Papers Presented at First Ontario INDUSTRIAL WASTE Conference

June 15th, 16th, 17th, 18th
1954

SPONSORED BY
THE POLLUTION CONTROL BOARD
OF ONTARIO

AT THE
Ontario Agricultural College
Guelph, Ontario.

FIRST

ONTARIO INDUSTRIAL WASTE CONFERENCE

This is a copy of the papers presented at the First Ontario Industrial Waste Conference. It was held at the Ontario Agricultural College at Guelph on June 15th to 18th, 1954. The Conference was sponsored by The Pollution Control Board of Ontario in an effort to focus attention on the industrail waste problem and to obtain the views of those who were well qualified to discuss waste treatment methods. The papers are printed in the order in which they appeared on the program.

Industrial wastes are one part of the pollution problem which faces all countries to-day. Municipal sewage is the other. Ontario is growing industrially at a fast pace. The problems involved in waste disposal are many and complex. They change rapidly with the development of new processes and new products. This first conference dealt with some of the many industrial wastes. Publication of the papers in this brochure is done with the objective of making this information available to a large number of persons and in that way to aid in the program of pollution abatement and control.

The Pollution Control Board is concerned with the effects of all kinds of pollution. The Board members come from those departments of Government interested in or having obligations in respect to pollution control. By acting jointly as a Board there can be co-ordination of efforts irrespective of the effect pollution may have on the many uses which are made of water and air in this Province.

The Pollution Control Board is sincerely grateful to The Honourable Mackinnon Phillips, M.D., C.M., Minister of Health, to Doctor J. D. MacLachlan, B.A., A.M., Ph.D., President of The Ontario Agricultural College and to all members of the staff of the College and the ladies who were responsible for planning the activities at the College, and to the authors of papers who so generously gave of their knowledge and time to assist in this major problem of pollution control.

For further information write to:

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Toronto, Ontario.

FIRST ONTARIO INDUSTRIAL WASTE CONFERENCE

- Sponsored By -

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GROUP RESEARCH ON INDUSTRIAL WASTES

- By -

A. D. McRAE

IMPERIAL OIL LIMITED

INTRODUCTION

ALTHOUGH MANY COOPERATIVE RESEARCH PROJECTS HAVE BEEN CARRIED OUT BETWEEN GOVERNMENT AND INDUSTRY ON PROBLEMS OF FUNDAMENTAL RESEARCH AND APPLIED RESEARCH, THERE HAS BEEN NO APPLICATION OF THIS VERY USEFUL PROCEDURE TO THE PROBLEM OF INDUSTRIAL WASTES. IT IS THE PURPOSE OF THIS PAPER TO DESCRIBE A COOPERATIVE RESEARCH PROJECT CARRIED OUT UNDER THE AUSPICES OF THE ONTARIO RESEARCH COUNCIL AND A GROUP OF SARNIA INDUSTRIES IN AN EFFORT TO ASSESS THE MAGNITUDE OF AIR AND WATER POLLUTION IN THE AREA.

COOPERATIVE RESEARCH IN GREAT BRITAIN(1)

IN THE LATTER PART OF THE 19TH AND THE EARLY YEARS OF THE PRESENT CENTURY THE LEADERS OF SCIENCE AND INDUSTRY IN GREAT BRITAIN WERE INCREASINGLY CONCERNED AT THE LACK OF CONTACT BETWEEN SCIENTIFIC RESEARCH AND INDUSTRIAL PRACTICE. THE MOST NOTABLE ACHIEVEMENT ALONG THESE LINES WAS THE ESTABLISHMENT OF THE NATIONAL PHYSICS LABORATORY IN 1900 AND THE FOUNDATION OF THE IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY IN 1907. FURTHER ACTION AND ADDITIONAL GOVERNMENT HELP BECAME EVEN MORE URGENT AT THE OUTBREAK OF THE FIRST WORLD WAR, AND IN 1915 THE ADVISORY COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH WAS CREATED "IN ORDER TO PROMOTE AND ORGANIZE SCIENTIFIC RESEARCH WITH A VIEW ESPECIALLY TO ITS APPLICATION TO TRADE AND INDUSTRY".

AFTER THE WAR, IT WAS ESSENTIAL THAT BRITAIN REGAIN THE LEAD IN INDUSTRIAL DEVELOPMENTS OR THE ECONOMY OF THE COUNTRY WOULD BE AT A VERY LOW EBB DUE TO RESTRICTED WORLD MARKETS. DURING THE PERIOD PRECEDING THE SECOND WORLD WAR THE RESEARCH ASSOCIATIONS FOUND DIFFICULTY IN CARRYING ON DUE TO LACK OF CAPITAL, LABORATORY FACILITIES AND ADVERSE ECONOMICAL CONDITIONS IN THE COUNTRY.

THE SCALE OF OPERATIONS INCREASED, HOWEVER, DURING THE WAR DUE TO THE DEMANDS MADE ON THEM BY THEIR INDUSTRIES AND BY GOVERNMENT DEPARTMENTS, AND, OF COURSE, A CORRESPONDING INCREASE IN THEIR INCOME WAS AVAILABLE.

THE POST WAR YEARS HAVE SEEN AN EVEN GREATER EXPANSION OF THE RESEARCH ASSOCIATION MOVEMENT. THERE ARE NOW 42 ASSOCIATIONS WITH A TOTAL INCOME OF 3.4 MILLION POUNDS STERLING OF WHICH 1.25 MILLION POUNDS STERLING IS A GOVERNMENT GRANT. THESE ASSOCIATIONS VARY GREATLY IN SIZE, THE LARGEST HAVING AN INCOME OF ABOUT 400,000 POUNDS STERLING WITH THE MAJORITY RANGING BETWEEN 20,000 AND 100,000 POUNDS STERLING. THE TOTAL STAFF IS NOW APPROACHING 4,000 PEOPLE, OF WHICH 1,000 ARE OF GRADUATE STANDING. THE GOVERNMENT, AT THE END OF THE WAR, DECIDED THAT THEIR GRANTS WOULD FORM A PERMANENT PART OF THE NORMAL INCOME AND SPECIAL GRANTS WOULD BE AVAILABLE FOR CAPITAL DEVELOPMENT.

WITH THE ASSURANCE OF CONTINUED GOVERNMENT SUPPORT PLUS THE SUBSTANTIAL CONTRIBUTION BY INDUSTRY, IT CAN BE ANTICIPATED THAT THE RESEARCH ASSOCIATIONS WILL CONTINUE TO GROW IN NUMBER AND SIZE AND TO MAKE AN INCREASING CONTRIBUTION TO INDUSTRIAL EFFICIENCY IN GREAT BRITAIN.

THE METHOD OF ASSESSING THE SUBSCRIPTION OF EACH MEMBER FIRM IS BASED ON THE SIZE AND ASSETS. THUS, THE SMALL FIRM, IN GENERAL CONTRIBUTES MUCH LESS THAN THE LARGER ONE, YET IT HAS THE SAME PRIVILEGES, ALTHOUGH AS A RULE IT WILL NOT HAVE THE SAME FACILITIES FOR EXPLOITING THE RESULTS OF RESEARCH. ON THE OTHER HAND, THE SMALL FIRM IS MORE LIKELY TO USE CERTAIN OF THE BENEFITS.

THE INDUSTRIAL ORGANIZATION AND DEVELOPMENT ACT 1947 PROVIDED FOR THE SETTING UP OF DEVELOPMENT COUNCILS FOR INDUSTRY. THE ACT GIVES POWERS FOR THE IMPOSITION OF LEVIES TO ENABLE DEVELOPMENT COUNCILS TO MEET THEIR EXPENSES AND TO EXERCISE THEIR FUNCTIONS. IT FURTHER PROVIDES, IF IT IS CONSIDERED EXPEDIENT, LEVIES ON INDUSTRIES WHERE THERE IS NO DEVELOPMENT COUNCIL.

COOPERATIVE RESEARCH CARRIED OUT THROUGH RESEARCH ASSOCIATIONS SERVES A NUMBER OF PURPOSES ESSENTIAL TO THE NATIONAL WELL-BEING. THE EXTENT TO WHICH THE EXPERIENCE OF THE UNITED KINGDOM IS TRANSFERABLE TO OTHER COUNTRIES IS FOR THEM TO DETERMINE. CANADA IS THE ONLY OTHER COUNTRY AT THE PRESENT TIME WITH A SIMILAR SCHEME, ALTHOUGH INDUSTRIAL RESEARCH DEPARTMENTS, GOVERNMENT LABORATORIES AND INSTITUTES FOR SPONSORING RESEARCH ARE WELL-KNOWN ABROAD.

THE DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH WHICH SPONSORS THE COOPERATIVE WORK ALSO MAINTAINS A WATER POLLUTION RESEARCH LABORATORY. THE DEPARTMENT CARRIES ON WORK ON INDUSTRIAL WASTES AND WATER QUALITY IMPROVEMENT, BUT AS FAR AS IT CAN BE LEARNED, INDUSTRY DOES NOT ENTER INTO THIS ACTIVITY ON A COOPERATIVE BASIS. (2)

ANTI-POLLUTION RESEARCH ACTIVITIES IN THE UNITED STATES

MANY STATE SPONSORED PROJECTS TO REDUCE AIR AND WATER POLLUTION HAVE BEEN INSTIGATED IN THE UNITED STATES, AND CITIES SUCH AS LOS ANGELES, PITTSBURGH AND CLEVELAND HAVE

developed their own air pollution reduction programs. Federal assistance is available to the individual States under Law #845 passed in 1948 in respect to water pollution abatement. At the present time, the Federal government has entered the field of research on air pollution. (3) An amendment of the Housing Act of 1954 relating to smoke elimination and air pollution prevention has been proposed and there is every likelihood of the amendment being passed. A sum of $5,000,000. is to be allotted and the Secretary of Health, Education and Welfare will undertake and conduct a program of technical research and studies concerned with:

(a) Costs of air pollution and excessive smoke

(b) Devices and methods for the prevention or elimination of excessive smoke and air pollution, or the collection of atmospheric contaminants.

(c) Guidance and assistance to local communities in smoke abatement and air pollution prevention and control.

The Act will also provide for loans to companies or individual householders to provide smoke abatement and anti-pollution equipment. The investment in such equipment may be amortized over a period of five years rather than the usual ten years specified by the Federal Income Tax Department. This special grant will be provided for a period of four years only which is too short a period to accomplish any long range plan of pollution control. However, it is certainly a generous gesture on the part of the Federal Government in the United States and will materially aid the air pollution abatement program.

Many industrial groups, such as the American Petroleum Institute and the Manufacturing Chemists' Association Inc. are actively engaged in air and water pollution abatement programs and information from these groups is readily available to anyone wishing to start a program of his own.

An example of a State sponsored air pollution advisory service is that of the State of Washington. In 1949, Arthur E. Langlie, Governor of Washington, recognized the seriousness of the air pollution problem and requested the Pollution Control Commission to initiate a survey to secure facts concerning the problems of air pollution as they apply to the State. In the report of the survey, it was recommended that the Governor appoint a State Advisory Committee on Air Pollution which included representatives of industry, community and civic organizations, educational and research institutions, State agencies and others concerned for the purpose of evaluating facts on air pollution and making recommendations as to legislation, policy or further action in the development of a State-wide air pollution program. At the present time after approval of this plan the organization was set in motion, and it is expected that the Washington Air Pollution Control Association will be the prime source of information, assistance and advice. (4)

CANADIAN ACTIVITIES

The Federal Government is chiefly concerned with air and water pollution if it affects International boundary w ters and land boundaries between Canada and the United States, and also if the problem is Interprovincial. The Federal Government, in the first case, makes use of the services of the International Joint Commission, a group represented by a Canadian Chairman with two assistants, and a similar group from the United States. Under the Canadian section a group of technical advisers are appointed from the Department of National Health and Welfare and from the Sanitary Engineering Section of the Department of Public Health of the Province concerned with the pollution problem. At the present time the group concerned with water pollution is operating from Sault Ste. Marie to the Niagara River while the air pollution group are chiefly concerned with pollution abatement in the Windsor-Detroit area.

In the Province of Ontario the Research Council of Ontario functioning under the Department of Planning and Development has an Advisory Committee on the Disposal of Industrial Waste. This Committee is composed of representatives from the Ontario Department of Health, Sanitary Engineering Division, the Ontario universities, industry and municipalites. The group has continued in its activity for a period of some six years in an advisory capacity and has sought for the solution of the problem involving the disposal of various types of industrial waste in the Province. The assistance of the Ontario Research Foundation (Research Laboratories) has been greatly appreciated by the Committee as has the experimental station of the Ontario Department of Health. Another group concerned with pollution control is the recently appointed Pollution Control Board of Ontario which also functions under the above-mentioned Minister. The Chairman of this group is head of the Sanitary Engineering Division, of the Department of Public Health of Ontario, and his Board is composed of representatives from the Department of Lands and Forests, Department of Agriculture, Department of Planning and Development, Department of Mines, Department of Municipal Affairs, The Ontario Research Council, municipalities and universities. (5)

ST. CLAIR RIVER RESEARCH GROUP (6)

FORMATION OF GROUP AND OBJECTIVES

On February 22nd, 1952, Professor A. C. Plewes and Dr. R. K. Stratford of the Ontario Research Council interviewed officials of the Polymer Corporation, Imperial Oil Ltd., and Dow Chemical of Canada, to discuss the possibility of organizing a group to commence studies on air and water pollution in the St. Clair River basin on a group research basis. The above companies were favourable towards the project and a memorandum was presented to the Research Council of Ontario on March 8, 1952 and the scheme, as outlined, was accepted by the Research Council.

A SUB-COMMITTEE OF THE ADVISORY COMMITTEE ON INDUSTRIAL WASTES OF THE COUNCIL WAS FORMED AND IT CONSISTED OF MEMBERS REPRESENTING THE ABOVE THREE COMPANIES, THE ONTARIO DEPARTMENT OF HEALTH AND THE DEPARTMENT OF LANDS AND FORESTS OF ONTARIO. A LOCAL INDUSTRIAL COMMITTEE WAS FORMED FOR THE SARNIA AREA WITH A CHAIRMAN ELECTED FROM THE THREE GROUPS. THE CHAIRMAN'S TERM OF OFFICE CONTINUES FOR 6 TO 12 MONTHS AFTER WHICH A NEW CHAIRMAN WAS CHOSEN FROM THE INDUSTRIAL REPRESENTATIVES. THE COMMITTEE WAS CHARGED WITH THE RESPONSIBILITY OF STUDYING BOTH WATER AND AIR POLLUTION, AND IT WAS DECIDED TO FOLLOW A RESEARCH PROGRAM ON AIR POLLUTION TO DETERMINE THE CONDITIONS EXISTING IN THE SARNIA AREA. THE STUDIES ARE CARRIED OUT UNDER THE GUIDANCE OF THE INDUSTRIAL REPRESENTATIVES BY A QUALIFIED SCIENTIST WITH MONTHLY MEETINGS HELD TO DISCUSS RESULTS OF THE AIR SURVEY.

MONEY APPROPRIATED FOR THE OVERALL STUDY WAS LEVIED ACCORDING TO THE NUMBER OF EMPLOYEES IN EACH COMPANY, AND THIS AMOUNT WAS MATCHED BY THE ONTARIO RESEARCH COUNCIL ON A 50/50 BASIS.

THE FUNCTION OF THE COMMITTEE DOES NOT INVOLVE REGULATORY MEASURES BUT AN EFFORT TO DETERMINE EXISTING CONDITIONS IN THE ATMOSPHERE AND THE DEVELOPMENT OF METHODS TO PREVENT AIR POLLUTION IF THE NEED ARISES. IT IS RECOGNIZED THAT THESE STUDIES WILL HAVE TO BE CONTINUED OVER A PERIOD OF AT LEAST TWO YEARS, AND THE ACTUAL SURVEY COMMENCED IN OCTOBER, 1952.

THIS PROJECT DOES NOT ENCROACH ON THE RIGHTS OF THE INTERNATIONAL JOINT COMMISSION, RATHER IT WAS PLANNED TO COOPERATE WITH THE COMMISSION WHENEVER POSSIBLE AND THE ASSISTANCE OF THE TECHNICAL ADVISERS OF THE COMMISSION IN AIR POLLUTION IS HEREBY GRATEFULLY ACKNOWLEDGED. THE SAME TECHNIQUE WAS FOLLOWED IN THE SARNIA AREA AS EMPLOYED BY THE INTERNATIONAL JOINT COMMISSION IN WINDSOR, AND, TO ASSIST THE PROGRESS OF THE SURVEY, EQUIPMENT FROM WINDSOR WAS LENT TO THE ST. CLAIR RIVER RESEARCH GROUP IN THE FORM OF HIGH VOLUME DUST SAMPLERS. THE ONTARIO RESEARCH FOUNDATION HAVE EMPLOYED A RESEARCH FELLOW TO DIRECT RESEARCH ON AIR POLLUTION IN ONTARIO WITH A SCIENTIST WORKING UNDER HIS DIRECTION IN THE SARNIA AREA.

IN 1953, THE CANADIAN OIL REFINERIES LIMITED, CABOT CARBON OF CANADA LIMITED, AND SUN OIL OF CANADA LIMITED, JOINED THE ST. CLAIR RIVER RESEARCH GROUP AND HAVE APPOINTED REPRESENTATIVES TO ACT ON THE LOCAL INDUSTRIAL COMMITTEE.

EQUIPMENT AND ACTIVITIES

A FIXED STATION FOR COLLECTING METEOROLOGICAL DATA WAS SET UP ALONG THE LINES OF PREVAILING WINDS IN THE RESIDENTIAL AREA OF SARNIA. THIS STATION CONTAINED APPARATUS FOR DETERMINING WIND VELOCITY, A THOMAS AUTOMETER FOR SO_2, DUST COLLECTING EQUIPMENT, ETC. A SIMILAR STATION MOUNTED ON A TRAILER HAS ALSO BEEN PROVIDED BY THE RESEARCH FOUNDATION FOR A COMPLETE ANALYSIS OF THE AIR IN OTHER LOCATIONS IN THE AREA.

A NUMBER OF DUST CANS HAVE BEEN SET UP AT VARIOUS POINTS IN THE SARNIA AREA TO DETERMINE DUST FALL. ADVICE ON THE METEOROLOGICAL ASPECTS OF THE PROBLEM IS BEING RECEIVED FROM THE CANADIAN METEOROLOGICAL SERVICE.

IN ADDITION TO THE ABOVE ACTIVITIES THE COUNCIL OF THE CITY OF SARNIA HAVE AUTHORIZED THE FORMATION OF AN ADVISORY COMMITTEE ON SMOKE ABATEMENT AND HAVE ASKED THE ST. CLAIR RIVER RESEARCH GROUP TO APPOINT A REPRESENTATIVE TO SIT ON THE COMMITTEE. THE FUNCTION OF THE COMMITTEE IS TO PROVIDE TECHNICAL ADVICE TO THE CITY MANAGER'S DEPARTMENT IN RESPECT TO WAYS AND MEANS OF REDUCING AIR-BORNE CONTAMINANTS.

RESULTS OF PROJECT TO DATE

THE RESEARCH PROJECT IS, OF NECESSITY, LONG RANGE. IT IS TOO EARLY TO REPORT ANY SIGNIFICANT RESULTS AT THE PRESENT TIME. IT HAS BEEN FOUND, HOWEVER, THAT DUST FALL IN THE SARNIA RESIDENTIAL AREAS IS LOW COMPARED TO OTHER CITIES HAVING A SIMILAR CONCENTRATION OF INDUSTRY.

THE RESULTS OF THE SURVEY OF AIR CONDITIONS WERE OF VALUE TO THE INTERNATIONAL JOINT COMMISSION'S TECHNICAL ADVISERS IN ASSESSING THE CONDITIONS EXISTING IN THE SARNIA AREA. THE INDUSTRIES HAVE FOUND THE SURVEY TO BE OF VALUE IN DETERMING REMEDIAL MEASURES FOR FUTURE INSTALLATION SHOULD THE CONDITION OF THE AIR BECOME CRITICAL. THE GROUP ARE ALERT AT ALL TIMES TO PREVENT ANY EMISSION OF UNDESIRABLE CONTAMINANTS TO THE ATMOSPHERE AND TO REDUCE SMOKE TO A MINIMUM.

THE SARNIA INDUSTRIES HAVE BEEN ACTIVE FOR MANY YEARS IN REDUCING WATER POLLUTION IN THE ST. CLAIR RIVER. THE WATERWAY IS ONE OF THE MOST ATTRACTIVE AND CLEAN STREAMS ON THE CONTINENT AND IT IS ESSENTIAL THAT IT BE PRESERVED AS A SOURCE OF POTABLE WATER AND RECREATION. TO THIS END, THE LOCAL GROUP HAVE JOINED FORCES WITH THE ONTARIO RESEARCH FOUNDATION AND THE ONTARIO DEPARTMENT OF HEALTH TO MAINTAIN A CLOSE CONTROL ON THE QUALITY OF WASTE WATER DISCHARGED. THE RESEARCH GROUP FEEL THAT IT IS JUST AS ESSENTIAL TO MEET THE OBJECTIVES OF THE INTERNATIONAL JOINT COMMISSION AS IT IS TO PRODUCE TOP SPECIFICATION MANUFACTURED PRODUCTS.

CONCLUSIONS

THE RESULTS OF COOPERATIVE RESEARCH PROJECT AT SARNIA FOR THE FIRST YEAR HAVE INDICATED THAT A GOVERNMENT AGENCY AND INDUSTRY CAN WORK TOGETHER TO ASSESS AND SOLVE PROBLEMS OF AIR AND WATER POLLUTION IN A CONSTRUCTIVE MANNER. ALTHOUGH SARNIA IS NOT A CRITICAL AREA IN RESPECT TO HEAVY POLLUTION, FUTURE EXPANSION IN THE INDUSTRIAL AREA MAY CREATE AN UNDESIRABLE CONDITION IN THE ATMOSPHERE AND THE RECEIVING BODIES OF WATER. THE FUNCTION OF THE PROJECT IN THE FUTURE WILL BE ONE OF EDUCATION OF NEWCOMERS IN THE INDUSTRIAL GROUP AND A PROGRAM OF IMPROVEMENT IN TECHNIQUES FOR POLLUTION ABATEMENT.

ALL OF THE EXISTING INDUSTRIES ARE FULLY AWARE OF THEIR RESPONSIBILITY TO THE COMMUNITY. THE MEMORY OF THE DONORA DISASTER AND DEATHS FROM THE LONDON FOG IS STILL WITH US. IT IS ESSENTIAL THAT THE METEOROLOGICAL DATA FOR THE DISTRICT BE STUDIED CAREFULLY OVER A LONG PERIOD TO ASSESS THE OCCURRENCE OF ATMOSPHERIC CONDITIONS WHICH MIGHT CONTRIBUTE TO TEMPERATURE INVERSIONS. NORMALLY, THE TOPOGRAPHY OF THE AREA DOES NOT LEND ITSELF TO A SUSTAINED SMOG CONDITION BECAUSE OF THE ABSENCE OF VALLEYS AND HILLS. HOWEVER, VIGILANCE IS NECESSARY AT ALL TIMES TO PREVENT ACCIDENTAL EMISSIONS OF IRRITATING CONTAMINANTS. THIS CAUTION IS ALSO APPLIED TO THE PROBLEM OF WATER POLLUTION TO PREVENT ACCIDENTAL SPILLS OF CHEMICALS WHICH MAY CONTRIBUTE TO THE TASTE AND ODOUR PROBLEMS OF MUNICIPALITIES DOWNSTREAM FROM THE INDUSTRIAL AREA. THE TECHNICAL ASSISTANCE OF THE ONTARIO RESEARCH FOUNDATION, THE INTERNATIONAL JOINT COMMISSION, AND THE ONTARIO DEPARTMENT OF HEALTH (EXPERIMENTAL STATION) HAS BEEN GREATLY APPRECIATED. THE INDUSTRIES HAVE ALSO PROVIDED MANY MAN-HOURS OF TECHNICAL ASSISTANCE AND LABORATORY FACILITIES TO ASSIST THE FOUNDATION IN THEIR SURVEY ACTIVITIES.

IT IS HOPED THAT THE ST. CLAIR RIVER RESEARCH PROJECT WILL SERVE AS A MODEL FOR FUTURE STUDIES OF POLLUTION ABATEMENT, ESPECIALLY IN THE EXTENSIVE RIVER SYSTEMS AND INDUSTRIAL AREAS IN CANADA. IN A STUDY OF THIS KIND, A COMPLETE UNDERTAKING OF MUTUAL PROBLEMS MAY BE ACHIEVED BY GOVERNMENT AGENCIES AND INDUSTRY. THE COST IS NOMINAL, ESPECIALLY IF SEVERAL INDUSTRIES UNITE TO PAY 50% OF THE COST, AND THE GOVERNMENT THE OTHER 50%. WHEN THE FACTS ARE OBTAINED, EACH INDUSTRY MAY PROCEED IN AN ORDERLY WAY TO SOLVE ITS OWN PROBLEMS WITH A FREE EXCHANGE OF INFORMATION AMONG THE PARTICIPANTS. THE GOVERNMENT, IN TURN IS, AT ALL TIMES, FULLY INFORMED OF THE PROGRESS OF THE ACTIVITIES AND IT DOES NOT HAVE TO APPLY LEGISLATION TO MAINTAIN A REASONABLE CONDITION OF CLEANLINESS IN THE ATMOSPHERE AND RECEIVING BODIES OF WATER.

NOTE: IN A SUBSEQUENT PAPER ON THIS PROGRAM, MR. B.C.NEWBURY, RESEARCH FELLOW WITH THE ONTARIO RESEARCH FOUNDATION WILL DESCRIBE THE TECHNIQUE OF SETTING UP A COOPERATIVE AIR POLLUTION SURVEY.

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UTILIZATION OF WASTE BY CANADIAN MINES

- By -

DONALD P. DOUGLASS

ONTARIO DEPARTMENT OF MINES

ROCK

ALL MINING OPERATIONS, BOTH OPEN PIT AND UNDERGROUND, PRODUCE WASTE ROCK. THE DISPOSAL OF THIS MATERIAL, AS WASTE, OR ITS UTILIZATION AS A VALUABLE BY-PRODUCT HAS ALWAYS BEEN ONE OF THE MAJOR PROBLEMS OF THE MINING INDUSTRY.

IN OPEN-PIT MINING, OPERATIONS MAY BE CARRIED TO A DEPTH OF 400 FEET, AND ROCK WALL MUST BE BENCHED BACK TO MAKE A SAFE SLOPE. THIS RESULTS IN A GREAT DEAL OF WASTE ROCK THAT MUST BE DISPOSED OF.

IN UNDERGROUND MINING, SHAFTS, CROSSCUTS, HOISTROOMS, AND CRUSHING, PUMPING, AND CHARGING STATIONS ARE USUALLY CUT IN WASTE ROCK; THIS IS DONE SO THAT VALUABLE ORE NEED NOT BE USED TO CONTAIN THESE OPENINGS. ALL THE ROCK FROM THIS WORK MUST BE HOISTED TO SURFACE BEFORE MINING CAN START.

AN IDEA OF THE AMOUNTS OF WASTE ROCK INVOLVED MAY BE HAD FROM THE RETURNS MADE LAST YEAR BY THE INTERNATIONAL NICKEL COMPANY AT SUDBURY TO THE ONTARIO DEPARTMENT OF MINES. LAST YEAR AT THEIR MINES, NEARLY A MILLION AND A QUARTER FEET OF DRIFTING AND CROSSCUTTING WAS DONE, AND ALMOST SEVEN HUNDRED THOUSAND TONS OF WASTE WAS HOISTED. A STANDARD CROSSCUT MEASURES ABOUT EIGHT BY EIGHT FEET AND THE MAIN CROSSCUTS WOULD BE ALMOST EIGHT BY TWELVE FEET. SOME OF THE LARGER SHAFTS ARE THIRTY BY EIGHTEEN FEET AND GO TO A DEPTH OF 4,000 FEET. THE EXCAVATION FOR SUCH A SHAFT COULD ACCOMMODATE A SMALL HOME, ALTHOUGH A 4,000 FOOT BASEMENT WOULD HARDLY BE ACCEPTABLE.

UNDERGROUND SPACE TO ACCOMMODATE HOISTING EQUIPMENT REQUIRES LARGE OPENINGS. WITH THEIR DOME-SHAPED CEILINGS, THEY RESEMBLE SMALL CHURCHES IN SIZE AND SHAPE.

THE SIZE OF UNDERGROUND OPENINGS IS KEPT AT

A MINIMUM, SINCE EXCAVATING SOLID ROCK IS AN EXPENSIVE OPERATION; THESE OPENINGS ARE ALSO SUBJECTED TO ROCK PRESSURE THAT INCREASES WITH DEPTH AND MUST BE SUPPORTED. HOWEVER, ALTHOUGH UNDERGROUND EXCAVATION IS NEVER GREATER THAN IS ABSOLUTELY NECESSARY, THE VOLUME OF WASTE ROCK INVOLVED IS STILL VERY LARGE.

ANOTHER EXAMPLE OF THE WORK DONE IN WASTE ROCK IS HAULAGEWAYS. AT THE HOLLINGER GOLD MINE AT TIMMINS ABOUT 400 MILES OF TRACK HAVE BEEN LAID IN THE UNDERGROUND WORKINGS.

THE EXAMPLES QUOTED GIVE SOME IDEA OF THE VAST AMOUNT OF WASTE ROCK PRODUCED AT SOME OF THE LARGER MINES. WHAT TO DO WITH THIS WASTE IS A PROBLEM THAT CONFRONTS ALL MINES.

THERE IS ALSO WASTE IN THE OREBODY ITSELF. AS MINING METHODS ARE IMPROVED, IT BECOMES POSSIBLE TO MINE ORES OF LOWER GRADE, AND THUS MORE AND MORE WASTE IS PRODUCED.

IN OREBODIES THE ACTUAL METAL CONTENT OF THE ORE IS ONLY A VERY SMALL PART OF THE WHOLE. THE AVERAGE GOLD CONTENT MINED IN ONTARIO AT THE PRESENT TIME IS ONLY ABOUT A QUARTER OF AN OUNCE PER TON OF ORE. AT THE KERR-ADDISON MINE ABOUT 4,500 TONS OF ORE ARE HOISTED DAILY AND FROM THIS LESS THAN 100 POUNDS OF PRECIOUS METAL IS EXTRACTED. THE REST IS WASTE. IN THE BASE METAL OREBODIES, THE AVERAGE METAL CONTENT MAY BE FROM ONE TO TEN PERCENT OF THE ORE.

THE INTERNATIONAL NICKEL COMPANY MINES ALMOST FOURTEEN MILLION TONS OF ORE A YEAR; TO TRANSPORT THIS ALL AT ONCE WOULD REQUIRE A TRAIN OF 50-TON CARS TWO THOUSAND MILES LONG. SUCH A TRAIN WOULD STRETCH FROM TORONTO TO MEDICINE HAT ALBERTA.

WASTE ROCK IS BEING PUT TO GOOD USE AND IS BEING EMPLOYED MORE AND MORE IN THE INCREASED DEVELOPMENT AND GROWTH OF THIS COUNTRY. DURING THE EARLY YEARS OF A MINE, ROCK IS NEEDED FOR THE LEVELLING AND CONDITIONING OF MINE YARDS AND TOWNSITES. IT IS ALSO USED AS RAILWAY BALLAST, IN CONCRETE AGGREGATE, CONVERTER FLUX, AND IN THE CONSTRUCTION OF ROADS. LANDING STRIPS FOR AIRCRAFT HAVE BEEN MADE FROM WASTE ROCK AT FLIN FLON, MANITOBA, AND IN INTERNATIONAL NICKEL COMPANY PROPERTY AT SUDBURY. WASTE ROCK IS USED TO FILL IN MINED-OUT AREAS UNDERGROUND.

AT THE BETHLEHEM IRON MINE AT MARMORA, ABOUT 18 MILLION TONS OF LIMESTONE OVERLYING THE OREBODY IS BEING REMOVED - AN AMOUNT SUFFICIENT TO COVER A 30-FOOT WIDE HIGHWAY WITH A FOOT OF CRUSHED ROCK FOR A DISTANCE OF 82 MILES. THIS MATERIAL HAS A POTENTIAL VALUE AND IS BEING STOCK-PILED FOR FUTURE USE.

AT A NUMBER OF LIMESTONE QUARRIES IN SOUTHERN ONTARIO, WHERE HIGH-GRADE LIMESTONE IS USED IN THE PRODUCTION OF LIME, THE FINES ARE SOLD FOR ROAD METAL AND AS A FILLER FOR FERTILIZER PRODUCTS.

As more and more uses are found for it, what was formerly called waste rock is now becoming valuable material.

TAILINGS

Ores are crushed dry to about 3/8-inch size, then ground in ball or rod mills in solution to the finer sizes required. They are ground to the fineness necessary to release the metal content for further concentration and extraction by solution or heat treatment. The nature of the ore and the ease of extraction vary considerably. It may be necessary to grind so fine as to allow 80 percent of the material to pass through a 300-mesh screen to permit satisfactory solution of the gold in a cyanide solution. At base metal mines grinding to 70 percent through a 200-mesh screen might be all that is required.

At gold mines the ore is agitated in tanks of a cyanide solution that dissolves the gold. The gold-bearing solution is then filtered off from the fine waste rock, or cake, and the gold is precipatated.

The fine waste or slimes contain an average cyanide content of 0.12 pounds per ton to which water is added to give a final cyanide content of 0.003 percent. The tailings are usually pumped, as about 50 percent solids, into a natural depression, usually a mosquito-breeding swamp or muskeg area.

In accordance with the ruling of the Judge of The Ontario Mining Court, tests taken at one mine in Northern Ontario showed less than one part cyanide in 10 million. Samples of water were taken periodically at a point not more than 50 feet from the point of entry.

The disposal of tailings at the concentrator of the International Nickel Company at Copper Cliff presents a problem of considerable difficulty. Tailings, after water separation, occupy 20 cubic feet per ton. This means that 175 million cubic feet of space is needed each year - equivalent to six feet of depth over an area a mile square. These tailings have to be pumped a distance of over three miles from the plant, through 12-and-16-inch pipelines.

A new method to make use of an important part of the tailings for underground fill was recently found. At the Kerr-Addison Mine, 45 percent of what was formerly called waste is pumped back into the mine as back-fill. This not only supports the underground workings that have been mined out but also reduces the rock-burst problem and fire hazard as well; it also cuts down the amount of sand and gravel formerly needed for this purpose.

The following news release by the International Nickel Company at Copper Cliff on July 29th, 1953, describes the method:

"WASTE MATERIAL FROM THE ORE HAS BEEN PUT TO GOOD USE TO INCREASE UNDERGOUND SECURITY IN A 'MERRY-GO-ROUND' OPERATION AT THE FROOD-STOBIE AND CREIGHTON MINES OF THE INTERNATIONAL NICKEL COMPANY OF CANADA, LIMITED.

SAND RECOVERED FROM MILL TAILINGS, THE WASTE IN THE ORE CONCENTRATING PROCESS, IS MIXED WITH WATER AND FLUSHED THROUGH PIPELINES BACK INTO THE GROUND WHENCE IT CAME. THERE IT SERVES AS FILL FOR MINED-OUT STOPES - SECTIONS OF THE MINES FROM WHICH THE ORE HAS BEEN REMOVED - OR TO STABILIZE AREAS PREVIOUSLY FILLED WITH ROCK.

THE SAND-FILLING SYSTEM IS A SIGNIFICANT DEVELOPMENT IN THE COMPANY'S $150,000,000 LONG-RANGE PROGRAM OF CONVERSION FROM OPEN-PIT AND UNDERGROUND MINING TO ALL-UNDERGROUND PRODUCTION AT ITS FIVE MINES IN THE SUDBURY DISTRICT OF ONTARIO.

FOR 20 YEARS WASTE ROCK HAS BEEN USED AT INCO'S FROOD-STOBIE MINE TO FILL THE MINED-OUT AREAS. RECENTLY IT WAS FOUND THAT SAND CONSTITUTED A MORE SUITABLE FILL, PERMITTING FASTER AND MORE EFFICIENT UNDERGROUND OPERATIONS. NOW IT IS PIPED INTO THE MINE AT THE RATE OF MORE THAN 3000 TONS A DAY.

THE WATER-BORNE SAND FILTERS AND PACKS INTO THE ROCK-FILLED AREAS AND SOLIDIFIES THEM SO THAT THEY ARE NOT ONLY SELF-SUPPORTING BUT ALSO STRONG ENOUGH TO SUSTAIN THE INCREASED WEIGHT AS REMAINING PILLARS OF ORE ARE REMOVED DURING THE SECONDARY STAGE OF MINING.

MORE THAN 3,500,000 TONS OF SAND FILL WILL BE REQUIRED TO STABILIZE ALL THE ROCK-FILLED AREAS OF THE FROOD-STOBIE MINE ALONE.

SAND IS ALSO BEING USED AS FILL INSTEAD OF ROCK IN CURRENT SQUARE-SET STOPE MINING AT FROOD-STOBIE AND CREIGHTON. THE SAND BEING USED FOR FILL AT CREIGHTON IS PUMPED DIRECTLY UNDERGROUND TO THE DEEPEST LEVELS FROM THE COMPANY'S NEW 10,000-TON CONCENTRATOR THERE. SAND FOR FROOD-STOBIE IS SHIPPED FROM THE COPPER CLIFF SMELTER TO THE MINE IN RAILWAY CARS.

THE DISTANCE THE SAND IS PIPED TO REACH STOPES ON THE LOWEST LEVEL OF THE CREIGHTON MINE IS 9,500 FEET, MORE THAN HALF OF IT ON THE HORIZONTAL.

THE SAND FOR FROOD-STOBIE, AFTER BEING DEWATERED AT THE COPPER CLIFF CONCENTRATOR AND SHIPPED TO THE MINE IN 78-TON CARS, IS DUMPED INTO BINS AT A SPECIAL PLANT AND THEN MIXED WITH WATER TO A CONSISTENCY OF ABOUT 60% SOLID. THE PULP IS DRAWN INTO A DISTRIBUTOR BOX WITH CONNECTIONS TO THREE 6-INCH

RUBBER LINED LINES THAT ENTER THE MINE THROUGH A SERVICE RAISE EXTENDING FROM 3,100 LEVEL TO SURFACE. ON EACH LEVEL OF THE MINE ARE DISTRIBUTION LINES EXTENDING INTO THE STOPES.

A SECTION TO BE SAND-FILLED IS BRATTICED OFF AND ENCLOSED WITH BURLAP. THE WATER DECANTS THROUGH SLOTS IN THE BRATTICING WHICH ARE SEALED ONE BY ONE TO PREVENT THE SAND ESCAPING AS THE LEVEL OF THE FILL RISES. THE SAND SETTLES NATURALLY AND NO HAND-LEVELLING IS NECESSARY TO PROVIDE A SMOOTH SURFACE ON WHICH TO START THE NEXT ROUND OF MINING, WHICH CAN PROCEED SHORTLY AFTER THE FILL IS POURED. SAND-FILL WATER DRAINS INTO THE LEVEL DITCHES AND IS PUMPED BACK TO SURFACE.

AN INDEPENDENT TELEPHONE SYSTEM PROVIDES DIRECT COMMUNICATION BETWEEN THE WORKING PLACES UNDERGROUND AND THE SAND-FILL PLANT AT SURFACE FOR CONTROL OF SAND DELIVERY."

THE NEW METHOD DESCRIBED IN THE RELEASE JUST QUOTED WILL RELEASE LARGE AMOUNTS OF SAND AND GRAVEL FOR THE CONSTRUCTION OF HOMES AND FACTORIES. DEPOSITS OF SAND AND GRAVEL TO MEET BUILDING REQUIREMENTS ARE BECOMING EXHAUSTED NEAR THE URBAN CENTRES IN ONTARIO, AND IN THE NEAR FUTURE, IT COULD EASILY BE THAT THESE MATERIALS WILL HAVE TO BE TRANSPORTED FROM CONSIDERABLE DISTANCES. THE HOLLINGER MINE, FOR EXAMPLE, HAS USED OVER 26 MILLION TONS OF SAND IN THEIR BACK-FILLING OPERATIONS. THE SULLIVAN MINE IN BRITISH COLUMBIA WILL BE USING 500,000 YARDS OF GRAVEL FOR BACK-FILLING THIS YEAR; THIS IS IN ADDITION TO THE NORMAL AMOUNT OF BACK-FILLING THAT GOES ON EVERY YEAR.

IN A NUMBER OF CASES, TAILINGS HAVE BEEN PUT TO EXCELLENT USE ON SURFACE AND HAVE ENHANCED THE VALUE OF THE SURROUNDING AREA. THIS MAY BE SEEN IN THE RECREATION GROUNDS AND PARKS AT THE MCINTYRE, MADSEN, HOLLINGER, AND LAKE SHORE, TO NAME ONLY A FEW MINES IN ONTARIO. IN PARTICULAR THE PARKS OF THE MCINTYRE AND HOLLINGER MINES AT TIMMINS AND OF THE INTERNATIONAL NICKEL COMPANY AT COPPER CLIFF ARE THE SHOW PLACES OF THEIR RESPECTIVE AREAS.

SLAG

SLAG IS A WASTE PRODUCT OF SMELTERS. AT THE INTERNATIONAL NICKEL COMPANY'S SMELTER AT COPPER CLIFF, SLAG IS SKIMMED INTO POTS HOLDING 16 TONS AND HAULED TO THE SLAG DUMP BY 60-65-AND-100 TON ELECTRIC LOCOMOTIVES IN TWO TRAINS OF 20 POTS EACH. THIS WASTE PRODUCT HAS BEEN SUCCESSFULLY USED AS ROAD MATERIAL AND RAILWAY BALLAST. AT THE NORANDA MINE, SLAG IS MIXED WITH TAILINGS FOR UNDERGROUND FILL. SLAG IS ALSO USED IN CONCRETE AGGREGATE AND AS INSULATING MATERIAL.

There is little likelihood that the slag dumps at Sudbury will ever be worked for the recovery of iron. However, because of the development of a new process, less slag per unit of nickel produced will be formed. It is estimated that these slag dumps cover an area of 500 acres and total 100 million tons of slag.

SULPHUR

Nickel and copper are produced from sulphide ores. The sulphur content of the ore in Ontario might be as high as 30 percent. To produce copper and nickel, much of the sulphur is burned and produces much flue gas containing sulphur gases in very low concentration. The disposal of these fumes has long been one of the major problems of the industry.

The fumes are collected and discharged at high temperatures from some of the highest stacks in the world. This provides further dilution of the fumes before they reach ground level.

Dust particles are removed by electrostatic precipitation, cross-flues, and settling chambers.

Recently a direct flash smelting process for heating copper concentrates was placed in operation at Copper Cliff by the International Nickel Company. This new process uses oxygen and makes the present large-scale output of liquid sulphur dioxide from furnace exhaust gases, by Canadian Industries Limited, at Copper Cliff, an economical one.

Sulphuric acid is also produced by Canadian Industries Limited, at Copper Cliff from copper converter gas. In 1953, 37,000 tons of sulphur dioxide was recovered as well as a large amount of sulphuric acid.

Sulphur has been recovered in various plants as liquid sulphur dioxide, sulphuric acid, and elemental sulphur. At Trail, British Columbia, about 1,100 tons of sulphuric acid a day are produced and used in the manufacture of fertilizers. Last year 600,000 tons of fertilizer was produced; this is being increased to 700,000 tons this year. About 300 tons of iron concentrates a day are drawn from the current tailings piped from the Sullivan concentrator. This amounts to about a quarter of the current mill supply of iron sulphides, and there is also the impounded iron-bearing tailings from former milling operations - an enormous backlog.

Most of the sulphur in the Sudbury area comes from an iron sulphide - pyrrhotite. Last year a solution was found to eliminate a greater portion of pyrrhotite from the concentrates. A plant is now under construction that will produce an estimated million tons of iron a year from concentrates that were formerly considered to be waste.

The 1947 report of the Ontario Research Foundation deals with the feasibility of economic recovery of all the sulphur contained in the fumes in the Sudbury area.

The capital required and the cost of raw material and power for the treatment of smelter fumes by present methods are so great that the recovery and sale of sulphur containing by-products must be part of such treatment. A process of removal only without compensating by-products could not be considered.

High expenditure for the purchases of large quantities of material such as coke, ammonia, and phosphate rock, and of power would be necessary. The amount of sulphur or sulphur-containing by-products that resulted would be so great as to dwarf the present Canadian market. Nor are the locations of the smelters suitable to compete for these markets. That heavy financial losses might be incurred in an undertaking of such magnitude is apparent. However, a continuous program of research on sulphur recovery is justified and is being carried on.

A special Sulphur Dioxide Committee was appointed several years ago for the purpose of carrying out research in connection with the effect of sulphur fumes on forest growth in the Sudbury basin area. This committee was fortunate in obtaining the services of Dr. M. Katz of the Defence Research Laboratories at Ottawa. Dr. Katz is considered the outstanding authority on this type of research in North America. A great deal of valuable information has already been compiled by the committee and the work is continuing.

In conclusion, it is apparent that mining produces waste the same as any other heavy industry. Many problems still remain to be solved. However, I trust I have been able to show that the mining industry has made remarkable strides by changing much of what was formerly waste into valuable products, and I am sure that in the future it will do even more.

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TREATMENT OF OIL WASTES

- By -

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The companies operating oil refineries have always had problems of water and atmospheric pollution. However, in recent years greatly increased industrial activity and the spreading out of urban centers of population have combined to make the problems more acute. Consequently all refiners are now extremely conscious of waste disposal. They are devoting more thought, time, and money to the matter than ever before. In addition, present indications are that their activities in this field will continue to increase in the future.

Up to the present time the handling of waste water has been a more serious problem than atmospheric pollution. However, the growth of residential areas close to refinery sites indicates that in the near future more attention will have to be given to smoke and fumes.

In Canada various pollution control groups have tended to adopt the International Joint Commission's standards for waste water effluents entering the boundary waters between Canada and the United States. Therefore, their figures are used as guides for effluent quality in many studies of pollution.

The recognized authority for methods of handling refinery wastes is the American Petroleum Institute's Committee on Disposal of Refinery Wastes. This group has published a manual presenting information to aid refiners in handling the wastes produced. The API Manual is in five sections, Volume I - Waste Water Containing Oil, Volume II - Waste Gases and Particulate Matter, Volume III - Chemical Wastes, Volume IV - Sampling and Analysis of Waste Water, and Volume V - Sampling and Analysis of Waste Gases (still in preparation). This manual is widely used in the selection and design of waste disposal equipment.

WASTE WATERS CONTAINING OIL

It is of first importance for refiners to prevent oil from escaping from the refinery in the effluent waters. To accomplish this it is common practice to use gravitational means for separating the oil from the waste water. Separation is dependent upon the difference in specific gravity between the oil and water. To accomplish the separation, the mixture of oil and water is passed through one or more box-like settling basins called separators. In the separator the velocity is greatly lowered, thereby reducing turbulence and providing time and conditions which enable the oil to rise to the surface and the sediment to settle. Most of the separators now in use have baffles and partitions dividing them into two compartments. The major portion of the oil is retained in the first section shortly after the waste enters the separator. Each compartment is equipped with a skimming device for removing oil from the surface of the water.

The recovered oil is removed to slop tanks. These are equipped with steam coils to heat the oil. This allows entrained water to separate out and be returned to the separator. The dry oil is returned to the refinery process system.

In general, no waste water should be allowed to leave the refinery property until it has passed through a separator. This does not apply to sources of water which are fully protected against the entrance of oil. However, due regard must be given to the possibility of spills and accidents and it is sound policy to pass all waste water through a separator. Also, in cases where oily water comes from several sources in a plant it is often advantageous to install small separators in the various departments to handle the individual wastes rather than to allow them to combine before entering the separator system. The two major reasons for this are:
(1) when water-oil mixtures resulting from cracking, topping, treating and other operations are allowed to combine they form, in many cases, emulsions which will not break in the separator;
(2) it is sometimes possible to return the oil recovered from the separator direct to the process from which it originated.

The API Manual gives complete design details of these separators. However, the general details can be described here. The maximum size unit is eight feet deep by twenty feet wide and of varying lengths. If a single unit of this size is inadequate then one or more additional units should be installed. A unit for any service should usually consist of at least two parallel sections so that the flow may be diverted through one side while cleaning and repairs are carried out on the other. Normally, the separator has two compartments termed the primary and secondary chambers. The waste water enters the end of the primary chamber through a row of parallel pipes into a distribution box. From here it flows over a weir the width of the separator and down through a box filled with Raschig Rings and thence down the length of the primary chamber. There

ARE NO PARTITIONS OR BAFFLES IN THIS CHAMBER EXCEPT AN OIL RETENTION BAFFLE AT THE FAR END. THE SEPARATED OIL IS REMOVED BY A SKIMMING DEVICE.

THE WATER THEN FLOWS OVER A WEIR AND ENTERS THE SECONDARY CHAMBER WHICH IS REQUIRED TO BE 60% OF THE ENTIRE LENGTH OF THE SEPARATOR. AGAIN THERE ARE NO BAFFLES EXCEPT ONE FOR OIL RETENTION AT THE OUTLET END. THE WATER FLOWS OVER A WEIR AND IS DISCHARGED FROM THE SEPARATOR. THE ENTIRE ARRANGEMENT IS CAREFULLY DESIGNED TO AVOID THE CREATION OF ANY TURBULENCE WHICH MIGHT TEND TO BREAK UP AND DISPERSE THE PARTICLES OF OIL.

IN ORDER TO OBTAIN A SATISFACTORY EFFLUENT A NUMBER OF PRECAUTIONS MUST BE TAKEN IN OPERATING THE UNIT. THE SEPARATOR MUST BE KEPT CLEAN AND IN GOOD REPAIR AND SEDIMENT MUST NOT BE ALLOWED TO ACCUMULATE IN THE BOTTOM. EMULSIONS SHOULD NOT BE ALLOWED TO ENTER THE SEPARATOR BECAUSE IT HAS LITTLE, IF ANY, CAPABILITY IN BREAKING THEM. THE CAPACITY OF THE UNIT SHOULD NOT BE EXCEEDED BY ALLOWING LARGE VOLUMES OF SURFACE WATER TO DRAIN INTO IT UNLESS THE UNIT HAS BEEN DESIGNED TO HANDLE RUN-OFF. ALSO, ALKALINE CHEMICAL WASTES SHOULD BE KEPT OUT BECAUSE THEY HINDER THE SEPARATION OF THE OIL.

HANDLING OF EMULSIONS

AS MENTIONED ABOVE, EMULSIONS OF OIL IN WATER WILL NOT SEPARATE OUT BY GRAVITY DIFFERENTIAL AT A PRACTICAL RATE. THIS IS BECAUSE THEY POSSESS SOME DEGREE OF STABILITY. IT IS THEREFORE, ESSENTIAL THAT THEY SHOULD BE TREATED PROPERLY AND SEPARATELY BEFORE THEY ARE ALLOWED TO ENTER THE MAIN DRAINAGE SYSTEM. ANY EMULSION DISCHARGE INTO THE MAIN DRAINAGE SYSTEM IS, IN MOST CASES, BEYOND CONTROL.

THE PROBLEM OF BREAKING EMULSIONS IS PRACTICALLY AN INDIVIDUAL ONE WITH EACH PLANT BECAUSE OF THE FACT THAT EACH PROCESS AND EACH TYPE OF CRUDE HAS A DIFFERENT EFFECT ON THE CHARACTER OF THE EMULSION. THEREFORE, NO SINGLE PROCEDURE OR METHOD CAN BE OUTLINED FOR ALL CONDITIONS. HOWEVER, SOME PROCESSES WHICH HAVE PROVED EFFECTIVE MAY BE DESCRIBED.

IF THE VOLUME TO BE HANDLED IS NOT TOO LARGE IT MAY BE SEGREGATED AND HEATED. MANY EMULSIONS CAN BE BROKEN IF THEY ARE HEATED TO SOME 180°F. IT MAY ALSO BE BENEFICIAL TO ADJUST THE pH AT THIS STAGE AS THERE IS USUALLY AN OPTIMUM RANGE FOR BREAKING ANY EMULSION. THIS MAY BE DETERMINED EXPERIMENTALLY IN THE LABORATORY.

ANOTHER WAY OF RIDDING WATER OF RELATIVELY SMALL AMOUNTS OF EMULSIFIED OIL IS TO ADD A FLOC TO THE WATER. THIS FLOC PICKS UP THE OIL AND SETTLES OUT LEAVING A CLEAR EFFLUENT OF VERY GOOD QUALITY. AN EXAMPLE OF THIS IS THE USE OF FERRIC SULPHATE AND LIME TO GENERATE A FLOC OF FERRIC HYDROXIDE. THE EFFLUENT FROM A PROPERLY OPERATED SYSTEM OF THIS TYPE WILL CONTAIN ABOUT TWO PARTS PER MILLION OF OIL OR LESS.

HOWEVER, THE SETTLED FLOC IS A SLUDGE WHICH IS, IN TURN, A WASTE WHICH POSES ITS OWN DISPOSAL PROBLEM.

THE API MANUAL CONTAINS SUGGESTIONS FOR A LABORATORY PROCEDURE TO BE USED IN EVALUATING VARIOUS CHEMICAL SOLUTIONS AS EMULSION BREAKERS.

CHEMICAL WASTES

CHEMICALS MAY FIND THEIR WAY INTO THE WASTE WATER FROM THE PETROLEUM PRODUCTS AND FROM THE CHEMICAL AGENTS USED IN TREATING THESE PRODUCTS. NOT MANY YEARS AGO IT WAS THE REFINER'S PRIME CONCERN TO MAINTAIN THE REFINERY EFFLUENT WATER FREE OF OIL AND SEDIMENT. TO-DAY IT IS EQUALLY IMPORTANT AND IN SOME CASES MORE IMPORTANT THAT CERTAIN CHEMICAL WASTES BE KEPT OUT OF THE WASTE WATER AND TREATED BEFORE LEAVING THE REFINERY. WITHIN THE LAST TWO OR THREE YEARS MANY NEW REFINERY INSTALLATIONS INCLUDE RATHER EXTENSIVE FACILITIES FOR TREATING THE MOST TROUBLESOME OF THESE WASTES.

THE TWO WASTES UNDER THIS CLASSIFICATION WHICH ARE RECEIVING THE MOST ATTENTION AT THE PRESENT TIME ARE SPENT CAUSTIC AND PHENOLS DISSOLVED IN THE EFFLUENT WATER.

HANDLING OF SPENT CAUSTIC SODA SOLUTIONS

IT IS ALMOST UNIVERSAL PRACTICE FOR REFINERS TO WASH THEIR GASOLINES WITH AN AQUEOUS SODIUM HYDROXIDE SOLUTION. THIS SOLUTION THEN CONTAINS SULPHIDES, MERCAPTIDES, PHENOLATES, AND SMALLER AMOUNTS OF OTHER OBJECTIONABLE CHEMICALS IN ADDITION TO SOME UNUSED CAUSTIC SODA.

THE MANNER IN WHICH THE SPENT CAUSTIC IS DISPOSED OF DEPENDS UPON VARIOUS FACTORS SUCH AS THE NATURE OF THE SOLUTION, THE AMOUNT OF DILUTION AVAILABLE, THE CHARACTERISTICS OF THE STREAM OR BODY OF WATER INTO WHICH THE EFFLUENT WILL BE DISCHARGED, ECONOMIC CONSIDERATIONS OF DISPOSAL, ETC. FOR THESE REASONS, THE ELECTION OF A SUITABLE TREATING METHOD IS LARGELY A PROBLEM WHICH MUST BE SOLVED BY THE INDIVIDUAL REFINERY TO SATISFY ITS PARTICULAR REQUIREMENTS. A FINAL DECISION REGARDING ANY PROCEDURE SHOULD NOT BE REACHED UNTIL THE EFFICIENCY OF THE METHOD HAS BEEN PROVEN BY LABORATORY TEST. METHODS OF DISPOSAL GENERALLY AVAILABLE WILL BE DISCUSSED BELOW.

1. DISCARDING WITHOUT TREATMENT INTO THE REFINERY SEWERS - IN GENERAL, THIS IS THE METHOD WHICH IS NOT AVAILABLE TO MANY REFINERS. A CAREFUL STUDY OF DILUTION AND OF LOCAL CONDITIONS SHOULD BE MADE BEFORE ADOPTING THIS PROCEDURE.

2. STORAGE IN OPEN PONDS AND SUMPS - IN SOME CASES SPENT CAUSTIC HAS BEEN DISCHARGED INTO OPEN PONDS FOR DISPOSAL BY SEEPAGE AND EVAPORATION. HOWEVER, THE AMOUNT OF SPACE AVAILABLE FOR PONDS IS USUALLY NOT SUFFICIENT AND THIS METHOD CAN BE

APPLIED ONLY OCCASIONALLY. INSTANCES HAVE BEEN REPORTED WHERE SEEPAGE OF CAUSTIC WASTES INTO WATER SANDS HAVE BEEN RESPONSIBLE FOR THE CONTAMINATION OF NEARBY WATER SUPPLIES.

3. SALE OF SPENT CAUSTIC FOR PROCESSING OUTSIDE THE REFINERY
IN SOME INSTANCES THIS WASTE CONTAINS SULFIDES, PHENOLATES, CRESOLATES, ETC. WHICH ARE OF VALUE TO CHEMICAL PROCESSING CONCERNS. TRANSPORTATION COSTS ARE USUALLY SUCH THAT THIS DEMAND IS RESTRICTED TO THE IMMEDIATE LOCALITY. HOWEVER, THE FEASIBILITY OF SALE SHOULD ALWAYS BE KEPT IN MIND. PROBLEMS OF SEGREGATION AND HANDLING MAY WELL BE SUCH THAT THERE IS LITTLE IF ANY PROFIT IN THE SALE, BUT IT SERVES AS A MEANS OF DISPOSAL OF THE SPENT SOLUTION.

4. PUMPING DOWN DISPOSAL WELLS - IN SOME LOCATIONS IT MAY BE PRACTICABLE TO DRILL A WELL INTO SALT WATER FORMATIONS, AND TO DISPOSE OF THE SPENT CAUSTIC BY PUMPING IT DOWN THIS WELL. LOCAL AND PROVINCIAL AUTHORITIES SHOULD ALWAYS BE CONSULTED AND THEIR CONSENT OBTAINED BEFORE THIS IS ATTEMPTED. ALSO, MUCH DETAILED STUDY SHOULD BE MADE TO MAKE SURE THAT THE WELL WILL HAVE ADEQUATE CAPACITY.

5. NEUTRALIZATION - IN SOME CASES SPENT SULFURIC ACID MAY BE AVAILABLE IN THE PLANT. THIS MAY BE USED TO NEUTRALIZE THE SPENT CAUSTIC. THE GASES EVOLVED SHOULD BE CONDUCTED TO A FUME BURNER OR A FURNACE WHILE THE ACID OILS WHICH SEPARATE OUT MAY BE DIVERTED TO THE REFINERY FUEL TANKS. THE REMAINING LIQUID MAY USUALLY BE DISCHARGED TO THE REFINERY SEWER SYSTEM.

6. NEUTRALIZATION WITH FLUE GAS - FLUE GAS MAY BE USED TO NEUTRALIZE SPENT CAUSTIC, AND THIS PROCESS IS FINDING MUCH FAVOR IN RECENT YEARS. THE SPENT CAUSTIC IS ALLOWED TO FLOW DOWN A PACKED TOWER WHILE THE FLUE GAS PASSES UP IT. UNOXIDIZED HYDROGEN SULFIDE AND SOME MERCAPTANS AND WEAK ORGANIC ACIDS ARE STRIPPED OUT AND THE RESULTING SOUR GAS MAY BE BURNED IN A FUME BURNER OR A FURNACE CHAMBER. ACID OILS ARE ALLOWED TO SEPARATE FROM THE CARBONATE SOLUTION, AND THEY MAY BE DIVERTED TO THE REFINERY FUEL SYSTEM. THE RESULTING LIQUID CONTAINS CARBONATES, BICARBONATES, SULFATES, SULFITES, THIOSULFATES, AND IS USUALLY SUITABLE FOR DISCHARGE WITH THE EFFLUENT WATERS UNLESS ITS OXYGEN DEMAND IS SUFFICIENT TO BE OF SOME CONCERN.

PHENOLIC WASTES

IN RECENT YEARS THE PRESENCE OF PHENOLIC COMPOUNDS IN THE EFFLUENT WATERS OF REFINERIES HAS ATTRACTED MUCH ATTENTION. THIS IS BECAUSE THE PRESENCE OF ONLY A FEW PARTS PER BILLION IN CHLORINATED DRINKING WATER HAS A VERY BAD EFFECT ON THE TASTE.

Several methods are available for treating the phenols. The best known are biological oxidation, the use of ozone, treatment with chlorine, or treatment with chlorine dioxide. Recently published information (1) shows that biological oxidation is by far the cheapest method when costs are computed on the basis of cost per pound of phenol destroyed. This type of unit has recently been installed in some Canadian Refineries.

The phenolic waters are fed to trickling filters. Adequate cultures of the required bacteria are usually available from raw water or cultivated soil. Temperatures must be controlled and chemicals added if ammonia, phosphates and nitrates are not present in the feed water.

DISPOSAL OF WASTE GASES

Troublesome waste gases may contain hydrogen sulfide and various other sulfur compounds, partially oxidized hydrocarbons, etc. These gases can usually be handled by confining them in a closed system and then proceeding in one of three ways. They must be burned in the furnace chamber of an existing furnace, burned in a specially built waste-gas furnace, or disposed of in a stack with the flue gas from any furnace. The details of the system will depend upon the equipment available in the refinery.

Recently the catalytic combustion of waste gases (2) has received some attention. Oxy-Catalyst, Inc., of Wayne, Pa., has a new combustion catalyst available. In brief any partially oxidized gas such as carbon monoxide can be completely oxidized and the heat liberated can be used to produce steam. It would seem likely that this type of equipment will find increasing use in the future.

The outstanding feature of pollution abatement in Canada is the excellent spirit of co-operation which exists between industry and government. Each has an understanding of the seriousness of the other's problems that is producing a maximum of results with a minimum of disputes over ways and means. This points to a bright future indeed for the purity of our water supplies.

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MUNICIPAL BY-LAWS AND INDUSTRIAL WASTES

- By -

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INTRODUCTION:

Sewage collection systems and treatment plants are probably the most abused, through misuse, of all public utilities. The causes of this situation are:

(a) The disregard for their limitations and capacities and the misbelief that a sewer can carry away any unwanted substances or objects, and that the sewage treatment plants will take care of them.

(b) A lack of regulations setting forth the uses and limitations of the system.

(c) The failure of municipal authorities to enforce what regulations prevail.

No doubt one of the purposes of this Conference is to make municipal officials and industrial organizations more conscious of the importance of controlled usage of public sewers and sewage treatment plants. I hope that in this paper I may touch briefly on some of the fundamental requirements of an ordinance essential to proper control. The adoption of such an ordinance is the first requirement if the intended usage is to be realized.

For years the discharge of industrial wastes into sewers and storm drain systems has been permitted by municipalities with very little regard for the possibility of menace to public health and safety, potential damage to the system or increased cost of maintenance and operation. No doubt cities have offered their disposal facilities to industries in order to induce them to establish and build in their cities. Probably at the time of this inducement they had little knowledge of the volume, character or effect of the industrial waste upon their sewers and drains, or the

OPERATION OF THEIR SEWAGE TREATMENT PLANTS.

IN MANY CASES THE RESULTS HAVE BEEN SERIOUS, BOTH TO THE COMMUNITY AND THE INDUSTRY. MANY CITIES HAVE BEEN FORCED TO INSTALL SEWAGE TREATMENT PLANTS TO PREVENT POLLUTION OF RIVERS AND STREAMS, AND, TOO FREQUENTLY, INDUSTRIAL WASTES HAVE CAUSED DETERIORATION OF THE STRUCTURES AND INTERFERENCE WITH SEWAGE TREATMENT PROCESSES. CONSEQUENTLY, THERE IS AN UNJUSTIFIABLE INCREASE IN MAINTENANCE AND OPERATING COSTS. THERE IS A SERIOUS HAZARD TO WORKMEN BECAUSE OF TOXIC GASES AND EXPLOSION HAZARDS IN SEWER MAINS. ON THE OTHER HAND, INDUSTRIES HAVE BEEN SLOW TO REALIZE THE POSSIBILITIES OF BY-PRODUCTS FROM THE WASTE THEY DISCHARGE. SOME INDUSTRIES HAVE RECTIFIED THIS CONDITION, OTHERS ARE STILL WASTEFUL.

THE RAPID EXPANSION WHICH WE ARE EXPERIENCING TO-DAY MAKES THE ESTABLISHMENT AND ENFORCEMENT OF AN ORDINANCE IMPERATIVE. IT IS UNLIKELY THAT ANY ORDINANCE OR WORKABLE FORMULA CAN BE DEVISED WHICH WILL BE APPLICABLE TO ALL CITIES IN THE PROVINCE, AND POSSIBLY THE SAME CO-OPERATION THAT IS NECESSARY FOR THE PROPER ENFORCEMENT OF REGULATIONS WILL BE MOST HELPFUL IN DECIDING THE POLICY TO FOLLOW. OFTEN PROBLEMS COMMON TO INDUSTRY WILL RESULT IN INDUSTRIES' RESEARCH INTO SUCH PROBLEMS AND THE CONSEQUENT RECOVERY OF BY-PRODUCTS WHOSE VALUE PAYS FOR THE COST OF TREATMENT FACILITIES SO INSTALLED.

BEFORE DISCUSSING FURTHER THE CLAUSES WHICH MUST BE INCLUDED IN ANY ORDINANCE, LET US JUST DISCUSS BRIEFLY THE EFFECTS OF INDUSTRIAL WASTES UPON SEWERS AND SEWAGE TREATMENT PLANTS. AS FAR AS THE PUBLIC IS CONCERNED THE MOST SPECTACULAR INCIDENT OF MISUSE IS EVIDENCED IN VIOLENT EXPLOSIONS AND FIRES RESULTING FROM THE DISCHARGE OF EXCESSIVE FLAMMABLE SUBSTANCES TO THE SYSTEM. IN 1932 A GASOLINE EXPLOSION IN MONTREAL INJURED 30 PERSONS, TORE UP 12 BLOCKS OF SEWERS AND RESULTED IN PROPERTY DAMAGES OF OVER A MILLION DOLLARS. IN 1914-- 6 MEN WERE KILLED WHEN A SEWAGE PUMPING STATION IN BOSTON EXPLODED. THERE ARE MANY EXAMPLES CLOSER TO HOME. AN EXPLOSION IN A SEWER IN KITCHENER RAISED A MANHOLE TOP TO THE HEIGHT OF THE POST OFFICE CLOCK. FORTUNATELY NO ONE WAS KILLED, HOWEVER A PEDESTRIAN HAD A BUTTON WIPED OFF HIS SPAT AS THE MANHOLE CASTING FELL TO THE GROUND. IT HAS BEEN CONCLUDED THAT 60% OF SEWER EXPLOSIONS IN GERMANY ARE CAUSED BY GASOLINE OR BENZINE, AND THE WASTES FROM CLEANING ESTABLISHMENTS AS WELL AS FUEL OILS HAVE BEEN RESPONSIBLE FOR MANY OTHERS. AGAIN, CLOSER TO HOME, KITCHENER LAST YEAR WAS FORCED TO CLOSE ONE OF THEIR SEWAGE TREATMENT PLANTS FOR A FEW DAYS WHEN THOUSANDS OF GALLONS OF FUEL ENTERED THE SEWER MAIN AS A RESULT OF A BROKEN VALVE AT ONE OF THE OIL COMPANIES. THERE WAS LUCKILY NO FIRE, BUT AN EXTREME HAZARD EXISTED FOR SOME DAYS.

SEWER CLOGGING IS USUALLY DUE TO THE ACCUMULATION OF GREASE, ROOTS AND MISCELLANEOUS DEBRIS. GREASE IS OFTEN THE WASTE FROM PACKING HOUSES, TANNERIES, BAKERIES, HOTEL KITCHENS, ETC. HEAVY GRITTY MATERIALS FROM 'BUS COMPANIES' WASH RACKS OR EVEN SERVICE STATIONS HAS ALSO BEEN KNOWN TO CAUSE CLOGGING. LARGE AMOUNTS OF HAIR FROM TANNERIES

FEATHERS FROM POULTRY ESTABLISHMENTS, WOOL FIBRES FROM TEXTILE PLANTS, SPENT GRAIN FROM BREWERIES HAVE CAUSED MANY INSTANCES OF CLOGGING, NOT ONLY IN THE SEWERS BUT THROUGHOUT THE TREATMENT PLANTS AS WELL. KITCHENER HAS EXPERIENCED DIFFICULTIES WITH EVERY ONE OF THOSE MENTIONED, PROBABLY TO A GREATER EXTENT AT ITS SEWAGE TREATMENT PLANTS THAN IN THE SEWERS THEMSELVES. HOWEVER A 48 INCH TRUNK SEWER, BUILT IN 1912, HAS HAD ITS EFFECTIVE DIAMETER REDUCED TO LESS THAN 3 FEET AND ITS VELOCITY TO ONLY A FEW FEET PER MINUTE BECAUSE OF THE ACCUMULATION OF HAIR ON THE WALLS OF THE SEWER. THIS HAIR HAS BEEN COATED WITH CHEMICAL SALT DEPOSITS WHICH GIVE IT A FABRIC-LIKE PROTECTION, MAKING CLEANING POSSIBLE ONLY BY MECHANICAL MEANS.

SERIOUS OVERLOADS HAVE BEEN CAUSED BY THE DISCHARGE OF GREAT QUANTITIES OF PROCESS WATER AND COOLING WATER INTO MUNICIPAL SEWERS.

THE EFFECTS ON SEWAGE TREATMENT PROCESSES ARE MANY. ACID PICKLING LIQUORS HAVE CAUSED VERY LOW pH VALUES. HAIR HAS CAUSED SEVERE CLOGGING AS WELL AS THE FORMATION OF THICK MATS OF SCUM IN THE TOPS OF DIGESTERS. GREASES FROM PACKING HOUSES AND TANNERIES HAVE CAUSED CLOGGING OF PIPE LINES, DIFFUSER PLATES AND OTHER ELEMENTS OF A PLANT, NOT TO MENTION THE EFFECTS OF EXTREMELY HIGH B.O.D. AND SUSPENDED SOLID RATINGS OF SOME INDUSTRIAL WASTES.

THERE MAY BE BENEFITS FROM SOME OF THESE FACTORS. HOWEVER, THEY NEVER OUTWEIGH THE ADDITIONAL COST OF TREATMENT AND FACILITIES. THEREFORE, GAS PRODUCTION FROM KITCHENER'S SEWAGE IS MORE THAN TWICE THAT OF NORMAL DOMESTIC SEWAGE BECAUSE OF THE HIGH SOLIDS CONTENT. ON THE OTHER HAND AN EXTREMELY HIGH LOAD OF SOLIDS REQUIRES GREATER DIGESTER CAPACITY FOR ITS REDUCTION TO INOFFENSIVE SLUDGE. IT IS TRUE SLUDGE MAY BE SOLD, BUT IT IS DIFFICULT TO REALIZE A PROFIT FROM SUCH AN OPERATION.

THE MUNICIPAL SEWAGE SYSTEMS AND TREATMENT FACILITIES MUST BE PROTECTED FROM EXTREME OVERLOADS AND THE OTHER FORMS OF MISUSE JUST MENTIONED. A SOUND ORDINANCE CAN BE BENEFICIAL TO BOTH THE INDUSTRY AND THE MUNICIPALITY BY WAY OF MAKING POSSIBLE MAXIMUM USE OF THE PUBLIC FACILITIES FOR ALL WASTES WHICH CAN BE HANDLED EFFECTIVELY. IT IS DOUBTFUL WHETHER ANY MUNICIPALITIES HAVE ANY REGULATIONS AT ALL, AND, IF THEY DO, WHETHER THEY ARE UP-TO-DATE AND ADEQUATE, OR WHETHER THEY ARE PROPERLY ENFORCED TO BRING ABOUT THEIR EFFECTIVENESS.

BEFORE COMMENCING TO WRITE A SET OF RULES, CERTAIN PRELIMINARY CONSIDERATIONS SHOULD BE STUDIED. MOST EXISTING PUBLIC HEALTH BY-LAWS PROHIBIT THE DISCHARGE INTO PUBLIC SEWERS OF ANY MATERIALS WHICH, IN THE OPINION OF THE CITY ENGINEER, ARE NOT IN THE INTERESTS OF PUBLIC HEALTH. TODAY SUCH A CLAUSE WOULD BE VERY INADEQUATE IN ALL BUT THE SMALLER COMMUNITIES. NEVERTHELESS, THE DELEGATION OF THE POWER TO DECIDE ACCEPTABLE WASTES AND PRETREATMENT REQUIREMENTS TO A COMPETENT MUNICIPAL OFFICIAL HAS ADVANTAGES. THE ARRANGEMENT IS FLEXIBLE AND GETS AWAY FROM ARBITRARY LIMITS, WHICH

MIGHT NOT BE FAIR IN ALL CASES AND ALLOWS JUDGEMENT TO PREVAIL. SOME SPECIFIC LIMITS AND PERMISSIBLE VARIATIONS OF WASTE CHARACTERISTICS ARE, THEREFORE, DESIRABLE, EVEN IN ORDINANCES FOR SMALLER MUNICIPALITIES SINCE SUCH AN INCLUSION OFFERS GUIDANCE AND SUPPORT TO THE MUNICIPAL AUTHORITY RESPONSIBLE FOR ENFORCEMENT.

IT IS NOT FAIR TO ELIMINATE ALL INDUSTRIAL DISCHARGES IN SEWERS SINCE THEY ARE NOT ALL OBJECTIONABLE. HOWEVER, THIS UTILITY (THE SEWAGE SYSTEM AND THE TREATMENT FACILITIES) SHOULD BE USED, MAINTAINED AND OPERATED IN THE PUBLIC INTEREST, MAKING IT UNWISE TO PERMIT USAGE OF THE WORKS WHICH WOULD RESULT IN EITHER PHYSICAL DAMAGE, OPERATIONAL DIFFICULTIES OR EXCESSIVE MAINTENANCE COSTS. AS MENTIONED THESE LIMITATIONS ARE OFTEN OVERLOOKED COMPLETELY BECAUSE OF THE DESIRE TO PROTECT AN INDUSTRY FOR THE BENEFICIAL EFFECTS TO TAXES AND PAYROLL.

THERE ARE THREE METHODS OF HANDLING THIS PROBLEM, NAMELY:

1. THE CITY ACCEPTS ALL WASTE AND ASSUMES FULL RESPONSIBILITY FOR ITS TREATMENT, EITHER AT ITS OWN EXPENSE OR WITH SPECIAL CHARGES TO INDUSTRY;

2. THE CITY REJECTS ALL INDUSTRIAL WASTE AND HOLDS INDUSTRY FULLY RESPONSIBLE FOR ITS TREATMENT AND DISPOSAL;

3. A COMBINATION OF THE TWO WHEREBY INDUSTRIAL WASTES ARE CONTROLLED AND MODIFIED AT THE SOURCE RENDERING THEM ACCEPTABLE INTO THE CITY'S SEWERS.

INDUSTRY WOULD RATHER SEE THE FIRST METHOD ADOPTED AND, SINCE THEY ARE INTERESTED IN MANUFACTURE AND NOT SEWAGE TREATMENT, WOULD RATHER PAY THE MUNICIPALITY THAN TREAT THEIR OWN WASTE. THIS IS UNFAIR TO THE GENERAL PUBLIC SINCE MUNICIPAL SEWAGE TREATMENT PLANTS ARE USUALLY DESIGNED TO TREAT DOMESTIC VOLUMES AND STRENGTHS OF SEWAGE AND SHOULD NOT BE CALLED UPON TO SERVE INDUSTRY, WHICH OFTEN CAUSES A FAILURE TO PERFORM THEIR PRIME FUNCTION. AS JUST MENTIONED IT IS NOT FAIR TO ELIMINATE ALL INDUSTRIAL WASTES, SO WHY NOT ADMIT THOSE WHICH ARE NO MORE OBJECTIONABLE THAN DOMESTIC SEWAGE, WHICH, OF COURSE, POINTS TO THE NEED FOR PRELIMINARY TREATMENT BY THE INDUSTRY TO FULFILL METHOD No. 3, I.E. TO RENDER THE WASTES ACCEPTABLE.

WASTES WHICH ARE EXTREMELY DANGEROUS BECAUSE OF THEIR FLAMMABLE NATURE, OR FOR ANY OTHER REASON THAT WOULD CAUSE SERIOUS PHYSICAL DAMAGE TO COLLECTION OR TREATMENT FACILITIES, SHOULD BE EXCLUDED ENTIRELY. IF SUCH A MOVE WERE ACCEPTABLE, COSTS OF TREATMENT BY MUNICIPALITIES WOULD BE IN LINE WITH THE COST OF TREATING NORMAL DOMESTIC SEWAGE, AND INDUSTRY WOULD HAVE TO BEAR THE COST OF PRETREATMENT, IF NECESSARY, OR OTHER MEANS OF DISPOSAL IF THE WASTE IS EXCLUDED.

A DISCUSSION OF CHARGES FOR SUCH A SERVICE IS NOT WITHIN THE SCOPE OF THIS PAPER, NEVERTHELESS THE ESTABLISHMENT OF PROPER REGULATIONS PROVIDES THE BASIS FOR FAIR

ECONOMIC CONSIDERATIONS SINCE PRACTICALLY ALL WASTES ENTERING THE SYSTEM WILL BE EQUALLY ACCEPTABLE AND FOR ECONOMIC PURPOSES PRACTICALLY EQUAL IN EFFECT.

IT IS QUITE APPARENT THAT A PROPER SET OF REGULATIONS, SUCH AS ARE DISCUSSED FURTHER ON IN THIS PAPER, CAN ONLY BE HAD AFTER A COMPLETE STUDY HAS BEEN MADE OF THE PROBLEMS INVOLVED AT EACH INDUSTRIAL PLANT AND AT THE MUNICIPAL SEWAGE TREATMENT PLANT. THE LIMITS SHOULD BE PRACTICABLE AND NO MORE RIGID THAN WILL BE NECESSARY TO PROTECT THE SYSTEM AND ITS OPERATION. INDUSTRIES, IT IS TRUE, KNOW THEIR OWN WASTES, BUT HAVE LITTLE KNOWLEDGE OF THEIR EFFECT ON THE MUNICIPAL PLANT, AND IN ORDER TO SET A STANDARD FOR ACCEPTABLE DISCHARGES A COMPREHENSIVE STUDY OF FLOWS AND ANALYSIS IS NECESSARY. OFTEN THE ANALYSIS OF INDUSTRIES' WASTES SHOWS POOR HOUSEKEEPING TO PREVAIL IN THEIR PLANTS WHICH, WHEN CORRECTED BY PROPER RECOVERY METHODS, CAN GO FAR IN PAYING FOR PRELIMINARY TREATMENT.

IT WOULD SEEM, THEREFORE, THAT A MODERN BY-LAW WOULD HAVE TO BE GIVEN VERY SERIOUS CONSIDERATION BY A SPECIAL COMMITTEE APPOINTED BY THE MUNICIPAL GOVERNING BODY. THE MUNICIPAL ENGINEER, WITH HIS PROFESSIONAL KNOWLEDGE AND PRACTICAL EXPERIENCE USUALLY HEADS SUCH A COMMITTEE AND IT WOULD SEEM DESIRABLE TO ALSO HAVE ON IT CONSULTING ENGINEERS OR CHEMISTS AS WELL AS SUPERVISORY OFFICIALS IN THE COMMUNITY WHO HAVE TECHNICAL OR CHEMICAL EXPERIENCE. IF THE CITY ENGINEER OR SUPERINTENDENT OF SEWERS IS NOT EXPERIENCED ON INDUSTRIAL WASTE PROBLEMS THEY WOULD CERTAINLY KNOW WHERE TO SECURE THE NECESSARY INFORMATION AND EVALUATE THE DISCUSSIONS WHICH MIGHT ENSUE.

IT IS FELT THAT THE CHAMBER OF COMMERCE SHOULD BE INTERESTED IN DRAFTING A BY-LAW, SINCE IT WOULD BE IN THEIR INTEREST TO BE ABLE TO CHOOSE A PROPER LOCATION WITHIN THE GENERAL METROPOLITAN AREA OF A CITY WHERE INDUSTRY MAY LOCATE WITH A MINIMUM OF SEWER PROBLEMS. INDUSTRY SHOULD HAVE A REPRESENTATIVE ON SUCH A COMMITTEE SINCE IT IS INTERESTED IN SERVING THE COMMUNITY. INDUSTRIES OBJECT TO BEING BARRED FROM THE USE OF MUNICIPAL FACILITIES BUT IT IS FELT, HOWEVER, THAT IN MOST CASES THEY DO NOT SEEK UNFAIR ADVANTAGES FOR THEMSELVES. FROM PAST EXPERIENCES IN SOME AMERICAN CITIES POLLUTION ABATEMENT BY STRICT GOVERNMENTAL ORDER IS POOR PUBLIC RELATIONS. THIS ALSO APPLIES TO THE ELIMINATION OF INDUSTRIAL WASTE OVERLOADINGS, AND IT IS CERTAIN THAT RESEARCH, THE EXCHANGE OF 'KNOW-HOW' AND CONSIDERABLE PUBLIC GOODWILL, AS WELL AS AN INTELLIGENT AGGRESSIVE ATTITUDE ON THE PART OF INDUSTRY, WILL GO FAR IN THE ESTABLISHMENT OF A WORKABLE ORDINANCE. PROOF OF THIS STATEMENT WAS DEMONSTRATED AT THE INDUSTRIAL WASTES CONFERENCE HELD AT PURDUE UNIVERSITY IN 1949, WHERE THE FOLLOWING REASONS WERE GIVEN FOR THE POOR COLLABORATION IN EVIDENCE IN MANY CITIES REGARDING MUNICIPAL INDUSTRIAL WASTES ORDINANCE.

1. THE UNREASONABLE ATTITUDE OF THE MUNICIPALITY TO ACCEPT NORMAL WASTES;

2. Improper preliminary analysis of industrial wastes and plant conditions;

3. Non-familiarity with industrial operations;

4. A poor ordinance. No delineation of characteristics of acceptable wastes;

5. Stubbornness in accommodating certain wastes by the sewage treatment plant personnel;

6. Poor control by industry over pre-treatment or failure to give prompt notice to the municipality of accidental losses due to breakdowns, etc.;

7. Unwillingness of industry to bear costs of pre-treatment;

8. Lack of interest by both parties in each others problems, often compounded with suspicion and mistrust.

Let us bear these in mind if we are faced with the preparation or enforcement of municipal ordinances on industrial wastes.

The composition of an industrial waste by-law will vary in each municipality and this particular section will be one of the many in a complete sewer ordinance properly introduced and providing penalties for violation. This document should also define all terms used therein in order to eliminate differences of interpretation that might result in dispute or litigation.

Six main points to consider when formulating an industrial waste standard are as follows:-

1. Method of collection

2. Segregation of unwanted wastes

3. Wastes causing structural damage

4. Waste containing oils and greases

5. Wastes with high B.O.D.

6. Toxic wastes.

To facilitate testing and control industrial wastes should be segregated at least to a point where sampling is possible. It is suggested that a control manhole be provided where industrial wastes enter the main sewer. Often it is best to segregate industrial waste from the sanitary sewage arising in a plant. This would permit control over industrial wastes discharged, by way of permitting suspension

WITHOUT DEPRIVING THE PLANT OF ITS SANITARY FACILITIES.

IT IS ALWAYS BEST TO SEGREGATE STORM WATERS OF COURSE, ALTHOUGH SPILLAGE WHICH BECOMES CONTAMINATED, IN THE CASE OF OPEN AIR INDUSTRIES SHOULD ENTER THE SEWERS. PROVISION SHOULD BE MADE TO SEGREGATE UNWANTED WASTE, THAT IS, MATERIALS NORMALLY FOREIGN TO THE SYSTEM. THIS WOULD INCLUDE SAND, METAL FILINGS, HEAVY SLUDGES, ETC. DISCHARGE OF PROCESS OR COOLING WATERS MUST BE GUARDED AGAINST FOR FEAR OF IMPOSING HEAVY OVERLOADS ON EXISTING CAPACITIES. TEMPERATURE SHOULD BE LIMITED TO PROTECT JOINTING COMPOUNDS AND NOT INTERFERE WITH BIOLOGICAL ACTIVITY. DETROIT SUGGESTS A MAXIMUM TEMPERATURE OF 150°F. WASTE CAUSING STRUCTURAL DAMAGE WOULD INCLUDE ACID WASTE AND WASTE CONTAINING, OR PRODUCING, SULPHIDES. THIS IS USUALLY GUARDED AGAINST BY STIPULATING A MINIMUM pH OF 6.0. THE TEMPERATURE LIMITATION IS ALSO A PROTECTION AGAINST STRUCTURAL DAMAGE BY WAY OF ELIMINATING JOINT SOFTENING. ALKALINE WASTES SELDOM CAUSE SERIOUS PROBLEMS.

OILS AND GREASES ARE BECOMING MORE SERIOUS WITH THE INCREASED USE OF DETERGENTS AND EMULSIFIED AGENTS IN THE HOME AND INDUSTRY. THE SANITATION DISTRICT OF LOS ANGELES COUNTY CLASSIFIES OILS AND GREASES AS EITHER FLOATING OR DISPERSED AND LIMITS FLOATABLE OILS TO 10 P.P.M. HOWEVER, THE EMULSION MUST BE STABLE AND NOT BE BROKEN BY FURTHER DILUTIONS AND FURTHER pH CHANGES.

SEVERAL LIMITATIONS HAVE BEEN SET ON B.O.D'S.

0.17 LBS. PER CAPITA IS THE NORMAL CONTENT FOR DOMESTIC SEWAGE. THIS WOULD VARY, OF COURSE, WITH WATER CONSUMPTION, BUT WOULD BE EQUIVALENT TO APPROXIMATELY 200 PARTS PER MILLION BASED ON 100 GALLONS PER CAPITA DAILY FLOW. IT HAS BEEN SUGGESTED THAT 300 P.P.M. WOULD BE A REASONABLE MAXIMUM. BY THE SAME APPROACH 350 P.P.M. SUSPENDED SOLIDS IS A REPRESENTATIVE CONTENT.

SOME OPINIONS URGE CAUTION IN ASSESSING SUCH OVERLOAD FACTORS TO INDUSTRY SINCE THE VALUE OF THE PRODUCT AND THE INDUSTRY TO THE COMMUNITY IS IMPORTANT. IT IS GENERALLY AGREED THEREFORE, THAT DECISIONS REGARDING OVERLOADS OF THIS NATURE BE LEFT TO THE JUDGEMENT OF THE SUPERINTENDENT OF SEWAGE TREATMENT. HE MAY APPROVE OR DISAPPROVE OF WASTES CONTAINING HIGHER CONCENTRATIONS, A SPECIAL SURCHARGE BEING IMPOSED IF WASTES CAN BE BETTER HANDLED AT THE SEWAGE TREATMENT PLANT. NEVERTHELESS, LIMITS SHOULD BE SET TO DIFFERENTIATE BETWEEN INDUSTRIAL AND DOMESTIC SEWAGE. THIS FLEXIBLE AND FAIR ARRANGEMENT IS FELT TO BE MOST PRACTICAL.

TOXIC WASTES, THAT IS THOSE CONTAINING GASOLINE, FLAMMABLE GASES, CLEANING COMPOUNDS AND ALL CYANIDES SHOULD BE CONTROLLED. CALIFORNIA HAS SET A LIMIT OF 10 P.P.M. DISCHARGE OF PHENOLS HAS DRAWN MUCH CONCERN FROM THE CITY OF BRANTFORD AND WILL INVOKE CRITICISM IN MOST WATER WORKS SUPERINTENDENTS. LIMITATIONS FOR TOXIC WASTES VARY CONSIDERABLY, HOWEVER, DEPENDING UPON THE END TYPE OF DISPOSAL.

Some substances are toxic to biological sewage treatment processes, others produce deadly poisonous hydrocyanic acid gas. These substances dictate rigid controlling or limiting regulations.

The foregoing has covered very briefly the limitations which seem necessary in excluding industries' very potent wastes from municipal sewage treatment plants. There is need for much detailed study, however, before any particular municipality can write an ordinance which will be as practicable as possible.

Before closing a few points on enforcement and penalties might be made. Proper enforcement is essential if the ordinance is to fulfill its intended purpose. In larger cities where sewage collection and treatment are under one department, the head of such department is usually the one to enforce such. The Federation of Sewage Works Associations suggests that full responsibility be delegated to one individual who might be titled Superintendent of Sewage Works. In smaller municipalities he may have to call upon the services of a capable consulting sanitary engineer or chemist.

It is necessary to decide upon a maximum penalty that would serve to deter wilful continued or occasional violation by an offender who might find payment of the penalty less expensive than compliance. Those set forth in various ordinances vary from a minimum of $1.00 to a maximum of $500.00. A maximum of $200.00 has been suggested.

Prosecution procedure is provided for automatically when the ordinance receives its official passage in the municipality. However, it would be best that a notice of violation fix a definite time limit for correction of the objectionable condition. This would be best varied to suit the nature and the extent of the necessary improvement.

THE INCIDENCE OF NITRATES IN RURAL ONTARIO WELL WATERS

- By -

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For several years the Department of Bacteriology of the Ontario Agricultural College has been testing, on request, water samples submitted from rural home and school wells. This testing has been of a bacteriological nature only.

In 1950 our attention was drawn to the incidence of methaemoglobinemia which had been caused by the high nitrate level of well waters used in infant feeding. A subsequent search of the literature revealed that surveys of nitrate bearing waters and reports of cases of methaemoglobinemia were available from several states of the United States (2,4,5,6,8,11,12,14,15,16,17), three provinces of Canada (1, 9,10,13), and also from Belgium and England. The condition is apparently widespread in the United States and Canada.

This new interest in nitrate levels of water supplies began in 1945 after the observations of Comly (4). It was he who had first associated the high nitrate level of the water supply with the methaemoglobinemia observed in two infants of 18 and 27 days old. Since this time many cases have been reported. The first fatal case in Canada was reported in Saskatchewan in 1948 (9). In this particular case the nitrate content of the well water was reported to be 1320 p.p.m. Cases have also been observed in Manitoba, Alberta, and Dryden, Ontario.

Cases of methaemoglobinemia in livestock, caused by the consumption of water containing high concentrations of nitrates, have also been reported. (3,18,19)

Because of the possible relationship to both

HUMAN AND ANIMAL HEALTH IN RURAL AREAS, AND BECAUSE OF THE APPARENT PAUCITY OF INFORMATION CONCERNING NITRATE LEVELS IN ONTARIO WATERS, IT WAS DECIDED TO CONDUCT THIS SURVEY. IN 1950, 1951, AND 1952, THIS WAS CONDUCTED ON A LIMITED SCALE. IN 1953 ALL WATER SAMPLES SUBMITTED FOR ROUTINE BACTERIOLOGICAL EXAMINATION WERE SUBJECTED TO SCREENING TESTS FOR NITRATE AND NITRITE CONTENT. THIS SAME YEAR A NUMBER OF WELL WATERS WERE SELECTED FOR PERIODIC EXAMINATION OVER A PERIOD OF AT LEAST ONE YEAR.

METHODS

AT THE BEGINNING OF THE SURVEY VARIOUS CHEMICAL AND BACTERIOLOGICAL TESTS WERE CONDUCTED ON EACH SAMPLE. AFTER EXAMINING MORE THAN 100 SAMPLES IN THIS MANNER, IT WAS THOUGHT THAT THE INFORMATION GAINED RELATIVE TO THE INCIDENCE OF NITRATES WAS OF LITTLE VALUE, AND THESE TESTS WERE ABANDONED.

THE SPOT TEST FOR NITRATES WAS THE DIPHENYLAMINE-SULPHURIC ACID METHOD. IT WAS ESTABLISHED THAT THIS TEST WOULD DETECT AS LITTLE AS 0.5 - 1.0 P.P.M. OF NITRATE NITROGEN. THOSE SAMPLES WHICH GAVE A POSITIVE TEST WERE THEN SUBJECTED TO THE QUANTITATIVE PHENOLDISULFONIC ACID TEST FOR NITRATES (20). READINGS WERE MADE BY MEANS OF A SPECTROPHOTOMETER, AND THE AMOUNTS DETERMINED FROM A STANDARD CURVE.

BECUASE OF THE INTERFERENCE AND POSSIBLE FALSE POSITIVE REACTIONS, ALL WATER SAMPLES WERE SPOT TESTED FOR NITRITE CONTENT BY MEANS OF TROMMSDORF'S REAGENT. THIS TEST WAS SENSITIVE TO 0.5-1.0 P.P.M. OF NITRITE NITROGEN.

SAMPLES FROM THE WELLS SELECTED FOR PERIODIC EXAMINATION TO DETERMINE THE FLUCTUATION IN NITRATE NITROGEN CONTENT WERE SUBJECTED TO THE QUANTITATIVE PHENOLDISULFONIC ACID TEST AND THE SPOT TEST FOR NITRITES. ALL SAMPLES WERE TESTED FOR BACTERIOLOGICAL EVIDENCE OF POLLUTION IN THE USUAL MANNER.

OBSERVATIONS

1. GENERAL SURVEY

(A) DUG WELLS - EXAMINATION OF TABLE I REVEALS THAT ALMOST HALF OF THE SAMPLES FROM DUG WELLS CONTAINED LITTLE OR NO NITRATE; 18.8 PER CENT CONTAINED MORE THAN 10 P.P.M. OF NITRATE NITROGEN. THE HIGHEST LEVEL DETECTED WAS 196 P.P.M.

SEVENTEEN PER CENT OF THE 0-1 P.P.M. NITRATE NITROGEN GROUP REGISTERED POSITIVE BACTERIOLOGICAL EVIDENCE OF POLLUTION; 18.4 PER CENT OF THE 1-10 P.P.M. GROUP; 38.2 PER CENT OF THE 11-20 P.P.M. GROUP; AND 22.2 PER CENT OF THE 21-30 P.P.M. GROUP. TWO OF THE SAMPLES CONTAINING MORE THAN 100 P.P.M. ALSO WERE POLLUTED. TWENTY-NINE PER CENT OF THOSE

WATER SAMPLES CONTAINING MORE THAN 10 P.P.M. WERE POLLUTED.

(B) DRILLED WELLS - EXAMINATION OF TABLE II REVEALS THAT 80 PER CENT OF THE SAMPLES FROM DRILLED WELLS CONTAINED LITTLE OR NO NITRATE. OF THIS GROUP 5.75 PER CENT WERE POLLUTED. FIVE PER CENT OF THE DRILLED WELL SAMPLES CONTAINED OVER 10 P.P.M. NITRATE NITROGEN. OF THIS GROUP NONE WAS POLLUTED.

THE FOLLOWING DATA MAY BE OF INTEREST: A DRILLED WELL 107 FEET DEEP YIELDED WATER CONTAINING 35 P.P.M. NITRATE NITROGEN; ONE OF 114 FEET DEPTH CONTAINED 25 P.P.M.; ONE OR 120 FEET CONTAINED 6.5 P.P.M.; AND ONE OF 180 FEET CONTAINED 17 P.P.M.

(C) DUG AND DRILLED WELLS - TABLE III IS A COMPOSITE TABLE OF THE RESULTS OF ALL WELL WATER EXAMINED. THIRTEEN PER CENT OF THOSE SAMPLES CONTAINED MORE THAN 10 P.P.M. NITRATE NITROGEN. THIRTY-SEVEN PER CENT OF THOSE SAMPLES CONTAINING MORE THAN 10 P.P.M. NITRATE NITROGEN WERE POLLUTED.

II. PERIODIC EXAMINATION OF WELL WATERS

EXAMINATION OF FIGURE I REVEALS THE FLUCTUATION IN NITRATE NITROGEN LEVELS DURING A PERIOD OF ONE YEAR. THESE WATERS WERE TESTED AT THE POINTS INDICATED ON THE GRAPHS. THE RESULTS OF THE BACTERIOLOGICAL TESTS FOR POLLUTION ARE INDICATED BY THE POSITIVE AND NEGATIVE SIGNS ABOVE THE ABSCISSA.

THE TERM SEASONAL MAY NOT BE JUSTIFIED IN VIEW OF THE FACT THAT THESE WATERS HAVE BEEN TESTED FOR A PERIOD OF ONE YEAR ONLY. THE FIGURES MIGHT NOT BE SO IRREGULAR HAD IT BEEN POSSIBLE TO TEST AT MORE FREQUENT INTERVALS. AMONG THE WELL WATERS THUS EXAMINED, THE RESULTS FROM NINE ARE PRESENTED, AND ARE THOUGHT TO GIVE A FAIR REPRESENTATION OF THE FLUCTUATIONS THAT APPARENTLY OCCUR. THE WELLS CHOSEN ARE AS FOLLOWS:

No. 1 - DRILLED WELL, 28 FEET DEEP, GUELPH VICINITY
No. 2 - SHALLOW DUG WELL, SOUTH OF LONDON
No. 3 - DUG WELL, 6 FEET DEEP, NEAR ST. JACOBS
No. 4 - DUG WELL, 45 FEET DEEP, NEAR AGINCOURT
No. 5 - DUG WELL, 15 FEET DEEP, NEAR PRESTON
No. 6 - DUG WELL, 15 FEET DEEP, NEAR HAWKSBURY
No. 7 - DUG WELL, 75 FEET DEEP, NEAR NEWMARKET
No. 8 - DUG WELL, 25 FEET DEEP, NEAR NEWMARKET
No. 9 - DRILLED WELL, 150 FEET DEEP, NEAR ELMIRA.

DISCUSSION

IT WOULD APPEAR FROM THE OBSERVATIONS MADE THAT THE INCIDENCE OF NITRATES IS GREATER IN DUG THAN IN DRILLED WELLS. A DRILLED WELL IS NOT, HOWEVER, AN INDICATION

OF NITRATE FREE WATERS.

ALTHOUGH A GREATER PERCENTAGE OF WELL WATERS WHICH CONTAIN NITRATE NITROGEN ARE POLLUTED, THERE STILL IS A HIGH PERCENTAGE OF NITRATE CONTAINING WATERS WHICH SHOW NO EVIDENCE OF POLLUTION. THIS IS IN AGREEMENT WITH PREVIOUS WORK DONE ELSEWHERE (8,11,13,14,16). FOR THIS REASON OTHER SOURCES OF NITRATES HAVE BEEN SUGGESTED (8,11,13,14,16). THESE SOURCES MIGHT INCLUDE SEASONAL LEACHING OF THE TOPSOIL, VEGETATION, FERTILIZERS, TREE ROOTS AND NITRATE DEPOSITS.

IT HAS BEEN POINTED OUT THAT THE FLUCTUATION IN THE NITRATE NITROGEN LEVELS CANNOT BE INTERPRETED AS SEASONAL UNLESS A SIMILAR PICTURE WAS OBTAINED OVER A PERIOD OF AT LEAST ANOTHER YEAR. IN A SIMILAR SURVEY CONDUCTED IN KANSAS (11) IT WAS FOUND THAT SEASONAL FLUCTUATION DID OCCUR IN FOUR MUNICIPAL WELLS OVER A TWO YEAR PERIOD. HERE IT WAS FOUND THAT A PEAK WAS REACHED IN THE WINTER SEASON, AND THIS PEAK FELL OFF SHARPLY DURING LATE SPRING AND SUMMER. IN A SIMILAR SURVEY OF WATER FROM WELLS IN ALBERTA THE MARKED FLUCTUATION OF NITRATE NITROGEN CONTENT HAS BEEN DEMONSTRATED.

SUMMARY

THE NITRATE NITROGEN LEVELS AND THE INCIDENCE OF POLLUTION OF 484 ONTARIO WELL WATERS HAVE BEEN DETERMINED. IT IS EVIDENT THAT NITRATE NITROGEN LEVELS ABOVE THE 10 P.P.M. WHICH HAS BEEN SUGGESTED AS THE MAXIMUM FOR SAFETY OCCUR IN SUCH WATER SUPPLIES. THIS CONDITION IS MOST COMMON IN DUG WELLS, BUT DRILLED WELLS ARE NOT FREE OF THIS POLLUTION. IT WOULD APPEAR THAT THESE NITRATE LEVELS ARE NOT THE RESULT OF POLLUTION FROM HUMAN AND ANIMAL SOURCES ONLY. THE NITRATE NITROGEN LEVEL MAY FLUCTUATE MARKEDLY AND A SINGLE TEST FOR NITRATE CONTENT IS OF DOUBTFUL VALUE.

TABLE I

NITRATE NITROGEN IN 308 DUG WELLS - 1950 - 1954

P.P.M.	No. OF SAMPLES	PERCENT OF TOTAL	PERCENT POLLUTED
0-1.0	147	47.72	17.68
1-10	103	33.44	18.44
11-20	34	11.03	38.23
21-30	9	2.92	22.22
31-40	3	0.97	0.0
41-50	6	1.94	0.0
51-60	2	0.64	0.0
61-70	1	0.32	0.0
108	1	0.32	0.0
114	1	0.32	100
196	1	0.32	100

18.8 PER CENT OF THESE WELL WATERS CONTAINED MORE THAN 10 P.P.M. NITRATE NITROGEN.

TABLE II

NITRATE NITROGEN IN 176 DRILLED WELLS - 1950 - 1954

P.P.M.	No. of Samples	Percent of Total	Percent Polluted
0-1.0	139	78.97	5.75
1-10	28	15.99	7.14
11-20	7	3.97	0.0
21-30	1	0.56	0.0
31-40	1	0.56	0.0

5.1 PER CENT OF THESE WELL WATERS CONTAINED MORE THAN 10 P.P.M. NITRATE NITROGEN

TABLE III

NITRATE NITROGEN IN 484 WELLS - 1950 - 1954

DUG AND DRILLED TYPES

P.P.M.	No. of Samples	Percent of of total	Percent Polluted
0-1.0	286	59.09	11.88
1-10	131	27.06	16.03
11-20	41	8.47	31.70
21-30	10	2.06	20.00
31-40	4	0.82	0.0
41-50	6	1.23	0.0
51-60	2	0.41	0.0
61-70	1	0.20	0.0
108	1	0.20	0.0
114	1	0.20	100
196	1	0.20	100

13.8 PER CENT OF THESE WELL WATERS CONTAINED MORE THAN 10 P.P.M. NITRATE NITROGEN.

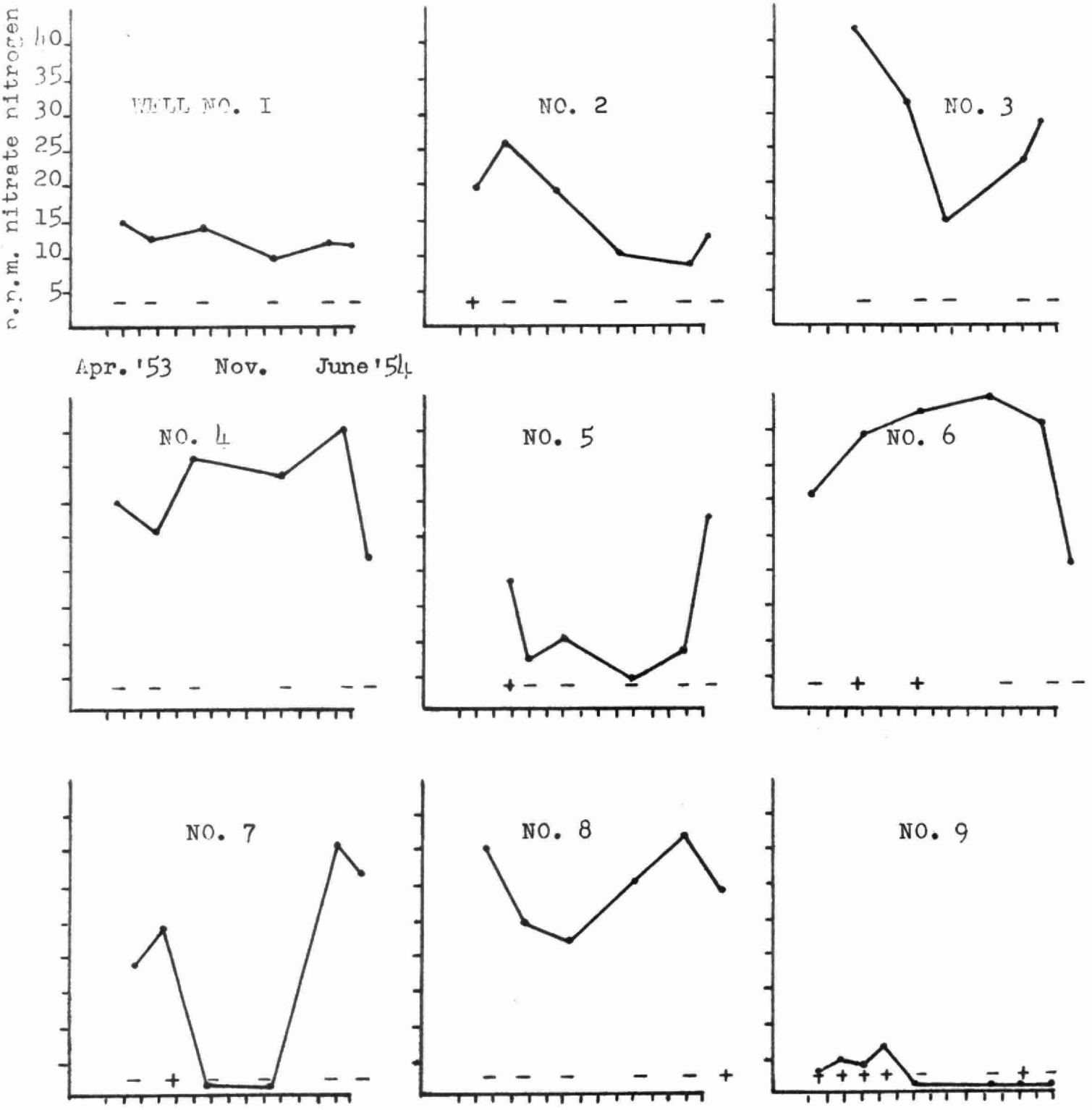

FIG. 1. SEASONAL FLUCTUATION OF NITRATE NITROGEN CONTENT IN NINE WELLS DURING A PERIOD OF ONE YEAR.

THE AUTHOR WISHES TO EXPRESS HIS APPRECIATION OF THE TECHNICAL ASSISTANCE OF MRS. M. LEITCH.

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DEOXYGENATING WASTES

- By -

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Deoxygenating wastes consist of all wastes which react with the oxygen dissolved in the receiving body of water and deplete or tend to deplete the amount of oxygen available for normal aquatic life. Such wastes originate in a wide variety of industries: in tanneries; in the manufacture of glue, gelatin, alchohol including breweries and distilleries; in wool scouring; in textile plants; in pulp and paper manufacture; in food processing plants such as meat packing, dairy and milk processing, corn products, beet sugar, fish processing, and food dehydration plants. Deoxygenating wastes include wastes usually regarded as chemical wastes, e.g. pickling liquor from the steel industries, organic chemical wastes and, of course, sanitary sewage. It is too broad a field to cover completely in such a short conference. Some phases of the particular problems of certain of the industries mentioned have been or will be dealt with by other speakers. It will, therefore, be only possible to deal with the principles involved in generalities. The opinions expressed are my own - not necessarily those of the Department.

Generally speaking the treatment of organic wastes is by either aerobic digestion or anaerobic digestion. Most wastes of this type can be successfully treated by the standard aerobic treatments of activated sludge or of high rate biofilters. There is a record of failure, but also of success, with aerobic treatment. There are several causes for the failure. One of the principal causes has been the lack of proper screening and/or settling before aerobic treatment. Another cause is the lack of adjustment of the hydrogen-ion concentration. The third and most important cause is that allowance has not been made in the design of the treatment plants for the high B.O.D. loadings of these types of wastes.

In the activated sludge system of treatment, it may be necessary for pretreatment of the waste to correct

THE PH, AND/OR TO ELIMINATE LARGE PARTICULATE MATTER. THE LENGTH OF TIME OF AERATION - OR AS OUR FRIENDS IN THE OIL INDUSTRY WOULD SAY, THE TIME OF RESIDENCE - MUST BE SUFFICIENT TO TAKE CARE OF THE MAXIMUM B.O.D. LOADING. IT IS ALSO ESSENTIAL TO HAVE A TANK FOR THE REAERATION OF THE ACTIVATED SLUDGE BEFORE IT IS DISCHARGED TO THE INCOMING WASTE. THIS SHOULD PROVIDE A BANK OF WELL CONDITIONED SLUDGE AS INSURANCE AGAINST FAILURE OF THE PRETREATMENT OR AGAINST SHOCK B.O.D. LOADINGS.

IN THE OXIDATION OF THESE WASTES ON HIGH RATE BIOFILTERS, THE SAME FACTORS HOLD TRUE. SUSPENDED SOLIDS IN THE APPLIED WASTE MUST BE REDUCED TO A MINIMUM TO PREVENT CLOGGING OF THE BED AND/OR THE DISTRIBUTION SYSTEM.

THE VOLUME OF EFFLUENT RECIRCULATED TO DILUTE THE INCOMING SEWAGE MUST BE GREAT ENOUGH TO REDUCE THE B.O.D. OF THE APPLIED MIXTURE TO ABOUT 100 P.P.M. SOME DESIGNERS HAVE TAKEN THE 24 HOUR B.O.D. LOADING AND CALCULATED THE VOLUME OF EFFLUENT RETURN FROM THAT FIGURE. IN MOST INDUSTRIES OF THIS TYPE THE HEAVY B.O.D. AND HEAVY FLOW IS FOR ABOUT AN EIGHT HOUR PERIOD, FOLLOWED PERHAPS FOR AN HOUR OR TWO WITH A LIGHTER WASTE AND SMALLER VOLUME FROM THE WASH UP. WITH A CONSTANT VOLUME RECIRCULATED AS CALCULATED FROM THE AVERAGE FIGURE, THE MIXTURE FOR ABOUT EIGHT HOURS HAS TOO HIGH A B.O.D. THIS INEVITABLY LEADS TO CLOGGING AND PONDING DUE TO A STIMULATED GROWTH OF SPHAEROTILUS NATANS. IT WAS STATED AT THE PURDUE CONFERENCE THAT PONDING ON BIOLOGICAL FILTERS WAS CAUSED BY A HIGH CARBOHYDRATE B.O.D. AND WAS NOT CAUSED BY PROTEIN B.O.D.

AN EXAMPLE OF FAILURE TO TAKE ALL FACTORS INTO CONSIDERATION IN DESIGN IS THAT OF A RENDERING PLANT. AN EXPENSIVE BIOFILTER WAS INSTALLED, BUT FAT REMOVAL FROM THE WASTE WAS NOT COMPLETE. THE FAT CONGEALED ON THE SURFACE OF THE BED AND IN A FEW HOURS THE FILTER WAS OUT OF WORKING CONDITION. A TYPE OF WASTE WHICH REQUIRES A CONSISTENT PRE-TREATMENT IS TANNERY WASTE. THE LIME WASTES MUST BE NEUTRALIZED AND COMPLETELY STABILIZED AND SETTLED BEFORE TREATMENT. OTHERWISE CALCIUM CARBONATE WILL DEPOSIT ON THE FILTER MEDIA, IN THE PIPE LINES AND ON ALL THE STRUCTURES WITH WHICH THE WASTE IS IN CONTACT. THIS WILL RUIN THE FILTER MEDIA AND ULTIMATELY RUIN THE PLANT ITSELF.

ANAEROBIC DIGESTION OF ORGANIC MATTER IS AN OLD DEVICE. THE SEPTIC TANK, THE DIGESTION TANK, EMSCHER TANK, TRAVISS TANK AND IMHOFF TANK ALL UTILIZE THE ANAEROBIC DIGESTION OF ORGANIC MATTER TO PRODUCE INERT HARMLESS SOLIDS WHICH ARE MORE OR LESS EASILY DE-WATERED.

THE EFFLUENT FROM THE SEPTIC TANK TYPE OF TREATMENT IS NEVER FULLY SATISFACTORY FOR DISCHARGE WITHOUT FURTHER TREATMENT. EVEN IF THE RESIDENCE PERIOD OF THE WASTE IS A WEEK OR TEN DAYS THE REDUCTION OF THE B.O.D. OF THE EFFLUENT IS INSUFFICIENT FOR DISCHARGE WITHOUT CAUSING A DEPLETION OF THE DISSOLVED OXYGEN IN THE RECEIVING BODY OF WATER.

Dr. R. Rupert Kountz of Pennsylvania State College in his paper on "Small Slaughter House Waste Treatment" stated that anaerobic treatment of that type of waste was unattractive. The tank volumes required to give the residence time required for a satisfactory effluent rendered anaerobic treatment impossible on economic grounds.

A proper disposal of anaerobic liquors such as the supernatant from digestion tanks, the liquor from dewatering digested sludge and the water from the elutriation of digested sludge has not yet been accomplished by the sanitary engineering fraternity. They solved one problem and created two new ones.

Chemical precipitation and chlorination are not to be recommended on any one of several counts - (a)costs; (b) trouble in the maintenance of proper dosage; (c) only the suspended solids are removed; soluble B.O.D. such as sugar is not removed; (d) removal and disposition of resulting sludge. In certain instances only chemical precipitation may be used to alleviate conditions.

Dr. Kountz in his paper, which was mentioned before, gave details of a simple successful and relatively inexpensive method of treating wastes from small slaughter houses. He used intermittent sand filtration, with emphasis on intermittent. There were two sand filters in series. The fresh waste was syphoned onto the first bed to give a loading of about 200,000 U.S.Gallons per acre. The effluent from the first bed was syphoned onto the second bed. The syphons discharged onto mats in the centre of the filters in order to spread the dose. This volume of waste should, if properly spread, put a depth of about six inches of liquor over the filter bed. The days when killing was in progress the syphons might discharge three or four times a day - but as these small plants do not kill every day there was a sufficient rest period for the restoration of the bed. It is essential that the volume of waste be kept to a minimum; no hose should be left wasting water onto the floor. Also emphasized was the necessity of removal of blood and solids before sewering - particularly fleshings and in the case of poultry killing plants, feathers. The volume of waste should run between 100 and 150 U.S.Gallons per animal; about 100 gallons per hog and 150 gallons per steer. It was stated that no odour nuisance resulted from these filters; the effluent was satisfactory for discharge; that freezing did not materially affect the beds as the waste was warm enough to thaw the frozen beds.

It should be noted that the foregoing was in Pennsylvania.

SUMMARY

1) Aerobic treatment for organic deoxygenating wastes offers the best and most economical method of treatment.

2) Anaerobic treatment for organic deoxygenating waste is only applicable where the effluent can be satisfactorily disposed of in tile drainage beds or subjected to other treatment before discharge to a water course.

3) It would be advisable to try to replace digestion of objectionable organic sludges by some other method possibly the Porteous process or some modification of that process. It should be possible to try that process on a pilot plant under North American conditions.

SPRAY IRRIGATION IN THE DISPOSAL OF INDUSTRIAL WASTES

CANNERY WASTES

- By -

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I wish to state at the very beginning that I am not here to speak to you as an authority on the handling and disposal of Industrial wastes. However, I am much interested in the subject and when my good friend, Dr. Berry, requested I discuss the subject of waste disposal from the viewpoint of cannery wastes, I could not refuse - but I fully expected to be able to obtain to speak to you in my place a man well versed and experienced in the subject. Unfortunately I am sorry to have to say I was unable at the last moment to make such an arrangement. Therefore, I will endeavour, with your indulgence, to present to you some aspects of the problem of the disposal of canning factory wastes.

Commercial canning on this Continent is approximately seventy-five years old. In the early days the production was relatively small and there was little or no problem in disposal in a satisfactory manner, the resultant waste products. The communities in which the factories were located were sparsely settled and the solids waste could be disposed of readily, and the liquid wastes were disposed of in the natural stream of the area.

As the canning industry grew, other industries developed and the communities became more thickly inhabited. This growth gradually made the old waste disposal methods inadequate and so waste disposal in the canning industry, like that of ther industries became a problem.

The commercial canner receives from the farm the products in the raw form and the amount of waste varies greatly in quantity - peas on vine; corn with husk and cob; apples, pears, peaches with skin and cores or pits. For instance the waste from cherries runs around 20% while that on corn may run as high as 85% with the percentage of waste from other products falling in between. Raspberries

HAVE A VERY LOW WASTE PERCENTAGE.

A LARGE PROPORTION OF THESE WASTES, IS IN THE SOLID FORM AND RELATIVELY EASY TO SEPARATE AND DISPOSE OF IN A SATISFACTORY MANNER, SUCH AS CORN HUSKS, APPLE SKINS, ETC. IN MANY INSTANCES THEY ARE RETURNED TO THE FARM AND USED AS FEED OR FERTILIZER.

THERE IS A LARGE VOLUME OF WASTES IN LIQUID FORM WHICH CONTAINS IN SOLUTION OR SUSPENSION A CONSIDERABLE PERCENTAGE OF ORGANIC VEGETABLE OR FRUIT MATTER. IT IS THIS TYPE OF LIQUID WASTE WHICH WE WISH TO CONSIDER AND WHICH IS THE IMPORTANT PART FROM POLLUTION AND NUISANCE VIEWPOINT.

THE COMMERCIAL CANNER MUST IN SELECTING A FACTORY LOCATION, GIVE FIRST CONSIDERATION TO TWO ESSENTIAL POINTS AND THESE ARE:

1. AN ADEQUATE, STEADY SUPPLY OF PURE WATER.

2. A SATISFACTORY AND NUISANCE FREE METHOD OF WASTE DISPOSAL.

BOTH THESE POINTS ARE OF EQUAL IMPORTANCE AND UNLESS THEY CAN BE SATISFACTORILY SOLVED THE LOCATION IS NOT A SUITABLE ONE FOR A CANNING FACTORY. HOWEVER, THERE IS THE PROBLEM WHERE SOME YEARS AGO A CANNING FACTORY WAS LOCATED IN AN AREA WHERE BOTH THESE CONDITIONS WERE SATISFIED BUT IN LATER YEARS, DUE TO THE DEVELOPMENT OF THE COMMUNITY BOTH INDUSTRIALLY AND OTHERWISE, THE WASTE DISPOSAL OF THIS ESTABLISHED FACTORY BECOMES A PROBLEM. THE COMMUNITY HAS GROWN BUT THE METHODS FOR WASTE DISPOSAL HAVE LAGGED BEHIND.

THE MOST SATISFACTORY METHOD OF THE DISPOSAL OF THE LIQUID WASTES, AFTER SCREENING BY THE CANNING FACTORY, IS INTO A MUNICIPAL DISPOSAL UNIT. BUT NOT ALL MUNICIPAL DISPOSAL PLANTS ARE ABLE TO HANDLE SUCH WASTE. FURTHER SINCE THE CANNING FACTORY IS USUALLY LOCATED IN RURAL AREAS, FREQUENTLY SUCH DISPOSAL UNITS ARE NOT IN EXISTENCE.

THE PROBLEM OF DISPOSAL OF THIS CANNING FACTORY WASTE HAS BEEN ATTACKED FROM A NUMBER OF DIFFERENT ANGLES WHERE MUNICIPAL DISPOSAL PLANTS WERE NOT AVAILABLE. THE FIRST AND OBVIOUS METHOD WAS TO SCREEN THE WASTE AND RUN THE LIQUID INTO EXISTING DITCHES, STREAMS, ETC. THIS IN MANY INSTANCES IS NOT SATISFACTORY, DUE TO THE HIGH B.O.D. OF SUCH WASTES, ITS EFFECT ON THE LIFE OF SUCH STREAMS, AND ITS POSSIBLE NUISANCE FROM THE POINT OF VIEW OF ODOUR.

IN ORDER TO REMOVE FROM THE WASTE, THE OBJECTIONABLE PORTIONS AS IT WAS DISCHARGED IN THE STREAMS, CANNERS WENT THROUGH AN ERA, WHEN INSTALLATIONS OF SETTLING BASINS AND VARIOUS SYSTEMS OF FILTERS USUALLY OF CRUSHED STONE OF VARIOUS SIZES, WERE MADE. THESE INSTALLATIONS WHILE UNDOUBTEDLY OF SOME VALUE, WERE NEVER ABLE TO GIVE A SATISFACTORY SOLUTION TO THE PROBLEM.

Another method tried on a fairly extensive scale was the biological filter in which the organic matter in the wastes was broken down by the action of bacteria. The canning industry is a seasonal operation, and the nature of the wastes vary greatly over the season. The biological filter for this reason has not proven to be a too satisfactory method for waste disposal in the canning industry. In addition the installation and the operational costs are very high.

Considerable work has been done on removal of the undesirable portions of canning factory wastes by sedimentation. This method has some application but again, due to the great variation in the nature of canning factory wastes and the cost of this method it did not prove to be the answer.

The next step and up to that time by far the most satisfactory is what is known as the lagoon method. It is used at present time when properly installed, with completely satisfactory results.

The lagoon method consists of mechanical screening of the liquid wastes to remove the suspended solids, treating the effluent liquid with a small quantity of nitrate and impounding the liquid in a large lagoon or small artificial lake.

The lagoon should be large enough to hold the season's production of the factory's waste liquid. It must be well built to prevent inroads into the banks by muskrats. The depth of the liquid in the lagoon should never exceed 5 feet, and it should be adjacent to a stream where the spent waste can be discharged harmlessly at suitable seasons of the year. We have stated that the lagoon should be large enough to hold the season's output of liquid waste. We would say that experience has shown that the rate of evaporation from such lagoon is relatively very large - on a normal summer day the evaporation far exceeds the average precipitation. No surface drainage water should, however, be allowed to enter the lagoon.

The location of the lagoon is of importance. It must be somewhat removed from human habitation as there is some odour coming from the waste as it undergoes decomposition. Prevailing winds must be carefully checked. If it can be situated on a soil of a good absorptive nature, the size of the lagoon may be somewhat smaller.

The lagoon for canning factory wastes is operating in a very satisfactory manner in a number of locations and promises to be continued as a method for handling such wastes.

An outgrowth of the lagoon is the spray irrigation system of handling canning factory wastes. We believe this idea was born from a lagoon installation which proved to be too small and the necessity arose to get rid of

LARGE QUANTITIES OF LIQUID WASTE. GROWING CROPS WERE IRRIGATED - WHY NOT USE THIS WASTE WATER FOR SUCH PURPOSE? IT WAS TRIED ON A PASTURE AND IN THIS INSTANCE WORKED. FROM THIS SMALL AND IN A WAY ACCIDENTAL BEGINNING THE SPRAY IRRIGATION SYSTEM OF WASTE DISPOSAL HAS BEEN EXTENDED TO HANDLING OF WASTES IN THE LAST FIVE OR SO YEARS FROM DIFFERENT TYPES OF FOOD FACTORIES AND ON THE WHOLE IS WORKING VERY SATISFACTORILY.

IT DOES APPEAR TO HAVE CERTAIN LIMITATIONS, PARTICULARLY IN RESPECT TO THE CROPS ON WHICH IT CAN BE USED AND THE NATURE OF THE LAND. WHILE IT SEEMS TO WORK QUITE WELL IN WOODED AREAS, IT IS NOT KNOWN THE ULTIMATE EFFECT IT WILL HAVE ON THE TREES. WOODED AREAS PRESENT A FURTHER PROBLEM INASMUCH AS THE TREES PRESENT OBSTACLES IN LAYING THE IRRIGATION LINES AND CHANGING OF THEM TO NEW LOCATIONS. WE KNOW OF NO RECOMMENDATIONS WHERE IT SHOULD BE USED ON ORCHARDS PARTICULARLY CULTIVATED ONES FOR REASONS THAT WE WILL REFER TO LATER.

HOWEVER, FOR PASTURES AND GRASS FODDER PRODUCING LANDS IT APPEARS TO BE WORKING QUITE SATISFACTORILY.

IN BRIEF THE METHOD IS TO THOROUGHLY SCREEN THE LIQUID WASTES THROUGH A TEN MESH SCREEN, - A SQUIRREL CAGE OR VIBRATING SCREEN SHOULD BE USED. A STATIONARY SCREEN SOON BECOMES CLOGGED AND WILL NOT ALLOW THE WATER TO PASS THROUGH. THE LIQUID IS ACCUMULATED IN A SMALL COLLECTING BASIN AND PUMPED FROM THERE TO THE LAND TO BE IRRIGATED. THE BEST OPERATION APPEARS TO BE TO PUMP THE EFFLUENT THROUGH TO THE IRRIGATED LAND WHEN IT IS STILL FRESH AND BEFORE DECOMPOSITION COMMENCES. THE MECHANISM FOR THE OPERATION OF THE IRRIGATION IS SIMILAR TO THAT USED ON REGULAR SPRAY IRRIGATION OTHER THAN THE PRELIMINARY SCREENING OF THE WASTE.

ONE PROBLEM IS IN THE PROPER SELECTION OF THE LAND AND THE CROP FOR THE IRRIGATION. THE AREA OF THE LAND WILL VARY WITH ITS NATURE AND THE QUANTITY OF LIQUID TO BE DISPOSED. LOCAL LAND SURVEYS CAN BE OF ASSISTANCE IN LAND SELECTION. EVEN BORINGS OF THE SOIL IS RESORTED TO IN SOME INSTANCES. GENERALLY QUITE A LARGE ACREAGE IS REQUIRED. IN SOME INSTANCES THE FACTORY HAS FOR SUCH PURPOSES AS MUCH AS FIFTY OR MORE ACRES.

WHILE THE SPRAY IRRIGATION SYSTEM CAN BE USED FOR DIFFERENT CROPS, PASTURE LAND HAS PROVEN TO BE MOST SATISFACTORY. GRASSES ABSORB THE WATER IN GREATER AMOUNTS AND WILL CONTINUE TO DO SO FOR MUCH LONGER PERIODS OF TIME.

TO ILLUSTRATE AN OPERATION WE WOULD TAKE ONE WHERE IN EARLY MAY A MIXTURE OF GRASSES CONSISTING OF INTERMEDIATE WHEAT, SMOOTH BROME, ORCHARD AND ALTA FESCUE WAS SOWN AND ALLOWED TO GROW UNTIL JULY WHEN THE FIRST SPRAY IRRIGATION OF FACTORY WASTES WAS APPLIED. THEN SPRINKLERS CONNECTED WITH AN IRRIGATION SYSTEM WERE USED DURING A NORMAL OPERATING DAY FOR 14 HOURS. THE SPRINKLER INSTALLATION CONSISTED OF ONE LATERAL LINE 1200 FEET LONG COMPOSED OF 30 FOOT SECTIONS OF 4" ALUMINUM PIPE WITH 1" CAST IRON PIPE RISERS

SPACED 60 FEET APART. EACH SPRINKLER DELIVERED 15 G.P.M. AT 45 P.S.I. PRESSURE.

THE FOLLOWING DAY THE LATERAL WAS MOVED A DISTANCE OF 60 FEET TO A NEW LOCATION. THE PEA PACK STARTED ON JULY 1ST, ENDING AUGUST 1ST, AND DURING THIS PERIOD 7½ ACRES OF LAND WERE USED FOR SPRAY IRRIGATION ON A PACK OF APPROXIMATELY 100,000 CASES OF PEAS. SUBSEQUENTLY THE LIQUID WASTES FROM A CORN PACK OF SOME 90,000 CASES, WERE DISPOSED OF BY IRRIGATION IN THE SAME AREA. THE REPORT IS THAT THE SYSTEM WORKED VERY SATISFACTORILY AND FREE FROM ANY NUISANCE VALUE. THE LAND UNDER THE SYSTEM USED ABSORBED THE LIQUIDS IN A SATISFACTORY MANNER, THE CROP GREW ABUNDANTLY AND THERE OCCURRED NO NUISANCE FROM ODOURS, ETC.

THE COVER CROP PLAYS A VERY IMPORTANT PART IN THE SYSTEM OF SPRAY IRRIGATION. IN THE INSTALLATION REFERRED TO ABOVE THE GRASSES WERE SOWN ABOUT MAY 1ST. DURING THE LATTER PART OF JULY THE GRASS HAY CROP ON PART OF THE AREA WAS CUT OVER A PERIOD OF SEVERAL DAYS. WASTES APPLIED AT THIS TIME TO UNCUT AREA WERE ABSORBED AT A RATE WHICH ALLOWED SPRINKING ON THE SAME AREA FOR THE ENTIRE DAY. HOWEVER, THE CUT AREA OF THE FIELD EXPOSED CONSIDERABLE BARE GROUND BETWEEN THE PLANTING ROWS AND WASTE ABSORPTION WAS REDUCED BY 50%. ON ONE AREA CUT FOLLOWING A RAIN, PACKING OF THE SOIL BY CUTTING AND HAULING OPERATIONS FURTHER REDUCED THE ABSORPTION TO ABOUT 25%.

FURTHER DEVELOPMENT OF THIS PARTICULAR OPERATION PLANNED FOR EXTENDING THE AREA BY ABOUT 75% WHICH WILL BE PLANTED TO ALFALFA AND CUTTING THE ALFALFA AT LEAST TEN DAYS BEFORE USING THE AREA FOR SPRAY IRRIGATION. THIS EXTENSION WAS PLANNED TO OBTAIN SOME FINANCIAL RETURN ON THE WASTE DISPOSAL SYSTEM. CATTLE WERE TO BE GRAZED ON THE GRASS FIELD. IN NEW JERSEY THE STATE BOARD OF HEALTH HAS GIVEN APPROVAL TO PASTURING MILK COWS ON SPRAYED AREAS PROVIDING THERE HAS BEEN A TEN DAY LAPSE SINCE THE SPRAY WAS DISCONTINUED.

IN PRINCIPLE THE METHOD OF SPRAY IRRIGATION APPEARS REASONABLY SIMPLE, BUT THERE REMAINS SOME PRECAUTIONS TO BE TAKEN AND CERTAIN PROBLEMS AND LIMITATIONS.

SOME OF THESE LIMITING FACTORS AND PRECAUTIONS ARE:

1. SATISFACTORY DISPOSAL DEPENDS ON SOIL ABSORPTION AND THE FACTOR OF FIRST CONSIDERATION IS AVAILABILITY OF LAND WITHIN ECONOMICAL PUMPING DISTANCE.
2. THE SELECTION OF PROPER COVER CROP IS OF PRIME IMPORTANCE. AN ADEQUATE COVER CROP WILL ALLOW RELATIVELY POOR ABSORPTION SOIL TO BE SATISFACTORY.
3. SPRAYING ON BARE OR ESSENTIALLY BARE SOIL WILL NOT RESULT IN A SATISFACTORY ABSORPTION WITHOUT RUN OFF. THE ROOT SYSTEM OF A GROWING COVER CROP HELPS DISPOSE OF ABSORBED GROUND MOISTURE.
4. CHOICE OF TYPE OF COVER CROP IS MOST IMPORTANT. SUCH CROPS AS PEAS, BEANS, SMALL GRAINS HAVE PROVEN TO BE

UNSATISFACTORY BECAUSE THEY COULD NOT TOLERATE THE QUANTITY OF WATER. IT DOES SEEM, HOWEVER, THAT DENSE, LOW GROWING GRASSES OF GOOD PASTURES ARE THE MOST SATISFACTORY. WITH FIELDS OF GOOD COVER CROP WASTE WATER CAN BE SPRAYED AT A RATE OF 0.4 TO 0.6 INCHES PER HOUR OVER A PERIOD OF ONE DAY'S OPERATION. A RECOMMENDED PRACTISE IS TO HAVE TWO LATERALS AND OPERATE EACH ON AN ALTERNATE BASIS OF ONE HOUR TO ALLOW FOR BEST ABSORPTION.

5. THE EFFECT OF LEACHING OF MINERAL CONSTITUENTS OF THE SOIL BY SPRAY IRRIGATION HAS NOT BEEN DETERMINED. FOOD PLANT WASTES, HOWEVER, WILL SUPPLY SOME NUTRIENTS. PEA WASTE FOR EXAMPLE WILL AVERAGE 46 P.P.M. ORGANIC NITROGEN AND 9 P.P.M. AMMONIA NITROGEN WITH A TOTAL PHOSPHORUS CONTENT OF 8 P.P.M. WITH 5 P.P.M. IN SOLUBLE FORM. CORN WASTE HAS AN AVERAGE OF 54 P.P.M. ORGANIC NITROGEN AND 2 P.P.M. AMMONIA NITROGEN. TOTAL PHOSPHATES AVERAGE 11 P.P.M. WITH 5 P.P.M. SOLUBLE. STUDIES OF SOIL ANALYSIS OVER SEVERAL YEARS ARE NEEDED TO GIVE RELIABLE INFORMATION ON THE EFFECT OF SPRAY IRRIGATION OF FACTORY WASTES.

6. PRE-SCREENING OF WASTES IS A MOST IMPORTANT STEP IN THIS SYSTEM OF CANNING FACTORY WASTES DISPOSAL. A 10 MESH SCREEN HAS BEEN SHOWN TO BE QUITE SATISFACTORY. THERE IS NO BENEFIT TO BE DERIVED FROM REMOVING VERY FINE SOLID MATERIAL OR USE OF 20 OR 40 MESH SCREENS. PRECAUTION SHOULD BE TAKEN, HOWEVER, TO PREVENT THE INCLUSION IN THE SCREENED WASTE WATER BY ACCIDENT, SOLIDS THAT SHOULD HAVE BEEN REMOVED. IT MAY BE NECESSARY TO INSTALL A STATIONARY SCREEN OVER THE END OF THE PUMP SUCTION PIPE WITH SIZE OF SCREEN OPENINGS APPROXIMATELY THAT OF NOZZLE. TREND IS TO 1/4" NOZZLE OPENING.

7. THE SPRINKLERS SHOULD BE CAPABLE OF DELIVERING 15 TO 25 G.P.M. OVER AN AREA OF 120 TO 140 FEET IN DIAMETER WHEN THE DISPOSAL IS ON A FIELD OR PASTURE.

8. THE SYSTEM SHOULD BE OF SUCH A SIZE THAT WILL ALLOW DISPOSAL OF WASTES WITH A MINIMUM OF HOLDING TIME. A SUMP HOLDING THE WASTE COLLECTED OVER A PERIOD OF 15 TO 30 MINUTES SHOULD BE AMPLE. IN THIS WAY THE WASTE IS DISPOSED OF BEFORE ODOURS ARE DEVELOPED.

9. LATERALS SHOULD BE REMOVED FROM CLOSE PROXIMITY TO HIGHWAYS, ETC. TO PREVENT ANY SPRAY BEING CARRIED ONTO THEM.

10. THE CONCENTRATED WASTE LIQUID FROM SEEPAGE OF PEA STACKS CANNOT BE USED IN SPRAY SYSTEM AS IT IS IN THE CONCENTRATED FORM HARMFUL TO CROPS, HAVING A BURNING EFFECT.

11. THE DISPOSAL OF WASTE ON LAND INVOLVES A CALCULATED

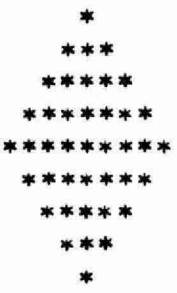
RISK IN THE POLLUTION OF WELLS AND STREAMS. THE RECORD IN THIS RESPECT, HOWEVER, IS ENTIRELY SATISFACTORY WITH POSSIBLY ONE OR TWO INSTANCES OF UNUSUAL CONDITIONS.

12. SPRAY IRRIGATION DESIGN AND INSTALLTION SHOULD BE UNDER THE DIRECTION OF ENGINEERS SPECIALIZING IN THIS FIELD.

WE HAVE ENDEAVOURED TO PRESENT TO YOU AN OUTLINE IN VERY GENERAL TERMS THE PROBLEMS OF DISPOSAL OF CANNING FACTORY WASTES, AND WE TRUST THAT IN SOME MANNER WE HAVE BROUGHT AT LEAST TO ONE MEMBER OF OUR AUDIENCE A NEW IDEA OR ANSWERED IN SOME WAY A QUESTION.

WE STATED AT THE OUTSET THAT WE ARE IN NO WAY TO BE REGARDED AS AN AUTHORITY IN THE FIELD. FURTHER, WE WISH TO STATE THAT WE HAVE USED IN THIS PAPER VERY LIBERALLY THE PUBLISHED PAPERS OF WHOSE WHO HAVE STUDIED AND REPORTED ON THE SUBJECT OF CANNING FACTORY WASTES. OUR MAIN SOURCE OF INFORMATION ON THE SPRAY IRRIGATION METHODS IS THE PUBLISHED WORK OF N. H. SANBORN OF NATIONAL CANNERS' ASSOCIATION RESEARCH LABORATORY OF WASHINGTON, D.C.

WE DO NOT CONSIDER THAT A FINAL SATISFACTORY SOLUTION FOR DISPOSAL OF CANNING FACTORY WASTES HAS BEEN FOUND. WE BELIEVE THAT THE FUTURE HOLDS DISTINCT PROMISE OF FURTHER DEVELOPMENTS. IN THE MEANTIME WHERE MUNICIPAL FACILITIES ARE AVAILABLE OR LAGOONS IN USE THE PROBLEM IS ONE OF GOOD CO-OPERATION AND PRACTISE. IN OTHER INSTANCES, THE PRESENT SYSTEMS, ALTHOUGH DIFFERING RADICALLY FROM ABOVE DESCRIBED TYPES AND VERY SIMPLE, ARE STILL FUNCTIONING WITHOUT PRESENTING A PROBLEM. FOR THOSE THAT ARE A PROBLEM, HOWEVER, CAREFUL STUDY AND APPRAISAL WILL HAVE TO BE GIVEN TO ALL POSSIBLE METHODS IN ORDER TO OBTAIN A COMPLETE AND LASTING SOLUTION TO A PROBLEM THAT IS IMPOSED, IN PART AT LEAST, BY THE RAPID EXPANSION OF INDUSTRY AND GREAT GROWTH IN OUR POPULATION.



SPRAY IRRIGATION IN THE DISPOSAL OF INDUSTRIAL WASTES

MILK WASTES

- By -

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Only a few weeks ago it was my privilege to attend a National Resources Conference in Ottawa. Although the entire field of conservation was covered at that meeting, a great deal of time was devoted to discussion of industrial wastes and stream pollution. It seems rather significant that this follow-up Conference should be convened so soon after the National meeting when prior to that there had not been one held in Canada in forty-eight years. I think it indicates a general awakening of public interest in this whole problem of waste disposal and water conservation. A meeting of this kind can serve a most important and useful purpose by permitting these problems to be brought out and discussed. Everyone then has a clear understanding of exactly what is involved. Once everyone does see the problem in the same light it usually follows that a solution is soon found. There is also less tendency then for us all to demand that the other fellow "do something about it" when, in reality, nobody knows quite what can be done about it. It is something like telling a man to brush the fly off his nose when his hands are tied behind his back. I think I can speak for the entire dairy industry in saying that the disposal of dairy plant wastes is probably the greatest headache that each plant operator has to contend with, and that we are more anxious than anybody to see some real solution to the problem. We can say then that the desire to do something is there, and we look to meetings like this one to help us find out just what we can do.

When you discuss pollution of large lakes and rivers like the North Saskatchewan, or Lake Ontario, then we can just about leave the dairy industry out of it. We do not enter the picture in a sizeable way, however, when it comes to pollution of small streams, brooks and drainage

DITCHES. I THINK WE CAN ALSO SAY THAT ANY SUCH POLLUTION WOULD BE LOCALIZED TO WITHIN ONE OR TWO MILES FROM THE PLANT INVOLVED. IT IS WHEN NUMBERS ARE CONSIDERED THAT DAIRY PLANT POLLUTION BECOMES SIGNIFICANT. THERE ARE OVER TWO THOUSAND IN THE PROVINCE OF QUEBEC, AND ABOUT 500 TO 600 IN THE PROVINCE OF ONTARIO. THEY ARE NEARLY ALL LOCATED IN REMOTE RURAL AREAS IN ORDER TO BE CLOSE TO THE MILK SUPPLY. WE CAN SAY THAT FEW, IF ANY, OF THESE PLANTS HAVE THE ADVANTAGE OF MUNICIPAL SEWAGE SYSTEMS AND THEY MUST PROVIDE THEIR OWN SOLUTION. THE DAIRY INDUSTRY IN THIS COUNTRY AND PARTICULARLY CHEESE PRODUCTION GREW VERY RAPIDLY. THE RESULT IS THAT MOST OF THESE PLANTS ARE SMALL AND THEIR LOCATION FROM A DRAINAGE STANDPOINT IS NOT ALWAYS THE BEST. A GREAT DEAL OF WORK HAS BEEN DONE IN THE PAST FEW YEARS BY BOTH FEDERAL AND PROVINCIAL GOVERNMENTS TO TRY TO CONSOLIDATE AND REBUILD MANY OF THESE SMALL PLANTS.

IT WOULD BE EASIER TO PRESENT A PAPER ON THE PROBLEMS INVOLVED IN HANDLING DAIRY WASTES THAN TO RECOMMEND WAYS TO CORRECT THEM. THE DAIRY INDUSTRY FEELS THAT THERE HAS BEEN A GREAT LACK OF KNOWLEDGE ON DAIRY WASTE DISPOSAL AND HAS RECOMMENDED THAT SOME RESEARCH PROJECTS BE STARTED. IT IS PRETTY WELL CONCEDED, HOWEVER, THAT SEPTIC TANKS JUST DO NOT WORK WITH DAIRY WASTES. A DAIRY FIRM INSTALLED ONE A FEW YEARS AGO THAT HAD ALL THE LATEST ENGINEERING IMPROVEMENTS BUILT INTO IT AT A COST OF $25,000. IT WAS A COMPLETE FAILURE. THERE HAVE BEEN SEVERAL OTHER IDEAS TRIED - ALSO COSTLY - BUT RESULTS HAVE BEEN PRETTY GENERALLY UNSATISFACTORY. LAGOONING HARDLY SEEMS TO BE THE ANSWER. THE VOLUME IS TOO GREAT AND THE NUISANCE PROBLEM IS SUCH THAT IT WOULD BE DIFFICULT TO OBTAIN SUITABLE LAND FOR THIS PURPOSE.

IN FACING THIS PROBLEM WE MUST ALSO REALIZE THAT THERE ARE ECONOMIC LIMITATIONS. WHEN WE CONSIDER THAT THE TOTAL INVESTMENT IN MOST OF THESE FACTORIES IS LESS THAN $25,000. IT IS HARDLY REASONABLE TO RECOMMEND INSTALLATIONS THAT WOULD COST SEVERAL TIMES THAT AMOUNT.

THE GREATEST SINGLE ITEM IN DAIRY PLANT WASTES IS WHEY. FOR EVERY POUND OF CHEESE PRODUCED THERE ARE NINE POUNDS OF WHEY TO DISPOSE OF. IT IS A VALUABLE BY-PRODUCT AND AN EXCELLENT FEED FOR HOGS. HOWEVER, DURING THE HEAVY MILK FLUSH MOST PLANTS HAVE FAR MORE THAN THEY CAN DISPOSE OF. A FEW LOCATED NEAR ENOUGH TO CORNWALL CAN SELL IT TO A FIRM WHICH HAS A LARGE WHEY PROCESSING PLANT THERE. THE AVERAGE PLANT WOULD HAVE FROM 10,000 TO 20,000 POUNDS OF WHEY FOR DISPOSAL EVERY DAY AND SOME PLANTS WOULD HAVE AS MUCH AS 50,000 TO 60,000 POUNDS. A GREAT AMOUNT OF IT FINDS ITS WAY INTO THE WASTE DRAINS.

SKIM MILK, BUTTERMILK, CHEESE PARTICLES AND MILK SOLIDS CARRIED IN WASH WATER ALL ADD TO THE LOAD AND SOME OF THESE ITEMS HAVE EXTREMELY HIGH B.O.D. IN THE CASE OF CHEESE, A B.O.D. OF 60%, SKIM MILK SOLIDS A B.O.D. OF 73.7% AND WHEY 3.5%.

If I had been asked to present this paper a year ago there would have been little encouragement I could offer. During the last year, however, we have been carrying out an experiment that shows every sign of being a success. We installed high pressure sprinkler heads in about 3-1/2 acres of pasture located near our plant at Berwick, Ontario. Through these we sprayed on the land all the wastes from the plant. There were two sprinkler heads located at opposite sides of the strip and these were used alternately. The field was observed fairly closely to see that sprinklers were not left on too long in one location. During the season the pasture remained good and there were no visible signs of damage. The farmer who owned the land felt that pasture conditions were better than usual. Wastes were drained from the plant to a 500-gallon tank and then pumped directly to the sprayers. It is most important that it be done in such a manner that it does not have time to become septic. There was no noticeable odour nuisance although the area under irrigation was just across a small river, not more than one hundred yards from the plant. As we have said before, we do not want to say too much about the final results until we have had at least two or three seasons' experience behind us. We are definitely encouraged, however, to the point where land arrangements are being made for similar installations at one other plant this year. At the original location at Berwick we are putting in four spray heads this year in place of two last year. Each head is mounted about six feet above ground and with a 40-pound pressure maintained in the line it sprays an area 160 feet in diameter. They are controlled automatically by a float switch in the 500-gallon tank. It was noticed the first year that the cattle had a strong preference for the grass growing closest to the sprays and when the automatic starter cut in they were frequently startled and stampeded. It was felt that they will become accustomed to this in time.

We know that as far as we are concerned we shall have a great deal to learn. We believe the old, well established pastures are better than land that has recently been under cultivation. Perhaps some heavy, broad-leaf crop would be better for evaporation purposes than a close cropped pasture, but we will have to find these things out by experience. I understand that there are different firms experimenting with overhead spray disposal systems in the States. Our own firm expects to have a number of large installations in the near future. One large installation now operating in the U.S.A. is getting rid of the equivalent of 40 inches of rainfall per day on one piece of land and apparently does it successfully.

It seems quite clear that a very encouraging lead has been discovered. We may have to spend a year or so yet working out details, but I think we can say with assurance that for dairy plant waste disposal the spray irrigation principle is the most hopeful outlook we have yet seen.

TREATMENT OF BEET SUGAR WASTES

- By -

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The beet sugar industry became established on a paying basis early in the 19th Century when Napoleon's blockade of the British Isles created a sugar shortage on the continent of Europe. The industry is comparatively young in Canada, having been started some fifty years ago. To-day production of sucrose from sugar beets is a major chemical industry. In 1952, Canada produced 298,245,300 pounds of beet sugar from 1,028,000 short tons of beets. This represents about one-quarter of Canada's annual sugar consumption. Based on 5-Day BOD, liquid wastes for the Canadian beet sugar industry have been estimated to have a population equivalent potential of 1,400,000.

ORGANIZATION AND OPERATION

Four companies operate seven beet sugar refineries in the Dominion. Refineries are located in the Provinces of Alberta, Ontario, Manitoba, and Quebec. In 1952, Alberta with three refineries harvested 46.5 per cent of the beets and Ontario with two refineries processed 33.1 per cent of the total for the Dominion. A Steffen house is located at Raymond, Alberta. It also works molasses from the other two Alberta refineries. The Taber, Alberta, and Chatham, Ontario, plants have continuous diffusers. The Raymond and Picture Butte, Alberta refineries use pulp silos whereas the other plants dry the pulp. The season lasts for some ten weeks beginning about October 1, in Alberta and Manitoba, and mid-October for Ontario.

DESCRIPTION OF PROCESS

THE SUGAR BEET IS APPROXIMATELY 75 PER CENT WATER AND 25 PER CENT DRY SOLIDS. THE SUGAR CONTENT MAY BE EXPEC ED TO VARY BETWEEN 15 AND 17 PER CENT DEPENDING ON THE SEASON AND THE REGION WHERE THE BEETS ARE GROWN. THE NON-SUGARS ARE COMPOSED OF CELLULOSE, NITROGENOUS COMPOUNDS, ASH, AND OTHER ORGANIC MATERIALS. PROCESS WASTES MAY BE EXPECTED TO CONTAIN ABOUT 4.6 PER CENT OF THE WEIGHT OF THE BEET IN ADDITION TO SOIL AND OTHER EXTRANEOUS MATERIAL REMOVED FROM THE BEET PREPARATORY TO SLICING.

FIGURE 1, IS A SIMPLIFIED FLOW DIAGRAM SHOWING BASIC STEPS IN BEET SUGAR MANUFACTURE AND POINTS IN PROCESS WHERE LIQUID WASTES ARE PRODUCED. FLOWING WATER IN FLUMES TRANSPORTS BEETS FROM STORAGE TO THE PLANT. THIS OPERATION WASHES MOST OF THE SOIL FROM THE BEETS, AND SCREENS ARE PROVIDED TO CATCH BEET TOPS, ROOTS, AND OTHER MATERIAL. THE WASHED BEETS ARE SLICED INTO LONG NARROW SECTIONS CALLED "COSSETTES." EXTRACTION OF SUGAR IS ACCOMPLISHED IN DIFFUSERS BY COUNTERFLOW OF HOT WATER THROUGH THE COSSETTES. THE EXTRACTED JUICE IS PURIFIED BY CHEMICAL TREATMENT AND FILTRATION, AND THEN EVAPORATED TO THE POINT WHERE SUGAR CRYSTALS FORM. SUGAR IS CENTRIFUGED FROM THE SYRUP, WASHED, DRIED, AND PACKAGED. THE SYRUP (MOLASSES) MAY BE MARKETED OR DIVERTED TO STEFFEN TREATMENT FOR MORE COMPLETE EXTRACTION OF SUGAR. THE SPENT COSSETTES CONSTITUTE HIGH GRADE STOCK FOOD AND ARE EITHER STORED WET IN OPEN SILOS OR ARE IMMEDIATELY DEWATERED AND BAGGED. A MORE DETAILED STATEMENT PERTAINING TO PROCESS AS RELATED TO WASTES HAS BEEN PUBLISHED (1).

VOLUME AND CHARACTER OF WASTES

VALUES CONSIDERED TO BE REPRESENTATIVE OF THE VOLUME AND CHARACTER OF BEET SUGAR MANUFACTURING WASTES ARE GIVEN IN TABLE 1. COGNIZANCE MUST BE TAKEN OF DIFFERENCES IN PROCESS EQUIPMENT AND OTHER PERTINENT FACTORS IN ESTIMATING WASTE VOLUME AND CHARACTER FOR A GIVEN FACTORY. A BRIEF DISCUSSION OF EACH OF THE PRINCIPAL WASTES IS PRESENTED IN SUBSEQUENT PARAGRAPHS.

FLUME WATER WASTE

FLUME WATER CHARACTERISTICS ARE INFLUENCED BY THE TYPE OF SOIL IN WHICH THE BEET IS GROWN, THE WEATHER DURING HARVEST, AND THE EXTENT OF SPOILAGE IN THE STOCKPILE. WET WEATHER DURING HARVEST MAY BE EXPECTED TO INCREASE THE QUANTITY OF SOIL CARRIED ON THE BEETS.

SUSPENDED SOLIDS ARE MOST VARIABLE, WITH VALUES AS HIGH AS 4,300 AND AS LOW AS 800 PPM. HAVING BEEN OBSERVED. FLUME WATER BOD NORMALLY VARIES BETWEEN 150 PPM. AND 250 PPM. BUT MAY TRIPLE IN CONCENTRATION WHEN TRANSPORTING FROZEN OR ROTTEN BEETS. THE VOLUME OF FLUME WATER AT DIFFERENT FACTORIES RANGES FROM 2,100 TO 3,100 GAL. PER TON OF BEETS.

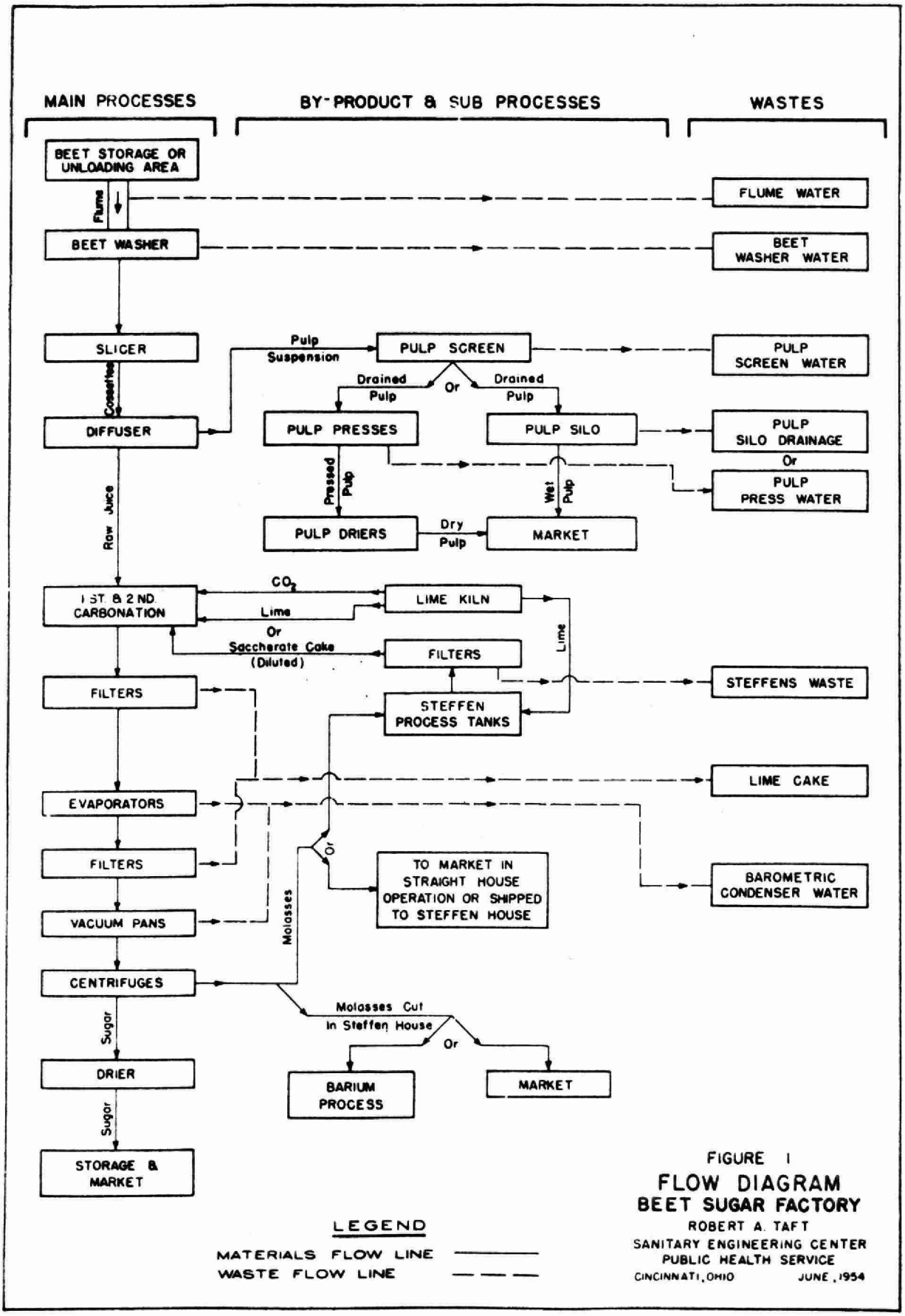

FIGURE 1

FLOW DIAGRAM
BEET SUGAR FACTORY

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JUNE, 1954

TABLE I - REPRESENTATIVE VALUES OF CHARACTER AND VOLUME OF BEET SUGAR MANUFACTURING WASTES

WASTE	FLOW, PER TON OF BEETS (GAL.)	B.O.D. 5-DAY, 20°C. (PPM)	SUSP.SOL. (PPM)	5-DAY B.O.D. PER TON OF BEETS SLICED (LB)
FLUME WATER	2,600	210	800-4,300	4.5
PULP SCREEN WATER:				
BOTTOM DUMP CELL-TYPE DIFFUSER..	240	980	530	2.0
SIDE DUMP CELL-TYPE DIFFUSER....	1,420	500	620	5.9
CONTINUOUS DIFFUSER[1].....	400	910	1,020	3.0
PULP PRESS WATER.....	180	1,710	420	2.6
PULP SILO DRAINAGE.....	210	7,000	270	12.3
LIME CAKE SLURRY.....	90	8,600	120,000	6.5
LIME CAKE LAGOON EFFLUENT.....	75	1,420	450	0.89
BAROMETRIC CONDENSER WATER.....	2,000	40		0.67

[1] WATER-TRANSPORTED PULP IN LIEU OF MECHANICAL CONVEYOR.

PULP SCREEN WATER

Pulp screen water is drained from the pulp through a screen. It is comprised of water contained in each cell when it is isolated from the diffusion circuit for dumping, plus water used to flush out the cells, and in certain cases, water added to create a pulp suspension, organic material in colloidal suspension, and a comparatively large amount of sugar and other organic material in solution. The sucrose content may be expected to vary between 300 to 600 ppm. A small amount of sand from the beets is also present. This waste has a temperature of about 50°C.

The concentration of the waste is dependent to a considerable extent on the type of diffuser and the efficiency of the pulp screen. Diffusers requiring large volumes of wash water give a relatively dilute waste, but the overall pollution load is increased. The BOD varies between 500 and 1,000 ppm, depending on the type of diffuser. The BOD of daily composites may vary as much as 50 per cent from the average. Pulp screen water from one plant with bottom dump diffuser cells had an average 5-day BOD of 980 ppm following screening through a 30-by 40- mesh vibrating screen (2).

PULP PRESS WATER

At factories where pulp is dried, the screened pulp is further dewatered in presses before drying. Water pressed from the pulp constitutes pulp press water. The characteristics of pulp press water vary with the physical quality of the pulp. They are similar to pulp screen water with somewhat higher solids and BOD. The sucrose content may average as much as 2,100 ppm. Pulp press water amounts to some 180 gallons per ton of beets, with a BOD averaging 1,700 ppm.

PULP SILO DRAINAGE

Pulp silo liquor drains from wet pulp during storage in open silos. The volume varies with the quantity of pulp stored, efficiency of the pulp screen, fermentation, and rainfall. The volume per ton of beets at two factories averaged 165 and 270 gallons respectively. Daily flow varied as much as 30 per cent from these average values. The BOD of these same wastes averaged 8,800 and 6,000 ppm, respectively, with daily composites varying as much as 50 per cent from the averages. Organic acids of decomposition create a pH of about 4 in this waste.

Pulp silo drainage is the one waste which does not cease at the end of factory operation. In fact, it may become more concentrated if pulp remains in the silo until warm weather. Data given in Table I for silo drainage are for the period the factories were operating (2).

LIME CAKE SLURRY

Lime cake forms when lime-treated and carbonated juice is filtered. It is common practice to dilute the cake with water to form a slurry which can be pumped. The amount of water added to the cake is dependent to some extent on the type of filter and the operator. These factors must be considered in comparing volumes and concentrations of the waste. Lime cake waste has been reported to range from 6,850 ppm to 10,250 ppm BOD, and from 107,000 to 137,000 ppm. suspended solids. The pH of the waste is about 11.7.

Available data indicate Steffen house lime cake slurry to have a somewhat higher BOD value per ton of beets than for a straight house. This suggests materials return with the saccharate from the Steffen process which are removed in the lime cake. Accepting this premise, it will be evident that lime cake waste from a Steffen house will be influenced by the amount of molasses worked.

STEFFEN WASTE

The filtrate produced in filtering saccharate cake from lime-treated diluted molasses in the Steffen process is known as "Steffen Waste". Because Steffen plants process varying amounts of foreign molasses in addition to their own, it is desirable to express Steffen waste on the basis of molasses worked. Steffen waste is reasonably uniform in volume and concentration, as will be appreciated from the following considerations.

Beet sugar molasses contains 60 per cent to 63 per cent sucrose (sugar), dry solids basis. The relation between sugars and non-sugars holds whether the molasses is produced in a straight house or a Steffen plant. On a total weight basis, molasses is about 50 per cent sucrose. It is customary in the industry to convert molasses to a 50 per cent sucrose basis, which likewise reduces the non-sugars to a common basis.

In Steffen house operation, the calcium saccharate returned to process carries with it inseparable non-sugars. These non-sugars tend to accumulate in the Steffen house molasses, and, if not eliminated from the system, eventually interfere with sugar crystallization and refining. A fair degree of uniformity in molasses worked by the Steffen process is achieved by correlating the amount of foreign molasses intake with Steffen molasses marketed.

Approximately 11 tons (2,640 gal.) of Steffen waste are produced for each ton of molasses worked. The pH may be as high as 12.6. Data in Table II apply to Steffen plants employing the combination, cold and hot, saccharate process.

TABLE II - STEFFEN WASTE CHARACTER AND VOLUME

FLOW, PER TON OF MOLASSES[1] PROCESSED (GAL.)	B.O.D. 5-DAY 20°C. (PPM)	TOTAL SOL. (PPM)	SUSP. SOL. (PPM)	5-DAY B.O.D. PER TON OF MOLASSES WORKED (LB.)
2,640	10,500	25,000 - 40,000	100 - 700	231

[1] CONVERTED TO 50 PER CENT SUCROSE (SUGAR) BASIS.

BAROMETRIC CONDENSER WATER

BAROMETRIC CONDENSER WATER COMES FROM THE MULTIPLE-EFFECT EVAPORATORS AND VACUUM PANS. THIS WASTE IS COMPARABLE TO FLUME WATER IN VOLUME, BUT IS RELATIVELY LOW IN POLLUTIONAL MATERIAL. ENTRAINMENT FROM THE LAST EFFECT VARIES WITH EVAPORATOR DESIGN AND OPERATION. EVAPORATOR CONDENSATES NOT RE-USED IN PROCESS AND HEATED WATER FROM OTHER SOURCES MAY BE DISCHARGED ALONG WITH BAROMETRIC CONDENSER WATER. EVAPORATION OF STEFFEN WASTE PRODUCES ADDITIONAL CONDENSER WATER.

MISCELLANEOUS WASTES

OTHER WASTES OF A COMPARATIVELY MINOR NATURE ARE THOSE FROM WASHING FILTER CLOTHS, EQUIPMENT, AND FLOORS, AND FROM THE TESTING AND CONTROL LABORATORY. SANITARY SEWAGE SHOULD BE SEPARATED FROM PROCESS WASTES.

POLLUTIONAL EFFECTS

LIQUID WASTES FROM MANUFACTURE OF BEET SUGAR ARE SIMILAR TO THOSE FROM OTHER FOOD PROCESSING INDUSTRIES. OXYGEN DEPLETION AND SLUDGE DESPOSITS ARE COMMON DAMAGES TO THE RECEIVING WATERS. DETRUCTION OF NORMAL AQUATIC LIFE AND SEVERE ODOR NUISANCES HAVE RESULTED FROM PROMISCUOUS DISCHARGE OF THESE WASTES. THE HIGH LIME CONTENT OF BEET SUGAR WASTES MAY IMPART SUFFICIENT HARDNESS TO THE RECEIVING WATER TO BE DETRIMENTAL TO ITS SUBSEQUENT USE. RELATIVELY HIGH-TEMPERATURE WASTE, SUCH AS BAROMETRIC CONDENSER WATER, MAY RAISE THE TEMPERATURE OF THE STREAM THEREBY DECREASING ITS OXYGEN CARRYING CAPACITY AS WELL AS ENCOURAGING GROWTH OF "SEWAGE FUNGUS".

WASTE REDUCTION

A DETAILED DISCUSSION OF REMEDIAL MEASURES WITHIN THE PLANT IS BEYOND THE SCOPE OF THIS PAPER. HOWEVER, RECENT SUCCESSFUL DEVELOPMENTS IN CANADA AND THE UNITED STATES ARE CONSIDERED WORTHY OF MENTION INASMUCH AS THEY HAVE DIRECT

BEARING ON THE WASTE CONTROL-POLLUTION ABATEMENT PROGRAM OF THE INDUSTRY.

PRESS AND PULP SCREEN WATER RETURN

HRUDKA HAS DEMONSTRATED THE FEASIBILITY OF RETURNING UNTREATED PRESS WATER DIRECTLY TO A CONTINUOUS DIFFUSER AT CHATHAM, ONTARIO (3). ACID CONDITIONS IN THE MIDDLE CELLS OF THE DIFFUSER WERE CONTROLLED BY INTERMITTENT ADDITION OF FORMALDEHYDE TO THE PRESS WATER RETURN TANK. TEMPERATURE IN THE DIFFUSER WATER SUPPLY TANK AVERAGED 55°C. WITH A MAXIMUM OF 65°C. BENEFITS DERIVED FROM THIS PRACTICE HAVE BEEN SUBSTANTIATED BY OPERATION DATA. PRESS WATER REUSE IS PRACTICED BY AT LEAST TWO BEET SUGAR PLANTS IN THE STATES; ONE EMPLOYS ELEVATED TEMPERATURE AND THE OTHER CHLORINATION FOR BACTERIAL CONTROL (1). IN ADDITION, COMBINED PRESS AND PULP SCREEN WATER ARE REPORTED CHLORINATED AND REUSED AT THREE PLANTS IN THE STATES.

STEFFEN WASTE RECOVERY

STEFFEN WASTE IS CONCENTRATED IN MULTIPLE EFFECT EVAPORATORS IN AT LEAST ONE PLANT IN THE STATES (4). THE SYRUP IS MIXED WITH AND DRIED ON BEET PULP THEREBY ENHANCING ITS VALUE AS STOCK FOOD. THIS RECOVERY PROCESS HAS BEEN REPORTED ECONOMICALLY SOUND. END LIQUOR FROM PRODUCTION OF MONOSODIUM GLUTAMATE CAN BE RECOVERED IN LIKE MANNER.

INDIVIDUAL WASTE TREATMENT

IT IS FREQUENTLY DESIRABLE TO TREAT MAJOR PROCESS WASTES SEPARATELY. THIS PROCEDURE PERMITS STEP-WISE REDUCTION OF THE POLLUTION LOAD AND POSSESSES THE INHERENT ADVANTAGE OF WORKING WITH A MINIMUM VOLUME. TEMPORARY STORAGE MAY BE INDICATED BECAUSE SEASONAL OPERATION CAUSES OVERHEAD TO BE COSTLY FOR TREATMENT OF THE WASTES AS PRODUCED.

FLUME WATER

TREATMENT CONSISTS OF SCREENING, GRIT REMOVAL, SEDIMENTATION WITH OR WITHOUT COAGULANTS IN TANKS EQUIPPED FOR CONTINUOUS SLUDGE REMOVAL, AND EITHERVACUUM FILTERS OR SLUDGE PONDS. A RETENTION OF 80 MINUTES IN THE SEDIMENTATION BASIN HAS BEEN RECOMMENDED. REMOVALS BY THIS TREATMENT HAVE BEEN REPORTED AS HIGH AS 92 PER CENT SUSPENDED SOLIDS AND 42 PER CENT 5-DAY BOD (5). STEFFEN WASTE HAS BEEN REPORTED SATISFACTORY AS A COAGULANT FOR FLUME WATER.

LIME CAKE SLURRY

THIS WASTE IS COMMONLY STORED IN PONDS PROVIDING SEVERAL DAYS DETENTION. SUCH TREATMENT REMOVES PRACTICALLY ALL OF THE SUSPENDED SOLIDS AND GIVES A SUBSTANTIAL REDUCTION OF BOD. THE VOLUME OF THIS WASTE IS SUCH THAT LAGOONING FOR THE ENTIRE SEASON IS FEASIBLE.

PULP SCREEN WATER AND PULP PRESS WATER

Even though re-use of this process waste as diffusion battery water supply should be generally accepted, such a process modification will be gradual in the industry and these wastes must be reckoned with in the interim. Fine screening materially reduces the concentration of these wastes and yields quantities of pulp having economic significance. Vibrating screens (30- by 40- mesh) have been successfully employed. This type of screen has a capacity for screening 22 gallons per square foot per minute of these wastes.

Coagulation of pulp screen and pulp press water with lime has been practiced, using a dosage of 500 ppm. to 600 ppm. CaO. Lime treatment requires a chemical feeder, mixing chamber, coagulation tank, sedimentation basin, and sludge disposal facilities. Coagulation for 20 to 30 minutes and a settling period of 2 hours has been recommended. Such treatment produces a water-clear effluent and BOD reductions as high as 47 per cent are reported. Other studies have shown as low as 30 per cent average 5-day BOD reduction for lime treatment. In any event, the effluent is still highly objectionable, in that the BOD remaining is high and the treated waste is caustic, containing considerable calcium.

COMBINED PROCESS WASTES TREATMENT

It is not uncommon that waste reduction requirements dictate some degree of treatment for each of the principal wastes. Under these conditions, combining the wastes for treatment rather than separate handling may well prove to be the most economical procedure and frequently it will be the most convenient. Recent beet sugar waste treatment studies in the States have included lagooning and broad field application, both on plant scale. Biological filters have proven satisfactory on pilot plant scale in Great Britain.

LAGOON DISPOSAL

Disposal of beet sugar wastes by the lagoon method has been practiced for years as a pollution abatement measure. The system has been recognized as a means of removing settleable solids and of permitting controlled release when there was adequate dilution. This method has been employed with limited knowledge of factors influencing natural purification and the degree of stabilization realized during storage.

The Minnesota Department of Health, Division of Water Pollution Control recently completed a comprehensive study of beet sugar waste disposal by lagooning (6). This investigational research was conducted in co-operation with the American Crystal Sugar Company at the Moorhead, Minnesota plant during and following the 1949, 1950, and 1951 seasons. The member states of the Missouri River Basin Sanitation Agreement and the Public Health Service were co-sponsors of the project. The most extensive waste studies were made during the 1950

CAMPAIGN WITH THE 1949 WORK BEING ESSENTIALLY EXPLORATORY AND THE 1951 WORK LARGELY CONFIRMATORY.

THE MOORHEAD PLANT, WITH A RATED CAPACITY OF 2800 TONS OF SUGAR BEETS PER DAY, WAS PLACED IN OPERATION IN 1943. THIS IS A STRICTLY MODERN REFINERY WITH A 21-CELL CONTINUOUS COUNTERFLOW DIFFUSER. THREE WASTE DISPOSAL LAGOONS WERE PROVIDED. TWO OF THESE, DESIGNATED "SOUTH" AND "NORTH" LAGOONS, ARE OF THE SAME SIZE. THEY HAVE A TOTAL AREA OF 81 ACRES AND A COMBINED CAPACITY OF 335 MILLION GALLONS WHEN FILLED TO A DEPTH OF 12 FEET. THE THIRD IS A RESERVE, SHALLOW LAGOON WITH AN AREA OF 50 ACRES AND A CAPACITY OF 50 MILLION GALLONS. DISCHARGE FROM THE LAGOONS IS THROUGH A COUNTY DITCH TO THE RED RIVER OF THE NORTH.

DURING 79 DAYS OF THE 1950 SEASON, THESE DISPOSAL LAGOONS RECEIVED 422 MILLION GALLONS (MG) OF WASTE. THIS WAS COMPOSED OF 404 MG FLUME WATER AND 18 MG FROM THE PULP PRESSES. AN ADDITIONAL 14 MG PULP PRESS WATER WERE USED TO FLUME LIME CAKE SLURRY TO A SEPARATE LIME DISPOSAL POND. THESE WASTE VOLUMES GIVE UNIT VALUES OF 1710 GALLONS FLUME WATER AND 134 GALLONS PULP PRESS WATER PER TON OF BEETS SLICED.

DAILY COMPOSITE SAMPLES THROUGHOUT THE 1950 CAMPAIGN WERE ANALYZED FROM THE PULP PRESS WATER AND THE COMBINED FLUME AND PRESS WATER AS DISCHARGED TO THE LAGOONS. THE WASTE IN THE SOUTH LAGOON WAS SAMPLED EVERY SECOND OR THIRD DAY DURING THE 1950 SEASON AND MONTHLY THEREAFTER UNTIL THE ICE BREAK-UP IN APRIL 1951. IN ADDITION TO SANITARY ANALYSES OF THE WASTES, LABORATORY EXPERIMENTS WERE CONDUCTED WITH DIALYSIS, pH ADJUSTMENT, FREEZING, AND EXTENDED STORAGE.

THERE WAS A SIGNIFICANT PROGRESSIVE INCREASE IN BIOCHEMICAL OXYGEN DEMAND (B.O.D.) CONCENTRATION OF THE WASTE DISCHARGED TO THE LAGOONS AS THE SEASON CONTINUED. DURING THE FIRST TWENTY DAYS OF THE CAMPAIGN, THE 5-DAY B.O.D. OF THIS WASTE AVERAGED 3.97 LBS/TON OF BEETS SLICED; THIS UNIT VALUE INCREASED TO AN AVERAGE OF 9.37 LBS. DURING THE LAST TWENTY DAYS OF THE SEASON. TOTAL AND SUSPENDED SOLIDS ALSO INCREASED BUT TO A LESSER DEGREE. PULP PRESS WATER B.O.D. REMAINED RELATIVELY CONSTANT THROUGHOUT THE SEASON. THIS INCREASE IN B.O.D. IN THE FLUME WATER WAS ATTRIBUTED TO HIGHER LOSSES OF SOLUBLE MATERIALS, RESULTING FROM "BLEEDING" OF THE BEETS, AFTER PROLONGED STORAGE DURING COLD WEATHER. THIS RAW WASTE B.O.D. INCREASE WAS REFLECTED IN THE LAGOONED WASTE.

RESULTS OF LAGOON STUDIES DURING THE 1950 CAMPAIGN INDICATED THAT 53 PER CENT OF THE 5-DAY B.O.D., 87 PER CENT OF THE TOTAL SOLIDS, AND 97 PER CENT OF THE SUSPENDED SOLIDS WERE REMOVED FROM THE WASTES BY LAGOONING. REMOVAL OF B.O.D. VARIED FROM 58 PER CENT DURING THE FIRST QUARTER OF THE SEASON TO 48 PER CENT FOR THE LAST QUARTER. THIS DECREASE IN EFFICIENCY TOWARD THE END OF THE SEASON WAS ASSOCIATED WITH INCREASE IN THE RATIO OF SOLUBLE TO NON-SOLUBLE CONSTITUENTS IN THE RAW WASTES AND THE INHIBITING EFFECT OF LOWER TEMPERATURES ON ANY BIOLOGICAL OXIDATION THAT MAY HAVE BEEN OCCURRING.

THE DATA REVEALED THAT AT ANY TIME DURING THE CAMPAIGN THE AMOUNT OF 5-DAY B.O.D. REMAINING IN THE LAGOONS WAS APPROXIMATELY HALF THE AMOUNT THAT HAD BEEN ADDED. DURING THE WINTER STORAGE PERIOD, NO MATERIAL CHANGE WAS DETECTED IN THE TOTAL QUANTITIES OF 5-DAY B.O.D., TOTAL SOLIDS, AND CHEMICAL OXYGEN DEMAND (C.O.D.) IN THE LAGOON. APPARENT INCREASES IN THE MEASURED CONCENTRATIONS OF THESE CONSTITUENTS WERE OFFSET WHEN CORRECTIONS WERE MADE FOR ICE COVER. THERE APPEARED TO BE LITTLE OR NO BIOLOGICAL ACTIVITY EFFECTIVE IN REDUCING THE CONCENTRATION OF THE WASTE AT THE NEAR OR BELOW FREEZING TEMPERATURES IN THESE LAGOONS. IT WAS CONCLUDED FROM THIS WORK THAT LAGOON TREATMENT OF BEET SUGAR WASTES, AT THIS LATITUDE, COULD BE EXPECTED TO GIVE VERY EFFICIENT REMOVAL OF SUSPENDED SOLIDS AND APPROXIMATELY 50 PER CENT REDUCTION IN 5-DAY B.O.D.

BOTTLE STUDIES WERE CONDUCTED ON LAGOONED WASTE COLLECTED BENEATH THE ICE. SAMPLES INCUBATED FOR 90 DAYS AT 20°C. SHOWED NO REDUCTION IN 5-DAY B.O.D. WHICH CONFIRMED FIELD OBSERVATIONS. PORTIONS OF THE SAME WASTE SAMPLES INCUBATED FOR 90 DAYS AT 20°C. WERE REDUCED 56 PER CENT IN 5-DAY B.O.D. WHICH CONFIRMED FIELD OBSERVATIONS. PORTIONS OF THE SAME WASTE SAMPLES INCUBATED FOR 90 DAYS AT 20°C. WERE REDUCED 56 PER CENT IN 5-DAY B.O.D. THESE RESULTS DEMONSTRATED THE INFLUENCE OF TEMPERATURE ON BIOLOGICAL OXIDATION AND INDICATED WHAT MIGHT BE EXPECTED WHEN ORGANIC WASTES ARE LAGOONED IN MILDER CLIMATES..

BROAD FIELD APPLICATION

EUROPEAN PRACTICE IN BEET SUGAR WASTE TREATMENT WAS INVESTIGATED BY A REPRESENTATIVE OF THE GREAT WESTERN SUGAR COMPANY IN THE FALL OF 1950. THIS WAS ONE PHASE OF REVIEW OF THE TECHNOLOGY OF BEET SUGAR MANUFACTURE AT SEVERAL PLANTS VISITED IN ENGLAND AND ON THE CONTINENT. OBSERVATIONS AT ELSDORF, GERMANY, INDICATED SATISFACTORY TREATMENT FOR FLUME WATER AND LIME CAKE SLURRY BY MEANS OF A SERIES OF SHALLOW DESILTING PONDS FOLLOWED BY FLOW OVER GRASSY PLOTS. A NEW PLOT WAS PLACED IN SERVICE EACH HOUR IN ORDER NOT TO DROWN OUT THE GRASS, SUFFICIENT PLOTS BEING PROVIDED TO PERMIT ROTATION. THE ELSDORF TREATMENT SYSTEM WAS REPORTED TO REDUCE THE 5-DAY B.O.D. TO 15 PPM.

BASED ON THESE OBSERVATIONS, THE GREAT WESTERN SUGAR COMPANY CONDUCTED LARGE SCALE WASTE TREATMENT STUDIES AT THE LOVELAND, COLORADO STEFFEN HOUSE BEET SUGAR FACTORY DURING THE 1951 SEASON. TWO GRASSY PLOTS, EACH 75 FEET WIDE BY 1100 FEET LONG, WERE USED IN CONJUNCTION WITH A SETTLING POND. ONE PLOT RECEIVED SETTLED WASTE AT THE RATE OF 1 CFS AND THE OTHER AT A RATE OF 1/2 CFS. THE 5-DAY B.O.D. OF THE SETTLED WASTE WAS REPORTED AS 604 PPM. THE EFFLUENT FROM THE PLOT RECEIVING 1/2 CFS HAD AN AVERAGE 5-DAY B.O.D. OF 416 PPM. INDICATING 31 PER CENT REDUCTION. ALTHOUGH THE RESULTS ACCOMPLISHED AT LOVELAND DID NOT APPROACH THOSE REPORTED AT ELSDORF, GERMANY, IT WAS THOUGHT THAT MORE COMPLETE TREATMENT COULD BE REALIZED FROM IMPROVED DISTRIBUTION AND OTHER REFINEMENTS. ACCORDINGLY,

THE COMPANY DECIDED TO TRY THIS SYSTEM OF TREATMENT ON PLANT SCALE AT THE BAYARD, NEBRASKA BEET SUGAR REFINERY.

THE BAYARD PLANT IS A TYPICAL STRAIGHT HOUSE WITH A RATED CAPACITY OF 1850 TONS OF BEETS PER DAY. LIQUID WASTES INCLUDE FLUME AND BEET WASH WATER, PULP SCREEN WATER, PULP PRESS WATER, AND LIME CAKE SLURRY. THE WASTE TREATMENT FIELD CONSISTS OF A RECTANGULAR TRACT OF LAND 1750 FEET WIDE AND 3500 FEET LONG. THE AREA WAS FIRST USED FOR WASTE TREATMENT DURING THE 1952 CAMPAIGN. LIMITED ANALYTICAL WORK IN THE FALL OF 1952, ON THE PART OF THE COMPANY, SHOWED PROMISING RESULTS.

THE PUBLIC HEALTH SERVICE BECAME INTERESTED IN THE BAYARD TREATMENT SYSTEM AS A POSSIBLE METHOD OF BEET SUGAR WASTE DISPOSAL IN OTHER AREAS. THIS INTEREST LED TO A CO-OPERATIVE FIELD STUDY AT BAYARD, NEBRASKA, BEGINNING OCTOBER 19TH, 1953, AND EXTENDING FOR A PERIOD OF APPROXIMATELY ONE MONTH. THIS INVESTIGATIONAL RESEARCH WAS SPONSORED AND DIRECTED BY THE MISSOURI DRAINAGE BASIN OFFICE, PUBLIC HEALTH SERVICE. CO-OPERATING AGENCIES INCLUDED: THE GREAT WESTERN SUGAR COMPANY, AND THE NEBRASKA AND WYOMING STATE PUBLIC HEALTH DEPARTMENTS. THE U.S. WEATHER BUREAU, U. S. GEOLOGICAL SURVEY, AND THE NEBRASKA DEPARTMENT OF ROADS AND IRRIGATION GAVE VALUABLE ASSISTANCE. RESULTS OF THIS FIELD STUDY ARE CONTAINED IN A REPORT DATED APRIL 1954 (7).

PROCESS WASTES FROM THIS PLANT ARE DISCHARGED THROUGH A DRAINAGE DITCH TO THE NORTH PLATTE RIVER. FLOW IN THE DITCH DURING THE BEET SUGAR SEASON WAS REPORTED AS 36 CFS AND THE RIVER DISCHARGE AT THE RAILROAD BRIDGE APPROXIMATELY 2-1/4 MILES BELOW BAYARD AVERAGED 1220 CFS. DURING THE PERIOD OF THE STUDY , PULP PRESS WATER WAS DISCHARGED DIRECTLY TO THE DRAINAGE DITCH THROUGH A SEPARATE SEWER. ALL OTHER PROCESS WASTES ENTERED A WASTE CANAL FROM WHICH THEY WERE PUMPED TO A DISTRIBUTION FLUME HAVING 4 INCH OUTLET PIPES TO THE FIELD. AFTER FLOWING ACROSS THE GRASSY SURFACE, THE WASTE WAS COLLECTED AT THE LOWER END IN A CANAL AND DISCHARGED TO THE DITCH. EFFLUENT FROM THE TREATMENT PLOT FLOWED SOME 6000 FEET TO NORTH PLATTE RIVER.

ON A POUNDS B.O.D. BASIS, 68 PER CENT OF THE WASTES PRODUCED WERE APPLIED TO THE TREATMENT PLOT, 18 PER CENT WERE DISCHARGED DIRECTLY, AND THE REMAINDER INADVERTENTLY REACHED THE DITCH UNTREATED. APPLIED WASTE HAD AN AVERAGE 5-DAY B.O.D. OF 483 PPM WHILE THE EFFLUENT FROM THE FIELD AVERAGED 158 PPM. B.O.D. WASTE VOLUME TO THE FIELD WAS 4.3 CFS, BUT ONLY 3.5 CFS WERE DISCHARGED FROM THE FIELD; THE DIFFERENCE WAS ATTRIBUTED TO SEEPAGE AND EVAPORATION. THE AVERAGE RETENTION ON THE FIELD WAS DETERMINED BY CHLORIDE TESTS TO BE 14.5 HOURS. THE B.O.D. REMOVAL IN PPM WAS 67 PER CENT, HOWEVER, OVER 73 PER CENT OF THE POUNDS B.O.D. APPLIED REMAINED ON THE FIELD. SUSPENDED SOLIDS REMOVAL EXCEEDED 99 PER CENT.

THE GRASSLAND FIELD ACTED PRIMARILY AS A SETTLING AREA WITH SUPPLEMENTAL BIOLOGICAL OXIDATION. SETTLEABLE SOLIDS WERE REMOVED IN THE UPPER QUARTER OF THE FIELD COINCIDENTALLY

WITH 60 PER CENT REDUCTION OF B.O.D. BIOLOGICAL ACTION IN THE LOWER THREE QUARTERS OF THE PLOT RESULTED IN AN ADDITIONAL 7 PER CENT B.O.D. REMOVAL AND ABOUT 10 PER CENT REDUCTION IN DISSOLVED SOLIDS. THE LIME SLURRY MAY HAVE CAUSED SOME CHEMICAL PRECIPITATION OF FINELY DIVIDED SOLIDS THOUGH THIS ACTION APPEARED NEGLIGIBLE. THE AREA WAS RELATIVELY FREE FROM ODOR. ALGAL AND PROTOZOAN GROWTHS WERE PRESENT IN LARGE NUMBERS, BUT SHORT CIRCUITING AND CHANNELING OF WASTES PREVENTED THEIR FULL UTILIZATION. IMPROVED DISTRIBUTION AND LEVELLING SHOULD INCREASE THE OVERALL EFFICIENCY OF TREATMENT FOR THIS GRASSLAND AREA.

THE DRAINAGE DITCH ABOVE THE BEET SUGAR PLANT HAD AN AVERAGE DISSOLVED OXYGEN CONCENTRATION OF 9.89 P.P.M. WHICH REPRESENTED 99 PER CENT SATURATION. THE TREATED AND UNTREATED BEET SUGAR WASTES REDUCED THE D.O. IN THIS DITCH WATER TO A MINIMUM OF 4.19 P.P.M. STREAM ANALYSES CONFIRMED THE DEGREE OF TREATMENT OBSERVED FOR THE GRASSLAND TREATMENT FIELD.

BRITISH RESEARCH

THE BRITISH WATER POLLUTION RESEARCH LABORATORY HAS REPORTED SATISFACTORY PILOT PLANT TREATMENT OF LAGOONED BEET SUGAR WASTES BY BIOLOGICAL FILTRATION (8). EXPERIMENTAL WORK WAS PERFORMED WITH RECIRCULATED FLUME WATER CONTAINING ABOUT 2 PER CENT PROCESS WASTES (PULP SCREEN AND PRESS WATER) AT BOTH STANDARD AND HIGH-CAPACITY RATES. THE EXPERIMENTAL FILTER WAS 12 FEET IN DIAMETER AND 6 FEET DEEP.

THIS EXPERIMENTAL WORK DEMONSTRATED THAT SETTLED FLUME WATER WAS AMENABLE TO BIOLOGICAL FILTRATION AND THAT THIS TREATMENT COULD BE RELIED ON TO CONSISTENTLY GIVE A TREATED WASTE WITH A 5-DAY B.O.D. LESS THAN 20 P.P.M. THE BRITISH CONCLUDED FROM THIS RESEARCH THAT, IF SETTLED WASTE WATERS WERE TREATED CONTINUOUSLY THROUGHOUT THE YEAR, A BIOLOGICAL FILTER 60 FEET IN DIAMETER AND 6 FEET DEEP SHOULD BE ADEQUATE FOR TREATING RESIDUAL WASTES FROM A FACTORY SLICING 2,000 TONS OF BEETS PER DAY (9). THIS SYSTEM STILL REQUIRES EXTENDED STORAGE OF A LARGE VOLUME OF WASTE.

SUMMARY

SEASONAL OPERATION MAKES IT IMPERATIVE THAT CAPITAL EXPENDITURES FOR TREATMENT OF BEET SUGAR WASTES BE HELD TO THE ABSOLUTE MINIMUM. THIS FACTOR PLACES A PREMIUM ON WASTE REDUCTION MEASURES AND REUSE. APPLICATION OF LAGOONING AND GRASSLAND FILTERS MUST NECESSARILY DEPEND ON THE DEGREE OF TREATMENT REQUIRED AND THE AVAILABILITY OF SUITABLE AREAS. IN ANY EVENT, THEY MAY BE CONSIDERED EXPEDIENT MEASURES UNTIL REUSE OF PROCESS WATER IS GENERALLY ACCEPTED OR MORE SATISFACTORY TREATMENT METHODS ARE DEVELOPED.

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Note: Gallonage figures used in this paper are U.S.GALLONS not Imperial. To convert to Imperial, take 5/6 of the U.S. Figures.

WASTE PROBLEMS IN THE PULP AND PAPER INDUSTRY

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The apparently ever-increasing world demand for pulp and paper products involving a wide range of end-use requirements has resulted in the development of a large and complex industry. Thus, we find ourselves to-day with a great number of mills in widely differing locations using raw materials and processes which have been found to meet specific market demands. For this reason the nature and relative importance of the waste problems vary greatly throughout the industry, and it becomes impossible to take the specific solution to some problem that existed at one mill and apply it to all. Nevertheless the principles involved may prove of special value in pointing to an alternative route.

It would seem worthwhile, therefore, to list in broad terms the waste problems that beset the industry, to examine the reasons that have led to this waste, to examine some of the solutions that have been found for specific cases, and where possible to indicate methods that might be used in other cases which have yet to be solved.

The major problems of material waste in the industry can be discussed under the following headings:

1. Waste due to cutting only selected trees of selected species (Forest and Woodlot)
2. Waste in limbs, tops, etc. (Forest and Woodlot)
3. Waste of bark (Forest or Pulp mill)
4. Waste of a portion of the wood in mechanical debarking (Pulp mill)
5. Waste of slabs, etc. (Saw mill)

6. Waste of chemical fractions of the wood other than cellulose (Pulp mill)

7. Waste of cellulose due to excessively drastic cooking conditions (Pulp mill)

8. Waste of digestion chemicals (Pulp mill)

9. Waste of cellulosic fibres through mechanical loss in processing (Pulp mill and Paper mill)

10. Waste of fillers, dyes, sizing chemicals in effluents (Paper mill)

11. Waste in processing waste papers (Paper mill)

The more important waste problems in items 1 to 5 associated with the handling of the wood are common to the industry as a whole, but the specific solution that will be found will be greatly influenced by the nature and locality of the forest and by the specific process subsequently employed at the mill. A satisfactory solution to these wood problems in many cases would involve a greater economic return than a solution to those in items 6 to 11 which involve the more apparent pollution problems.

Thus the following discussion will review the underlying reasons for the existence of these problems in relation to the wood itself and to the important individual processes so that the inter-relationship of the problems will become more apparent.

The industry, which in Canada now involves a gross annual return of over a billion dollars was largely built up at a time when less technical information and rather different economic conditions prevailed. Thus in dealing with specific waste problems at any given mill, some of which may involve very large capital expense, it is necessary to consider such expenditure in relation to other problems in the mill, and also to alternative processing that might be followed.

Basically one requires cellulose fibre in a form suited to a specific end use, and its method of production should be such as to give it at the lowest possible cost. Obviously, elimination of waste will bear an important role in this picture, and the relative merit in producing the fiber by any given route. However, it is necessary to consider this in relation to raw material, alternate processing routes, and the suitability of the product to specific end use.

Cellulose fiber provides an ideal substance as a basis for the sheeted material required for the many uses to which paper is applied. Such fiber may be obtained, in relatively pure state, from cotton or linen, and had these materials, in rag form, been available in sufficient quantity for our present paper demands, and at low cost, it is unlikely that our waste

PROBLEMS WOULD WARRANT A DISCUSSION HERE TO-DAY.

STARTING ABOUT 100 YEARS AGO THE ALTERNATIVE USE OF WOOD WAS FORCED ON THE INDUSTRY, AND FRACTIONAL UTILIZATION OF THE TREE, AND THEREFORE, WASTE RESULTED.

TO UNDERSTAND THE ORIGIN OF THIS WASTE OR POTENTIAL CO-PRODUCTS WE SHOULD PERHAPS REVIEW THE STRUCTURAL AND CHEMICAL PORTIONS OF THE TREE.

THE TREE IS A HIGHLY DEVELOPED BIOLOGICAL ENTITY HAVING SPECIALIZED PHYSICAL AND CHEMICAL COMPONENTS. THE ROOT HAIRS ABSORB WATER AND MINERAL NUTRIENT, THE LEAVES ABSORB CARBON DIOXIDE, WHICH, REACTING WITH WATER UNDER THE ACTION OF LIGHT FORM WATER-SOLUBLE ORGANIC MATTER WHICH SUBSEQUENTLY BECOMES WOOD SUBSTANCE. SEPARATING THESE TWO ARE THE ROOT SYSTEM, THE TRUNK, AND THE BRANCH AND TWIG SYSTEM. THESE LATTER STRUCTURAL PARTS SUPPORT THE LEAVES, AND ACT AS CONDUCTIVE SYSTEM BETWEEN ROOT HAIRS AND LEAVES. THE WATER-SOLUBLE ORGANIC MATTER CARRIES BACK DOWN FROM THE LEAVES DURING THE GROWING SEASON, WHERE AT THE CAMBIUM, OR INTERFACE BETWEEN WOOD AND BARK, IT FURTHER REACTS TO FORM WATER-INSOLUBLE WOOD AND BARK ELEMENTS. THE WOOD THUS PROVIDES THE MAIN STRUCTURAL AND CONDUCTING FUNCTION WHILE THE BARK PROVIDES A WATER VAPOUR BARRIER TO PREVENT EXCESSIVE EVAPORATION.

THE WOOD CONSISTS ESSENTIALLY OF HOLLOW FIBERS OR CELLS OF ABOUT 1 TO 4 CM. IN LENGTH, THESE FIBERS BEING ABOUT 100 TIMES AS LONG AS THEY ARE THICK. THESE HOLLOW FIBERS ARE ORIENTED WITH THEIR AXIS PARALLEL TO THAT OF THE TRUNK OR BRANCH, ARE SEALED AT THE END, BUT ADJACENT FIBERS HAVE INTERCONNECTING PASSAGES THROUGH THEIR WALLS, SO THAT TOGETHER THEY FORM AN INTERLOCKING CAPILLARY SYSTEM. THE CHIEF CHEMICAL CONSTITUENT OF THE FIBERS IS CELLULOSE, A LONG-CHAIN POLYMERIZED CARBOHYDRATE. THE FIBERS ARE CEMENTED TOGETHER WITH LIGNIN, WHICH TENDS TO STIFFEN THE STRUCTURE. THE HEMICELLULOSES, A GROUP OF LESS HIGHLY POLYMERIZED CARBOHYDRATES MAKE UP THE THIRD MAIN CLASS OF CHEMICAL CONSTITUENTS OF THE WOOD, AND THEY ARE ALSO LARGELY LOCATED IN THE INTERFIBER ZONE. THE PROPORTION OF THESE VARIOUS CHEMICAL CONSTITUENTS VARY FROM SPECIES TO SPECIES, BUT IN GENERAL THE CELLULOSE AMOUNTS TO 45% TO 55%, THE LIGNIN 17% TO 28%, AND THE HEMICELLULOSE ABOUT 20% TO 30% OF THE WOOD SUBSTANCE. MINOR CONSTITUENTS SUCH AS ROSIN, SALTS, FATS, TANNINS, ETC. MAY AMOUNT TO 2% TO 12%. IN ADDITION TO THE FIBERS REFERRED TO ABOVE OTHER PHYSICAL ELEMENTS ARE PRESENT IN MINOR QUANTITY SUCH AS PITH CELLS, RAY CELLS, AND IN THE CASE OF THE BROAD-LEAFED WOOD SPECIES, VESSELS.

CELLULOSIC BAST FIBER IS PRESENT IN BARK, BUT THE CELLULOSE PERCENTAGE IS LOWER THAN IN THE WOOD, AND MISCELLANEOUS SUBSTANCES SUCH AS ROSIN, TANNINS, FATS, ETC. ARE FOUND IN MUCH HIGHER PERCENTAGES.

EARLY IN THE DEVELOPMENT OF THE PULP AND PAPER INDUSTRY IT WAS FOUND THAT THE TRUNK OF THE TREE, AFTER REMOVAL OF BARK, FORMED THE MOST CONVENIENTLY HANDLED AND SUITABLE MATERIAL FOR PULPING. IT WAS ALSO FOUND THAT THE CONIFERS, WHICH

HAVE TWO OR THREE TIMES GREATER FIBER LENGTH THAN THE BROAD-LEAFED SPECIES, GAVE BETTER STRENGTH FOR ANY GIVEN METHOD OF PULPING. IT WAS ALSO FOUND THAT SPRUCE AND BALSAM, WHICH CONTAIN LESS ROSIN THAN PINE WERE MORE EASILY HANDLED.

WHILE WOOD REMAINED PLENTIFUL IN RELATION TO PULP DEMAND, PEELED SPRUCE AND BALSAM FORMED THE MAJOR RAW MATERIAL FOR ALL PULPING PROCESSES. IN OUR EASTERN FORESTS WHERE THESE SPECIES ARE OFTEN MIXED WITH OTHER CONIFERS AND HARDWOODS IT HAS MEANT A HIGH-GRADING OF THE STANDS WITH THE LESS DESIRED SPECIES LEFT TO REPRODUCE AND TAKE OVER THE AREA. MOREOVER, THE HARDWOODS ALSO TEND TO FORM THE INITIAL COVER AFTER FOREST FIRES, WITH THE RESULT THAT THE CHARACTER OF OUR FORESTS IS CHANGING. OBVIOUSLY THE NEED IS TO DEVELOP OPERATIONS BASED ON THE HARDWOODS AND OTHER NEGLECTED SPECIES, AND THIS WILL BE REFERRED TO IN DISCUSSING THE VARIOUS PULPING METHODS.

GROUNDWOOD PULPING

THE FIRST METHOD DEVELOPED FOR PROCESSING WOOD WAS THE GROUNDWOOD PROCESS. THIS CONSISTS OF PRESSING THE BARKED LOGS, IN THE PRESENCE OF WATER, AGAINST A STONE GRINDING WHEEL WHICH MECHANICALLY TEARS THE FIBERS APART WHILE TO A GREATER OR LESS EXTENT BREAKING THEM DOWN INTO FRAGMENTS THUS PROVIDING A LARGE SURFACE AREA FOR REBONDING INTO THE PAPER SHEET. THE RESULTING PULP IS SEPARATED FROM SPLINTERS AND OTHER GROSS MATERIALS, AND THEN MAY BE PUMPED DIRECTLY TO THE PAPER MILL. THE PRODUCTION OF THIS PULP RESULTS IN LITTLE WASTE AFTER THE LOG ENTERS THE GRINDERS OTHER THAN A SMALL PERCENTAGE OF WATER SOLUBLE MATERIAL AND FIBER FRAGMENTS LOST IN DRAINAGE OF WATER AT THE PAPER MACHINE. UNFORTUNATELY, THE QUALITIES OF THIS PULP ARE SUCH THAT IT CAN BE USED IN ONLY CERTAIN GRADES. ITS MOST IMPORTANT USE IS IN NEWSPRINT WHICH NORMALLY CONTAINS 80%-88%, THE BALANCE BEING NORMALLY UNBLEACHED SULFITE WHICH IS ADDED TO INCREASE THE STRENGTH OF THE SHEET IN ORDER TO ALLOW IT TO RUN WITHOUT UNDUE BREAKAGE ON THE PAPER MACHINE AND PRINTING PRESS. IT ALSO FINDS USE IN OTHER PRINTING GRADES, BUT ITS LOW STRENGTH MAKES IT UNSUITABLE FOR USE IN WRAPPING PAPERS, BAGS, ETC., AND ITS POOR STABILITY TO LIGHT MAKES IT UNSUITABLE FOR FINE PAPERS WHERE PERMANENCE MUST BE CONSIDERED. THESE UNDESIRABLE FACTORS APPEAR TO BE RELATED TO THE PHYSICAL DAMAGE OBTAINED IN GRINDING, AND THE FACT THAT THE TOTAL HEMICELLULOSE AND LIGNIN FROM THE WOOD WHICH COVER INTACT SECTIONS OF THE FIBER DO NOT PROVIDE A COMPLETELY SATISFACTORY BOND UNDER PAPERMAKING CONDITIONS.

DENSE HARDWOODS SUCH AS BIRCH HAVE NOT BEEN SUCCESSFULLY CONVERTED TO USEABLE GROUNDWOOD SINCE THEY TEND TO GRIND DOWN TO FLOUR-LIKE FRAGMENTS. POPLAR AND RESINOUS CONIFERS SUCH AS PINE ARE NOW FINDING LIMITED USE, BUT SPRUCE AND BALSAM ARE STILL PREFERRED. WHERE CLEANLINESS OF GROUNDWOOD PULP IS REQUIRED THE EXCLUSION OF BARK FROM THE LOG HAS BEEN CONSIDERED OF IMPORTANCE, AND PORTIONS OF THE LOG CONTAINING INGROWN BARK AROUND KNOTS, ETC. HAVE BEEN MECHANICALLY REMOVED AT THE MILL BEFORE FURTHER PROCESSING. THUS THE SPECIFICATIONS

SET AT THE GROUNDWOOD MILL HAVE BEEN HIGH: SELECTED SPECIES, STRAIGHT LOGS, RELATIVELY FREE OF KNOTS AND ROT. THEREFORE, UNLESS THE LOGGING OPERATION HAS BEEN INTEGRATED WITH ONE USING WOOD FOR SOME OTHER PROCESS, CONSIDERABLE WASTE RESULTS IN THE FOREST. MINIMIZATION OF THIS FOREST WASTE REQUIRES FURTHER RESEARCH ON EQUIPMENT AT THE MILL. ONE LINE OF ATTACK ON WHICH WE HAVE BEEN WORKING IN OUR OWN LABORATORY IS THE DEVELOPMENT OF EQUIPMENT THAT WILL REMOVE BARK FRAGMENTS FROM THE FINAL PULP, THE OPERATION DEPENDING ON THE DIFFERENCES IN SHAPE AND SPECIFIC GRAVITY. PRELIMINARY RESULTS WITH THIS EQUIPMENT, NOW KNOWN AS THE BAUER-CLEANER, INDICATES THAT VERY CONSIDERABLE TOLERANCE TO BARK IN THE LOGS MAY BE ALLOWED. RESEARCH ON IMPROVED METHODS OF MECHANICAL DISINTEGRATION COULD RESULT IN SOMEWHAT IMPROVED STRENGTH AND GREATER UTILIZATION OF SPECIES.

CHEMICAL PULPING PROCESSES

THE SO-CALLED CHEMICAL PULPS ARE THOSE IN WHICH THE LOG IS FIRST REDUCED TO CHIP FORM, AND THEN DIGESTED, AT ELEVATED TEMPERATURE AND PRESSURE, WITH CHEMICALS WHICH WILL SELECTIVELY DISSOLVE THE INTERFIBER BINDING MATERIALS, THE LIGNIN AND HEMICELLULOSE, SO THAT THE FIBERS WILL SEPARATE FROM EACH OTHER. THE CELLULOSE IS SIMULTANEOUSLY SUBJECT TO CHEMICAL ATTACK SO THAT THIS DOES NOT CONSTITUTE A QUANTITATIVE SEPARATION IN THE NORMALLY IMPLIED SENSE. THUS A CHEMICAL PULPING DIGESTION WILL NORMALLY BE STOPPED WHILE THE RESIDUE STILL CONTAINS APPRECIABLE AMOUNTS OF LIGNIN AND HEMICELLULOSE. IF A WHITE PULP IS DESIRED THE REMAINING LIGNIN IN THE PULP WILL BE REMOVED BY BLEACHING.

OF THE CHEMICAL PULPING METHODS THE FIRST TO BE DEVELOPED WAS THE ALKALINE PROCESS, INITIALLY USING CAUSTIC SODA AND SODIUM SULFIDE. THE FORMER IS KNOWN AS THE SODA PROCESS, THE LATTER, BECAUSE THE MIXED REAGENT IS DERIVED FROM SODIUM SULFATE, THE SULFATE PROCESS. UNBLEACHED PULPS PRODUCED BY EITHER MODIFICATION ARE DARK BROWN IN COLOUR. THE SULFATE PROCESS IS MILDER IN ACTION, AND TENDS TO GIVE LESS CELLULOSE DEGRADATION AND, THEREFORE, A HIGHER YIELD AND BETTER STRENGTH FOR ANY GIVEN DEGREE OF DELIGNIFICATION. THUS SULFATE PULP FROM LONG FIBERED CONIFEROUS WOOD TERMED KRAFT GIVES THE STRONGEST COMMERCIALLY AVAILABLE PULP, AND THIS IS THE PULP THAT FINDS USE IN CEMENT BAGS, GROCERY BAGS, WRAPPING PAPERS, ETC.

UNTIL ABOUT 25 YEARS AGO LITTLE SUCCESS WAS OBTAINED IN BLEACHING THIS PULP, BUT BLEACHING TECHNIQUES HAVE BEEN ESTABLISHED AND IMPROVED SO THAT TO-DAY IT IS POSSIBLE TO OBTAIN HIGH BRIGHTNESS PULPS RETAINING THEIR FULL STRENGTH. IMPROVEMENTS IN PULPING AND BLEACHING OF ALKALINE PULPS FROM THE SHORT FIBRED BROAD-LEAFED WOODS HAVE ALSO RESULTED IN GREATLY IMPROVED STRENGTH COMPARED WITH THAT FORMERLY OBTAINED SO THAT SUCH PULPS CAN BE USED WITH ADVANTAGE AS MAJOR RATHER THAN MINOR CONSTITUENTS IN MANY FINE PAPER FURNISHES.

IT WOULD APPEAR THAT IN SPITE OF CERTAIN PROBLEMS THIS PROCESS CAN BE SUCCESSFULLY APPLIED TO VIRTUALLY ALL

WOOD SPECIES AVAILABLE IN THE TEMPERATE ZONE, WITH THE LONG FIBERED CONIFEROUS WOODS GIVING TOP STRENGTH PULPS AND THE SHORT FIBERED BROAD-LEAFED WOODS GIVING MEDIUM STRENGTH PULPS. THIS PROCESS ALSO ALLOWS A REASONABLE TOLERANCE OF BARK AND OF ROT IN THE WOOD. IT, THEREFORE, APPEARS TO OFFER SPECIAL PROMISE IN A PROGRAMME DIRECTED TOWARDS ELIMINATION OF FOREST WASTE.

THE UNBLEACHED YIELD OF PULP OBTAINED FROM THE CHIPS WILL RANGE BETWEEN ABOUT 43% AND 48% WITH CONIFEROUS WOODS, AND BETWEEN ABOUT 48% AND 55% WITH THE BROAD-LEAFED WOOD SPECIES. APPROXIMATELY 0.5% TO 2.5% OF THE WOOD WILL BE INSUFFICIENTLY COOKED TO ALLOW READY DISINTEGRATION OF THE FIBERS AND THIS MATERIAL IN THE FORM OF SHIVES IS MECHANICALLY REMOVED FROM THE PULP. THE BALANCE OF THE WOOD GOES INTO SOLUTION IN THE COOKING LIQUOR AND THE RESIDUAL LIQUOR IS TERMED BLACK LIQUOR.

SINCE THE INCEPTION OF THIS INDUSTRY IT HAS BEEN COMMON PRACTICE TO EVAPORATE THE LIQUOR, AND BURN IT FOR THE RECOVERY OF SODIUM SALTS, WHICH ARE OBTAINED AS SODIUM CARBONATE, AND SODIUM SULFIDE IN A SMELT. THIS SMELT IS DISSOLVED IN WATER AND TREATED WITH LIME WHICH CONVERTS THE CARBONATE TO CAUSTIC SODA, AND THE LIME TO CALCIUM CARBONATE. THE DECANTED LIQUOR IS THEN RECYCLED TO THE PROCESS AS FRESH COOKING LIQUOR WHILE THE CALCIUM CARBONATE MAY BE RECONVERTED TO LIME BY BURNING IT IN A KILN, THUS GIVING A SECOND CYCLIC SYSTEM.

WITH THIS RECYCLING OF CHEMICAL THE COST OF PRODUCTION IS MATERIALLY REDUCED. THE COMBUSTION OF THE LIQUOR INVOLVES SPECIAL PROBLEMS, AND INITIALLY LITTLE OF THE HEAT VALUE WAS RECOVERED. OVER THE PAST TWENTY YEARS CONSIDERABLE DEVELOPMENT HAS TAKEN PLACE IN BOTH FURNACE DESIGN AND AUXILLIARY EQUIPMENT WITH THE RESULT THAT EXTREMELY HIGH THERMAL EFFICIENCY MAY BE OBTAINED, OF THE ORDER OF 95%, AND SUFFICIENT STEAM OVER AND ABOVE THAT REQUIRED FOR EVAPORATION IS NOW AVAILABLE TO OPERATE THE MILL.

A MORE EFFICIENT UTILIZATION OF THE WOOD COULD BE OBTAINED IF ONE OF THE FRACTIONS CONTAINED IN THE BLACK LIQUOR COULD BE ISOLATED, AND USED FOR SOME PURPOSE HAVING A GREATER VALUE THAN FUEL. WHERE RESINOUS WOODS SUCH AS PINE ARE USED A MATERIAL KNOWN AS TALL-OIL TENDS TO SEPARATE ON EVAPORATION OF THE LIQUOR, AND THIS PRODUCT CAN BE CONVERTED TO PRODUCTS OF THE TYPE OF ROSIN AND SOAP. IN MANY CASES THE QUANTITY AVAILABLE IS INSUFFICIENT TO WARRANT SUCH CONVERSION, AND IN THIS CASE IT IS BURNT WITH THE LIQUOR.

SINCE THE LIGNIN ACTS AS A STIFFENING AGENT IN THE TREE IT OCCURRED TO US THAT IF ISOLATED, IT MIGHT BE USED IN PLASTICS AND OTHER STRUCTURAL MATERIALS. A METHOD WAS WORKED OUT BY US FOR ISOLATING A PORTION OF THE LIGNIN FROM THE BLACK LIQUOR, THE BALANCE OF WHICH GOES THROUGH THE NORMAL RECOVERY CYCLE. THIS DEVELOPMENT LED TO THE PRODUCTION OF THE LAMINATED PLASTIC KNOWN AS ARBORITE. THIS IS MADE BY IMPREGNATING PAPER SHEETS WITH RESINS AND CONSOLIDATING THEM TO A

PLASTIC BOARD BY PRESSING AT ABOUT 150°C AND 700 LB./SQ.IN. PRESSURE. IN THE DECORATIVE GRADES THE PRINTED BLEACHED SURFACE SHEET IS IMPREGNATED WITH A COLOURLESS RESIN, WHILE THE CENTRE SHEETS CONSIST OF UNBLEACHED PAPER IMPREGNATED WITH A SOLUTION OF LIGNIN AND PHENOLIC RESIN.

OTHER POTENTIAL USES FOR THIS LIGNIN PRODUCT HAVE BEEN DEVELOPED. ONE, INVOLVING ITS USE FOR REINFORCING RUBBER, APPEARS TO OFFER RATHER MAJOR PROMISE. ANOTHER INVOLVES ITS USE AS A DISPERSING AGENT FOR THE PRODUCTION OF CERAMICS.

IT IS BELIEVED THAT IMPORTANT DEVELOPMENTS FOR SELECTIVE UTILIZATION OF NON-FIBROUS INGREDIENTS OF THE LIQUOR CAN BE DEVELOPED, BUT THAT THESE ARE NOT LIKELY TO EQUAL THE POTENTIAL SUPPLY (IN THE CASE OF LIGNIN, A HALF-MILLION TONS PER YEAR IN CANADA) IN THE FORESEEABLE FUTURE.

IN SPITE OF THE EXCELLENT UTILIZATION INHERENT IN THIS PROCESS BOTH STREAM AND AIR POLLUTION PROBLEMS CAN EXIST. LOSSES OF BLACK LIQUOR IN WASHING THE PULP CAN BE UNDESIRABLE IF THE WATER COURSE IS SMALL. NORMALLY A LOSS OF ABOUT 5% OF THE LIQUOR IN THIS WAY HAS BEEN CONSIDERED NORMAL, AND RECOVERY OF THE LAST FEW PERCENT WOULD INVOLVE CONSIDERABLY GREATER WASHING AND EVAPORATING FACILITIES THAN ARE NORMALLY EMPLOYED. MOREOVER, THE COST OF EVAPORATION, AT LEAST FOR THE LAST PORTIONS, WOULD BE GREATER THAN THE VALUE OF THE RECOVERED CHEMICAL. TALL OIL SHOULD NOT BE RUN TO THE RIVER AS IT IS DETRIMENTAL TO FISH LIFE.

FROM THE AIR POLLUTION STANDPOINT ABOUT 5% OF THE CHEMICAL IN THE RECOVERY FURNACE COMES OFF AS A FUME. METHODS ARE AVAILABLE FOR RECOVERING THIS, USING EITHER ELECTROSTATIC PRECIPITATION OR WET METHODS OF SCRUBBING. THE MOST SERIOUS POLLUTION PROBLEM IS ODOUR RESULTING FROM HYDROGEN SULFIDE AND MERCAPTAN. METHODS TO ALLEVIATE THIS INVOLVE CONDENSATION OF ALL VAPOUR WITH OXIDATION OF CONDENSATE AND OXIDATION OF THE BLACK LIQUOR BEFORE FURTHER PROCESSING IN THE RECOVERY PLANT.

THE SULFITE PROCESS IS THE OTHER IMPORTANT METHOD FOR PRODUCING CHEMICAL PULP, THE NORMAL REAGENT BEING A MIXTURE OF CALCIUM BISULFITE AND SULFUROUS ACID. THE UNBLEACHED PULP OBTAINED FROM SPRUCE IS A LIGHT MANILLA COLOUR WHICH CAN BE READILY BLEACHED. ITS STRENGTH WHEN MADE FROM SPRUCE IS INTERMEDIATE BETWEEN THAT OF SULFATE AND GROUNDWOOD. PRIOR TO THE DEVELOPMENT OF BLEACHING METHODS FOR SULFATE PULPS IT WAS CONSIDERED THE MOST VERSATILE PULP AVAILABLE. IN THE UNBLEACHED STATE IT COULD BE USED DIRECTLY TO STRENGTHEN NEWSPRINT OR FOR PAPER BOARD. WHEN BLEACHED IT COULD BE USED FOR BONDS, BOOK AND OTHER FINE PAPERS. WHILE STILL USEFUL FOR THESE PURPOSES IT IS NO LONGER INDISPENSABLE.

THE WOOD REQUIREMENTS ARE MUCH MORE RIGID FOR THIS PULP THAN THEY ARE FOR SULFATE. MINOR INGREDIENTS SUCH AS PINOSYLVIN IN THE HEART WOOD OF SOME SPECIES SUCH AS PINE REACT WITH THE LIGNIN UNDER THE ACID CONDITIONS PREVAILING, THUS

PREVENTING ITS SOLUTION FROM THE WOOD, AND THEREFORE COMPLETE PULPING. MANY OF THE BROAD-LEAFED WOODS CAN BE PULPED, BUT THEIR STRENGTH IS LOW IN RELATION TO ALKALINE PULPS FROM THE SAME WOOD. BARK IS NOT CONVERTED TO FIBER IN THIS PROCESS SO THAT SPECIAL MEANS MUST BE PROVIDED FOR REMOVING THE LAST TRACES, EITHER BEFORE OR AFTER COOKING.

IN GENERAL, IT WOULD SEEM THAT IF SULFITE PULP IS TO RETAIN A LEADING POSITION IN THE INDUSTRY IT IS ESSENTIAL THAT MODIFICATIONS BE DEVELOPED WHICH WILL RESULT IN GREATER VERSATILITY WITH REGARD TO WOOD SPECIES, WHICH WILL GIVE BETTER STRENGTH, AND WHICH WILL SHOW GREATER TOLERANCE TO BARK.

THE COST OF THE LIMESTONE AND SULFUR REQUIRED FOR THE DIGESTION IS RELATIVELY SMALL, AND IT HAS BEEN NORMAL PRACTICE TO DISCHARGE THE SO-CALLED "WASTE SULFITE LIQUOR" TO THE RIVER. A GREAT DEAL OF STUDY HAS BEEN GIVEN TO THIS PARTICULAR WASTE PROBLEM.

IF THE LIQUOR IS EVAPORATED AND BURNED WITH HEAT RECOVERY, AN ASH CONSISTING LARGELY OF CALCIUM SULFATE AND SULFIDE IS OBTAINED, AND THIS CANNOT BE RECYCLED TO THE PROCESS. HOWEVER, WHEN A MAGNESIUM BISULFITE LIQUOR IS USED, MAGNESIUM OXIDE AND SULFUR DIOXIDE ARE OBTAINED WHICH CAN BE RECOMBINED TO FORM FRESH COOKING LIQUOR. THIS CYCLIC PROCESS HAS BEEN OPERATING IN ONE MILL FOR SOME TIME WHILE A SECOND ONE IS STARTING UP THIS SUMMER. THIS RESULTS IN CONSIDERABLE ECONOMY TO THE PROCESS SINCE BOTH HEAT AND DIGESTION CHEMICALS ARE RECOVERED. SUCH PROCESSING PLACES THE MILL ON A PAR WITH THE SULFATE PROCESS INSOFAR AS EFFLUENTS ARE CONCERNED, BUT ITS INSTALLATION INVOLVES HIGH CAPITAL COST. A FEW MILLS ARE BURNING EITHER CALCIUM BISULFITE OR AMMONIUM BISULFITE LIQUOR FOR THE RECOVERY OF HEAT, BUT WITHOUT RECOVERY OF THE BASE, THIS INVOLVING LESS EQUIPMENT, AND THEREFORE, LOWER CAPITAL COST THAN WHERE THE CYCLIC MAGNESIA PROCESS IS USED.

MANY ATTEMPTS HAVE BEEN MADE TO RECOVER SPECIFIC PRODUCTS FROM THE WASTE SULFITE LIQUOR. SINCE 1937 WE HAVE BEEN RECOVERING VANILLIN WHICH IS OBTAINED FROM THE WASTE SULFITE LIQUOR BY ALKALINE HYDROLYSIS, AND MORE RECENTLY OTHERS HAVE STARTED PRODUCTION. UNFORTUNATELY, THE MAIN USE OF VANILLIN APPEARS TO BE IN THE FLAVOURING FIELD, AND WITH THIS LIMITED MARKET ONLY MINOR QUANTITIES OF WASTE SULFITE LIQUOR CAN BE USED IN THIS WAY. IN OUR PROCESS, THE FINAL EFFLUENT LIQUOR IS BURNED, BUT BECAUSE OF THE SMALL QUANTITY OF LIQUOR INVOLVED IT HAS NO APPRECIABLE EFFECT ON THE OVER-ALL POLLUTION PROBLEM. WHEN VANILLIN IS PRODUCED IT IS NECESSARY TO CONFINE THE SULFITE MILL TO THE USE OF CONIFEROUS WOODS SINCE THE BROAD-LEAFED SPECIES, HAVING LIGNIN OF SLIGHTLY DIFFERENT COMPOSITION, ALSO YIELD SYRINGALDEHYDE WHICH CANNOT BE COMMERCIALLY SEPARATED FROM THE VANILLIN.

ANOTHER POSSIBLE PRODUCT WOULD BE FURFURAL WHICH IS USED IN THE PRODUCTION OF NYLON. HOWEVER, THIS CAN ONLY BE ECONOMICALLY PRODUCED IF THE MILL IS OPERATING ON BROAD-LEAFED WOODS WHICH HAVE HIGH PENTOSAN CONTENT FROM WHICH THE FURFURAL IS OBTAINED.

Alcohol is being produced by a few mills by fermentation of the sugars found in the waste liquor and which result from hydrolysis of the hemicellulose. In other mills, yeast is being produced.

A few mills are evaporating the liquor, with the resultant product being used for miscellaneous purposes such as road binder, linoleum cement, etc.

These varied, commercial operations based on the waste sulfite liquor are indicative of what can be done. However, it is equally apparent that we are still a long way from the point where we can use the two and a half million tons of sulfite liquor solids available in Canada each year.

The air pollution problem with the sulfite process provides no special unsolved problems. The only odour discharged results from sulfur dioxide which can be scrubbed from the gas.

Semichemical Pulping Processes

Semichemical pulps form a fourth category of pulp. These are produced by very mild cooking conditions such that insufficient interfiber matter is dissolved to allow the chips to spontaneously disintegrate. The softened chips are subsequently broken down by mechanical action. A number of mills have been recently built, chiefly in the United States, in which broad-leafed wood species are treated with a neutral sodium sulfite solution. The resultant pulps are obtained in the 65% to 75% yield range. They are normally a light manilla colour in the unbleached stage. They can be bleached at rather high cost to give a pulp in about the 55% yield range. These pulps are normally used, at least as partial replacement, in applications where coniferous sulfite pulp would have been used.

These mills have been largely built in locations where spruce and balsam are no longer available, and this development is of special importance from the standpoint of forest utilization.

Much research has been expended on developing a suitable recovery system for these mills, and it is believed that this problem can be solved, at least in the case of the larger mills. In the meantime the effluent liquors are being discharged into the river. No special air-pollution problems are involved with these mills.

A few Canadian mills previously producing unbleached sulfite or sulfate chemical pulps from coniferous woods have found it possible to stop the digestion at about the 65% yield and defiber the pulp mechanically. For certain applications it has been found that the resultant product is quite satisfactory, and this reduces the wood requirement for any given quantity of pulp produced.

PAPER MILL WASTES

The problems of waste in conversion of pulp to paper largely result from mechanical loss of fiber, filler, dyes, etc. Methods of recovery include flotation "Save-alls", rotary filter type save-alls, etc. The cost of equipment and the value of material recovered will vary greatly depending on the type of paper produced.

WOOD UTILIZATION

With the above background let us now return to the problem of overall wood utilization. On the west coast a rather unique condition prevails which has resulted in a rather fortunate solution. In many areas the stands consist almost exclusively of conifers of very large diameter and height. It has been found necessary, when logging for lumber production, to cut out all trees at one time in an area since the trees if isolated blow down. By clear cutting small areas in a checkerboard manner these areas reseed with the same species. The Douglas Fir and spruce are largely converted to lumber, but all of the hemlock cut was not required for this purpose. It was found that the hemlock could be used for the production of sulfite pulp. More recently it was found that if the saw-logs were debarked by hydraulic means the slabs could be converted to sulfate pulp. The tremendous size of these logs greatly simplified this debarking operation. Thus, the pulping industry has been largely integrated with the lumber industry, using as raw material wood which would otherwise be waste.

In the east this situation is not so easy. With the smaller diameter trees the cost of debarking ahead of the sawmill is very high, particularly with the broad-leafed woods. Studies are now being made which may greatly improve the situation. It is possible, by girdling the tree, and painting the exposed wood with a sodium arsenate solution to kill the tree while at the same time loosening the bark. If the tree is then cut the following year much of the bark will drop off at the site. From our own test operations it is impossible to state how complete this removal will be. However, equipment has been developed which will largely separate bark from wood after the wood has been chipped, while at the same time methods for removing bark specks from the pulp have been markedly improved. Thus it is hoped that by a combination of these methods our chances for better forest utilization will be greatly improved. Means for handling and chipping the tops and limbs and sawmill slabs form an obvious part of such a study.

To summarize, our research and active mill experiments dealing with waste and the waste problem are proceeding on a broad front, and no doubt this is the case throughout the industry. Each problem must be considered not only in great detail by itself, but also in relation to all other items affecting the process, and its cost. It is felt that in this way we will be better able to plan an orderly sequence in relation to our final goal.

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TREATMENT OF CYANIDE WASTES

- By -

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CYANIDE IS USED QUITE SUCCESSFULLY IN THE PLATING AND CLEANING OF METALS. IN THE PLATING OPERATION CYANIDE IS USED IN THE BATHS TO HOLD THE HEAVY METALS AND TO AFFORD A SATISFACTORY ELECTROLYTE FOR THE PLATING OF A UNIFORM THICKNESS OF THE METAL ON THE SURFACE OF THE PART BEING PLATED. IN THE CLEANING OR "STRIPPING" OF OLD PLATED SURFACES FROM THE BASE METAL CYANIDE SOLUTIONS ARE OFTEN USED IN PREPARATION BEFORE REFINISHING OR OTHER SURFACE TREATMENT PROCESSES.

IN BOTH OF THE ABOVE OPERATIONS VERY LITTLE OF THE CYANIDE IS LOST FROM SOLUTION OTHER THAN BY "DRAG-OUT" OF THE PLATING OR STRIPPING SOLUTION INTO A FRESH WATER RINSE WHICH IS UTILIZED FOR THIS PURPOSE; I.E. TO RINSE OFF CYANIDE SOLUTION ADHERING TO THE SURFACE OF THE METAL PARTS. THE QUANTITY OF "DRAG-OUT" IS DEPENDENT ON THE SHAPE OF THE PARTS BEING FINISHED, THE AMOUNT OF SHAKING OR AGITATION PROVIDED WHEN THE PARTS ARE RAISED ABOVE THE LIQUID SURFACE AND THE TIME ALLOWED BEFORE DIPPING THE RACK OR BARRELLED PARTS INTO THE RUNNING RINSE WATER TANK. THEREFORE, MOST OF THE CYANIDE LOST IN METAL FINISHING OPERATIONS GOES DOWN THE SEWER, AND SINCE IT IS ADMITTEDLY A VERY TOXIC AND POISONOUS SUBSTANCE IT IS BECOMING MORE AND MORE ESSENTIAL THAT THE RINSE WATER OVERFLOWS BE TREATED BEFORE DISCHARGE INTO SURFACE STREAMS, GROUND WATER TABLES OR SEWAGE TREATMENT SYSTEMS.

CYANIDES ARE DENOTED BY THE CHEMICAL SYMBOL CN AND ARE, OF COURSE, COMPOSED OF CARBON AND NITROGEN. IT IS PURCHASED AS SODIUM CYANIDE NACN, POTASSIUM CYANIDE KCN OR AS SALTS OF THE HEAVY METALS SUCH AS COPPER, CAD-

MIUM, ZINC, SILVER AND THE LIKE. THE PLATING BATHS ARE MADE UP ACCORDING TO SPECIRICATION FOR THE TYPE OF PLATING OR STRIPPING OPERATIONS THAT ARE REQUIRED AND BECOME RATHER INVOLVED CHEMICALLY DEPENDENT UPON THE REQUIREMENTS OF THE JOB. IN THE TREATMENT OF RINSE WATERS FROM CYANIDE PLATING OR FROM CYANIDE STRIPPING OPERATIONS WE ARE CONCERNED PRIMARILY WITH THE QUANTITY OF CYANIDE AS CN WHICH IS PRESENT IN SOLUTION NO MATTER HOW IT MAY BE TIED UP WITH THE VARIOUS HEAVY METALS OR OTHER CHEMICAL SUBSTANCES. DESTRUCTION OF THE CYANIDE COMPOUND CAN BE ACCOMPLISHED IN A NUMBER OF WAYS, BUT THE ALKALINE CHLORINATION METHOD HAS PROVEN MOST ECONOMICALLY FEASIBLE AND FOOL-PROOF IN ITS APPLICATION. A FEW OF THE OTHER METHODS WHICH HAVE BEEN TRIED INCLUDE:

1. ACIDIFICATION WITH AN ACID FORMING HYDROCYANIC GAS WHICH IS BLOWN OFF TO THE ATMOSPHERE. THIS METHOD HAS BEEN USED IN PLANT SCALE OPERATIONS WITHOUT TOO MUCH SUCCESS DUE TO THE HAZARDS OF FORMING HCN, AND DIFFUSING IT IN THE ATMOSPHERE AND DUE TO THE DIFFICULTY IN ELIMINATING CYANIDES BY THIS MEANS IN THE LOWER CONCENTRATIONS USUALLY ENCOUNTERED IN RINSE WATER WASTES.

2. COMPLEXATION WITH METALLIC SALTS WHICH PRODUCES INSOLUBLE METALLIC CYANIDE COMPOUNDS WHICH ARE REMOVED BY PRECIPITATION. DUE TO THE COST OF THE METALLIC PRECIPITANT, THIS PROCESS HAS THE DISADVANTAGE OF BEING VERY EXPENSIVE.

3. OXIDATION WITH A BASIC OXIDIZING AGENT, SUCH AS CHLORINE, AND AN ALKALI TO PRODUCE CYANATES CNO OR TO BREAK DOWN THE CYANIDE RADICAL, TO CARBON DIOXIDE AND NITROGEN OR NITROUS OXIDES.

MOST PLATING SOLUTIONS, AND THEREFORE, THE RINSE WATERS DISCHARGED AS WASTES, CONTAIN HEAVY METAL SUCH AS COPPER, ETC. CYANIDE COMPOUNDS PLUS EXTRA OR EXCESS CYANIDE IN THE FORM OF THE SODIUM OR POTASSIUM CYANIDE SALT. IN THE TREATMENT OF THE RINSE WATERS WE MUST DETERMINE FIRST THE DEGREE OF TREATMENT REQUIRED AND SECONDLY THE BEST METHOD OF PHYSICAL ARRANGEMENT OF TANKS AND EQUIPMENT TO ACCOMPLISH THE RESULTS. IN SOME INSTANCES IT IS POSSIBLE TO GET BY WITH OXIDATION OF ONLY THE FREE EXCESS CYANIDE SALTS TO CYANATES, BUT IN MOST CASES THE OXIDATION OF ALL CYANIDE TO CYANATES WILL BE REQUIRED AND IN SPECIFIC INSTANCES COMPLETE DESTRUCTION OF BOTH THE CYANIDES AND CYANATES IS NECESSARY. THE DEGREE OF TREATMENT WILL BE DICTATED BY THE POINT OF FINAL DISPOSAL OF TREATED EFFLUENT, THE REQUIREMENTS OF THE REGULATORY BODY AND THE DICTATES OF GOOD PRACTICE IN WHICH PUBLIC RELATIONS OF THE PLANT AND THE SURROUNDING NEIGHBORHOOD PLAYS A MAJOR ROLL.

TABLE I

REACTIONS SHOWING OXIDATION OF CYANIDES WITH CHLORINE

Destruction of Cyanides to Cyanates

I.a. $2Cl_2 + 2NaCN \longrightarrow 2CNCl + 2NaCl$

I.b. $2CNCl + 4NaOH \longrightarrow 2NaCNO + 2NaCl + 2H_2O$

I. $2Cl_2 + 4NaOH + 2NaCN \longrightarrow 2NaCNO + 4NaCl + 2H_2O$

	CHLORINE	SODIUM HYDROXIDE	SODIUM CYANIDE	SODIUM CYANATE	SODIUM CHLORIDE	WATER
PARTS	2.73	3.07	1 (As CN)			
	1	1.125				

Destruction of Cyanates to Carbon Dioxide (as Bicarbonates) and Nitrogen

2.a. $3Cl_2 + 4H_2O + 2NaCNO \longrightarrow 3Cl_2 + (NH_4)_2CO_3 + Na_2CO_3$

2.b. $3Cl_2 + 6NaOH + (NH_4)_2CO_3 + Na_2CO_3 \longrightarrow 2NaHCO_3 + N_2 + 6NaCl + 6H_2O$

2. $3Cl_2 + 6NaOH + 2NaCNO \longrightarrow 2NaHCO_3 + N_2 + 6NaCl + 2H_2O$

	CHLORINE	SODIUM HYDROXIDE	SODIUM CYANATE	SODIUM BICARBONATE	NITROGEN	SODIUM CHLORIDE	WATER
PARTS	4.09	4.62	1 (As CN)				
	1	1.125					

Destruction of Cyanides to Carbon Dioxide (as Bicarbonates) and Nitrogen

3. $5Cl_2 + 10NaOH + 2NaCN \longrightarrow 2NaHCO_3 + N_2 + 10NaCl + 4H_2O$

	CHLORINE	SODIUM HYDROXIDE	SODIUM CYANIDE	SODIUM BICARBONATE	NITROGEN	SODIUM CHLORIDE	WATER
PARTS	6.82	7.69	1 (As CN)				
	1	1.125					

TABLE II

REACTION OF CYANIDES WITH VARIOUS CHLORINE COMPOUNDS

A. FOR DESTRUCTION OF CYANIDES TO CYANATES:

SOURCE OF CHLORINE COMPOUND	CHLORINE COMPOUND WITH CAUSTIC	SODIUM CYANIDE	SODIUM CYANATE	SODIUM CHLORIDE	WATER
1. Chlorine Gas: Cl_2	$Cl_2 + 2NaOH$	$+ NaCN \longrightarrow$	$NaCNO$	$+ 2NaCl$	$+ H_2O$
2. Chlorine Water: $Cl_2 + H_2O \rightleftharpoons HOCl + HCl$	$HOCl + HCl + 2NaOH$	$+ NaCN \longrightarrow$	$NaCNO$	$+ 2NaCl$	$+ 2H_2O$
3. Sodium Hypochlorite: $Cl_2 + H_2O \rightleftharpoons HOCl + HCl$; $HOCl + HCl + 2NaOH \longrightarrow NaOCl + NaCl + 2H_2O$	$NaOCl + NaCl$	$+ NaCN \longrightarrow$	$NaCNO$	$+ 2NaCl$	

B. FOR DESTRUCTION OF CYANIDES TO CARBON DIOXIDE (AS BICARBONATES) & NITROGEN

SOURCE OF CHLORINE COMPOUND	CHLORINE COMPOUND WITH CAUSTIC	SODIUM CYANIDE	SODIUM BICARBONATE	NITROGEN	SODIUM CHLORIDE	WATER
1. Chlorine Gas: Cl_2	$5Cl_2 + 10NaOH$	$+ 2NaCN \longrightarrow$	$2NaHCO_3$	$+ N_2$	$+ 10NaCl$	$+ 4H_2O$
2. Chlorine Water: $Cl_2 + H_2O \rightleftharpoons HOCl + HCl$	$5HOCl + 5HCl + 10NaOH$	$+ 2NaCN \longrightarrow$	$2NaHCO_3$	$+ N_2$	$+ 10NaCl$	$+ 9H_2O$
3. Sodium Hypochlorite: $Cl_2 + H_2O \rightleftharpoons HOCl + HCl$; $HOCl + HCl + 2NaOH \longrightarrow NaOCl + NaCl + 2H_2O$	$5NaOCl + 5NaCl + H_2O$	$+ 2NaCN \longrightarrow$	$2NaHCO_3$	$+ N_2$	$+ 10NaCl$	

FROM: - PROCEEDINGS -
REGIONAL CONFERENCE ON
INDUSTRIAL HEALTH,
HOUSTON, TEXAS.

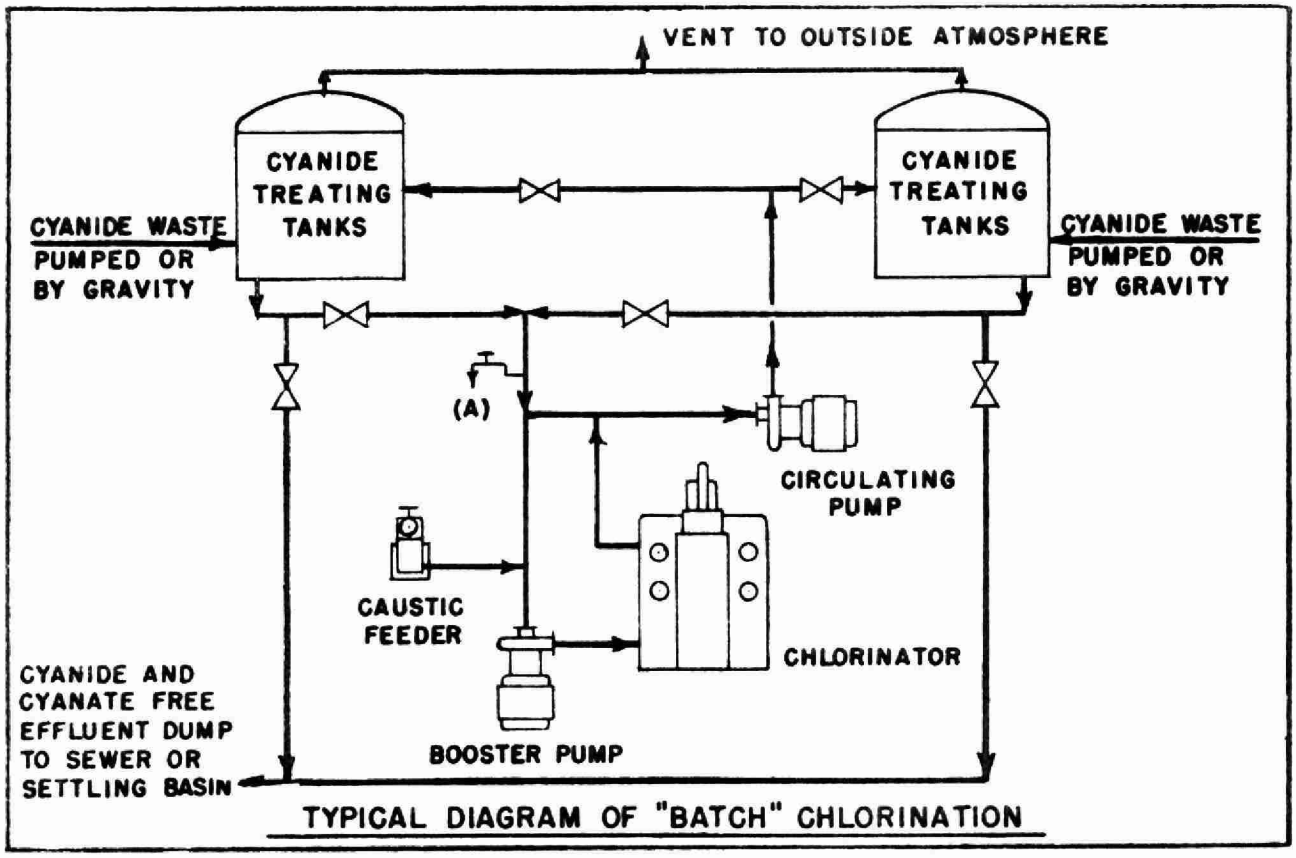
Chlorine in any form; i.e. as a gas, hypochlorite solution or the solid calcium hypochlorite will combine with CN to form first of all CNCl. This is cyanogen chloride and as such the toxicity of the solution has not been materially reduced. This cyanogen chloride forms first at any point on the pH scale, and its subsequent conversion by hydrolysis or decomposition to the cyanates (CNO) is dependent entirely on the alkali present or added to the solution. Below a pH of 8.0 the cyanogen chloride stays in solution indefinitely without converting to cyanates. At pH 8.5 and above the cyanogen chloride is decomposed to the cyanate form with increasing rapidity as the pH of the solution increases. For example, at pH 9.0 approximately 80% to 90% of the cyanogen chloride goes to cyanates within 2 or 3 minutes reaction time. The 10% to 20% remaining in solution after, say, 3 minutes will more slowly convert to cyanates with complete conversion being accomplished within 15 to 30 minutes.

In the presence of heavy metals (almost always encountered) the reactions are basically the same but an additional factor enters the picture. When the excess free cyanide is converted to cyanogen chloride and on to cyanates by the chlorine and caustic some of the heavy metals may come out of solution in the form of a metallic cyanide percipitate. For example, copper, which is the worst offender, precipitates as a cuprous cyanide and forms a very definite visible white floc in the solution. The cyanide tied up with this copper is still toxic due to its extended solubility and, therefore, usually must be broken down by additional chlorine and caustic to convert it to the cupric hydroxide, oxide or carbonate form. This required 1 to 1-1/2 hours contact time in the presence of a chlorine residual.

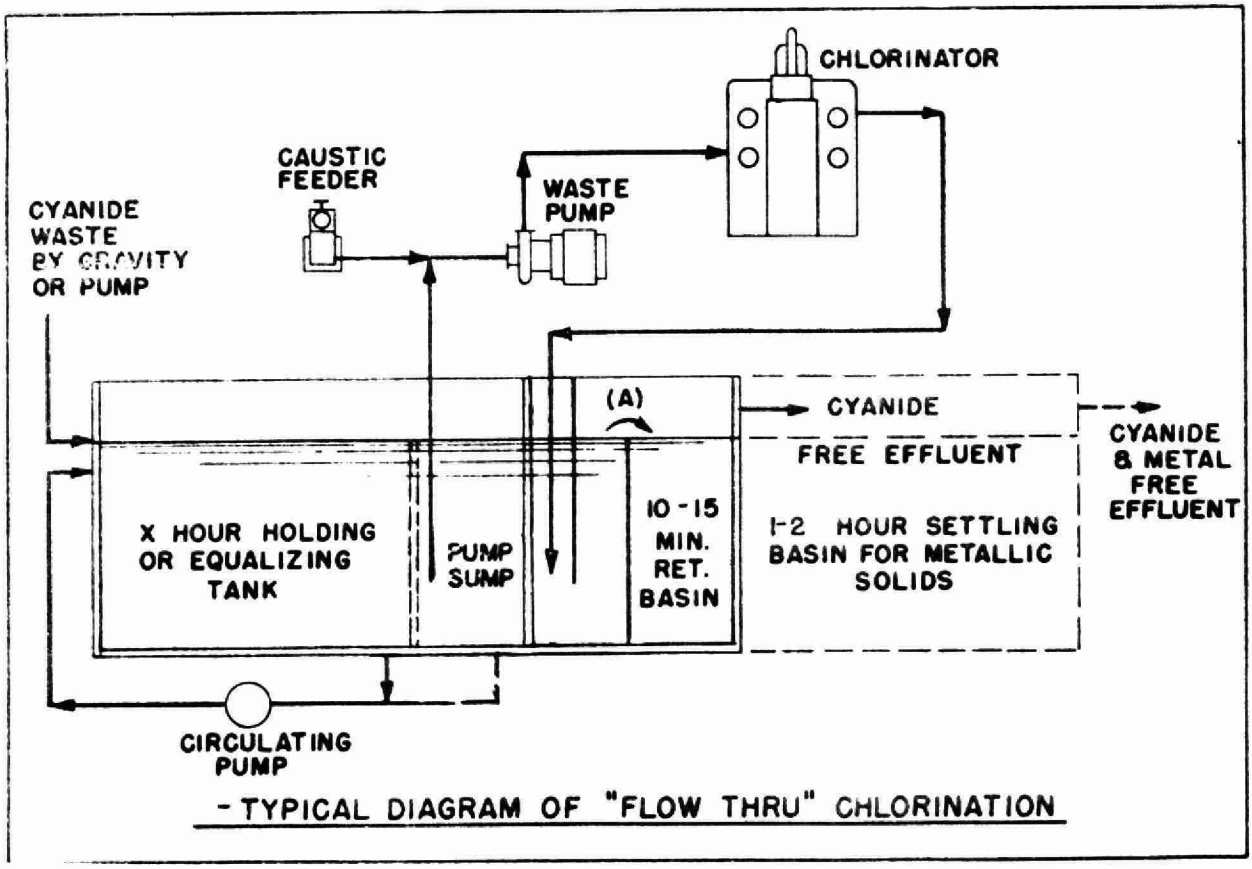
The cyanates produced as noted above will be decomposed by the addition of more chlorine to ammonium carbonates and with sufficient contact time (30 minutes to 1 hours) will be converted to carbon dioxide in the form of sodium bicarbonate, nitrogen, nitrous oxides and salt.

The first reaction noted above converting cyanides to cyanogen chloride and cyanates requires a theoretical 2.73 lbs. of chlorine for every pound of CN oxidized. 3.07 lbs. of caustic per lb. of cyanide are also required. Theoretically an additional 4.09 lbs. of chlorine and 4.62 lbs. of caustic per lb. of CN will break down the cyanates into the final end products. These theoretical values are minimum requirements, and we have found in practice that a good working figure is 4 - 4/12 lbs. of chlorine and 4-1/2 to 5 lbs. of caustic per lb. of CN to oxidize to cyanates and double these amounts to obtain complete destruction of the cyanates.

Treatment plants that have been set up in the States have fallen into one of two general classifications; (1) batch treatment, (2) flow-thru treatment.



TYPICAL DIAGRAM OF "BATCH" CHLORINATION



- TYPICAL DIAGRAM OF "FLOW THRU" CHLORINATION

FROM: - ALKALINE CHLORINATION OF CYANIDE BEARING WASTES - WALLACE & TIERNAN TECHNICAL ARTICLE TA-IC-1.

BATCH TREATMENT IS THE SIMPLEST AND MOST FOOL-PROOF METHOD, REQUIRING THE MINIMUM OF EQUIPMENT AND CONTROLS, BUT REQUIRING HOLDING TANKS OF SUFFICIENT CAPACITY TO STORE AT LEAST AN 8 HOUR DISCHARGE OF THE WASTE STREAM. YOU CAN APPRECIATE THAT THIS SOMETIMES GETS INTO ENORMOUS TANKAGE AND FOR THAT REASON THE FLOW-THRU SYSTEM HAS BEEN EMPLOYED WITH DEVELOPED CONTROLS TO PROVIDE SAFETY IN TREATMENT. IN THE BATCH TREATMENT SET-UP THE WASTE IS COLLECTED IN ONE TANK UNTIL FULL THEN DIVERTED TO A SECOND HOLDING TANK WHILE THE FULL TANK IS BEING CIRCULATED AND TREATED WITH CHLORINE AND CAUSTIC. THIS METHOD ELIMINATES ALL THE VARIABLES ENCOUNTERED SUCH AS FLUCTUATIONS IN CONCENTRATION AND FLOW AND LEAVES ONLY THE ONE VARIABLE "TIME OF TREATMENT" TO BE CONSIDERED. EQUIPMENT AND TANKS MUST BE SIZED TO PROVIDE A FACTORY OF SAFETY IN TIME REQUIRED TO TREAT ANY ONE BATCH SO THAT THIS BATCH CAN BE TREATED, DRAINED OFF AND THE TANK READY FOR FILLING AGAIN BY THE TIME IT IS NEEDED. IT IS A SIMPLE OPERATION, BUT REQUIRES THE ATTENTION OF AN OPERATOR TO START UP THE EQUIPMENT TO DETERMINE WHEN TREATMENT IS COMPLETED, CHANGE VALVES, TANKS, ETC.

THE FLOW-THRU TREATMENT SYSTEM PRESENTS MANY PROBLEMS AND MUST BE DESIGNED SPECIFICALLY FOR THE JOB TO TAKE INTO CONSIDERATION ALL THE FACTORS OF VARIABLE CONCENTRATIONS, VARIABLE FLOWS, RATES OF CHANGE IN FLOW, AND CONCENTRATION AND CONTACT TIME REQUIRED FOR THE TREATMENT TO BE COMPLETED. THERE ARE SO MANY POSSIBLE ARRANGEMENTS AND FACTORS EFFECTING DESIGN THAT IT WOULD BE IMPOSSIBLE TO COVER THEM IN THIS PAPER. HOWEVER, IT IS POSSIBLE TO DESIGN AND OPERATE A FLOW-THRU CYANIDE WASTE TREATMENT SYSTEM WITH AUTOMATIC CONTROLS WHICH DO NOT TAKE THE PLACE OF AN OPERATOR, BUT MERELY PROVIDE SUFFICIENT TOOLS TO CONTROL THE PROCESS TO THE DESIRED LEVEL OF TREATMENT.

THIS TREATMENT PROCESS PRODUCES A SLUDGE COMPOSED OF THE HEAVY METALS IN THE FORM OF METALLIC CYANIDE OR METALLIC HYDROXIDES, OXIDES AND CARBONATES DEPENDING ON THE DEGREE OF TREATMENT EMPLOYED. THESE SLUDGES ARE NOT DIFFICULT TO HANDLE (CAN BE READILY PUMPED) BUT THE FINAL DISPOSAL OF THEM BECOMES A PROBLEM BECAUSE IT IS DIFFICULT TO CONCENTRATE AND SEPARATE THEM FROM THE ENTRAINED WATER. IF DRAWN FROM A SETTLING TANK THE SLUDGE WILL CONTAIN 96% TO 99% WATER AND THROUGH A SYSTEM OF CONCENTRATION TANKS CAN BE CONCENTRATED TO 10% OR 12% SOLIDS. SOME COMBINATIONS CAN BE SUCCESSFULLY VACUUM FILTERED OR DRIED ON SLUDGE DRYING BEDS DOWN TO A 50% TO 60% MOISTURE CAKE, WHILE OTHERS SEEM TO RESIST ALL KNOWN METHODS OF DEWATERING AND PRESENT A DIFFICULT PROBLEM. MOST GENERALLY IN THE STATES THE METALLIC SLUDGES FROM THESE PROCESSES ARE LAGOONED WITH THE SUPERNATANT EVENTUALLY BEING DRAWN OFF TO THE SURFACE STREAMS AND THE RESULTANT CONCENTRATED SLUDGE PERIODICALLY REMOVED AND USED FOR LAND FILL.

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SETTING UP AN AIR POLLUTION SURVEY

- By -

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INTRODUCTION

Yesterday, Mr. McRae told you how the industries in the Sarnia Area set up their Group Research project some eighteen months ago. I now want to give you some idea of the work involved in surveying that atmospheric pollution situation in an industrial area such as Sarnia.

In some ways, Sarnia is a typical medium-sized city, with a population of about 45,000 and having about a dozen industrial firms. It is not typical in that the major industries are all in one field of endeavour, namely, Petroleum and Organic Chemicals and also in that it is a border city. Little is known of the pollution sources close at hand across the border.

BEHAVIOUR OF POLLUTANTS

Before we can discuss the sampling of an area for pollutants, it is necessary to understand clearly the behaviour of pollutants, and the factors which govern this behaviour.

For practical purposes, pollutants are divided into three main classes termed (I) Deposited Dust, (II) Aerosols and (III) Gases.

Deposited Dusts include all solid particles which are large enough to settle out reasonably quickly under the influence of gravity. Usually 5 mirons is taken as the dividing line and particles above this size are considered to be Deposited Dust. This is the gritty material you sweep up from your porch or veranda and originates

MAINLY FROM BOILER HOUSES AND GRINDING PROCESSES.

DEPOSITED DUST IS MEASURED BY COLLECTING SAMPLES OF THE DUST WHICH SETTLES OUT EITHER IN JARS OR SPECIALLY DESIGNED CANS TO MINIMIZE PICK-UP LOSSES FROM THE WIND. IN THE PAST, THIS WAS A FAVOURITE MEASUREMENT, BUT RECENTLY IT HAS ASSUMED LESS IMPORTANCE. IT REQUIRES ABOUT A MONTH TO COLLECT A MEASURABLE SAMPLE SO THAT CORRELATION WITH WIND DIRECTION AND OTHER METEOROLOGICAL VARIABLES IS IMPOSSIBLE, AND ANY STATISTICAL TREATMENT REQUIRES SEVERAL YEARS' RECORDS TO OBTAIN A SUFFICIENTLY LARGE NUMBER OF OBERVATIONS.

THE TERM AEROSOLS COVERS ALL SOLIDS AND LIQUID PARTICLES BELOW 5 MICRONS. THESE PARTICLES ARE TOO SMALL TO BE INFLUENCED APPRECIABLY BY GRAVITY AND BEHAVE AS A COLLOIDAL SUSPENSION. THEY INCLUDE SMOKES, FUMES AND MISTS ARISING FROM COMBUSTION PROCESSES (BOILERS, INTERNAL COMBUSTION ENGINES, ETC.), METALLURGICAL AND CHEMICAL OPERATIONS. SAMPLES OF AEROSOLS ARE TAKEN BY PULLING MEASURED VOLUMES OF AIR THROUGH FILTER MEDIA, USUALLY PAPERS.

THERE ARE TWO WAYS OF MEASURING THE AMOUNT OF AEROSOLS IN THE AIR. THE FIRST METHOD, USING THE HIGH VOLUME SAMPLER, FILTERS ABOUT 60 C.F.M. OF AIR THROUGH A SPECIAL FILTER AND, AT THE END OF A PERIOD OF 8 TO 24 HOURS, THE WEIGHT OF DEPOSIT IS DETERMINED. THIS GIVES AN ABSOLUTE MEASURE OF THE AMOUNT OF "FLOATING" SOLIDS PER UNIT VOLUME IN THE AIR. THIS METHOD IS USED TO SAMPLE THE AIR WITH REFERENCE TO A SOURCE OR SOURCES OF POLLUTION AND ALSO TO GIVE SAMPLES FOR FURTHER CHEMICAL OR SPECTROGRAPHIC ANALYSIS. THE OTHER METHOD REQUIRES A SAMPLE RATE OF ABOUT 3 C.F.M. AND PRODUCES A STAIN ON A FILTER PAPER IN 1 TO 2 HOURS, THIS STAIN BEING ASSIGNED A NUMERICAL VALUE DEPENDING ON ITS EFFECT ON THE LIGHT TRANSMITTANCE OR REFLECTANCE OF THE PAPER. THIS METHOD GIVES VALUES WHICH ARE RELATED TO THE SOILING PROPERTIES OF THE ATMOSPHERE AND APPROACHES MORE NEARLY THE VALUES WHICH A HOUSEWIFE MIGHT BE EXPECTED TO ASSIGN TO THE AIR. IT SHOULD BE POINTED OUT THAT THERE IS NO RELATIONSHIP BETWEEN THE VALUES OBTAINED BY THE TWO METHODS; THE FORMER, BEING A GRAVIMETRIC METHOD, RESPONDS MAINLY TO THE LARGER PARTICLES AND THE LATTER TO THE SUBMICRON PARTICLES WHICH ARE MORE EFFECTIVE IN LIGHT SCATTERING.

GASES INCLUDE ALL THE PERMANENT GASES NOT NORMALLY CONSIDERED CONSTITUENTS OF THE ATMOSPHERE AND ALSO VAPOURS OF VOLATILE LIQUIDS (LIGHT HYDROCARBONS, ETC.). UNDER NORMAL CIRCUMSTANCES, ONLY SULPHUR DIOXIDE IS RECORDED AMONG THE GASES, AND DUE TO THE MULTITUDINOUS SOURCES OF SO_2, IT IS WIDELY USED AS AN INDICATOR OF THE GENERAL POLLUTION LOAD IN AN AREA. OTHER GASES, H_2S, NO_2, Cl_2, HCN, HF, ETC. ARE ANALYZED BY CHEMICAL MEANS ONLY IF THE LOCAL INDUSTRIAL PROCESSES INDICATE SUCH GASES AS BEING POSSIBLE CONTAMINANTS.

METEOROLOGY

IT HAS LONG BEEN APPRECIATED THAT THE DEGREE

OF POLLUTION AT ANY TIME IS A FUNCTION NOT ONLY OF THE RATE OF PRODUCTION OF POLLUTION, BUT ALSO OF THE METEOROLOGICAL CONDITIONS. THE INFLUENCE OF WIND DIRECTION AT ANY SELECTED POINT IS, OF COURSE, PARAMOUNT SINCE IT DETERMINES WHETHER INDUSTRIAL POLLUTION TRAVELS TOWARDS OR AWAY FROM THE AREA. ANOTHER IMPORTANT PROPERTY OF THE WIND IS ITS TURBULENCE WHICH PROMOTES MIXING OF THE POLLUTED AIR WITH CLEAN AIR FROM ALOFT. THIS TURBULENCE IS PRODUCED BY TWO SEPARATE MECHANISMS; ONE IS THERMAL TURBULENCE PROMOTED BY THE SUN'S RADIATION AND THE OTHER A MECHANICAL TURBULENCE RESULTING FROM THE WIND VELOCITY. BOTH THESE FACTORS CAN BE ASSESSED FROM THE WIND VELOCITY AND DIRECTION TRACES IF A SUFFICIENTLY LIGHT SENSING HEAD IS USED TO FOLLOW MINOR VARIATIONS IN THE VELOCITY OR DIRECTION. ANOTHER PROPERTY OF THE ATMOSPHERE WHICH IS ASSUMING A DOMINANT ROLE IN AIR POLLUTION STUDIES IS THE VERTICAL TEMPERATURE DISTRIBUTION IN THE LOWER 200-500 FT. OF THE ATMOSPHERE. UNDER NORMAL CONDITIONS AND ESPECIALLY IN THE PRESENCE OF THERMAL TURBULENCE, THERE IS A DECREASE IN TEMPERATURE WITH HEIGHT. THIS RESULTS IN THE LOW-LYING WARM AIR TENDING TO RISE THROUGH THE DENSER UPPER AIR. WHEN THE REVERSE OCCURS, AND RADIATION LEADS TO POCKETS OF COLD AIR UNDERNEATH A WARM UPPER LAYER, THE ATMOSPHERE BECOMES STABLE AND VIRTUALLY NO VERTICAL MIXING TAKES PLACE. SINCE THIS CONDITION IS USUALLY ACCOMPANIED BY VERY LIGHT WINDS, THE ATMOSPHERE RESEMBLES A POND RATHER THAN A MOUNTAIN STREAM AND POLLUTION LEVELS BUILD UP CONTINUOUSLY UNTIL EITHER THE SUN'S HEAT PROMOTES THERMAL TURBULENCE OR THE WIND VELOCITY INCREASES.

THIS STABLE ATMOSPHERE IS BECOMING ONE OF THE BIGGEST HAZARDS TO OUR CIVILIZATION. IT IS NOT UNCOMMON SINCE IT OCCURS FOR A FEW HOURS ABOUT ONE DAY IN THREE OVER MOST OF THE WORLD, OCCASIONALLY IT WILL LAST FOR 20 TO 30 HOURS, AND INFREQUENTLY IT WILL LAST FOR SEVERAL DAYS. THIS CONTINUOUS STABLE ATMOSPHERE FOR A PERIOD OF OVER FOUR DAYS WAS THE PRIMARY CAUSE OF THE MEUSE, DONORA AND LONDON DISASTERS. FORTUNATELY THESE OCCURRENCES ARE RARE, BUT, ALTHOUGH DEATH SELDOM RESULTS FROM A STABLE ATMOSPHERE LASTING FOR LESS THAN FOUR DAYS, SHORTER PERIODS MUST REPRESENT A STRAIN ON THE METABOLISM OF THE LOCAL POPULATION.

THE SURVEY IN SARNIA

THE FOUNDATION'S SURVEY IN SARNIA REFERS SPECIFICALLY TO THE ATMOSPHERE IN THE BUSINESS AND RESIDENTIAL AREA. THE SURVEY IS BEING CARRIED OUT TO DETERMINE THE EFFECTIVENESS OF THE WASTE DISPOSAL METHODS OF THE LOCAL INDUSTRIES. EACH FIRM IS RESPONSIBLE FOR THE TESTING PROGRAM WITHIN ITS OWN BOUNDARIES ALTHOUGH THE FOUNDATION GIVES ADVICE AND CORRELATES IN-PLANT DATA WITH ITS OWN FINDINGS. THE FOUNDATION ALSO SETS UP STATIONS WITHIN THE PLANT BOUNDARIES WHEN SUITABLE SITES ARE LACKING OUTSIDE, BUT WE DO NOT FEEL THAT THE GROUP FUNDS SHOULD BE USED TO SOLVE THE PROBLEMS OF AN INDIVIDUAL FIRM. THIS WILLINGNESS OF THE INDIVIDUAL FIRMS TO ASSESS AND CORRECT THEIR OWN DEFICIENCIES IS THE KEY TO THE SUCCESS OF THE SARNIA SURVEY AND WE SHOULD LIKE TO PUT ON RECORD OUR APPRECIATION OF THE CO-OPERATION OF THE FIRMS INVOLVED AND THEIR WILLINGNESS TO SUPPLY HELP IN THE FORM OF ELECTRICIANS,

INSTRUMENT FITTERS, CARPENTERS, ETC. AS NEEDED.

FIGURE 1 IS A MAP OF SARNIA SHOWING THE LOCATION OF THE MAJOR INDUSTRIAL PLANTS IN THE AREA, AND OF THE SURVEY SAMPLING STATIONS. THE LOCATIONS NAMED $X_1 - X_6$ AND $P_1 - P_5$ REFER TO DEPOSITED DUST CANS SET OUT BY IMPERIAL OIL LIMITED AND POLYMER CORPORATION LIMITED RESPECTIVELY. THESE ARE MOSTLY ON INDUSTRIAL PROPERTY, BUT THE RESULTS ARE MADE AVAILABLE TO THE SURVEY AND ARE CORRELATED WITH THE SURVEY'S RESULTS IN THE REPORTS.

SINCE METEOROLOGICAL RECORDS INDICATED THAT THE PREVAILING WIND IN SARNIA IS SOUTHWEST, A MASTER STATION SITE WAS SELECTED TO THE NORTHEAST OF THE MAJOR INDUSTRIAL AREA (SITE R_1). THE SELECTION OF THIS SITE IS OF GREAT IMPORTANCE. THE AIM IS TO SELECT A POINT IN THE RESIDENTIAL AREA AS NEAR AS POSSIBLE TO THE AREA OF MAXIMUM POLLUTION BUT SUFFICIENTLY OPEN TO ALLOW THE METEOROLOGICAL INSTRUMENTS TO OBTAIN RELIABLE RECORDS OF WIND VELOCITY ETC. R_1 IS SITUATED IN TECUMSEH PARK, AND ALTHOUGH SOME OF THE TREES ARE CLOSER THAN ONE WOULD WISH, IT IS REASONABLY CLOSE TO THE AREA EXPECTED TO BE MOST AFFECTED BY THE LARGE INDUSTRIAL PLANTS.

THE EQUIPMENT AT R_1 INCLUDES THE ANEMOMETER, AN AUTOMATIC SULPHUR DIOXIDE RECORDER, A HIGH VOLUME SAMPLER FOR GRAVIMETRIC DETERMINATION OF AEROSOLS, A HEMEON SAMPLER FOR DETERMINATION OF AEROSOLS BY THEIR SOILING PROPERTIES, AND A DEPOSITED DUST CAN.

STATIONS R_2-R_9 REPRESENT SUBSIDIARY STATIONS AT WHICH DEPOSITED DUST CANS ARE EXPOSED. POWER IS ALSO AVAILABLE FOR HIGH VOLUME OR HEMEON SAMPLERS. THESE STATIONS ARE LOCATED TO CHECK ON THE POLLUTION FROM SOURCES OTHER THAN THE MAIN SOURCES UNDER CONSIDERATION (THUS R_9 CHECKS ON THE DETROIT EDISON POWER PLANT WITH SOUTHWEST WINDS AND R_8 ON THE CEMENT PLANT WITH WEST WINDS). HERE AGAIN, A COMPROMISE IS NECESSARY TO FIND LOCATIONS WITH SUFFICIENT EXPOSURE AND TO AVOID ERRORS DUE TO THE SHIELDING EFFECT OF HIGH BUILDINGS. USUALLY, THE DUST CANS ARE SITUATED ON FLAT ROOFED BUILDINGS SUCH AS SCHOOLS AND THE SUCTION SAMPLERS ARE LOCATED IN NEARBY ROADS. WE ARE GRATEFUL TO THE ONTARIO HYDRO-ELECTRIC POWER COMMISSION, WHO NOT ONLY PROVIDED DROP-LEADS ON HYDRO POLES TO ALLOW US TO TAKE CURRENT, BUT SUPPLIED CROSS ARMS ABOUT 10 FEET ABOVE GROUND LEVEL ON WHICH THE INSTRUMENTS COULD BE MOUNTED.

MOBILE UNIT

LATER, I SHALL GIVE YOU SOME IDEA OF THE COSTS INVOLVED IN THESE SURVEYS AND YOU WILL THEN APPRECIATE THAT TO EQUIP THE SUBSIDIARY STATIONS WITH MORE THAN SIMPLE INSTRUMENTS WOULD COST A PROHIBITIVE AMOUNT. THE RECORD OF SULPHUR DIOXIDE CONCENTRATION AT ONE LOCATION ONLY IS OF LITTLE VALUE AND THE INTRODUCTION OF FURTHER SAMPLING STATIONS IS IMPERATIVE. IN ORDER TO BE ABLE TO USE A LARGE NUMBER OF

SAMPLING SITES, A MOBILE UNIT HAS BEEN DESIGNED AND BUILT. THIS UNIT, WHICH IS ON DISPLAY AT THE CONFERENCE, IS ALSO EQUIPPED WITH A POWER GENERATOR SO THAT IT CAN, IF NECESSARY, OPERATE AWAY FROM THE PUBLIC SUPPLY. THIS UNIT CAN CARRY ALL THE INSTRUMENTS AVAILABLE AT THE MASTER STATION R_1, AND A COMPARISON CAN BE MADE IN THE RECORDS. WE HAVE OPERATED THIS UNIT AT A LOCATION SHOWN IN FIGURE I NEAR X_1. IN THIS LOCATION, THE SULPHUR DIOXIDE FUMIGATIONS WHICH ALL ARRIVE AT R_1 WITH SOUTHWEST WINDS CAN BE SEPARATED SINCE THE INDUSTRIAL AREAS SPREAD FROM SOUTH TO NORTHWEST AND THE CANADIAN NATIONAL RAILWAYS ROUND HOUSE IS APPROXIMATELY NORTHEAST OF THE MOBILE RECORDER.

FURTHER WORK

NO INVESTIGATION OF THIS TYPE CAN BE PLANNED FAR AHEAD. AFTER THE INITIAL START UP, EACH STEP IS INDICATED BY THE DATA ACCUMULATED. AT SARNIA, THE DETROIT EDISON POWER PLANT IS COMPARABLE WITH THE BOILER HOUSES ON THE CANADIAN SIDE, AND AN ASSESSMENT OF THE CONTRIBUTION OF THIS PLANT WILL BE NEEDED. OUR RESULTS ALSO INDICATE A RELATIVELY INTENSE POLLUTION SOURCE NEAR R_6 WHICH IS ON THE EDGE OF THE SHOPPING AREA. THIS WILL ALSO NEED INVESTIGATION.

COSTS

MANY WORTH-WHILE PROSPECTS NEVER GET BEYOND THE IDEA STAGE DUE TO A LACK OF KNOWLEDGE OF THE COSTS INVOLVED. THE FOLLOWING FIGURES INDICATE THE APPROXIMATE DUTY AND TAX-FREE PRICES OF THE EQUIPMENT USED IN THE SARNIA SURVEY. IT WOULD, OF COURSE, BE POSSIBLE TO USE SNAP OR AD HOC SAMPLING IN MANY CASES IN PLACE OF AUTOMATIC SAMPLERS, BUT DUE TO THE RAPIDITY WITH WHICH ATMOSPHERIC CONDITIONS CHANGE, WE BELIEVE THE FOLLOWING TO BE THE MOST EFFECTIVE SELECTION OF EQUIPMENT.

2	AUTOMATIC SULPHUR DIOXIDE RECORDERS	$ 6,600.
1	ANEMOGRAPH	1,700.
8	DEPOSITED DUST CANS	360.
4	HEMEON SAMPLERS	800.
4	HIGH VOLUME SAMPLERS	1,040.
1	MOBILE UNIT	4,500.
1	FIXED STATION	500.
1	VEHICLE	2,700.
		$ 18,200.

SUMMARY

AN AIR POLLUTION SURVEY IS SET UP INITIALLY TO SAMPLE THE AIR AT LOCATIONS WHICH OUR PRESENT INADEQUATE THEORY INDICATES TO BE AREAS OF HIGH POLLUTION. AS WELL AS SAMPLING AND ANALYZING THE POLLUTANTS, METEOROLOGICAL DATA ARE COLLECTED TO DETERMINE PARAMETERS NEEDED FOR THEORETICAL CALCULATIONS WHICH ARE IN MOST CASES COMPLETELY UNKNOWN.

To avoid setting up costly pieces of equipment at a number of locations, a mobile unit is used and its location is selected from a consideration of the data collected at the Master Station. While it is thus possible to define the most polluted areas, determine the nature and sometimes the origin of the pollutant, the absolute level of pollution is at all times controlled by meteorological conditions. It is thus never possible to determine a maximum pollutant level which will never be exceeded, since a stable atmosphere, like a drought or a heat wave can always "break the record" and last longer than ever before. Our only defence lies in keeping pollution at the lowest level consistent with economic industrial operations.

POLLUTION IN RELATION TO STREAM LIFE

- By -

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INTRODUCTION

That heavy pollution of a river has an adverse effect on fish and other aquatic forms is common knowledge. Wiebe, in a special report on stream pollution in Wisconsin (85) says that game fish were absent from the waters of the Mississippi River from the cities of St. Paul and Minneapolis as far down as Prescott, a distance of 37 miles, although they were abundant above this section and occurred in increasing numbers below it. This absence was related to oxygen deficiency of the water, brought about by sewage let into the river, which was so marked in August as to be insufficient to support fish of any kind. Even at Red-wing, about 20 miles below Prescott, the oxygen supply was below that required for fish for 11 days in August. The investigators did not consider that the river had fully recovered from the effects of sewage, mainly from the above-mentioned two large cities, even at a distance of 110 miles down-stream as many of the forms most sensitive to pollution were not present.

An analagous situation is reported by Henderson (30) in connection with the establishment in 1940 of a rayon factory by the Viscose Corporation on the Shenandoah River in West Virginia. This stream had a good history of fishing prior to 1940 but subsequently became barren for a stretch of about 35 miles and conditions for fishing were reported to be very poor in the next twenty miles. Depletion of bottom organisms on which the fish depend for food was found to be about 98% as compared with pre - 1940 values and values for parts of the river above the factory. When tested the water of the stream came up to the usual standards of unpolluted water. The oxygen, carbon dioxide, acid-alkaline reaction, and turbidity were all within the acceptable limits by present standards. A toxic chemical in the effluent was

SUSPECTED AND EVENTUALLY IT WAS FOUND THAT LETHAL CONCENTRATIONS OF ZINC SULPHATE WERE RESPONSIBLE FOR THE KILLS OF FISH AND OTHER ORGANISMS RESULTING IN THEIR ELIMINATION. AT THE TIME OF THE REPORT (1949), SOME IMPROVEMENT HAD BEEN EFFECTED, BUT CONDITIONS HAD NOT BEEN RESTORED TO THE PRE - 1940 LEVEL.

IN THE UNITED STATES, MORE DENSELY POPULATED AND MORE HIGHLY INDUSTRIALIZED IN MANY SECTIONS THAN IS ONTARIO, THE POLLUTION OF RIVERS IS RECOGNIZED AS A NATIONAL PROBLEM OF THE GREATEST IMPORTANCE. ONE HAS BUT TO CONSULT SOME OF THE REPORTS OF SURVEYS OF RIVERS SUCH AS FORBES AND RICHARDSON (24), STUDIES ON THE BIOLOGY OF THE UPPER ILLINOIS RIVER; U.S.PUBLIC HEALTH SERVICE (74), OHIO RIVER POLLUTION CONTROL; NEW YORK STATE CONSERVATION DEPARTMENT, (50,51,52,53,54,55), BIOLOGICAL SURVEYS OF RIVER SYSTEMS; WISCONSIN STATE BOARD OF HEALTH (85), REPORT ON STREAM POLLUTION IN WISCONSIN; AND MANY OTHERS TO REALIZE THE WIDESPREAD NATURE AND SERIOUSNESS OF THE PROBLEMS.

IN ONTARIO THERE ARE SIMILAR PROBLEMS AND SOME OF THE CASES HAVE BEEN REFERRED TO BY MACKAY (44), AND IN THE ONTARIO DEPARTMENT OF PLANNING AND DEVELOPMENT'S CONSERVATION REPORTS (58), WITH INCREASING URBANIZATION AND INDUSTRIALIZATION AN INCREASE IN SUCH CASES IS INEVITABLE UNLESS SATISFACTORY HANDLING OF INDUSTRIAL WASTES PROVIDES SOLUTIONS.

ALMOST ALL EFFLUENTS CARRYING INDUSTRIAL WASTES CREATE A POLLUTION PROBLEM WHEN THEY EMPTY INTO SMALL STREAMS WHERE THE RESULTING DILUTION OF THE EFFLUENT IS NOT ENOUGH TO REDUCE THE CONCENTRATION OF TOXIC MATERIALS BELOW DANGEROUS LEVELS, ADENEY (2); AKERLINDH (3) AND WELLS (79). FROM THE STANDPOINT OF BIOLOGICAL CONDITIONS OF STREAMS POLLUTION RESULTS EVEN IN THE CASE OF EFFLUENTS WHICH HAVE BEEN TREATED TO REDUCE SOME OF THE EFFECTS. IN SOME CASES WHERE THE EFFLUENT IS IMPOUNDED AND RELEASED IN LARGE QUANTITY INTERMITTENTLY THE EFFECT ON FISH OR OTHER ORGANISMS IS MORE DISASTROUS THAN IF THE EFFLUENT WERE ALLOWED TO FLOW CONTINUALLY INTO THE STREAM AS THE PROPORTION OF POLLUTANT TO VOLUME OF FLOW OF THE STREAM MAY BE HIGHER THAN CAN BE TOLERATED IN THE FIRST CASE, BUT NOT IN THE SECOND. WITH LARGER RIVERS OR LARGE BODIES OF WATER MORE SEWAGE MAY BE ADMITTED WITHOUT DELETERIOUS EFFECTS ON THE LIFE OF THE WATER, BUT IT IS ALONG SUCH RIVERS OR BODIES OF WATER THAT TOWNS ARE CONCENTRATED AND THE ADDITIVE EFFECT OF ALL THESE MAY OVERTAX THE CAPACITY OF THE STREAM, AND THIS PROBLEM MAY BE EXPECTED TO INCREASE AND CALL FOR MORE ADEQUATE MEASURES. FLOWING WATER OF STREAMS PRESENTS DIFFERENT PROBLEMS IN REGARD TO POLLUTION THAN DO BODIES OF STATIC WATER IN WHICH ACCUMULATION OF WASTE OVER LONG PERIODS OF TIME TAKES PLACE, AKERLINDH (3); JANSA & FISCHERDROM (35).

CRITERIA OF POLLUTION FROM THE BIOLOGICAL STANDPOINT

FOR THE PURPOSE OF THE PRESENT PAPER, POLLUTION IS ANY INFLUENCE ON THE STREAM BROUGHT ABOUT BY THE INTRODUCTION OF MATERIALS TO IT WHICH ADVERSELY AFFECTS THE ORGANISMS LIVING IN THE STREAM, EITHER BY KILLING THEM DIRECTLY OR INTERFERING WITH THEIR HABITS IN SUCH A WAY AS TO REDUCE THE NUMBERS

SERIOUSLY OR EXCLUDE THEM FROM THE STREAM OR PART OF THE STREAM. SUCH INFLUENCES MAY BE BROUGHT ABOUT THROUGH THE INTRODUCTION OF ABNORMALLY HIGH AMOUNTS OF SILT WHICH MAY BE A RESULT OF IMPROPER FARMING PRACTISE, ADDITION OF MATERIALS SUCH AS COAL DUST, SAWDUST, BARK, PULP FIBRE OR OTHER SEDIMENTS WHICH HAVE THE EFFECT OF PRODUCING STERILE BOTTOM CONDITIONS FROM THE BIOLOGICAL STANDPOINT, THE ADDITION OF TRADE WASTES EITHER OF THE DEOXYGENATING OR TOXIC CLASS WHICH ARE DETRIMENTAL TO LIFE IN THE STREAM. ALSO POISONS ADDED TO THE STREAM EITHER DIRECTLY FOR THE PURPOSE OF CONTROLLING STREAM INHABITING FORMS SUCH AS BLACK FLIES, OR WHICH EVENTUALLY REACH THE STREAM AS A RESULT OF SPRAYING OF THE FOREST OR OTHER VEGETATION WHERE THESE PRACTISES ARE INJURIOUS TO FISH MAY BE CLASSED AS POLLUTION. THIS IS ESPECIALLY SO WHERE THE BIOLOGICAL BALANCE IS UPSET AND MAY NOT BE REGAINED FOR A LONG PERIOD OF TIME AND WHEN IT IS MAY BE A LESS SATISFACTORY ONE FROM THE STANDPOINT OF FISHERIES.

SUCH A DEFINITION MAY BE AT VARIANCE WITH A DEFINITION OF POLLUTION FROM THE PUBLIC HEALTH OR HYGIENIC STANDPOINT AND IN SOME CASES IMPLIES MORE AND IN SOME LESS EXACTING STANDARDS OF WATER PURITY THAN IN THE LATTER CASE.

TYPES OF POLLUTING MATERIALS THEIR SOURCES AND EFFECTS ON ORGANISMS

IT IS DIFFICULT, BECAUSE OF THEIR GREAT DIVERSITY, TO ARRANGE A SCHEME OF CLASSIFICATION OF INDUSTRIAL POLLUTANTS. FOR SOME PURPOSES THEY ARE TREATED UNDER THE HEADINGS OF THE INDUSTRIAL PROCESSES WHICH PRODUCE THEM AS FOR INSTANCE, WASTES OF LUMBER AND PULP MILLS, MINES, DAIRY, TANNERY, CANNING, OIL WELLS, OIL REFINERIES, COAL GAS AND COKE PLANTS AND MANY OTHERS. SEE WISCONSIN STATE BOARD OF HEALTH (85), U.S. PUBLIC HEALTH SERVICE (74).

SOME OF THESE PROCESSES PRODUCE EFFLUENTS WHICH HAVE SOME CHARACTERISTICS IN COMMON WHICH HAVE LED TO ANOTHER SYSTEM OF CLASSIFICATION BASED ON THE EFFECT OF THE EFFLUENT ON THE RECEIVING STREAM, WARD (77), ELLIS (23), AND BARTSCH (8). THE CLASSIFICATION OF ELLIS (23), IS USED WITH SOME MODIFICATIONS AND DIVIDES THE POLLUTANTS INTO THE GROUPS SUSPENSOIDS OF SOLIDS AND EMULSOIDS, DEOXYGENATING SUBSTANCES AND SPECIFIC TOXIC CHEMICAL SUBSTANCES. THERE IS OVERLAP IN THIS SYSTEM AS THE CONSTITUENTS OF AN EFFLUENT MAY HAVE MECHANICAL, DEOXYGENATING AND TOXIC EFFECTS. FREQUENTLY, HOWEVER, ONE OF THESE EFFECTS DOMINATES AND CHARACTERIZES IT FROM THE STANDPOINT OF EFFECT ON ORGANISMS.

SUSPENSOIDS OF SOLIDS AND EMULSOIDS

IN THIS GROUP MAY BE PLACED EROISION SILT, ROCK DUST FROM LIMESTONE MILLS, ASBESTOS MILLS, LUCITE AND OTHER TYPES OF MINES. THESE ARE INORGANIC MATERIALS TO WHICH SHOULD BE ADDED COAL DUST AND CINDERS WHICH ARE ALSO DURABLE MATERIALS, AND THEIR REMOVAL FROM A STREAM DEPENDS ON TRANSPORT BY WATER OR

ARTIFICIAL CLEANING OF THE STREAM BOTTOM. OTHER MATERIALS FALLING IN THIS CATEGORY AND UNDER MOST CONDITIONS ALSO DURABLE ARE SUCH ORGANIC MATERIALS AS BARK OF TREES, SAWDUST AND WOOD PULP FIBRE WHICH PERSIST FOR MANY YEARS AS A LAYER ON THE BOTTOM. OILS, EITHER CRUDE OR REFINED UNDER SOME CONDITIONS BECOME ASSOCIATED WITH THE BOTTOM MATERIALS IN A STREAM, ELLIS (23). THESE MATERIALS, AT LEAST THE MORE FINELY DIVIDED, WHILE IN SUSPENSION PRODUCE A TURBIDITY OR MUDDINESS WHICH INTERFERES WITH THE PENETRATION OF LIGHT INTO THE WATER AND THUS AFFECTS TEMPERATURE, WALLEN (76), OF THE WATER AND THE GROWTH OF GREEN PLANTS, ELLIS (22). THE LATTER EFFECT IS OF MORE IMPORTANCE IN LAKES OR THE DEEPER AND MORE PLACID SECTIONS OF LARGE RIVERS THAN IN SMALL STREAMS. TURBIDITY, PARTICULARLY IN LAKES, MAY ALSO BE CAUSED BY LIVING ORGANISMS SUCH AS BACTERIA AND ALGAE AND HAS SOME OF THE SAME EFFECTS ON LIGHT PENETRATION AS MENTIONED ABOVE, ROSENBERG (65).

THE DIRECT EFFECT OF SILTS AND OTHER SUSPENSOIDS ON FISH IS ACCORDING TO COLE (17), NOT SIGNIFICANT UNDER MOST CONDITIONS. A CONTINUOUS SECRETION OF MUCOUS FROM THE GILLS AND OTHER SURFACES KEEPS THEM CLEARED OF THE PARTICLES. MARSON (40), HAS HOWEVER, DRAWN ATTENTION TO THE FACT THAT IF CERTAIN ACIDS OR OTHER CHEMICAL WASTES WHICH COAGULATE THE MUCOUS OR PREVENT ITS SECRETION ARE PRESENT IN THE WATER, THE EFFECT OF SILT AND OTHER PARTICULATE MATTER GREATLY ACCENTUATES THE CLOGGING OF DELICATE RESPIRATORY SURFACES. SUCH SEDIMENTS ALSO INTERFERE WITH THE NORMAL ACTIVITIES OF THE FISH BY DESTROYING SPAWNING SITES.

THE MOST GENERAL DETRIMENTAL EFFECT ON THE BIOTA OF A STREAM OF POLLUTANTS OF THIS CLASS OR OF ANY PARTICULATE MATTER WHICH SETTLES IS TO PRODUCE A MATT ON THE BOTTOM WHICH GREATLY ALTERS IT BY FILLING UP ALL INTERSTITIAL SPACES IN WHICH MANY FISH FOOD ORGANISMS LIVE, &INTERFERING WITH THE FEEDING AND RESPIRATORY MECHANISMS BY CLOGGING, ELLIS (23); MOORE (45); HORE & NAIR (32); KNAPP (37).

IN THE CASE OF SAWDUST, PULP FIBRE AND OTHER SEDIMENTS WITH AN ORGANIC CONTENT THERE IS AN ADDITIONAL DETRIMENTAL EFFECT BROUGHT ABOUT BY THE CONTINUAL DEMAND OF THE MATERIALS OR ASSOCIATED ORGANISMS FOR OXYGEN THUS CONTRIBUTING TO DEPLETION OF THE DISSOLVED OXYGEN OF THE WATER, ELLIS (23) DYMOND, DELAPORTE ET AL (21).

ELLIS (23), ALSO STATES THAT SILTS, ALTHOUGH INORGANIC, ARE INSTRUMENTAL IN "LAKING DOWN" SUCH ORGANIC WASTES AS OILS, CHEMICAL WASTES, AND PULPS IN BEDS ON THE FLOOR OF THE STREAM WITH DISASTROUS RESULTS TO THE BOTTOM FAUNA, INCREASING THE STERILE CHARACTER OF THE BOTTOM AND DEPLETING THE WATER OF OXYGEN IN A SUSTAINED MANNER.

UNDER SOME CONDITIONS INSOLUBLE SALTS OF HEAVY METALS SUCH AS LEAD ARE PRECIPITATED ON THE BOTTOM WITH A CUMULATIVE EFFECT. WITH EVEN SLIGHT CHANGES IN THE CONDITIONS THE PRECIPITATE OF THIS RESERVOIR DISSOLVES AND LETHAL CONCENTRATIONS OF LEAD SALTS ARE PRODUCED, CARPENTER (12,13); BEHRENS (10); NEWTON (57).

Deoxygenating Substances

Introduction

Many effluents of industrial concerns are chifely characterized by their high organic content with high biochemical oxygen demand and resulting depletion of dissolved oxygen in the receiving stream. These may have, in addition, chemical constituents which alter the effect on the stream and organisms living in the water, but when the latter fraction is not dominant such effluents have much the same effect as does domestic sewage. Among industrial wastes whose effluents are deleterious because of their effect in reducing the oxygen are, mills products, packing plants, canning factories, breweries and distilleries, beet sugar, paper pulp, tanneries, dye works, starch factories and laundries. Some of these more than others have, in addition, toxic substances which are known to be harmful to fish and other organisms, Ellis (23). The most pronounced result, however, is the reduction in dissolved oxygen. This may be very serious or not depending on the initial oxygen demand of the material and its oxidizability, the ratio of the discharge of the effluent to the discharge of the river or stream, and the ability of the water of the stream to reaerate. This depends on the character of the water course whether deep, shallow, fast or slow, turbulent or placid and the kinds and numbers of plants and animals present.

The B0.O.D., a measure of the potential of the effluent to use oxygen, is at a maximum, as far as the stream is concerned, at the outfall and decreases as oxidation proceeds. Depletion of oxygen in the water of the streams proceeds more or less rapidly from the outfall downstream depending on the type and amount of oxidizable material in relation to the size and character of the stream. The oxygen may be reduced to non detectable amounts in some casew, and a considerable length of streams may be involved. In cases where depletion in oxygen is complete the process of decomposition of the organic matter continues through the agency of anaerobic forms of life.

Depending on the character of the stream, whether slow-flowing or rapid, deep or shallow, there is slow or rapid reaeration of the water from the atmosphere. Where the demand of the sewage for oxygen is great this reaeration is not sufficientto offset depletion but when the demand has been reduced with the oxidation of much of the material reaeration gradually raises the level of the dissolved oxygen in the water and eventually it reaches the normal level for unpolluted water some distance downstream, and the stream is then referred to as purified. The graphical representation of the amount of oxygen sag curve and has been illustrated by many investigators including Whipple (81), State of New York Conserv. Comm. (49). A Mathematical formula for the oxygen sag curve is given by Streeter and Phelps (68), relating dissolved oxygen and B.O.D. with reaeration the only source of oxygen. This formula has since been somewhat expanded by Jansa and Akerlindh (38), and Howland (33). An equation for the process without reaeration or recovery is algso given. With a

KNOWLEDGE OF THE VALUE FOR THE TERMS OF THIS EQUATION AS THEY APPLY TO THE EFFLUENT AND THE RECEIVING STREAM IT IS POSSIBLE TO PREDICT WITH SOME ACCURACY THE POLLUTIONAL EFFECT THAT AN EFFLUENT WOULD HAVE ON THE STREAM.

EFFECTS ON BIOTA, RESPIRATORY MECHANISMS AND INDICATOR ORGANISMS

THE DIFFERENCES IN DISSOLVED OXYGEN AMOUNT HAVE SUCH A STRIKING EFFECT ON THE BIOTA OF THE STREAM THAT DEFINITE THOUGH ARBITRARY ZONES HAVE BEEN RECOGNIZED. THE ZONE OF RECENT POLLUTION OR DEGRADATION, THROUGH WHICH THE AMOUNT OF DISSOLVED OXYGEN IS FALLING, IS CHARACTERIZED BY A PROGRESSIVE REDUCTION IN ORGANISMS WHICH ARE CHARACTERISTIC OF AN UNPOLLUTED RIVER. AT THE POINT WHERE THE PERCENTAGE SATURATION OF OXYGEN REACHES APPROXIMATELY 40 (3.5 PARTS PER MILLION AT SUMMER TEMPERATURES), WHICH IT DOES INEVITABLY WHEN THERE IS SERIOUS ORGANIC POLLUTION, BEGINS A NEW ZONE KNOWN AS THE ZONE OF ACTIVE DECOMPOSITION OR SEPTIC ZONE AND THIS ZONE PERSISTS DOWN TO A POINT WHERE THE OXYGEN HAS AGAIN RISEN TO ABOUT THE 40 PERCENT SATURATION LEVEL. WITHIN THIS ZONE THE OXYGEN REACHES ITS MINIMUM AT WHAT IS KNOWN AS THE CRITICAL POINT, AND IF THERE IS AN ENTIRE LACK OF OXYGEN AT THIS POINT NONE BUT ANAEROBES ARE FOUND, AND METHANE GAS AND FOUL ODOURS ARE PRODUCED. DOWN TO THIS POINT IN THE SEPTIC ZONE THE NUMBER AND TYPES OF ORGANISMS REQUIRING DISSOLVED OXYGEN ARE REDUCED THOUGH THE ORGANISMS WHICH DO LIVE THERE MAY BE PRESENT IN GREAT NUMBERS AS IS OFTEN THE CASE WITH TUBIFEX, THE SEWER WORM, AND A FEW OTHERS, BARTSCH AND CHURCHILL (9). BEYOND THE CRITICAL POINT SOME OF THESE SAME TOLERANT FORMS COME IN AGAIN WHEN THE OXYGEN CONTENT OF THE WATER HAS RISEN AGAIN TO APPROXIMATELY THE 40 PERCENT SATURATION LEVEL.

THE SECTION OF STREAM THROUGH WHICH THE OXYGEN CONTENT OF THE WATER IS INCREASING AND PARTICULARLY FROM THE POINT ARBITRARILY MARKING THE LOWER LIMIT OF THE SEPTIC ZONE IS KNOWN AS THE ZONE OF RECOVERY. IN THE UPPER PART OF THIS ZONE ONLY THE ORGANISMS MORE TOLERANT OF LOW OXYGEN, SUCH AS TUBIFEX AND THE BLOODWORM, CHIRONOMUS TENTANS, ARE PRESENT BUT THESE MAY BE VERY ABUNDANT. WITH GREATER IMPROVEMENT DOWNSTREAM MORE AND MORE VARIETIES OF THE MORE SENSITIVE ORGANISMS APPEAR UNTIL THE FAUNA IS SIMILAR TO THAT OF AN UNPOLLUTED STREAM AND THE RIVER IS SAID TO HAVE RECOVERED COMPLETELY AT THE LOWER END OF THE RECOVERY ZONE.

AT WHAT POINT THE RIVER CAN BE CONSIDERED TO HAVE COMPLETELY RECOVERED IS A MOOT QUESTION AT PRESENT AMONG INVESTIGATORS. AT SOME POINT IN THE RECOVERY ZONE, GREEN PLANTS PARTICULARLY A PONDWEED, POTAMOGETON PECTINATUS, AND A BRANCHING ALGA, CLADOPHORA SP., GENERALLY APPEAR AND SOME HAVE CONSIDERED THAT THIS IS A SIGN THAT THE STREAM HAS RECOVERED COMPLETELY OR ALMOST COMPLETELY. OTHERS INCLUDING WILSON (84) COSIDER THAT NOT UNTIL THESE PLANTS HAVE BEEN REDUCED TO THE AMOUNT NORMALLY FOUND IN AN UNPOLLUTED STREAM CAN COMPLETE RECOVERY BE CONSIDERED TO HAVE TAKEN PLACE. THE ALGAE WHICH UTILIZE THE HIGH NITROGEN AND PHOSPHORUS SALTS OF THE WATER, INCREASE PRODIGIOUSLY IN THE RECOVERY ZONE IN MANY CASES. THE

STREAM IS FERTILIZED BY THE POLLUTING MATERIALS AND PLANT GROWTH IS GREATLY INCREASED. DURING DAYLIGHT HOURS THESE ALGAE USE UP SOME OXYGEN IN THEIR RESPIRATORY PROCESSES BUT PRODUCE ALSO GREAT AMOUNTS OF OXYGEN IN THE PROCESS OF PHOTOSYNTHESIS UTILIZING CARBON DIOXIDE AND GIVING OFF OXYGEN TO THE WATER. THIS RESULTS FREQUENTLY IN SUPERSATURATION OF THE WATER WITH RESPECT TO OXYGEN DURING THE DAY WITH DEPLETION AT NIGHT AS SHOWN BY GAUFIN AND TARZWELL (27). SPRAGUE (67), HAS RECORDED VALUES OF OXYGEN AS LOW AS 1 PART PER MILLION (6% SATURATION) AND AS HIGH AS 12 PARTS PER MILLION (150% SATURATION) FOR THE SAME LOCATION IN THE UPPER PART OF THE ALGAL SECTION IN A STREAM RECEIVING SEWAGE TREATED BY AN ACTIVATED SLUDGE PROCESS. LOWER DOWN IN THE ALGAL SECTION VALUES AS HIGH AS 22 PARTS PER MILLION (270% SATURATION) WITH A CORRESPONDING LOW OF 2 PARTS PER MILLION (12% SATURATION) WERE RECORDED. THE HIGH AND LOW VALUES ARE INDICATIVE OF THE FLUCTUATION OVER A TWENTY-FOUR HOUR PERIOD. THE HIGH OXYGEN ACCELERATES THE PURIFICATION PROCESS BUT DURING THE NIGHT TIME, WHEN PHOTOSYNTHESIS STOPS AND OXYGEN IS PROGRESSIVELY REDUCED BY THE RESPIRATION OF THE PLANTS AND ANIMALS AND BY OXIDATION OF THE SEWAGE, CONDITIONS BECOME UNSUITABLE FOR MANY ORGANISMS.

FROM THE BIOLOGICAL STANDPOINT THIS EXTREME FLUCTUATION IN THE AMOUNT OF DISSOLVED OXYGEN HAS A SERIOUS EFFECT AND THE FAUNA, WHICH MIGHT BE EXPECTED TO BE RICH BECAUSE OF THE ABUNDANT PLANT FOOD SUPPLY IS INSTEAD POOR, AS THE ORGANISMS, MORE SENSITIVE TO OXYGEN DEFICIENCY, DO NOT INHABIT THIS STRETCH. THERE IS A POSSIBILITY ALSO, THAT IN THIS SITUATION, THE EXCESSIVELY HIGH CONCENTRATION OF OXYGEN DURING DAYTIME IS A DETRIMENTAL FACTOR AS SUCH CONCENTRATIONS HAVE BEEN SHOWN BY HUBBS (34), AND WIEBE (83), TO BE TOXIC TO SOME FORMS. THERE WERE NO FISH IN THE UPPER PART OF THE ALGAL SECTION AND ONLY MORE TOLERANT SPECIES IN THE LOWER AS REPORTED BY SPRAGUE (67) THE ALGAL SECTION, THEREFORE, CANNOT BE CONSIDERED TO BE SUITABLE FOR FISH EVEN THOUGH THE WATER OF THIS PART MAY BE PURE BY OTHER CRITERIA. THE ALGAL SECTION ALSO MAY BE DETRIMENTAL IN ANOTHER WAY AS IN LATE SUMMER THE PLANTS FREQUENTLY DIE AND THE MASS OF DEAD MATERIAL DECOMPOSES PRODUCING A SEPTIC CONDITION MUCH LIKE THAT OF A RECENTLY POLLUTED REGION AND IS AT THIS TIME UNSUITABLE FOR ANY BUT THE MOST TOLERANT FORMS. AT SUCH TIMES A NUISANCE SITUATION DEVELOPS WITH FOUL ODOUR DETECTABLE FOR A DISTANCE OF SEVERAL MILES FROM THE STREAM.

SO CHARACTERISTIC ARE THE ORGANISMS ASSOCIATED WITH THE ZONE OF RECENT POLLUTION, SEPTIC ZONE AND ZONE OF RECOVERY IN CASES OF POLLUTION BY ORGANIC WASTES, NOT COMPLICATED BY OTHER TOXIC MATERIALS, THAT THEY HAVE COME TO BE USED AS INDICATORS OF THE DIFFERENT DEGREES OF POLLUTION CHARACTERIZED MAINLY BY OXYGEN DEFICIENCY OF THE WATER. THE INFORMATION FROM INDEX ORGANISMS FORMS A VALUABLE ADJUNCT TO CHEMICAL TESTS, THE DISTRIBUTION OF THE FORMER BEING A RESULTANT OF THE LATTER AS DOUDOROFF (20) HAS NOTED. SOME OF THE ORGANISMS INVOLVED HAVE BEEN CRITICALLY EVALUATED IN THIS CONNECTION BY SEVERAL INVESTIGATORS INCLUDING N.Y. STATE CONSERV. COMM., ANN.REPT., (49); RICHARDSON (63); BARTSCH (8); GAU-

FIN AND TARZWELL (27) AND PATRICK (59). THE BIOTIC RESPONSE IN THE STREAM WHICH FOLLOWS MOST CLOSELY THE OXYGEN SAG CURVE IS SHOWN BY THE CURVE INDICATING THE VARIETY (NUMBERS OF KINDS) OF ORGANISMS ACCORDING TO BARTSCH AND CHURCHILL (9). THIS RESULTS FROM THE ELIMINATION OF ORGANISMS IN ORDER OF THEIR TOLERANCE OF OXYGEN DEFICIENCY AND THEIR REAPPEARANCE AS RECOVERY IN THIS FACTOR TAKES PLACE. IN EXTREME REDUCTION OF DISSOLVED OXYGEN THE SEPTIC ZONE IS INHABITED ONLY BY ANAEROBIC TYPES OR BY SCAVENGING TYPES WHICH BY SOME SPECIAL RESPIRATORY DEVICE, AS ILLUSTRATED BY THE RAT-TAILED MAGGOT, THE LARVA OF THE SEWAGE FLY, AND THE HOUSE MOSQUITO, CULEX, AND ARE INDEPENDENT OF DISSOLVED OXYGEN, KROGH (38), THORPE (72) AND THORPE AND CRISP (73). SUTER AND MOORE (71) GIVE A LIST OF ORGANISMS CHARACTERISTIC OF THE ZONES AND ALSO A LIST OF FISHES IN ORDER OF THEIR OXYGEN REQUIREMENT.

THE RESPIRATORY MECHANISMS, WHEN CONSIDERED FROMM THE MORPHOLOGICAL STANDPOINT ONLY, PROVIDE SOME EXPLANATION OF THE VARIOUS DEGREES OF TOLERATION OF OXYGEN DEFICIENCY EXHIBITED BY ORGANISMS. THEY MAY BE CLASSIFIED AS FOLLOWS:

I. TYPES BREATHING BY BLOOD GILLS OR BY THE GENERAL SURFACE OF THE BODY.

(A) FISHES
(B) CLAMS AND SNAILS OTHER THAN LUNG BREATHERS (PULMONATES)
(C) LEECHES AND SOME OTHER ANNELIDS WORMS INCLUDING TUBIFEX AND LIMNODRILUS
(D) CRUSTACEANS
(E) CHIRONOMID LARVAE AND PUPAE, SOME WITH A HEMOGLOBIN BLOOD PIGMENT (BLOODWORMS)

II. TYPES BREATHING BY TRACHEAL GILLS.

NYMPHS OF AQUATIC INSECTS SUCH AS DRAGONFLIES. LARVAE AND PUPAE OF CADDISFLIES, DOBSONFLIES, AQUATIC MOTHS, SOME BEETLES, AND SOME DIPTEROUS FLIES.

III. TYPES WITH OPEN TRACHEAL SYSTEM.

(A) LARVAE OF MANY BEETLES, AND SOME DIPTEROUS FLIES INCLUDING THE RAT-TAILED MAGGOT, SEWAGE OR FILTER FLY AND THE HOUSE MOSQUITO WHICH UTILIZE ATMOSPHERIC AIR OBTAINED THROUGH A TUBE.

(B) SOME SCAVENGERS AND PREDATORS INCLUDING NYMPHS AND ADULTS OF BUGS WHICH RESPIRE ATMOSPHERIC AIR THROUGH A TUBE AND ADULTS OF SOME AQUATIC BEETLES AND NYMPHS AND ADULTS OF SOME BUGS WHICH BREATHE BY MEANS OF A BUBBLE OR FILM OF GAS FUNCTIONING AS A GILL.

IV TYPES WITH LUNGS.

MOSH PULMONATE SNAILS WHICH BREATHE BY TAKING AIR INTO THE LUNGS.

In the first and second groups are found the types most sensitive to oxygen lack but different degrees of sensitivity characterize members within each.

Among the most sensitive of aquatic organisms are larvae of mayflies, stoneflies and caddisflies which breathe by means of tracheal gills. Some of these are more sensitive than others in this respect but a variety of them is an indication that recovery in oxygen is almost complete, Gaufin and Tarzwell (27). More tolerant species of these groups are few in number, and, if these were known, the value of this category as a criterion of recovery would be increased. Gaufin and Tarzwell (27), report a species of mayfly of the genus Callibaetis as being tolerant and Sprague (67), reports two species of this same genus from the algal section of the Avon River, Ontario, at a point where nocturnal depletion of oxygen is extreme. One of other tracheal gill breathers, generally considered as being sensitive to low oxygen, and including a caddisfly larva, Cheumatopsyche, are listed by the same author from the same section.

The most tolerant or resistant forms are some members of group III and three of these, the rat-tailed maggot, the sewage fly (Psychoda) and the house mosquito, (Culex pipiens) if present in numbers indicate the septic zone. Suter and Moore (71) have shown that the rat-tailed maggot (Eristalis Tenax) can exist under conditions where the dissolved oxygen ranges from 0 to 40% saturation which is the range characteristic of the septic zone. It is apparently an obligative pollution form and therefore a positive indicator of such. The most resistant forms are ones which are independent of dissolved oxygen and include anaerobic bacteria and some scavenging forms such as aquatic beetles and bugs which have special respiratory mechanisms which make it possible for them to be independent of dissolved oxygen.

The most characteristic organisms of water with intermediate oxygen levels such as occur at the beginning of the zone of recovery or at the lower end of the zone of degradation are the annelid worms Tubifex and Limnodrilus and the slightly less tolerant bloodworms, particularly Chironomus tentans. These forms are in a general way characteristic of the limiting conditions for the most tolerant species of fishes. They are frequently present in great numbers, the annelids forming patches of red on the bottom appearing like the pile of a carpet, and when well represented and in the absence of other more sensitive types are a good indication of the beginning of the zone of recovery and the end of the zone of degradation. From these groups of organisms the chief biological indicators of organic pollution have been chosen.

Suter and Moore (71) have given a list of fishes in order of their requirements with respect to oxygen as follows:

High: Brook trout, smallmouth bass, landlocked salmon and yellow perch

INTERMEDIATE: LARGEMOUTH BASS, PUMPKIN SEED AND BULLHEAD.
LOW: MINNOWS (STONE ROLLER, SHINER AND CREEK CHUB) SUCKER.

OXYGEN CONTENT OF 50% SATURATION HAS BEEN SET BY SOME AS THE MINIMUM FOR FISH BUT SOME ARE KNOWN TO HAVE SURVIVED IN CONCENTRATIONS AS LOW AS 1.5 PARTS PER MILLION OR ABOUT 20% SATURATION. MORE RECENT INVESTIGATION OF THE OXYGEN REQUIREMENTS OF THE EASTERN SPECKLED TROUT (BROOK TROUT) ARE PUBLISHED BY FRY (25).

AS DOUDOROFF (20) HAS POINTEDOUT, POLLUTION CAN BE DETECTED READILY BY CHEMICAL TESTS, BUT THE CHARACTERISTIC ORGANISMS ILLUSTRATE THE RESULTANT EFFECT ON THE BIOTA OF POLLUTIONAL INFLUENCES NOT ONLY OF THE MOMENT BUT OF THE PAST. VAN HORN (75), HAS STATED - "A CHEMICAL ANALYSIS WILL GIVE A PICTURE OF STREAM CONDITIONS AT THE TIME THE SAMPLES WERE TAKEN. ON THE OTHER HAND, THE BIOLOGICAL SITUATION IS AN INDICATION OF THE CONDITIONS WHICH HAVE EXISTED IN THE STREAM FOR A LONG PERIOD. IN A SENSE THE CHEMICAL DATA MAY BE TAKEN AS A DESCRIPTION OF THE CAUSE, WHEREAS THE BIOLOGICAL DATA ARE INTERPRETED AS THE EFFECT OF ANY GIVEN STREAM CONDITION." IT SHOULD BE ADDED THAT BECAUSE OF THE LAG IN THE RESPONSE TO IMPROVEMENT IN CHEMICAL CONDITIONS BIOLOGICAL CRITERIA WILL GENERALLY GIVE AN INDICATION OF SERIOUS POLLUTION OF THE INTERMITTENT TYPE, AS FOR INSTANCE NOCTURNAL DEPLETION OF OXYGEN AS MENTIONED ABOVE, OR SLUGS OF TOXIC CHEMICAL EFFLUENT WHICH WOULD PERHAPS ESCAPE DETECTION UNLESS CHEMICAL TESTS WERE CARRIED OUT AT THE APPROPRIATE TIME.

SPECIFIC TOXIC CHEMICAL SUBSTANCES

WITH THE DECOMPOSITION OF ORGANIC MATTER SOME CHEMICALS INCLUDING SULPHUR AND AMMONIUM SALTS ARE PRODUCED WHICH ARE TOXIC TO SOME ORGANISMS. THEIR TOXIC EFFECT IS, THEREFORE, SUPERIMPOSED ON THE EFFECT OF OXYGEN DEPLETION. IN MANY INDUSTRIAL WASTES THE TOXIC CHEMICAL COMPONENTS DOMINATE THE RESULTING POLLUTIONAL SITUATION AND DIFFERENT ATTACKS HAVE BEEN MADE IN THE INVESTIGATION OF SUCH WASTES.

MUCH EXPERIMENTAL WORK, BEGINNING WITH PENNY AND ADAMS (60), AND WEIGELT ET AL. (78), HAS BEEN DONE ON THE EFFECT OF DIFFERENT CONCENTRATIONS OF CHEMICALS ON ORGANISMS UNDER DIFFERENT CONDITIONS. ONE OF THE EARLY WORKS ON THIS CONTINENT IS THAT OF SHELFORD (66). SOME OF THE LITERATURE IS GIVEN IN THE LIST OF REFERENCES AND INCLUDES THE PAPERS OF BELDING (11), CARPENTER (13,14), SUTER AND MOORE (71), WIEBE (82), WELLS (79), COLE (16), ELLIS (23), NAUMANN (47,48) HART, DOUDOROFF AND GREENBANK (29) ROETMANN (64), ANDERSON (4,5), GALTSOFF ET AL. (26), AND GERSDORFF (28).

THOUGH 17 SPECIES OF FISHES, 6 OF CRUSTACEA, 7 OF CLAMS AND SEVERAL OF INSECTS WERE INVOLVED IN THE EXPERIMENTAL WORK TWO HAVE EMERGED AS THE CHIEF LABORATORY TYPES, THE GOLDFISH (CARAUSSIUS CARAUSSIUS) AND THE WATER FLEA (DAPHNIA MAGNA). ELLIS (23) HAS CONTRIBUTED MUCH TO THIS FIELD AND HAS SUMMARIZED MOST OF THE INFORMATION AVAILABLE IN OTHER

WORKS UP TO 1937. IN THE FOLLOWING PARAGRAPHS FREQUENT REFERENCE WILL BE MADE TO THIS WORK AND FOR MORE EXTENSIVE TREATMENT OF SOME OF THE POINTS REFERENCE SHOULD BE MADE BY THE READER TO THIS STANDARD REFERENCE.

AN AN EXAMPLE OF OSMOTIC EFFECT, ELLIS (23) TESTED THE SURVIVAL OF THE GOLDFISH IN DIFFERENT CONCENTRATIONS OF SODIUM CHLORIDE IN FILTERED MISSISSIPPI WATER AND FOUND THAT WITH STRENGTHS GREATER THAN 1:1000 BY WEIGHT (10,000 PARTS PER MILLION), THE FISH DIED IN LESS THAN FOUR DAYS. SINCE SODIUM CHLORIDE IS A WASTE IN OIL WELL OPERATION THIS INFORMATION IS ALSO APROPOS OF THE SUBJECT OF POLLUTION.

THE EFFECT OF ELEVEN ACIDS WHICH ARE CONSTITUENTS OF VARIOUS TYPES OF TRADE WASTES WERE TESTED ON THE GOLDFISH BY THE SAME AUTHOR. HE CONCLUDES THAT ACIDITY NEAR THE MAGNITUDE OF pH 4.0, REGARDLESS OF THE ACID OR ACIDSALT COMBINATION PRODUCING THIS ACIDITY, WILL BE LETHAL FOR FRESHWATER FISHES IF THE ACIDITY IS MAINTAINED. IN CONCENTRATIONS PRODUCING A pH LESS ACID THAN pH 4.0 THE LETHALITY DEPENDS ON THE PARTICULAR ACID INVOLVED. TESTS WITH DAPHNIA MAGNA SUGGEST THAT WERE FISHES UNPROTECTED BY MUCOUS THE LETHAL HYDROGEN-ION CONCENTRATION FOR ACIDS IN GENERAL WOULD BE NEAR pH 5.5. DAPHNIA, NOT PROTECTED BY MUCOUS, FAILED TO SURVIVE IN pH MORE ACID THAN 5.4 AND THE AUTHOR NOTES THAT pH 5.5 CORRESPONDS TO THE ISOELECTRIC POINT AT WHICH MANY PROTEINS FOUND IN TISSUES ARE COAGULATED.

THE SAME AUTHOR DETERMINED THE pH OF VARIOUS ACIDS IN HARD WATER AT WHICH GOLDFISH SURVIVED FOR FOUR DAYS OR LONGER AND DIED IN LESS THAN FOUR DAYS IN MORE ACID CONCENTRATIONS. THE RESULTS ARE AS FOLLOWS: SULPHURIC 4.0, HYDROCHLORIC AND CITRIC 4.5, LACTIC 4.6, NITRIC AND TARTARIC 4.9, ACETIC 5.5, OXALIC 5.8, BENZOIC 5.9, CHROMIC 7.3, AND TANNIC 7.8.

ON THE BASIS OF PARTS PER MILLION OF ACID PRESENT IN THE PARTICULAR HARDWATER USED AND NEGLECTING THE pH THE SAME ACIDS ARE LISTED BY ELLIS IN ORDER OF THEIR LETHAL EFFECT ON THE GOLDFISH TOGETHER WITH THE TRADE WASTE WHICH THEY CHARACTERIZE AS FOLLOWS:

TANNIC	10 PPM.	TANNERY, BARK WASTE OF MILLS
CHROMIC	100 PPM.	TANNERY.
SULPHURIC	130 PPM.	COAL AND IRON MINE.
HYDROCHLORIC	159 PPM.	CHEMICAL AND DYE WORKS.
NITRIC	200 PPM.	CHEMICAL WORKS.
BENZOIC	200 PPM.	COAL TAR.
OXALIC	200 PPM.	DYEING, TANNING, BLEACHING.
TARTARIC	200 PPM.	WINERY.
ACETIC	348 PPM.	BEET SUGAR, VINEGAR, WINERY.
LACTIC	430 PPM.	DAIRY
CITRIC	625 PPM.	CITRUS-FRUIT

IN THE SAME PAPER ELLIS (23) HAS EVALUATED THE TOXICITY FOR THE GOLDFISH OF SOLUTIONS OF SALTS OF EIGHT METALS, OF FOUR SULPHUR AND SELENIUM COMPOUNDS AND NINE OTHER

CHEMICALS FOUND IN INDUSTRIAL WASTES. IN ADDITION HE GIVES A LISTING OF 114 CHEMICALS WHICH MAY BE FOUND AS STREAM POLLUTANTS WITH RESULTS OF RESEARCH CONDUCTED BY MANY WORKERS RESPECTING THE CONCENTRATIONS WHICH WERE LETHAL TO ORGANISMS UNDER THE EXPERIMENTAL CONDITIONS. IN SOME CASES THESE WERE NOT AS WELL CONTROLLED AS IN OTHERS WITH CONSEQUENT DISCREPANCIES APPEARING.

SOME TOXIC CHEMICALS, TAKEN FOR THE MOST PART FROM ELLIS (23) ARE LISTED BELOW TOGETHER WITH SOME OF THE INDUSTRIES INVOLVED.

ACETONE	GAS AND COAL-TAR, CHEMICAL, PAINT
ALUMINUM POTASSIUM SULPHATE	TANNERY
AMMONIUM SULPHIDE	ORGANIC
AMMONIUM CARBONATE	GAS HOUSE
AMYL ALCOHOL	DISTILLERY
BROMINE	CHEMICAL
CADMIUM CHLORIDE	PIGMENT, CALICO PRINTING
CALCIUM CHLORIDE	OIL WELLS, ROAD SURFACING
CHLORINE	CHEMICAL
COBALTOUS CHLORIDE	ELECTROPLATING, CHEMICAL, PIGMENT
CRESYLIC ACID	MINE FLOTATION, LIVESTOCK
CUPRIC SULPHATE	COPPER AND BRASS
FERROUS SULPHATE	WIRE AND TINPLATE
FERRIC CHLORIDE	WIRE AND TINPLATE
HYDROGEN SULPHIDE	ORGANIC
LEAD NITRATE	MINING AND SMELTING
METHYL MERCAPTAN	PULP
NAPHTHENIC ACID ETC.	CRUDE OIL
NICKELOUS CHLORIDE	ELECTROPLATING
PHENOL	GAS HOUSE, STOCK DIPS
POTASSIUM CYANIDE	ORE REF., COKE, CHEMICAL, ELECTROPLATING
POTASSIUM HYDROXIDE	SOAP, DYE
POTASSIUM XANTHATE	MINE FLOTATION, SOIL INSECTICIDE
SODIUM CHLORATE	MINE FLOTATION
SODIUM FLUORIDE	DISTILLERY
SODIUM SULPHITE	PULP
SODIUM SULPHIDE	PULP
SULPHUR DIOXIDE	CHEMICAL, BLEACHING
STANNOUS CHLORIDE	BRASS
ZINC SULPHATE	MINING, SMELTING, REFINING, RAYON.

SOME OF THE CHEMICALS LISTED ARE VERY TOXIC TO FISH AND OTHER AQUATIC ORGANISMS, AND EVEN WHEN PRESENT IN LOW CONCENTRATION SUCH SUBSTANCES MAY PRESENT THE MOST SIGNIFICANT HAZARD OF AN EFFLUENT. CARPENTER (13) HAS DEMONSTRATED THAT LEAD AT A CONCENTRATION OF 0.33 PARTS PER MILLION MAY BE LETHAL TO FISH. ZINC SULPHATE WAS SHOWN BY HENDERSON (30), TO BE AN EXTREMELY TOXIC CONSTITUENT OF THE EFFLUENT OF A RAYON MILL PRODUCING THE MORTALITY OF FISH DESCRIBED EARLIER IN THIS PAPER. VAN HORN (75) HAS CONCLUDED THAT, OF THE MANY CHEMICALS IN THE EFFLUENT OF A TYPICAL KRAFT PULP MILL, THE SULPHUR COMPOUNDS AND PARTICULARLY THE SULPHIDES AND MERCAPTANS ALONG WITH RESIN AND FATTY ACIDS AND THEIR SODIUM SALTS ARE POTENTIALLY THE MOST DANGEROUS TO THE AQUATIC HABITAT. KUPZIS (41), CONSIDERS THAT NAPHTHENIC ACIDS AND NAPHTHENE DERIVATIVES ARE THE

MOST TOXIC SUBSTANCES TO FISH OF THOSE MATERIALS FOUND IN THE WATER SOLUBLE FRACTION OF CRUDE OIL.

EFFECT OF TOXIC SUBSTANCES ON THE INDIVIDUAL

ELLIS (23), HAS GROUPED CHEMICAL POISONS INTO THREE CATEGORIES ACCORDING TO THE WAY IN WHICH THEY KILL THE ORGANISMS. THE EFFECTS OF SUBLETHAL AMOUNTS IN ALTERING THE BEHAVIOUR OF FISH AND OTHERS IS NOT CONSIDERED IN THIS ARRANGEMENT.

IN THE FIRST CATEGORY ARE SUBSTANCES WHICH DO NOT ENTER THE FISH BUT ADVERSELY AFFECT THE SURFACE OF GILLS AND OTHER AREAS. AMONG THESE ARE SOME SALTS OF SEVERAL OF THE HEAVY METALS, SOME ACIDS AND SOME OTHER CHEMICALS WHICH COMBINE READILY WITH THE MUCOUS SECRETED BY THE FISHES' SKIN, MOUTH AND GILLS, PRODUCING INSOLUBLE COMPOUNDS. IF THE DILUTION OF THE CHEMICAL IS GREAT ENOUGH OR THE SUPPLY OF THE POLLUTANT IS LIMITED IN ITS TIME OF ACTING THE SECRETION OF ADDITIONAL MUCOUS MAY WASH AWAY THE PRECIPITATED COMPOUND AS IT IS FORMED SO THAT NO SERIOUS DAMAGE RESULTS. IN MORE SERIOUS CASES OF STRONGER CONCENTRATION OR LONGER EXPOSURE THE PRECIPITATED COMPOUND COVERS THE BODY, THE LINING OF THE MOUTH AND THE GILLS. RESPIRATORY FAILURE ENSUES RESULTING IN THE DEATH OF THE FISH. THIS WAS FOUND TO BE BECAUSE OF COATING OF THE GILL FILAMENTS IN SUCH A WAY AS TO PREVENT THE WATER REACHING THE EPITHELIUM, OR IN MORE PRONOUNCED CASES GILL MOVEMENT WAS IMPEDED OR STOPPED AND CIRCULATION OF THE BLOOD IN THE CAPILLARIES STOPPED AS IT IS DEPENDENT ON THIS MOVEMENT.

ANOTHER CLASS OF POLLUTANTS SUCH AS ACETIC ACID, AND VOLATILE EXTRACTS OF CRUDE OIL DO NOT PRODUCE PRECIPITATES WITH THE MUCOUS BUT ALSO BRING ABOUT RESPIRATORY FAILURE. IN THESE INSTANCES THE CHEMICAL DAMAGES THE EPIDERMAL CELLS OF THE GILL SURFACE CAUSING STASIS OF THE BLOOD IN THE UNDERLYING CAPILLARIES WITH RESULTING ASPHYXIATION. THEY MAY ALSO INTERFERE WITH THE MAINTAINING OF SALT BALANCE OF THE BLOOD BY INJURING THE CHLORIDE-SECRETING CELLS OF THE GILL SURFACE, KEYS AND WILLMER (36) OR IMPAIR THE FUNCTION OF CELLS OF THE GILL EPITHELIUM IN EXCRETING NITROGENOUS WASTES.

IN THE THIRD CATEGORY ARE SUBSTANCES WHICH DO NOT PENETRATE THE EXTERNAL MEMBRANES OF THE BODY AND ARE POISONOUS ONLY WHEN SWALLOWED AND ABSORBED THROUGH THE GASTROINTESTINAL EPITHELIUM OR DAMAGE THAT EPITHELIUM. THESE ARE KNOWN AS INTERNAL POISONS AND MAY BE TAKEN INTO THE MOUTH AND SWALLOWED AS FOOD OR INADVERTENTLY ALONG WITH FOOD. CASES HAVE BEEN OBSERVED BY ELLIS OF FISH NOT SWALLOWING POLLUTED WATER IN WHICH THEY WERE PLACED UNTIL THE END OF A PERIOD OF ABOUT FORTY-EIGHT HOURS. SUBSEQUENTLY THEY SWALLOWED WATER EVEN WHEN NOT BEING FED, POSSIBLY AS COMPENSATION FOR WATER LOSS. AMONG THE INTERNAL POISONS SOME CHEMICALS WHICH ARE CUMULATIVE IN THEIR TOXIC EFFECT ARE PARTICULARLY SUBTLE IN THEIR ACTION AS THEY CAUSE DEATH ONLY AFTER LONG PERIODS AS THE TOTAL AMOUNT INGESTED IS GRADUALLY INCREASED BY BEING CONTINUALLY SWALLOWED.

Application of the Experimental Data to the Problem of the Toxic Effect of Industrial Wastes

While it cannot be questioned that these materials are toxic in the concentrations used in and under the conditions existing for the experiment their toxicity to organisms in streams is generally a more complicated matter. Dilution may be so great as to render the most toxic of them harmless whereas a less toxic substance may be discharged in such large amounts as to produce lethal concentrations in the receiving water. However, from the biological side even sublethal concentrations of some chemicals may be detrimental as fish react to some by avoiding them and thus may be excluded from a section of river or be barred in their migrations.

Regarding the applicability of results of experiments on fish of the effect of individual chemical constituents of effluents Ellis (23) states" ...as has been repeatedly pointed out in this paper arbitrary application of lethality data to specific pollution problems is absolutely impossible owing to many limiting factors various of which have been discussed in previous sections." Among these he has pointed out the significant influence of one salt on the lethal effect of another by determining the change in toxicity of a solution of copper sulphate on the goldfish in the presence of calcium chloride and varying concentrations of sodium nitrate. He also demonstrated that 100 parts per million of chromic acid in hard water did not kill goldfish while the same amount in soft water did. In a number of other cases toxicity of acids and salts was much higher in soft than in hard (buffered) waters. The information from experiments is, however, a valuable guide to potential toxicity and in conjunction with information on the chemistry of the effluent and of the receiving water predictions can be made on the effect on the biota, Ellis (23).

Toxicity of Industrial Effluents for Stream Inhabitants

Effluents of industrial plants, employing essentially the same processes, vary over wide ranges depending on a number of factors including variation in detail of handling the waste materials including reclamation techniques. The pollutional effect on a stream is further complicated by the physical, chemical and biological characteristics of water of the receiving stream and the relative rates of discharge of effluent and stream.

The usual toxic effect of some common types of industrial effluents is summarized by Ellis (23). Those in this list having specific toxic effect on fishes of a critical nature include wastes of coal-gas plants, metal refineries, steffens house, sulphite pulp, strawboard, chemical works, tanneries and dye works. Others which may be critical are, mine flotation, oil wells (crude oil and brine), beet sugar, spent lubricants, bittern liquors, tin plate and wire mills and starch factories. Another group is listed as being possibly

CRITICAL AND INCLUDE, ASBESTOS WORKS, COAL AND IRON MINE DRAINS, DAIRY INDUSTRIES, PACKING PLANTS, CANNING FACTORIES, BREWERIES AND DISTILLERIES, PAPER PULP, SAWDUST, LAUNDRIES AND WOOL-WASHING PLANTS. THIS LIST IS NOT COMPLETE BUT TO IT SHOULD BE ADDED PLANTS PRODUCING RADIO-ACTIVE SUBSTANCES WHOSE WASTES ARE BEING INVESTIGATED FROM THE STANDPOINT OF THEIR IMMEDIATE EFFECT ON ORGANISMS AND OF THE POSSIBLE LONG TERM INFLUENCE ON THE SPECIES THROUGH GENETIC ALTERATION.

SELECTED REFERENCES, GIVING IN MOST CASES THE EFFECT OF THE EFFLUENTS OF SEVERAL DIFFERENT INDUSTRIAL PROCESSES ON FISHES AND OTHER ORGANISMS ARE GIVEN IN THE U.S. PUBLIC HEALTH SERVICE REPORT ON OHIO RIVER POLLUTION CONTROL (74), WISCONSIN STATE BOARD OF HEALTH SPECIAL REPORT ON STREAM POLLUTION IN WISCONSIN (85), AND STATE OF NEW YORK CONSERVATION COMMISSION REPORTS ON SURVEYS OF RIVER SYSTEMS (50-55).

WITH MANY INDUSTRIAL EFFLUENTS THERE IS, IN ADDITION TO SPECIFIC TOXICITY, THE DEOXEGENATING EFFECT OF DECOMPOSING ORGANIC CONSTITUENTS AND THE FORMATION OF A POLLUTION MAT OF PARTICULATE MATTER. THE DELETERIOUS CHARACTER OF THESE HASALREADY BEEN MENTIONED. ANY OF THE THREE, TOXIC PROPERTY, DEOXEGENATING PROPERTY OR SEDIMENTING OF THE BOTTOM MAY PREDOMINATE IN THE EFFECT OF ANY POLLUTION FROM THE BIOLOGICAL STANDPOINT. WHEN SPECIFIC TOXIC CHEMICALS ACCOMPANY ORGANIC WASTE THEY MAY KILL OUT THE ORGANISMS WHICH OTHERWISE WOULD BE PRESENT TO AID IN THE RAPID DECOMPOSITION OF ORGANIC MATERIAL AND CONSEQUENTLY THE SERIOUSLY POLLUTED SECTION OF THE STREAM MAY BE GREATLY EXTENDED.

OWING TO THE VARIABLE NATURE OF INDUSTRIAL WASTES IN WHICH DEOXYGENATING SUBSTANCES, PARTICULATE MATTER AND COMPLEX COMBINATIONS OF SPECIFIC TOXIC CHEMICALS MAY ALL BE SIGNIFICANT IN THE RESULTING POLLUTION, THE INFORMATION WHICH MAY BE GLEANED FROM A STUDY OF THE ORGANISMS INHABITING THE POLLUTED SECTION OF THE STREAM REGARDING THE NATURE OF THE POLLUTION IS MUCH LESS THAN IN THE CASE OF POLLUTION BY ORGANIC MATTER ALONE. CONSEQUENTLY NO SERIES OF ORGANISMS HAS EMERGED WHICH MIGHT SERVE AS INDICATORS OF THE POLLUTIONAL EFFECT OF MANY TRADE WASTES.

ALTHOUGH THE EFFECT OF MANY CHEMICALS ON ORGANISMS IS KNOWN THERE IS LITTLE INFORMATION AVAILABLE ON THE EFFECT OF THE SAME SUBSTANCES UNDER THE CONDITIONS IN WHICH THEY OCCUR IN AN EFFLUENT. THERE IS SOME DESCRIPTIVE WORK ON THE EFFECT OF TYPICAL TRADE WASTES ON ORGANISMS AND SOME EXPERIMENTAL IN WHICH ORGANISMS WERE SUBJECTED TO THE WASTE MATERIAL, BUT AS HAS BEEN POINTED OUT ABOVE THE TRADE WASTES DIFFER SO GREATLY EVEN WHERE THE SAME INDUSTRIAL PROCESSES ARE INVOLVED AS TO MAKE THE RESULTS OF EXPERIMENTAL WORK ALONG THIS LINE OF LIMITED APPLICATION.

CONTROL OF PESTS BY CHEMICALS AND INHERENT DANGERS TO STREAM ORGANISMS

THERE ARE OTHER CLASSES OF SPECIFIC TOXIC MATERIALS THAT DO NOT COME UNDER THE HEADING OF INDUSTRIAL WASTES,

BUT MAY BE POLLUTANTS OF STREAMS. THIS GROUP INCLUDES FERTILIZERS, BOTH OF THE SOIL AND WATER, STOCK DIPS, ALGICIDES AND HERBICIDES, INSECTICIDES, PISCICIDES, WATER PURIFYING AGENTS AND ROAD-SURFACING MATERIALS. THESE MATERIALS ARE INDISPENSIBLE AIDS TO MAN, IF SCIENTIFICALLY APPLIED, BUT IF USED INDISCRIMINATELY AND WITHOUT REGARD FOR THEIR POSSIBLE INJURIOUS EFFECTS ON STREAM LIFE MAY IN SOME CASES DO MUCH HARM.

CHILI SALTPETRE (SODIUM NITRATE), A SOIL FERTILIZER, HAS BEEN SHOWN BY POWERS (61), TO BE TOXIC TO FISH IN CONCENTRATIONS WHICH MAY BE BUILT UP IN STREAMS AND PONDS BY RUN-OFF FROM FIELDS. PHENOL, CRESOL AND SOME OF ITS RELATED CHEMICALS, USED AS DISINFECTANTS AND PARTICULARLY AS SHEEP DIPS, IF DISCHARGED INTO WATER ARE HIGHLY TOXIC TO FISHES AND OTHER FORMS, ADAMS (1), DEMYENENKO (19). IN ADDITION, THE FORMER, EVEN IF NOT CONCENTRATED ENOUGH TO KILL, IMPARTS A STRONG PHENOLIC SMELL TO THE FISHES FLESH MAKING IT UNPALATABLE. SODIUM ARSENITE AND COPPER SULPHATE USED IN THE CONTROL OF AQUATIC PLANTS AND IN WATER-PURIFICATION ARE HIGHLY TOXIC CHEMICALS, THE CONCENTRATION OF WHICH MUST BE CAREFULLY CONTROLLED IN ORDER TO GIVE THE DESIRED EFFECT WITHOUT ENDANGERING OTHER FORMS OF LIFE, WIEBE (82), SURBER AND MEEHAN (70), MOYLE (46), AND BARNICKOL AND CAMPBELL (7). THAT THESE SUBSTANCES ARE TOXIC TO FISH AND OTHER FORMS IS INDICATED BY THE USE, PARTICULARLY OF COPPER SULPHATE IN THE CONTROL OF COARSE FISH, CATT (15), AND IN THE CONTROL OF SNAILS. CHLORAMINE, CHLORAMINE T, AND CHLORINE ARE EMPLOYED IN WATER PURIFICATION AND THE CONCENTRATIONS ARE CAREFULLY CONTROLLED FOR THIS PURPOSE, ADAMS (1). THE SAME AUTHOR DESCRIBED THE TOXIC EFFECTS OF POTASSIUM PERMANGANATE ON CRUSTACEANS AND ELLIS (23) ITS TOXICITY FOR GOLDFISH. IT IS, NEVERTHELESS, USEFULLY EMPLOYED IN DISINFECTING HATCHERY TROUGHS OR FISH THEMSELVES.

IN FISHERIES MANAGEMENT PROGRAMMES IT IS SOMETIMES ADVANTAGEOUS TO KILL THE COARSE FISH IN A STREAM OR POND BEFORE INTRODUCING GAME FISH. THE CHEMICAL, ROTENONE, THE POISON IN THE DERRIS POWDERS OF COMMERCE, IS WIDELY USED FOR THIS AND THE INFORMATION RELEVANT TO THIS USE IS SUMMARIZED BY KRUMHOLZ (39). THIS POISON, IN THE CONCENTRATIONS USED IN TAKING FISH, DOES NOT AFFECT OTHER VERTEBRATES BUT DOES KILL INSECTS WHICH ARE IMPORTANT IN THE DIET OF MANY FISH AND, THEREFORE, PRECAUTIONS MUST BE TAKEN TO ENSURE A NET FAVOURABLE RESULT FOR THE OPERATION. THE POISON, IF SCIENTIFICALLY HANDLED, CAN BE APPLIED TO RESTRICTED PARTS OF LAKES FOR THE PURPOSE OF CONTROLLING POPULATIONS OF COARSE FISH WITHOUT ADVERSELY AFFECTING THE FISH IN OTHER PARTS OF THE LAKE, STROUD (69).

WITH SOME METHODS OF APPLICATION AND PARTICULARLY IN THE AERIAL SPRAYING OF FOREST AND FRUIT TREES, INSECTICIDES MAY FIND THEIR WAY INTO STREAMS IN QUANTITIES INJURIOUS TO THEIR BIOTA. ARSENICALS USED IN THIS WAY, PRESENT THE SAME HAZARDS TO AQUATIC ORGANISMS AS THEY DO WHEN EMPLOYED AGAINST AQUATIC VEGETATION. THE USE OF D.D.T. AND RELATED CHEMICALS AS INSECTICIDES HAS BECOME GENERAL AND THESE POISONS

MAY REACH THE WATERS OF STREAMS IN SEVERAL WAYS. WHERE THEY ARE USED IN SPRAYING A FOREST OR ORCHARD THEY MAY FALL DIRECTLY INTO THE STREAM OR REACH IT IN WATER DRAINING OFF THE LAND. HOCKING (31), ATTRIBUTES THE ABSENCE OF BLACK FLIES IN STREAMS IN THE VICINITY OF CHURCHILL, MANITOBA, TO THE CONTINUING EFFECT OF SIGNIFICANT AMOUNTS OF D.D.T. CONTAINED IN RUN-OFF WATER FROM AREAS SPRAYED PREVIOUSLY. IT FOLLOWS THAT SPRAYING OF FORESTS WITH D.D.T. MAY RESULT IN SERIOUS POISONING OF STREAMS BECAUSE OF HIGH CONCENTRATIONS OF THE POISON WHICH MAY RESULT IN A PARTICULAR DRAINAGE BASIN UNDER SOME METEOROLOGICAL CONDITIONS.

SOME SEWAGE TREATMENT PLANTS USE D.D.T. IN CONTROLLING THE NUMBERS OF THE FILTER-FLY, AND THE CHEMICAL MAY PASS INTO THE STREAM WITH AN EFFECT ON THE FAUNA WHICH IN THE PRESENT STATE OF OUR KNOWLEDGE CANNOT BE PREDICTED, WILSON (84). ANOTHER USE OF D.D.T. AND RELATED COMPOUNDS IS IN MEASURES TAKEN FOR THE ERADICATION OF BLACK FLIES FROM STREAMS EITHER BY LOCAL INTRODUCTION OF THE POISONS INTO THE WATER OR BY AERIAL SPRAYING. THE LARVAE AND PUPAE OF THESE FLIES LIVE IN THE MORE RAPID SECTIONS OF STREAMS AND RIVERS. WITH HIGH CONCENTRATIONS AND UNDER SOME SPECIAL CONDITIONS OF THE STREAM D.D.T. INSECTICIDES KILL FISH AND WIPE OUT THE AQUATIC INSECTS WHICH ARE THE FOOD OF MANY SPECIES AS WELL AS KILLING THE BLACK FLIES, LANGFORD ET AL (42). ARNASON ET AL (6), IN AN OPERATION TO CONTROL BLACK FLIES IN THE SASKATCHEWAN RIVER REPORT THAT WITH THE CONCENTRATIONS USED BLACK FLIES AND OTHER AQUATIC INSECTS WERE KILLED BUT THAT FISH WERE NOT. THESE AUTHORS DO NOT GIVE INFORMATION ON THE DIFFERENTIAL EFFECT OF THE POISON ON DIFFERENT TYPES OF AQUATIC ORGANISMS WHICH MIGHT RESULT IN AN UPSET IN THE POPULATION BALANCE AMONG THEM. DAVIES (18), HAS, HOWEVER, GIVEN PERTINENT DATA IN THIS CONNECTION FOR POPULATIONS OF BLACK FLIES IN A STREAM WHICH WAS TREATED WITH HIGH CONCENTRATIONS OF D.D.T. BY AERIAL SPRAY IN 1944 AND REPORTED ON BY LANGFORD, ET AL. (42). THE AVERAGE EMERGENCE OF BLACK FLIES OF ALL SPECIES FROM ONE SQUARE YARD DURING THE SEASON FOR THE YEARS 1939-1943, APPROXIMATELY 2200 INDIVIDUALS. IN 1945, THE YEAR FOLLOWING THE TREATMENT, THE NUMBER WAS ONLY 57 INDIVIDUALS AND SEVEN OF THE ELEVEN SPECIES TAKEN IN PREVIOUS YEARS WERE NOT REPRESENTED IN THE COLLECTIONS.

IN THE FOLLOWING TWO YEARS, 1946 AND 1947, THE NUMBERS OF BLACK FLIES EMERGING FROM A SQUARE YARD AVERAGED APPROXIMATELY 37,400 OR 17 TIMES THE NUMBERS PRIOR TO TREATMENT, AND THE NUMBERS IN 1947 WERE NEARLY THREE TIMES AS LARGE AS IN 1946. FURTHERMORE, THERE WAS IN THIS CHANGE A DISPROPORTIONATELY LARGE INCREASE IN THE NUMBERS FOR ONE SPECIES, SIMULIUM VENUSTUM, THE ONLY SPECIES OF THOSE REPRESENTED WHICH BECOMES A SERIOUS NUISANCE. IT MADE UP NEARLY 50% OF THE TOTAL IN 1946 AND OVER 70% IN 1947. IT WOULD APPEAR FROM THESE DATA THAT THE BALANCE AMONG THE POPULATIONS OF STREAM INSECTS HAD BEEN SIGNIFICANTLY ALTERED BY THE SPRAYING TREATMENT AND THAT THE UPSET FAVOURED THE BLACK FLIES. PART OF THE EXPLANATION OF THIS RESULT MAY BE IN THE FACT THAT BLACK FLIES DISPERSE READILY AND ARE THUS ABLE TO REPOPULATE STREAMS BY IMMIGRATION. MANY OF THE OTHER AQUATIC INSECTS ARE RESTRICTED IN THEIR MOVEMENTS TO THE IMMEDIATE VICINITY OF THE STREAM IN WHICH THEY LIVE AS LARVAE AND WHEN ELIMINATED

FROM AN ISOLATED LOCALITY MAY FAIL TO RETURN FOR A VERY LONG PERIOD. THE IMPLICATION OF THIS IS THAT UNLESS TREATMENT IS REPEATED AT FREQUENT INTERVALS THE SPRAYING OF STREAMS OVER AN EXTENSIVE AREA FOR THE CONTROL OF BLACK FLIES WILL PROBABLY AGGRAVATE RATHER THAN AMELIORATE THE NUISANCE.

SUMMARY

1. TWO CASES OF SERIOUS POLLUTION OF RIVERS AND THE EFFECT ON FISH ARE CITED FROM THE LITERATURE.

2. POLLUTION FROM THE BIOLOGICAL STANDPOINT FOLLOWS DIFFERENT CRITERIA THAN THOSE OF POLLUTION FROM THE PUBLIC HEALTH OR HYGIENIC STANDPOINT.

3. THE MAIN POLLUTANTS ARE CLASSIFIED UNDER THE HEADINGS, DEOXYGENATING, SUSPENSOIDS AND EMULSOIDS, SPECIFIC TOXIC CHEMICAL SUSTANCES, TOXICITY OF INDUSTRIAL EFFLUENTS FOR STREAM INHABITANTS, AND A FURTHER GROUP UNDER THE HEADING:- CONTROL OF PESTS BY CHEMICALS AND INHERENT DANGERS TO STREAM ORGANISMS.

4. THE USEFULNESS OF BIOLOGICAL INDICATORS IN THE DETECTION OF POLLUTION, PARTICULARLY IN THOSE CASES DOMINATED BY DEOXYGENATING MATERIALS IS STRESSED. THEIR USE SUPPLEMENTS THAT OF CHEMICAL TESTS PARTICULARLY IN CASES IN WHICH THERE IS POLLUTION OF AN INTERMITTENT KIND.

5. THE USE OF BIOLOGICAL INDICATORS IN CASE OF POLLUTION CAUSED BY TOXIC CHEMICAL SUBSTANCES OF EFFLUENTS IS MORE LIMITED AS NOT ENOUGH IS KNOWN ON DIFFERENTIAL EFFECTS ON THE BIOTA TO CLASSIFY EFFECTS IN A DETAILED WAY.

6. SEE PAGE 108

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Insert on page 103:

6. The inherent dangers of indiscriminant use of plant, fish and insect poisons, and other chemicals in streams are pointed out and especially for cases where a serious upsetting of balance among the organisms may result.

POLLUTION AND WATERFOWL

- By -

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The Canadian Wildlife Service, which I represent here, is part of the Department of Northern Affairs and National Resources. It is the federal agency charged with carrying out the commitments of Canada under the Migratory Birds Treaty with the United States, and in that capacity it is responsible for the annual revision of the Migratory Bird Regulations. The Service also makes arrangements for the annual Federal-Provincial Wildlife Conference, at which wildlife administrators of the Federal Government and the Provinces meet to discuss problems of mutual interest.

During the past thirty years the harm done to wildlife by pollution of waters has been repeatedly discussed at those Conferences, and as far back as 1924 a resolution was adopted recommending Federal legislation to control discharge of oil and oil wastes into Canadian waters. In 1948 the Conference proposed that a special provision should be inserted in the Migratory Bird Regulations to control pollution which might affect waterfowl. That provision, which was incorporated in the Regulations and is still in effect, reads as follows:

> "No person shall knowingly place, cause to be placed or in any manner permit the flow or entrance of oil, oil wastes or substances harmful to migratory waterfowl into or upon waters frequented by migratory waterfowl or waters flowing into such waters or the ice covering either of such waters."

Although we have had that provision for six years, no convictions have been made under it. The principal reason is that most waters frequented by migratory waterfowl and subject to pollution are in the developed areas of the

COUNTRY AND ARE COVERED BY PRIOR LEGISLATION, SUCH AS THE FISHERIES ACT AND FEDERAL LAWS DEALING WITH HARBOURS, NAVIGABLE WATERS AND SHIPPING. MIGRATORY WATERFOWL MAY BE HARMED BY POLLUTION NOT COVERED BY THOSE LAWS, BUT SUCH INSTANCES ARE LIKELY TO BE OF A LOCAL AND TEMPORARY NATURE, DIFFICULT TO DETECT, AND OFTEN ESCAPING OBSERVATION AND REPORT.

OUR OFFICERS HAVE FROM TIME TO TIME REPORTED SPECIFIC INSTANCES OF DAMAGE TO WATERFOWL BY POLLUTION. IN SOME OF THOSE CASES IT WAS FOUND THAT ACTION WAS BEING TAKEN AGAINST THE OFFENDERS UNDER OTHER LAWS. IN THE OTHER CASES, EITHER THE POLLUTION COULD NOT BE TRACED TO ANY INDIVIDUAL OR CORPORATION, OR ELSE IT PROVED TO BE ACCIDENTAL. SINCE OUR REGULATION CONTAINS THE WORD "KNOWINGLY", IT DOES NOT COVER ACCIDENTAL OR INVOLUNTARY POLLUTION.

WE BELIEVE, HOWEVER, THAT THE REGULATION SERVES A VALUABLE PURPOSE. IT GIVES US THE POWER TO PROSECUTE A DELIBERATE OFFENDER IN SOME CIRCUMSTANCES WHERE OTHER LEGISLATION DOES NOT APPLY. IN ADDITION, BY ITS EXISTENCE IT AFFIRMS THE INTEREST OF WILDLIFE ADMINISTRATION IN QUESTIONS DEALING WITH POLLUTION.

LAST YEAR'S CONFERENCE AGAIN DISCUSSED THE CONTINUING THREAT OF POLLUTION TO WILDLIFE. IT ADOPTED A RESOLUTION URGING THAT THE FISHERIES ACT, AND OTHER LEGISLATION SHOULD BE STRENGTHENED TO COMPEL INDUSTRIES TO AVOID OR ELIMINATE POLLUTION OF WATERS BY OIL OR OTHER WASTES. THE RESOLUTION DID NOT SPECIFICALLY RECOMMEND ANY CHANGE IN THE MIGRATORY BIRD REGULATIONS, WHICH ARE THE ONLY FORM OF LEGISLATION IN WHICH THE CANADIAN WILDLIFE SERVICE COULD TAKE ANY ACTION IN THE MATTER. THIS SERVICE, HOWEVER, UNDERTOOK AN INVESTIGATION OF THE EFFECTS OF POLLUTION ON WILDLIFE IN CANADA. OUR FIELD OFFICERS WERE ASKED TO REPORT ON THE SITUATION IN THEIR OWN DISTRICTS. I SHALL NOW GIVE YOU A SUMMARY OF THEIR REPORTS, TAKING THE PROVINCES FROM EAST TO WEST.

IN NEWFOUNDLAND THE PROBLEM IS MAINLY CONFINED TO COASTAL WATERS. OIL POLLUTION COMES FROM FIVE MAIN SOURCES:

(1) THE CLEANING OUT OF FUEL OIL TANKS BEFORE RE-LOADING WITH WHALE OR SEAL OIL;
(2) THE DISCHARGE OF USED LUBRICATING OIL FROM SHIPS;
(3) WASTE OIL IN BILGES;
(4) ACCIDENTAL LEAKS FROM STORAGE TANKS AND PIPE LINES;
(5) WRECKS, INCLUDING SHIPS SUNK DURING THE WAR. POLLUTION FROM THAT SOURCE MAY PERSIST FOR YEARS AFTER THE ACTUAL LOSS OF THE SHIP.

BIRDS AFFECTED IN NEWFOUNDLAND ARE PRINCIPALLY SEA DUCKS AND OTHER SEA BIRDS, SUCH AS MURRES. IN THE WORST CASES, THE FEATHERS ARE COATED SO THICKLY THAT THE BIRDS CANNOT FLY, SWIM OR DIVE, AND QUICKLY PERISH. IF THE POLLUTION IS LESS HEAVY, THE BIRDS MAY BE SO HANDICAPPED THAT THEY

ARE WEAKENED AND UNABLE TO MOVE QUICKLY, AND SO FALL EASY VICTIMS TO PREDATORS OR HUMAN RESIDENTS. IT IS REPORTED THAT IF SUCH WEAKENED BIRDS ARE TAKEN BY RESIDENTS WITHIN A DAY OR TWO, THEIR QUALITIES AS HUMAN FOOD ARE NOT AFFECTED, BUT AFTER A FEW DAYS THE BIRDS ARE THIN, AND THEIR FLESH IS TAINTED WITH OIL.

THE TOTAL ANNUAL LOSSES OF SEA BIRDS FROM POLLUTION ON THE NEWFOUNDLAND COASTS ARE VERY LARGE, ESPECIALLY IN SUCH AREAS AS THE STRAITS OF BELLE ISLE AND THE SOUTH COAST OF THE AVALON PENINSULA. IN ONE PARTICULAR CASE, DEAD AND DYING BIRDS WERE FOUND ALONG 80 MILES OF SHORELINE WITHIN TWO WEEKS OF THE WRECK OF A SHIP WHICH CARRIED 200 TONS OF FUEL OIL. IN ONE SETTLEMENT ALONE, IT WAS SAID THAT RESIDENTS SECURED ABOUT 1,500 DUCKS FOR FOOD AS THE RESULT OF THAT WRECK.

IN PRINCE EDWARD ISLAND AND MOST OF NEW BRUNSWICK LOSSES OF SEA BIRDS FROM OIL POLLUTION ARE GENERALLY SMALL. MANY NOVA SCOTIA LOCALITIES ON THE ATLANTIC COAST HAVE REPORTED LOSSES IN RECENT YEARS. THE BLAME IS GENERALLY PLACED ON WRECKS AND BILGE FROM OIL-BURNING SHIPS, ALTHOUGH THERE ARE ALSO PROBABLE LONG-LASTING EFFECTS FROM TANKERS SUNK DURING THE WAR.

A SPECIAL PROBLEM IS CAUSED IN NEW BRUNSWICK BY PORTABLE SAWMILLS. THESE OFTEN OPERATE NEAR STREAMS. SAWDUST FROM THEIR SAWDUST PILES IS WASHED INTO THE STREAMS BY RAIN, CAUSING HARM TO FISH AND OTHER AQUATIC LIFE WHICH MAY NOT BE OBSERVED UNTIL AFTER THE MILL HAS LEFT THE DISTRICT. -- THE SPRAYING OF LARGE FOREST AREAS WITH DDT, TO CONTROL SPRUCE BUDWORM, HAS ALSO LED TO THE KILLING OF FISH AND AQUATIC INVERTEBRATES IN CERTAIN AREAS.-- AN UNUSUAL CASE IS REPORTED FROM WOODSTOCK, NEW BRUNSWICK, WHERE A TROUT STREAM HAS BEEN RUINED BY WASTES DISCHARGED FROM A STARCH FACTORY ACROSS THE INTERNATIONAL BOUNDARY IN THE STATE OF MAINE.

IN QUEBEC THE MOST SERIOUS PROBLEM IS RIVER POLLUTION BY CITY SEWAGE AND INDUSTRIAL WASTES. SPORTSMEN'S ASSOCIATIONS HAVE PROTESTED AGAINST DAMAGE TO FISHERIES FROM THOSE SOURCES, BUT NO HARM TO WATERFOWL FROM THOSE CAUSES HAS BEEN REPORTED. SOME OIL POLLUTION HAS OCCURRED ON THE LOWER ST. LAWRENCE AND ALONG THE COAST OF THE GASPE PENINSULA, BUT SHIPPING OWNERS AND OPERATORS HAVE GENERALLY BEEN VERY CO-OPERATIVE AND OBSERVANT OF THE LAW. ANY SERIOUS CASES OF POLLUTION CAUSED BY SHIPPING IN THAT AREA IN RECENT YEARS APPEAR TO HAVE BEEN ACCIDENTAL.

IN ONTARIO THERE ARE SEVERAL CRITICAL AREAS. THE SPANISH RIVER IN NORTHERN ONTARIO IS AN EXAMPLE OF A RIVER, DISTANT FROM LARGE CENTRES OF POPULATION, POLLUTED BY CHEMICAL WASTES FROM PULP AND PAPER PLANTS. THE DON RIVER AT TORONTO, AND THE THAMES AT LONDON ARE HEAVILY POLLUTED BY FACTORY WASTES AND CITY SEWAGE. IN THOSE RIVERS FISH ARE MORE SERIOUSLY AFFECTED THAN OTHER WILDLIFE. A CHRONIC POLLUTION SITUATION AFFECTING WATERFOWL, AND OF INTERNATIONAL CONCERN, OCCURS ON THE DETROIT RIVER BETWEEN DETROIT AND WINDSOR. FISH AND WATER-

FOWL ARE AFFECTED BY POLLUTION AT HARBOURS ALONG THE GREAT LAKES WATERWAYS, FROM KINGSTON TO SARNIA; THERE OIL FROM SHIPPING IS ADDED TO CITY AND INDUSTRIAL WASTES AS A SOURCE OF DAMAGE.

IN THE WESTERN PROVINCES HARM TO WILDLIFE BY POLLUTION HAS BEEN MORE LOCALIZED. THERE HAVE IN THE PAST BEEN COMPLAINTS BY WINNIPEG ANGLERS ABOUT THE DUMPING OF MUNICIPAL SEWAGE AND OIL WASTES INTO THE RED RIVER, BUT CITY AUTHORITIES AND INDUSTRIAL CONCERNS HAVE CO-OPERATED TO REDUCE POLLUTION FROM THOSE SOURCES. NO HARMFUL EFFECTS ON DUCKS OR MUSKRATS HAVE BEEN REPORTED.

THERE HAS BEEN SOME DAMAGE TO FISH, AND OCCASIONALLY TO DUCKS, THROUGH OIL POLLUTION IN MOOSE JAW CREEK IN SASKATCHEWAN. AT KAMSACK WASTES FROM AN OIL REFINERY HAVE BEEN POURED INTO A CREEK WHICH EMPTIES INTO THE ASSINIBOINE RIVER, BUT NO HARM TO FISH OR WILDLIFE HAS BEEN REPORTED. THERE HAVE BEEN MANY COMPLAINTS FROM PRINCE ALBERT ABOUT OIL AND INDUSTRIAL POLLUTION OF THE NORTH SASKATCHEWAN RIVER, SAID TO ORIGINATE IN EDMONTON, BUT FISH AND WILDLIFE IN SASKATCHEWAN DO NOT APPEAR TO BE AFFECTED.

ABOUT TWO YEARS AGO OUR BIRD-BANDING SECTION RECEIVED A REPORT ABOUT A BANDED DUCK FOUND DEAD IN AN OIL PIT NEAR BLACKFOOT, ALBERTA. THE FINDER SAID THAT MANY DUCKS LOST THEIR LIVES IN THE OIL PITS, AND THIS SERVICE THEREUPON MADE AN EXTENSIVE INVESTIGATION. IT WAS FOUND THAT CRUDE OIL IN SURFACE PITS HAD INDEED CAUSED THE DEATH OF A NUMBER OF DUCKS NEAR BLACKFOOT AND LLOYDMINSTER, THE DUCKS EVIDENTLY MISTAKING THE OIL FOR WATER IN DIM LIGHT. HOWEVER, SURFACE OIL PITS WERE BEING RAPIDLY ELIMINATED AS OIL FIELDS WERE DEVELOPED, AND THEY ARE NO LONGER CONSIDERED TO BE A SERIOUS THREAT TO WATERFOWL.

FOR SEVERAL YEARS CALGARY SPORTSMEN HAVE BEEN PROTESTING AGAINST THE DISCHARGE OF OIL WASTES INTO THE BOW RIVER IN THAT AREA. THE WASTES DO NOT APPEAR TO KILL FISH, BUT THEY DO GIVE THE FISH AN UNPLEASANT TASTE. WE UNDERSTAND THAT THE OIL REFINERIES ARE TAKING STEPS WHICH MAY SOLVE THE PROBLEM.

ACCORDING TO OUR REPORTS, POLLUTION IS NOT A SERIOUS THREAT TO WILDLIFE RESOURCES IN BRITISH COLUMBIA. SOME ACCIDENTAL DISCHARGES OF OIL INTO STREAMS HAVE BEEN REPORTED, BUT INDUSTRIES ARE GENERALLY CO-OPERATIVE AND PROVINCIAL LAWS ON THE SUBJECT ARE WELL OBSERVED. OCCASIONALLY WATERFOWL ARE KILLED IN COASTAL WATERS BY OIL DISCHARGED FROM SHIPS, BUT THE LOSSES ARE COMPARATIVELY SMALL.

AN UNUSUAL CASE IS ON RECORD OF CANADA GEESE DYING OF LEAD POISONING IN THE STATE OF WASHINGTON. THERE WAS SOME EVIDENCE THAT THE SOURCE OF THE TROUBLE IN THAT CASE COULD BE TRACED TO MINE TAILINGS AT SPILLIMACHEEN, BRITISH COLUMBIA, MORE THAN 100 MILES NORTH OF THE INTERNATIONAL BOUNDARY.

In the Northwest Territories and the Yukon, pollution problems are almost non-existent. A few years ago some concern was caused by arsenical fumes from a smelter near Yellowknife. The fumes are heavy and tend to sink through the air, so that in winter a dangerous concentration of arsenic was built up on the snow for a considerable distance from the smelter. One child and several domestic animals died as the result of eating snow or drinking puddle water so contaminated. Probably wildlife was also affected, but we have no reports on that point. We are informed that the situation has been greatly improved, and that there is no longer any danger to human beings, or presumably to wildlife, from normal smelter operations.

TO SUMMARIZE:

Pollution of coastal waters by oil from shipping is a serious threat to aquatic birds in certain areas of Newfoundland and on the Atlantic coast of Nova Scotia; it causes occasional damage on the lower St. Lawrence and the coast of British Columbia; elsewhere in Canada it is almost negligible.

Pollution of inland waters by oil from shipping exists along the St. Lawrence waterway, especially in harbour areas, and affects fish and waterfowl.

Pollution of rivers and lakes by city sewage and industrial wastes, including oil refinery wastes, affects fish, and to a lesser extent waterfowl, in the more thickly-populated regions of Ontario and Quebec, and in a few other areas. In some cases the pollution does not directly harm the fish in those inland waters, but it impairs their flavour and destroys the amenities of sport fishing.

Apart from oil shipping, city sewage, and industrial wastes, the only other type of pollution reported was caused by smelter fumes. It is not a common type, and is not believed to constitute a threat to wildlife in Canada.

From the summary which I have given, it is evident that administration of the Migratory Birds Convention Act is closely concerned with control and prevention of pollution in Canadian waters. Section 40, of the Migratory Bird Regulations affirms our interest in the problem, and ensures that we keep in touch with developments. In actual practice, many senior interests -- federal, provincial, and municipal -- are involved, and control measures on account of those interests are normally invoked before waterfowl management is brought into the picture. It appears to us that the Canadian Wildlife Service, as the federal agency responsible for migratory bird administration, should continue the policy of co-operation with those senior interests instead of strengthening our own regulation against pollution. In that way we shall avoid duplication of effort and dissipation of energy. On occasion, our regulation may have to be enforced when no other measures are applicable, but in general we may expect

POLLUTION AND THE FISHERIES

- By -

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DEFINITION OF POLLUTION IN RESPECT TO FISHERIES

For all practical purposes, pollution in respect to fish may be defined as the addition of any substance to waters inhabited by fish which will limit their growth and/or decrease their survival. It is quite true that a few substances occur naturally which might be regarded as pollutants. Perhaps the hydrogen sulphide from underwater volcanoes, hot springs or decaying vegetation is an example. We also know that certain natural poisons occur in the food organisms of fish, which, although they do not affect the fish, can be detrimental to human health. These natural substances are, however, so rare as to be of little real consequence in the overall picture.

TYPES OF POLLUTION AFFECTING FISH:

Domestic sewage certainly pollutes many waters from the standpoint of human health, but there are few proven examples of this being directly harmful to fish except in concentrations far beyond that which would be tolerated under present day conditions. As a matter of fact, we may sometimes be forced to admit that the change in physico-chemical conditions resulting from such discharge may be beneficial. Domestic sewage does contain bacteria, perhaps, pathogenic, which is ingested by shellfish. Since animals such as oysters are often eaten in the raw state, a source of real trouble is thus created even though the bacteria have not affected the growth and survival of the shellfish.

The greatest source of pollution in the

FISHERIES SENSE IS UNDOUBTEDLY FROM WASTE DISCHARGED FROM INDUSTRIAL PLANTS. IN THIS CATEGORY ARE MANY OF THE EFFLUENTS FROM THE PULP AND PAPER INDUSTRY, IRON, COAL, GAS, OIL, MILK AND MEAT PROCESSING, AND OTHER OPERATIONS. OF THESE, THE MOST COMMON TYPES ARE THOSE WHICH HAVE A HIGH OXYGEN DEMAND. WHEN THESE ENTER A WATERWAY THEY BECOME DILUTED AND THEN UTILIZE THE OXYGEN IN THE WATER, REDUCING IT FROM THE NORMAL 8 TO 11 PARTS PER MILLION TO LESS THAN 5 PARTS PER MILLION USUALLY CONSIDERED NECESSARY FOR FISH. THE RESULT IS THAT THE FISH DIE OF ASPHYXIATION SHOWING SYMPTONS OF CYANOSIS.

IN GENERAL THE END PRODUCTS OF THESE OXIDATION PROCESSES ARE INERT AND HARMLESS, BUT SOME OF THE INTERMEDIATE SUBSTANCES MAY BE EXTREMELY POISONOUS. FOR EXAMPLE, THE SPENT PICKLING LIQUORS FROM THE IRON AND STEEL INDUSTRIES CONTAIN ZINC SALTS WHICH ARE VERY TOXIC TO FISH.

WHILE THE END PRODUCTS MAY BE CHEMICALLY INERT, THEY MAY CAUSE MECHANICAL DAMAGE. THE SLUDGE FROM IRON OR LIME MANUFACTURE OFTEN SETTLES ON THE BOTTOM, AND THROUGH CUTTING OFF THE OXYGEN CIRCULATION, MAKES IMPOSSIBLE THE GROWTH OF PLANTS AND ANIMALS WHICH SUPPORT FISH LIFE. IT MAY ALSO SETTLE ON THE GILLS OF FISH, IF THEY ARE IN THE VICINITY, AND CAUSE SUFFOCATION. THE WASTE SHORT FIBRES FROM PULP MILLS HAVE THE SAME EFFECT. OIL MAY COAT THE FISH, AND IN ADDITION IN SETTLING TO THE BOTTOM, IT ABSORBS MUD PARTICLES FORMING AN IMPERVIOUS OOZE. BARK AND HEAVY LOGS MAY BE DETRIMENTAL IN COATING THE RIVER BOTTOMS AND COVERING THE SPAWNING GROUNDS.

EXTENT OF POLLUTION FOR FISH:

THERE IS HISTORY OF DAMAGE TO FISHERIES BY POLLUTION IN ALMOST EVERY INDUSTRIAL REGION. THE LONGEST EXPERIENCE HAS BEEN IN EUROPEAN RIVERS AND ESTUARIES. DURING THE PAST TWENTY YEARS CONSIDERABLE STUDY OF THE PROBLEM HAS BEEN MADE IN THE UNITED STATES. THESE WORKS ARE INFORMATIVE AND WELL DOCUMENTED IN THE LITERATURE. IN GENERAL, HOWEVER, THERE HAS BEEN LITTLE SUCCESS IN RECTIFYING ANY EXISTING DAMAGE SINCE ALTERATIONS TO EXISTING INDUSTRIES ARE EXPENSIVE AND INVARIABLY THE CONTENTION IS RAISED THAT THE LIVELIHOOD OF THE WORKERS WILL BE AFFECTED.

POLLUTION OF FISHERIES IN CANADA AND PREVENTATIVE LEGISLATION:

IN CANADA THE PROBLEM OF POLLUTION IN FISHERIES HAS LONG BEEN RECOGNIZED SINCE IT HAS BEEN COVERED IN THE ACTS AND REGULATIONS FOR SOME TIME. IN FACT, THE PRESENT LAW WHICH IS LITTLE DIFFERENT FROM THE ORIGINAL IS FAR STRONGER THAN IS GENERALLY REALIZED. AS IT STANDS IF A SINGLE FISH IS KILLED AS A RESULT OF ANY SUBSTANCE HAVING BEEN DISCHARGED INTO A WATERWAY, IT WOULD BE DIFFICULT TO AVOID RESPONSIBILITY. IN THIS CONNECTION, SECTION 33 OF THE FISHERIES ACT IS PERTINENT:

33. (1) No one shall throw overboard ballast, coal ashes, stones, or other prejudicial or deleterious substances in any river, harbour or roadstead, or in any water where fishing is carried on, or leave or deposit or cause to be thrown, left or deposited, upon the shore, beach or bank of any water or upon the beach between high and low water mark, remains of offal of fish, or of marine animals, or leave decayed or decaying fish in any net or other fishing aparatus; such remains or offal may be buried ashore, above high water mark.

(2) No person shall cause or knowingly permit to pass into, or put or knowingly permit to be put, lime, chemical substances or drugs, poisonous matter, dead or decaying fish, or remnants thereof, mill rubbish or sawdust or any other deleterious substance or thing, whether the same is of a like character to the substances named in this section or not, in any water frequented by fish, or that flows into such water, nor on ice over either such waters.

(3) No person engaging in logging, lumbering, land clearing or other operations, shall put or knowingly permit to be put, any slash, stumps or other debris into any water frequented by fish or that flows into such water, or on the ice over either such water, or a place from which it is likely to be carried into either such water.

In order to clarify the thinking, attention should be drawn to the unique position of fisheries legislation. At Confederation it was agreed that the Dominion Government should have legal jurisdiction in coastal and inland fisheries. All laws and regulations were thus to be passed by the Federal Government. Fisheries was the only resource which was handled in this manner.

Although the British North American Act gave full legislative responsibility for the regulation of fisheries, both coastal and inland, to the Government of Canada, in the years following confederation, certain administrative responsibilities, particularly in the case of fresh water fisheries, were delegated to the Provinces in varying degrees. Consequently, while all fisheries laws and regulations are made at Ottawa, the job of administration of these laws and regulations is carried out in some cases by federal officers and in others by provincial officers according to the administrative arrangements with the different provinces.

I stress this position since the matter has recently become very prominent due to the pollution of the North Saskatchewan River. In such circumstances the Federal Government may consult in the solution if requested by all parties concerned but would find it difficult, without infringing its agreements with the individual provinces to take

DIRECT ACTION ON ITS OWN IN THE PROBLEM SINCE RESPONSIBILITY FOR THIS HAS BEEN DELEGATED TO THE PROVINCES.

UNTIL RECENT YEARS VERY LITTLE ATTENTION APPEARS TO HAVE BEEN GIVEN TO POLLUTION AS IT AFFECTS FISHERIES. THERE ARE PROBABLY SEVERAL REASONS FOR THIS ALLEGED, BUT NOT REAL, NEGLECT. IN THE FIRST PLACE, THERE HAVE ALWAYS BEEN VIRGIN AREAS WHERE FISH WERE PLENTIFUL AND UNAFFECTED. WE COULD THUS EXPAND AND MAINTAIN THE RESOURCE. EVEN IN THE INDUSTRIAL AREAS THE PROBLEMS WERE RELATIVELY FEW AND COULD BE HANDLED ON AN "AD HOC" BASIS. AS A RESULT OF THE RECENT RAPID SPREAD OF POPULATION AND THE GREAT INCREASE IN INDUSTRIALIZATION, THERE ARE FEW VIRGIN AREAS AND GREAT INCREASES IN THE ADDITION OF FOREIGN SUBSTANCES TO WATER. BECAUSE OF THE FEAR THAT A VALUABLE RESOURCE MAY BE DESTROYED, THE PROBLEM HAS COME TO BE CONSIDERED MORE SERIOUSLY AND AT GREATER LENGTH.

ACTION AND PROCEDURES IN COMBATTING POLLUTION:

THE FISHERIES DEPARTMENTS HAVE BEEN FORCED IN THE LAST FEW YEARS TO TAKE ACTION MANY TIMES. A REVIEW OF THE APPROACH TO SOLUTION AND THE PROCEDURES FOLLOWED IN ONE OR TWO CASES MAY BE OF INTEREST.

ON THE PACIFIC COAST IN THE PROVINCE OF BRITISH COLUMBIA WHERE INDUSTRIAL DEVELOPMENT IS RELATIVELY NEW YET PROCEEDING APACE, THE OPPORTUNITY HAS BEEN AVAILABLE TO PREDICT IN THE PLANNING STAGES THE DEGREE OF POLLUTION WHICH MAY OCCUR. IT IS THUS POSSIBLE TO PROPOSE WAYS AND MEANS OF KEEPING IT WITHIN TOLERABLE LIMITS. THE SUCCESS OF THIS POLICY, OF COURSE, DEPENDS ON THE CO-OPERATION OF THE INDUSTRIES IN REALIZING THAT SOLUTIONS CAN BE REACHED SO THAT THE NEW PLANTS CAN COEXIST WITH THE FISHERY RESOURCE AND IN APPRECIATING THE FACT THAT THERE IS NOTHING TO BE GAINED BY KILLING OUT ONE RESOURCE AND REPLACING IT WITH ANOTHER OF LITTLE MORE VALUE ECONOMICALLY. TO DATE INDUSTRY HAS BEEN FOUND TO BE VERY REASONABLE. THEY HAVE FOLLOWED VERY CLOSELY THE PROCEDURE IN THIS PROVINCE WHICH REQUIRES THAT ANY PLANT DISPOSING OF EFFLUENT MUST HAVE A CLEARANCE FROM THE HEALTH AND FISHERIES AUTHORITIES. ON RECEIPT OF AN APPLICATION, CLOSE EXAMINATION IS MADE AND EVERY EFFORT EXPENDED TO DEVISE MEASURES TO PROTECT THE FISH AND ACCEPT THE INDUSTRY.

WHILE MANY SITUATIONS CAN BE EASILY CORRECTED SOME ARE VERY DIFFICULT. SPECTACULAR RESULTS ARE SOMETIMES OBTAINED. AS AN EXAMPLE, A PULP MILL WAS PROPOSED FOR ALBERNI INLET ON THE WEST COAST OF VANCOUVER ISLAND. AFTER INVESTIGATION THE COMPANY WAS ADVISED THAT THE WATERS WOULD NOT TOLERATE A SULPHITE OPERATION IN SO FAR AS THE FISHERIES WERE CONCERNED. A SULPHATE PLANT WAS, THEREFORE, SUBSTITUTED TO THE MUTUAL SATISFACTION OF INDUSTRY AND GOVERNMENT. ON THE FRASER RIVER INDUSTRIAL DEVELOPMENT IS BEING CLOSELY WATCHED SINCE IT IS KNOWN THAT THE WATER IN THE ESTUARY IS NEARING THE LIMIT OF TOLERABLE POLLUTION FOR FISH. SEVERAL INDUSTRIES, INCLUDING A MILK PLANT AND AN IRON PICKLING PLANT, HAVE BEEN REFUSED LICENSES UNTIL SOME METHOD OF ALLEVIATING THEIR EFFECTS CAN BE DEVISED.

On the east coast in the Maritimes Area, we are faced with somewhat different problems undoubtedly due to the differences in the fish populations and the economy. At the present time, in order to save large stands of timber a spraying programme for spruce budworm is in effect. After consultation it was realized that the fishery resource might be affected but it was essential to save the forestry resource. For this reason efforts were directed towards applying the spray in such dilutions and solution as to remove the possibility of damage. The industry involved has co-operated with good results.

The so-called indirect pollution from sewage disposal has a great effect because of the wide distribution of population. In co-operation with the National Health and Welfare Department, we have been forced to close to fishing many shellfish beaches in order to remove the possibility of affecting the health of those who eat the product. It has been possible, however, to advise those concerned how to alleviate the disposal problem and it has also been possible to suggest a cleansing method.

Finally we should perhaps mention what might be considered pollution of natural occurence. On both coasts certain species of clams feed heavily on a protozoan which in itself contains a very active poison. If these clams are eaten, the result may be very serious, including paralysis and dealth. There are some methods of processing by which limited toxicity from this source may be removed such as canning under special conditions. On the other hand the areas where this cannot be done are rigidly quarantined to remove the possibility of death.

The most difficult problem facing us at the present time is correction of pollution from plants already established. It has been pointed out that this is a costly procedure. The fact is that when such plants were operating normally in early years they may not themselves have caused serious pollution. The addition of others without controls has just been enough to make conditions impossible for fish survival. New problems also arise as new technological procedures are introduced. We think of the use of arsenite to prevent wood borers in log booms, and the establishment of oil refineries on rivers. We must, however, face the situation with a full appreciation that the problem exists and agree that by co-operation a solution may be reached in most cases.

I have not mentioned effect on Fishing gear.

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THE CONFERENCE IN REVIEW

- By -

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The attendance of some 150 people at a Conference of this type clearly indicates the growing interest people have with regard to air and water pollution.

It is most ineffectual to pass laws governing pollution if the subject has not been carefully studied previously. While it is probably true that with our present knowledge industry can materially reduce air and water pollution, in many cases it would be most uneconomic, and would place an undue burden upon the industry.

The situation in any area suffering from pollution should first receive a survey. In some cases our knowledge is sufficient to permit supplying the industry with the necessary information, and at the same time affording some service. If it is difficult to determine the source of contamination, or if the method of treatment is costly, then some research work should be carried on. An example of an effective undertaking of this type is the group research being carried on at Sarnia under the auspices of the Research Council of Ontario. This is a case where industry is working in co-operation with the Provincial Government in an honest attempt to find ways and means of reducing both air and water pollution. Lastly, if the industries in question are not prepared to adopt modern methods of pollution control, then it is necessary to set up the necessary controls.

Mr. McRae's paper, the first of the symposium, dealt with group research. Mr. D. Douglass gave a paper on the utilization of mine wastes. Apparently their problem is only to determine the best use of the large quantity of inert material resulting from mining. Kenneth Cashmore's paper on the treatment of oil wastes was an excellent review of much of the work of the A.P.I. on this subject. A paper by E. G. Hackborn, dealing with municipal by-laws in connection with industrial waste, was not reviewed. R. A. Johnston's paper

ON THE INCIDENCE OF NITRATES IN RURAL WATER SUPPLIES GAVE A NEW AND POSSIBLY MORE ACCURATE METHOD FOR DETERMINING WATER CONTAMINATION. AN EXCELLENT PAPER BY A. V. DELAPORTE ON DE-OXYGENATING WASTES INDICATED SOME OF THE LATEST METHODS OF DISPOSING OF INDUSTRIAL CONTAMINANTS. THE REVIEWER SUGGESTED THAT THE AUTHOR MIGHT LOOK INTO THE POSSIBILITY OF USING PRE-CIPITANTS, COAGULANTS, AND IN SOME CASES, SIMPLIFY THE DISPOSAL PROBLEM BY SEGREGATING VARIOUS WATERS IN THE PLANT IN ORDER TO HAVE THE POLLUTED MATERIAL IN AS CONCENTRATED FORM AS POSSIBLE FOR TREATING. IT WAS ALSO SUGGESTED THAT IF MILORGANITE WAS THE BASIS FOR VITAMIN B12, THERE WAS GOOD REASON TO BELIEVE THAT OTHER CHEMICALS COULD BE FOUND IN OTHER WASTE MATERIALS.

MR. H. W. POWELL AND MR. T. B. COOPER GAVE PAPERS ON THE DISPOSAL OF CANNERY AND MILK WASTES. IT WAS SUGGESTED THAT MORE PROGRESS MIGHT BE MADE IF A SOIL BIOLOGIST WERE TO WORK WITH THEM. H. BLACK'S PAPER ON THE TREATMENT OF SUGAR BEET WASTES, AND DR. GEORGE TOMLINSON'S PAPER ON PULP AND PAPER WASTES, INDICATE HOW MUCH STUDY HAS BEEN GIVEN BY LARGE INDUSTRIAL GROUPS AND ASSOCIATIONS IN AN ENDEAVOUR TO SOLVE THE WASTE PROBLEMS OF SUCH INDUSTRIES. NO DOUBT THERE ARE MANY CHEMICALS THAT COULD AND WILL BE OBTAINED FROM SUCH WASTES WITH NEW POLLUTION TREATMENTS. IT IS SUGGESTED THAT IT MIGHT BE A GOOD IDEA TO ESTABLISH A CHART SHOWING THE PRO-GRESS MADE, FOR EXAMPLE, IN PERIODS OF FIVE YEARS, ON THE BASIS OF THE CHANGE TO THE PLANT AND THE STREAMS. THEREUPON MR. NEWBURY'S PAPER ON THE SETTING-UP OF AN AIR POLLUTION SURVEY INDICATES HOW LITTLE WE KNOW OF THIS VERY DIFFICULT PROBLEM, AND THAT THERE ARE UNDOUBTEDLY YEARS OF WORK AHEAD BEFORE WE CAN POSSIBLY COME UP WITH ANY VERY EFFECTIVE ANSWER TO THIS PROBLEM.

THE RESEARCH FOUNDATION HAS TWO FUNCTIONS. ONE IS TO CARRY OUT RESEARCH ON BOTH AIR AND WATER POLLUTION, AND THE OTHER IS A SERVICE TO INDUSTRIES.

IN ENGLAND THE OIL INDUSTRIES ARE CO-OPER-ATING WITH THE GOVERNMENT IN CARRYING ON A STUDY OF OIL POL-LUTION ALONG THE COASTS. IT IS SUGGESTED THAT THOSE INTER-ESTED IN THIS SUBJECT SHOULD KEEP US IN CLOSE TOUCH WITH THIS WORK.

WASTE DISPOSAL IS A SUBJECT THAT CAN BE CLOSELY RELATED TO COUNTRY AND CITY PLANNING. THERE IS NO QUESTION BUT THAT WE CAN AND SHOULD VERY MATERIALLY REDUCE POLLUTION IN THE AIR AND RIVERS OF ONTARIO. IT IS, THEREFORE, MOST GRATIFYING TO SEE AN INCREASE IN PUBLIC INTEREST. EVERY EFFORT SHOULD BE MADE TO FIND WAYS AND MEANS OF CHEAPLY AND EFFECTIVELY REDUCING POLLUTION PROBLEMS TO A MINIMUM.

IT IS THE RIGHT OF EVERY CITIZEN, NO MATTER WHERE HE IS, TO HAVE CLEAN AIR AND CLEAN WATER. WHILE THE EMPHASIS ON POLLUTION REGARDING STREAM LIFE AND WATER FOWL IS UNDOUBTEDLY IMPORTANT, IT IS MORE IMPORTANT IN RELATIONSHIP TO THE HUMAN BEING.

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