A PRELIMINARY STUDY ON THE FLOTATION WASTEWATER FROM APPLE PACKING PLANTS IN THE OKANAGAN REGION OF BRITISH COLUMBIA

by

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1. INTRODUCTION

The apple processing industry in the Okanagan is maintained by a large number of fruit cooperative unions, seven of which are studied in this report. The plant operations include washing, waxing, sorting, grading and packaging. The operating season for these plants begins in September and continues through to the following spring.

The main source of contaminated wastewater from these plants is the flotation wash. Wastewater from this operation is normally dumped once a week in a single batch discharge. Most of the plants studied discharge untreated wastewater into natural water courses including Okanagan Lake.

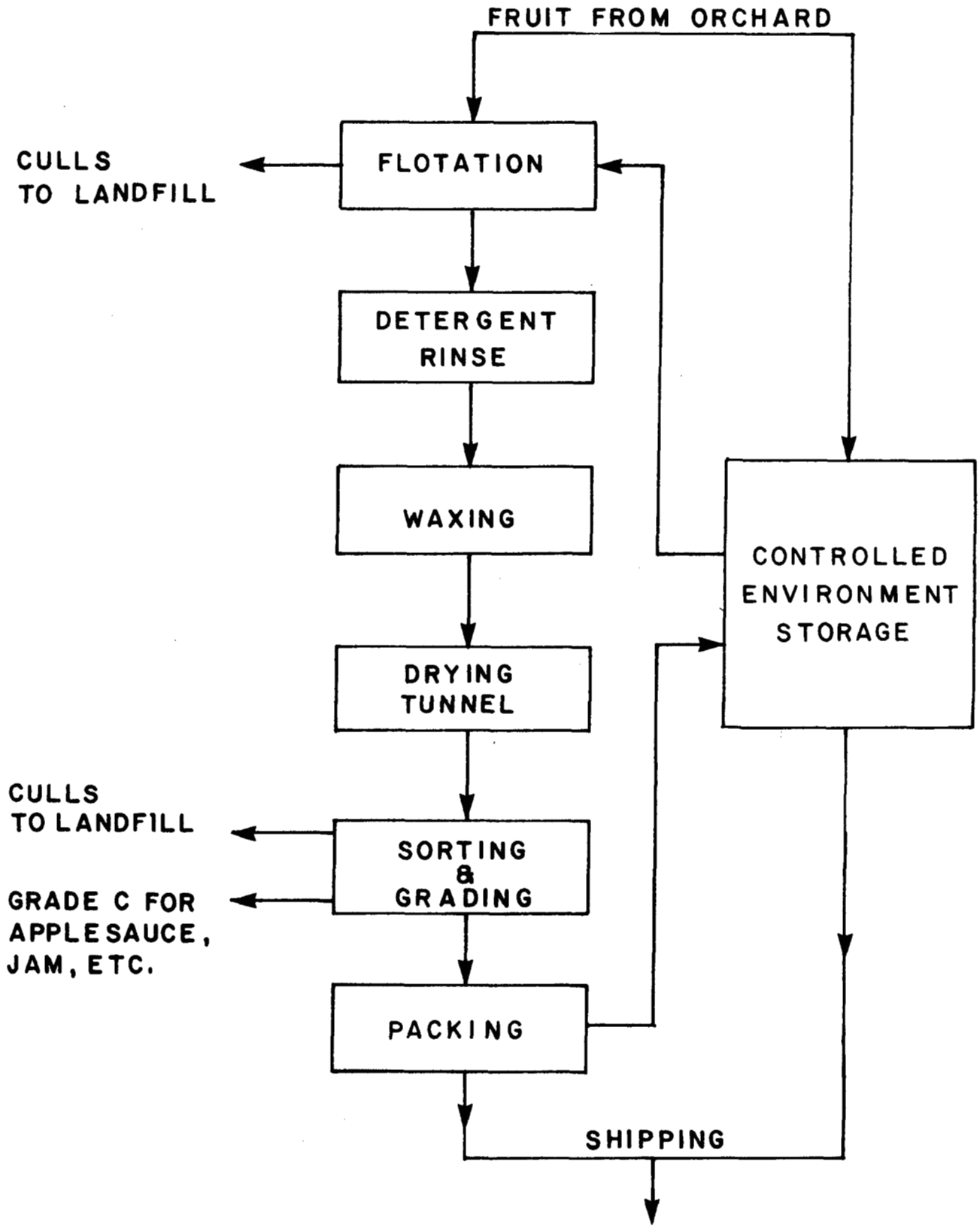
The principal objective of the survey was to obtain information on possible deleterious effects of the wastewater discharges on the receiving water environment. The samples collected were forwarded for analysis to the Environment Canada Laboratory in West Vancouver. The sampling techniques and analytical methods are detailed later in the report.

1.1 Apple Processing Plant Operation

The method of operation outlined in this report is typical of the production lines found throughout the industry. A flow sheet of general operations is represented in Figure 1.

The apples are transferred from the orchards in 850 pound crates and stored in controlled environment warehouses at a temperature slightly above freezing. The processing begins with the immersion of the crate into a flotation tank where soil, leaves and most of the adhering solids are separated from the fruit. The apples are transported along a shallow trough which is connected at one end to the flotation tank and at the other end to a belt conveyor as shown in Figure 2. At this point some of the inferior apples termed "culls" are removed from the line. The apples in the trough are picked up by the belt and transported through a detergent spray which removes any adhering residue from the apples. The run-off

FIGURE I. APPLE PROCESS LINE



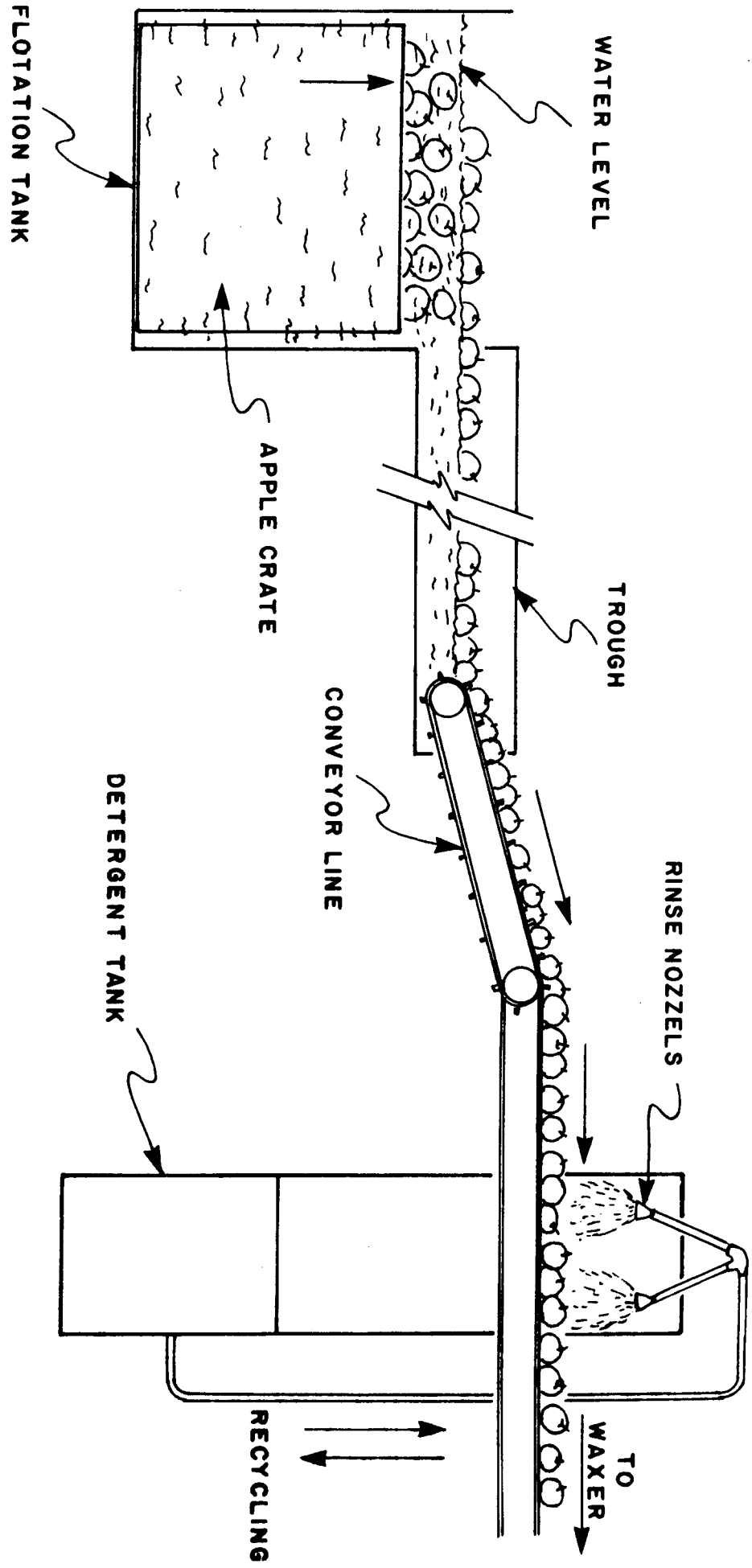


FIGURE 2. FLOTATION AND RINSE LINE

water from this operation is collected in a tank and recycled to the spray nozzles. Following the detergent rinse, the apples are coated with a fine spray of vegetable wax. The apples are then dried with warm air and subsequently graded and the remainder of the culls are removed. Finally the graded apples are packed in boxes prior to shipping.

1.2 Sources of Wastewater

The principal source of contaminated wastewater is the flotation rinse system. This consists of both the tank water and the trough water with a combined volume ranging from 800 to 2,700 Imperial gallons. This water is emptied periodically as a batch discharge. In addition, small quantities of water originating from leaks and spills on the line are continuously being discharged.

The detergent rinse water volume ranges from 80 to 150 Imperial gallons and is released as a batch discharge usually at the end of each day. Table 1 outlines the wastewater volumes and discharge frequencies for the respective operations.

Domestic wastewater in most operations is discharged to a septic tank and tile field. The cooling water from the storage area is continuously being discharged during the operating season and the volumes discharged range from 100,000 to 500,000 Igpd. Cooling water discharges are usually released into the same receiving system as the flotation water.

2. METHODS AND MATERIALS

Seven processing plants were studied in this report. The grab samples collected from the flotation line at each plant were:

i. five gallons in a plastic jerry can for bioassay;

ii. one gallon in a polyethylene bottle for chemical analysis.

The samples were kept cold and transported to the laboratory facilities located in West Vancouver, where the tests were performed. Analytical determinations were carried out as outlined in Standard Methods[1].

[1] Standard Methods, 13th edition, A.P.H.A., A.W.W.A., W.P.C.F.

TABLE 1. WASTEWATER VOLUMES AND DISCHARGE FREQUENCIES

Company	Fruit Production	Wastewater Volumes (I.G.)		Discharge Frequencies	
	Tons per Day	Flotation	Detergent	Flotation	Detergent
A	65	2315	174	weekly	daily
B	60	2318	162	*biweekly	daily
C	60	1651	150	weekly	daily
D	60	1028	81	weekly	daily
E	90	2322	236	weekly	daily
F	50	2754	187	weekly	daily
G	90	3164	166	*biweekly	daily

* Biweekly - Once every two weeks.

Bioassays were not collected at every plant due to varying plant operating schedules and laboratory restrictions.

For each sample collected the following parameters were measured:

(a) Bioassay Test - TLm_{96} - the Median Tolerance Limit is defined as the concentration of sample at which 50% of the test fish survive after a 96 hour exposure time. Various dilutions of the effluent were made up and each dilution was set up in a ten litre aquarium. The aquaria were placed in a water bath held at 11°C ± 1°C and the dissolved oxygen content of each dilution was maintained at or above 9.5 mg/ℓ by continuous aeration. Underyearling coho salmon (Oncorhynchus kisutch)were used as the test fish in each sample.

The mortality versus time for each dilution was plotted on a graph and a TLm_{96} was established[1].

The loading densities represent the ratio of the weight of fish to the volume of water used in each test. This ratio is expressed in grams per litre and it should be noted that in general the higher the loading density used the longer the fish survival time, or alternatively, the less stress placed on the test fish present. The usually acceptable maximum loading density is one gram per litre.

(b) The five-day Biochemical Oxygen Demand (BOD_5) determination measures the quantity of oxygen required for the stabilization of the oxidizable organic matter by aerobic bacteria within a period of five days at a temperature of 20°C.

When discharged to a water course, wastes with high BOD_5 concentrations may cause reductions in the oxygen level of the receiving waters and consequently pose a danger to aquatic life.

[1] See bioassay records, Bioassay Laboratory, EPS, Pacific Region

(c) Total Organic Carbon (TOC) determination measures the quantity of organic carbon present in the sample. The TOC results when compared to the BOD_5 results for a waste, give valuable information concerning the characteristics of the organic constituents in the sample. In cases where there are no toxic constituents in the sample, the ratio of the BOD_5 to the TOC is usually greater than 1. A Beckman Total Carbon Analyzer Model 915 was used for TOC determinations. For these determinations, the procedure as outlined by the Beckman Corporation for the Model 915 analyzer was followed.

(d) The Total Residue (TR) determination measures the amount of solids present in the sample. This includes dissolved and suspended solids.

(e) The Non-Filterable Residue (NFR) is that portion of the total residue retained by a (1) micron filter. It represents the total suspended solids found in the sample.

(f) The Total Phosphate ($T.PO_4$) determination measures the quantity of phosphates (compounds such as Na_3PO_4, HPO_4, $Na_3(PO_3)_6$) both inorganic and organic present in a sample.

(g) pH is a measure of the hydrogen ion concentration on a scale from 0 to 14, with 7 being neutral value. Waters below pH 7 are acidic; above pH 7 are basic. Abnormally high or low levels of pH are known to cause toxicity to fish. The normally accepted range is pH 6.5 - 8.5.

3. RESULTS AND DISCUSSION

The chemical analyses as outlined in Table II do not indicate any significantly high concentrations of the parameters considered. The residue data shows that the majority of the solids in the effluent exist as dissolved matter. The levels of biochemical oxygen demand and total

organic carbon are not high enough to indicate that any significant oxygen depletion of the receiving water would occur. However, the fact the biochemical oxygen demand over a five day period is consistently lower than the total organic carbon, indicates the presence of some toxic compound which inhibits the biological breakdown of the organic materials in the sample. The phosphate levels would only be of concern if the wastewater was discharged to a small, confined receiving water. The pH levels are all well within acceptable limits (pH 6.5 - 8.5).

The bioassay results shown in Table III, indicate that the four samples taken were toxic to fishlife. The toxicity appears to increase with the age of the flotation water.

The only known toxic substances associated with the apples are the various pesticides used by the growers. These include organochlorines, organophosphates and elemental sulfur, all of which were detected in samples of the wastewater. The analyses were performed by the Environmental Management Service, Water Quality Laboratory in North Vancouver.

The specific compounds could not be identified and therefore quantitative analysis was impossible but the pesticide residues found in the samples are the suspected source of toxicity.

4. CONCLUSIONS

This study was performed for the purpose of determining the potential effects on the environment due to the wastewater discharge from the apple processing industry. As a result the following conclusions were reached:

(a) The apple processing industry is in some cases discharging batches of wastewater which are proven to be toxic to fish.

(b) The toxicity seems to increase with the usage time of the flotation water.

(c) There is indication of the presence of pesticide residues, including organochlorines, in the flotation water. This is the most probable source of toxicity.

TABLE 2. ANALYTICAL RESULTS OF FLOTATION WATER

Company	pH	BOD_5 mg/ℓ	TOC mg/ℓ	TR mg/ ℓ	NFR mg/ℓ	$T.PO_4$ mg/ℓ
A	7.0	53	88	144	46	1.0
B	7.3	20.5	98	619	101	0.51
C	7.4	150	368	1,540	381	2.8
D	7.2	34	112	914	71	1.0
E	7.1	77	140	666	31	1.7
F	7.2	19.5	64	662	78	0.73
G	7.0	11	31	270	18	0.35

Average ratio of BOD_5 to TOC is 0.39.

TABLE 3. BIOASSAY RESULTS FOR FLOTATION WATER

Company	Flotation Water Usage Interval	*Fish Loading Density (g/ℓ)	TLm_{96} (Bioassay) (% by volume)
A	2 days	2.43	75.0%
B	- -	- -	- -
C	- -	- -	- -
D	- -	- -	- -
E	- -	- -	- -
F	7 days	3.21	3.2%
G	4 days	3.21	18.0%
	14 days	2.06	13.5%

* The loading densities in all tests were higher than the recommended one gram per litre maximum, and therefore the toxic limits shown are probably higher than they would have been had the recommended loading densities been used.

5. RECOMMENDATIONS

This study was only intended to provide a preliminary report, but certain definite problems have been recognized. On the basis of the above conclusions the following recommendations are presented:

(a) The wastewater from the flotation and rinse operations should be diverted to a suitable treatment system as an interim measure against further contamination of the receiving waters.

(b) A sampling program should be undertaken to study, in detail, all aspects of water contamination originating from all fruit packing operations.

(c) Studies should be carried out on the use of pesticides in the Okanagan region. These studies should include the methods of application, the characteristics of the pesticides and the impact of their residues on the environment. In addition, pesticides with less harmful environmental characteristics should be investigated as alternatives.