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WASH Field Report No. 449

POLLUTION PREVENTION ASSESSMENT

SEVCO TANNERY
SEVLIEVO, BULGARIA

Prepared for the Bureau for Europe
and the Newly Independent States, Office of Environment,
U.S. Agency for International Development
under WASH Task No. 533

by

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WASH RELATED REPORTS

Wastewater Treatment Plant O&M Audit Training at Gabrovo and Veliko Tarnovo, Bulgaria. October 1994. Field Report No. 447. Prepared by Douglas Abbott, Michael Jamiolkowski III, and William Hogrewe.

Water Quality Pre-Investment Studies in the Yantra Basin in Bulgaria. August 1993. Field Report No. 408. Prepared by Max Clark, David Laredo, and William Hogrewe.

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ABOUT THE AUTHOR

Dr. Thomas Thorstensen is a chemist, chemical engineer, and professional engineer who has extensive experience in the leather industry. He has taught leather technology on the university level, and for the bulk of his professional life operated his own laboratory serving the leather industry in research, testing, and engineering. His skills include practical leather processing and tannery environmental problem solving. He has consulted for USAID, the United Nations, the World Bank, and the private sector worldwide. He is a past president of The American Leather Chemists Association and a former member of the board of the International Union of Leather Trades Chemists. In addition to numerous technical papers he has written two books, *Practical Leather Technology* and *Fundamentals of Pollution Control for the Leather Industry*.

He is currently consulting to the industry on a worldwide basis through TSG Inc., a private corporation.

EXECUTIVE SUMMARY

The Sevco Tannery in Sevlievo, Bulgaria, is the major industry in a town of about 20,000 people. The tannery presently has a nominal production of 11 to 12 tons of pigskins that are made into leather for garments and shoes. The quality of the leather is good, and the company is developing sales in international markets. Plans and construction are now underway to increase production to 35 tons a day of pigskins and cattle hide leather. This new production will require a new facility on site and a new wastewater treatment system.

The purpose of this study, funded through the WASH Project by USAID Europe Bureau's Environment Office, was to maximize pollution prevention at the plant and to suggest cost-effective methods of pollution control. The activity was carried out during two visits to Sevlievo in July and September 1994.

The production of leather is highly polluting, primarily from the waste materials from the hides and skins. Suspended solids and BOD_5 from the skins amount to 100 kg and 60 kg, respectively, per 1000 kg of skins; processing also contributes about 200 kg of soluble solids per 1000 kg of skins. The chemical wastes from the processing will include objectionable sulfides and trivalent chromium salts.

To conduct this study, the WASH consultant used 1988 data from the Ministry of the Environment, data from the U.S. Environmental Protection Agency on American tanneries, and observations of current practices in the Sevlievo tannery.

The recommended treatment system, based on this study, is separate treatment of the waste streams. The streams are to be divided into three flows. The early production steps of soaking, unhairing, liming, and deliming result in alkaline waste, which would be collected and treated. The chrome tanning wastes are to be recycled so the major source of chromium in the waste stream can be eliminated. The remaining wastes are slightly acidic and relatively low in suspended solids and BOD_5. These acid wastes are to be treated in a physical chemical coagulation and clarification in the present wastewater treatment plant.

The main sources of pollution are from the early stages of the leather production process. These wastes are to be collected and screened; then the sulfides in the system are destroyed by air oxidation using a catalyst. The sulfide-free wastes can then be neutralized to the isoelectric point of the proteins to precipitate the proteins. The sludge recovered can then be dried and sold either as fertilizer or as animal feed.

Tests run at the tannery indicate that this approach would be cost-effective in the removal of the pollutants and could be of positive economic value to the tannery. Recycling of the chromium will be of great importance as cattle hide processing is increased. Savings in chemicals should more than cover the costs of chromium recovery. The value and costs of protein recovery are yet to be determined.

The tannery is continuing work on optimization of the treatment of the three separated stream flows. Data obtained in these studies will then be used in the modification of designs for the new treatment plant.

The impact of the tannery treatment system on the proposed municipal system will greatly depend on the effectiveness of the treatment system at the tannery.

Chapter 1

INTRODUCTION

This study is a continuation of earlier work by the WASH Project in the Yantra basin. In the Sevlievo area, the projected influent loads from the Sevco Tannery are in excess of those projected for the municipality. Tanning is a highly polluting industry, generating more suspended solids and BOD_5 from each ton of skins tanned than would be generated by one thousand people of a municipality.

At present, both the municipal treatment system in Sevlievo and the tannery treatment system are in the planning stage. A treatment system for increased production of leather is needed urgently and, according to current plans, will be in operation before the municipal system. The purpose of this study is to determine the most cost-effective methods of waste minimization and treatment of the tannery wastewaters.

The company, Sevco Ltd., is presently tanning salted pigskins at the rate of 2,500 skins per day. This is 10,000 to 11,000 kg of skins. A limited number of cattle hides are also being tanned for upper leather for shoes. The company is planning to increase production to 35,000 kg of hides and skins per day.

At present, a new works building is under construction. This building is large enough to provide room for the new production. The expansion will also involve some changes in the present production facility. A new wastewater treatment plant is also being constructed, designed for the new expanded production and to supplement the present wastewater treatment plant.

Both the new tanning facility and the new wastewater treatment plant are to be built from available company funds from a profitable operation. Some government loan funds are available for the wastewater treatment facility, but there are no funds available for the municipal treatment facility. At present the bank interest rate is in excess of 60 percent. At this rate, it is not practical for the municipality to borrow from the banks. In contrast, the tannery has been following a fast turnover policy on accounts to avoid loan expenses. By this policy, the company has been able to maintain full production and full employment. Being a major employer, the tannery is very valuable to the community.

At present the tannery is treating its wastewater in an "end of the pipe" physico-chemical treatment system. The wastes generated vary in composition from time to time during the day, and equalization of the wastes is limited. There is no automatic control system to balance flow and composition variations. Furthermore, some of the equipment for sludge removal is out of order.

The tanning process used by Sevco is normal for the industry. Salted skins are washed, fleshed, and unhaired in the usual manner. Wastes from soaking and unhairing are released during the morning hours to early afternoon. These wastewaters contain high BOD, TSS, TDS, alkalinity, and pH. A detailed investigation of the wastewaters from each production process and hourly composite waste was conducted in 1988. These data are consistent with EPA studies of the leather industry in the United States for similar production.

Chapter 2

FINDINGS

The present wastewater treatment system of the Sevco Tannery treats all of the production wastes. The waste streams from the production processes flow to the treatment plant as they are discharged from individual batch operations. The composition of the combined influent to the wastewater treatment plant varies widely both in flow and composition depending on the time of day and the production operations being discharged.

As mentioned above, a detailed study was undertaken in 1988 on the composition of the waste streams from the different production operations and the influent and outflow from the wastewater treatment plant. These data are thorough and present a clear picture of the wastes generated; these data are the best available and provide the basis of the present study. (A portion of the data from the 1988 study is presented in Table 1.)

Pigskin is processed in this tannery by methods commonly used in the industry. The salted skins are soak washed, unhaired, limed, delimed, pickled, and chrome tanned without removing the skins from the hide processors.

The hide processors are each equipped with pumps for feeding, recirculating, and discharging the process solutions as needed. The mechanical design and pumping system of the hide processors allows complete control of the wastes generated. This allows the waste streams to be separated for collection and treatment by methods specific for each stream.

The soaking and wash wastes from the pigskins contain salt, dirt, blood, manure, fats, and pigskin degradation materials. The solution is slightly alkaline and contributes most of the dissolved solids found in the combined waste stream. The soak and wash waters also contribute about 20 percent of the suspended solids, 20 percent of the BOD_5, 40 percent of the grease and 50 percent of the dissolved solids in the combined influent stream.

The unhairing and liming wastes are the most concentrated waste streams in the tannery. The solution is strongly alkaline, containing about 50 percent of the suspended solids, 60 percent of the BOD_5 and 60 percent of the grease found in the combined influent waste stream.

Deliming and pickling waste streams contain dissolved solids (salt), some acid but relatively less suspended solids—about 5 percent of the combined waste and 10 percent of the BOD_5 of the combined waste stream.

The chrome tanning spent solutions contain salt, sodium sulfate, chromium salts, fats, and suspended leather particles. These spent wastes are lower in chromium than those from cattle hide tanning due to differences in the tanning conditions. This variation will be of importance as production is shifted to more cattle hide processing.

TABLE 1

WATER TREATMENT PLANT MIXED INFLUENT

HIGHS & LOWS ONE DAY*

mg/ℓ

FLOW	HIGH	LOW	AVERAGE
pH SU	8.5	6.0	7.6
TS mg/ℓ	15,200	6,880	10,850
TDS mg/ℓ	13,890	3,426	6,445
TSS mg/ℓ	5,689	2,960	4,360
BOD_5 mg/ℓ	4,320	1,160	2,434
FAT mg/ℓ	1,665	218	933

* *From 1988 Study*

The balance of current waste streams are from the coloring and fatliquoring (oiling), cooling water, and general clean up operations. These wastes are low in suspended solids, low in BOD_5 and slightly acid. The combined acid wastes (omitting the chrome tanning wastes) are about 50 percent of the total volume of the waste stream and contain about 25 percent of the suspended solids and 10 percent of the BOD_5.

The wastewater treatment plant, as evaluated, is not operating at optimum capacity. The study indicated that about 60 percent of the flow treated is from process streams that are less concentrated, with regard to TSS and BOD, than the balance of the waste. This being the case, it was recommended that the less concentrated waste stream be treated only in the present wastewater treatment system. The diluted wastes could be given minimal treatment, allowing the concentrated wastes to be more effectively treated due to a lower flow rate through the new wastewater treatment system. The benefits of this change would be very important to the tannery and the municipality in regard to the quality of effluent discharged.

2.1 The Tannery Processes

2.1.1 Unhairing and Liming

The hair is removed from the skin by the action of lime $CaO{\cdot}H_2O$ and sulfides NaS and NaSH. This process is done in mixers, similar to cement mixers, modified for hide processing. The solutions are moved by the rotating action of the mixer. There is good application of the chemicals with a minimum of solution. The solutions can be pumped easily from the equipment for discharge or recycling. Labor required is minimal, as the skins are removed by reversing the rotation of the mixer. This equipment is considered "state of the art" in the industry.

Washings are necessary at the end of the unhairing process and result in a highly polluting waste stream. The unhairing waste stream is high in BOD and TSS. The solution also contains sulfides and calcium hydroxide. The pH is over 12. Skin degradation products, including hair particulate, proteins, and fats, make this waste the most serious problem of pollution control in the tannery.

2.1.2 Deliming and Bating

The deliming and bating step is done in the same mixers without removing the skins. This is a combined process in which the lime $CaO{\cdot}H_2O$ is removed from the skin and the pH of the skin is brought to a near neutral condition. The skin becomes very soft as the swelling of the skin is decreased with the pH change. The bating refers to the treatment of the skin with some enzymes to further clean the skin and remove some undesirable proteins. The wastewater from this step in the production contains very little BOD and TSS. The pH is about 7 to 8. Animal fats are less than 100 mgl.

2.1.3 Pickling and Chrome Tanning Wastes

Chrome tanning is done in the mixers as a continuation of the previous steps. Prior to chrome tanning, the skins in process are in danger of bacterial damage. When the salt is removed, bacterial activity can begin. Prompt processing through unhairing, liming, and deliming prevents significant bacterial damage.

The skins in the mixer are treated with a salt solution and acid. In most production forming, the salt is sufficient to make a concentration of 30-40 g/l, after dilution, with the water carried over from the deliming-bating step. This is needed to prevent osmotic swelling during the acid conditions of the chrome tanning. The wastewater from the pickling need not be dumped but may be used in the chrome tanning.

Chrome-tanned leather is wrung free of absorbed water. The leather, at this stage, can be a saleable product as "Wet Blue." There is a large international market for "Wet Blue" in cattle and other hides and skins. The chrome-tanned skins are sorted for quality then split to the desired thickness. The thickness is further adjusted by shaving (essentially a parallel to planning in lumber). The shaving generates chrome leather shavings as a solid waste that can be sold as a raw material for reconstituted leather.

Chrome tanning is done with trivalent chromium salts, the most common being a basic chromium sulfate with the formula 2(Cr OH SO4)-Na_2SO_4. The pH during chrome tanning starts at about 2 or 3 and increases to between 3.5 and 4.0, depending on the leather being made and the tanner's formula. This pH control assures penetration of the tanning salts through the skin.

Chrome tanning waste solutions contain chromium at concentrations of 200 to 1,000 mgl, depending on the conditions of pH and temperature.

2.1.4 Retanning, Coloring, and Fatliquoring

The chrome-tanned leather and splits (inner layer of the skin) are retanned, dyed, and fatliquored in drums or retanning machines. This process gives the leather the color and feel desired in the final product. Formulas for this step are as varied as the leather being made. The system is a series of processes conducted in sequence in the drum or retanning machine without removing the leather from the equipment. There are numerous washes, and a large volume of wastewater is generated.

The wastewater contains spent retanning materials, including vegetable tanning wastes, specialty products, dyes, and some oil. The solution is about pH 4 to 6 with relatively low BOD and TSS. Suspended solids are primarily small particles of leather fiber.

2.1.5 Other Sources of Tannery Wastewater

The balance of the wastewater from a tannery is from machinery clean-up, finishing spray booth washes, vacuum drier cooling water, and perhaps sanitary wastes.

2.2 Wastewater Treatment

At present, there is no municipal wastewater treatment facility for sanitary wastes. Eventually, the pretreated tannery wastes will be combined with the sanitary wastes for secondary treatment prior to discharge to the river. The tannery wastes, before treatment, will contain between 5 and 8 kg of BOD_5 per 1000 kg of hides and skins processed. At 35,000 kg per day of production, the BOD loading from the tannery operations will exceed the BOD loading contribution of the municipality. Effective operation of the tannery wastewater treatment plant will be important in the design, capital cost, and operation and maintenance of the municipal treatment plant.

Indirectly, wastewater treatment at the tannery is related to the construction of the municipal plant. The present economic problems of the country and district are not expected to change in the immediate future. Effective pretreatment of the tannery wastes could make a difference as to when and under what conditions the municipal plant is built.

In the present tannery wastewater treatment system, wastes are combined as they are generated. The combined stream is dosed with lime, rough screened, and the heavy solids settled. Grease is removed by flotation. The stream is then dosed with coagulant and ferrous sulfate and settled. The sludge is removed, and provision is made for air drying of the sludge. This system is shown in Figure I.

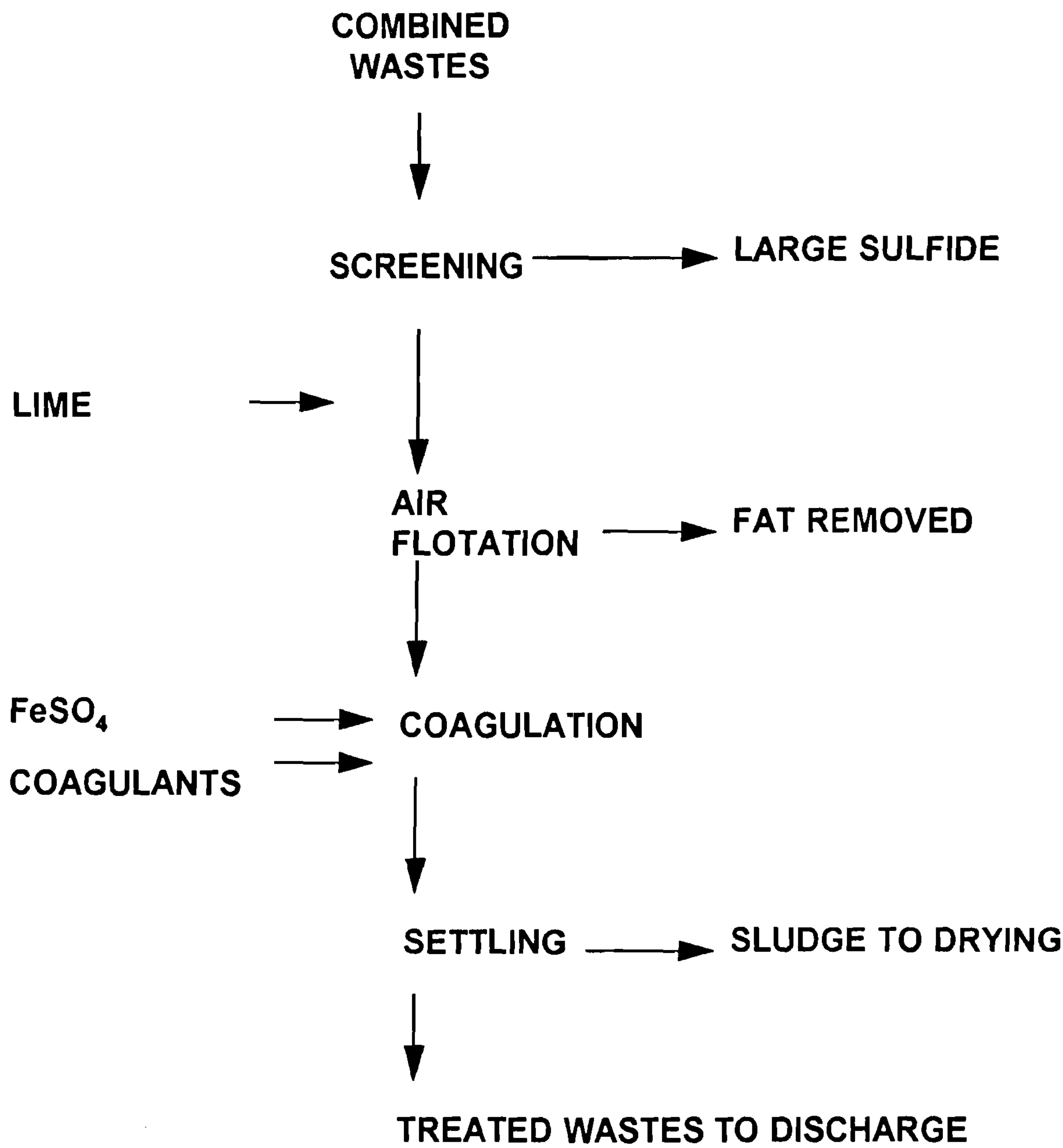
The present system was the basis for the preliminary design of the new treatment plant: large tanks for complete equalization followed by dosing and primary settling. Such a system is known to be effective if kept in balance.

In the planned increase in tannage, higher concentrations will be found in the undiluted spent tanning solutions. In the tannage of cattle hides, concentrations of 2,000 to 5,000 mgl are common. The chrome tanning wastewater will also contain dissolved solids of more than 20,000 mgl. These solids are primarily NaCl and Na_2SO_4.

For the future, the tannery must achieve a very effective and efficient wastewater treatment system. If treated wastes from the tannery are sent to the new municipal treatment plant, they must be as low in suspended solids and BOD_5 as possible. High loadings of BOD_5 from tannery wastes would require a very large and costly municipal treatment system. If the tannery chose to discharge its treated wastes directly into the river, the municipal treatment system would be required to decrease the BOD_5 to very low levels. Costs of such treatment would be a serious problem for the tannery, which is now competing on the international market.

FIGURE I

PRESENT TREATMENT SYSTEM



<u>FUTURE PLAN</u>:

SYSTEM TO BE USED FOR COMBINED ACID WASTES.

2.2.1 Proposed Separation of Waste Streams

The plan now under consideration for the tannery involves separation of the waste streams to allow separate treatment and recovery of sludge. The proposed system is as shown in Figure II. The soak, unhairing, liming, and deliming solutions are to be collected for a full day's production. These combined wastes will be about half of the total volume of wastes and will contain 75 percent of the suspended solids and 80 percent of the BOD_5. All of the sulfide wastes and lime wastes will contain no chromium. The sulfide and lime wastes will be treated for sulfide removal, lime removal, and grease removal. The remainder of the solution will be adjusted in pH and coagulated. The resulting sludge will be dried and sold as fertilizer or possibly as animal feed.

The spent chrome tanning solutions will be collected and recycled. In cattle hide processing, savings in the chromium chemicals used can be as much as 30 percent. Recycling and reuse methods are well known in the industry and do not require innovative technology. This plan is shown in Figure III.

The balance of the wastes from the retan, color, and fatliquoring streams, plus the other waters, will be treated in the same manner as the present combined waste stream. The conditions will be optimized to the stream composition. The acid waste stream, according to present plans, will be treated in the present wastewater treatment plant.

2.2.2 Investigation of Treatment Methods

Treatment of the soaking, unhairing, and deliming wastes has been investigated using an innovative approach. A sample was prepared to duplicate the combined wastes, including the wash waters. This was done by taking concentrated wastes from each of the three steps and mixing the solutions with water to conform to the production wash water. A total of 90 liters of this mixed solution was then available for testing. The sulfide oxidation technology is shown in Figure IV.

Sulfide removal was the first step. A portion of the well-mixed composite solution (60 l) was placed in a plastic barrel. To this solution was added 60 grams (1 g/l) of manganese sulfate. An air hose was put in the barrel, weighted to keep the end of the hose on the bottom of the barrel. Compressed air was introduced into the solution at a rate that kept the solution well mixed. Samples of the solution were taken over a four-hour period and the solution analyzed.

The solutions were placed in glass cylinders to observe the settling of suspended solids. There was an immediate settling of some hide particulate matter, including hair.

FIGURE II

WASTE STREAMS DIVIDED SYSTEM

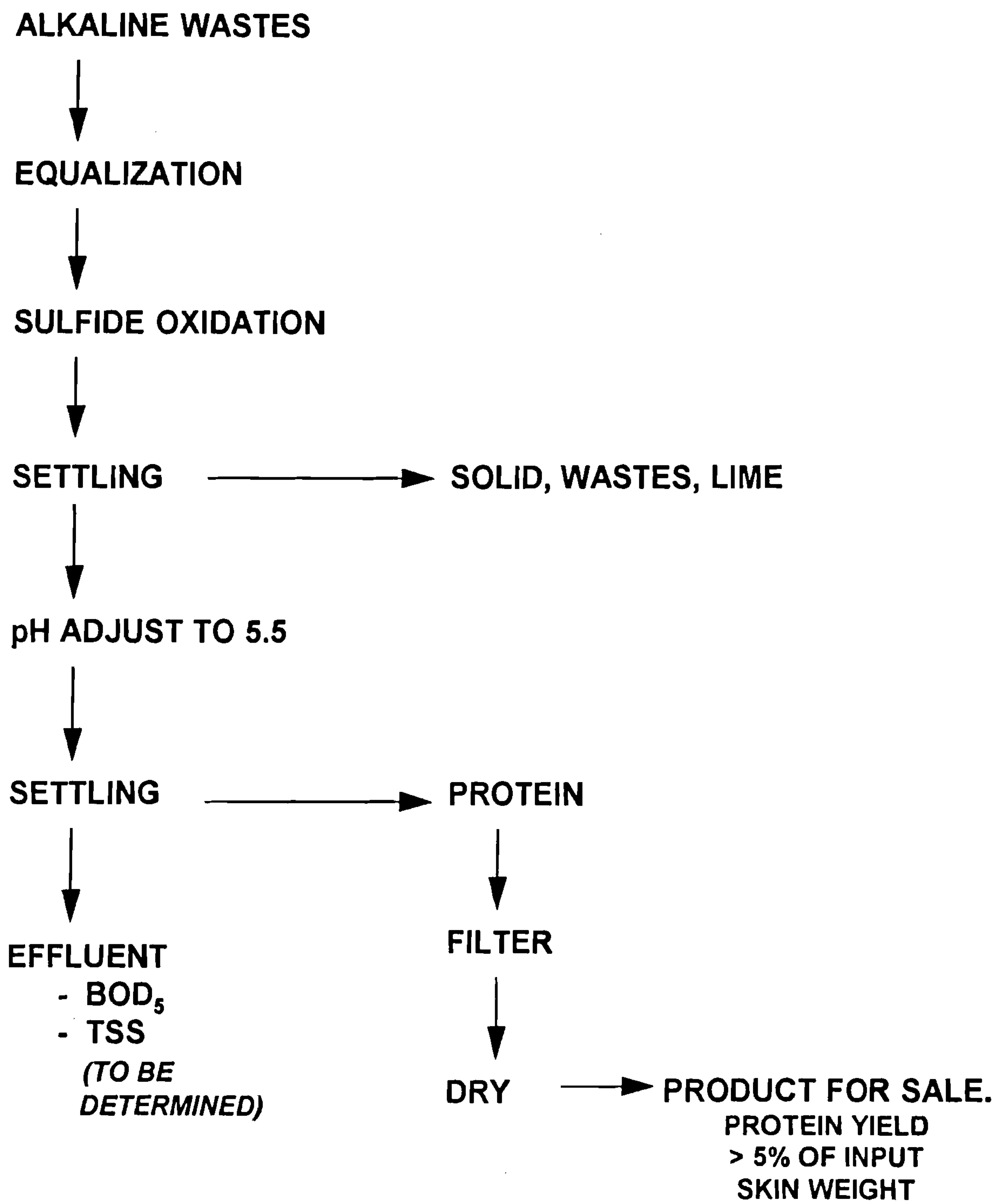


FIGURE III

CHROME TANNING RECYCLING

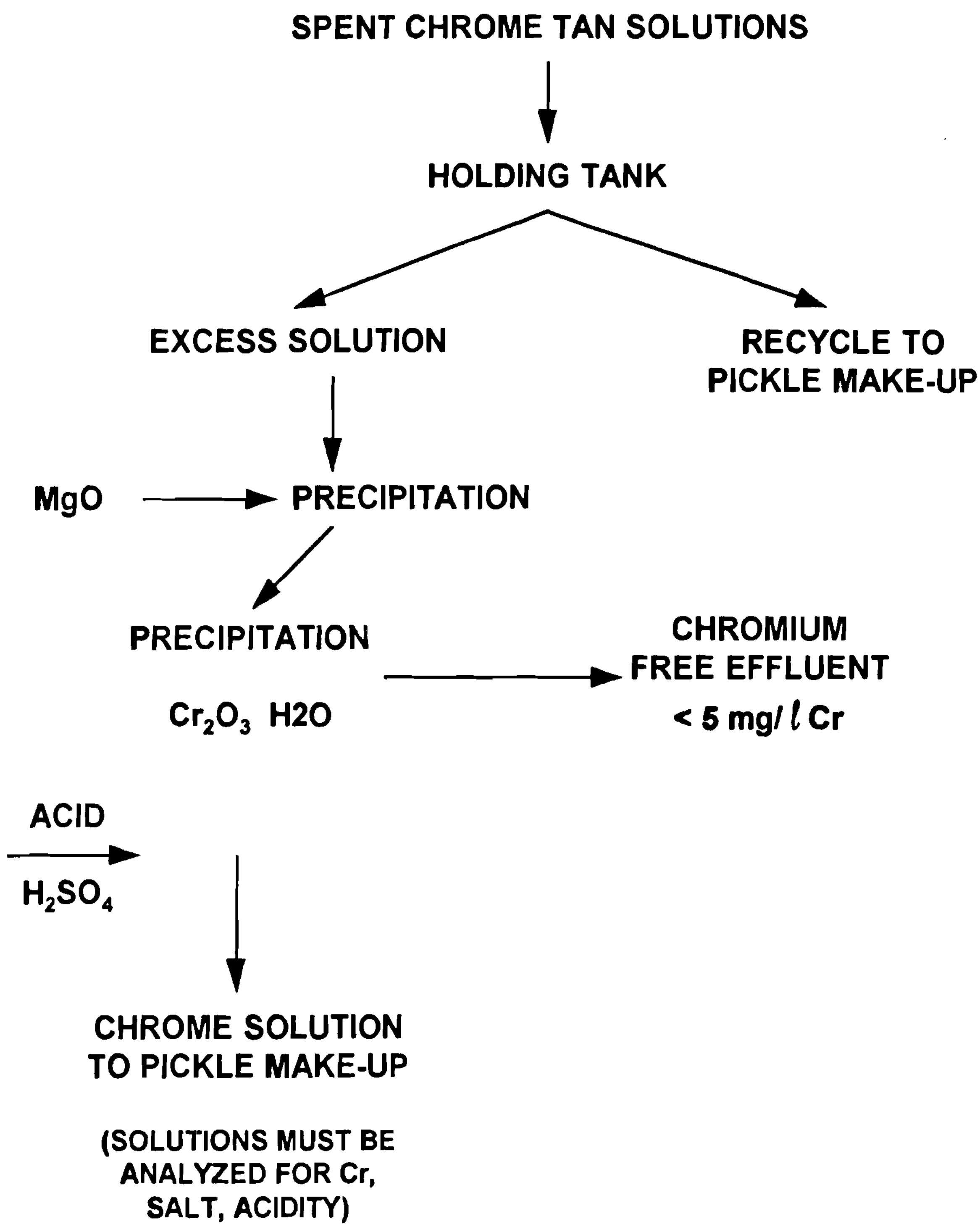
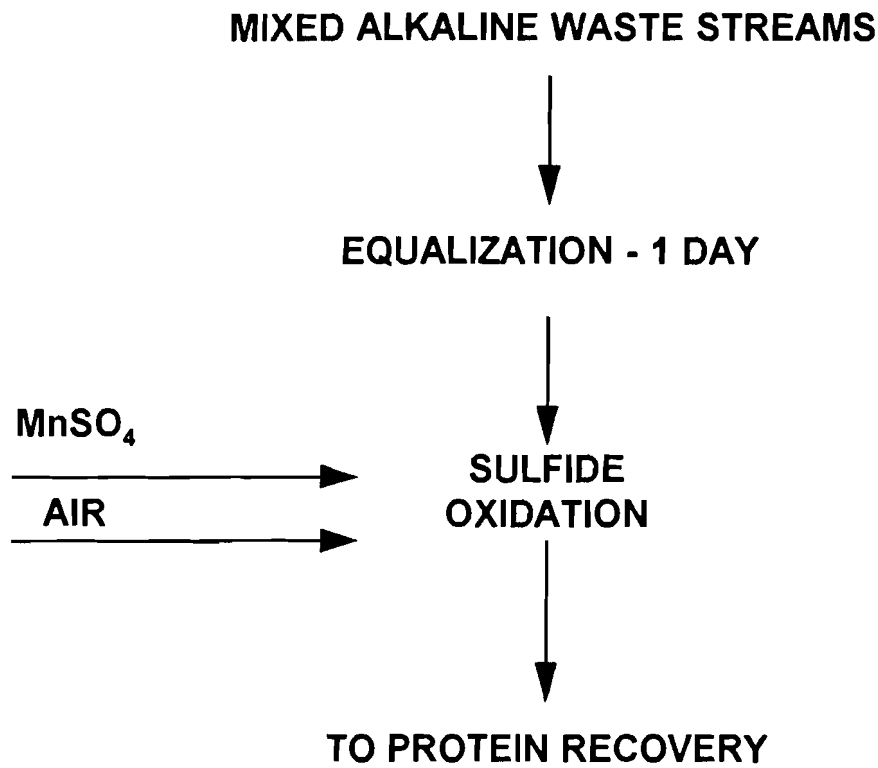


FIGURE IV

NEW TECHNOLOGY SULFIDE OXIDATION



$$2\ Na_2S + O_2 + 2\ H_2O \longrightarrow 2\ S^0 + 4\ NaOH$$

AIR OXIDATION CAN DECREASE SULFIDE TO < 5 mg/ℓ

Lime remained in suspension, and grease slowly rose to the surface. Along with the hide particulate matter there was a settling of a white flocculent material. This material has not been definitely identified.

The supernatant solution was analyzed for sulfides by titration with potassium ferrocyanide. The lime in the solution was titrated with hydrochloric acid. Results of the test are shown in Table 2. Sulfide in the solution decreased at a rate equal to that found in similar industrial applications of this system. The method is common practice to remove sulfides; removal of sulfides to less than 5 mg/l is normal. The data indicate that this system will work with the waste stream.

The lime in this test did not settle quickly, presumably due to the presence of grease in the sample. In a treatment system in which the grease was removed prior to sulfide oxidation, it is expected that the lime would settle and could be removed.

After sulfide oxidation, the solution was acidified to pH 5.5. At this pH, near the isoelectric point of the proteins, there was rapid coagulation of the proteins into a flocculent precipitate. The precipitate settled clear in less than five minutes and was filtered, dried, and weighed. The weight of the precipitated protein was equal to 6 percent of the weight of the pigskin wastes, represented by the wastewater tested.

This treatment system is now under continuing study. The conditions of grease removal, optimization of the sulfide oxidation system, settling of the lime, and production of a protein by-product are all under investigation.

The possibilities of this approach to tannery wastewater treatment are very encouraging. The precipitated protein could have value either as fertilizer or as chicken feed. The amount of protein removed corresponds closely to the BOD_5 generated by the tannery processes included in the waste stream.

TABLE 2

SULFIDE OXIDATION

SAMPLE COMPOSITION

10 ℓ	-	SOAK
10 ℓ	-	LIME SULFIDE SPENT
10 ℓ	-	DELIMING
60 ℓ	-	WATER (WASH DILUTIONS TOTAL)

HOURS	SULFIDE	LIME IN SURFACE
0	920 mg/ ℓ	1709 mg/ ℓ
1	470 mg/ ℓ	--
2	315 mg/ ℓ	--
3	276 mg/ ℓ	1420 mg/ ℓ
4+	253 mg/ ℓ	1687 mg/ ℓ

PROCEDURE: Add 1 g $MnSO_4$ / ℓ of Sample. Aerate Continuously: Sample for Analysis. At start and at one hour intervals. Analyze liquid layer below fat and above sludge.

Chapter 3

CONCLUSIONS

The benefits of the proposed system can be both environmental and economic. These benefits include:

1. Possible savings in the costs of the tannery treatment system. The use of mixers in this tannery makes the recommended sulfide oxidation and the chrome tanning solution recycling low-cost waste minimization options.

2. Possible savings in the cost of the municipal treatment system by BOD_5 reduction at the tannery. High loadings of BOD_5 from tannery wastes would require a very large and costly municipal treatment system.

3. Decrease in the amount of chromium-containing sludge and cost savings in tanning materials through recycling of the chrome tanning solution. The volume of chromium in the tanning effluent can be greatly decreased by recycling the spent chrome tanning solutions. This is not only an environmental benefit but also is an economic benefit for the tanner. Tannery personnel have had some experience with chromium recycling and recognize its benefits. Practical refinement of the system for application in this tannery could be done during the next visit.

4. Creation of a saleable by-product, either fertilizer or chicken feed, from precipitated tannery proteins.

During the development and optimization of this system, the design of the new production facility and the tannery wastewater treatment system are proceeding. Although the system outlined above will require some new equipment, such equipment does not require much space and will be compatible with a conventionally designed treatment system. The data obtained from the continuing development project will be the basis of the engineering of the system.

The findings and material discussed in this report should have widespread application in the Bureau for Europe and the New Independent States (ENI). It is suggested that ENI share this with other donors working with tanneries in other parts of the region.

Appendix A

BULGARIAN SEVCO FORMS

SOAK

ТАБЛИЦА №1

за физ. хим. състав на отпадните води от опресняване, обезмасляване и подготовка на косъма за скубене

№	Показател	Дим.	1	2	3	4	Средно
1	Лаб. номер	—	104	111	123	124	—
2	Дата	—	10 V. 88	15 VI 88	19 VII 88	7 IX 88	--
3	pH	—	10.2	9.8	10.0	11.0	10.2
4	HCO_3	мгекв/л	80	64	86	42	68
5	Окисляемост	мгО/л	3520	4264	8264	11600	6912
6	$БПК_5$	—	4080	5628	10382	18384	9619
7	ХПК	—	6000	7020	12820	22820	12165
8	Разтворени		39880	36824	26384	16384	29868
9	600°C		9324	6394	7320	6204	7310
10	Загуби		30556	30430	19064	10180	22558
11	НРВ-105°C		16326	18420	22020	26124	20723
12	600°C		2432	2126	2626	3926	2778
13	Загуби		13894	16294	19394	22198	17945
14	Сух остатък 105°C		56206	55244	48404	42508	50591
15	600°C		11756	8520	9946	10130	10088
16	Загуби		44450	46724	38458	32378	40503
17	Мазнини / сапуни		3771	4224	3864	2320	3544
18	Сулфиди		16	24	20	18	20
19							
20							
21							
22							

ТАБЛИЦА №2

за физ. хим. състав на отпадните води
от: ...Варосване......................

№	Показател	Дим.	1	2	3	4	Средн
1	Лаб. номер	—	103	110	125	129	—
2	Дата	—	4 V 88	15 VI 88	18 VII 88	6 IX 88	—
3	pH	—	>12	>12	>12	>12	—
4	Алкалност ~~HCO_3~~	мгЕ/л	90.2	72.4	60.4	134	89
5	Окисляемост	мгО/л	8364	10380	7280	8340	8591
6	БПК$_5$	—"—	10230	14480	18220	16340	14818
7	ХПК	—"—	42.000	30000	46100	38200	39075
8	РАЗТВ. В-ВА ~~[illegible]~~ 105°C		22384	38264	26326	38638	31403
9	600°C		14260	26320	20820	19220	20155
10	Загуби		8124	11944	5506	19418	11248
11	НРВ-105°C		18634	24204	20864	12104	18952
12	600°C		8356	6326	5326	4820	6207
13	Загуби		10278	17878	15538	7284	12745
14	Сух остатък 105°C		41018	62468	47190	50742	50355
15	600°C		22616	32646	26146	24040	26362
16	Загуби		18402	29822	21044	26702	23993
17	Сулфиди		1240	2320	3240	1480	2070
18	Мазнини		5896	8234	6202	5234	6392
19	Утки след 2 ч	мл	~~12~~	~~2.1~~	~~2.6~~	10	6.6
20	Влага	%	87	95.5	82	87	87.4
21	Плуващи в-ва сл. 2 ч	мл	84	92	72	60	78
22	Влага	%	96	97.4	96.6	97.2	96.8

ТАБЛИЦА №3

за физ. хим. състав на отпадните води
от: Обезваряване и смръзкдане

№:	Показател	Дим.	1	2	3	4	Средно
1	Лаб. номер	—					
2	Дата	—	4 V 88	16 VI 88	18 VII 88	6 IX 88	-
3	pH	—	7.5	7.6	7.5	7.5	7.5
4	HCO_3	мгE/л	—	—	—	—	—
5	Окисляемост	мгO/л	30	38	56	30	39
6	$БПК_5$	—"—	68	94	102	80	86
7	ХПК	—"—	240	240	420	280	280
8	Сух остатък 105°C		220	326	418	344	327
9	600°C		184	221	220	206	208
10	Загуби		36	105	198	136	119
11	НРВ-105°C		162	124	120	204	154
12	600°C		84	68	60	78	73
13	Загуби		78	56	60	126	71
14	Сух остатък 105°C		382	450	538	548	481
15	600°C		268	289	280	284	281
16	Загуби		114	161	258	264	200
17	Хлориди		120	560	480	526	422
18	Мазнини		82	80	76	56	74
19							
20							
21							
22							

(3) (4)

ТАБЛИЦА №4

за физ. хим. състав на отпадните води
от: Пиккиранс

№	Показател	Дим.	1	2	3	4	Средно
1	Лаб. номер	—					
2	Дата	—	4. V. 88	15 V 88	19 VIII 88	6 IX 88	-
3	pH	—	6.0	5.9	6.2	6.4	6.1
4	Киселинност HCO_3	мгЕ/л	2.2	2,1	2,2	2.4	2,2
5	Окисляемост	мгО/л	204	384	92	190	218
6	$БПК_5$	—	360	830	124	420	434
7	ХПК	—	3210	9800	2100	5000	5028
8	Сух остатък 105°C		22380	62324	18104	34120	34232
9	600°C		21920	60382	12236	32342	31720
10	Загуби		460	1942	5868	1778	2512
11	НРВ-105°C		1120	4382	682	1926	2028
12	600°C		926	1126	438	828	830
13	Загуби		194	3256	244	1098	1178
14	Сух остатък 105°C		23500	66706	18786	36046	36260
15	600°C		22846	61508	12674	33170	32550
16	Загуби		654	5198	6112	2876	3710
17	Мазнини		74	40	62	54	58
18							
19							
20							
21							
22							

ТАБЛИЦА №5

за физ. хим. състав на отпадните води
от: ... Дъбене ...

№	Показател	Д.мп	1	2	3	4	Средн
1	Лаб. номер	—	105	112	126	127	
2	Дата	—	4 V 88	15 VI 88	19 VII 88	7 IX 88	
3	pH	—	4,0	3,6	4,1	5,0	4,1
4	HCO_3	мгЕ/л	35	50	60	40	46
5	Окисляемост	мгО/л	504	784	1426	1320	1008
6	$БПК_5$	—	560	820	1720	1380	1120
7	ХПК	—	5200	4860	2920	3700	4170
8	Разтв. в-ва тък 105°C		38504	42384	3524	13826	2456
9	600°C		34222	32820	1282	9240	1939
10	Загуби		4282	9564	1242	4586	5169
11	НРВ-105°C		1562	1126	3320	1630	191
12	600°C		728	992	2124	994	116
13	Загуби		834	134	1196	836	75
14	Сух остатък 105°C		40066	43510	6844	15456	2647
15	600°C		34950	33812	3406	10034	2055
16	Загуби		5116	9698	3438	5422	5919
17	Утаяващи се в-ва	мл/л	16	9,8	210	220	113
18	Влага %		98	98,7	96,8	97,5	97,7
19	Хром $^{+3}$		220	180	152	102	164
20	Хром $^{+6}$		0,0	0,0	0,0	0,0	0,0
21	Мазнини		—	—	—	—	—
22							

(6)

ТАБЛИЦА №6

за физ. хим. състав на отпадните води от... багрилни... апарати - след. багрене и намасляване

№	Показател	Дим.	1	2	3	4	Сред[illegible]
1	Лаб. номер	—	102	109	128	136	-
2	Дата	—	6 V 88	17 XI 88	19 VII 88	7 IX 88	-
3	pH	—	5.1	4.1	5.3	5,5	5.[illegible]
4	Киселинност ~~HCO_3~~	мгЕ/л	2.8	1.0	1.1	2.6	1.[illegible]
5	Окисляемост	мгО/л	326	264	286	98	24[illegible]
6	$БПК_5$	—"—	436	292	308	104	28[illegible]
7	ХПК	—"—	1120	1280	1340	420	104[illegible]
8	РАЗТВ. В-ВА при 105°C		3960	3212	1680	1452	257[illegible]
9	600°C		2524	1924	998	796	156[illegible]
10	Загуби		1436	1288	682	656	101[illegible]
11	НРВ-105°C		324	286	504	236	338
12	600°C		120	89	72	90	93
13	Загуби		204	197	432	146	24[illegible]
14	Сух остатък 105°C		4284	3498	2184	1688	291[illegible]
15	600°C		2644	2013	1070	886	165[illegible]
16	Загуби		1640	1485	1114	802	126[illegible]
17	Мазнини		82	52	92	50	69
18							
19							
20							
21							
22							

ТАБЛИЦА № 8

за физ. хим. състав на отпадните води от: след маслозадържатели

№	Показател	Дим.	1	2	3	4	Средно
1	Лаб. номер	—	108	115	120	208	
2	Дата	—	6 V 88	17 VI 88	19 VII 88	7 IX 88	
3	pH	—	7	8	9	10	8,5
4	HCO_3	мгЕ/л	—	—	—	—	
5	Окисляемост	мг/л	3480	800	980	680	1485
6	$БПК_5$	—	2560	1640	1680	940	1705
7	ХПК	—	4000	3200	4800	2030	3507
8	Сух остатък 105°C		8502	10200	8340	4300	7835
9	600°C		538	6840	6320	3040	5397
10	Загуби		3116	3360	2020	1260	2438
11	НРВ-105°C		4410	980	920	1840	2786
12	600°C		700	340	296	380	429
13	Загуби		3710	640	838	1460	1357
14	Сух остатък 105°C		12912	11180	9260	6140	10623
15	600°C		6086	7180	6616	3420	5826
16	Загуби		6826	4000	2644	2720	4797
17	мазнини		1580	804	1820	1990	1548
18							
19							
20							
21							
22							

ТАБЛИЦА №9

за физ. хим. състав на отпадните води
от... изход. преч. станция

№	Показател	Дим.	1	2	3	4	Средно
1	Лаб. номер	—	107	114	122	209	
2	Дата	—	6 V 88	17 VI 88	19 VIII 88	7 IX 88	
3	pH	—	8.2	7	8	8,5	8
4	HCO_3	мгекв/л	—	—	—	—	—
5	Окисляемост	мгО/л	1520	520	1060	420	880
6	$БПК_5$	—"—	1880	2040	1480	640	1510
7	ХПК	—"—	4000	3020	2840	1020	2720
8	Сух остатък 105°С		4452	6650	4620	2450	4793
9	600°С		2234	3240	1340	1240	2014
10	Загуби		2218	3410	3280	1210	2779
11	(НРВ - 105°С		2210	966	860	912	1237
12	600°С		524	324	320	420	397
13	Загуби		1696	642	540	492	840
14	Сух остатък 105°С		6662	7616	5480	3362	5780
15	600°С		2758	3564	1660	1660	2411
16	Загуби		3904	4052	3820	1702	3379
17	S		28	32	16	21	24
18	мазнини		402	557	650	818	606
19	NH_4		540	380	260	400	394
20	Cl		80	62	80	102	81
21							
22							

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таблица 1

параметър Parameter		вход Inlet	изход Outlet
Q_ϕ	m3/h	110	110
Q_{max}	m3/h	300	110
Q_d	m3/d	2600	2600
pH	(-)	8	8,5
SS НВ	mg/l	7600	200
COD ХПК	mg/l	5700	2800
BOD_5 $БПК_5$	mg/l	2200	900
PO_4^{-3}	mg/l	7	-
N_{total}	mg/l	160	120
NH_4^+	mg/l	60	60
N_{org}	mg/l	100	-
Cl^-	mg/l	1000	400
S^{2-}	mg/l	200	< 1
SO_4^{-2}	mg/l	400	400
Cr^{+3}	mg/l	7	< 2
fats мазнини	mg/l	2000	6

Забележка: Показателите в колона "изход" са след физикохимичното третиране и утаяването

Appendix B

LETTERS FROM MINISTRY OF ENVIRONMENT AND SEVCO

MINISTRY OF ENVIRONMENT

67, W. Gladstone Str., 1000 Sofia, Bulgaria ✧ Tel. (.. 359 2) 88 14 40, Fax (.. 359 2) 52 16 34

F A X M E S S A G E

Fax No:	703 243 9004	**Date:**	12.12.1994
To:	**Craig HAFNER**	**Pages:**	1
	WASH PROJECT		
	Sevlievo Tannery Assessment report		
From:	**Nikolai Kouumdiev**, Ministry of Environment		

Dear Craig,

At present the tannery is treating its wastewater in an "end of the pipe" physicochemical treatment system. The wastes generated vary in quantity and concentration from time to time during the day. The tannery new treatment system is in the planing stage. A new WWTP is designed for the expanded production and will ignore the present WWTP and the process is design again an "end of the pipe".

The recommended treatment system is separate treatment of the waste streams that will be divided into three flows:

- alkaline waste;
- chrome tanning waste;
- Acid wastes.

At present there is no **automatic control system to balance flow and concentration variations** that will be helpfully for detailed investigation of the wastewaters from each process and to **adjust and redesign suitable equipment and treatment scheme** On the same time is needed to be assess proposed treatment from **cost-effective point.**

For the future the tannery must achieve very effective wasetewater treatment. If Sevko chose to discharge its treated wastewaters directly in the river they should meet 15 mg/l BOD_5 and 50 mg/l SS.

Practical refinement of the system for application in this tannery should be done in future during the next visit.

Sincerely yours,

Nikolai

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SEVKO Ltd. - Sevlievo

tel: 0675/60-91, 46-60
fax: 0675/48-21
telex: 67598

5400 Sevlievo, Bulgaria
st. De[illegible]erica 1
'SEV[illegible]' Ltd.

We agree with the data in Mr. Thorstensen report.

Concerning the recycling of waste chromium solution, the concentration of chromium in them is less than 0.7 mg/l, which is in fact less than 10% of the chromium quantity used. Nevertheless, we have envisaged in the new plant tanks for waste chromium solutions and their recycling/second use.

Concerning the use of manganese sulphate in separate treatment of waste solution (acid & alkaline flow) the data is viable.

Concerning the optimisation of the existing treatment system, it will be necessary, as a step towards the new one to make additional research & analysis with which to pass over to design. This activity will need cost-benefit analysis on the basis of which it will be necessary to explore the possibility for financing the project implementation It is impossible to think of using bank credits at the present interest rates in Bulgaria - 80%.

Please accept our sincerest thanks for sending the consultant Mr.Thorstensen to make a study on our waste waters & provide us with a highly professional scheme.

Sevko Ltd - Sevlievo

Camp Dresser & McKee International Inc.
Associates in Rural Development, Inc.
International Science and Technology Institute
Research Triangle Institute
University Research Corporation
Training Resources Group
University of North Carolina at Chapel Hill

WASH Operations Center
1611 N. Kent St., Room 1001
Arlington, VA 22209-2111
Phone: (703) 243-8200
Fax: (703) 243-9004
Telex: WUI 64552
Cable Address: WASHAID

THE WASH PROJECT

With the launching of the United Nations International Drinking Water Supply and Sanitation Decade in 1979, the United States Agency for International Development (A.I.D.) decided to augment and streamline its technical assistance capability in water and sanitation and, in 1980, funded the Water and Sanitation for Health Project (WASH). The funding mechanism was a multi-year, multi-million dollar contract, secured through competitive bidding. The first WASH contract was awarded to a consortium of organizations headed by Camp Dresser & McKee International Inc. (CDM), an international consulting firm specializing in environmental engineering services. Through two other bid proceedings since then, CDM has continued as the prime contractor.

Working under the close direction of A.I.D.'s Bureau for Science and Technology, Office of Health, the WASH Project provides technical assistance to A.I.D. missions or bureaus, other U.S. agencies (such as the Peace Corps), host governments, and non-governmental organizations to provide a wide range of technical assistance that includes the design, implementation, and evaluation of water and sanitation projects, to troubleshoot on-going projects, and to assist in disaster relief operations. WASH technical assistance is multi-disciplinary, drawing on experts in public health, training, financing, epidemiology, anthropology, management, engineering, community organization, environmental protection, and other subspecialties.

The WASH Information Center serves as a clearinghouse in water and sanitation, providing networking on guinea worm disease, rainwater harvesting, and peri-urban issues as well as technical information backstopping for most WASH assignments.

The WASH Project issues about thirty or forty reports a year. WASH *Field Reports* relate to specific assignments in specific countries; they articulate the findings of the consultancy. The more widely applicable *Technical Reports* consist of guidelines or "how-to" manuals on topics such as pump selection, detailed training workshop designs, and state-of-the-art information on finance, community organization, and many other topics of vital interest to the water and sanitation sector. In addition, WASH occasionally publishes special reports to synthesize the lessons it has learned from its wide field experience.

For more information about the WASH Project or to request a WASH report, contact the WASH Operations Center at the above address.