A STUDY ON LOG-CONDITIONING
WASTEWATER FROM VENEER PRODUCTION
IN THE BRITISH COLUMBIA INTERIOR

TECHNICAL REPORT 1972

by

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ABSTRACT

The quality of untreated or treated log-conditioning chest effluent from veneer/veneer-plywood plants are examined. It is concluded that untreated conditioning chest effluent can cause severe pollution problems and that biological treatment significantly improves the wastewater quality.

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INTRODUCTION

To enable easier peeling of logs, veneer/veneer-plywood plants located in the British Columbia interior find it necessary to condition peeler logs with hot water or steam. Wastewater from the log-conditioning operation has been suspected of causing a significant water pollution problem. In anticipation then, that guidelines for the treatment and disposal of such effluents will likely need to be formulated, this survey was undertaken to obtain detailed information on log-conditioning wastewater and on the general veneer/veneer-plywood operation.

Problems arise with log chest wastewater due to organic constituents (e.g. tannin-lignins, phenols, resin acids) of the wood being washed and/or dissolved out from the wood-cellulose matrix.

These constituents upon entering receiving waters are known to cause colour and taste problems at low concentrations, and at higher concentrations can be detrimental to the biota of receiving waters; cause direct toxicity to aquatic life in localized areas; cause a dissolved oxygen depletion due to the high oxygen demand of the organic wastes; or could contaminate groundwater sources of streams, rivers or lakes. Many of those organisms which are adversely affected are important links in the aquatic food life chain and their absence or depletion can effectively destroy a watercourse's ability to support resident and migratory fish populations. In addition any associated bottom growth which may result could have detrimental effects on fish spawning areas.

There are numerous veneer/veneer-plywood plants located in the interior of British Columbia. Thirteen plants were visited. Where possible, samples were collected for field analysis and for further analysis at the Vancouver laboratory. The focal point of this survey was the problem area related to log-conditioning wastewater and the objective of the survey was to provide further insight into the wastewater problems associated with veneer production. The survey provided sufficient information to formulate initial guidelines for wastewater treatment and indicated that further study should be carried out on certain problem areas related to veneer production.

VENEER/VENEER-PLYWOOD PLANT OPERATION

The method of operation, which is described below, was observed at a majority of the plants visited. A flowsheet of general plant operations is shown in Figure 1.

Prior to conditioning, logs from the storage area are stripped of bark by a mechanical debarking unit(s); then cut into "filtches" (lathe size peeler logs of 8' length) and collected in bins. The filtches are loaded into steam or hot water conditioning chests (approximately 8' wide) and are held in these chests for a number of hours depending on the time of year. The retention time during the winter months can be as long as 30 hours and during the summer months as brief as 8 hours. After conditioning, the filtches are then peeled into "green veneer". In a plant without a dryer the "green veneer" is then trimmed and bundled, and shipped to plywood assembly plants for drying and assembly. The entire process from the log storage area to the veneer lathe and cutter is described as the "green end". In a plant with a dryer, the "green veneer" is transferred to the drying operation. Again depending on the type of plant, the dried veneer is then either bundled and shipped to a plywood assembly plant, or passed along to the plant's plywood assembly operation.

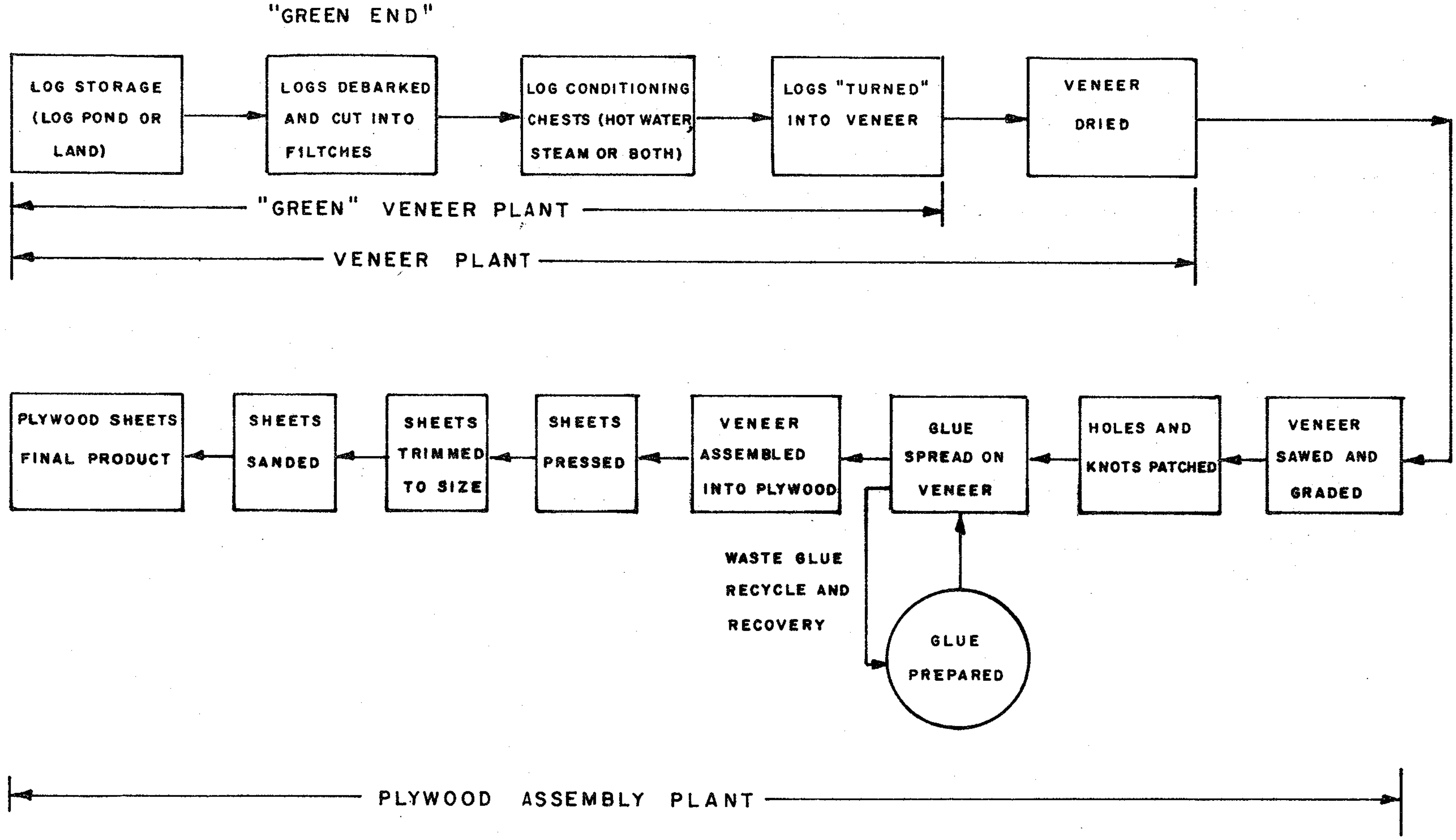

FIGURE I - TYPICAL B.C. INTERIOR PLYWOOD PLANT FLOW DIGRAM.

In the plywood assembly operation, the dry veneer is graded, and any holes or knots patched. During the lay up stage which follows, phenolic resin glue is applied to both sides of the core veneer and the core veneer placed alternately between sheet veneer. The process is repeated until the required pre-determined number of plys of veneer is attained. This is termed a panel. Panels then pass to a press where pressure and heat are applied to cure the adhesive. After the pressing operation the rough edges of the panels are trimmed and the panel is then either left rough or sanded. The final product is packaged for shipment.

The general chacteristics of the plants visited are depicted in Table I.

CONDITIONING CHEST OPERATION

In this survey, primarily two methods for conditioning logs were noted (1) hot water and (2) steam. Of the plants visited, six of twelve used hot water, four used steam. The remaining two employed variations of steam and hot water (either hot water with steam assist or steam with hot water assist).

Plant No.	% Species Processed (approx. yearly avg.)					Type of Conditioning			Veneer Dryer	Plywd	Production (sq. ft. of 3/8" per day)
	Spruce	Balsam	Fir	Pine	Hdwd	Hot Water	Steam	Comb.			
1	95	*	*	*	5	x					170,000 (veneer)
2	50	-	50	-	-	x					320,000 (veneer)
3	90	-	-	10	-		x				235,000 (veneer)
4	95	-	5	-	-		x		x	x	300,000 (plywood)
5	75	*	25	*	-	x					400,000 (veneer)
6	70	-	30	-	-	x					380,000 (veneer)
7	-	-	100	*	-		x		x	x	88,000 (plywood)
8	32	32	36	-	-			x	x	x	600,000 (plywood)
9	-	-	95	*	-		x		x	x	330,000 (plywood)
10	65	-	35	-	-	x			x	x	170,000 (plywood)
11	60	-	40	-	-	x			x		335,000 (veneer)
12	80	-	-	-	-			x			260,000 (plywood)
13	†										

* Trace
† under construction

TABLE I - PLANT CHARACTERISTICS

(a) HOT WATER CONDITIONING

The water used for conditioning is heated in a basin which is usually located adjacent to the log chests. Water temperature in the basin is maintained at approximately 55 - 60°C. Hot water is sprayed over the logs via an overhead sprinkler system within the log chest and the hot water cascading through the stacked logs softens the wood thereby permitting easier peeling. All water that is not absorbed by the filtches or lost to evaporation is collected in floor drains and recycled to the heating basin. Daily addition of fresh make-up water is necessary to compensate for losses due to evaporation and absorption (Figure 2). Periodically, as the recycled water becomes contaminated, the entire contents of the basin must be discharged and the basin recharged with fresh water.

(b) STEAM CONDITIONING

Steam for conditioning of logs is generated in the plant boiler and injected into the steam chests. The steam comes in contact with the logs and as with hot water conditioning, the wood softens to permit easier log peeling.

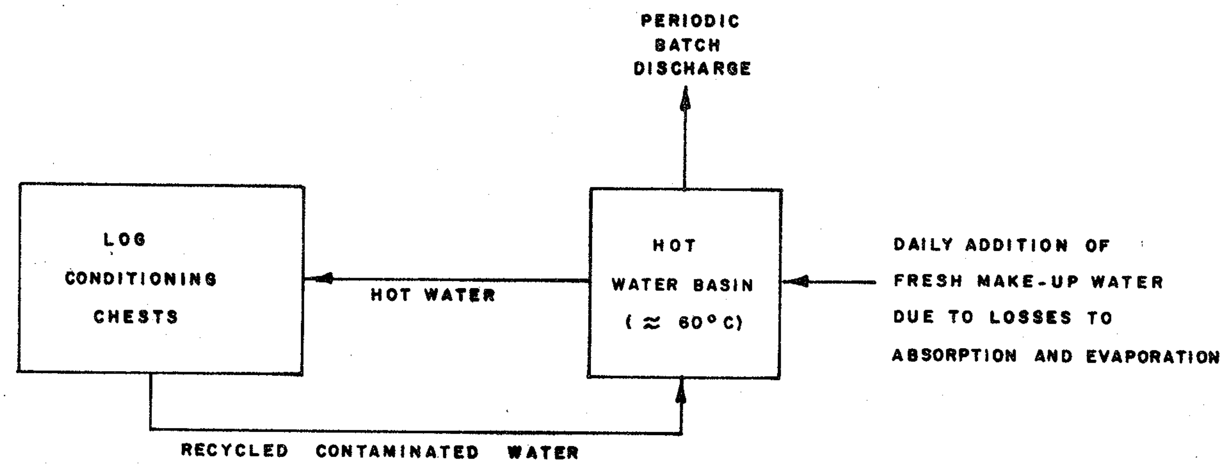

FIGURE 2 - FLOW DIAGRAM FOR HOT WATER CONDITIONING

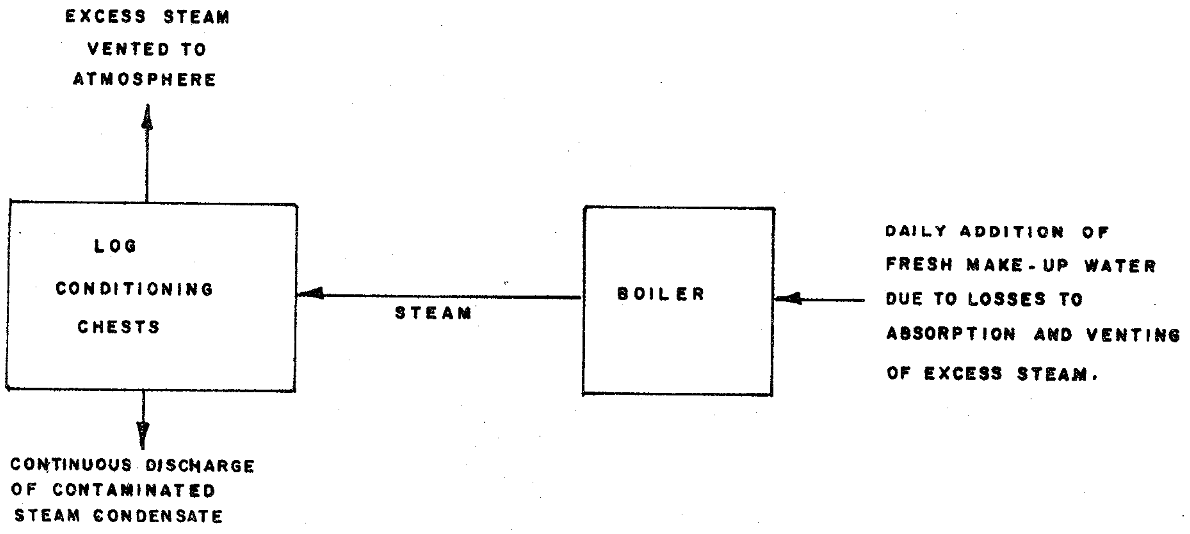

FIGURE 3 - FLOW DIAGRAM FOR STEAM CONDITIONING

The steam condensate which results is contaminated by the various wood constituents and is drained to a sump and subsequently discharged. Because of the waste constituents in the steam condensate, recycling and re-boiling is presently not practised. (See Figure 3).

(c) STEAM-HOT WATER CONDITIONING

This is merely a combination in varying degrees of the above two operations.

CONDITIONING CHEST WASTEWATER

The approximate quantity of wastewater discharged from the log-conditioning operation for plants visited is shown in Table II.

The samples of log-conditioning wastewater collected at each of the plants were:

(i) five gallon samples for bioassay test;
(ii) smaller samples for chemical analyses.

The samples were flown to Vancouver and determinations started within twenty-four hours. Field tests were completed on site. The field and laboratory results are shown in Table III. For an explanation of the measured parameters see Appendix A.

PLANT NO.	FREQUENCY OF DISCHARGE*	AMOUNT DISCHARGED (gals.)*	AMOUNT OF DAILY MAKE-UP WATER* (gpd)	REMARKS
1	Weekly	5,000	Not available	
2	Not available	Not available	100	
3	Continuous	500	-	
4	Continuous	2,500	Not available	
5	Every 2 weeks	26,000	Not available	2 basins @ 13,000 gals. discharged alternately.
6	Every 2 weeks	10,000	Not available	
7	Continuous	150 - 200	-	
8	Continuous	1,000 - 1,500	-	
9	Continuous	15,500	-	This includes boiler blowdown.
10	Every 2 weeks	6,000	Not available	
11	Every 3 or 4 weeks	1,300	100 - 200	
12	Every 3 or 4 weeks	Not available	Not available	
13	-	-	-	Not in operation at time of survey.

*No official records kept. These are estimates given by plant personnel.

TABLE II - QUANTITY AND FREQUENCY OF DISCHARGE OF CONDITIONING CHEST WASTEWATER

Plant	pH		BOD5 (mg/ℓ)		COD	TOC	TR	RAS	Phenols	Tannin-lignin	TLm-96
No.	Field	Lab	Avg.	Range	(mg/ℓ)	(mg/ℓ)	(mg/ℓ)	(mg/ℓ)	(mg/ℓ)	(mg/ℓ)	(%)
1		4.82	2510	2100-2940	12959	6282	9820	3.08	.704	30645	1.35
	5.5	5.91	1290	1260-1320	2257	883	1700	1.57	.550	3300	15[1]
2	6.5-7	5.17	380	300-415	568	82	514	0.79	.034	270	24
3		6.68	785	780-840	1568	680	2303	0.70	.580	2500	13.5[2]
	7	7.12	1980	1900-2100	4723	1524	4862	0.77	.080	400	76
4	5.5	5.15	3240	3180-3300	7702	2776	4490	6.12	.060	4355	4.8
5	5	5.21	3870	3660-4080	9357	3194	6350	3.54	.560	3870	13.5
6	7.5	7.51	710	660-720	1727	556	1711	4.50	.035	967	7.7
7	4	4.32	5600	---	7840	3344	4050	2.80	.816	7926	2.4
8	5.5	5.40	1070	930-1500	1520	898	5059	2.14	.225	1600	13.5
	6.5	6.92	70	60-90	393	94	527	0.75	.112	210	100[3]
9	7.5	5.74	1545	1500-1620	5155	951	2400	4.90	*	3467	13.5
	7.5	7.54	40	---	433	106	1750	0.50	.015	480	(non-toxic)[2]
10	5	5.20	1500	1400-1560	2507	1228	1960	2.10	.148	3200	12
11		6.72	2880	2820-2940	5200	2206	5710	5.75	*	3125	7.2
12	5	5.08	5650	5400-5800	12703	4692	9278	6.20	.275	5806	3.9
13[4]	-	-	-	-	-	-	-	-	-	-	-

*Sample Broken
[1] effluent from settling pond
[2] effluent from treatment pond
[3] effluent from log pond
[4] not in operation at time of survey

TABLE III - SAMPLE RESULTS

TREATMENT AND DISPOSAL OF LOG-CONDITIONING WASTEWATER

The methods of wastewater disposal and/or treatment which were encountered in this investigation were:

(i) direct discharge of untreated wastewater;
(ii) settling pond prior to discharge;
(iii) biological treatment prior to discharge.

DIRECT DISCHARGE OF UNTREATED WASTEWATER

Four of the plants visited discharge untreated wastewater directly to either a lake or stream. Disposal of untreated effluent to exfiltration ponds or to land is presently also practised by five of the plants, but further evaluation of this procedure would be necessary to fully understand the possible effects of these discharges on groundwater sources.

SETTLING

Use of a settling pond prior to discharge was noted at one plant (see Table III - Plant No. 1) The analytical results for the grab sample indicates that in providing quiescent conditions, there is a measurable reduction in the oxygen demand and solids concentration of the wastewater.

However, as indicated by the bioassay results, a significant portion of the toxic constituents in the wastewater are dissolved or colloidal and could not be adequately removed by physical means such as settling.

BIOLOGICAL TREATMENT

Two plants presently provide biological treatment - one an extended aeration system, and the other a conventional bio-pond system.

(a) EXTENDED AERATION

The treatment facility consists of an earthen lagoon designed to retain the wastewater flow for approximately eleven months. Spaced equally along the floor of the lagoon are lengths of perforated plastic pipes. These pipes are connected to a continuously operating air compressor which supplies air to the lagoon. The established aerobic biomass utilizes and degrades the various waste components thereby improving the effluent quality. Over a one month period during the spring freshet the treated contents of the lagoon are drained to a nearby watercourse.

For the analytical results on the collected sample see Table III - Plant No. 3.

At the time of this survey, the planned draining of the lagoon contents was to be in approximately one months time. The grab sample therefore is presumed to be representative of the effluent characteristics.

The effectiveness of this system is marginal. This is probably due to (1) insufficient aeration and (2) climatic conditions. Due to the low temperatures during the winter months the biomass activity is minimal which results in essentially no biological treatment of the lagoon contents. (Note: The temperature of the lagoon contents at the time of the visit was 0°C.) As the warmer spring months advance the biomass becomes more active and exerts an increased demand for oxygen. However, if the air compressor is incapable of providing sufficient oxygen to meet the demand for oxygen, biological treatment would be limited. The likely end result is that the lagoon contents are inadequately treated.

(b) CONVENTIONAL AERATION

This consists of two aerated earthen lagoons connected in series. Following the bioponds, the effluent is filtered and then discharged to an exfiltration pond.

A continuous flow is directed through this system and in this manner differs from the periodic release from the extended aeration lagoon. The incoming wastewater is consistantly between 20 - 30°C and the heat content in the influent is probably sufficient to maintain the temperature in the lagoon at a level which sustains moderate biological activity. (Note: The biopond temperature was 11°C at the time of the visit). From the results of the grab sample obtained (see Table III - Plant No. 9) this system appears to function well.

DISCUSSION OF RESULTS

TOXIC CONSTITUENTS

For each sample collected at a plant, three parameters which are known to cause toxicity were measured. These were phenols, resin acid soaps and tannin-lignins. From these analyses on log-conditioning wastewater, it was thought that the data would provide insight into the toxicity threshold concentrations of the combined constituents and further information on the toxicity threshold concentration of individual constituents.

All three compounds in sufficient concentrations are toxic to fish. A wide range of phenol concentrations have been reported to be toxic to various fish but...

generally the phenol concentration which will not interfere with any designated beneficial use for fish and aquatic life is 0.2 mg/ℓ [1].

From the same reference [1], resin acids have been reported to be toxic to fish at concentrations as low as 1.0 mg/ℓ. However well documented information on toxicity characteristics of resin acid soaps and tannin-lignins, and designated concentrations for these constituents which do not adversely effect fish are not known.

From the results of samples collected (Figures 4,5,6, and 7) and the calculated concentrations of phenols, RAS and tannin-lignins in the bioassay solutions (Table IV), combined with the literature information, the indication is that for log-conditioning effluent to be non-toxic the following concentrations should not be exceeded:

phenols <0.2 mg/ℓ
RAS <0.5 mg/ℓ
tannin-lignin <500 mg/ℓ

This observation agrees favourably with the result for the effluent from the biopond of Plant No. 9:

phenols = 0.015 mg/ℓ
RAS = 0.50 mg/ℓ
tannin-lignin = 480 mg/ℓ

OXYGEN DEMAND AND TOTAL ORGANIC CARBON

An attempt was undertaken in this study to determine if a simple mathematical relationship existed between three parameters (BOD_5, COD and TOC), for if it did, further laboratory analyses on log-conditioning effluent could be significantly reduced and simplified.

For the laboratory results correlations were drawn between BOD_5 and TOC, and COD and TOC. The equations of the claculated lines of best fit and the correlation coefficient are as follows:

$$BOD_5 = 49 + 1.29\ TOC\ (r = 0.976)\ \ldots\ldots\ldots\ldots(1)$$

$$COD = 214 + 2.60\ TOC\ (r = 0.971)\ \ldots\ldots\ldots\ldots(2)$$

The slopes of the above two equations are significant at the 0.005 level. Equations (1) and (2) from the linear regression analyses are also shown in Figures 8 and 9.

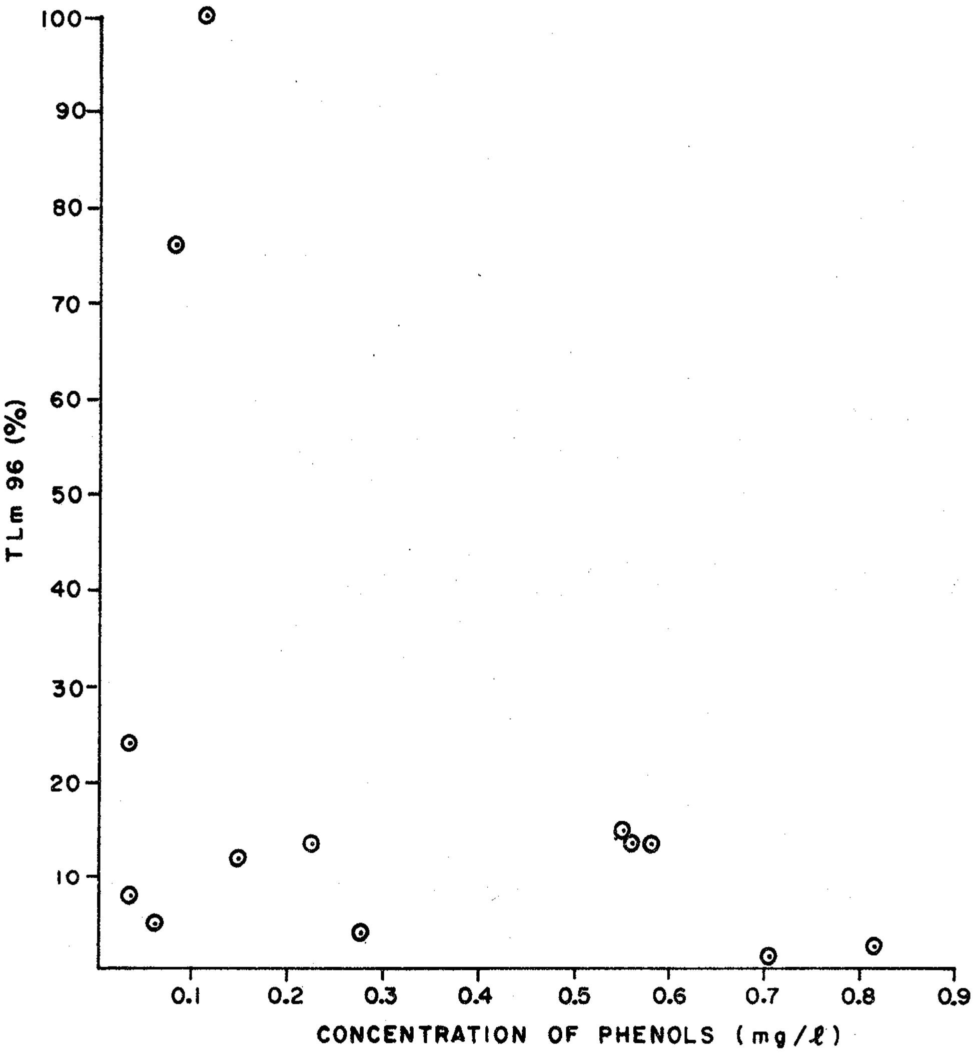

FIGURE 4 - TOXICITY OF LOG-CONDITIONING WASTEWATER vs PHENOLS CONCENTRATION.

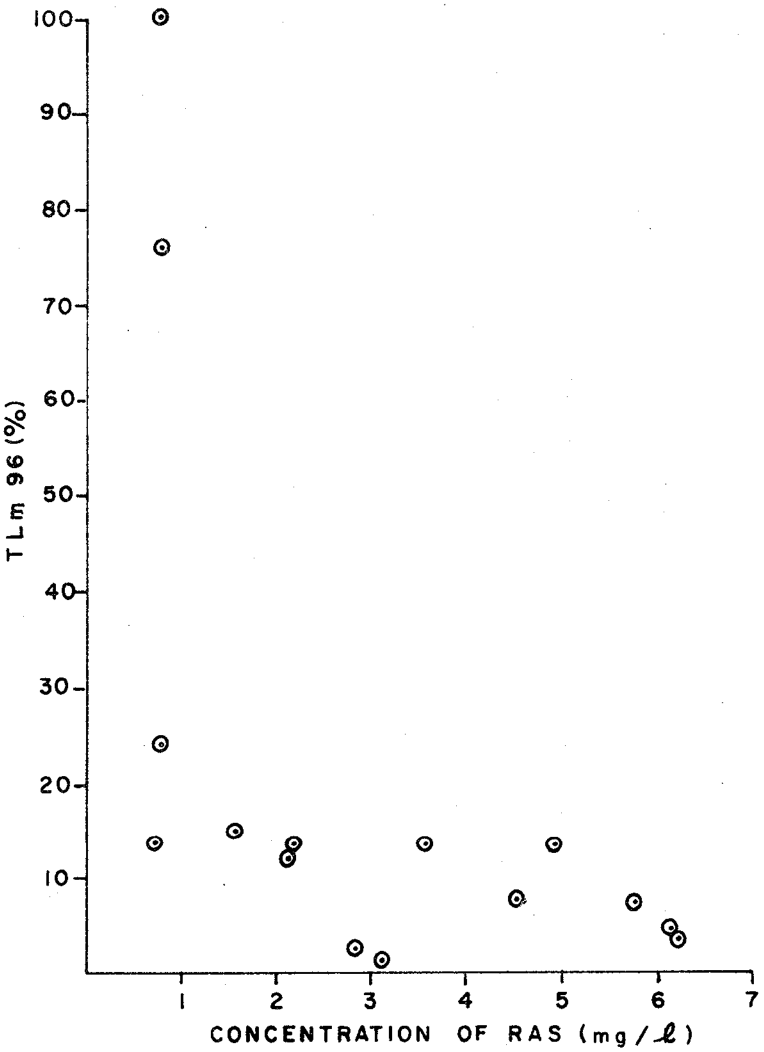

FIGURE 5 - TOXICITY OF LOG-CONDITIONING WASTEWATER vs RESIN ACID SOAP CONCENTRATION.

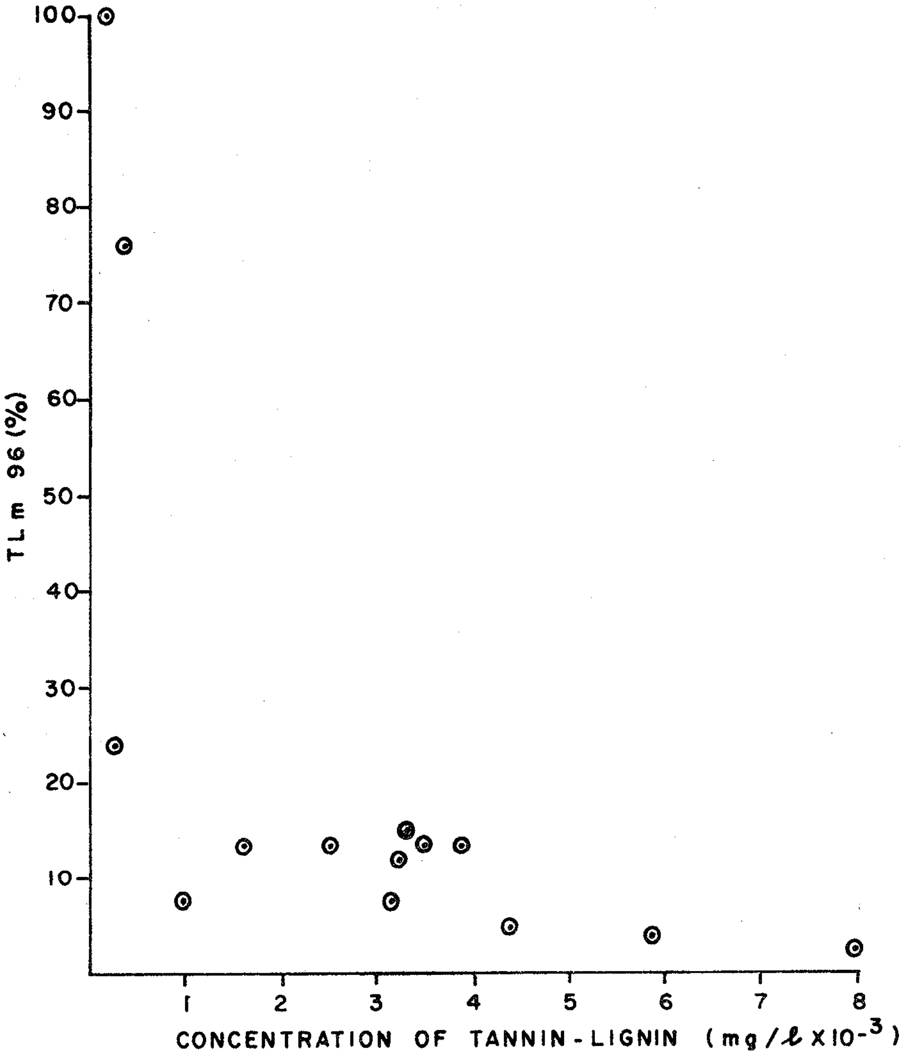

FIGURE 6 - TOXICITY OF LOG-CONDITIONING WASTEWATER vs TANNIN-LIGNIN CONCENTRATION.

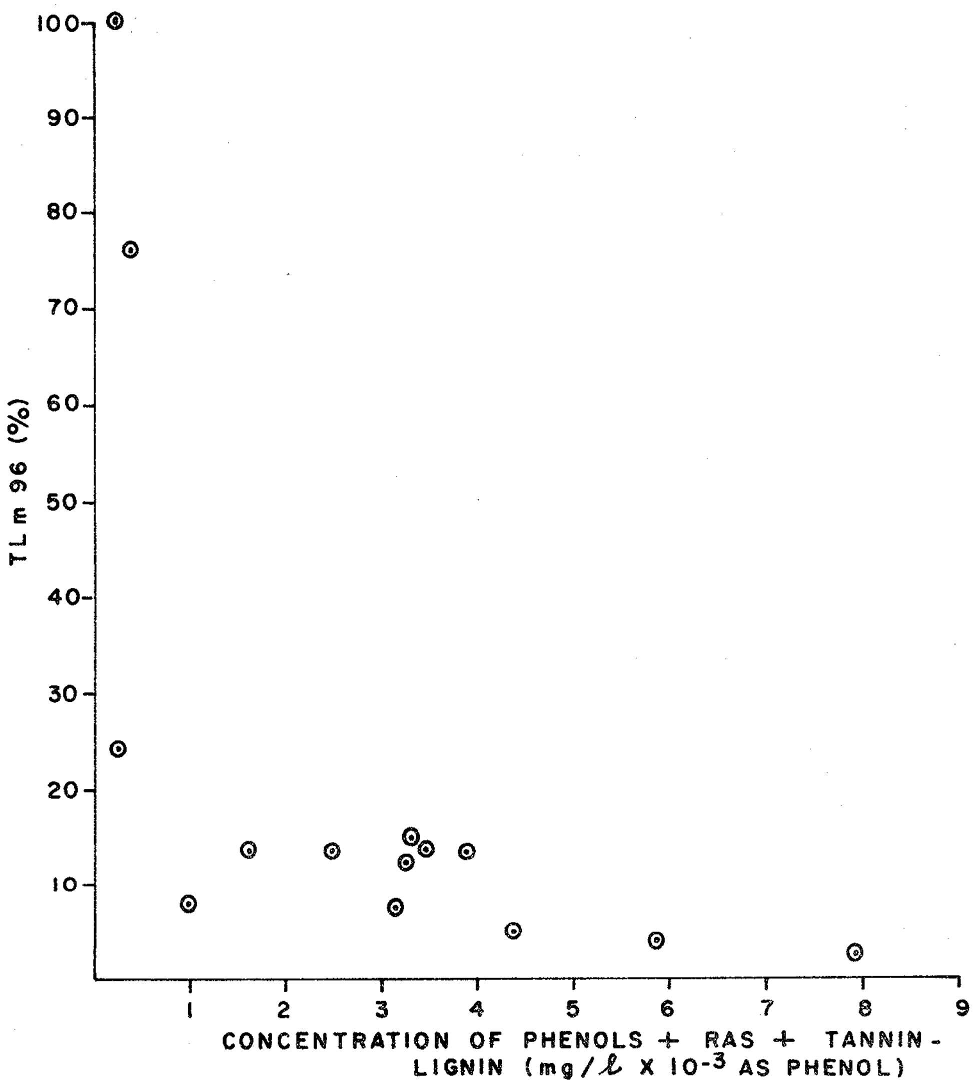

FIGURE 7 - TOXICITY OF LOG-CONDITIONING WASTEWATER vs TOTAL TOXIC CONSTITUENTS CONCENTRATION.

Plant No.	TLm - 96 (%)	Phenols* (mg/ℓ)	RAS (mg/ℓ	Tannin-lignin (mg/ℓ)	Threshold of Toxicity (%)	Phenols (mg/ℓ)	RAS (mg/ℓ)	Tannin-lignin (mg/ℓ)
1	1.35	.0095	.042	413.7	1.0	.0070	.031	306.5
	15	.0825	.236	495.0	10	.0550	.157	330.0
2	24	.0082	.190	64.8	18	.0061	.142	48.6
3	13.5	.0783	.095	337.5	10	.0580	.070	250.0
	76	.0608	.585	304.0	32	.0256	.246	128.0
4	4.8	.0029	.294	209.0	3.2	.0019	.196	39.4
5	13.5	.0756	.478	522.5	10	.0560	.354	387.0
6	7.7	.0027	.347	74.5	5.6	.0020	.252	54.2
7	2.4	.0196	.067	190.2	1.8	.0147	.050	142.7
8	13.5	.0304	.289	216.0	10	.0225	.214	160.0
	100	.1120	.750	210.0	56	.0627	.420	117.6
9	13.5	-	.660	468.0	10	-	.490	346.7
	-	-	-	-	(non-toxic)	.0150	.500	480.0
10	12	.0200	.252	432.0	5.6	.0083	.118	179.2
11	7.2	-	.414	225.0	3.2	-	.184	100.0
12	3.9	.0107	.242	226.4	1.8	.0050	.112	104.5
13†	-	-	-	-	-	-	-	-

*The figures listed in this table for phenols, RAS and tannin-lignins are calculated values based on the results for the TLm-96 and Threshold of Toxicity and the concentration of each constituent in the original sample. For sample calculations see Appendix B.

†Not in operation at time of survey.

TABLE IV - CALCULATED CONCENTRATIONS OF PHENOLS, RAS AND TANNIN-LIGNINS FOR THE BIOASSAY DETERMINATIONS

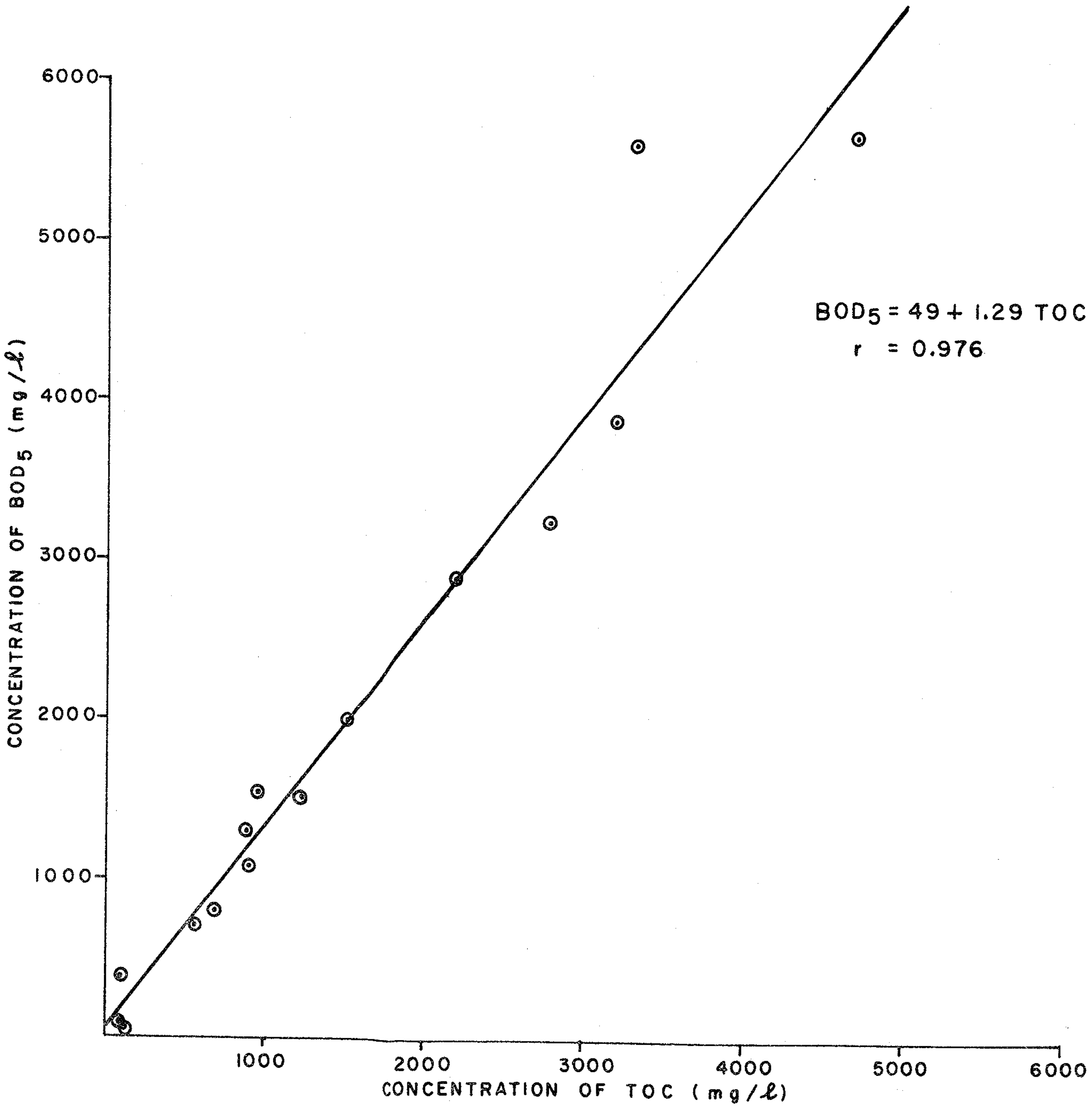

FIGURE 8 - TOC vs BOD_5 FOR LOG-CONDITIONING WASTEWATER

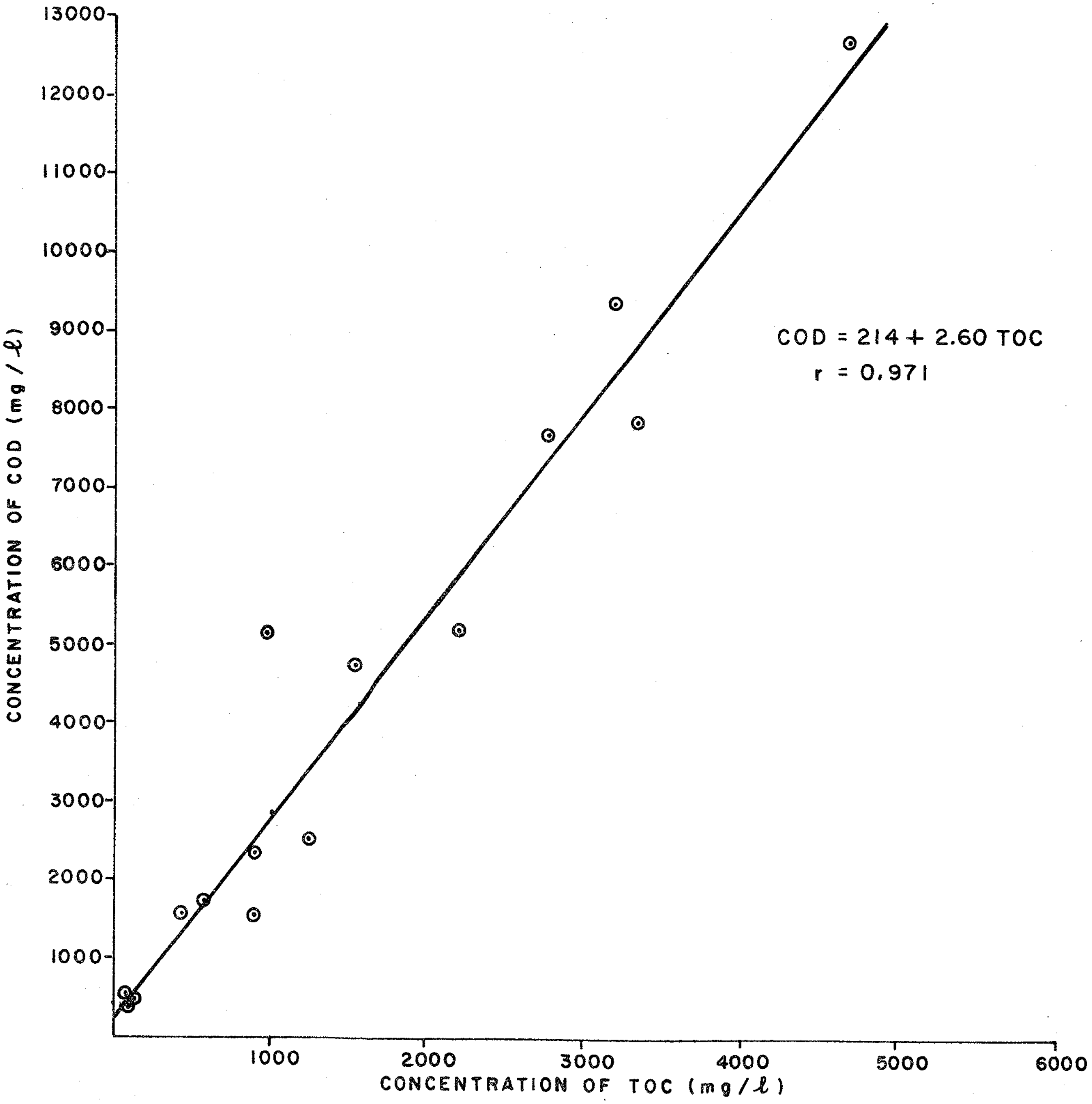

FIGURE 9 - TOC vs COD FOR LOG CONDITIONING WASTEWATER

CONCLUSIONS AND RECOMMENDATIONS

This program was directed to the development of preliminary guidelines for the disposal and/or treatment of log-conditioning wastes for the interior of British Columbia. Whereas the conclusions and recommendations pertain to those plants visited, the findings in this study, are believed to be applicable on a general basis.

With regard to this study the following conclusions were reached.

(1) Untreated wastewater from either hot water or steam conditioning chest can cause severe pollution problems.

(2) Wastewater from log-conditioning chests is acutely toxic to the test fish.

(3) Direct disposal of untreated wastewater to lakes or streams is an unsuitable method of ~~a~~ disposal.

(4) Direct disposal of untreated wastewater to exfiltration ponds is a more acceptable method but further studies are necessary to determine the effects of these discharges on groundwater supplies.

(5) To appreciably decrease the toxicity of the effluent additional treatment other than settling is required.

(6) Biological treatment of log-conditioning effluent produces a more acceptable effluent with regard to toxicity and pollution problems.

(7) The heat value of the wastewater should be used efficiently to aid biological degradation of the waste.

Since this study was only a preliminary undertaking, the general recommendations for future studies are (1) a monitoring program on these plants to determine the variability of the wastewater characteristics; (2) a monitoring program on present biological systems, and, (3) a study on the effects of these discharges on groundwater sources.

Acknowledgments

We wish to thank the plant managers and members of their staff for the assistance afforded us during this survey. Special appreciation is due to Mr. John Watkins for his help in authoring this report and to Miss Maria Pichichero for compiling and typing this report.

Bibliography

[1] McKee, J.E., Wolf, H.W., Water Quality Criteria, Publication 3-A, State Water Resources Control Board (April, 1971).

[2] APHA, AWWA, WPCF, Standard Methods for the Examination of Water and Wastewater (1971). American Public Health Association, Inc., 13th Edition.

[3] NCASI Technical Bulletin No. 11 (1947).

[4] Kamloops Pulp and Paper Co. Limited. Technical Department Procedure (October 6, 1967).

Appendix A

Definition of parameters:

(a) Analytical Determinations

pH - measure of the hydrogen ion concentration. Extreme readings are 0 and 14. Neutral pH is 7. Abnormally high or low pH readings are known to cause toxicity to fish. Normally accepted levels of pH are 6.5 to 8.5. pH Hach Kits were used for field measurements; lab measurements were completed as according to Standard Methods [2].

BOD_5 - the five day biochemical oxygen demand (BOD) determination measures the quantity of oxygen required for the stabilization of the oxidizable organic matter by aerobic bacteria within a specified time (5 days) and at a given temperature (20°C). When discharged to a watercourse, wastes with high BOD concentrations cause reductions in the oxygen level of the receiving waters and consequently pose a danger to aquatic life. BOD determinations were completed as outlined in Standard Methods [2] with the exception that there was no seeding of the dilution water.

COD - the chemical oxygen demand determination provides a measure of the total quantity of oxygen required for oxidation to carbon dioxide and water of most organic compounds, by the action of strong oxidizing agents under acid conditions. The COD test in conjunction with the BOD test sometimes is helpful in indicating toxic conditions and the presence of biologically resistant organic substances. COD determinations were completed as according to Standard Methods [2].

TR - the total residue by evaporation determination measures the amount of solids present in the sample. This includes dissolved and suspended solids. TR determinations were completed as according to Standard Methods [2].

TOC - the total organic carbon determination measures the quantity of organic carbon present in the sample. The TOC result when compared to the BOD_5 result for a waste, gives valuable clues concerning the characteristics of the organic constituents in the sample. A Beckman Total Carbon Analyzer Model 915 was used for the TOC determinations. For these determinations, the procedure as outlined by the Beckman corporation for the Model 915 analyzer was followed.

Phenols - this determination measures the quantity of phenols present in the wastewater. Only phenols of a low molecular weight will be measured in this determination. Interferences occur when the para position to the phenolic hydroxyl is occupied. The method is only an approximation representing the minimum phenol present. The results are expressed as mg/ℓ phenol assuming one OH group per benzene ring (i.e. C_6H_5OH). Phenols are known to be toxic to fish at low concentrations. For these determinations, the procedure for the antipyrine dye formation method as outlined in Standard Methods [2] was followed.

Tannin-Lignin - this determination measures the quantity of an extremely complex group of poly phenolic compounds present in a sample and not specifically tannins and lignins. The results are therefore estimates of the tannin-lignin concentration. Tannins and lignins are known to cause toxicity problems with fish and aquatic life. The results are reported as mg/ℓ phenol assuming one OH group per benzene ring. The determinations were completed as according to Standard Methods [2].

RAS - the resin acid soaps determination estimates the resin acid soaps by the Liebermann resin reaction. In the determination metallic resinates, resin acid salts, all resin acids and resinates driers are converted to and measured as abietic acid, a resin acid. This method provides only an estimate of resin acids due to interferences from sterols, terpenes and humus. More precise techniques are being developed. Resin acid soaps are known to be toxic to fish at low concentrations. The determinations were completed as according to references [3]and [4].

(b) BIOASSAY DETERMINATIONS

TLm 96 - the median tolerance limit (TLm) is defined as the concentration of a substance evoking 50% response (i.e. mortality) in a sample of test animals within the prescribed exposure intervals (e.g. 96 hours).

Threshold of Toxicity - the threshold of toxicity is defined as the concentration of a substance evoking the first response (i.e. mortality) in a sample of test animals within the prescribed exposure intervals (e.g. 96 hours).

APPENDIX B

SAMPLE CALCULATIONS FOR TABLE IV

In calculating the phenols concentration for Plant No. 1, the dilution water used for the bioassay determinations was assumed not to be contaminated with phenols, RAS or tannin-lignins.

Phenols concentration of the collected sample (for Plant No. 1) is 0.704 mg/ℓ.

(a) TLm - 96 = 1.35%

$$(1.35)\ (0.704) + (98.65)\ (0) = 100(x)$$

x(calculated phenols concentration in bioassay solution) = 0.0095 mg/ℓ

(b) Threshold of toxicity = 1.0%

$$(1.0)\ (0.704) + (99.0)\ (0) = 100(y)$$

y(calculated phenols concentration in bioassay solution) = 0.0070 mg/ℓ

The same calculations were completed for each sample and listed in Table IV.