APPENDICES

Advice on environmental, social and institutional aspects of the proposed tannery industrial areas, Punjab, Pakistan

(appendices 1 to 4)

APPENDIX 1

Letter from DGIS dated 16 November 1995, in which the Commission has been asked to submit an advisory report

Ministry of Foreign Affairs

The Hague

Commissie voor de milieu-effectrapportage
t.a.v. de heer drs. J.J. Scholten
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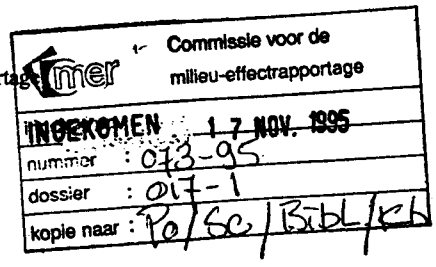


Directorate-General
International Cooperation

Date : 16 November 1995

Re : PTA/Pakistan
WW92850
JRC 381-93
MER/95/18

Ref : DST/MI
583/95

The Pakistan Tanners Association submitted a proposal for a Clean Technology Programme to the Royal Netherlands Embassy in Islamabad, Pakistan.

In order to speed up the final appraisal and formulation process for the assistance to the formentioned Clean Technology Programme, the Environment Programme of DGIS (DST/ML) in collaboration with the Pakistan country desk (DAL/CO) would like to receive your advice on the review of the existing information and initiatives. The information should be reviewed in the light of the recommendations formulated in the advisory review of the EIS for the Kasur Tanneries Effluent Treatment Plant of January 1994. The advice must be formulated from the environmental point of view including the institutional and socio-economic aspects.

We would like to recieve your recommendations/specifications for follow up activities in the process of appraisal and formulation of this projectproposal as well, including the potential application of EIA to the decision making for such follow up activities. This may imply that in a subsequent stage the Commission could be requested to prepare a advice for the specific guidelines for EISs pertinent to the follow up activities.

At the meeting on 3 November 1995, it was agreed that the working group would appraise as soon as possible, but before 21 November 1995 the information mentioned below:

* Introduction of cleaner technologies in Tannery Clusters of Punjab
* Techno-economic study of combined effluent treatment plants for tannery clusters in Punjab
* Memorandum from OS islamabad to DAL/CO, DST/ML and DST/TA concerning Pakistan = Milieu = Clean Technology programme for Tannery Clusters ("PTA").
* additional correspondence

With reference to the EIA agreement between DGIS and the Commission, I would appreciate receiving a proposal concerning membership of the working group and the budget for the aformentioned desk appraisal report.

THE MINISTER FOR DEVELOPMENT COOPERATION
For the Minister
Head Environment Programme,

K.A. Koekkoek

APPENDIX 2

Project information

Proposed Activity: Preparation of a strategy for development of the tannery sector on various locations in Punjab, Pakistan.

Categories: Industrial development, Tanneries

Project numbers: WW92850, JRC 381-93, MER/95/18; Commission for EIA 017

Progress: On request of the Minister for Development Cooperation the Commission for EIA formulated an advise on appraisal of:

- a study on introduction of cleaner technologies in tannery clusters of Punjab;
- a techno-economical study of combined effluent treatment plants for tannery clusters in Punjab;
- additional correspondence.

In the advice the Commission formulates recommendations for follow-up activities in the process of appraisal and formulation of the project proposals contained in these studies and the potential use of environmental impact assessment in the process of decision making for such follow-up activities. On 5 February 1996 this advice has been submitted to the Netherlands Minister for Development Cooperation.

Composition of the working group of the Commission for EIA:
Mr I. van der Putte
Mr J.S.A. Langerwerf
Mr P.T. Lanser
Mr J.W. Kroon (chairman)

Technical secretary: Mr R.A.M. Post.

APPENDIX 3

Appraisal of the studies

General
In the studies submitted to the RNE in Islamabad a distinction can be made in a technical part, that describes and evaluates technical options, and a part that formulates project proposals, including financing suggestions.

The technical studies are of a general and essentially abstract nature. In the opinion of the Commission they offer insufficient location specific information to support concrete interventions in the tannery clusters. Therefore, the Commission will restrict itself to an appraisal of the technical information in the studies and will formulate its recommendations for interventions in the next chapter.

The study 'Introduction of cleaner technologies'
General
The study gives a fairly complete overview of the general situation in the leather industry in development countries and of the alternative technological options. The alternatives however, are not in all cases completely up to date and relevant. Moreover their applicability and feasibility for each specific cluster cannot be assessed, as comprehensive cluster profiles are not available.

Technologies
In the next paragraphs opinions are expressed with regard to the technologies described in the study.
Curing
Curing technology cannot be considered to be an item that can usefully be addressed in a programme for the tannery sector. Curing is not an activity of the tanneries. On a worldwide scale curing causes environmental problems. These problems can probably not be solved on a country level.
Unhairing
There is probably no environmentally sound alternative for destructive dehairing with sulphide.
Deliming
From the environmental viewpoint the simple use of biologically degradable acids is for smaller and bigger tanneries as interesting as the sophisticated CO^2 technology. Due to its simplicity of application it is probably more feasible.
Degreasing
For the same reason the use of degradable emulgatoring agents must yield a higher priority than correct application of organic extractors.
Pickling
One of the most serious and enduring problems of chrome tanning is the emission of chlorides. Therefore, the use of biologically degradable salts like sodium sulphate in the pickling process must be given priority.
Chrome tanning
Indeed, until some years ago chrome recovery was one of the key processes in improving environmental performance of the tannery sector. In the actual situation, however, well executable tanning processes are available in which chrome absorption rates of 90% are realized. The remaining water produced by the process can be completely recycled as pickle solvent. Without any investment and without processes unknown to the tannery sector these tanning processes reduce the chrome and sulphate emissions of the main tanning operation to nil. Moreover chrome consumption is reduced to 60% of the usual level. Such alternatives must be given high priority.

Social aspects
The socioeconomic analysis of the tannery sector is incomplete. The total number of tanneries (426) is given several times, but not the numbers of small, medium and large scale enterprises. Furthermore, there is no definition of these categories, nor is it clear which market they serve and which market shares they have. This indication seems important as most of the proposals are focusing on the medium and large scale tanneries. It is even said (page 4-2, § 2) *"that leather processing by its nature and characteristics, is not the activity of small scale processing..."*. It is not clear what this implies for the future of the small scale processing. If this statement is true, relocation, as proposed (page 4-2, § 3) seems not so very useful.

The same chapter describes a market segmentation according to which small scale processors produce low grade leather for the local market while medium and large scale tanners concentrate on the international market. It might be assumed that the low grade leather is equally low priced and therefore not interesting and/or profitable for the bigger factories. As a result the local market is served by the small scale tanneries. Closing of these tanneries will deprive the local market of low grade leather at affordable prices. The authorities might well consider this as undesirable.

The study does not elaborate on social effects or the proposed relocation program.

The study does not give data on employment and loss of employment if smaller tanneries will have to close. It must be assumed that restructuring of the sector will have considerable socioeconomic costs. These costs should be balanced against environmental and health benefits.
Workers in small scale might well be more unskilled and poor than labourers in the bigger tanneries. If so, closing down of smaller tanneries would disproportionally affect the former group. In that case a possible contribution of the RNE would be in contradiction with Dutch policy of poverty alleviation. The problem should be studied more closely.

The study does not analyse the financial capacity of the various categories of tanneries. The costs of proposed in-tannery measures are considerable (more than 200.000 DGL per tannery), whereas the financial advantages, if any, are not clear. Even if these investments would be profitable, there is no certainty that small scale tanners will be able to raise the necessary funds, especially when they belong to the more informal sector to which PTA intervention is not directed.

Financial aspects
Investment costs of cleaner technologies proposed are given in table 6.1 of the study. There are no estimates of operation and maintenance costs. There are benefits in the form of recycled materials and by-products, and economies in de use of water, salts, raw materials, et cetera. Financial estimates of these benefits are not made. Thus it is not clear if the proposed technologies are fully cost recovering or not. The chance that calculating entrepreneurs embark on investments of which the financial consequences are unknown seems questionable.

Techno-economic study CETP's
Technics
This study provides interesting general information with regard to the main concentrations of the Punjab leather industry. For two locations that are considered to be important (Sialkot: cluster Sambrial Wazirabad Road with 32 tanneries and Sheikhupura: cluster Lahore Sheikhupura Road with 17 tanneries) the situation is worked out based on more concrete data about the quantities and composition of the effluent produced and concrete technologies and budgets for CETP establishment. In the framework of this study, logically, priority has been given to those locations that have land available for installation of a CETP.

What is missing in this study is the stressing of the importance of an integrated approach in which establishment of central facilities is initiated after and fine tuned to results of in-house arrangements. The proposed central facilities are entirely based on actual emissions without taking in account positive results of the in-house environmental improvement program. Though UASB technology has been mentioned as promising, it is rejected on erroneous grounds. This, however, cannot be blamed on the authors of the study, as the knowledge that supports this conclusion is of to recent date.

For one of the two locations the establishment of a CETP after successful introduction of essential in-tannery measures and based on a reassessment of the emissions seems a promising option. In the study, however, the participation of the smaller tanneries has insufficiently been addressed.

Economy
Effluent treatment plants do not generate additional income or economies. They cost money. The benefits can be considerable but are mainly of a social character. The study gives a budget for the project including an attribution of the costs. Operation and maintenance of the plans should be borne by the local tanners' associations. The precise modalities are not elaborated. It is doubtful that members that are not connected to such a plant are willing to pay for it. The users might be reluctant to pay as well, when their direct competitors are not paying for it and they do not get any direct benefit from it. Furthermore, the Sialkot Tanners' Association is not affiliated with the PTA and in Sheikhupura there is no tanners' association at all. From the study it cannot be concluded who is responsible for the decision that the tanners should pay and if the tanners participated in this decision making.

MILIEV-proposal HASKONING
As such, this proposal does not seem to offer a basis for concrete action within the framework of the approach as proposed by the Commission. There is, however, an interesting aspect to this proposal as it addresses socioeconomic issues. The study proposes to handle the social functions of the tanneries and the chances for survival as function of the chosen central production or effluent treatment facilities. If combined with the two preceding proposals and concentrated on a single location (more or less logically this should be Sialkot) the Commission thinks that the proposal offers indeed interesting prospects.

APPENDIX 4

Schematic representation of the results of recent research in India

Recent developments in integral environmental technologies for chrome leather processing in the framework of the "TNO-CLRI Programme for the Indian Leather Sector in the Field of Environmental Technology"

J.S.A. Langerwerf
Netherlands Organisation for Applied Scientific Research (TNO), Delft ,The Netherlands

Lecture presented at IULTCS congress in Friederichshafen, May 1995

Introduction

In the year 1987 a Dutch fact finding mission reported on the urgency of finding solutions for the environmental problems associated with the economically important, fast extending but strongly polluting, Indian leather industry. The Mission and the Indian Central Board for the Prevention and Control of Water Pollution recognised this problem as a priority industrial counselling topic to be worked out further primarily by TNO and the Council of Scientific and Industrial Research India (CSIR), more specifically, the Central Leather Research Institute at Madras.

As a result of an ensuing comprehensive analysis the situation with regard to the Indian leather industry can be characterised in the following way:

Economics
The Indian leather industry encompasses more than 2000 tanneries partly scattered over the country, partly concentrated in specific areas in regions like Kanpur, Agra, Calcutta and in Tamil Nadu in the regions: Madras, Ranipet, Ambur and Vaniambady.
The total production capacity will increase this decade by a factor of 1.5 to an amount equivalent to about 1500 k.tonne of salted hides in the year 2000. About 50% of the production is exported as leather or, increasingly, as final products such as footwear, garments and leathergoods. For this reason at the moment the leather industry is the third when ranking the Indian industries with regard to earning foreign currency. At the end of the century Indian leather industry is expected to have a world market share of 10%. No doubt this progress will be of great benefit to the Indian economy but will also impose substantial threats to the environment and the conditions of living especially in areas in the neighbourhood of concentrations of tanneries. Especially the production of the high quality chrome leather is expected to increase strongly. As this way of leather making also represents the most complicated environmental problems, the TNO-CLRI programme is entirely focused on this process.

Environment
The production of chrome leather as such can be seen as a form of environmental technology that upgrades wastes of both the meat industry (hides) and the chemical industry (e.g. trivalent chromium) to a valuable durable end product namely chrome leather. Unfortunately, however, during the conventional way of chrome leather production, about 50% of the raw materials is emitted as strongly polluting, sometimes badly smelling, wastes. Per tonne of salted hides, the most important raw material, the following emissions may occur: solid organics more than 100 kg (COD), dissolved organics 200 kg (COD); sulphides 15 kg (S); sulphates 100 kg (S); chlorides 300 kg (Cl); dissolved trivalent chrome 15 kg (Cr); chrome containing solids approximately 30 kg (Cr) dispersed over variable

amounts of leather scrap and more than 1 tonne of chrome-containing sludge, when all waste streams flow together without any precautions and sludges separate by natural settling.
The emission of organics leads to evident environmental problems. As a consequence of its biodegradability organic pollution is more an acute than a long term problem.
Apart from creating an environmental problem the low chrome uptake during tanning and subsequent emission of about 40% of the chrome applied in the main tanning implies a serious yet unnecessary loss of valuable raw material. Moreover, the accompanying emission of chlorides and sulfates may so seriously pollute the soil that at some places the groundwater cannot even be used for certain phases of the leather making process. Evidently this kind of soil pollution is most serious in arid areas away from the open sea.

The TNO-CLRI Programme

Research priorities:
The aim of the TNO-CLRI programme is to enable the Indian leather sector to solve relevant environmental problems efficiently and effectively. For this reason, apart from the joint research by TNO and CLRI, great emphasis is given to the implementation of the results that emerge from the programme in the Indian leather sector.
A prerequisite for reaching maximum research effectivity is that the Indian leather industry is prepared and able to apply the results of the research executed. Thus apart from expected environmental benefits and scientific attainabilities, relevant research issues were especially selected on the basis of the level of environmental sophistication of the Indian leather sector.
Such level of sophistication is defined as the degree to which the management of a tannery has the inclination, skill, capacity, discipline and tools to effectively cope with the environmental impact of its tannery.

To operationalize this approach, the environmental sophistication of the Indian leather industry is pragmatically subdivided into the levels: 0, 1, 2, 3 and 4. Level 0 represents the old fashioned, strongly polluting "laissez faire" approach; level 4 characterizes situations in an economically sound tannery with well-controlled, low polluting production processes. This implies good quality control, high exhaustion chrome tanning by means of chrome-recycling or sophisticated tanning techniques, maximum recycling of salt-containing process waters and biological and physico-chemical treatment of the dissolved organic wastes, sulphide and residual sulphate to compounds which can be reused or discharged as limited amounts of low-polluting wastes. At level 4, one recalcitrant practical problem left is the emission of sodium chloride which is implicitly introduced into the leather production process as preservation salt of the raw hide material.
The intermediate levels 1, 2 and 3 refer to other well-recognisable situations in the chrome-leather industry of India. By adjusting our research priorities to the problems to be solved by individual tanneries, when increasing their environmental sophistication by one or more levels, we were able to create a smooth path along which, also for the less developed small remote urban tanneries, the environmental situation can be improved effectively and efficiently.

Programme structure
The programme is executed under the supervision of the TNO Institute of Environmental Sciences and comprises:
- joint research by a number of institutes.

- extension of the environmental laboratory of CLRI.
- training of Indian staff.
- implementation of existing environmental technology and especially of the research results of the programme in the Indian leather sector.

The total programme involves a manpower input of 6000 mandays over a period of 4 years, starting with the inception phase on 1 May 1991. The total investments, mainly aimed at setting up and extending the environmental laboratory at the CLRI premises, amounts 1.5 million Dutch guilders. The programme is financially supported by a budget of 5.5 million Dutch guilders made available by the Directorate of International Cooperation (DGIS) of the Netherlands Ministry of Foreign Affairs.

The joint research programme is executed by:

- TNO Institute of Environmental Science, Delft,
- TNO Institute of Environmental and Energy Research, Apeldoorn,
- TNO Institute of Applied Physics, Eindhoven,
- Wageningen Agricultural University,
- CLRI Madras ,
- Regional Research Laboratory of CSIR at Trivandrum,
- Central Salts and Marine Chemicals Research Institute of CSIR at Bhavnagar,
- Leather Technology Centre of the British Leather Confederation (BLC) in Northampton, UK,
- private consultants in he Netherlands (Haskoning), India (Paramount, SVV) and UK (late W.P. Walker).

The research programme comprises six different projects:

1) Biological Treatment covering:
   Starting with the experiences gathered in Kanpur by TNO together with other consultants the special aim of the programme was to find a solution for two remaining recalcitrant problems: an anaerobic technology which is applicable to tannery waste water without substantial (3 times!) dilution with domestic waste waters and a technology to convert the sulfide produced into useful easy to handle products: biogas and elemental sulfur.
   - the study of five experimental Upflow Anaerobic Sludge Blanket (UASB) reactors on bench scale, by TNO Delft, assisted by the Wageningen Agricultural University, on the development of UASB-treatment of tannery waste waters to convert the organic wastes present to a great extent into methane and the sulfide and sulfate compounds into recoverable, valuable chemicals: biogas and elemental sulfur.
   - training and research activities on pilot scale experiments on the same topics by CLRI trainees with an existing 10 m^3 UASB-reactor at the premises of a tannery in Kanpur, India, under the guidance of TNO and Haskoning.
2) Removal of Dissolved solids covering:
   the application of evaporation ion-exchange and membrane technologies on pretreated waste waters; a study by TNO Apeldoorn and an assessment of the local possibilities by CLRI.
3) Lagooning covering:
   - activities by CLRI, guided by TNO Delft, to assess the actual situation in four representative tanneries, to formulate advices for improvement and to assist Indian tanneries to implement these advices.
4) Utilization of chrome containing solid wastes covering:

- investigations of the application of chrome containing sludge in brick making by TNO Eindhoven, CLRI and the Regional Research Laboratory Trivandrum.

5) Chrome recovery and recycling covering:
   - a study and research by TNO Delft, CLRI and the British Leather Confederation on three experimental lines with respect to the recovery and reuse of chrome by precipitation and meanwhile the reuse of the spent sulphate.
   - a study by CLRI and the Central Salts and Marine Chemicals Research Institute in Bhavanagar on electro dialysis technology to treat brackish ground water, to apply this in the leather making process and to make, with the same facility, spent chrome and sulphate reusable in the chrome tanning process.
6) Cleaner Chrome Tanning covering:
   - a study and research by TNO Delft, CLRI and the Leather Technology Centre on five experimental lines to prevent, or substantially reduce, the emission of chrome and sulfate by application of high exhaustion chrome tanning procedures and reuse of residual process waters.

The setting-up and extending of the environmental laboratory of CLRI covers the investment in and installation of:

- general modern laboratory facilities including AAS, HPLC, UV-VIS, Titrator, Microscope.
- special facilities: UASB-, chrome recovery- and tanning units on bench- and pilot-plant scale .

To use this infrastructure in the most effective way CLRI is extending the tanning activity at its premises to a level of substantial regular professional production.

The training programme covers:

- the training during half a year of four CLRI technicians by Haskoning and TNO in the handling and experimental application of the UASB technology with a 10 m^3 pilot plant at the premises of a tannery in Kanpur, India.
- the training of the same staff during 1-3 months in the laboratories of TNO and Wageningen Agricultural University in the theory and practice of the experimentation and the application of (an)aerobic waste water treatment technologies and modern (analytical) chemistry and computer technics in environmental laboratories.
- the on site training of CLRI staff by TNO with regard to optimum use of the lab facilities purchased as part of the investment programme.
- activities in the frame work of a recently formulated, detailed dissemination programme by CLRI covering the implementation by demonstration and introduction of environmental technology to the management and technicians of a substantial number of tanneries in six different regions all over India.

The implementation programme covers:

- The setting-up and execution of practical applications of environmental technologies in Indian tanneries together with local management and technicians in five different tanneries in the regions: Kanpur, Vanyambadi, Ambur and Madras.
- The dissemination of the progress of the Programme to the Indian leather sector, during the yearly LEather Research and Industry Get together (LERIG) at Madras.
- The dissemination of programme information by print and electronic audio/visual (e.g. national and regional TV) media.

- The presentation of lectures at Indian Universities by European scientist who visit India in the frame work of the programme.
- The presentation of lectures to international scientific fora to acquire international acknowledgement of the quality of the output of the programme. This will generate additional confidence to the Indian user industry with regard to the state-of-the-art level of the technologies being implemented.

Status of the Programme per 1 January 1995

After concluding the inception phase in 1992 and setting the research priorities, two years of extensive cooperative activities on more than 20 lines of interest led to a focusing to about 10 promising lines and more than 5 novel practicable and effective environmental technologies. Apart from this a better insight was obtained with regard to logistic means which may drastically improve the environmental situation of individual tanneries and clusters of leather factories in India. The European research part was concluded well ahead of schedule. This left more than 1.5 year for the most important implementation activities in India.

Important breakthroughs of the research programme:

- The UASB-experiments in Kanpur demonstrated and the bench scale experiments in Delft and Wageningen scientifically confirmed that UASB-technology can be applied successfully on tannery waste water without the, hitherto essential, addition of communal waste water. The production of methane as well as the conversion of sulfate and the recovery of elemental sulfur turned out to be very effective. Schematically during retention times of about 12h the following retentions take place in the UASB/sulfur removal process developed.
- anaerobic digestions

  methane formation:

  $COD \xrightarrow[>60\%]{} CO_2 + CH_4$ (0.2 m^3/kg COD)

  sulfate and sulfur reduction:

  $COD + SO_4 \xrightarrow[>90\%]{} CO_2 + H_2S$

  $COD + S \rightarrow CO_2 + H_2S$

- absorbtion of the hydrogen sulfide stripped, by oxydation with ferri chelate to elemental sulfur:

  $H_2S + Fe(III).chel \rightarrow S + Fe(II).chel. + 2H^+$

- regeneration of spent iron chelate by aeration

  $Fe(II).chel + O + 2H^+ \rightarrow Fe(III).chel + H_2O$

Due to the high selectivity of iron(III)-chelates for H_2S absorbtion at the selected pH, hardly any CO_2 is removed. Thus the maximum amount of the CO_2 generated is utilized to neutralize the alcaline waste waters entering the UASB.
Although the COD conversion in a UASB is much higher than in the usually practiced lagooning techniques, an aerobic post treatment is necessary to comply with the local environmental legislation.
A patent application on this subject has recently been filed.

The boundary conditions required are well within general starting points with regard to environmental efficiency and include: in-factory measures in order to avoid unnecessary complication of end-of-pipe techniques by reducing the chrome and sulfate emissions as far as possible and limiting the use of non biodegradable chemicals, like biocides, in the leather making process to minimum amounts of low toxicity types.

- The removal of dissolved solids (NaCl) is hardly practicable. The only alternative found is collection of adhering dry salts from raw hides and of the first soaking liquors altogether containing about 75% of the preservation salts. Instead of drying in solar pans and disposal as "dry" salt at the tannery premises, transport to sea seems the only practicable way to solve this tough environmental problem. Reconstitution to preservation salt is economically not feasible this product is expected to be about ten times as expensive as the market available material.

- (An)aerobic lagooning, the typical "tropical approach" to treat tannery waste water is found to be hardly effective. The reduction of of COD-load is very low. This is at least partly due to a "sulfur driven" bacterial fotosynthesis :

This counteracts the effect of anaerobic biodegradation. For this reason, especially under tropical conditions, the emission of sulfate to partly anaerobic open sewer systems may lead to never ending stenche- and pollution problems:

- Application of chrome containing solid wastes as an internal source of energy in the brickmaking process turned out to be successful. By application of a reductive cooling process, after firing, black/grey light weight bricks are obtained containing negligable amounts of extractable hexavalent chromium with an estimated 10% less energy consumption. During the cooling process, which was tested on a technical scale, the hexavalent chrome inevitably formed during firing, is practically completely converted into the trivalent form.

- Process-integrated chrome recovery is proved to be successful when performing the precipitation with weak, (pK=9) anion exchangers in basic form and regeneration of the spent resin by means of lime. The chrome precipitates formed are extremely compact and the gypsum obtained, when regenerating the resin, has a low content (<0.1% Cr) of chromium. This allows for a broad applicability of the gypsum e.g. in the Indian building industry. Schematically the following reactions apply:

  Chrome precipitation:

  $$2\ \text{Resin-N} + 2\,H_2O + SO_4^{=} + Cr(OH)^{++} \rightarrow [\text{Resin-NH}^{+}]_2.SO_4 + Cr(OH)_3\downarrow$$

  Resin regeneration by means of lime:

$[Resin\text{-}NH^+]_2.SO_4 + Ca(OH)_2 \rightarrow 2\ Resin\text{-}N + CaSO_4 \downarrow$

A patent application has recently been filed. The known precipitations by means of lime and magnesium oxide were studied further to make them easier applicable also by smaller tanneries and to combine them with efficient sulfate removal options. Promising approaches are tested now on appreciable scale to obtain a reliable starting position for the implementation in practice.

- Two very effective, process-integrated high exhaustion chrome tanning procedures have been discovered with chrome uptakes over 90%. This allows for a complete reuse of residual process liquors, effectively leading to a 100% chrome uptake and prevention of chrome- and sulphate-emissions from main chrome tanning.

Effectivity of existing technologies and of the integrated approach developed

INEFFECTIVITY OF EXISTING PROCESSES

- the usual central (an)aerobic lagooning technology is ineffective, partly because of:
  - counteracting sulfur driven fotosynthesis by which the anaerobically formed sulfide and carbon dioxide is re-converted into sulfur and biomass,
  - partly because large amounts of chrome containing solid wastes are produced,
  - partly because large amounts of sulfates and other salts continue to contaminate the soil .
- the existing technology of anaerobic treatment in which the sulfide intoxication is suppressed by dilution with domestic waste water ("Kanpur model") is ineffective because:
  - in a great number of cases no(t) (enough) domestic waste water is available, the sulfide formed is partly emitted and the residual sulfide must be oxidized again to sulfate. This does not solve soil contamination. Moreover, particularly in tropical areas, it introduces again possibilities of sulfur-driven photosynthesis when emitting the treated effluent into anaerobic canals containing organic wastes.
- Scientifically the existing chrome recycling technologies are more or less overtaken by high exhaustion chrome tanning techniques and reuse of spent liquors. Without additional infrastructural measures this technique enables a 100% effective chrome uptake and complete sulfate recycle in main tannage. This leads to a 50% lower chrome- and sulfate-consumption and a corresponding reduction of the integral emissions.

THE INTEGRATION OF THE ENVIRONMENTAL TECHNOLOGIES DEVELOPED:

- This starts with in-tannery measures on:
  - critical use of water and avoiding, where possible, the application of nonbiodegradable and especially toxic chemicals like salts and especially sodium chloride and certain biocides.

- proper collection and storage of chrome containing solid wastes to be treated externally.
- introduction of high exhaustion chrome tannage inclusively reuse of spent liquors in order to minimize chrome and especially sulfate emission and to gain in this way maximum biogas production.
- removal of adhering conservation salt from the raw hides, collection of soak liquors and disposing of this salt stream into sea.

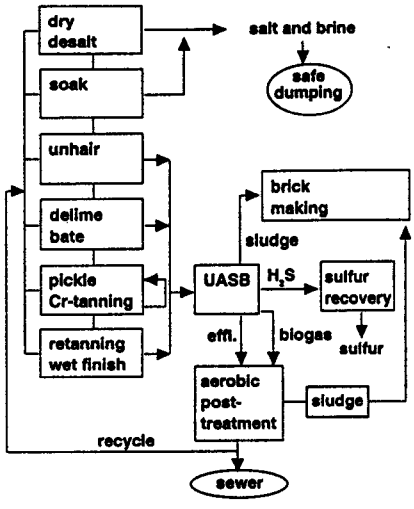
• It is followed by (de)centralized waste treatment processes comprizing:

- treatment of the waste waters in anaerobic reactors preferably of the UASB type and in any case comprising an on line sulfide removal/sulfur recovery system.
- treatment of the UASB effluent in aerobic systems driven by the biogas produced in the UASB reactor.
- reuse of the treated effluent for less critical leather making processes and floor washing
- external application of the chrome containing sludges in brickmaking processes comprising a reductive cooling phase.

Optimal integration of the in-tannery, add-on and end-of-pipe technologies developed .

Integral approach

Flow scheme



Potential reduction of emissions per tonne hide

	soak lime delime	picking tanning	wet-finish	ef-fluent	
m³ : water	5*	1	11	17	(35)
kg:COD	150	0	15	1	(100)
S	27	0	30	6	(50)
Cl	50	0	20	50	(300)
Cr	-	0	5	0	(20)
Cr sludges	-			0	(1000)
BIOCIDES	±	-	-	±	(+)

* (incl. floor wash)
(values in brackets without treatment)

As discussed this method will lead to:

- low emissions of chrome, sulfate and COD and offers possibilities to really comply with the existing environmental regulations.
- the recycling steps included will substantially reduce the consumption of chrome, sulfate and water.
- the treatment requirements with regard to space and energy needed are minimised.

Although the Indian leather sector shows already great interest in this process it is considered to be of paramount significance to firstly execute an adequate field trial on technical scale under practical conditions in order to gain reliable figures with regard to the techno-economic merits of it.

Negotiations have been started to execute such a trial in a tannery cluster in Ambur, India as an extension of the TNO-CRLI Programme.