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COSTS OF TANNERY WASTE TREATMENT

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*This document has been prepared without formal editing.

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LIST OF SYMBOLS AND ABBREVIATIONS

AOX	Adsorbable organic halogens (halogenated hydrocarbons)
BOD_5	5 days biochemical oxygen demand
BSE	Bovine spongiform encephalopathy (“Mad cow disease”)
^0C	Degrees Celsius
(C)ETP	(Common) effluent treatment plant
CLRI	CENTRAL LEATHER RESEARCH INSTITUTE, CHENNAI, India
COD	Chemical oxygen demand
Cr	Chromium
Cr_2O_3	Chromium oxide
CSO	Civil society organization
CTC	CENTRE TECHNIQUE CUIR CHAUSSURE MAROQUINERIE, Lyon, France
d	day
DS	Dry solids
EC	EUROPEAN COMMISSION
EPA	Environment protection authority.
ETP	effluent treatment plant
EU	EUROPEAN UNION
EUR (€)	Euro (the common currency of EU)
g	gram
h	hour
ha	hectare (1 ha = 10,000 m^2)
H_2S	Hydrogen sulphide
HPLC	High-pressure liquid chromatography
INR	Indian Rupee
IUC	Chemical test methods
ISO	International Organization for Standardization
kg	kilogram
kW(h)	kilowatt (hour)
l	litre
LDPE	Low-density polyethylene
m	meter
m^3	cubic meter
min	minute
mg	milligram
MLSS	Mixed liquor suspended solids
NGO	Non-governmental organization
OSH	Occupational safety and health
pH	Negative logarithm of hydrogen ion concentration
RPM	Rotation per minute (1/min)
RO	reverse osmosis
R&D	Research and development
s	second
S^{2-}	Sulphide
SO_4^{2-}	Sulphate
SS	Suspended solids
TDS	Total dissolved solids
TKN	Total Kjeldahl nitrogen

t	ton[ne]
TSS	Total suspended solids
UK	United Kingdom
UNIDO	UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATIONS
US$	United States dollars
USA	United States of America
VOC	Volatile organic compound
W	watt
y	year

Mention of the names of firms and commercial products does not imply endorsement by UNIDO.

INTRODUCTION

Leather manufacture is a water-intensive process and generates a significant volume of liquid and solid waste. Only about 50 % of the raw hide collagen ends up as finished leather whereas only about 20% of the large number of chemicals used in the process is absorbed by leather. Typically, one tonne of wet salted hide generates about half a tonne of solid wastes (of different dry matter content) and almost as much of sludge dewatered to about 30% of dry matter content. Untreated liquid, solid and air emissions generated by the tanning industry can thus pose a serious threat to the environment, particularly to surface and ground water.

Lower production costs because of lower wage levels and less stringent environmental protection are considered the primary factors responsible for relocation of the tanning industry to the South during the last 2-3 decades.

The current environmental situation varies from country to country and even from region to region within some large countries. Some tanners in industrialized countries hold the view that lax environmental regulations and poor enforcement account for lower production costs, higher competitiveness and hence further the expansion of the tanning industry in developing countries. On the other hand, many concerned citizens and non-governmental organizations (NGOs) or civil society organizations (CSO) in developing countries suspect that industrialized countries have deliberately forced the relocation of the tanning industry to be free of the pollution it causes.

Public interest is growing in what is perceived as environment- and consumer friendly products, manufactured under environmentally acceptable conditions whereas some see it as artificial technical barriers to trade.

Drawing on replies to a questionnaire sent to Panel participants, informal contacts and data available with UNIDO and the consultant, the paper attempts to provide a brief global overview of the waste treatment and disposal cost in the tanning industry; understandably, legislative and cleaner technology aspects could not be disregarded.

Given the variety of factors associated with the *treatment system* as such (primary, primary and biological or even tertiary; with or without appropriate sludge disposal; alone or with other wastewaters), *construction* (time span, cost of land, grants/subsidies, modifications) *direct operation costs* (depreciation of civil works and equipment included or not), the comparison of waste treatment costs can be only taken as indicative.

LEGISLATIVE ASPECTS, MONITORING AND ENFORCEMENT

Presenting a comparative evaluation of discharge standards in a single table is no easy task either. In some countries only a few parameters are subject to control, while in others countless parameters, in some cases more than two hundred, are prescribed. Standards within one country can vary from one region to another.

More recently discharge limits for endocrine disruption substances (alkyl/phenol etoxylates, a group of detergents used extensively in tanning industry) are also being introduced.

Norms for the discharge of treated effluent to both surface and sewer vary between industrialized and developing countries: even for basic parameters such as chemical oxygen demand (COD) and suspended solids (SS) norms in industrialized countries are stricter.

However, contrary to the widespread (mis)perceptions, the main differences are not so much in discharge limits per se; they stem primarily from the fact that regular and stricter monitoring and enforcement measures are much better established in industrialized countries. However, these are also becoming increasingly reliable in many developing countries thanks to enhanced public awareness and changing global trade requirements that exert considerable pressure on tanners to conform to the country's environmental regulations.

Obviously, both technology and treatment costs are determined by the specific norms that apply. The marginal costs of treatment rise sharply when higher levels of purification are required (e.g. reducing COD from 250 to 160 mg/l or SS from 100 to 40 mg/l).

***Table 1:* Discharge limits for treated tannery effluent**
(Except pH all in mg/l)

Parameter	India		Italy		France	
	Surface	*Sewer*	*Surface*	*Sewer*	*Surface*	*Sewer*
pH	5.5-9	5.5-9	5.5-9.5	5.5-9.5	5.5-9.5	5.5-9.5
COD	250	-	160	500	125	2000
BOD_5	30	350	40	250	30	800
Suspended solids, SS	100	600	40-80	200	35	600
Ammonia nitrogen (as NH_4)	50	50	15	30		
TKN	100	-	-	-	10 - 30	150
Nitrate nitrogen (as N)	-	-	20	-	-	-
Sulphide (S^{2-})	2	-	1	2	-	-
Hexavalent chromium, Cr^{6+}	0.1	2.0	0.2	0.2	0.1	0.1
Trivalent chromium, Cr^{3+}	-	-	-	4.0	-	-
Total Chrome (as Cr)	2	2.0	2.0	4.0	1.5	1.5
Phenol index	1.0 *	*5.0	-	-	0.1	0.1
AOX*	-	-	-	-	1.0	1.0
Chlorides (as Cl^-)	1000**	1000**	1200*	1200	-	-
Sulphates (as SO_4^{2-})	1000**	1000**	1000*	1000	-	-
TDS	2100**	2100**	-	-	-***	-
Aluminium (as Al)	-	-	1.0	2.0	5 (Al + Fe)	5 (Al + Fe)
Iron (as Fe)	-	-	2.0	4.0	5 (Al + Fe)	5 (Al + Fe)

* *Phenolic compounds expressed as C_6H_5OH.*

** *TDS norms at present enforced only in the State of Tamil Nadu but 7,500 mg/l TDS are tolerated by the authorities.*

In Santa Croce, Cuoidepur and Fuccechino: chlorides – 5,000 mg/l; sulphides – 1,800 mg/l.
In Arzignano: chlorides – 2,900 mg/l; sulphides – 1,800 mg/l.
In Solofra: chlorides – 3,500 mg/l; sulphides – 1,500 mg/l.

*** *In France no discharge limits pertaining to chlorides, sulphates and TDS have been prescribed except in special cases. (The authorities do not insist on norms relating to COD and nitrogen, if the effluent is treated alongside with domestic sewage in a combined treatment plant).*

Discharge limits for treated tannery effluent *(cont.)*
(Except pH all in mg/l)

Parameter	Ethiopia	Kenya (Nakuru)	Nigeria		Slovakia		
	Surface	*Sewer*	*Surface (chrome)*	*Surface (vegetable)*	*Surface*	*Sewer*	*Sewer (1 Nov 2007)*
pH	6-9	6.5-8.0	6-9	6-9	6.0-9.0	6.0-9.0	6.0-9.0
COD	500	1000	80 (2800)*	160	500	2200	800
BOD_5	200	500	100 (1000)*	50	50	1100	
Suspended solids, SS		600	40 (800)*	30	40	500	500
Ammonia nitrogen (as NH_4)	30	20			100	45	45
TKN							
Nitrate nitrogen (as N)					120	70	70
Sulphide (S^{2-})		2	1.0 (8)*		2	13	2
Hexavalent chromium, Cr^{6+}		0.05	0.1		0.1	0.1	0.1
Trivalent chromium, Cr^{3+}			2.0				
Total Chrome (as Cr)		3	2.0		1	1	0.8
Phenol index		10					
AOX*							
Chlorides (as Cl^-)	1000	1000	50	50			
Sulphates (as SO_4^{2-})		1000					
TDS		3000				5500	4500-5000?
Aluminium (as Al)							
Iron (as Fe)							

*Proposed in the State of Kano.

Discharge limits for treated tannery effluent *(cont.)*
(Except pH all in mg/l)

Parameter	Tunisia			Zimbabwe, Harare	Brazil	Europe, general range	
	Surface	*Sewer*	*See*	*Sewer*	*Surface*	*Surface*	*Sewer*
pH	6.5-8.5	6.5-9.0	6.5-8.5	6.8-9.0	6.0-9.0	5.5-9.5	5.5-9.5
COD	90	1000 (2000)	90	3000	360	70/<160	<500/2000
BOD_5	30	400 (1000)	30	1000	120	20/<40	<250/800
Suspended solids, SS	30	400	30	600	1,0	35/<80	<200/600/750
Ammonia nitrogen (as NH_4)					5,0	2.0/<15	<30/60/180
TKN	1	100	30	200	10,0	10 – 30	90/150
Nitrate nitrogen (as N)					-	25.0/<20	100/150
Sulphide (S^{2-})	0.1	3 (8)	2		0,2	0.5/<1	<2/<10
Hexavalent chromium, Cr^{6+}	0.01	0.5	0.5	Nil	0,1	0.1/<0.2	0.1/<0.2/0.5
Trivalent chromium, Cr^{3+}	0.5	4	2	Nil	-	NA	2
Total Chrome (as Cr)				10	0,5	1.0/<2	1.5/2/<4
Phenol index	0.002	1.0	0.05	10	0,1	0.1/0.3/NA	0.1-2
AOX*		-			-	NA/1	1-2
Chlorides (as Cl^-)	700	2000	-	500	-	500/<1200	<1200/2500/2860
Sulphates (as SO_4^{2-})	600	600	1000	1000	-	600/<1000	<250/600/<1000
TDS				2000	-	NA	NA
Aluminium (as Al)	5.0 (10)	10 (20)	5.0 (10)		10	5.0/<1	<2 or 5/20
Iron (as Fe)	1.0	5.0 (15)	1.0	25	15	5.0/<2	<4 or 5/10

CLEANER TANNING TECHNOLOGIES

The pressure to adopt cleaner technologies normally emanates from environmental imperatives such as the need to meet specific discharge norms, reduce treatment costs or comply with occupational safety and health (OSH) standards. To date some of such technologies have been adopted on a broader scale in industrialized countries.

The new processes have been developed with the aim of reducing pollution without incurring any negative impact on leather quality. The typical primary targets are: lower water consumption, improved uptake of chemicals, better quality/re-usability of solid waste and reduced content of specific pollutants such as heavy metals and electrolytes.

The spread of cleaner technologies and processes has been neither spontaneous nor extensive. For all the claims about favourable cost-benefit ratios and/or environmental benefits to be derived from many of these technologies, tanners are not quick in adopting them (***Table 2***).

Table 2: **Cleaner technology options used by the leather producing industry**

PROCESS STAGE	Brazil	France	India	Italy	East Africa	Mexico	Nigeria	Slovakia	Tunisia	Europe (general)
Preservation/curing										
Fresh hides and skins	***	**	-	*	*		-	**	-	**
Chilling/ice	*	-	-	*	-		-	**	-	**
Drying	*	*	-	-	**		**	-	**	*
Use of antiseptics	*		-	-	-		-	-	-	-/*
Soaking										
Green fleshing	-	**	*	*	*		-	-	-	*/**
Trimming	***	***	***	**	***		**	-	**	***
Manual or mechanical desalting	***	**	**	***	***		-	*	*	***
Unhairing - liming										
Enzyme supported unhairing	-	-	*	**			*	***	*	*
Hair-save unhairing	***	**	**	**	*		*	-	**	**/***
Recycling of lime floats	**	*	*	*	**		*	-	*	*
Splitting of limed pelts	**	**	-	**	-		*	***	*	***
Deliming										
Carbon dioxide deliming	-	-	-	**	-		-	-	-	**
Use of weak acids	*	***	-	**	**		*	*	*	**
Tanning										
Solvent free degreasing	**	-	***	*	**		*	-	*	***
Recycling of the pickling float	-	*	-	*	-		-	-	*	*
Direct recycling of the tanning float	*	*	-	*	*		-	-	-	*
Chrome recovery by precipitation	*	**	***	***	*		**	***	*	**
High exhaustion chrome tanning	*	***	*	***	*		*	*	*	**

PROCESS STAGE	Brazil	France	India	Italy	East Africa	Mexico	Nigeria	Slovakia	Tunisia	Europe (general)
Three compartments drums[1]	-	*	-	**	*		*	**	*	*/**
Wet white production	-	*	-	*	-		*	*	*	**
Vegetable tanning										
Drum/drum-pit tanning	-	***	***	*	**		*	-	**	**
Closed circuit pit tanning	-	-	**	*	-		-	-	-	**
Dyeing										
Environment. acceptable dyes & auxiliaries	***	***	***	***	***		**	***	***	***
Use of three-compartments drums[1]	-	-	*	*	*		*	**	*	*
Finishing										
Water based finishes	***	***	***	**	***		**	***	**	***
Safe cross-linking agents	?		*	**	**		**	***	**	***
Roller coating	***	***	**	***	***		**	**	**	***
Other cleaner technologies										
(Strict) water management	*	**	**	***			-	**	-	**
Energy management	*	**	-	**			*	**	**	**
Solid waste separation	*	**	-	***			*	**	*	**

[1]Practical experience from Slovakia (*I. Kral*): Better drainage, easier washing/cleaning, suitable for automation but costlier investment & maintenance, more energy required for heating and *no water saving*.

CHROME MANAGEMENT

Given the widespread (public) perception of and importance attached to the role of chrome in the tanning industry, this issue is highlighted separately.

In a typical effluent treatment process, chrome can be almost fully eliminated. Reaching the discharge norm for chrome in liquid emissions is thus not considered a serious issue anywhere in the world. However, the chromium removed is in effect transferred to sludge.

In Europe and in the United States of America (USA) the sludge generated by tannery effluent treatment plants is not categorized as hazardous waste. However, owing to its chromium content, its disposal, especially land application is subject to many restrictions in Europe.

In almost all developing countries chromium-containing tannery sludge is still treated as hazardous waste either because they fear that the trivalent chromium content might be converted to hexavalent chromium (which might leach and pose a threat to humans) or simply because they still adhere to earlier industrialized country legislation; in that respect India offers a very interesting example.

In an effort to boost up cleaner technologies resulting in lower chrome content in the sludge, the authorities have specified limits for various contaminants in the sludge, below which it would not be considered hazardous. The order dated 5 January 2000 specified a limit of 5 g/kg as the limit of chromium and was hoped to promote better chrome management. However, in March 2004 the order was modified virtually nullifying the benefit of the earlier order, reportedly fearing misuse of the provisions. At present, tannery sludge, irrespective of chrome content in the sludge, is considered hazardous in India and need to be disposed off in secured landfills.

Untanned and tanned wastes generated by the tanning industry are not classified as hazardous waste in industrialized or developing countries; however, the European legislation will soon prohibit the disposal in landfills of solid waste containing more than 10% organic matter.

An interesting and enlightening example of chrome management is the leather cluster in Santa Croce sull'Arno, Italy. The tanners there operate a central chrome recovery unit as a private not-for-profit company. Installed in 1981, the plant has the capacity to process, in an 8-hour shift, 400-500 m^3/d of spent chrome liquor with an average chrome content of 3-4 g/l as Cr_2O_3. The capital cost of the plant was US$ 5 million. The tannery pays about US$ 0.20/kg of regenerated chrome liquor with an average Cr_2O_3 content of 9-10% by weight; this is close to the market price for basic chrome sulphide.

In 2000 the plant recovered about 490 t of Cr_2O_3 at a total cost of about US$ 1.45 million. The average cost for the treatment of effluent sent to the Aquarno common effluent treatment plant (CETP) was US$ 2.6/m^3. About 1,600 t of sludge were produced and transferred to the Ecoespanso landfill at an average cost of US$ 66.8/t.

At one point of time there were about 100 chrome recovery units in India practicing chrome precipitation with magnesium oxide and its re-use. However, since concerns about genuine or perceived negative impact on the leather quality prevailed over the rather modest cost benefit (long pay-back period), many of them discontinued their operations; something similar also happened in China.

The drive of the leading car manufacturers to produce easily disposable/recyclable vehicles made, as a side effect, a significant impact on the tanning technology. Possibly the most propulsive sector, production of automotive leathers, now churns out mostly chrome-free leathers. Scientific arguments that, apart from its ease in application, cost, superior performance and, ultimately, superior overall environmental performance, chrome tanning is still the method of choice in most cases, remain unheard. Poorly informed and/or misled public opinion easily buys the view that chrome-free leathers, *a priory*, should be more environment-friendly.

TYPICAL EFFLUENT TREATMENT TECHNOLOGIES AND (C)ETP PERFORMANCE

The basic effluent treatment principles & stages are worldwide quite similar and typically comprise:

- **Physical-chemical treatment** to segregate settleable solids:
  - Mechanical pre-treatment, including grease and grit removal.
  - Equalization with pH correction and sulphide oxidation using forced aeration.
  - Chemical treatment: coagulation, flocculation.
  - Solids separation by sedimentation or, less frequently, by diffused air flotation, DAF.
  - Dewatering and disposal of the primary sludge (plate and belt filter presses, centrifuges; sludge drying beds mostly as back up).*

    **Remarks:* In a few countries a separate treatment line for the main chrome bearing streams is mandatory.

    In most industrialized countries, i.e. countries with municipal sewerage network and wastewater treatment plants, individual factory treatment ends at this stage.

- Activated sludge-based **biological treatment** to eliminate organic matter:
  - Forced aeration by surface aerators, fine bubbles bottom diffusers or (Venturi) ejectors.
  - Recycling of the activated sludge (floc).
  - Nitrogen removal by nitrification (extensive aeration) and denitrification (anoxic conditions)[2]
  - Fine tuning of the process by adding nutrients (phosphorus), antifoaming substances etc.
  - Sedimentation and removal of excess sludge.
  - (Secondary) sludge dewatering and disposal.

However, considerable differences can be encountered in the level of sophistication of the equipment installed, the extent of on- and off-line monitoring and the manner in which the process is implemented. For the same reasons, performance as well as investment and running costs also differ considerably.

In a very few countries one can also find:

- **Tertiary treatment:**
  - Extensive chemicals treatment, including Fenton/wet oxidation, mainly to destroy the hard to break, residual COD.

[2]It is surprising that in a short note in a recent issue of one international leather magazine reporting on the opening of a new tannery effluent treatment plant it is claimed that nitrification/dinitrification had never been used in the tanning industry before.

Table 3: **Comparison of performance of selected (C)ETPs in France, Italy and India, 2000**

PARAMETER	FRANCE			ITALY			INDIA		
	Raw effluent	*Treated effluent*	*% reduction*	*Raw effluent*	*Treated effluent*	*% reduction*	*Raw effluent*	*Treated effluent*	*% reduction*
PH	-	-	-	7.73	7.49		7.07	7.47	
COD	6,003	142	97.6	8,992	170.2	98.1	3,549	460	87.0
BOD_5	1,965	18	99.1	2,884	11.2	99.6	1,328	84	93.7
SS	3,064	21	99.3	4,146	30.9	99.3	2,179	112	94.9
$N\text{-}NH_4$	-	-	-	279	9.1	96.7	-	-	-
TKN	380	28	92.6	413	30	92.7	-	-	-
$N\text{-}NO_3$ (as N)	-	-	-	-	12.8	-	-	-	-
Sulphides (S^{2-})	-	-	-	80	0	100.0	83.5	1.5	98.2
Total Cr	20	0.5	97.5	91	0.2	99.8	54.6	2.8	94.9
Chlorides (Cl^-)	-	-	-	4,185	2,966	29.1	-	-	-
Sulphates (SO_4^{2-})	-	-	-	1,833	1,415	22.8	-	-	-
TDS	-	-	-	-	-	-	8,857	8,712	1.6

Note: All parameters, except pH, are in mg/l.

In Italy, meeting the COD limit of 160 mg/l set for discharge to surface water is the most difficult task. Very often tertiary treatment has to include the Fenton process (oxidation) in order to meet the limit. In India, where the (C)ETPs treat tannery effluent exclusively and discharge the treated effluent to surface water, the degree of purification required is indeed high. The values for COD and TDS are not strictly enforced.

AIR POLLUTION

The tanning industry is not a major air polluter. The main air pollutants are hydrogen sulphide and ammonia emanating from liming, deliming and pickling operations and waste treatment operations as well as volatile organic compounds (VOC) used in the finishing department. This holds especially true for in tanneries with poor housekeeping practices, including improper handling of solid waste. Incineration of tanned leather wastes is a health hazard whereas the new sludge treatment technologies (such as thermal drying and pyrolysis) may produce exhaust gases (fumes) that pose a threat to the environment and workforce alike. Standards governing exhaust gases have been set and are relatively strictly enforced in industrialized countries.

Table 4: **Emissions from aqueous and solvent finishes in various items of equipment**

	Air flow	Concentration*
	Nm^3/h	*$mg\ C/Nm^3$*
Aqueous finishing		
Spraying cabinet	10,000 - 20,000	20 - 200
Drying tunnel	200 - 500	~20
Solvent finishing		
Spraying cabinet	10,000 - 20,000	1,250 - 2,000
Drying tunnel	200 - 500	190 - 300
Roller coating machine	1,000 - 3,000	150 - 300
Drying tunnel after roller coating	200 - 500	100

*Owing to the use of different organic compounds as solvents, expressed as mg C/Nm^3.

For many applications, aqueous finishing does not yield the same result in terms of quality and performance as solvent finishing.

Some examples of current legislation and practices are given below.

France

- When the use of VOC exceeds 2 kg/h, the maximum permissible carbon content of the product in the gaseous emissions is 110 mg/m³.
- When the use of specified VOC such as formaldehyde exceeds 0.1 kg/h, the maximum permissible concentration in the gaseous emissions is 20 mg/m³.

As of October 2005:

- For tanneries using 10-25 tons of VOCs/year: 85 g/m²For tanneries using more than 25 tons of VOCs/year: 75 g/m²
  The industry presses for the limit of 150 g/m² for small leather goods and upholstery leather.

Slovakia

- VOC – depending on the installed capacity: 75-85 g/m²
- Solid particles: 3 mg/m^3

Workplace:

H_2S	max. 14.0 mg/m^3
Solid aerosol	max. 10.0 mg/m^3
MgO aerosol	max 4.0 mg/m^3
Solid aerosol – $Ca(OH)_2$	max. 0.5 mg/m^3
Cr	max. 0.1 mg/m^3
Noise	85 dB

Italy

The main problem is that of malodour emanating from CETPs is a very serious issue, the typical counter-measures adopted are:

- Use of pure (liquid or gas) oxygen instead of air to avoid stripping.
- Covering potential sources of bad smells, extraction of gases/vapours and treatment of exhaust air with wet scrubbers prior to emission into the atmosphere. The scrubbers are mainly alkaline, sometimes acid and alkaline.
- Occasional admixture of oxidants (mainly hydrogen peroxide) or strong alkali (lime and NaOH).
- In some CETPs bio-filters are used to clean the exhaust air.

All sludge treatment plants adopting thermal drying or pyrolysis have integrated exhaust gas cleaning systems to be able to meet specified standards.

India

A few tanneries have installed scrubbers for vapours from spray units; however, most of the tanneries only use a chimneystack and exhaust fan to convey the fumes into the atmosphere. Municipal authorities in the area concerned prohibit the burning of chrome shavings and buffing dust; offenders are fined.

The main sources of bad smells within the (C)ETP are the receiving sump, equalization tank, anaerobic lagoon and sludge lines. Standard rectification measures include improving admixture and aeration in the receiving sump and equalization tank to prevent settling of putrescible solids and oxidize sulphides; for this reason anaerobic lagoon are being closed.

At present, there is no regulation related VOC. However separate standards are applicable for air quality that mainly prescribes the following parameters: SO_2, Oxides of Nitrogen as NOx, Suspended Particulate Matter (SPM), Respirable Particulate Matter (RPM), Lead and Carbon monoxide.

Finishing is mainly done using water based finishes and not solvent based finishes, hence VOC is not at present a problem.

SALINITY

TDS in tannery effluent mainly emanate from salts used in the preservation of raw stock and certain processing stages such as liming, pickling and chrome tanning. Some TDS comes from finishing. As a rule, however, about 70% of the TDS enters the effluent in the beamhouse.

In most industrialized countries where after preliminary treatment, tannery effluent is mixed with domestic sewage and treated in combined effluent treatment plants, no TDS limit is prescribed. Likewise, TDS limits are not prescribed for the marine discharge of treated effluent. However, many developing countries lack domestic sewage treatment plants. Moreover, tanneries are located in places where no facilities are available for diluting their effluent with domestic sewage. In such locations, the effluent invariably has to be discharged to surface water; hence strict limits are prescribed for both TDS and chlorides. Tamil Nadu is a case in point. Continual discharge of treated tannery effluent, high in TDS and chloride, is reported to have affected soil fertility and contaminated the ground water, making the soil unfit for agricultural and the water unsuitable for drinking or other domestic purposes. An attempt had been made to address this problem by imposing segregation of soak and pickle liquors and their evaporation in solar evaporation pans albeit with unsatisfactory effect.

Thus, in addition to manual or mechanical desalting of raw stock reducing the TDS in effluent by some 15%, in despair, reverse osmosis (with or without being combined with domestic effluent) is seen as a possible solution.

SLUDGE TREATMENT AND DISPOSAL

Following the typical sludge producing stages within the tannery (C)ETP, i.e. thickening, dewatering (plate and belt filter presses, centrifuges; sludge drying beds mostly as back up) bringing its dry solids (DS) content above 25-30 %, the sludge is ready for permanent disposal.

Tannery sludge and sanitary effluent (sewage) sludge are very much alike. The legislation/standards pertaining to the limits are therefore the same for both; the pre-requisites for disposal of sludge or use in agriculture (such as stabilization, pathogenic content, hygienic aspects and odour) are also identical.

That notwithstanding, tannery sludge displays three distinct differences:

- greater inorganic matter content,
- greater heavy metal content, especially chromium,
- greater sulphur compound content.

As said earlier, chromium content in tannery sludge is the main constraint on its use or safe disposal. Given the high toxicity of hexavalent chromium, many environmental standards also limit total chromium. This limitation arises for want of insufficient knowledge of the difference in properties between trivalent and hexavalent chromium or for fear that trivalent chromium may be transformed into hexavalent chromium during waste disposal/re-use or chlorination of drinking water.

Landfilling in ordinary or special landfills remains the prevailing disposal method. Regrettably, in many developing countries, properly designed, constructed and/or maintained landfills are not available; tannery sludge is just dumped without any control.

Other, more advanced sludge handling and disposal methods are:

- Chemical conditioning: With quick lime, thus increasing the sludge dry solids content and improving its appearance and smell.
- Composting: Usually aerobic, in either open or closed systems, the compost applied in cultivation of inedible plants.
- Thermal treatment: Drying, vitrification, pyrolysis – gasification etc. resulting in lightweight aggregates/oil.

In Italy the maximum permissible content of trivalent chromium in sludge destined for conversion into by-products (e.g. compost or bricks) is 2.5 g/kg DS. In France, since July 2002 it is not possible to deposit in landfill solid waste containing any recoverable value, including energy. Recovery must be effected at an acceptable cost, yet no limit has been fixed to determine the level of acceptability. In India, sludge may be deposited in municipal landfills if the chromium content is within prescribed levels.

Under the *EC Landfill Directive*, the UK must reduce landfilling of biodegradable municipal waste to 75% of 1995 arising by 2010, 50% by 2013 and 35% by 2020.

Standards set for the land application of sludge in several countries are presented in ***Table 5*** (see next page).

***Table 5:* Sludge re-use standards for land application**

Parameter	China	Den-mark	France	Ger-many	Nether-lands	Belgium	Norway	Sweden	Switzer-land	United Kingdom	USA
Chromium (mg/kg dry soil)	90- 400*	100	150	100	100**	150				600	No limit
Chromium (mg kg dry sludge)		100	1,000	900	500	500	200	150	1000		No limit
Suggested annual chromium loading (kg/ha/year)			6.0	2.0	1.0	2.0	0.4	1.0	2.5		No limit
Maximum recommended chromium loading (kg/ha)			360	210	100		4			1,000	
Suggested maximum annual sludge solids application (t/ha/year)		1.5	3.0	1.7	2 (arable) 1 (grass)		2	1	2.5		
Maximum sludge solids loading (t/ha)				167	200		20	5 in 5 year			
Minimal soil pH			6.0							6.5 (arable) 6.0 (grass)	

Source: CTC, France

Remarks: *In China tolerance limits for trivalent chrome contained in soil depend on quality standard of soil (dry or paddy land) and its pH. The most astringent norms apply to soils of limited quality used to protect natural background and resources irrespective of pH and use. The most lenient norms apply to soils of critical quality used to maintain normal plant growth and pH 6,5 – with 400 mg/kg (paddy).

**Varies according to clay content.

SOIL POLLUTION

Under normal conditions, the discharge of properly treated solid waste or liquid waste disposed of by the tanning industry should not result in soil pollution; at present, no specific regulations pertaining to soil pollution by tanneries have been promulgated in industrialized or developing countries.

Table 6: **Limit values for selected soil pollutants in some industrialized countries**

	France	Germany	Germany	Netherlands
		Industrial area	*Residential area*	
Arsenic	37	140	20	
Cadmium	20	60	20	12
Total chromium	7,000	1,000	400	
Copper	240	3,000	600	190
Mercury	7	80	20	
Lead	400	2,000	400	530
Total hydrocarbons	5,000			
Benzene	5		12-30	0.5

Note: All values in mg/kg

In a landmark judgment of 1996, the SUPREME COURT of India ruled that tanners in Tamil Nadu should compensate owners of agricultural land that had been allegedly damaged on account of untreated effluent having been discharged on their land in the past.

EFFLUENT TREATMENT COSTS – STRUCTURE, DISTRIBUTION, TARIFFS

Owing to the complexity of factors involved, it is extremely difficult, well nigh impossible, to make an accurate comparison of the investment and operation costs related to effluent treatment. Nevertheless, in this chapter an attempt is made to identify the main pointers and indicate the orders of magnitude for at least a few selected countries.

Typical (C)ETP investment costs

Due to many differences in conditions under which the plant was set up a direct comparison is not possible. Typically, in industrialized countries external financial assistance took the form of long-term, low-interest loans (1% per annum in France) while, for example, in India, the government subsidized up to 50% of the investment costs for common effluent treatment plants, the remainder being met by the tanners from their own contributions and via loans at current rates of interest.

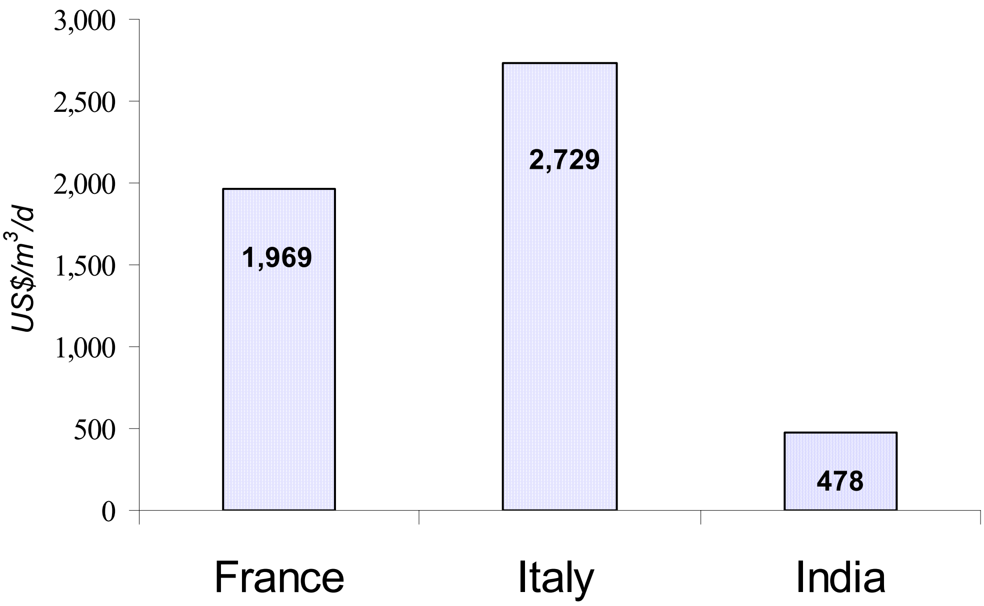

Figure 1: **Comparison of specific investment costs in 2000**

A very recent overview indicates that within the same state (Tamil Nadu) in the same country, for various reasons, the CETP investment costs vary from only about US$ 250 to nearly US$ 900/m^3 of installed capacity, the average being about US$ 600/m^3/day.

Typical (C)ETP operation costs

Treatment costs are customarily expressed in terms of cost/m^3 of treated effluent. However, since treatment costs are governed by effluent quality, it would be more accurate, especially for the purposes of comparison, to have them defined in terms of specific costs per kg of pollutant (COD, BOD_5, SS, etc) treated/eliminated.

France

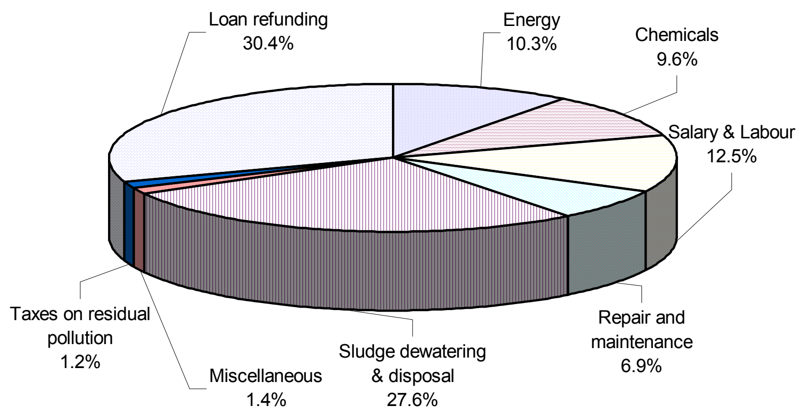

Figure 2: **Distribution of total costs in a large French ETP**

Italy

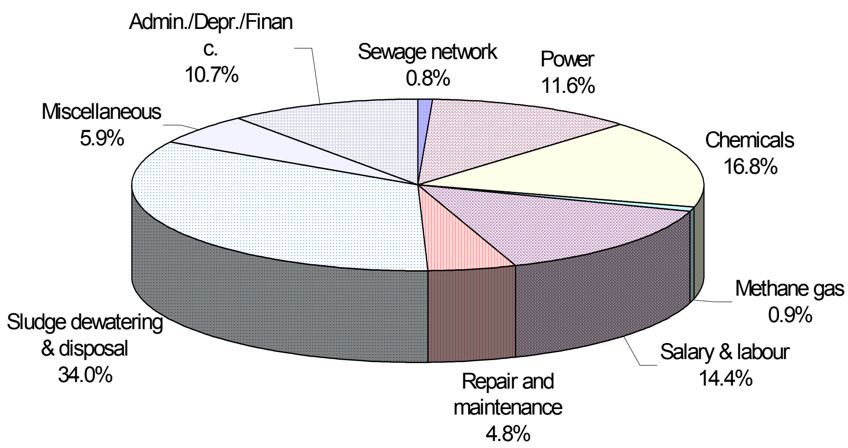

Figure 3: **Distribution of average total costs in Italian CETPs**

Significant differences are to be found among CETPs in terms of average treatment costs per m^3 of effluent.

Tariff structure

The treatment tariff in one cluster was originally based on average parameters of typical processing systems (categories). Today, however, with the installation of fixed samplers at the tannery discharge point, the tariff is universally computed according to a formula that takes into account the pollution load of the specific effluent: suspended solids and COD and, in a few cases, ammonia-nitrogen as well. Other parameters (e.g. chlorides and sulphide)

enter into the formula more as penalizing factors, the aim being to force tanneries to respect discharge standards.
The formulae adopted have a dual structure: fixed and variable costs. Variable costs are linked to effluent volume, pollution loads and penalties related to discharged effluent. In general, CETP managements tend to increase fixed costs, thus reducing the difference between various types of tannery operations.

Table 7: **Tariff based on estimated pollution load in Italy**

Group	Class	Activity/Production	Parameter	Adopted value *mg/l*
1	E	Spraying cabins	COD	20,000
	F1	Chemicals producers	SS	10,000
			Chloride	10,000
2	D	Liming and production of wet-blue leather	COD	15,000
			SS	13,000
			Chloride	15,000
3	B	Sole leather production	COD	13,000
	B1	Full process (vegetable tanning)	SS	10,000
	B0	Processing of vegetable split	Chloride	10,000
4	A	Full process (chrome and mixed tanning)	COD	8,000
			SS	7,000
			Chloride	8,000
5	C1	Full process of haired leather (fur)	COD	6,000
			SS	2,000
			Chloride	10,000
6	C2	Partial vegetable process	COD	8,000
			SS	2,000
			Chloride	3,000
7	C	From wet-blue to finished leather	COD	6,000
	C3	From limed pelt to finished leather	SS	2,000
	F	Processing of tannery solid wastes	Chlorides	3,000
	G	Processing for third parties		
	G1	Fleshing and splitting machineries		

The cost charged to tanneries is calculated according to the following formula:

$$TREATMENT \quad COST = K + \left(\frac{COD_i}{COD_m} \times h + \frac{SS_i}{SS_m} \times z\right) + \left[(COD_i \times 0.6) + SS_i\right] \times SC + j(Cr) + y(Cl)$$

Where:

Symbol	Definition	Formula
K	Fixed costs (IL/m^3)	Annual fixed costs (IL): total volume of treated effluent (m^3/year)
h	COD removal costs	[Annual variable costs (IL): total volume of treated effluent (m^3/year)] x 0.75
z	SS removal costs	[Annual variable costs (IL): total volume of treated effluent (m^3/year)] x 0.25
y	Adjustment factor related to chloride limit (detected by sampling and analysis)	See ***Table 21*** A1
j	Adjustment factor related to chrome limit (detected by sampling and analysis)	See ***Table 21*** A2

Symbol	Definition	Formula
SC	Sludge disposal cost	COD_i x SS_i x (average sludge disposal cost (IL/kg): Total kg of SS and COD treated by the plant in the year)
COD_i	COD of plant effluent determined by sampling and analysis or assumed for the specific activity class	
COD_m	Average COD of the raw mixed effluent analyzed at the CETP inlet	
SS_i	SS of plant effluent determined by sampling and analysis or assumed for the specific activity class	
SS_m	Average SS of the raw mixed effluent analyzed at the CETP inlet	

India

In India the highest component in the overall structure of the treatment costs is power while the sludge handling and disposal costs are comparatively very low.

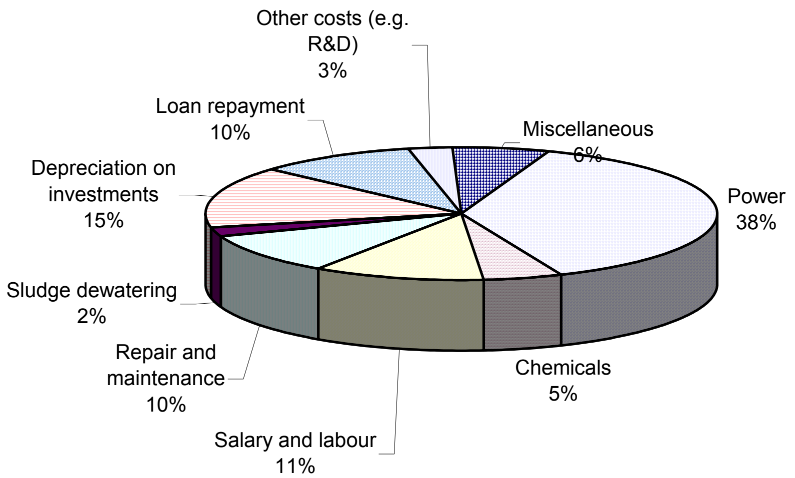

Figure 4: **Structure of the average total cost in selected CETPs in India in 2005**

Tariff structure

CETPs in India have not yet started charging member tanneries on the basis of their actual contribution to the pollution load: they charge them on the basis of actual treatment costs divided by a factor corresponding to each tannery's installed capacity and the rate varies from US$ 0.15 to US$ 0.37/kg of raw material processing capacity.

However, finally, one CETP started charging fixed (processing capacity/installed drums) and variable (CETP operational costs) related rates whereas at another one flow meters have been installed in each tannery and charges are based on the actual flow rates (US$ 0.78/m^3)

plus penalties for excess of TDS, chromium etc in the effluent according to randomly made analyses.

Table 8: **Specific effluent treatment costs in 2000**

	France	Italy	India
Average flow m^3/y	480,438	2,736,000	632,880
Average cost US$/y	919,320	11,597,760	563,532
Specific cost US$/$m^3$	1.91	4.24	0.9

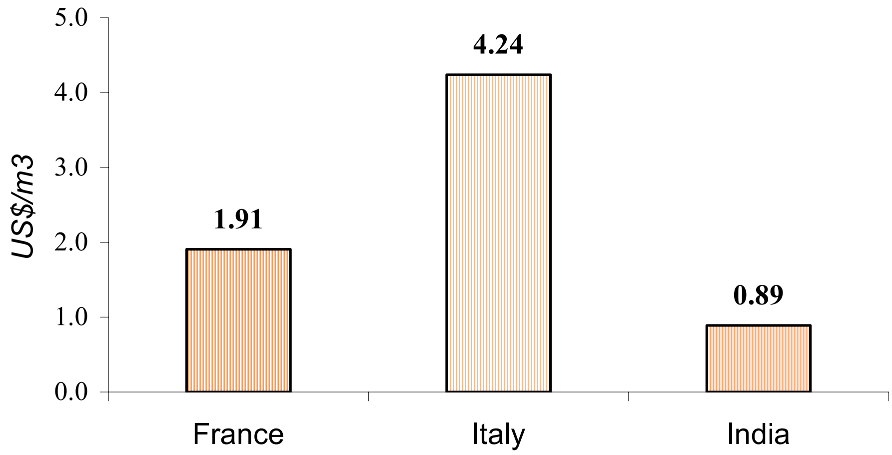

Figure 5: **Comparison of average specific treatment costs in 2000**

It should be noted that in reality the specific costs calculated per kg of $COD_{destroyed}$ are closer than those for m^3 of treated effluent.

***Table 9*: Typical structure of the cost of tannery effluent treatment**

Component	India		Italy		France	
	US$/m³	%	US$/m³	%	US$/m³	%
Energy	0.28	20	1.21	11.0	0.06	4.4
Chemicals	0.20	14	1.10	10.0	0.21	15.2
Salary & labour	0.13	9	1.43	13.0	0.27	19.5
Repair and maintenance	0.05	4	0.66	6.0	0.07	5.1
Sludge dewatering & disposal	0.05	4	4.07	37.0	0.36	26.0
Depreciation	0.14	10	1.10	10.0	-	-
Miscellaneous (loans, taxes, etc)	0.54	39	1.43	13.0	0.06	4.4
Biological treatment, municipal WWTP	-	-	-	-	0.35	25.4
Total	**1.39**	**100**	**11.0**	**100.0**	**1.35**	**100**

Component	Brazil		Slovakia		European region	
	US$/m³	%	US$/m³	%	US$/m³	%
Energy	0.50	59	0.25	6.5		6 – 30
Chemicals	0.14	16	0.44	11.4		20 – 30
Salary & labour	0.08	10	0.43	11.2		10 – 30
Repair and maintenance	0.03	3	0.27	7.0		7 – 15
Sludge dewatering & disposal	0.10	12	0.17	4.4		10 - 35
Depreciation	-	-	1.1	28.6		
Miscellaneous (loans, taxes, etc)	-	-	0.19	4.9		1 - 6
Biological treatment at the municipal WWTP			0.6	15.6		
Charges by WWTP for pollution over the limits			0.4	10.4		
Total	**0.85**	**100**	**3.85**	**100**	**6-9**	**100**

The table is based on replies to UNIDO questionnaire June 2005

Typical sludge disposal costs

Most CETPs in the Tamil Nadu state in India have been set up on large grounds so that, in absence of proper landfills, they have been able to construct simple landfills (compacted clay covered with LDPE sheets) within their own compounds. Based on the pilot demonstration landfills established in Tamil Nadu, the capital cost of a basic safe landfill is estimated at about US$ 460/t DS (excluding cost of land) and the operational cost about US$ 28/t DS.

The cost of landfills as per CLRI design, depending on the capacity, location and geological features of the region, varies from US$ 9-46/t DS.

Table 10: **Typical costs of sludge disposal or utilization in Italy**

Mode of disposal or utilization of CETP sludge	*US$/t*
Sludge supplied to fertilizer plants: 25% as wet (30/35% DS) and 75% as dry (80% DS)	55.00
Dry sludge (80% DS) supplied to brick factories	45.00
Chemical stabilization of wet sludge (35% DS) with quicklime	7.10
Sludge disposal in the ETP off-site landfill	74.00
Sludge disposal in sanitary landfill (one ETP)	90.50
Disposal in ETP on-site landfill	28.60

Composting tannery sludges has been extensively investigated, especially in China and India. Although compost quality has been found to be good, its marketing poses great difficulties. Currently some tanneries in India use the compost they produce for the cultivation of inedible plants (e.g. cotton, castor seed, eucalyptus, teak, etc.) on their own plots of land. Another trial, involving mixing sludge with fleshings to generate biogas and electricity, was carried out in a pilot plant set up by the CETP at Melvisharam in cooperation with UNIDO, the Indian MINISTRY OF NON-CONVENTIONAL SOURCES OF ENERGY and the CENTRAL LEATHER RESEARCH INSTITUTE (CLRI).

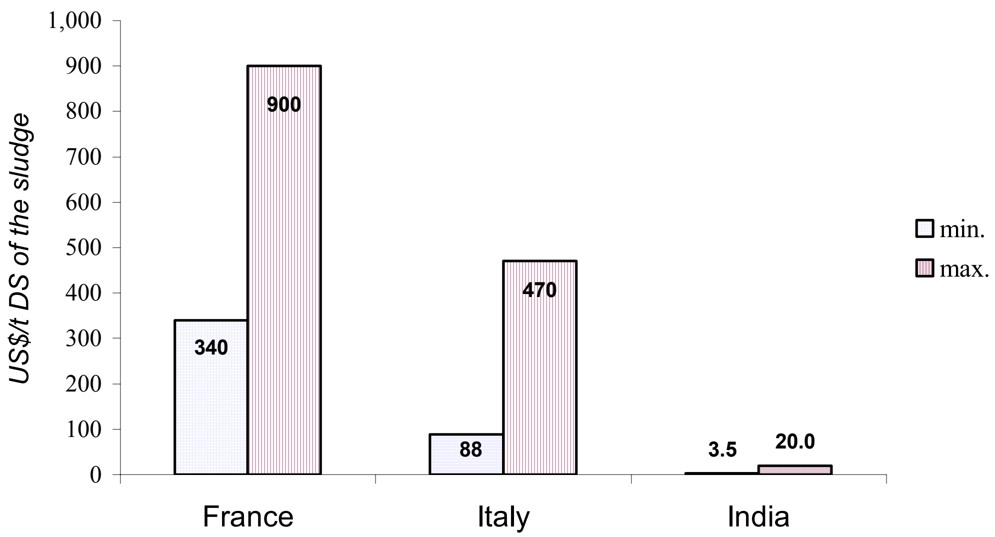

Figure 6: **Specific sludge treatment and disposal costs**

SOLID WASTES FROM TANNERIES

The more traditional a tannery, the higher the probable volume of solid waste generated. Since in many developing countries the tanneries are semi-mechanized and often use locally produced machinery and equipment that lack precision, the waste produced is higher.

The nature of solid wastes generated by a tannery (in addition to sludges) and, as a consequence, the legislation pertaining to their possible utilization and/or disposal is very different. In general, tannery solid waste can be categorized as

- **Untanned wastes**
  - Green and lime fleshings
  - Hair
  - Lime splits
- **Tanned wastes**
  - Chrome splits
  - Chrome/vegetable shavings
  - Unusable tanned splits
  - Buffing dust
  - Crust and finished leather trimmings

The amount of solid generated varies greatly, depending on the raw material characteristics, technology and the type of leathers produced; in the leather literature there is sufficient data about the volumes produced.

In our case, it is of interest to see what are possible gains or, more frequently, costs associated with utilization and/or disposal of the solid waste occurred to the tanner.

Evidently, apart from legislation, specific local circumstances, i.e. demand for a certain kind of solid waste serving as a raw material for another industry is essential.

France

Table 11: **Cost of disposal of solid wastes in a French tannery**

Type of waste	Quantity	Type of treatment	Total cost	Cost
	t/year		*US$/year*	*US$/t*
Hairs	80	Rendering plant	11,258	141
Fleshings	280	Rendering plant	39,427	141
Lime splits	95	Gelatine factory	0	0
Blue shavings	110	Leather-board factory	10,770	98
Trimmings	7.5	Sorting center	605	81
Buffing dusts	< 0.1	Sorting center	9	89
Special wastes (solvents)	2	Incineration	1,086	543
Common wastes	40	Sorting center	4,200	105
Chrome sludge	110	Landfill 1st class	27,056	246
Total	**724.6**		**94.411**	Average: **130.30**

The value of US$ 94,411 represents 1.2% of the tannery's turnover or 2.7% of production cost. Expressed in different terms, costs run to US$ 82.5/t of salted raw hides used in the tannery (calfskins).

Italy

Based on the data collected from various companies operating in Italy, costs for solid waste disposal incurred by tanneries fall within the following range:

	US$/t
Hair	29 - 34
Trimmings and fleshings	36 - 62
Unusable splits, chrome shavings	34 - 46
Vegetable shavings	14

India

In India, tanners still do not have to pay anything for the disposal of solid wastes. On the contrary, they earn some money by selling them. The typical rates are:

	US$/t
Raw trimmings	22-43
Hair/wool	16-65
Fleshings (40% moisture)	54-60*
Chrome shavings	13
Vegetable shavings	152
Trimmings	10-30

*Price paid by user industry to intermediaries who collect fleshings from tanneries, dry them to a certain extent and convey the load to the user industry. Tanners generally do not derive any income from waste disposal, but they do not incur any expenditure either.

In the ***Table 12*** below an attempt has been made to make an overview of the situations concerning tannery solid wastes in selected countries.

Table 12: **Utilization and disposal of tannery solid wastes in selected countries**

	France	Italy	India	Slovakia	Africa	European region
UNTANNED						
Raw hide trimmings	N.a.	N.a.	Glue manufacture in factories & cottage industries; one big unit in and some cottage industries make dog chews. Tanners receive **US$ 22-43/t.**	N.a.	N.a.	N.a.
Hair	Rendering plant Cost to tanners for disposal: **US$ 141/t.**	Fertilizer, price paid by tanneries **US$ 30-34/t** of hair; fertilizer sold at **US$ 183/t**.	Wool taken at **US$ 16-65/t**, used to make cheap blankets. Hair from hair-sheep and goats used in felt making and also exported.	Used to be sold to producers of animal feed.		N.a.
Fleshings (limed)	Cost: **US$ 141/t.** *Fat & protein recovery:* only to animals other than ruminants *Protein recovery* as energy source by incineration *Compost making:* mandatory to maintain temperature of 60-65^{0}C inside the piles. *Glue:* one factory for technical glue *Biomethanation* tested in a plant for domestic refuses.	Grease and proteins for animal feed and fertilizers; due to the BSE the recovered protein used solely for agriculture. Tanners pay **US$ 36-62/t.**	*Glue production*, mainly for adhesive for consumers in the industry of abrasives, corks, paint, pencils, safety matches, paper, sports goods and textile. Competition from synthetic adhesives. *Poultry feed:* Protein as partial substitute for fish meal from dried fleshings. **No cost, no gain** to tanners from disposal of fleshings.	Used in fat & protein production; the tannery pays **US$ 30/t** taken away. On the basis of 14 %/t of raw hide the cost of disposal about **US$ 4.5/t.**	*Zimbabwe:* Disposed at the municipal dumping site. Cost **US$ 20/t** (transport) + **US$ 3** (site)= **US$ 23/t.** *Ethiopia:* sold to glue manufacturer at **US$ 30/t.**	Used for biogas, industrial fats and technical products, composting, on-site treatment with recovery of energy. Utilization is usually **no cost, no gain** operation; disposal cost up to **US$ 90/t**.

	France	Italy	India	Slovakia	Africa	European region
Lime split waste	Gelatine production: fit for human consumption only from the certified animals & following specific procedures. **No cost, no gain.**		Negligible lime-splitting done.			See above.
TANNED						
Wet blue split waste and shavings	Cost: **US$ 98/t.** Exported for *leather-board* manufacture to Germany and Spain. Project for *fertilizer* production abandoned owing to O&M costs. *Incineration* and pyrolysis being evaluated.	For blending into fertilizers (after hydrolysis & drying). Tanners pay **US$ 34-47/t.**	Tanners sell at **US$ 13/t.** *Leatherboard* manufacture: chrome shavings mixed with vegetable shavings (ratio 1:2 ratio) *Fertilizer* in Kolkata by a crude process of cooking chrome shavings, reportedly used on tea estates.		Some recovered for *gloving* and football leather. *Municipal dumping* site; shavings sometimes compacted to reduce the volume.	Leather-board, protein hydrolisate, composting, technical products; landfill & incineration. Disposal cost: **US$ 90-130/t**, in some Eastern countries some **US$ 30/t**.
Vegetable tanned trimmings and shavings	N.a.	Leather-board and fertilizer. Tanners pay **US$ 14/t**.	Tanners sell at **US$ 150/t.** Leather-board manufacture.	N.a.		N.a.
Finished leather trimmings	Non-hazardous landfill.	Non-hazardous landfill.	Reuse; uncontrolled disposal, incineration; very minor cost.	Reuse; non-hazardous landfill, cost **US$ 30/t.**	Sold to micro leather goods manufacturers; in **Kenya** at **US$ 1-1.5/kg.**	Cost: Non-hazardous landfill. **US$ 90-130/t**; gasification.& incineration: up to **US$ 150-200/t**

CONCLUSIONS

Environmental pressures by the legislature and general public over the past twenty years have had a dramatic impact on tannery operations worldwide. Many tanners in industrialized countries hold the view that lax environmental regulations and poor enforcement account for lower production costs (and hence an expansion of the tanning industry) in developing countries. On the other hand, many concerned citizens and NGOs in developing countries consider that by linking raw material export restrictions to incentives for processing to higher stages, their own governments have indirectly supported the long-term strategy of some industrialized countries intent upon ridding themselves of an industry seen as a major source of pollution.

In this paper an attempt has been made to provide a comparative overview of the cost of treatment of tannery liquid and solids emissions. In that context, due to their direct effect, legislative aspects, cleaner tanning methods, utilization and disposal of solid wastes and sludge have also been highlighted.

The main conclusions derived from the analysis of the information gathered can be summarized as follows:

1. Norms for discharge of treated effluent to surface or sewers, even for basic parameters such as COD and SS differ. There are also considerable variations in limits for TDS.

2. Notwithstanding above, and contrary to the widespread (mis)perceptions, the main differences are not so much in discharge limits per se; they stem primarily from the fact that regular and stricter monitoring and enforcement measures are much better established in industrialized countries.

3. Cleaner tanning technologies have failed to make the progress expected in either industrialized or developing countries. The methods most frequently adopted are: processing of fresh (green) hides; mechanical desalting; hair-save liming; carbon dioxide deliming; improved chrome management; avoidance of formaldehyde; and low-VOC finishing. Considerable progress has been made towards reducing water consumption.

4. The primary motivation for adopting such technologies has been the need to comply with specific discharge norms, reduce treatment costs or meet OSH requirements.

5. Strict norms are prescribed for chrome in effluent and sludge in both industrialized and developing countries; many tanneries have even set up chrome recovery units. However, most tanners for quality concerns, avoid using the recovered chrome.

6. The fundamental principles of technology for treatment of tannery effluents all over the world are very much alike, especially for the primary (physical-chemical) stage; for the secondary (biological) step it prevails the activated sludge method. However, many tanneries in industrialized countries enjoy the advantage/benefit of the municipal sewage and wastewater plants carrying out the biological treatment; in addition to it, dilution with urban wastewaters mitigates the problem of salinity of tannery effluents being a serious constraint in arid regions.

7. Given the complexity of factors involved, it is extremely difficult, well nigh impossible to make an accurate comparison of investment and operational costs related to effluent treatment.

8. The notably higher specific investment costs per cubic meter of effluent treated in industrialized countries (for example US$ 1,970 in France, US$ 2,730 in Italy as compared to US$ 480 in India) are a direct consequence of the more sophisticated technology, machinery and equipment employed to reach the higher levels of purification. At the same time, the lower specific investment costs in developing countries are also attributable to the lower cost of indigenous machinery and equipment and cheaper construction costs.

9. Air pollution control provides a picture of striking differences. In Europe stringent regulations are being introduced in respect of VOC emissions emanating from leather finishing, whereas such regulations are almost non-existent in developing countries. Air emissions from (C)ETPs are one of the top priorities in Italy where sophisticated systems that CETPs employ to check air pollution and malodours are a major contributory factor to high treatment costs.

10. Sludge disposal also offers interesting contrasts. Although the tannery sludge is not regarded as hazardous in industrialized countries, the cost of dewatering and disposal represents about 40 % of the operational costs that treatment plants as compared to only about 5% in India. With more stringent norms for organic content and recovery of valuable by-products from sludge expected soon, these costs will escalate further.

11. A similar contrast is seen in the case of solid wastes. In industrialized countries tanneries have to pay significant amounts (representing 2.7% of total production costs in a French tannery) to have their solid waste taken away. In India, tanners derive a modest income by selling them.

12. Authorities in Italy and India increasingly insist that norms for total dissolved solids, TDS (salinity) be met. At present, such an approach is limited to arid zones (where the scope for diluting tannery effluent with domestic sewage or a larger water body does not exist and marine disposal is ruled out) and regulations have been temporarily relaxed. With the ever-growing water scarcity in many parts of the world, these norms, in all likelihood will be applied universally.

13. Although apparently no specific regulations have yet been formulated in industrialized countries, soil pollution by tanneries is likely to become a subject of regulatory control in the foreseeable future. The issue is also taking on importance in developing countries as evidenced by the heavy fine recently imposed on Indian tanners.

14. Treatment costs and their apportionment among tanneries vary widely compared in terms of cubic meter of effluent treated, costs are considerably higher in industrialized countries (US$ 1.91/m^3 in France and US$ 4.24/m^3 in Italy as compared to US$ 0.90/m^3 in India). Compared in terms of kg COD eliminated (US$ 0.32/kg in France, US$ 0.48/kg in Italy and US$ 0.29/kg in India) or kg SS eliminated (US$ 0.25 in France, US$ 0.41 in Italy and US$ 0.18 in India), the gap is much narrower.

15. Not surprisingly, the structure of the treatment costs vary considerably: Whereas power consumption accounts for more than 50% of the operational costs in India, chemicals account for about 14% and 19% of the operational costs in France and Italy, respectively, while salary and labour costs account for about 18% and 16% in France and Italy, respectively.

16. Distribution of treatment costs among tanneries served by common effluent treatment plants in France and Italy is primarily based on pollution load and computed using complex formulae. In India, however, calculations are done in a rather direct and simple manner, based on volume and/or raw material input, thus it does not offer the tanneries any incentive to reduce their pollution load.

17. New challenges related to environmental protection and consumer safety are coming to the fore, confronting industry in industrialized and developing countries alike. The current high cost will rise still further with the introduction of new regulations, jeopardizing the sustainability of the industry. Survival and/or further expansion of the tanning industry in any country will to a large extent hinge on its ability to meet the current and future environmental challenges in an innovative and cost-effective manner.

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Annex 1

CURRENT UNIT PRICES AND GROSS WAGES

A direct comparison of the main investment (construction) and operation costs (power, chemicals, labour) provides a picture of interesting contrasts.

US$

DESCRIPTION	Unit	Brazil	France	India	Kenya	Nigeria	Slovakia	Tunisia	European region
Construction									
Cost of earth excavation	m^3	0.15-8.33		1.75–4.0	-		-	10	
Cement, 50 kg	bag	6.25		3.8-4	6.9	7.2	5.0	3.2	
Iron bars, 8 or 12 mm	kg	1.08		0.65-0.75	0.8/1.0	6.8	2.2/5.0	6.0	
Sand	m^3	8.3-16.7		11.0-12.0	27	10.0	25.0	10.0	
Gravel	m^3	10-16.7		10.0	10		16.0	12.0	
Concrete, ordinary	m^3	75-92		29-35	5		65.0	280	
Bricks	piece	0.10		0.04	0.2		1.5		
Hollow blocks, 9x18", suitable for reinforcement	piece	0.33-0-42		0.6 (8x13")	0.9		1.7		
Chemicals									
Hydrated lime, 25 kg/bag	kg	-	0.2	0.08	0.13	0.26	0.1	0.07	
Manganese sulphate	kg	0.15	0.3	0.3	1.27		0.6	0.7	
Aluminium sulphate, 50 kg/bag	kg	0.30	0.2	0.1	0.27	0.44	0.22	0.3	
Aluminium polychloride	kg	0.40		0.5					
Polyelectrolyte, 25 kg/bag	kg	-	6.0	7.0	8.0	8.0	4.0–6.0	7.6	
Water & electricity									
Water from the main supply	m^3	-	0.65	0.2-0.3	0.6		0.1+0.1* 0.6+0.6	0.63 + 0.086	

DESCRIPTION	Unit	Brazil	France	India	Kenya	Nigeria	Slovakia	Tunisia	European region
Electricity from the main	kWh	-	0.06	0.093	0.13	0.068	0.1-0.2	0.075 + 0.016	
Electricity from the generator	kWh	-		0.15	-	0.112			
Salaries, wages, work time									
Mason	day	12.5		4.7-5.8	6.7	4.8	25	10	
Helper	day	10		2.9-4.0	3.3	2.4	12-16	12	
Non-skilled worker	month	9	180	2.3-3.5	3.3	100	12-14		7-200
Skilled worker	month	-	250			160		300	
Technician/foreman	month	500		125-245	270	250	500-600	400	215-1320
Mechanical engineer/chemists	month	1700		350-500	650	500	600-1000	725	320-6500
Number of working days	week	6	5	5-6	6		5	5	5
Number of working days	year	290	217	260-300	306		250	270	217-257

*Different cost of technical (process) and drinking water.

Annex 2

COMMON TANNERY EFFLUENT TREATMENT CO. LTD (RANITEC), INDIA[3]

Introduction

Ranipet is an industrial town in the state of Tamil Nadu. It is one of the important leather tanning centres of India. There are about 275 tanneries operating in and around this town. To treat the effluent from these tanneries six common effluent treatment plants were planned in the area. Four of these have been completed and are operational. Of these, the CETP managed by TALCO RANIPET TANNERS ENVIRO CONTROLS LIMITED, CETP-Ranitec in short, is located in Ranipet, 110 km from Chennai (Madras), on the Ranipet by-pass road on the Chennai-Bangalore national highway.

The CETP is managed by CETP-Ranitec, a company formed by 76 tanners who are its members. This company is registered under the *Indian Companies Act* and managed by a BoD drawn from its members.

General Information

Total number of tanneries	76
Number of tanneries operating now	76
Date of commissioning	5 June 1995
Total processing capacity of the tanneries	125,000 kg/day
Current production from the cluster	86450 kg/day
Raw material processed	Buffalo & cow hides & calf skins
Number of tanneries processing raw to El/finished leather	61
Number of tanneries processing wet blue/EI to finished leather	11
Number of tanneries doing chrome tanning	10
Number of tanneries doing vegetable tanning	62
Number of tanneries doing dry operations	4
Designed flow rate to the CETP	4000 m^3/d
Current flow rate to the CETP	1679 m^3/d

Project Planning and Execution

Design

The basic design of the project was done by ENKEM ENGINEERS, Chennai later modified by the UNIDO subcontractor TECHPROJECT, Croatia.

Finance

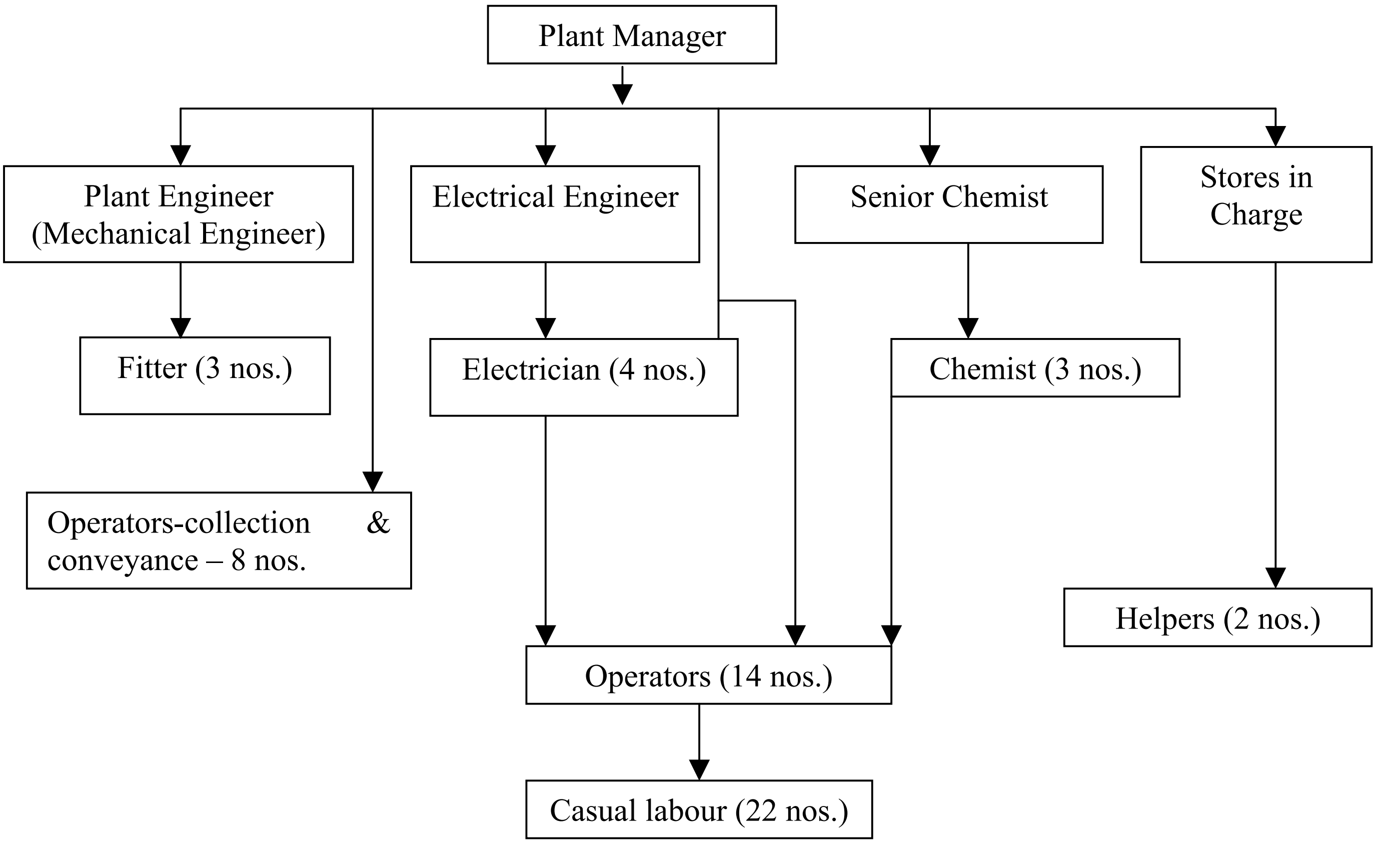
The total investment in the CETP, as of date, is INR 75 million including the various up gradations carried out in the CETP, of which INR 16.5 million was received as subsidies from Government and INR 26 million contributed as equity by the tanners and the balance as soft loan from a bank.

[3]Contribution by *Mr. K.V. Emmanuel*, UNIDO expert.

CETP-Ranitec received assistance from UNIDO in the form of selected equipment like mechanical screen, decanter centrifuge, floating aerators for degassifier etc., valued at INR 5 million (not included in the figure of INR 75 million) besides continued technical assistance from national and international experts.

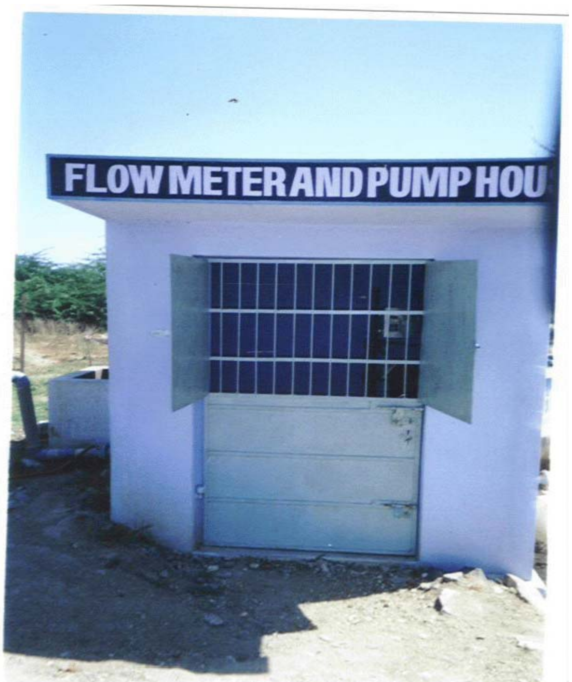
Implementation
The company formed by the tanneries jointly with TAMIL NADU LEATHER CORPORATION LTD. (TALCO) by name TALCO RANIPET ENVIRO CONTROL SYSTEMS LTD. (Ranitec) implemented the project. ENKEM ENGINEERS, Chennai undertook the construction of the CETP on turnkey basis.

Management
The overall management of the CETP is carried out by the BoD and the day-to-day administration by a Plant Manager, who is a qualified environmental engineer. The organigram of the CETP as at present is as follows:



The current Plant Manager, *Mr. Sajid Hussain*, is a qualified environmental engineer with considerable practical experience. He has been at the helm of affairs since 1998.

Recovery of operational cost
The cost of operation and maintenance of the plant, repayment of loan with interest and other expenditures relating to the plant are covered by monthly contributions made by the tanner members according to their respective effluent quantities. The effluent quantities are measured using electro-magnetic flow meters installed in the modified pre-treatment units.



Picture 1 – New flow meter pump house

Picture 2 – Flow meter installation

Upgradation of the CETP

Over the last 9 years, the CETP has undergone many up-gradation processes. The notable among them were the UNIDO assisted up-gradation in the year 1997-1998 and the up-gradation with Government of India's ASIDE assistance in the year 2004-2005. Other than these, modifications were carried out by the CETP on their own and the most important of these was the replacement of metallic structures in the CETP (mainly clarifier walkways) with concrete structures, which reduced the corrosion potential in the plant substantially.

UNIDO assistance

Besides giving technical assistance during the design, implementation and ongoing operation and maintenance, UNIDO at the request of the plant management conducted a detailed assessment of the CETP and identified specific measures for upgrading this as a model CETP in 1997. As a follow up of this report

- UNIDO supplied the following equipment to the CETP.
- Improved maintenance of collection and conveyance system.
- Providing two submersible mixers in the receiving sump.
- Installation of two pre-settlers to reduce solids load in subsequent treatment units.
- Repair of sludge centrifuge.
- Obtaining additional laboratory instruments such as a portable DO meter, flame photometer, online DO meter and online pH meter.
- Spare floating aerator for degasification tank.
- Improved operation & maintenance.
- OSH improvement measures including PPE.

The total cost of the UNIDO inputs works out to US$ 160,000, including the software component of technical assistance.

A three-week in house training programme for the operating staff of the CETP was organised by UNIDO during October-November 1998. Besides this, a number of training workshops were

organised by UNIDO and participated by key staff of the CETP. This also included training in occupational safety and health.
UNIDO has initiated some pilot and demonstration projects at this CETP, such as safe landfill for disposal of sludge from the CETP, experimental reed bed etc.

ASIDE sponsored up-gradation
The CETP was up-graded with partial assistance from Government of Tamil Nadu under the *Assistance to States in Infrastructure Development for Exports (ASIDE)* scheme at a cost of US$ 380,000.
Under this scheme, following modifications were carried out in the CETP:

- Providing an additional mechanical bar screen.
- Replacement of floating aerator in the equalization tank with less power consuming submersible mixers.
- Conversion of the fixed aerators in the aeration tank to a diffused aeration system.
- Providing an additional secondary clarifier.
- Effluent polishing treatment system with pressure sand filters and activated carbon filters.
- Certain plant automation works such as DO based operation of blowers.
- Anaerobic lagoon and Degassifier tank were removed from the process scheme.

Many of these measures were earlier recommended by the UNIDO experts.

Picture 3 – New mechanical bar screen

Picture 4 – Equalisation tax with new mixers

Picture 5 – Modified primary clarifier

Picture 6 – Rotary screen & pre-settlers

The Treatment Process

Pre-treatment in Individual tanneries
The pre-treatment in individual tanneries comprises of segregation of saline and chrome liquor and separate processing of the same as well as removing coarse solids and grit from the remaining combined effluents.

Chrome segregation.
Five tanneries are utilising a common chrome recovery unit of capacity 9 m^3/d and three tanneries have their own chrome recovery units. Other tanneries are mostly vegetable tanning units. When occasional chrome tanning is done in any unit without an operational chrome recovery units, these units segregate the chrome liquor, collect it in a tank and precipitate the chrome by adding magnesium oxide solution. A private company, Chemways, Vellore, takes the precipitated chrome sludge. This company regenerates chrome by adding sulphuric acid and sells the recovered chromium, after mixing the fresh basic chromium sulphate with it as required, to the small tanners in Ranipet on a commercial basis.

Pre-treatment of effluent other than chrome liquor
The pre-treatment system provided in individual tanneries connected to CETP-Ranitec comprises the following:

- Segregation of saline effluent streams i.e. soak and pickle liquor and evaporation in solar evaporation pans within the premises of each tannery. The solar pans have been designed on the basis of average rate of evaporation of 4.5 mm per day.
- Screening and pre-settling of other combined effluent in a pre-treatment unit and removal & disposal of screenings and grit.

The area specified for the solar evaporation pans as well as the size of pre-treatment units depend on the production capacity of the tannery. Typical design of a pre-treatment system is given in ***Annex 3***. Norms for pre-treatment units prescribed according to the production capacity of the tanneries are given in the sheet attached to ***Annex 3***.

Picture 7 – Three views of modified pre-treatment systems

Collection and conveyance system

The CETP has two collection wells the effluent from which finally joins a gravity line. Effluent from some tanneries reaches the CETP through a gravity line. Effluent from 22 tanneries mostly located on both sides of Amoor road after pre-treatment is discharged into manholes in the collection and conveyance network which is collected in one of the pumping stations (PS-1) and then pumped to the second pumping station (PS-2). Effluent from 38 tanneries, mostly located on the north of national highway, NH 4, after pre-treatment is discharged into manholes leading to a pumping station. Effluent from all these units is pumped from PS-2 to a catch pit from where it flows to the CETP through a gravity line. Effluent from 16 tanneries located in the south of national highway NH 4 is discharged into manholes in the gravity collection and conveyance line which is directly connected to the gravity line leading to the CETP receiving sump. The layout of collection and conveyance system is given in ***Appendix 2.2***, *Figure 3*.

Treatment process in CETP

The effluent is admitted in the receiving sump through a mechanically cleaned bar screen. The sump is provided with an ejector aerator to prevent settling of solids in the sump. Thereafter the effluent is pumped to a pre-settler for setting of coarse solids in the effluent. The pre-settlers have been found to remove approximately 40% of the suspended solids in raw effluent and the sludge removed from the pre-settlers has been found to dry faster compared to the sludge from the primary clarifier.

The overflow of the pre-settlers passes through a rotary type mechanically cleaned screen (model Konica, ITALPROGETTI make). The mechanical screen removes particles up to 3 mm size present in the raw effluent.

The effluent from the mechanical screen flows into an equalisation tank provided with 6 submersible mixers for homogenisation of effluent. The equalised effluent is then pumped to the flash mixer where alum, lime and polyelectrolyte slurry are added.

The effluent enters a primary clarifier via a baffle channel. The chemical sludge settles in the bottom of the primary clarifier. The physico-chemical treatment removes approximately 30-40% of BOD, 35-45% of COD and almost all chromium.

The overflow of the clarifier is admitted into an aeration tank with 1.2 days retention time, operating on Extended Aeration Activated sludge process, with diffused aeration system. Three blowers of 2000 m^3/h capacity each have been installed to maintain a DO of 1.5 mg/l. The outflow from the clarifiers have a BOD of around 30 mg/l. To further improve the effluent characteristics and colour, the effluent is passed through Pressure Sand Filters and Activated Carbon Filters after the addition of Alum and polyelectrolyte in the flash mixer and flocculation in the flocculator.

The treated effluent meets the discharge standards of TNPCB for which plant has been designed. The sludge settled during the physico-chemical treatment in the primary clarifier is taken to sludge well and then pumped to a sludge thickener. The thickened sludge is dewatered either in a centrifuge or in sludge drying beds. The dewatered sludge is disposed of in the sludge dumping site. The back washing effluent from sand filters and activated carbon filters is discharged back to the Receiving Sump.

The system has been regularly operating for the past over 9 years.

CETP Components and their Specifications

No	Unit	Sizes	Design details based on design flow
1.	Design flow	4000 m^3/day	Minimum inflow: 1,000 m^3/d Maximum inflow: 4,000 m^3/d Average inflow: 2,311 m^3/d
2.	Pump Station-1	8.5 m dia x 6.39 T.D, 2.1M SWD	16.75 kW each, 160 m^3/h, inflow: 1,185 m^3/d
3.	Pump Station-2	8.5 m dia x 6.32 T.D, 1.8 m SWD	22 kW each, 400 m^3/h, inflow: 3069
4.	Stand by bar screen chamber I (for gravity line)	3.7 m x 1.9 m x 4.0 m TD Screen bar: 10 mm x 50 mm Spacing: 12 mm	Inflow: 100 m^3/h Velocity though screen: 0.8 m/s Invert level: 3.0 m from below ground Bar spacing: 12 mm

No	Unit	Sizes	Design details based on design flow
5.	Stand by bar screen chamber II (For pressure line)	2.47 m x 1.7 m x 2.67 m TD. Screen bar: 10 mm x 25 mm Spacing: 10 mm	Inflow 400 m^3/h Velocity though screen: 0.8 m/s Invert level: 2.17 m from below ground. Bar spacing: 10 mm
6.	Mechanized Rake bar screen Chamber	4.0 m x 1.0 m x 4.6 m TD	Inflow 500 m^3/h Velocity though screen: 0.8 m/s Invert level: below 3.6 m from ground Bar spacing: 5mm 0.75 kW, RAKE type screen
7.	Receiving sump	Dia: 9.0 m Swd: 2.25 m TD: 7.15 m	22 kW each, Inflow: 500 m3/h HRT: 20 min. 2.5 kW FLYGT make submersible ejector, 1 No.
8.	Pre-settler	5.0 m dia x 5.0m TD (3.0 m hopper bottom depth & 2.0 m vertical depth) – 2 Nos.	HRT: 20 min.
9.	Rotary Fine Screen	Rotary Drum Spacing: 3.0 mm, Capacity 200 m^3/h.	3.7 kW ITALPROGETTI rotary fine Screen with 3 mm opening, with auto back wash for cleaning the screen.
10.	Equalization basin	42 m x 20 m Total depth: 3.375 m FB: 0.5 m	11 kW pump each, HRT: 15.12 h 6 No.; 2.5 kW FLYGT make submersible mixer
11.	Flash mixer-I	2.5 m x 2.5 m x 2m SWD	HRT: 4.5 min 96 RPM, 3.7 kW
12.	Baffle channel No of baffles Size Spacing	11.2 m x 1.2 m x 1.0 m 18 0.75 x 1.20m 0.45 m	DP: 4.83 min
13.	Primary clarifier	Dia: 15 m SWD: 3.0 m FB: 0.5 m	2.2 kW, 3 RPH, DP: 3.2 h SOR: 22.63 $m^3/m.d$ WLR: 84.9 $m^3/m.d$
14.	Primary Sludge Pump House	Size: 3.05 m x 3.05 m x 3.05 m	2 Nos. x 7.5 kW each Sludge pumps, 160 m^3/h
15.	Aeration tank I & II	30 m x 28 x 3 m SWD FB: 0.5 m each	F/M: 0.15/day MLSS: 4,000 mg/l MLVSS:3,200 mg/l DP: 30.24 h Recycle: 66 to 150% 37 kW, 3 blowers of 2,000 m^3/h capacity each, 300 mm Dia, 750 Nos. disc diffusers
16.	Secondary clarifier - I	Dia: 15 m SWD: 2.5m FB: 0.5 m	1.5 kW each, 3 RPH, SOR: 11.3 $m^3/m^2.d$ WLR: 42.5 $m^3/m.d$ SLR: 45.25 $kg/m^2.d$

No	Unit	Sizes	Design details based on design flow
17.	Secondary clarifier - II	Dia: 15 m SWD: 2.5 m FB: 0.5 m	1.5 kW each, 3 RPH, SOR: 11.3 m^3/m^2.d
18.	Secondary Sludge Pump House	Size: 4.05 m x 3.05 m x 3.05 m H	2 Nos. x 5.5 kW each Sludge pumps, 60 m^3/h 1 No. x 11 kW Sludge pump, 200 m^3/h
19.	Flash mixer-II	2.5 x 2.5m Depth: 2.1m	2.2 kW, 93 RPM, DP: 4.73 min
20.	Flocculator	6.0 m x 6.0 m Depth: 2.5 m	2.2 kW, 10 RPM, DP: 32.4 min
21.	Filter Feed Pump House	Size: 6.5 m x 3.50 m x 3.05 m H	2 Nos. x 15 kW Filter feed pump
22.	Filter Backwash Tank	6.0 m x 6.0 m Depth: 1.5 m	
23.	Pressure Sand filters-2 Nos. and activated carbon filters-2 Nos.	PSF - Dia: 3 m Height: 1.8 m ACF-Dia: 3.5 m Height: 2 m	Inflow 90 m^3/h (each filter) Filtration Capacity: PSF: 12 m^3/m^2/h ACF: 10 m^3/m^2/h
24.	Sludge drying beds	15 m x 8 m x 1 m Nos.45	Drying period: 10 days Application Depth 40 cm Primary sludge: 360 m^3/d at 2% conc. Secondary sludge: 143 m^3/d at 1.5% conc. Sludge application rate: 240 m^3/d

Operational Features

Operational parameters

Operational parameter	Factors maintained at present
Chemical dosage prior to primary clarifier	300-400 ppm of alum and 200 ppm of lime, anionic polyelectrolytes at the rate of 1 ppm
Nutrients	No nutrient is added at present
Dissolved oxygen	DO level in aeration tank is 2.5 mg/1
Sludge recirculation	Around 35%
MLSS concentration	Degassifier tank: 200 mg/1 & aeration tank 2200 mg/1
Sludge wasting	Approximately 10% of the aerobic bio sludge
Screenings removal and sludge withdrawal timing	The screenings from screens are removed once a shift. Sludge from primary clarifier is withdrawn once every 2-3 hours

Maintenance
- Oiling & greasing cycle: 15 & 20 days respectively
- Frequency of painting Once in six months

Power consumption
- Total connected load: 373 kW
- Operating load: 312kW
- Capacity of diesel generating set: 380KVA

Laboratory
The laboratory is accommodated in two small rooms in the first floor of the chemical house, with sizes: 10 ft x 12 ft and 8 ft. x 10 ft respectively.
Room No. 1 is generally used for the main analysis. The equipment available in this room is:

No.	Instrument/equipment	Number of units
1.	Flocculator apparatus	1
2.	Hot air oven	1
3.	Fume cupboard	1
4.	COD apparatus	1
5.	Distilled water still	1
6.	Electric Bunsen	2
7.	Heating mantle – 3 Nos.	2
8.	Vacuum pump	1

Room No. 2 is used as the instrumentation room. The instruments in this room are:

No.	Instrument/equipment	Number of units
1.	BOD incubator	1
2.	Spectrophotometer	1
3.	pH meter	1
4.	DO meter	1
5.	Electronic balance	1
6.	Dhona monopan balance	1
7.	Refrigerator	1
8.	Flame photometer	1
9.	Microscope	1

Analysis done in the laboratory
Various analyses done in the laboratory are as follows:

Parameter	Raw effluent	Pre-settler outlet	Equali-sed raw effluent	Clari-flocculator outlet	Anaero-bic lagoon outlet	Degassi-fier outlet	Clarifier outlet	Final treated effluent
pH	daily	daily	daily	daily	daily	daily	daily	daily
Suspended solids	daily	daily	daily	daily	daily	daily	daily	daily
Total dissolved solids			daily	daily	daily		daily	daily
Chlorides			weekly					weekly
Sulphides	daily		daily					
Sulphates			weekly		monthly			monthly
BOD_5	daily		daily	daily	daily	weekly	daily	daily

Parameter	Raw effluent	Pre-settler outlet	Equali-sed raw effluent	Clari-flocculator outlet	Anaero-bic lagoon outlet	Degassi-fier outlet	Clarifier outlet	Final treated effluent
COD	daily		daily	daily	daily	daily	daily	daily
Total chromium	daily		daily	daily				daily
Phosphates			weekly					weekly
Ammonia nitrogen			weekly	weekly				weekly
Nitrates			weekly					weekly
Total Kjeldahl Nitrogen			weekly	weekly				weekly
Total nitrogen								weekly
DO					daily*	daily		daily
MLSS					daily*			
MLVSS					daily*			
Acidity					daily			
Volatile acids					daily			
Alkalinity					daily			

*Aeration

Note: All values except pH are reported in mg/1.

Testing of samples from other points such as outlet of receiving sump, anaerobic lagoon, primary and secondary sludge samples etc. is done occasionally and when required.

Manpower

Personnel	Qualification and experience
Plant manager	M.Tech. (Env. Eng.) with 9 years experience in ETP management
Plant Engineer	Graduate in mechanical engineering with 10 years experience in the Ranipet CETP project
Sr. Chemist	B.Sc. Chemistry with 9 years experience in effluent testing
Lab Chemist	(female) B.Sc. Chemistry with 2 year experience in effluent testing
Chemist	Post Graduate in Chemistry, 2 year experience in effluent testing.
Electrical Engineer	Diploma in electrical engineering with 10 years experience in electrical maintenance
Civil Engineer	Diploma in civil engineering with 5 years project experience
Stores in charge	Graduate with 6 years experience in material management

Monitoring

Following is the list of log sheets presently maintained in the CETP:

- Pumping details
- Chemical dosages and stock
- Aeration details
- Operation details of other equipment
- Sludge details
- Complaints register
- Stores and spare parts register
- Maintenance schedule

The log sheets are reviewed on a daily basis by the Plant Manager and necessary instructions for modification in operation and maintenance are given in consultation with the chemist and other engineers.

Effluent Characteristics Before and After Treatment

(Average for the period from 1 January 2004 to 30 June 2005)

No.	Parameter	Unit	Raw effluent	After chemical treatment	After biological treatment*	After polishing	TNPCB norms**
1.	pH		7.3	7.9	7.3	7.3	5.5 - 9.0
2.	Suspended solids	mg/1	3,855	142	78	18	100
3.	BOD	mg/1	1,525	944	27	16	30
4.	COD	mg/1	5,420	225	234	178	250
5.	Chromium	mg/1	31	0.8	0.3	0.1	2
6.	Sulphides	mg/1	79	22	1.9	1.8	2
7.	TDS	mg/1	9,865	9,988	9,945	10,030	2,100

*Considered as the treated effluent in most cases
**For discharge to inland surface waters

Cost of Treatment

(Average monthly cost from 1 January 2004 to 31 Dec 2004)

No.	Cost component	Cost in INR	Cost in US$
1.	Power	595,919	13,544
2.	Chemicals	324,087	7,366
3.	Salary & labour	221,805	5,041
4.	Repair and maintenance	107,641	2,446
5.	Laboratory analysis	6,307	143
6.	Sludge dewatering	60,095	1,366
7.	Miscellaneous	269,308	6,121
8.	Consents & license	4,524	103
9.	Loan repayment	702,947	15,976
10.	Other costs (R&D etc.) lump sum	0	0
11.	Depreciation on investment	265,551	6,035
	Total	**2,558,185**	**58,141**

Treatment cost per cubic meter of effluent: INR 36.89/m^3 (US$ 0.84/m^3)
Cost per kg of BOD removed: INR 24.63/kgBOD (US$ 0.56/kgBOD)
Cost per kg of COD removed: INR 7.12/kgBOD (US$ 0.16/kgBOD)

ISO Certification for the CETP

In the year 2000, the CETP has achieved a unique distinction among all the CETPs in the region, when it became the first CETP to secure ISO 9001 certification. The certification and the consequent data maintenance, particularly in terms of preventive maintenance and monitoring has helped the CETP very much in maintaining good performance and near zero break down in the CETP. The ISO training team has selected some of the CETP staff among their own inspection.

DNV

DET NORSKE VERITAS

QUALITY SYSTEM CERTIFICATE

Certificate No. QSC – 3137

This is to certify that the Quality System of

TALCO RANIPET TANNERY EFFLUENT TREATMENT CO. LTD.

at

Walajapet, Vellore District, India

has been found to conform to the Quality System Standard:

ISO 9002:1994

This Certificate is valid for the following product or service ranges:

OPERATION AND MAINTENANCE OF COMMON EFFLUENT TREATMENT PLANT

Place and date:
Rotterdam, November 15th, 1999

This Certificate is valid until:
November 15th, 2002

for the Accredited Unit:
DNV CERTIFICATION B.V.,
THE NETHERLANDS

Accredited by the RvA

Original Certification date:
November 15th, 1999

Paal Johansen
Management Representative

N. Venkateswaran
Lead Auditor

Lack of fulfilment of conditions as set out in the Appendix may render this Certificate invalid.

DOCNO. CERTUS_9718

DNV CERTIFICATION B.V. Haastrechtstraat 7, 3079 DC Rotterdam, The Netherlands, TEL.INT.:+31 10 2922 688, FAX:+31 10 4796 788

Worker's Safety

The CETP has come up with an impressive record on worker's safety. The workers engaged in manhole cleaning has been provided with air supply units and personal protective measures have been made compulsory to all the workers inside the plant.

Picture 9 – Personal protective wear for workers

Picture 10 – Mobile air supply unit

CETP as a Training Ground

It was a dream comes true for the CETP management when it started using the facilities as a training ground for training professionals in the pollution control field, not only from India, but also from neighboring countries. To augment the facilities for training, the CETP has recently constructed a fully air-conditioned conference hall with audio-visual facilities needed for organizing international seminars.

Picture 11 – Distribution of training kit to trainee

Picture 12 – Trainees from Pakistan

Conclusions

The Ranitec CETP was one the earliest attempt to demonstrate sustainable and economically viable regional model incorporating anaerobic treatment technologies believed to be beneficial in cost factors. Though this notion could not be proved in the CETP, the successive up-gradations, also abandoning the anaerobic step and adopting more conventional biological treatment systems, did help the CETP to carve a niche as a model for the region.

A decade later its commissioning, the performance of the CETP is quite satisfactory in all counts, more due to a pro-active CETP management and the technical support it received.

Appendix 2.1

List and address of suppliers of equipment

Item	Supplier	Local service / person / agent
CETP turnkey contractor/supplier of all drives	ENKEM ENGINEERS PRIVATE LTD Poonamalle High Road (Near KMC), Chennai-600010 Ph. 044-6411362 Fax: 044-6411788	ENKEM ENGINEERS PRIVATE LTD Poonamalle High Road (Near KMC), Chennai-600010 Ph. 044-6411362 Fax: 044-6411788
Decanter centrifuge	HUMBOLDT WEDAG INDIA LTD. 12A, Camac Street Kolkata-700017 Phone: 2242-7366 Fax: 24278068	HUMBOLDT WEDAG INDIA LTD. 12A, Camac Street Kolkata-700017 Phone: 2242-7366 Fax: 24278068
Rotary type mechanical screen	ITALPROGETTI ENGINEERING Via Lungarno, Pacinotti, 59A-56020, San Romano, Pisa, Italy. Ph: 0039-571-450477 Fax: 0039-571-450301	TANMAC INDIA 25, Jawaharlal Nehru St., 3rd Floor, Pondicherry. 605 001 Ph: 0413-39429
Submersible pumps	KISHOR PUMPS P. LTD., A-13/H,MIDC, Pimpri, Pune. 411 018, India Ph: 91-20-27472616 Fax: 91-20-27472617	BEAM ENGINEERS, 102, Mogappair, Madras-50 Ph: 6266465/6257915
Centrifugal pumps	FABRIKEN AGENCIES (P) LTD No.11 7th Cross St. Shastri Nagar, Adyar, Chennai-600087 Ph: 91-44-24983944/5265615 Fax: 91-44-4670687	FABRIKEN AGENCIES (P) LTD. No.11 7th Cross St. Shastri Nagar, Adyar, Chennai-600087 Ph: 91-44-24983944/5265615 Fax: 91-44-4670687
Screw pumps	ALPHA HELICAL PUMPS 2/131-A, Venkitapuram Road, Venkitapuram Post, Coimbatore. 641 014 Ph: 91-422-2627329 Fax: 91-422-2627298	ALPHA HELICAL PUMPS 2/131-A, Venkitapuram Road, Venkitapuram Post, Coimbatore. 641 014 Ph: 91-422-2627329 Fax: 91-422-2627298
Mechanical bar screen, and diffused aeration	POLUTECH LTD. Parry House, 43, Moore Street, Chennai-600001. Phone:+91-44-25358308 Fax: +91-44-25358302	POLUTECH LTD. Parry House, 43, Moore Street, Chennai-600001. Phone:+91-44-25358308 Fax: +91-44-25358302
Ejector and submersible mixer	ITT FLYGT AB Gesällvägen 33, 174 87 Sundbyberg, Sweden Ph: +46 8 - 475 60 00 Fax: +468 - 475 69 00	ITT FLYGT AB Gesällvägen 33, 174 87 Sundbyberg, Sweden Ph: +46 8 - 475 60 00 Fax: +468 - 475 69 00

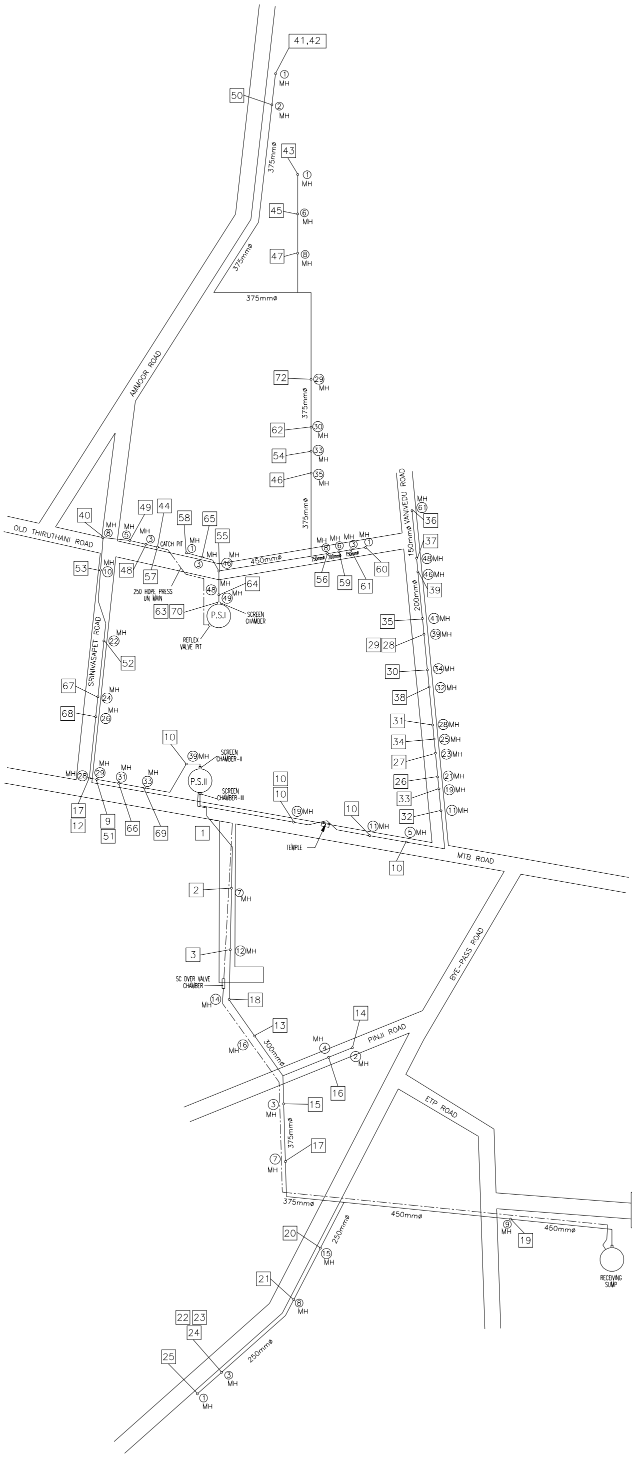
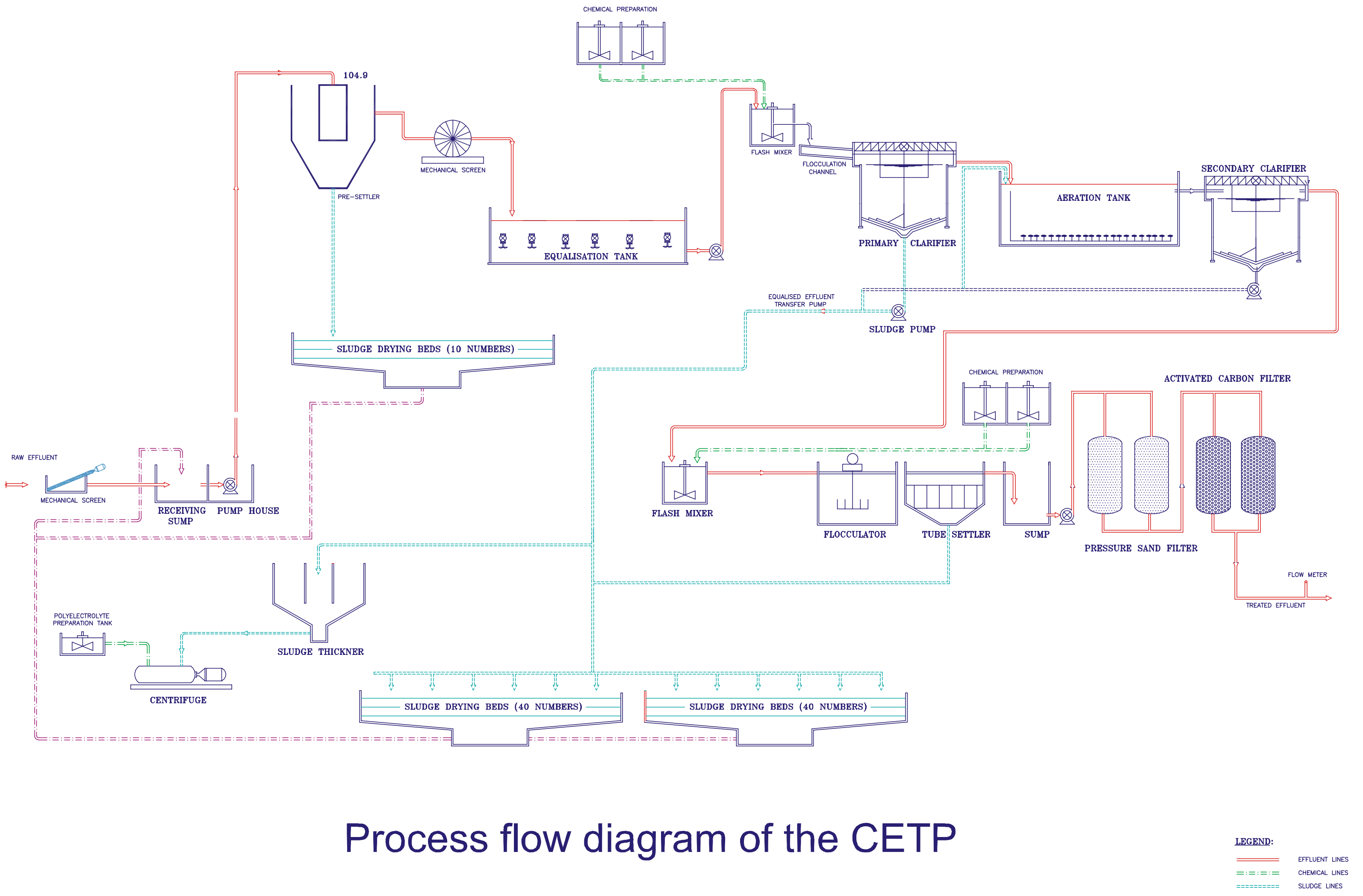


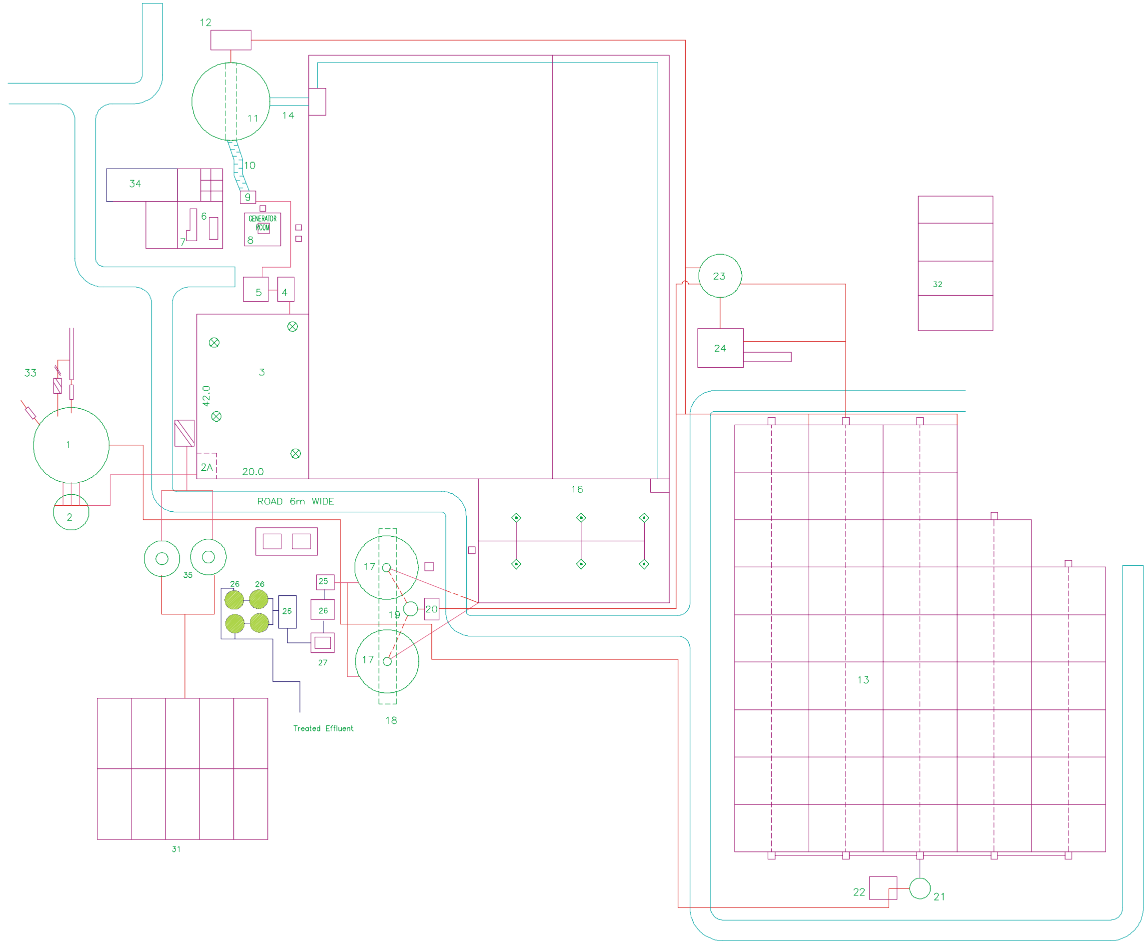
FIG 2 CONVEYANCE SYSTEM FOR CETP RANIPET

Appendix 2.2



Process flow diagram of the CETP

Appendix 2.3



LAYOUT PLAN OF THE CETP

S.No.	UNIT
1	RECEIVING SUMP
2	RECEIVING SUMP PUMP HOUSE
2A	SCREEN CHAMBER
3	EQUALISATION TANK
4	FEED PUMP HOUSE
5	FEED PUMP HOUSE
5A	AERATORS
6	DAP TANK (2 Nos)
6A	ALUM TANK (2 Nos)
7	LIME TANK 2 Nos
8	CHEMICAL HOUSE
9	FLASH MIXER
10	BAFFLED CHANNEL
11	PRIMARY CLARIFIER
12	PRIMARY SLUDGE PUMP HOUSE
13	PRIMARY SLUDGE DRYING BEDS 40 Nos
14	OVERFLOW CHANNEL
15A	ANAERABIC LAGOON
15B	DEGASSIFYING TANK
16	AERATION TANK
17	SECONDARY CLARIFIER
18	TREATED EFFLUENT CHANNEL
19	SECONDARY SLUDGE SUMP
20	SECONDARY SLUDGE PUMP HOUSE
21	FILTERATE SUMP
22	FILTERATE PUMP HOUSE
23	SLUDGE THICKENER
24	CENTRIFUGE HOUSE
25	TERTIARY FLASH MIXER
26	FLOCCULATOR
27	TUBE SETTLER
28	MULTIGRADE FILTERS (2 noS.)
29	ACTIVATED CARBON FILTERS (2 Nos.)
30	FILTER PUMP HOUSE
31	SLUDGE DRYING BEDS FOR PRE–SETTLER
32	SLUDGE LANDFILL
33	MECHANICAL SCREEN
34	NEW CONFERENCE HALL

Annex 3

MAIN FEATURES OF WASTE TREATMENT IN THE LEATHER DISTRICT OF S. CROCE SULL'ARNO, ITALY[4]

Historical overview

Investments

Millions of EUR

	Plant/Intervention	Total investment
COMMON EFFLUENT TREATMENT PLANTS		
AQUARNO	CETP	60.82
CUOIODEPUR (I)	CETP	36.46
CUOIODEPUR (II)	Sludge drying unit	7.24
PONTE A CAPPIANO (FUCECCHIO)	CETP	16.96
CASTELFRANCO DI SOTTO	CETP	5.63
CONSORZIO RECUPERO CROMO	Joint Cr recovery	5.85
CONSORZIO S.G.S.	Treatment of fleshings	9.20
ECOESPANSO	Thermal sludge treatment	44.90
Sub-total 1		**187.06**
INTERVENTIONS AT THE TANNERY SITES		
Tanneries in the municipalities of S. Croce, Castelfranco and Fucecchio	Pre-treatments (screens, settling tanks, etc.)	14.05
Tanneries in the municipalities Ponte a Egola and S. Miniato	Pre-treatments (screens, settling tanks, etc.)	3.62
Municipalities of S. Croce, Castelfranco and Fucecchio	Installation of flow-meter and sampling devices	11.79
Municipalities Ponte a Egola and S. Miniato	Installation of flow-meter and sampling devices	4.01
Municipalities of S. Croce, Castelfranco and Fucecchio	Interventions for tacking air pollution	16.98
Municipalities Ponte a Egola and S. Miniato	Interventions for tackling air pollution	5.50
The entire district	Intervention for limiting noise pollution	2.36
Sub-total 2		**58.31**
GRAND TOTAL		**245.37**

*Total until 2003, no significant changes in 2004.

[4] Contribution by Giuseppe Clonfero, UNIDO consultant.
Source: ASSOCIAZIONE CONCIATORI DI SANTA CROCE (Tanners Association of Santa Croce).

Annual operation cost
(*Including costs of financing & depreciation*)

Millions of EUR

Year	Tannery sub-district							
	Santa Croce sull'Arno (AQUARNO)		Ponte a Cappiano (Fucecchio)		Castelfranco di Sotto		Ponte a Egola (CUOIODEPUR)	
	Effluent	*Sludge*	*Effluent*	*Sludge*	*Effluent*	*Sludge*	*Effluent*	*Sludge*
1993	9.79	5.82	2.69	1.14	0.86	0.25	4.09	3.36
1994	11.95	7.25	3.10	1.24	0.79	0.25	4.03	3.10
1995	11.27	9.95	3.10	1.29	0.83	0.36	5.62	4.63
1996	10.15	8.06	3.10	1.35	0.87	0.38	5.12	4.73
1997	10.65	11.02	3.10	1.43	0.55	0.54	5.26	6.49
1998	12.02	10.37	3.05	1.74	0.80	0.61	4.80	7.42
1999	10.92	9.13	3.20	1.58	1.19	0.56	5.76	4.50
2000	11.79	10.99	3.50	1.54	1.49	0.67	6.29	3.53
2001	11.14	12.22	3.77	1.76	1.46	0.66	6.40	3.49
2002	9.59	11.72	3.87	2.1	0.89	0.59	6.25	3.12
2003	9.30	8.72	3.63	2.45	0.84	0.56	5.58	2.84

Selected information about year 2004

Capacity

CETP	Capacity			
	P. E./day*		t COD/day	
	Design	Used in 2004 (average)	Design	Used in 2004 (average)
AQUARNO	1,800,000	1,200,000	234	156
CUOIODEPUR	830,000	700,000	107.9	91
PONTE A CAPPIANO (FUCECCHIO)	400,000	300,000	52	39
CASTELFRANCO DI SOTTO	250,000	**	32.5	**

**P.E. = population equivalent (130 g COD per day)*
***From year 2004 the effluents are directly piped to AQUARNO plant*

Volume of industrial effluents treated (approx. values)

CETP	Volume of industrial effluents treated *(million m^3)*
AQUARNO+ CASTELFRANCO	3.4
CUOIODEPUR	1.2
PONTE A CAPPIANO (FUCECCHIO)	0.7
Total	**5.3**

Total volume of municipal wastewater treated: about 4.25 million m^3

COD_f and SS treated

CETP	Total treatment cost	Total industrial effluent treated	Total COD_f	Total SS (tonnes)
	million EUR	*million m^3*	*t*	*t*
AQUARNO + Castelfranco + Ponte a Cappiano (Fucecchio)*	33.77	4.1	24,600	19,680
CUOIODEPUR	11.30	1.2	10,022	8,985
Total	**45.07**	**5.3**	**34,622**	**28,665**

**Including ECOESPANSO costs for sludge drying, thermal treatment and disposal.*
***Including sludge drying and disposal.*

Notes:

1. COD_f is the COD of the raw effluent after neutralization pH 7 and filtration or sedimentation (the raw COD is about twice the COD_f).
2. The treatment cost be shared 60% for COD removal and 40% for solid removal. This distribution is arbitrary but reflects the real situation encountered in several plants.

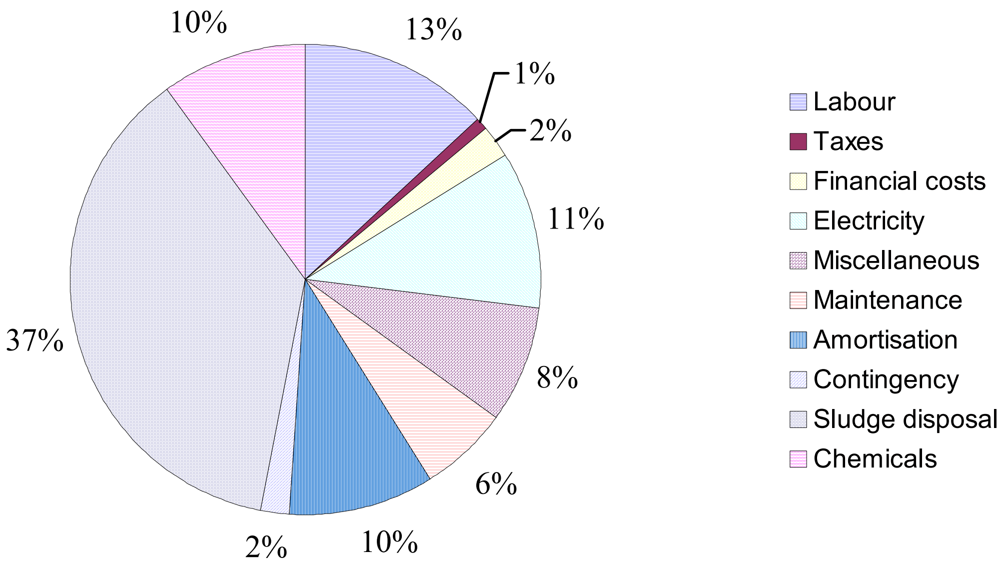
COD_f and SS treatment costs

CETP	Total cost of treating COD_f	Total cost of treating SS	Average cost	Average cost
	million EUR	*million EUR*	*€/kg COD_f*	*€/kg SS*
AQUARNO + Castelfranco + Fucecchio(*)	20.26	13.51	0.820	0.686
CUOIODEPUR	6.78	4.52	0.676	0.503

Average operational cost for the entire leather district, year 2004

Total operational costs: EUR 45.1 million
Average treatment cost: EUR 8.8/m^3 (**industrial effluents only)*

Cost structure



Cost of electricity:	EUR 0.08/kWh
Average cost of landfilling:	EUR 90/t of residue

Main parameters of the CETP CUOIODEPUR, year 2004

Total volume of treated industrial effluents:	1.16 million m^3
Total treatment cost:	EUR 11.3 million

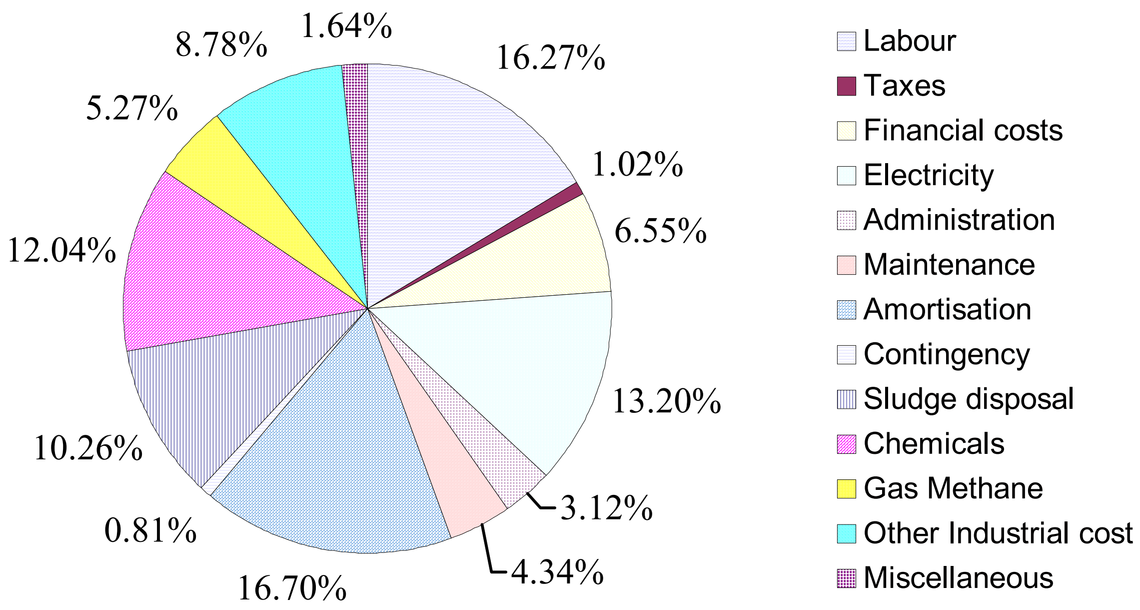
Characteristics of the raw industrial effluent(*)

Value	pH	SS	COD_{raw}	$COD_{filtered}$	$N\text{-}NH_4$	S^{2-}
Average	7.5	4,196	12,958	6,510	315	125
Minimum	6.7	3,984	11,121	5,630	209	41
Maximum	8.7	9,120	14,853	7,336	385	222

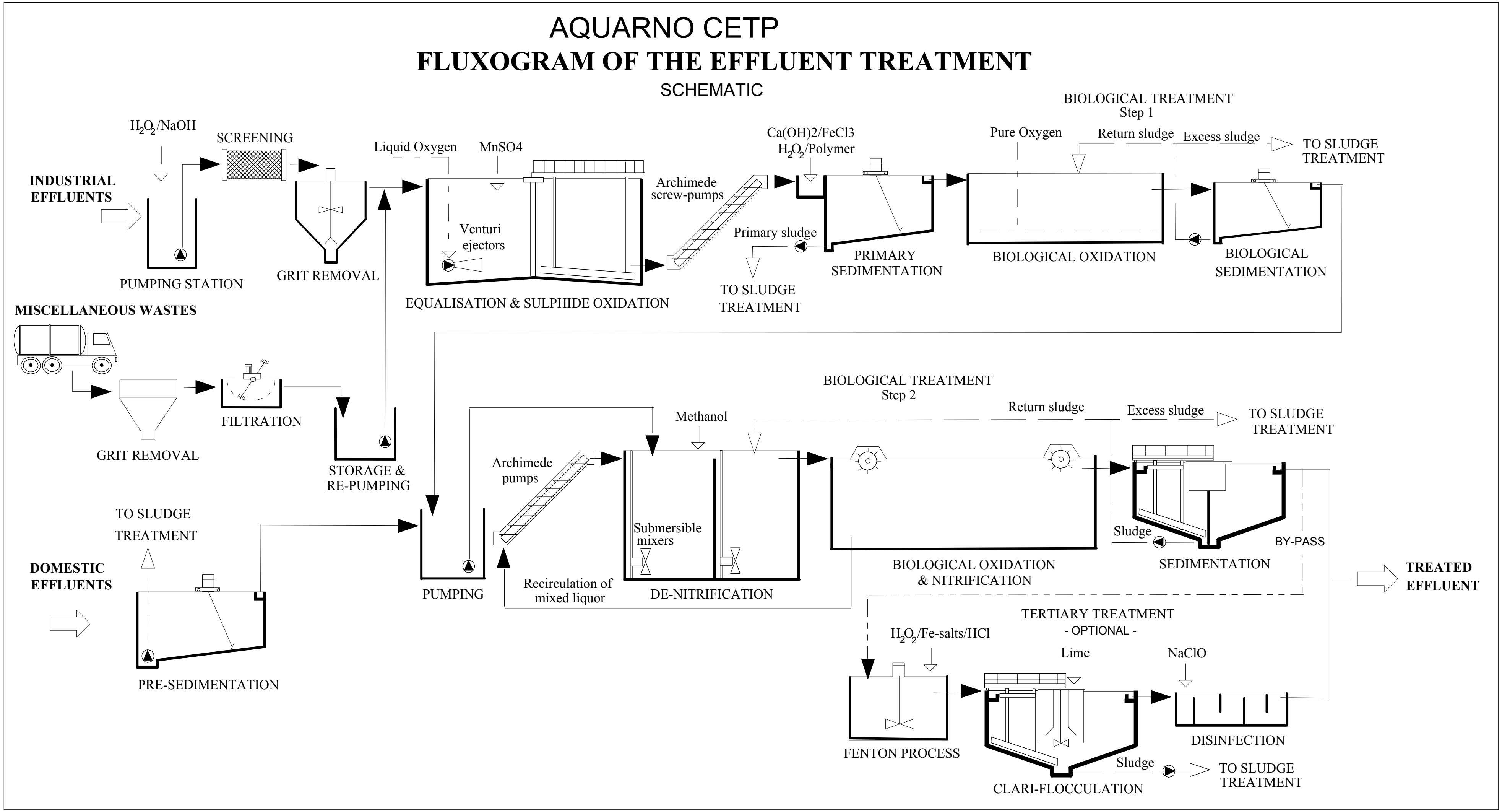
(*) calculated on the monthly base

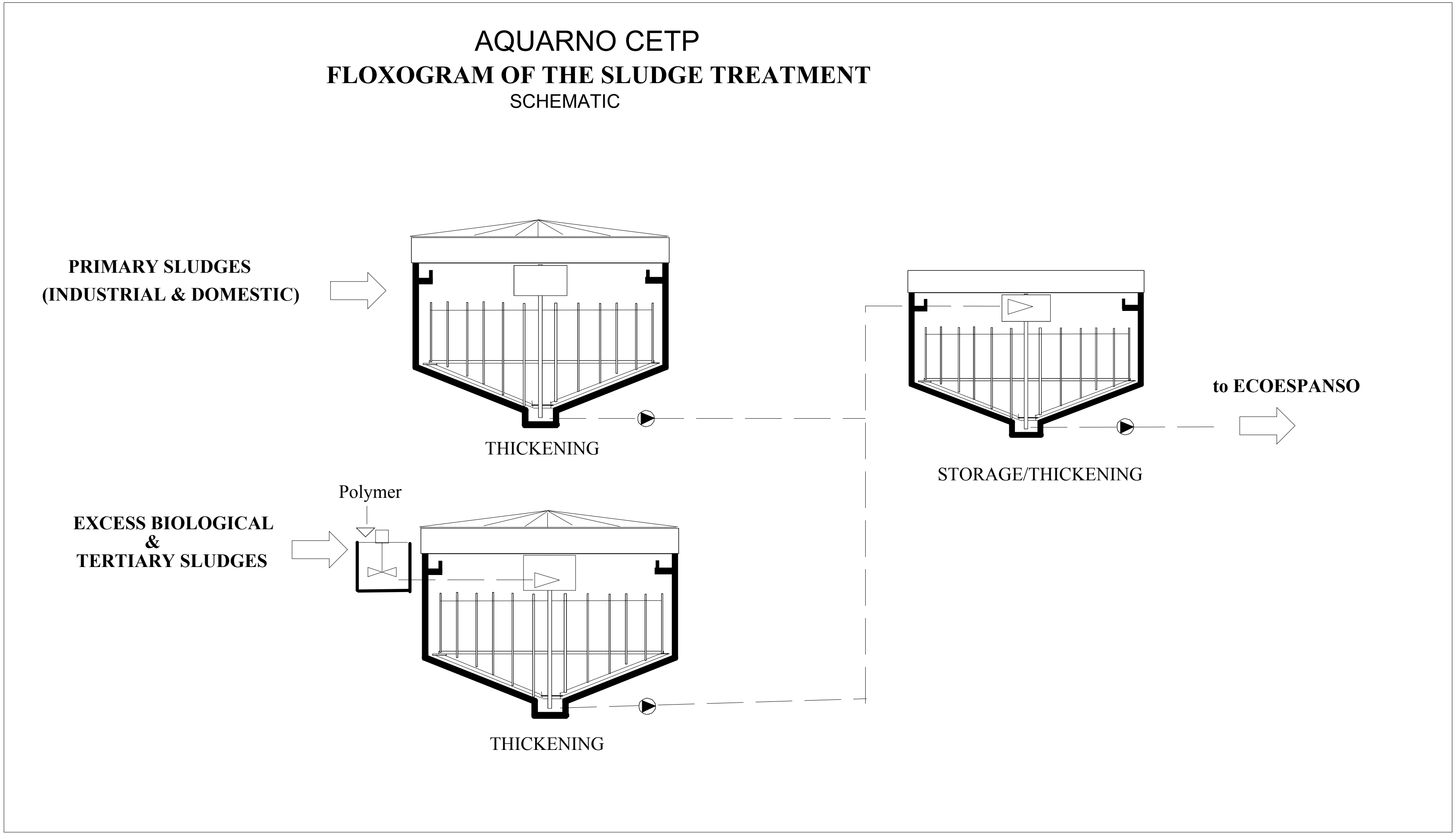
Total produced sludges:	16,500 tonnes as DS
Sludge production:	14.2 kg DS/m^3 of treated industrial effluent
Average $COD_{filtered}$ (inlet):	6,510 mg/l
Average SS (inlet):	4,196 mg/l
Average treatment cost:	EUR 9.73 /m^3
Specific treatment cost	
- per kg $COD_{filtered}$:	EUR 1.49
- per kg SS	EUR 2.32

Cost structure



Average cost of landfilling:	EUR 90/t of residue
Cost of methane:	EUR 25/t of dried sludge (80% DS)
Average cost for sludge (80% DS) taken by fertilizer producers:	EUR 40/t


AQUARNO CETP
FLUXOGRAM OF THE EFFLUENT TREATMENT
SCHEMATIC
INDUSTRIAL EFFLUENTS
H_2O_2/NaOH
SCREENING
PUMPING STATION
GRIT REMOVAL
Liquid Oxygen
MnSO4
Venturi ejectors
EQUALISATION & SULPHIDE OXIDATION
Archimede screw-pumps
Ca(OH)2/FeCl3
H_2O_2/Polymer
Primary sludge
TO SLUDGE TREATMENT
PRIMARY SEDIMENTATION
BIOLOGICAL TREATMENT Step 1
Pure Oxygen
Return sludge
Excess sludge
TO SLUDGE TREATMENT
BIOLOGICAL OXIDATION
BIOLOGICAL SEDIMENTATION
MISCELLANEOUS WASTES
GRIT REMOVAL
FILTRATION
STORAGE & RE-PUMPING
BIOLOGICAL TREATMENT Step 2
Return sludge
Excess sludge
TO SLUDGE TREATMENT
Methanol
Archimede pumps
Submersible mixers
Recirculation of mixed liquor
DE-NITRIFICATION
BIOLOGICAL OXIDATION & NITRIFICATION
Sludge
SEDIMENTATION
BY-PASS
TREATED EFFLUENT
TO SLUDGE TREATMENT
DOMESTIC EFFLUENTS
PRE-SEDIMENTATION
PUMPING
TERTIARY TREATMENT
- OPTIONAL -
H_2O_2/Fe-salts/HCl
Lime
NaClO
FENTON PROCESS
CLARI-FLOCCULATION
Sludge
TO SLUDGE TREATMENT
DISINFECTION


AQUARNO CETP
FLOXOGRAM OF THE SLUDGE TREATMENT
SCHEMATIC
PRIMARY SLUDGES
(INDUSTRIAL & DOMESTIC)
THICKENING
Polymer
EXCESS BIOLOGICAL
&
TERTIARY SLUDGES
THICKENING
STORAGE/THICKENING
to ECOESPANSO