filter
Activated Sludge
Rapid Gravity Filter

CASE
A III Chrome Side Upper Leather Tannery - Input and Effluent as A I
Urban Location - Full Flow Balancing
Treatment Otherwise as A II

CASE
B I Modern Rapid Vegetable Sole Leather Tannery

(Daily input 200 African Hides/day = 4,000 Kg. soaked weight; Assume Effluent at 60 m^3/day,
BOD 5,100 mg/l
Suspended Solids 4,500 mg/l)
(Ref. UNIDO Working Paper ID/WG 157/9 - A RAPID, ULTRA ECONOMIC PROCESS FOR PRODUCING SOLE LEATHER IN DEVELOPING COUNTRIES, IN ORDER TO AID THE SUBSEQUENT PRODUCTION AND EXPORT OF LEATHER SHOES)

Rural Location - Treatment as A I

CASE
B II Modern Rapid Vegetable Sole Leather Tannery - Input and Effluent as B I.

Urban Location - Treatment as A III

The cost estimates for the proposed treatment schemes may be seen in Table XV

TABLE XV

SUMMARY OF COST ESTIMATES IN INDIA OF EFFLUENT TREATMENT SCHEMES

(Ref: Major treatment schemes detailed in Vol. II Part II of this report.)

	SCHEME	FLOW	BOD (mg/l)	1975 COST (in $)
A I	Chrome Side Upper Leather Tannery - Rural Area	250 m³/day	3600	23,125
AII	Chrome Side Upper Leather Tannery - Urban Area (Limes Balancing)	25 m³/hr	3600	138,500
AIII	Chrome Side Upper Leather Tannery - Urban Area (Full Flow Balancing)	11 m³/hr	3600	[illegible]
B I	Vegetable Sole Leather Tannery - Rural Area	60 m³/day	5100	7,250
BII	Vegetable Sole Leather Tannery - Urban Area (Full Flow Balancing)	60 m³/day	5100	27,150

I. Side Leather Tannery (approaching 1,000 hides per day) (Ref: ID/WG 157/11.)

If one examines the cost estimates for the Chrome Upper Leather Treatment Scheme summarized in Table XV it will be seen that "Full Flow Balancing" is more economic (see Vol II Part II). However for examination the "Limes Balancing only" cost estimate will allow a large margin to cover possible on-costs due to local circumstances.

Thus U.S. $ 138,500 is suggested as the capital cost for tannery effluent scheme relating to an input of 17,472 Kg. daily. This represents U.S.$ 158·47 per 20 Kg. Hide per day. This may be compared with the U. S.$ 65·0 (500 hides daily) or U.S. $ 107 (50 hides per day) shown in Table XIV earlier.

The suggested "Fixed Capital" without effluent treatment plant for the tannery in ID/WG 157/11 for this tannery to process 1,200 African Hides daily(equivalent to 874 hides at 20 kg. daily) was U.S.$ 2,460,600. Thus the Effluent Treatment Plant at that level would represent some .... **5·63%** of the "Fixed Capital" of the tanning unit.

The "Fixed Capital" referred to in ID/WG 157/11 relates to costs in an African country where a high percentage of building materials and machinery are imported. Under Indian conditions (or elsewhere where low cost techniques are established in the civil engineering field), it is conceivable that tannery fixed costs would be 50% of those calculated for the African unit, under such conditions the U.S.$ 138,500 for Effluent Plant would represent ....11·26% of the "Fixed Capital" of the tanning unit.

A 1974 Tropical Products Institute of the U.K. Report (77) published some suggested Capital Figures for tanneries. Figures may be abstracted from this report relating to a tannery with a throughput of 21,000 Kg. daily (i.e. equivalent to 1,050 hides at 20 Kg. daily). For such a unit a 1972 "Fixed Capital Cost" of Stg. £ 764,900 is quoted, i.e. U.S.$ 1,835,760. Accepting the U.S.$ 158·47 capital per 20 kg. hide per day, the effluent treatment capital would be U.S.$ 166,393. (The report itself gives a composite cost for ancillary services and effluent disposal of U.S.$ 239,280). Our calculated effluent scheme would therefore represent ... 9·06% of the fixed cost of the tanning unit.

<u>VARIATIONS OF FROM 5·63% THROUGH 9·06% TO 11·26% OF EFFLUENT TREATMENT CAPITAL COSTS AS PERCENTAGE OF TANNERY FIXED CAPITAL CAN BE SEEN IN THE ABOVE EXAMPLES COSTED. WHEN VIEWED AGAINST THE 37·3% WHICH IS THE LOWEST AMERICAN PERCENTAGE QUOTED IN TABLE XVI THE IMPORTANCE OF ADOPTING "LOW COST" TECHNIQUES WHERE POSSIBLE IS FORCIBLY SHOWN.</u>

TABLE XVI

RELATIONSHIP OF CAPITAL COST OF EFFLUENT TREATMENT TO PLANT REPLACEMENT

Values - U.S. E.P.A. Estimates (73) (74)

Plant Size - [illegible] kg Hides	BPT Level U.S. $ [illegible]	Plant Replacement Value U.S.$ [illegible]	Effluent Treatment Capital Cost as % of Replacement Values :
x Small - 113 Hides day	366	245	1[illegible]%
Small - 340 " "	4[illegible]3	635	74·5%
Medium [illegible] " "	[illegible]	1.200	[illegible]·6%
Large 2,[illegible] " "	1,152	3,115	37·3%

II Vegetable Sole Leather Tannery (200 Hides per day) (Ref: ID/WG 157/9)

Although the calculations refer to a sole leather tannery of specified size, the data could be related to any vegetable tannery of similar throughput.

From Table XV it will be seen that the capital cost of U.S.$ 27,150 for Full Flow Balanced Effluent Treatment relates to an urban situation. The UNIDO Working Paper ID/WG 157/9 suggests two possible fixed capital costs for such a production unit :-

A - U.S.$ 231,452 - Low Cost Project - includes maximum local manufacture, and reconditioned machinery.

B - U.S.$ 534,902 - A Prestige Project - all new machinery.

Again it may be seen that the capital costs estimated within this report for the effluent treatment plant, as a percentage of the fixed capital, are .... 11·7% - 5·1%

Again it appears that using "low cost" techniques the "treatment" capital costs do not approach the high levels suggested by U.S.E.P.A. (149% for 113 hides/day; 74·5% for 340 hides/day).

It is possible that the tannery fixed capital could be reduced in certain countries by 50% (as discussed in the chrome tannery case), and even under such circumstances, the effluent treatment capital costs, as a percentage of the tannery "Fixed Capital" would only be from 23·4% - 10·2% for this relatively small production unit.

E FINANCIAL EFFECTS OF CAPITAL COSTS OF TANNERY EFFLUENT TREATMENT

In previous sections of this report estimated capital costs have been quoted for tannery effluent treatment systems. Of more importance is the effect of such capital expenditure on costs, sales prices and competitiveness. The high levels of cost suggested in the U.S.A. (not yet in operation, but due to be enforced by July 1977?) would have a massive effect on sale prices (73) and the following Table may be of interest:-

TABLE XVII

PERCENT CHANGE IN PRICE NEEDED (*)

Tannery Size	B.P.T. Treatment	B.A.T. Treatment
100 U.S. Hides Daily (113 Hides @ 20 Kg)	9.0	13.5
300 " " " (340 " " " ")	3.6	5.8
700 " " " (791 " " " ")	2.2	3.7
2,000 " " " (2,268 " " " ")	1.3	2.0

* Such that net income remains constant.

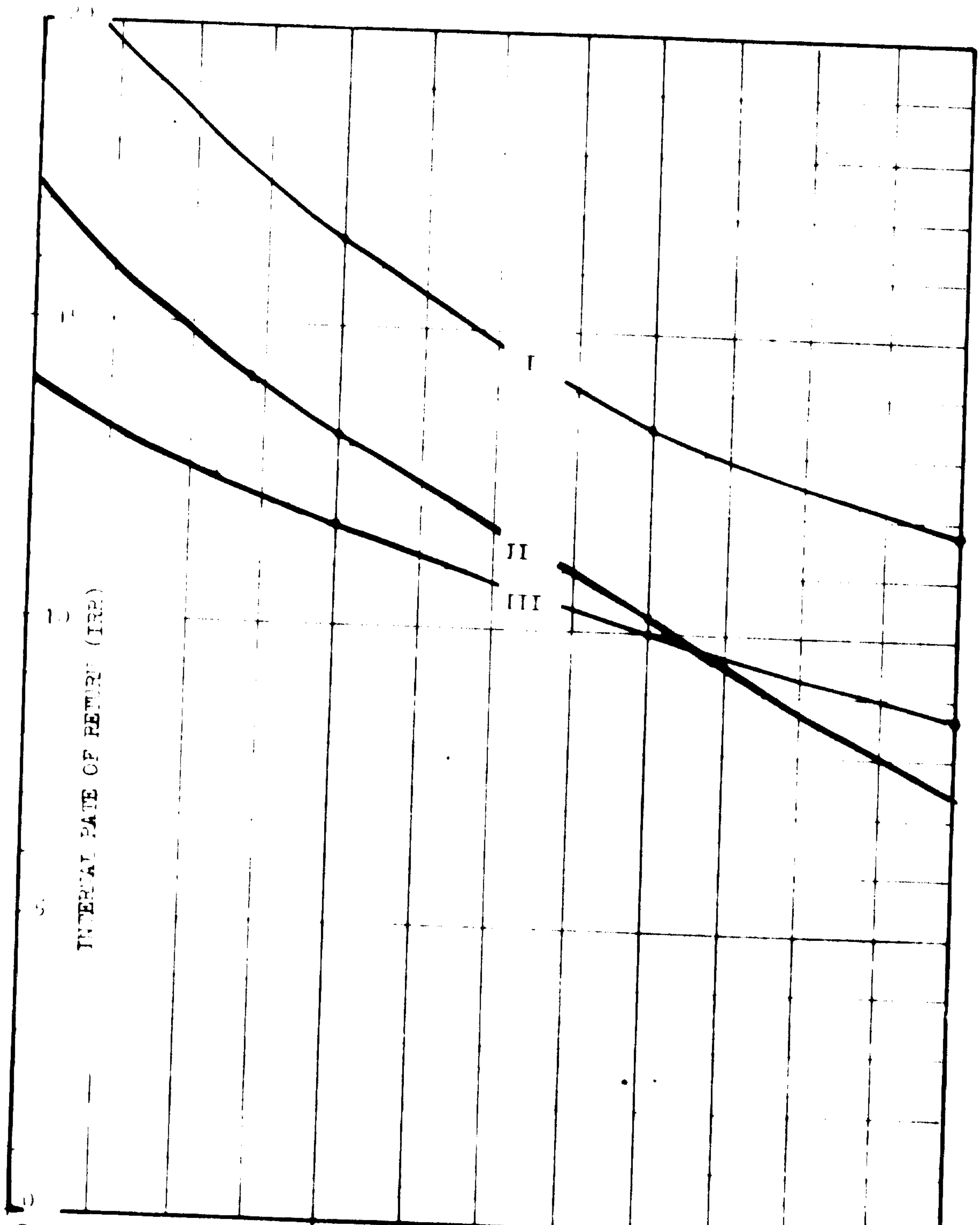
The U.S. study suggests that some 30% of "small"? tanneries (300 hides per day) may be forced to close due to the financial impact of installing effluent control systems. With such large benefits of economy of scale the larger units are given a distinct advantage.

The high on-costs due to effluent control measures as outlined above for the U.S.A. have provided ammunition for tanners in many countries who were unwilling to install control plant. With possible burdens of 9% or later 13.5% it is easily proven to Government or municipal authorities that industry would be globally uncompetitive. However, the present study does not indicate that in most developing countries cost burdens will approach the U.S.A. levels, and if "low cost" systems are used, together with their minimal economy of scale, these gross disparities in burden will not be forthcoming.

Available estimates obtained during the area studies of this project of the on-cost due to installation of effluent control facilities appear much lower in those Afro-Asian countries where pollution control is practised, and the price uplift necessary appears in general to be from 0.5 to 2.0%. (72) Not an unrealistic price to pay for an undoubted improvement to the environment.

FIGURE IX

DIAGRAMMATIC EXPOSE OF RELATIONSHIPS OF IRR VALUES TO THE INVESTMENT COST FOR EFFLUENT TREATMENT PLANT FOR TANNERY PROJECTS AS GIVEN IN ID/WG.137/11



Investment in U.S.$ 400,000 $ 800,000 $ 1,200,000
Finished leather case (16·25%) Finished leather case (32·5%) Finished leather case (48·75%)
(Effluent Treatment Capital Cost as Percentage of Tannery "Fixed Costs")

LEGEND

I READY TO FINISH

II WET-BLUE

III FINISHED

I. In order to prove the validity of the 0·5 - 2·0% price uplift needed compared to the U.S. E.P.A. 1·3 - 9·0% (B.P.T.) a financial analysis was made of the effect of varying effluent treatment costs using capital and production costs contained in ID/WG 157/11 (Side Leather Tannery - 17,472 Kg. daily input). The result is the diagramatic expose of relationships of I.R.R. values to the investment cost for effluent treatment plant, as shown in Figure **IX**. Using Figure **IX** and the control costs/fixed capital percentages established earlier for the side leather tannery - 5·63 - 11·25% it can be shown that the effect on capital aspects of effluent treatment will be (for **Finished Leathers**) :-

		Lowering of I.R.R.
Zero Effluent Treatment Costs	- 14·0 I.R.R.	-
5·6% " " "	- 12·9 I.R.R.	1·1
11·2% " " "	- 12·2 I.R.R.	1·8

Certainly the lowering of I.R.R. by 1·1 - 1·8% is in line with the reported 0·5 - 1·0% effect on costs observed during the area studies.

II Calculations for the smaller vegetable tannery (Ref. ID/WG 157/9) (higher B.O.D. assumed than for chrome tannery, therefore data if used for chrome tannery would show extra high effluent charge), suggests normal control costs/fixed capital percentages of 5·1% - 11·7%. If these percentages are used with Figure **IX** (not designed for this purpose, but unlikely to yield greatly different results), the effect of the effluent treatment costs will be

		Lowering of I.R.R
Zero Effluent Treatment costs	- 14·0 I.R.R.	-
5·1% " " "	- 13·0 I.R.R.	1·0
11·7% " " "	- 12·1 I.R.R.	1·9

Even if the effluent treatment costs are doubled (i.e. effect of possible 50% lowering of fixed capital in certain situations) the control costs/fixed capital percentages would be 10·2 - 23·4% and the effect of effluent treatment costs will be :-

		Lowering of I.R.R
Zero Effluent Treatment	- 14·0 I.R.R.	-
10·2% " " Costs	- 12·3 I.R.R.	1·7
23·4% " " "	- 10·8 I.R.R.	3·2

ANNEX I

COMPOSITION OF TYPICAL "NON-ENVIRONMENTALLY SOUND" TANNERY EFFLUENT

		Chrome Tannage	Both	Vegetable Tannage
ph			ca. 10	
Total solids	mg/l		10,000	
Total ash	mg/l		6,000	
Suspended solids	mg/l	2,500		1,500
Ash in suspended solids	mg/l	1,000		500
Settled solids (2 h)	ml/l	100		50
BOD_5	mg/l	900		1,700
$KMnO_4$ - value	mg O_2/l	1,000		2,500
COD ($K_2Cr_2O_7$)	mg/l	2,500		3,000
Sulphide	mg/l		160	
Total nitrogen	mg/l		120	
Ammonia nitrogen	mg/l		70	
Chrome (Cr)	mg/l	70		-
Chloride (Cl^-)	mg/l		2,500	
Sulphate ($SO_4^{=}$)	mg/l		700	
Phosphor (P)	mg/l		1	
Ether Extractable	mg/l		350	

ANNEX II

AMOUNTS OF POLLUTION PER TON OF RAW MATERIAL (SALT WEIGHT)

		Chrome Tannage		Vegetable Tannage	Range
Alkalinity	eq/t		750		
Total solids	kg/t		675		350 - 1,250
Total ash	kg/t		375		250 - 450
Suspended solids	kg/t	150		75	70 - 200
Ash in suspended solids	kg/t	60		25	25 - 60
Settled solids (2 h)	m^3/t	6		3	1·5 - 7·5
BOD_5	kg/t	60		85	40 - 100
IOD	kg/t		10		
$KMnO_4$ - value	kg O_2/t	70		120	
COD ($K_2Cr_2O_7$)	kg/t		175		120 - 280
Sulphide	kg/t		7		
Total Nitrogen	kg/t		10		
Ammonia nitrogen	kg/t		3		
Chrome	kg/t	4·5		0	
Chloride	kg/t		160		
Sulphate	kg/t		40		
Phosphor	kg/t		0·07		

ANNEX III (REF. INDIAN AREA STUDY)

TAMIL NADU STATE REGULATIONS

In this State the disposal of liquid industrial effluent into rivers, tanks, municipal drains or sewers is governed by Rule 17 of the Tamil Nadu Factories Rules, 1950 and Section 36 of the Tamil Nadu Public Health Act 1939.

These are reproduced below :

Rule 17 of the Tamil Nadu Factories Rules 1950

Disposal of trade wastes and effluents :

1) In the case of a factory where the drainage system is proposed to be converted to the public sewerage system, prior approval of the arrangements made shall be obtained from the local authority.

2) In the case of a factory situated in a place where a public sewerage system exists, prior approval of the arrangements made for the disposal of the trade wastes and effluents shall be obtained from the Public Health Authorities or such authority as the State Government may appoint in this behalf.

Tamil Nadu Public Health Act 1939, as modified up to 8th January 1970 Chapter IV. Drainage - Acticle 36 (Pollution of water-courses Prohibited).

No person shall, save as may be generally or specially prescribed :-

1) put, or cause to be put, or cause to fall or flow or be carried, or knowingly permit to be put or to fall or flow or be carried, into any water course

(a) any solid or liquid sewage matter, or

(b) any poisonous, noxious or polluting liquid proceeding from any manufactory or manufacturing process, or

2) put, or cause to be put, or cause to fall or be carried, or knowingly permit to be put or to fall or be carried, into any water-course, so as, either singly or in combination with other similar acts of the same or any other person, to interfere with the due flow of such water-courses, or to pollute the water therein the solid refuse of any manufactory, manufacturing process or quarry, or any rubbish or cinders, or any other waste or putrid solid matter, or

3) commit nuisance in or in the neighbourhood of any watercourse.

ANNEX IV (REF. INDIAN AREA STUDY)

I.S.I. STANDARDS FOR THE DISPOSAL OF INDUSTRIAL EFFLUENTS

Characteristics		Tolerance limits for industrial effluents discharged		
		Into Inland Surface Waters (IS:2490-1974)	Into Public Sewers (IS:3306-1974)	On Land for Irrigation (IS:3307-1965)
BOD, 5 days, 20°C	mg/l	30	500[a]	500
COD	mg/l	250	-	-
pH		5.5-9.0	5.5-9.0	5.5-9.0
Suspended solids	mg/l	100	600[b]	-
Total dissolved solids (inorganic)	mg/l	-	2100*	2100
Temperature	°C	40	45	-
Oil and grease	mg/l	10	100	30
Phenolic compounds	mg/l	1.0	5	-
Cyanides	mg/l	0.2	2.0	-
Sulphides	mg/l	2.0	-	-
Fluorides	mg/l	2.0	-	-
Total residual chlorine	mg/l	1.0	-	-
Insecticides	mg/l	Absent	-	-
Arsenic	mg/l	0.2	-	-
Cadmium	mg/l	2.0	-	-
Chromium (hexavalent)	mg/l	0.1	2	-
Copper	mg/l	3.0	3	-
Lead	mg/l	0.1	1	-
Mercury	mg/l	0.01	-	-
Nickel	mg/l	3.0	2	-
Selenium	mg/l	0.05	-	-
Zinc	mg/l	5.0	15	-
Chlorides	mg/l	-	600*	600
Boron	mg/l	-	2	2
Sulphates	mg/l	-	1000*	1000
Per cent Sodium		-	60	60
Ammoniacal Nitrogen	mg/l	50	50	-
Radioactive materials				
Alpha emitters	/uc/ml	10^{-7}	10^{-7}	10^{-9}
Beta emitters	/uc/ml	10^{-6}	10^{-6}	10^{-8}

a Subject to relaxation or tightening by the local authority.

b Relaxable to 750 by the local authority.

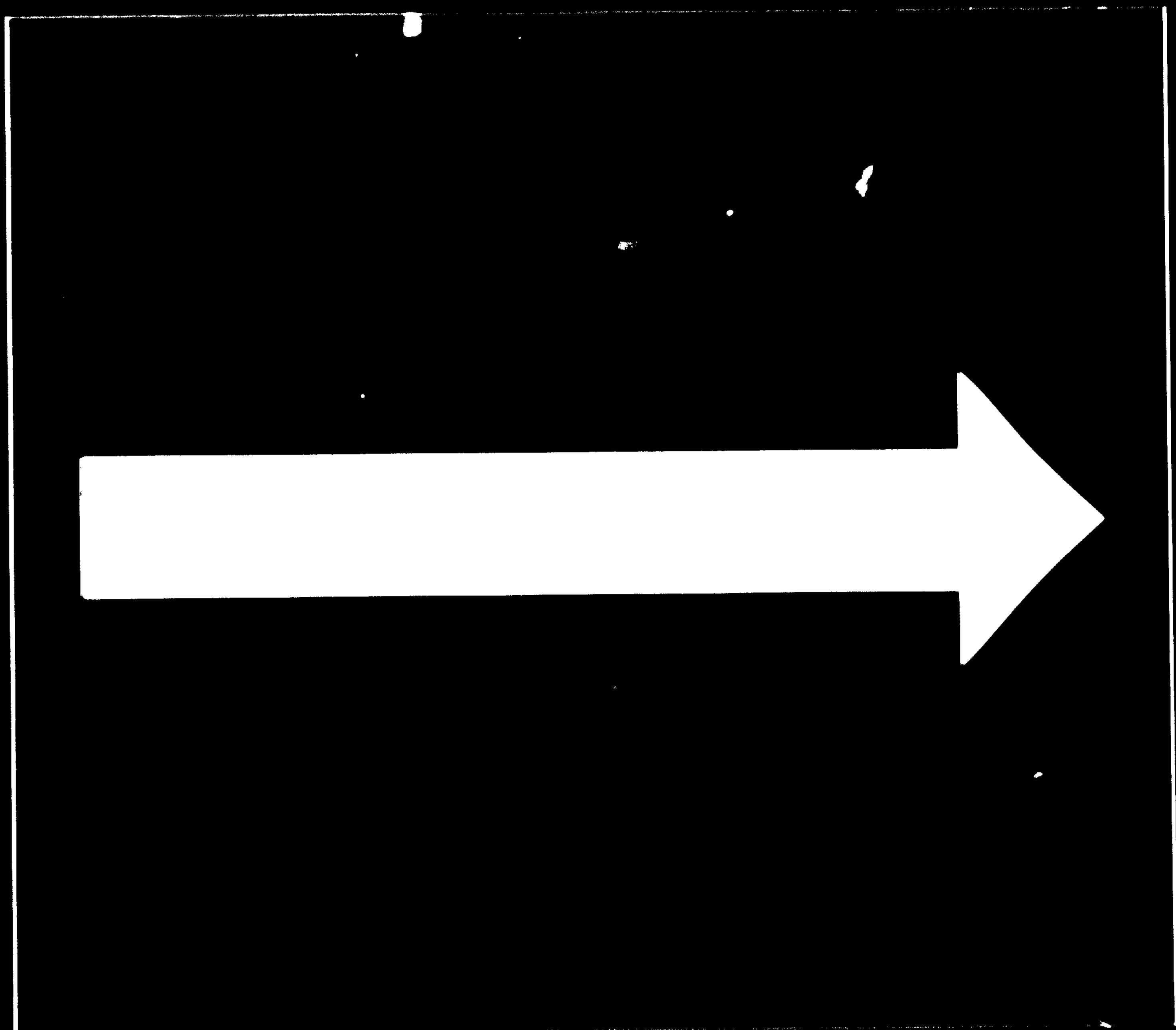
* These requirements shall apply only when after treatment the sewage is disposed of on land for irrigation.

ANNEX V (REF. ARGENTINE AREA STUDY)

SOME CHARACTERISTICS OF TANNERY EFFLUENTS

Characteristic		Unit	Liming	Beamhouse [2]	Tanning [3]	Treated Liquid [4]
Colour	Of waste water		Dark Grey	Slightly yellow	Greenish Grey	Slightly yellow
	Of sedimentary water		Dark Grey	Slightly yellow	Greenish grey	Slightly yellow
Appearance	Of the sediment		Floccular	Slightly Floccular	Floccular	Floccular
	Of the sedimentary water		Turbid	Turbid	Turbid	Turbid
Odour			Putrid	Odourless	Sulphurous	Sui generis
pH			11·4	9·3	6·6	7·9
Solids	Totals	p.p.m.	34,310	5,342	16,216	16,576
	Fixed	" "	20,206	5,094	14,016	14,086
	Volatile	" "	14,104	248	2,200	2,490
Solids in suspension	Totals	p.p.m.	2,140	444	3,344	1,042
	Fixed	" "	940	180	1,272	686
	Volatile	" "	1,200	256	2,072	356
Sedimentable Solids	In 10 minutes	ml/lt.	9	-	194	3
	In 2 hours	" "	30	0·1	162	5
	2 hours Total	p.p.m.	1,570	-	2,926	1,006
	2 hours Fixed	" "	650	-	1,820	669
	2 hours Volatile		920	-	1,106	337
Chlorides (Cl)		p.p.m.	7,362	1,931	5,586	6,958
Alkalinity ($CaCO_3$)		p.p.m.	2,750	330	-	1,100
Acidity (H_2SO_4)		p.p.m.	-	-	98	-
Total sulphides ($S^=$)		p.p.m.	156	trace	61	n/c
Organic nitrogen		p.p.m.	464	21	31	139
Ammonia nitrogen		p.p.m.	48	69	13	20
Consumed Oxygen (MnO_4K)	Gross liquid	p.p.m.	860	145	390	630
	Sediment Liquid 2 hrs	p.p.m.				
BOD 5 days at 20°C	Gross Liquid	p.p.m	3,691	176	1,092	832
	Sediment Liquid 2 hrs.					
Chlorine demand		p.p.m.	5,848	129	638	532
Fatty substances (extracted by organic solvents)		p.p.m.	92	32	54	80
Dissolved oxygen		p.p.m				0

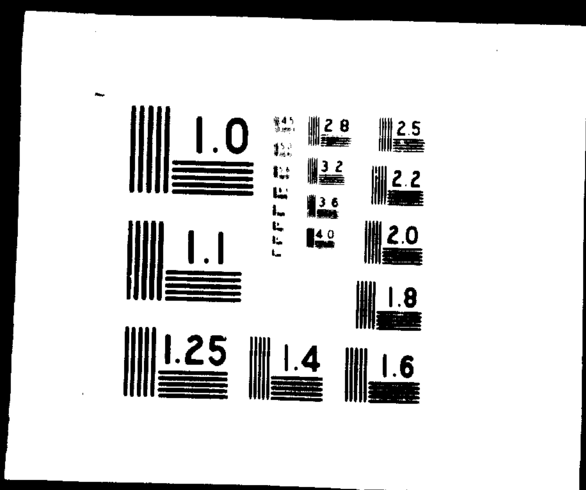
(Source 3)



76.01.13

2 OF 2

06587



REFERENCES - VOLUME I

1 M. Durairajan: "Seminar on Industrial Pollution and Remedies" Institute of Engineers. Trivandrum, India 1974

2 J. A. Villa: "Argentine - The Leather Industry and its Environmental Impact" UNIDO - Vienna 1975 - Restricted.

3 Gomez Brizuela: "Aguas Residuales de Curtiembres." (Tannery Waste Waters)

4 H. Young: The Leather Manufacturer, 90 (No. 10,) 17 (1973)

5 N. M. Ellis: "Water Conditions Affecting life in Elephant Butte Reservoir", Bull. U. S. Bur. Fish. 49, 257 (1940)

6 G. M. Fair; J. C. Geyer; D. A. Okun: "Water and Wastewater Engineering", John Wiley and Sons Inc. New York (1966)

7 J. E. McKee; H. W. Wolf: Water Quality Criteria, The Resources Agency of California, State Water Quality Board, Publication No. 3-A (1963)

8 Water Quality Criteria, FWPCA, U.S. Department of Interior, Washington D.C. (1968)

9 R. K. Hervey: Bot. Gaz. 111 (1) 1 (1949)

10 B. A. Southgate: "Treatment and Disposal of Industrial Waste Waters", Department of Scientific and Industrial Research, H. M. Stationery Office, London (1948).

11 "Cleaning our Environment - The Chemical Basis for Action", American Chemical Society, Washington D.C. (1969)

12 R. N. Chakraborty; K.L. Saxena; A. Q. Khan: "Stream Pollution and its Effect on Water Supply : A Report of a Survey", Proceedings of Symposium on Problems in Water Treatment, CPHERI, Nagpur (India) 1964

13 A. B. Semple; T.L. Hobday: "Control of Anthrax", Lancet 2, 507 (1959).

14 W. A. Moore et. al. "Effects of Chromium on Activated Sludge Process", Jour. Wat. Poll. Cont. Fed., 33, 54 (1961)

15 C. R. Harihara Iyer; R. Rajagopalan; S. C. Pillai: Current Science, 10 187 (1967)

16 G. J. Thabaraj; S. M. Bose; Y. Nayudamma: "Utilization of Tannery Effluents for Agricultural Purposes", Environmental Health, 6, 18 (1964)

17 IULCS Effluent Commission Report via Jour. Soc. Leather Tech. and Chem., 56 (2) 40 (1972)

18 H. Chapman: Diagnostic Criteria for Plants and Soils, University of California Report, 1963, pp. 793

19 R. L. Sykes: Journal of the British Leather Manufacturers Research Association 1973 March P. 61. RESTRICTED CIRCULATION

20 W. H. Taylor: "Disposal of Tannery Wastes", Sanitalk, 1, 4 24 (1953)

21 A. S. Hariharan: "Industrial Wastes Discharges and Pollution of Ground and Subsurface Waters", 12th Indian Standards Convention, December 1968

22 Municipal Sewer Ordinances, Manual of Practice No. 3, Federation of Sewage and Industrial Wastes Association, Washington D. C. (1957)

23 Tolerance Limits of Industrial Effluents, IS 3306-1965
Indian Standards Institution, New Delhi, India

24 E. W. Moore: "wastes from the Tanning, Fat Processing and Laundry Soap Industries", Industrial Wastes, their Disposal and Treatment, ed., W. Rudolfs, Reinhold Publishing Corporation N. Y. (1953)

25 P. R. Bhaskaran, et. al: "Treatment and Disposal of Tannery wastes in Uttar Pradesh (India)," Symp. Utilization Byproducts of Leather Industry, CLRI, Madras (1960)

26 A. Bolde; B. Rosenthal: "High Lime Tannery Wastes Cause Incrustation", Wastes Engineering, 31, 150 (1960)

27 C. N. Sawyer: "Some New Concepts Concerning Tannery Wastes and Sewers", Jour. Wat. Poll. Cont. Fed., 37, 722 (1965)

28 S. G. Burgess: "The Analysis of Trade Waste Waters", The Treatment of Trade Waste Waters and the Prevention of River Pollution, ed., P.C.G., Issac, Pergamon Press Oxford 1957

29 N. L. Nemerow: Liquid Waste of Industry, Addison-Wesley Publishing Co. Reading, Massachusetts (1971)

30 IULCS Tannery Wastes Commission Report via J.S.L.T.C. 58 (1) (1974)

31 R. S. Ingols; E. S. Kirkpatrick: Analytical Chemistry, 24, 1881 (1952)

32 D. A. Bailey: "Tannery Effluents and Their Treatment", Effluent and Water Treatment, May & June 1970

33 P. L. McCarty: "Anaerobic Waste Treatment Fundamentals" Public Works, 91, 11 (1964)

34 R. E. McKinnery: Microbiology for Sanitary Engineers. Mcgraw-Hill Book Co., Inc., New York 1962, pp. 170

35 T. C. Thorstensen; Practical Leather Technology, Van Nostrand Reinhold Co., New York, 1969

36 S. K. Barat: "The Problem of Odour in Tan Liquors", ALTECH., 1957 I (2) 103

37 W. Rudolf: Industrial Wastes, Reinhold Publishing Co., New York, 1953

38 W. L. Faith: Air Pollution Control. John Wiley & Sons Inc., New York, 1959.

39 A. Turk: "Obnoxious Odours" Industrial Wastes, 1958 3 (1) 9

40 Anon: Quarterly Safety Summary, 1966, 37, 31

41 K. Knop; D. Schurman: "Hydrogen Sulphide A Fatal Hazard in Tanneries", Occupational Safety Hlth. Abs., 1963, 1 (9) 616

42 V. P. Gupta; P. J. Makhijani; N. S. Manikiker: "Accidental Death Due to Poisoning from Hydrogen Sulphide in a Tannery" Occup. Safety. Hlth. Abs. 1966, 4 (3) 172

43 O. Schmid: "Health Hazards and How to Deal with Them", Gerbereiwiss, Praxis, 1965, 17 (3) 224.

44 H. H. Borgstedt; "The Toxic Hazards of Epoxy Resins", Industrial Med. & Surgery, 1963 32 (10), 426, via. Occup. Safety Hlth. Abs. 1965, 2 (9) 603

45 C. Halamek: "Conversion of Leather Waste Into Feeding Stuff" Gerberiewiss Praxis 1970, 22 (11) 60; via J. Soc. Leather Tech. and Chem., 1970, 54, 541

46 R. L. Sykes: J. Soc. Leather Tech. Chem., 1973, 57 (2) 123

47 Halamek, Suchomel and Pektor : "The Proper Utilization of Byproducts from Hides and Skins, Leather and Leather Products Industries". U.N.I.D.O. ID/WG 79/10 UNIDO Vienna 1971

48 IULCS Effluent Commission IVth Meeting via J. Soc. Leather Tech. Chem. 1973, 57, 63

49 G. Halamek; M. Radil; J. Lachnak; Kozarstivi, 1957, 275 via J. Am. Leather Chem. Assoc. Abs. 1958, 53, 661.

50 A. Steigmann: Das Leder 1960, 11, 12

51 R. Hafter; H. Homann: ibid, 1972, 23 (9) 184

52 M. M. Raie; N. Shakier; N. M. Batty; Sci. Ind. Pakistan, 1967, 5, 575, via. J. Soc. Leather Tech. Chem., Abs., 1970 54 (12) 452

53 H. H. Leiner; C.P. West: "Adhesive Compositions" U.S. Pat. 2, 958, 605 via. J. Am. Leather Chem. Assoc. Abs., 1961,56 (6)317

54 G. Staimsby; A. G. Ward: J. Soc. Leather Tech. and Chem. 1969, 53, 2.

55 Anon, Leather Trades Review, 1959, 131, 283

56 H. Herfeld; W. Pauckner; Leder Hautemarket Tech. Beilage, pp 16 (Feb. 1961), J. Soc. Leather Tech. Chem., Abs., 1962 46, 313.

57 Idem, Gerbereiwiss praxis, 1963, 6, 13

58 W. Pauckner, ibid, 1971, 23 (33) 201, via J. Soc. Leather Tech. Chem., 1972, 56, 156

59 R. A. Hauck: J. Am. Leather Chem. Assoc. 1974, 69 (5) 195

60 F. Stather; J. Am. Leather Chem. Assoc., Abs., 1940, 35, 174

61 Anon J. Soc. Leather Tech. Chem., Abs., 1953, 37, 100

62 R. Exner: ibid, 1960, 55, 110

63 A. Ka amura; H. Okamura: Das Leder 1969, 20 (6) 121

64 H. Okumara; H. Ota; Y.Moro-hashi: Hikaku Kagaku, 1968, 15 (3) 119, JSLTC Abs., 1971, 55, 148

65 H. H. Young; E. H. Majka; R.H. Eshbagh: U.S. Pat. 3, 116, 200, 1960, via JSLTC 1965, 49 (12) 486

66 H. Okamura; K. Shirai: J. Am. Leather Chem. Assoc., 1972, 67 (4) 148

67 Y. Nayudamma; G. Lakshminarayana: "Utilization of Leather Waste", ALTECH, 1956-57, 6 (1) 33

68 D. Woodroffe: "Utilization of Vegetable Tanned Splits and Shavings". Proc. Symp., Utilization of By-products Leather Industry, CLRI (Madras) 1960

69 Y. Nayudamma: "Wealth from Leather Waste" ibid, 1960 pp. 81

70 R. N. Chakraborty, et. al. Environmental Health, 1967, 9, 162

71 D. A. Bailey: "The Effect of Legislation on the Future Use of Water in the Leather Industry". JSLTC 1973 - Page 5

72 Personal Communication to the Editor.

73 Economic Analysis of Proposed Effluent Guidelines - Leather Tanning and Finishing Industry - U.S. Environmental Protection Agency EPA - 230/1-73-016 - October 1973.

74 Development Document for Effluent Limitations Guidelines and New Source Performance Standards for the Leather Tanning and Finishing - U.S. Environmental Protection Agency - EPA - 440/1-74-016-a- March 1974.

75 Cost Estimates for Various Low Cost Effluent Treatment Processes for Tannery Effluent - B. B. Bhalerao & D. Raghuraman - Central Public Health Engg. Research Institute, Nagpur - CLRI, Adyar Madras Seminar Feb. 1972

76 Seminar on "Treatment and Disposal of Tannery and Slaughterhouse Wastes" held at CLRI Madras - 20, February 1972.

77 C. J. Lockhart-Smith; R. G. H. Elliott: "Tanning of Hides and Skins" - Tropical Products Institute, London, July 1974

76.01.13