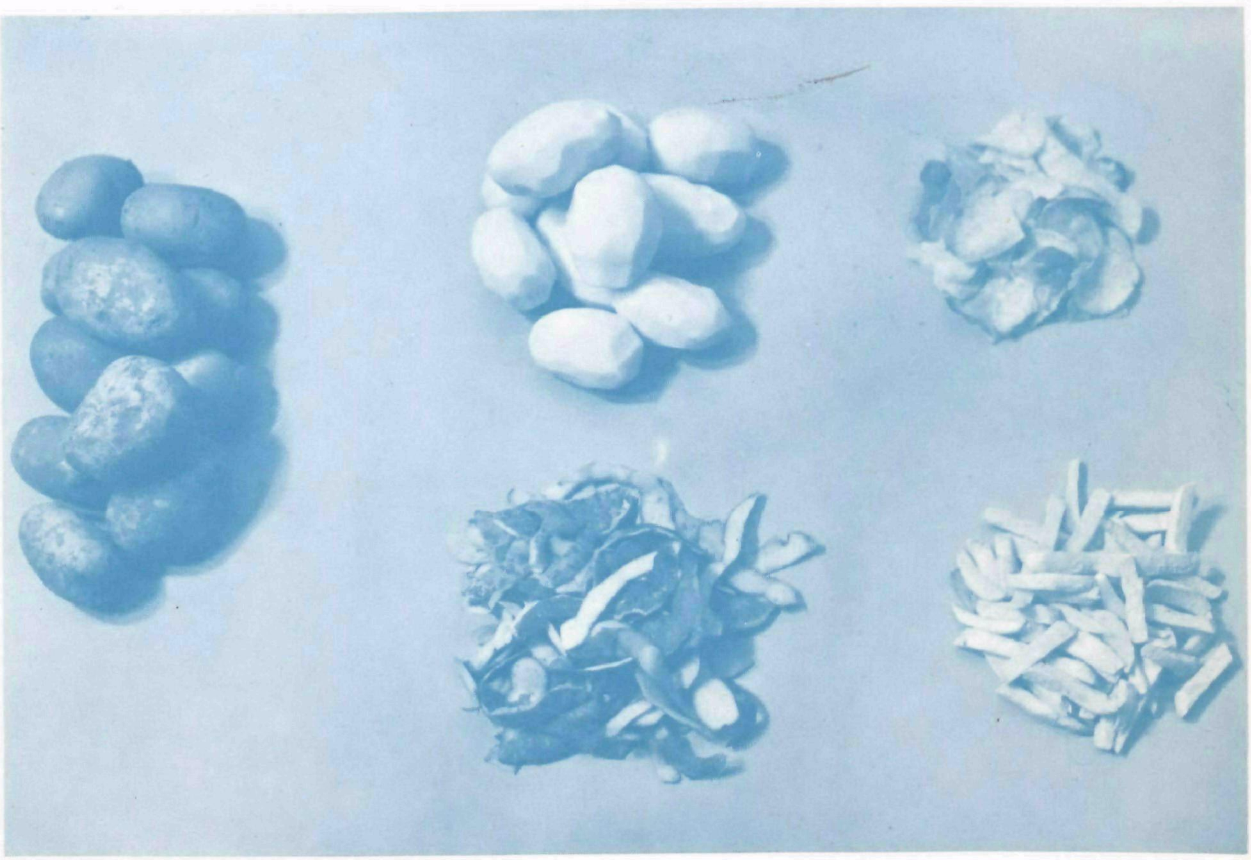
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

NORTHWEST REGION, PACIFIC NORTHWEST WATER LABORATORY

POTATO WASTE TREATMENT



PROCEEDINGS OF A SYMPOSIUM

March 8, 1968

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FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

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CLEAN WATER

POTATO WASTE TREATMENT

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U. S. DEPARTMENT OF THE INTERIOR
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FOREWORD

Processing of potatoes has grown markedly during the past fifteen years, especially in the Western States. Unfortunately, waste production has increased as rapidly as the processing. Several of the nation's largest fishkills have resulted, in part, from this increasing wasteload. Research is being done on treatment of potato processing wastes by various interested parties. It is for this reason that this symposium was scheduled so that existing knowledge could be shared and the gaps identified so that future research and demonstration efforts will be properly channeled.

JAMES R. BOYDSTON, Chief
Treatment and Control
Research Program

PERSPECTIVES AND PROBLEMS IN TREATMENT OF POTATO PROCESSING WASTES

by

James R. Boydston[1]

The Federal Water Pollution Control Administration is pleased to join with the University of Idaho today in sponsoring this symposium on the status of waste treatment technology in the potato processing industry. May I welcome you to this important session and offer my agency's keen interest in the combined expertise you can bring to bear on a major pollution problem we face: water pollution from the discharge of inadequately treated potato wastes.

I'd like to begin this session with a few brief comments on FWPCA's interest in this symposium and to set the stage for the important papers on the agenda before us.

To put our problem in broad perspective, I'm sure I need not emphasize to Idahoans that potatoes are about the most important vegetable crop grown in the United States -- after all, a quarter of the nation's potato crop is grown right here in Idaho. That's a pretty significant percentage when we consider that the total average annual potato production in this country is about 300 million hundred weight, or 15 million tons.

For our purpose today, however, an even more significant statistic is that the wastes produced in processing a ton of these potatoes is equivalent in organic strength to the wastes of a population of 300 to 500. In other words, the average daily national potato production can create an untreated waste load equivalent to 6 to 8 million people, and in Idaho alone a population equivalent of about 2 million. If discharged untreated, or inadequately treated, to our freshwater streams, these wastes create serious pollution problems.

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Since that significant percentage of the national potato crop is grown right here in Idaho, it is not surprising that many of the pollution problems from this source also occur here. For example, Milner Reservoir has had the dubious honor of four of the nation's largest fishkills since 1960--due principally to the combined effect of inadequately treated potato wastes and the curtailment of streamflow at the dam. Other examples occur to you, I know. The severe pollution in the Snake Basin has resulted in stringent State and Federal requirements for treatment of those wastes -- and technology has barely kept abreast of the need. Water quality standards--which were adopted last year in compliance with the Water Quality Act of 1965 -- require that all wastes receive the highest and best degree of treatment, consistent with the goal of maintaining or restoring water quality to make it suitable for the wide variety of uses the public demands.

It doesn't take a crystal ball to project population growth and industrial production to see that even secondary waste treatment may not be adequate to preserve minimum water quality. Future demands for water for recreation, irrigation, municipal and industrial supply, propagation of fish and wildlife, and other uses will exceed the limited supply of water, unless it is kept clean and usable. There is little we can do to increase the natural supply of water; so we must reuse our limited supplies many times along the streams' course to the ocean. This water reuse will be impossible without adequate waste treatment. And the definition of "adequate" will mean higher and higher levels of treatment as our economy grows and our demands for clean water increase.

In this context, the purpose of our meetings here assumes great importance to the State of Idaho and the potato processing industry. For while the State Department of Health and the FWPCA require the maintenance and restoration of water quality, it will be in the public's best interests to achieve that goal in the most economical and efficient manner. Not only is the degree of treatment an important consideration, therefore, but we must continually seek more efficient and less costly means of providing that treatment. These are the areas of research we hope to define today, as we learn more of the present state of the art in potato waste treatment.

Before I turn the meeting over to the other speakers for the technical presentations, may I offer a few words on FWPCA's interest in this field and the ways we hope to assist in solving these problems. Congress has directed the FWPCA to spearhead an expanded program of pollution control research. This national research program has been divided among several research laboratories, each assigned responsibilities for specified areas of research. The Pacific Northwest Water Laboratory in Corvallis is designated as the national center for research into new or improved methods for treatment of wastes from the potato processing industry. (Other national research programs centered in Corvallis include eutrophication, disposal of wastes to marine waters, pulp and paper waste treatment, and thermal pollution from the power industry.) In potato waste treatment research, the funds to initiate the program have been curtailed in this national budget-cutting year; but it has been possible to undertake cooperative studies at the J. R. Simplot Company plant at Burley, Idaho.

In addition, the Clean Waters Restoration Act of 1966 made grant moneys available, for the first time, directly to industry for research to demonstrate new or improved methods of waste treatment which will have industry-wide applications. One of the first grants awarded was $483,000 to the R. T. French Company to demonstrate the use of surface aerated ponds in the combined treatment of wastes from potato processing. Construction of this full-scale facility is expected to begin shortly at the Shelley, Idaho plant. Upon completion, the company will determine plant efficiencies and investigate operational methods to obtain optimum treatment. Total project costs for this venture will exceed $700,000.

FWPCA grants are also available for university research into new treatment methods. We recognize that industry and university talents provide excellent capabilities for research into the pollution problems we have found. Consequently, we have adopted a policy of promoting extramural research. In fact, it is expected that the inhouse research by FWPCA may be the smaller part of the total Federal dollars expended on water pollution control research as a whole.

With this brief background on my agency's interests in these discussions today, may I close by reaffirming our interest in a cooperative approach to the development of potato waste treatment technology. We will continue to look to the industry and the universities for expertise in solving pollution problems. We welcome this opportunity for a direct and formal exchange of current knowledge and the chance to discuss future needs together.

MECHANISMS OF ANAEROBIC WASTE TREATMENT

by

Gordon L. Dugan[1] and William J. Oswald[2]

"Anaerobic" as the name implies from its Greek root origin, literally means "life without air." Such life in ponds will be the major subject of this paper, but in a discussion of anaerobic mechanisms in waste treatment, it is advantageous also to explore the aerobic or "air-life" mechanisms, since the two groups are interrelated in almost all of the steps involved in waste treatment processes.

With regard to an aquatic environment, the zone containing dissolved oxygen is called the aerobic zone. Dissolved oxygen is utilized by most organisms ranging from bacteria to fish. In most natural waters dissolved oxygen in equilibrium with the atmosphere has a concentration of from 8 to 9 mg/l. Many factors such as temperature of the water, oxygen consuming or producing organisms, and turbulence of the water, affect the dissolved oxygen content which in general may range from less than 1 milligram per liter (mg/l) to 4 above saturation. The saturation point increases with decrease in temperature. Free oxygen produced from algal growth can bring about a condition known as supersaturation in which the dissolved oxygen content of the water may exceed saturation assuming a value equivalent to equilibrium with atmospheres having more than 21% oxygen. Supersaturation generally occurs during warm sunny days when algal growth is at a maximum. The dissolved oxygen concentration will tend to decrease to saturation or less at night when, due to a lack of light, there is no photosynthesis.

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Waters in which no detectable dissolved oxygen is present are classified as anaerobic or "septic". Organisms which live under this condition must obtain their energy from chemical reactions which lead to production of alcohol, acid and methane. Some of the various types of anaerobic waste treatment processes presently being used are carried out in the well known municipal and industrial digestion tanks, anaerobic and facultative ponds, Imhoff tanks, and septic tanks. There are many variations and combinations of these basic systems, but essentially the basic principles are the same for all. These processes of fermentation will be discussed in greater detail later in this paper in conjunction with the major topic of pond design.

The facultative stabilization pond is emphasized in this presentation because this is the most versatile type of pond available at present and because interest in this type of waste treatment facility is on the increase. The comparative position of the facultative pond with respect to the aerobic and anaerobic pond is of interest. In Figure 1 are illustrated the three basic types of ponds, viz. aerobic, anaerobic, and facultative. Although ponds are often designated by various names, such as lagoons, oxidation ponds, stabilization ponds, and waste conversion ponds, in this discussion, the classification given in Figure 1 will be used. This classification, suggested by Oswald at the Manhattan Conference in 1960 is as follows: Those ponds in which only the reactions above the point where dissolved oxygen becomes zero (termed the oxypause) occur, which provide aerobic oxidation and photosynthetic oxygenation, should be classified as <u>aerobic</u> ponds. Ponds in which the anaerobic reactions below the oxypause line are the predominant ones, are called <u>anaerobic</u> ponds. Ponds in which an aerobic zone exists in the surface strata and an anaerobic zone exists in the lower strata are termed <u>facultative</u> ponds.

Although it is appreciated that a multitude of interdependent complex chemical, physical, and biological reactions occur both simultaneously and in sequence in the stabilization of organic waste, only typical overall carbohydrate reactions will be considered in this paper. In the following simplified reactions, carbohydrate is typified by the simplified formula

$$(CH_2O)_x$$

By referring to Figure 1 it can be seen that in aerobic oxidation carbohydrate and oxygen combine to yield carbon dioxide, water and energy.

$$(CH_2O)_x + O_2 \longrightarrow CO_2 + H_2O + \text{energy}$$

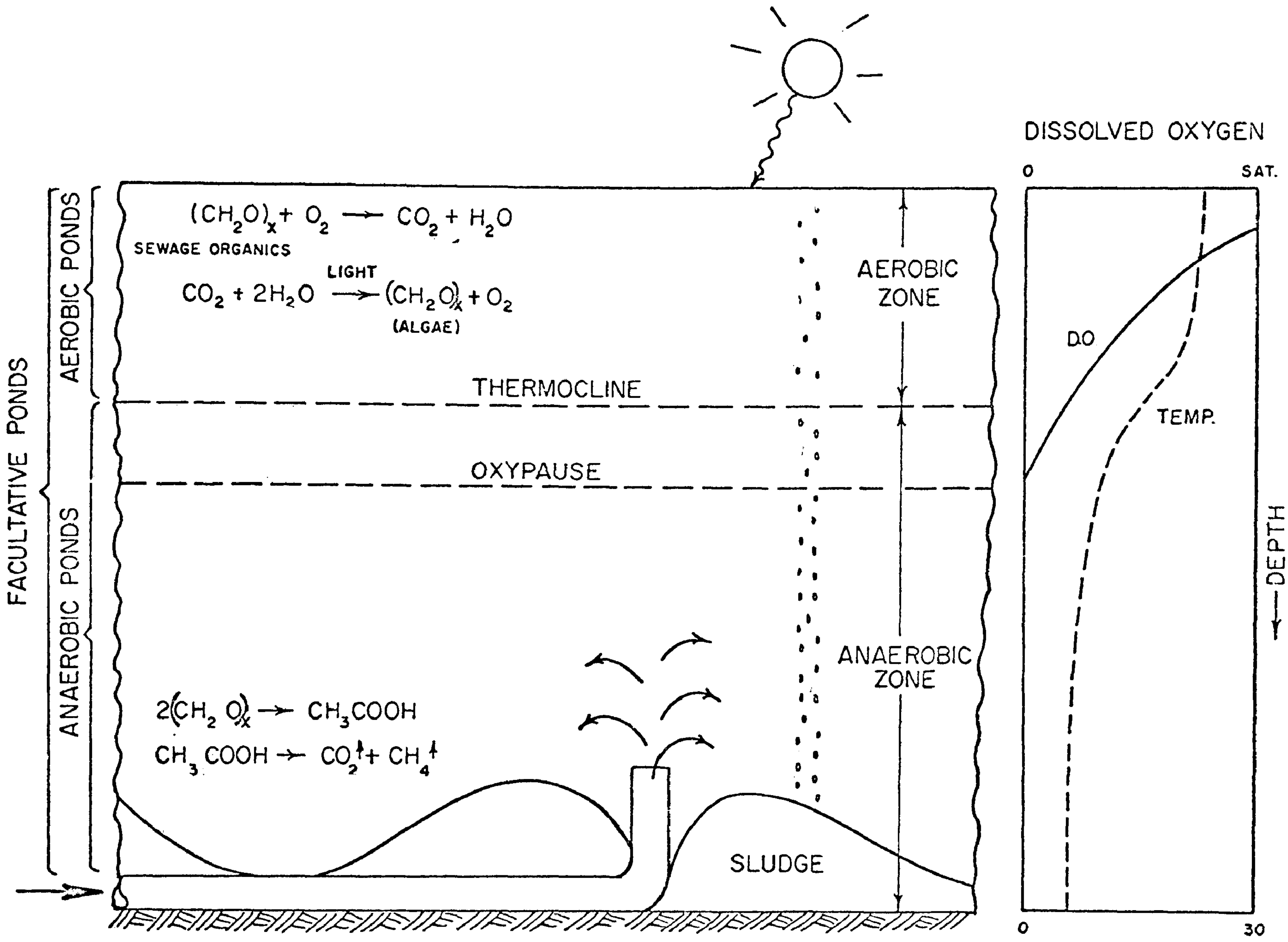

FIGURE I. SCHEMATIC CROSS SECTION OF A STABILIZATION POND

In the photosynthetic reaction algae use carbon dioxide, water, and solar energy to form algae cells and free oxygen as indicated by the equation:

$$CO_2 + 2H_2O \xrightarrow{\text{Solar Energy}} (CH_2O)_x + O_2 + H_2O$$

Oxygen released photosynthetically is, in turn, utilized by the bacteria in completing the symbiotic semi-cycle. The algal cells may be removed by harvesting (mechanical, centrifugation, or chemical flocculation), discharged in the effluent, or allowed to settle into the anaerobic zone as happens in a facultative pond.

Broadly speaking, decomposition takes place as two phases in the anaerobic zone. The two phases are the "acid" phase and the "gas" phase. In the "acid" phase settled sludge is broken down to organic volatile acids and energy, and in the "gas" or "methane" phase, the organic volatile acids are converted to carbon dioxide (CO_2), methane (CH_4), hydrogen (H_2), nitrogen (N_2), and minor amounts of other gases.

The general reactions occurring in an anaerobic pond or in the anaerobic portion of a facultative pond are also depicted in Figure 1. The reactions are essentially the same as those occurring in a conventional digester, except with respect to gas composition. In a digestion tank the composition of the gases is approximately 60% CH_4, 30% CO_2, 5% H_2, and 5% inert gas (eg. N_2). In an anaerobic pond, the composition is generally 60% CH_4, less than 5% CO_2, 5-10% H_2, and 20 to 30% N_2. The reason for the high nitrogen content in the gases discharged from facultative ponds is not fully understood.

In Table 1 is presented a summary of the major reactive phases that occur in a facultative pond. It should be noted that the optimum growth conditions for the several phases differ greatly. Therefore, compromises are necessary. The aerobic phases are more closely compatibile than the anaerobic phases. The acid formers can reach their maximum activity in 10 to 20 days, whereas it takes from 40 to 50 days for the methane formers to do so. Another discrepancy is that the optimum pH range of the volatile organic acid formers is from 4.5 to 7.5, whereas the optimum pH range for methane formers is from 6.8 to 7.2. Therefore, if the acid formation is allowed to proceed too rapidly, the pH level will drop to a point at which the slower growing methane formers would be inhibited. Should this happen, the acid formers will predominate, and as a

TABLE I

SUMMARY OF THE MAJOR REACTIVE PHASES IN WASTE DISPOSAL PONDS

Phase	Characteristics					Environmental Factors				
	Organisms	Substrate	Products	Time Req'd (days)*	Odors Produced	Temp. (°C)	Oxygen	pH	Light	Toxic Compounds
Aerobic Oxidation	Aerobes	Carbohydrates, proteins	CO_2 + NH_3	5-10	None	0-40	Required	7.0-9.0	Not Req'd	Cr^{+++} NH_3^{+}
Photosynthetic Oxygenation	Algae	CO_2 NH_3	Oxygen Algae	10-20	None	4-40	Required Under Certain Conditions	6.5-10.5	Req'd	Ca^{++} Cl_2 Cr^{+++}
Acid Formation	Facultative Heterotrophs	Carbohydrates, Proteins, Fats	Organic acids	10-20	H_2S	0-50	Required Under Certain Conditions	4.5-7.5	Not Req'd	Cr^{+++}
Methane Fermentation	Methane Producers	Organic Acids	CH_4, CO_2, H_2	40-50	H_2S	6-50	Not Required	6.8-7.2	Not Req'd	O_2, Detergents

*Time required to develop a stable population result the pH level will continue to decrease. Unless the situation is corrected, a condition will arise in which the system is said to be "stuck" or "sick". The term applies both to digesters and to ponds. Volatile organic acids have a very foul odor and along with hydrogen sulfide (rotten egg odor) are responsible for most of the odor nuisances of ponds. The parameters used to monitor the condition of the anaerobic phase generally are pH, gas production, volatile acid content, and alkalinity.

Operationally, in the interest of time and efficiency in initiating ponds, it is recommended that digesters, facultative ponds, and anaerobic ponds be seeded with a well-digested sludge, preferably from the same type installation as the one being initiated. It is also recommended that aerobic ponds and facultative ponds be seeded with an algae culture. The amount of seed to use depends on availability and the economics of transporting the seed, but if odorous conditions seem likely to cause public concern, however, the greater the quantity of seed, the greater will be the chance of successfully starting the system in a shorter period time with less odor.

Once an acid-gas balance is established, anaerobic decomposition proceeds normally and organic material introduced to a digester is broken down to gases and stabilized sludge. The digester acid-gas balance can be upset by excessive organic loading, shock loading, and toxic compounds. In the case of methane forming bacteria, oxygen is very detrimental. To maintain anaerobic conditions, the pond must be deep enough and sufficiently short in the direction of the prevailing wind so that wave action will not result in overturn and conveyance of dissolved oxygen into the anaerobic sludge. The thermocline, above which a strata of warmer bouyant oxygenated water is located, helps to protect the pond from having vertical circulation. Another method which has been used to keep dissolved oxygen from the sludge, is to reduce the surface area of the sludge deposits. In Figure 2 are illustrated three methods which have been successfully used. In the first method (2A) the bottom of the pond is in the shape of an inverted funnel. In the second (2B), the bottom is shaped as an inverted cone. In the third (2C), an enclosure structure is constructed on the pond bottom.

The importance of temperature should not be overlooked in anaerobic waste treatment. Its importance is indicated by the shape of the curve in Figure 3. Based on the information shown,

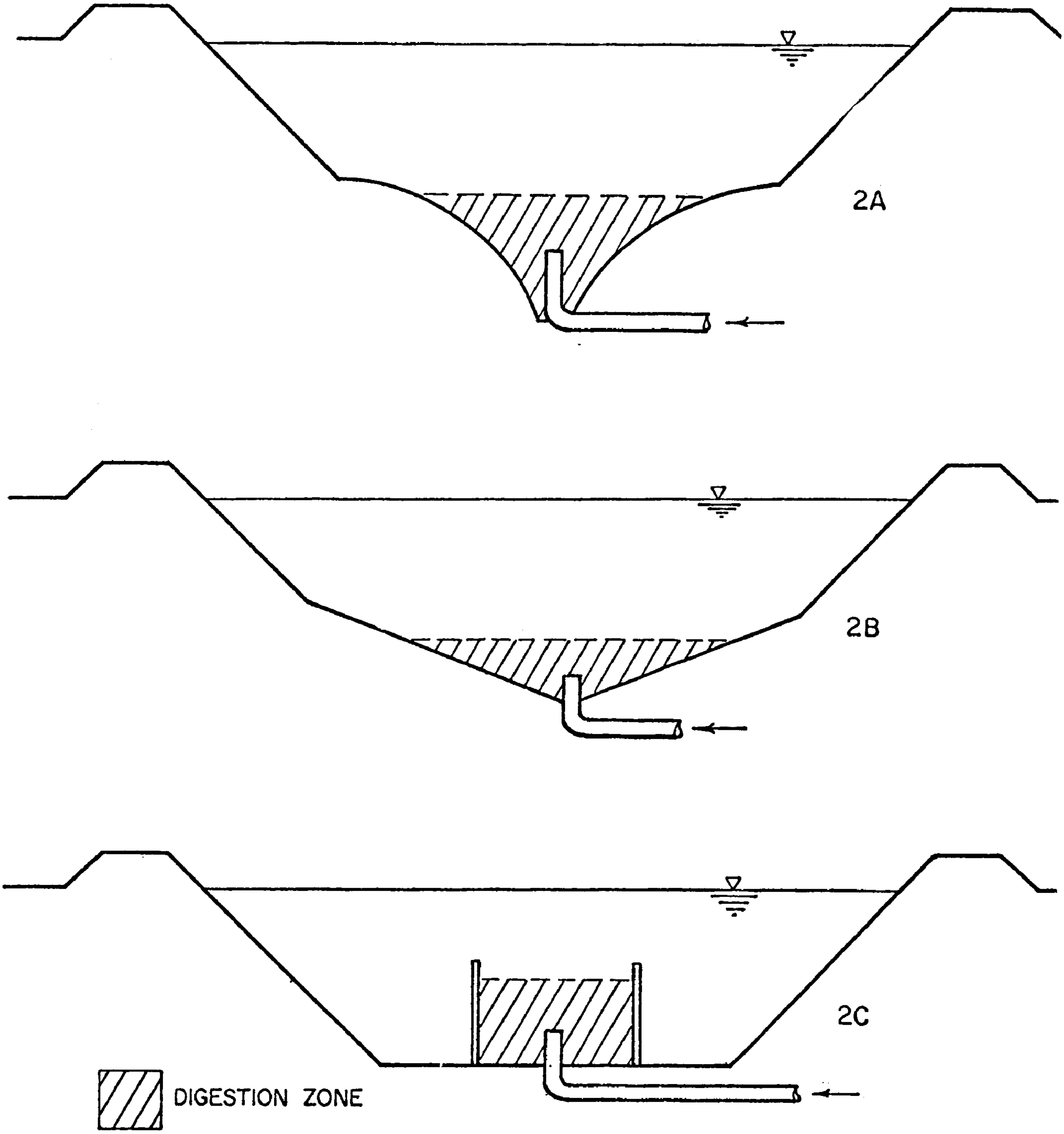

FIGURE 2. SLUDGE PROTECTION METHODS

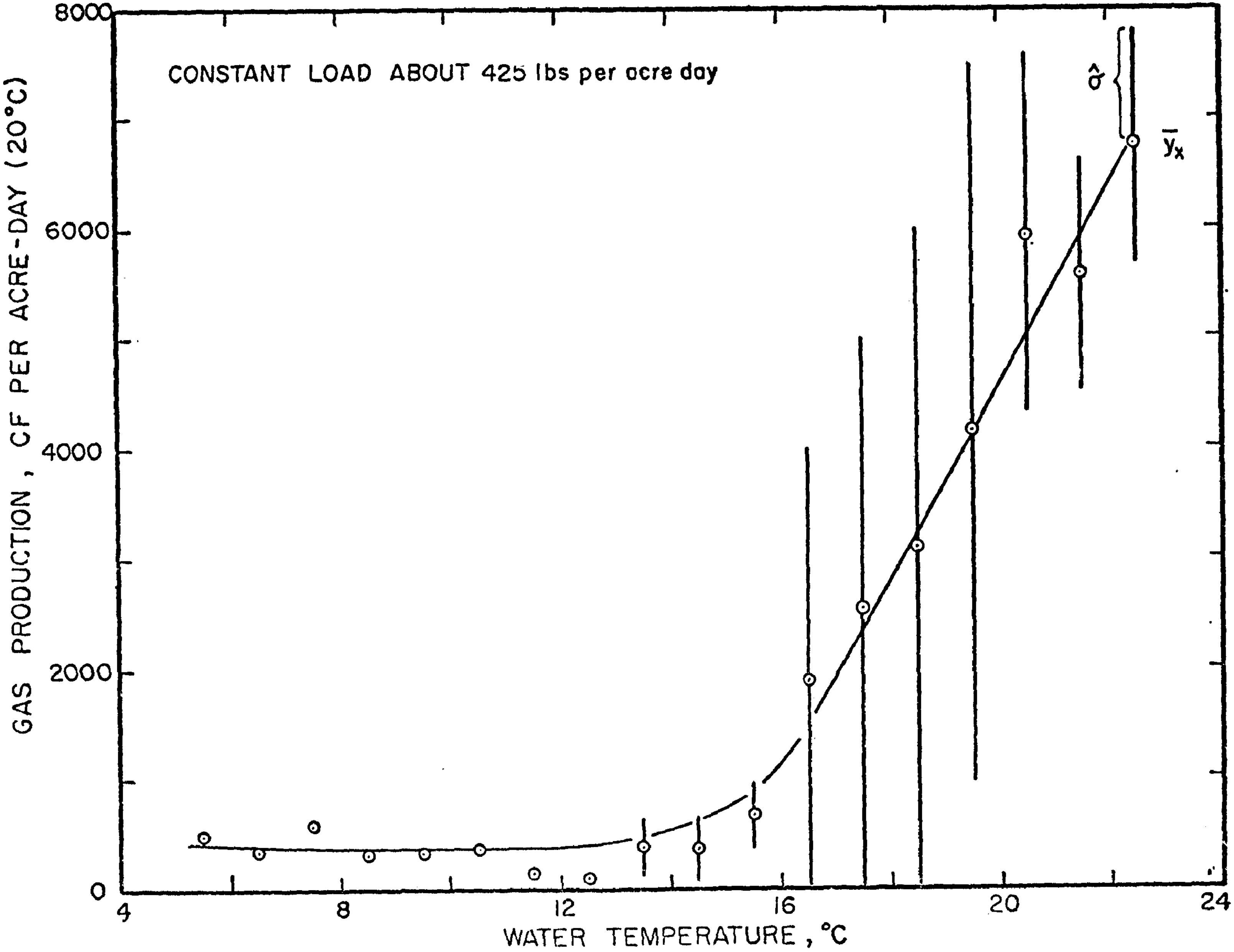

FIGURE 3. EFFECT OF WATER TEMPERATURE ON GAS PRODUCTION

the minimum functional operating temperature for a significant fermentation appears to be 15°C (59°F). Gas production is negligible and waste stabilization is greatly reduced at temperatures less than 12°C. In order to take advantage of enhanced gas production with increased temperature, most modern municipal digesters are heated to temperatures ranging from 29°C (85°F) to 43°C (110°F), with the average around 35°C (95°F). Gas usually is collected in the digester plenum and is burned to heat the digester, adjacent buildings, and other structures. Any excess is burned as an open flame. Because the temperature in ponds declines with depth if the depth of the unheated pond is too great, the sludge temperature will remain too low for effective waste stabilization to take place. Experience indicates that 14 feet is the approximate maximum functional depth for an unheated pond for most climatic conditions.

Typical digester loading is measured in terms of pounds of volatile solids per cubic foot of digester volume per day (lbs vs/cf-day); whereas, a pond loading generally is measured in pounds of 5-day biochemical oxygen demand per acre of surface area per day (lbs-BOD_5/ac-day). Digesters usually are operated within the range of 0.08 to 0.1 lbs vs/cf-day. Aerobic ponds can be loaded as high as 200 lbs BOD5/ac-day. Facultative ponds generally are loaded at 20 to 50 lbs-BOD_5/ac-day. However, once they are operating properly, they may be loaded as high as 150 lbs BOD_5/ac-day. With established methane fermentation, anaerobic ponds have been maintained satisfactorily at 1000 lbs BOD_5/ac-day.

Pond loading also is expressed in terms of number of people per acre per day. The rule of thumb conversion figure for changing per capita to BOD_5 is that one person produces approximately 0.2 lb BOD_5/ day. The five-day BOD (BOD_5) is considered to be approximately 2/3 that of the ultimate BOD. The ultimate BOD refers to the amount of oxygen needed to completely stabilize a given sample of organic matter. The ultimate BOD test is usually considered complete after an incubation period of 20 days. The effect of applied BOD loading on gas production is illustrated in Figure 4. Maximum gas production efficiency as indicated by ft^3 of gas per lb of BOD in the facultative-anaerobic pond at Woodland, California, apparently occurred when the loading was about 25 lb BOD_5/ac-day.

The detention time for a digester is approximately 30 days; for an aerobic pond, 3 days; for a facultative pond, 90 days; and

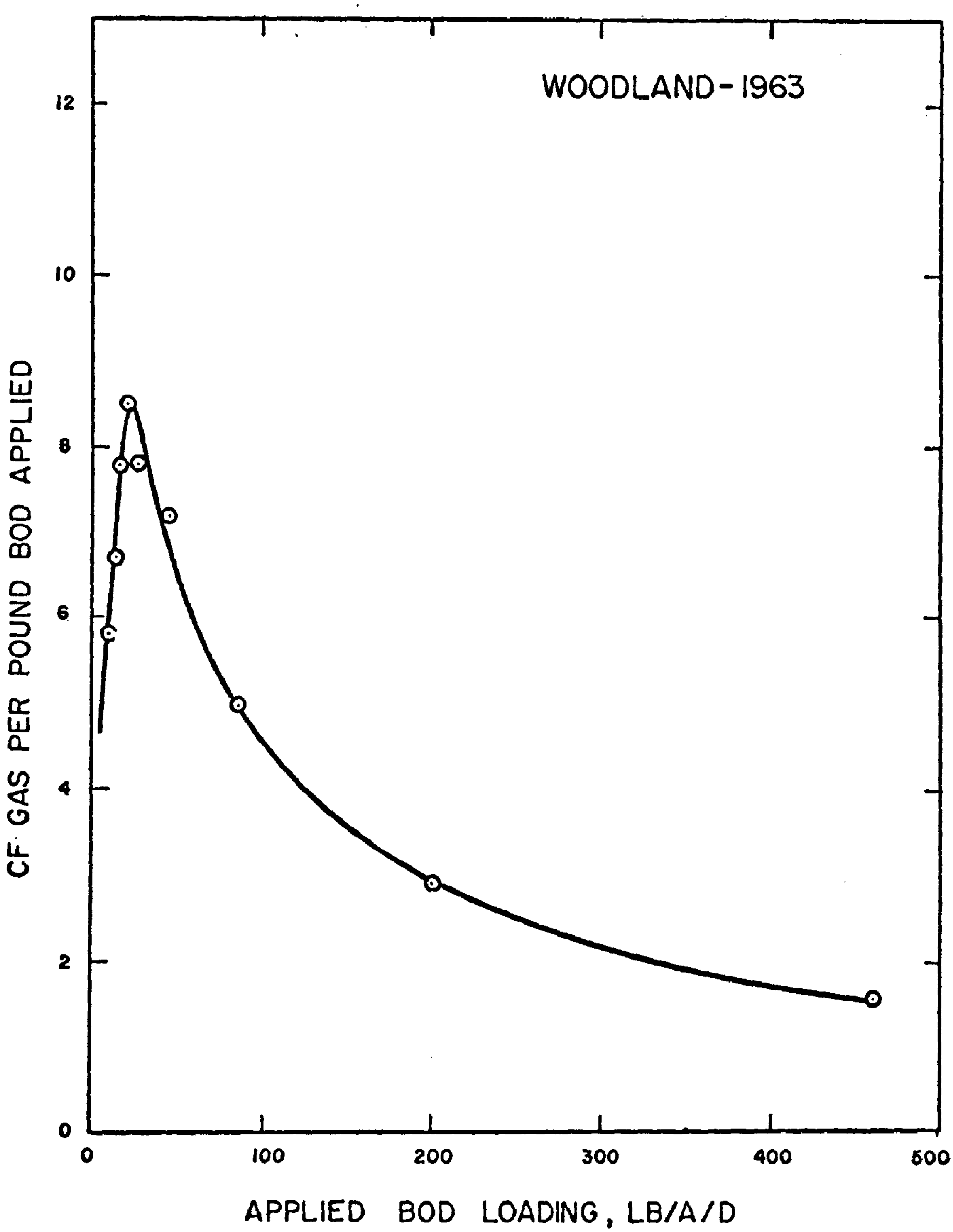

FIGURE 4. GAS PRODUCTION AS A FUNCTION OF APPLIED BOD LOADING

for anaerobic ponds, 8-10 days. The efficiency of BOD_5 removal in an aerobic pond is approximately 80%; in a facultative pond, 85 to 95%; and in an anaerobic pond, about 70%. Efficiencies of digesters usually are not calculated since the influent solids contain about 75% volatile solids/total solids (% VS/TS), and these are considered stabilized at 50% VS/TS. Digesters are designed to receive only the settled solids from waste water, the remaining liquid portion being discharged or subjected to further treatment; whereas, ponds are designed to receive waste water with or without the settled solids removed.

The position of the oxypause to some extent influences the classification assigned to various ponds. In Figure 5 is shown a curve based on the performance of several ponds in which the depth of the oxypause is plotted as a function of the average BOD_5 loading. The plot pertains to autumn conditions. In the summer the curve moves to the right, and in the winter it moves to the left. With use of the information in Figure 5, a designer may estimate the depth at which the oxypause will occur and the waste water treatment operator may estimate the loading required to keep the oxypause in a desired position.

Digesters in many cases have been operated for a number of years with very little trouble if they are designed, maintained, and operated properly. Ponds also have been successful in proportion to the correctness of design and to the degree of operation and maintenance applied. One common source of trouble related to design has been the use of ponds of approximately three feet in depth. Such ponds usually are loaded at low rates so that aerobic conditions initially will prevail. A result of this design is extensive growth of algae. A secondary effect is that unless the algae cells are removed in some way, their concentration becomes so great that light penetration becomes limited and their oxygen production is inhibited. When the concentration of algae becomes excessive, algal cells agglomerate and settle to the pond bottom where together with settled organic wastes they form a sludge blanket. Under these circumstances, anaerobic conditions develop and volatile organic acid formation occurs. If the pond depth is too small, methane formers are frequently inhibited as a result of any mixing such as wind action which may bring dissolved oxygen into contact with the settled sludge. Oxygen is lethal to methane bacteria and under such conditions, volatile organic acid formation continues unabated but methane conversion stops; hence, extremely foul odors result. As stated previously, if such conditions are

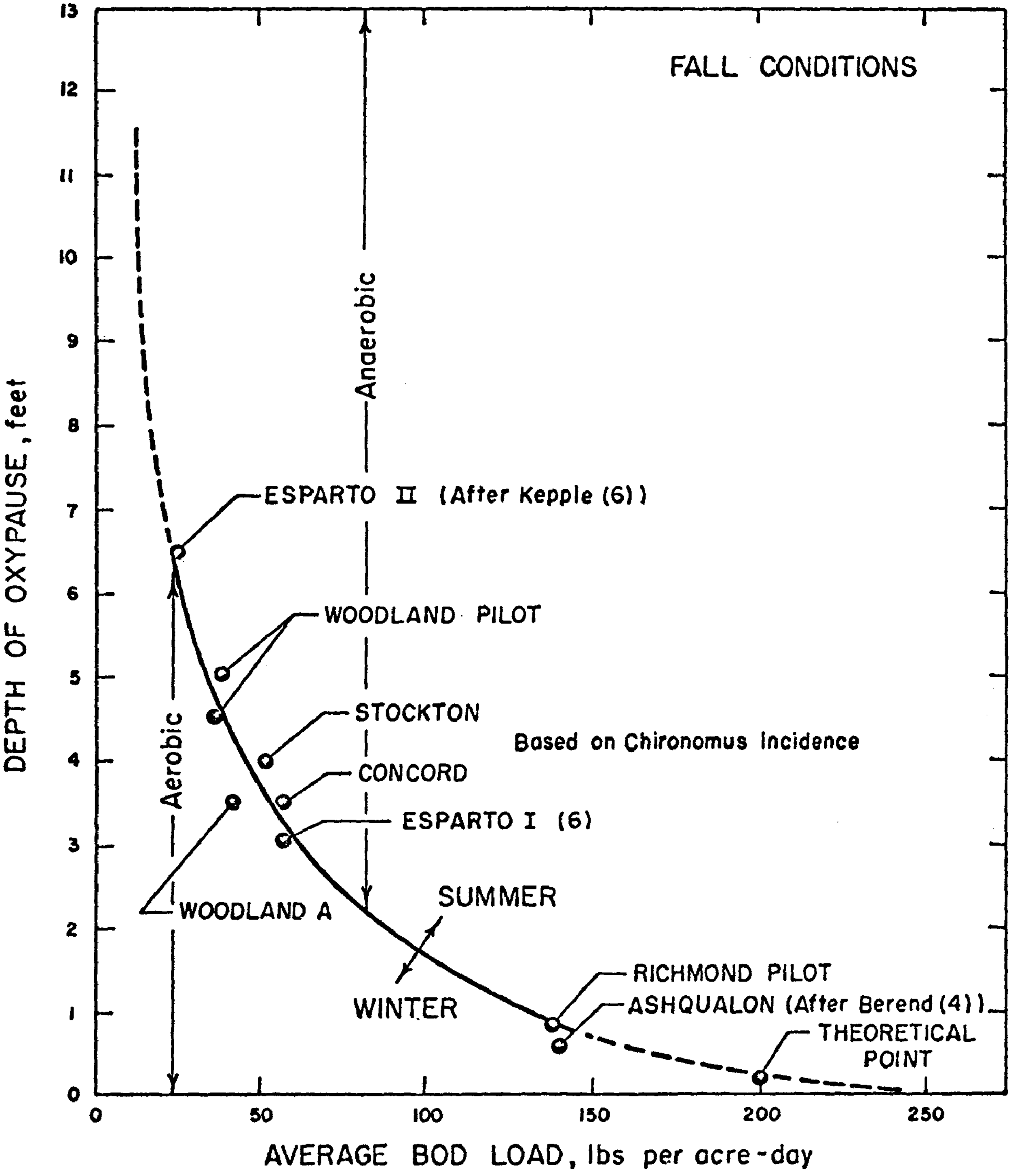

FIGURE 5. OXYPAUSE DEPTH AS A FUNCTION OF THE AVERAGE BOD LOAD

to preclude, it is imperative that some of the algae be removed continuously or that the pond contents be mixed periodically to prevent settling in which case the algae are removed with the effluent. To eliminate the foul odors so often characteristic of shallow ponds, it usually is necessary to deepen the pond if it is possible to do so to protect the sludge or to install mechanical aerators to keep the entire pond contents aerobic. The difficulties coming from shallowness can be avoided by keeping the minimum operating depth of a facultative pond at six to seven feet. On the other hand, the maximum liquid depth of an aerobic pond in which algal growth and removal is to be practiced should be about 12 inches.

Anaerobic ponds have a great waste disposal potential since they can be loaded at many times the rate normally used for conventional facultative ponds. The greatest drawback of high loading of anaerobic ponds at present is the risk of excessive odor production. Odors have been controlled in some cases by pumping liquid from an aerobic pond or aerobic portion of the pond to the surface of the anaerobic pond. The aerobic pond effluent usually is warmer than the water in the anaerobic pond, and thus tends to remain on the upper surface. The sulfide gases are oxidized in this layer, and odors from the volatile organic acids are decreased in magnitude. Purple sulfur bacteria growing on the surface of an anaerobic pond apparently tend in some cases to act as deodorizing agents, in that they oxidize reduced sulfur compounds to inorganic sulfur.

In conclusion it should be emphasized that anaerobic ponds have a great potential, but at present there is not enough information available to permit the development of a design safe from odor nuisance. Additional research should be conducted to determine the type of organic waste which can be successfully treated in anaerobic ponds. Work should also be carried out in order to establish design criteria and operating parameters with the objective of obtaining relatively trouble-free anaerobic operation. If the location of the pond is such that odors would be objectionable, it is recommended that surface aeration must be applied in amounts necessary to preclude odor or as an alternative the additional use of land for a well-designed and operated facultative pond should be considered.

RECENT DEVELOPMENTS IN ANAEROBIC WASTE TREATMENT

by

D. A. Carlson[1]

Although the conventional digester for solids stabilization has been in use in sewage treatment systems for many years, the use of anaerobic systems in waste treatment has, until recently, been a second stage operation following primary and secondary treatment under aerobic conditions. Anaerobic systems for direct in-line operation with waste waters were thought to be inefficient odor producing schemes which would not provide satisfactory BOD removal or reasonable effluent quality. However the anaerobic cultures can provide very satisfactory direct treatment under proper environmental conditions. In fact anaerobic treatment offers some very definite advantages over aerobic biological systems in that (a) the process is not restricted by the cost or rate of pumping oxygen into the stabilization system, (b) much of the energy of the incoming wastes is conserved in useful form in the production of methane gas, and (c) the problem of disposal of excess biological solids is significantly less than in aerobic systems since solids production in the anaerobic stabilization process is an order of magnitude less than that in conventional aerobic treatments such as the activated sludge process.

Feasible anaerobic treatment of wastes relatively dilute as compared with primary sludge involves the necessity of increasing the organism-substrate contact time without providing for detention of the carriage water over inordinately long time periods. For example, the conventional digester provided satisfactory stabilization over periods of months whereas feasible direct treatment of wastes streams requires detention times in the order of a day. The necessary mechanism is the utilization of much higher concentrations of very active anaerobic biota.

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[1]Professor, University of Washington, Seattle, Washington

The basic problem to the anaerobic organism is that of energy available to the cell in the organic compounds present in the incoming waste stream. The aerobic bacteria can utilize oxygen as the hydrogen acceptor in aerobic treatment and thereby realize the release of much of the energy in the compound. For example:

$$\text{glucose} + \text{oxygen} \xrightarrow[\text{activity}]{\text{bacterial metabolic}} \text{carbon dioxide} + \text{water} + \text{energy}$$

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + 686 \text{ kilocalories/mole}$$

The anaerobic bacteria must provide for oxidation-reduction in the compounds in the waste so that

$$C_6H_{12}O_6 \xrightarrow[\text{activity}]{\text{bacterial metabolic}} 3CH_4 + 3CO_2 + 47.6 \text{ kilocalories/mole}$$

The methane produced represents stored energy and burns with the evolution of 212.8 kcal/mole. The three moles of methane contain 638 kcal or 93 percent of the energy released during aerobic oxidation of the mole of glucose. In other words, to provide the necessary energy to sustain normal metabolic activity the anaerobic bacteria must stabilize $\frac{680}{47.6}$ or 14.4 times as much glucose as the aerobic bacteria to have the same amount of energy released. Looking at the ATP production from glucose, the aerobic bacteria can extract 38 moles ATP per mole of glucose while the anaerobic bacteria can develop only 2 moles of ATP per mole of glucose.

Organisms, like other living systems, have the twin purposes of using food for energy and for synthesis of new cellular material. Substrate can be shown as being divided into f_1S the fraction of substrate going to cell mass synthesis, f_2S the fraction of

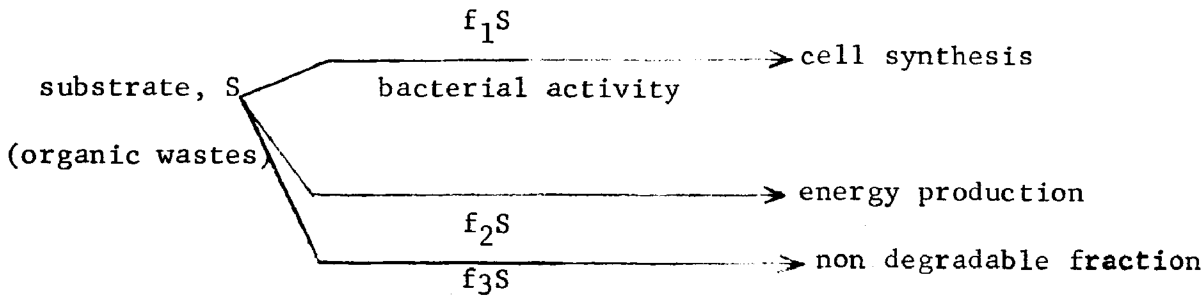

Figure 1. The Stabilization of Substrates in Waste Treatment

substrate used in energy production, and f_3S the non degradable or biologically resistant fraction which accumulates. Then $f_1S + f_2S + f_3S = S$ or $f_1 + f_2 + f_3 = 1$. If, under anaerobic conditions, the amount of substrate used for energy production must be over 14 times greater than the substrate fraction used for energy production under aerobic conditions, then the amount of substrate available for anaerobic cell synthesis must be only 7 percent of that available to the aerobic bacterial cell. Therefore the production of anaerobic cell mass must be about an order of magnitude less than the production of aerobic cells using the same substrate. The disposal of excess solids is thereby significantly reduced in anaerobic systems. (Values for f_1 in f_1S (Figure 1) in cell synthesis can be expected to be about 0.3 to 0.8 for aerobic systems and 0.02 to 0.10 for anaerobic systems.)

The Anaerobic Contact Process

Hot process waters are often an enigma for design engineers in the construction of waste treatment facilities. Anaerobic waste treatment systems, however, operate better at temperatures significantly higher than normal stream temperatures. When, in addition, the waste organics solids concentrations are in the range of a few percent rather than tenths of a percent of the weight of the total waste then processes such as the anaerobic contact process should be considered as suitable treatment methods for the stabilization of potato wastes. (Organic solids concentrations as low as 1000/ mg/l have been treated feasibly by the anaerobic contact process (1,2).)

The use of high concentrations of mixed liquor solids allows, with mixing and recycle, intimate contact of waste organics and viable organisms. Whereas in the conventional digester, there is concern over the fraction of volatile suspended solids that is actually viable cell mass, there is, in a rapid recycle of high organism concentrations, the opportunity to maintain highly viable volatile solids as compared to the conventional digester.

The anaerobic contact process is quite similar to an anaerobic activated sludge system. This contact process is used by the Wilson and Company plant at Albert Lea, Minnesota (1). The system consists of collection of the incoming waste stream in a wet well. From the wet well waste waters are heated and sent on to the digester units. An equalizing tank was provided in tandem with the wet well so that flow peaks could be spread over the 24 hour day.

In the digester the incoming warm wastes (about 90°F) are mixed with recycled solids to give a mixed liquor suspended solids concentration of 7000-12000 mg/l. Under these conditions 12 to 13 hours detention time is sufficient to give 90% BOD removal and 90% suspended solids removal. Thus with BOD loadings of about 0.15 lbs/cu ft digester/day the digesters removed 1000 to 1450 mg/l of BOD.

As described above the anaerobic contact process stabilizes wastes with the production of gases such as methane and carbon dioxide and some growth of new biological cells. The methane can be used to provide energy to the process in the form of heat by combustion. The cellular growth is essential to maintaining viability of the working biological culture.

One of the necessary considerations in an anaerobic system is the separation of the produced gases from the biomass. Often the gases formed remain as small bubbles enmeshed in the anaerobic sludge so that extrication of these bubbles can be a problem. Shear stress or vacuum pressures can be applied to the stream leaving the digester so that gaseous products can be induced to leave the biomass.

Following the degasifiers, the sludge is shunted to gravity separators where the sludge can be settled and returned to the digesters and supernatant can be routed to oxidation ponds for final polishing prior to disposal in the receiving waters.

The Anaerobic Filter

While the anaerobic contact process has been used at ambient temperatures, in the treatment of cooler wastes by anaerobic cultures, the anaerobic filter offers promise as a means of stabilizing potato wastes. Recent studies by Young and McCarty (3) and Webster and Carlson (4) indicate the feasibility of removing the COD of waste streams by anaerobic filters.

The anaerobic filter is an upflow rock filter wherein wastes are introduced at the base of a rock support system for an anaerobic culture. The culture did not attach to the stones alone but grew as discrete particles in the interstitial spaces. Since the flow is upward through the water covered rocks these sludge particles are suspended in the rock-water system as the water and gas bubbles travel upward out of the system. The solids retention time is in the order of hundreds of days; that is the solids are retained in the system for long periods of time with gradual accumulation of solids to the point where solids removal could be necessary. The filter can be operated at ambient temperatures of about 25°C to obtain COD removals of 68% at 4.5 hour detention time up to over 90% COD removal at detention times of 18 hours and greater for influent COD's of 1500 mg/l of volatile acids waste. With protein-carbohydrate synthetic wastes COD removals of 63, 84, and 97% were obtained with detention times of 4.5, 9 and 18 hours and influent COD's of 1500 mg/l (3).

Other studies with pulp mill sulfite waste liquors at 110°F and about 4 days retention time produced up to 90% BOD reductions for an initial BOD_5 of 30,000 mg/l (4). Recycle rates of 8:1 were used in 30 inch long, 6 inch diameter filters containing limestone rock media. COD reductions were about 25%. At a recycle rate of 2:1 BOD reduction was 50%. The gas generation was very high in these columns. At 110°F the gas produced created so much agitation in moving up the filter that it was difficult to maintain the culture in the column. Even at ambient room temperature the gas production rate was 0.5 liter per hour in this filter containing 9.6 liters of liquor.

In the initial stages of stabilization relatively high concentrations of sulfur dioxide were produced along with dimethyl mercaptan. But after the acclimation period the sulfur dioxide production diminished and hydrogen sulfide and methane became large fractions of the gas produced. In this more stable phase of activity the pH stayed in the range of 6.5 to 7.

Two basic cultures developed in the filter during the stabilization period. During production of SO_2, a black culture was dominant in the rock interstices while at the foam level at the top of the column a white culture was in evidence. As the sulfur dioxide concentration diminished the white colony moved further down into the interstices between the limestone rocks. Photomicrographs showed long bacterial rods as the dominant fraction of the black cultures. The white culture appeared as a mixture of larger yeastlike organisms interspersed with the bacterial cells. Under stable stabilization activity the white culture penetrated throughout the filter.

This study indicated that soluble wastes such as sulfite waste liquors are amenable to treatment on anaerobic filters. The effective filter length seems to about two to three feet of rock support system.

Since the anaerobic filter will lend itself to soluble or colloidal wastes, the potato wastes should be treatable on the anaerobic filter. These rock filters should provide a relatively simple treatment system for biodegradation of potato waste streams and deserve further laboratory and pilot plant research to determine the feasibility of application to field installations. The prospects of a relatively simple process with adequate gas stripping and odor control may be quite attractive to industry.

Odor Control

The anaerobic processes have the problem of producing odors which could be objectionable to persons living in the vicinity of the treatment facility. Recent studies on soil filters, however, indicate that the soil can selectively remove the polar gases from exhaust gas streams while allowing methane to pass through the soil filter with little or no loss. The soil filter provides complete removal of hydrogen sulfide within less than a foot of soil depth. Current studies indicate that the soil removal capacity is a function of the bacterial population, the physiochemical properties of the soil, and the oxygen and moisture content of the system (5,6).

Soil capacity for removal of hydrogen sulfide is enhanced by gas concentration, the presence of oxygen and the leaching of sulfates by flow through moisture. Soil capacities for hydrogen sulfide removal in bath feed systems have been shown experimentally for forest humus soils to be from 0.04 pound of H_2S per cubic foot of soil at an H_2S concentration of 1000 mg/l to 2.45 pounds of H_2S per cubic foot of soil at an H_2S concentration of 100,000 mg/l (7). On a flow through basis at a rate of 10% H_2S in an air flow of 2540 $ml/min/ft^2$ soil column, Lynden loam soil capacity has been shown to be 0.3 lb of H_2S per square foot of soil 6 inches deep (5). In addition the soil sulfidation capacity can be rejuvenated at least 5 times so that total soil capacity is 1.5 lb H_2S per square foot of 6 inches deep soil or 3 lb H_2S per cubic foot of soil. Capacity of the soil was reached when the exhaust H_2S concentration reached 5% of the incoming H_2S concentration.

Pumping stations on Mercer Island, Washington, previously plagued by odor problems, have been operating for over 5 years using soil filters as the odor control mechanisms. The soil filter appears to be a useful means of removing odors from gas streams.

Summary

The anaerobic contact process and the anaerobic filter offer promise as prospective treatment facilities for stabilization of wastes from potato processing. These treatment methods deserve further research in on-line operation in potato processing plants. Degasifiers and odor control systems should be portions of the research receiving special attention so that laboratory and pilot studies can be adapted to satisfactory field installations.

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PILOT PLANT STUDIES ON SECONDARY TREATMENT OF POTATO PROCESSING WASTES

by

Kenneth A. Dostal[1]

As most of you present today know, potato processing in Idaho has had a rapid expansion during the past 15 years. The $23,000,000 payroll and $52,000,000 plant investment by the 11 members of the Potato Processors of Idaho Association in 1965-66 represent growth of more than 10 times that of comparable 1950 figures (1). Unfortunately, waste production has also kept pace with this expansion.

The Idaho State Health Department has worked, and is working, closely with the Processors in the development of effective waste treatment methods. As a result of past cooperative efforts, all major potato processing plants presently discharging into the Snake River or its tributaries now provide primary treatment of their waste stream. But even with primary treatment, these waste combined with others have resulted in fishkills and other pollutional problems during periods of low flow in the Snake River. The Processors are now faced with the problem of providing secondary treatment of their wastes.

In 1964, the consulting firm of Cornell, Howland, Hayes & Merryfield was retained by the Engineering Committee of the Potato Processors of Idaho Association to assist in the design and operation of pilot plant facilities. These facilities were used to check the feasibility of several secondary treatment systems. During 1965 and 1966, the pilot plants located at the J. R. Simplot Co.'s waste treatment plant in Burley, Idaho, were operated and enough data gathered to allow establishment of design criteria for trickling filter, activated sludge and conventional stabilization ponds. One of the conclusions from this work was: "Additional study should be given anaerobic ponds and flow-through aeration basins to more closely determine the capabilities of these systems in secondary treatment of potato process water." (2)

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In July 1966, the Northwest Regional Office of the Federal Water Pollution Control Administration (FWPCA) received a request for technical assistance from the Idaho State Health Department. The request was for assistance to the Engineering Committee to aid in data collection and analysis for the development of design criteria for anaerobic ponds and surface-aerated aeration basins. The Technical Projects Branch of the FWPCA located in the Pacific Northwest Water Laboratory in Corvallis, Oregon, was assigned responsibility for the study since this was a logical extension of a previously authorized study on aerated lagoon treatment of food processing wastes. A memorandum of understanding was drawn up and signed by the three participating groups: Potato Processors of Idaho, Idaho State Health Department, and Technical Projects, FWPCA.

The objective of the study was the completion of pilot plant studies of secondary treatment of potato processing wastes. Specifically, the two methods of treatment to be investigated were an anaerobic lagoon followed in series by a surface-aerated, aerobic lagoon and secondly, a surface-aerated aerobic lagoon.

Federal authorization for this type of study comes from the Federal Water Pollution Control Act, as amended. Section 5(b) of the Act provides that the FWPCA may, "... upon request of any State water pollution control agency, conduct investigations ... concerning any specific problem of water pollution confronting any ... industrial plant, with a view to recommending a solution of such problem."

Description of Processing Plants

The Simplot Burley Processing Company processes about 75,000 tons of potatoes per year. It is a highly automated processing plant and produces instant mashed potatoes and related specialties. The potatoes are washed, lye peeled, cut, automatically sorted for flakes or granules, dehydrated, and packed for shipment. Water use is about 1.2 mgd.

The J. R. Simplot Heyburn plant is one of the largest potato processing plants in the world. It processes approximately 180,000 tons per year. Products include french fries, potato specialties, and potato starch. Here, too, the potatoes are washed and lye peeled; then trimmed, blanched, processed, and packed. Water use totals about 5.0 mgd.

Table 1 presents average figures for waste production per ton of potatoes processed as measured during the 1966-67 processing season. These figures are based on the combined waste and total potato production at both plants, but they do not include fat recovered or solids screened out for cattle feed.

Table 1

Waste Production per Ton of Raw Potatoes

Parameter	
BOD_5	92 lbs.
COD_s	208 lbs.
TVS (Total Volatile Solids)	165 lbs.
SS (Suspended Solids)	106 lbs.
SVS (Suspended Volatile Solids)	105 lbs.
Process Water	4,170 gal.

About 4200 gallons of water were used per ton of potatoes processed. The raw waste from the plant contained 92 pounds of five-day Biochemical Oxygen Demand (BOD), 208 pounds of Chemical Oxygen Demand (COD), and 106 pounds of suspended solids per ton. It should be mentioned that these values were higher than those measured during previous processing seasons.

Waste Treatment Plant

Waste streams from both potato processing plants are piped to a primary waste treatment plant. They first enter a receiving tank and are passed through two 5-foot diameter, 10-foot long rotary drum screens. All solids retained on the +20 mesh screens are stored in bins.

The remaining waste water then enters a 100-foot diameter clarifier with an overflow rate of about 800 gallons per day per square foot. Additional solids settle out in the clarifier and the overflow passes through a Parshall flume and is discharged to the Snake River.

The solids collected from the clarifier are pumped through a centrifuge. Resulting sludge is stored in bins and the centrate is either returned to the clarifier or discharged to the river.

The screenings and the sludge from the centrifuge are trucked to a cattle feed-lot operation for use as part of the animals' diet.

During the last (1966-67) processing season, the primary clarifier effluent had the characteristics shown in Table 2. The pH ranged from 7.1 to 11.6 with a median of 10.4. Temperature, which is quite important when designing any biological treatment process, averaged 74° Fahrenheit. Standard Methods COD ranged from 2500-6000 and averaged 3400 mg/l. The five-day BOD averaged 1680 mg/l and the suspended solids averaged 740 mg/l.

Table 2

Characteristics of Primary Clarifier Effluent

Parameter	Range	Mean
pH	7.1-11.6	--
Temp. °F	63-79	74
COD_s, mg/l	2520-6000	3400
BOD_5, mg/l	1180-2080	1680
SS, mg/l	90-3190	740

Pilot Plants

The pilot plant facility of the Potato Processors is located at the primary waste treatment plant in Burley, Idaho. Three sealed earthen ponds with ancillary pumps and piping make up the facility. Each pond is 40 feet square at the water surface and about 10 feet deep in the center. With side slopes of 3 to 1, each pond has a capacity of about 50,000 gallons.

The flow diagram of the pilot plant facilities is shown on Figure 1. Operation of the three pilot lagoons can be broken down into three periods. From September through December 1966, ponds II and III were operated as covered anaerobic units while awaiting

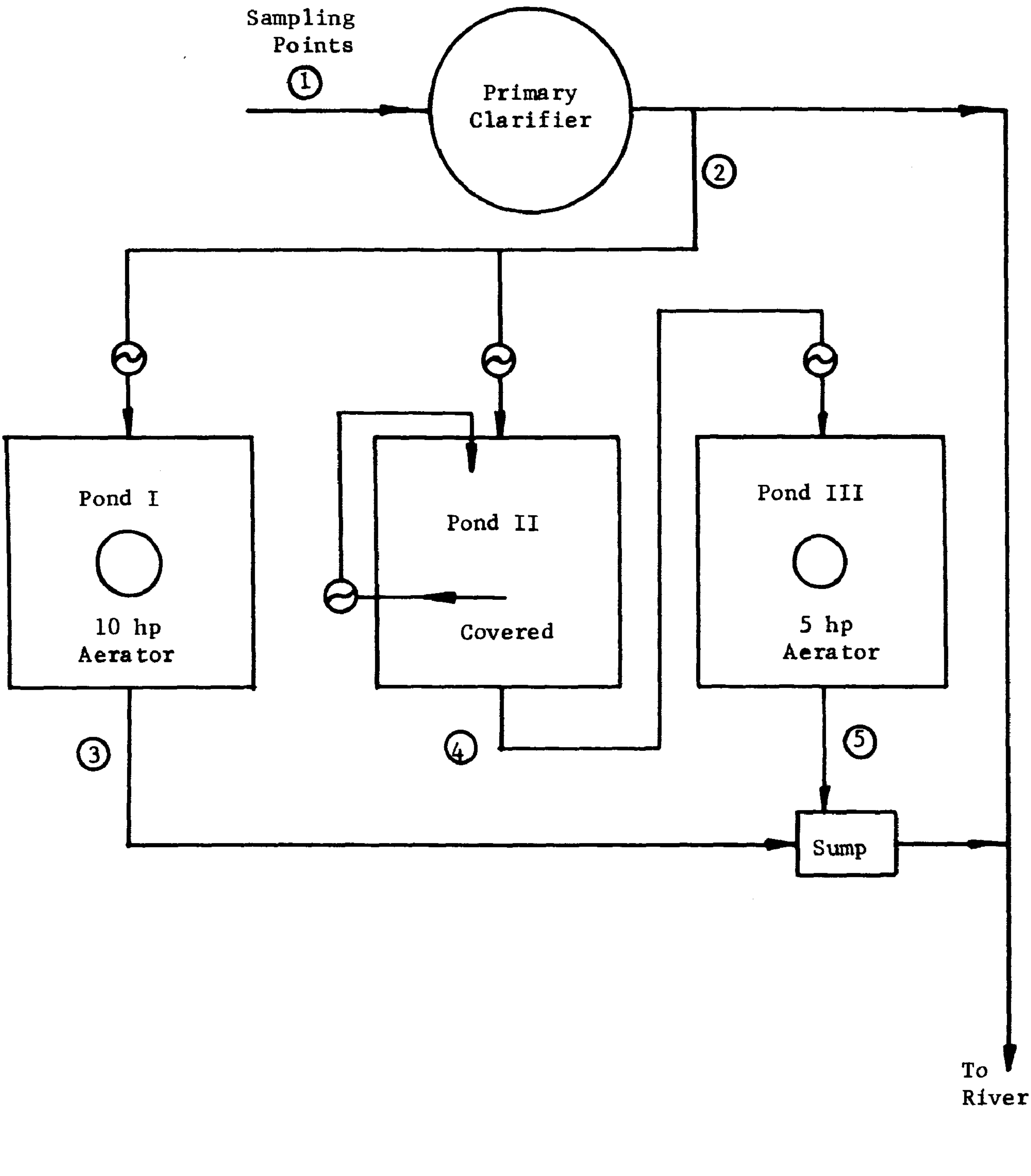

Figure 1 FLOW DIAGRAM OF PILOT PLANTS

delivery of two surface aerators. From January 1967, to the end of processing last spring, ponds II and III were used in series. Pond II continued as a covered anaerobic pond and pond III was an aerobic cell containing a 5 hp floating surface aerator. During the current (1967-68) processing season all three ponds are being used. Ponds II and III are being operated the same as last spring. Pond I contains a 10 hp surface surface aerator and is receiving clarifier overflow. Thus far this season, pond I has been fed at one-half the rate of pond II so that the detention time in pond I will be equal to the sum of the detention times in ponds II and III. By varying the hydraulic and organic loads on these two systems it is hoped that sufficient data will be accumulated to design an economic system.

Last season eight-hour composite samples were taken of the clarifier influent and overflow, and grab samples of the pond effluents. This processing season all samples are eight-hour composites. The samples are split and then shipped by bus in iced containers to the Idaho State Health Department laboratory and to the laboratory in Corvallis.

Most of the analyses are performed according to the 12th edition of Standard Methods. The tests included: pH, temperature, alkalinity, SS, VSS, TS, TVS, D.O., COD_s, National Canner's Association modified COD_m, BOD_5, Total Organic Carbon (TOC), Soluble Organic Carbon (SOC), volatile acids, total and ortho phosphate, nitrite, nitrate, ammonia, and total Kjeldahl nitrogen.

Results

During the first period of operation when both ponds were operated as parallel anaerobic ponds they were fed at rates which resulted in theoretical detention times of 20 and 4 days for ponds II and III, respectively. The contents of neither pond was mixed and judging by the data obtained both ponds experienced detention times well below theoretical. Table 3 presents a brief summary of some of the data collected during this period of operation. As shown, both the pH and temperatures measured in the effluents were very similar. The five day BOD was reduced from 1490 mg/l to 1160 mg/l or 22 percent by pond II. Across pond III the BOD reduction averaged 17 percent. Standard Methods COD reduction by both ponds averaged about 6 percent higher than the BOD reductions shown here. NCA COD reduction was markedly higher; 76 percent for pond II and

71 percent for pond III. Although organic reductions as measured by COD_s and BOD were low, the COD_m test shows that the molecular structure of some of the organics was being altered. Suspended solids were reduced by 62 percent in pond II and 56 percent in pond III. Since greater than 95 percent of the suspended solids entering the ponds was volatile, much of the COD_s, and BOD reductions shown here could be attributed to SS sedimentation within the ponds. This was demonstrated in earlier work; when the temperatures were cold, good removals were measured, but as the sludge temperature started to rise in the spring, increased biological breakdown of the sludge resulted in an effluent worse than the influent in many cases.

Table 3

Summary of Anaerobic Pond Operation

Parameter	Influent to ponds	Pond II[a] Effluent	Pond III[b] Effluent
pH range	10.3-11.8	6.3-7.0	5.8-7.1
Temp. range, °F	65-77	60-68	61-69
BOD_5, mg/l	1490	1160 (22)[c]	1240 (17)
COD_m, mg/l	2380	570 (76)	700 (71)
SS, mg/l	950	360 (62)	420 (56)

(a) Pond II - detention time = 20 days
(b) Pond III - detention time = 4 days
(c) Percent reduction

The second period of operation when anaerobic pond II was followed by aerobic pond III has been covered by a progress report, copies of which are available. Today I'll briefly summarize some of the high points. As a result of work which had been done earlier on the anaerobic ponds a pump was installed on anaerobic pond II to mix the contents. When this study period was stopped, no sludge layer was found on the bottom--it operated as a complete-mixed pond.

During this period, the two ponds in series were operated at three different hydraulic loadings as shown in Table 4. Initially both ponds were fed at a rate of 4 gpm which resulted in detention times of 8.8 days each or 17.5 for the two ponds in series. The rate was then increased to give a detention time of 5 days in each pond and finally 2.4 days each. Average temperatures in the anaerobic pond ranged from 62 to 71°F at these three hydraulic loadings and from 42 to 53°F at the aerobic pond. Daily temperatures were as low as 32°F in the aerobic pond with some ice formation around the edges.

Table 4

Pilot Plant Feed Rates

	Anaerobic Pond II		Aerobic Pond III	
Date-1967	gpm	days	gpm	days
2-23 to 3-20	4.0	8.8	4.0	8.8
3-20 to 4-23	7.0	5.0	7.0	5.0
4-30 to 5-27	15.0	2.4	15.0	2.4

No attempt was made to hold the volatile acids or the ratio of volatile acids to alkalinity below any set values in the anaerobic lagoon. The volatile acids concentration ranged from 600 to 3500 mg/l and the ratio ranged from 0.5 to 3.5. It has been reported(3) that a volatile acids: alkalinity ratio above 0.8 is inhibitory to methane production in anaerobic digestion. The aim in this study was not complete digestion of the wastes, but hopefully an alternation of the organic material to forms which might be more rapidly treated aerobically.

Table 5 presents a summary of the organic loadings and the SS, COD, and BOD reductions for the three different levels of hydraulic loading. At the first level both ponds had a detention time of 8.8 days and a BOD loading of about 10 lbs/day/1000 cu. ft. The anaerobic pond reduced the suspended solids by 82 percent, COD by 33 percent, and BOD by an average of 25 percent. The aerobic pond, which was fed the effluent from the anaerobic pond, reduced the incoming COD by 49 percent and the BOD by 88 percent. Due to the buildup in microorganisms, the suspended solids increased by 230 percent upon passage through the aerobic lagoon. The overall reductions shown are the averages obtained across the primary clarifier plus the anaerobic pond plus the aerobic pond. Although the suspended solids were only reduced 74 percent, the BOD was reduced by 95 percent. Again, it should be pointed out that both the anaerobic and aerobic ponds were complete-mixed units and these reductions are based on the effluents with all solids remaining.

Table 5

BOD Loadings and Pilot Plant Efficiencies

	Detention Time Days	BOD Loading lbs/day 1000 ft^3	Reduction - %		
			SS	COD_S	BOD
Anaerobic pond	8.8	11	82	33	25
Aerobic pond	8.8	8	-230	49	88
Overall			74	73	95
Anaerobic pond	5	22	35	15	12
Aerobic pond	5	20	-75	58	87
Overall			66	82	94
Anaerobic pond	2.4	46	52	15	13
Aerobic pond	2.4	40	-226	28	64
Overall			51	68	81

After reducing the detention times to 5 days in each pond, the BOD loading doubled to about 20 lbs/day/1000 cu. ft. on each pond. Reductions by the anaerobic pond dropped to slightly less than one-half the values measured at the lower loading. The suspended solids increase in the aerobic pond was less, 75 percent compared to 230 percent, whereas the BOD reduction was the same and the COD reduction slightly higher. Overall reduction was 8 percent lower for suspended solids, 9 percent higher for COD, and similar for BOD.

Increasing the hydraulic loading from 7 to 15 gpm reduced the detention time from 5.0 to 2.4 days. The BOD loading on the anaerobic pond averaged 46 lbs/day/1000 cu. ft. and on the aerobic pond 40. Suspended solids reduction in the anaerobic pond increased, but this was due to the fact that the influent had a higher suspended solids concentration. Both the COD and BOD reductions remained the same. Through the aerobic pond, both the COD and BOD reduction fell off significantly; COD from 58 to 28 percent and BOD from 87 to 64 percent. Total reductions across the clarifier plus both ponds were lower for all three parameters.

As mentioned earlier, this processing season all three ponds are being utilized. The anaerobic pond and the aerobic pond in series are being run at about the same loadings as last year. The third pond with a 10 hp aerator is being operated in parallel with a detention time equal to the sum of the detention times in the anaerobic pond and aerobic pond. These two systems will be operated until the end of processing this spring.

Thus far, the two ponds in series have been functioning similar to last year. The parallel aerobic pond has reduced the BOD to the same levels as the two ponds in series. This is shown in Figure 2. The horizontal scale is the total BOD in the effluent, including all SS. The left-hand scale is the detention time in aerobic pond III. This pond receives the effluent from the anaerobic pond, so the total detention time through both ponds would be twice the values shown here or the same scale as shown for the parallel aerobic pond on the right-hand side.

The circles represent averages from last year for the two ponds in series. Squares are averages from this year's data for the two ponds in series. The triangles represent the data collected this year on the all aerobic system, pond I. If these points can all be adequately described by a single curve, and this appears to be the case, then the anaerobic pond is accomplishing as much as would be accomplished by an added increase in detention time in an aerobic system such as pond I.

This figure ignores several things such as varying influent strength and different average operating temperatures but it is useful. Even though the BOD reduction across the anaerobic pond at any given detention time is not equivalent to the reduction that could be obtained across an aerobic system with the same detention period, there are evidently changes in the waste characteristics upon passage through the anaerobic pond which makes the effluent more treatable aerobically.

Preliminary Cost Estimate

The data collected thus far was used to make some rough cost estimates to see if a combination anaerobic-aerobic system might result in lower total annual charges than an all aerobic system. The following assumptions and prices were used to develop the cost estimates.

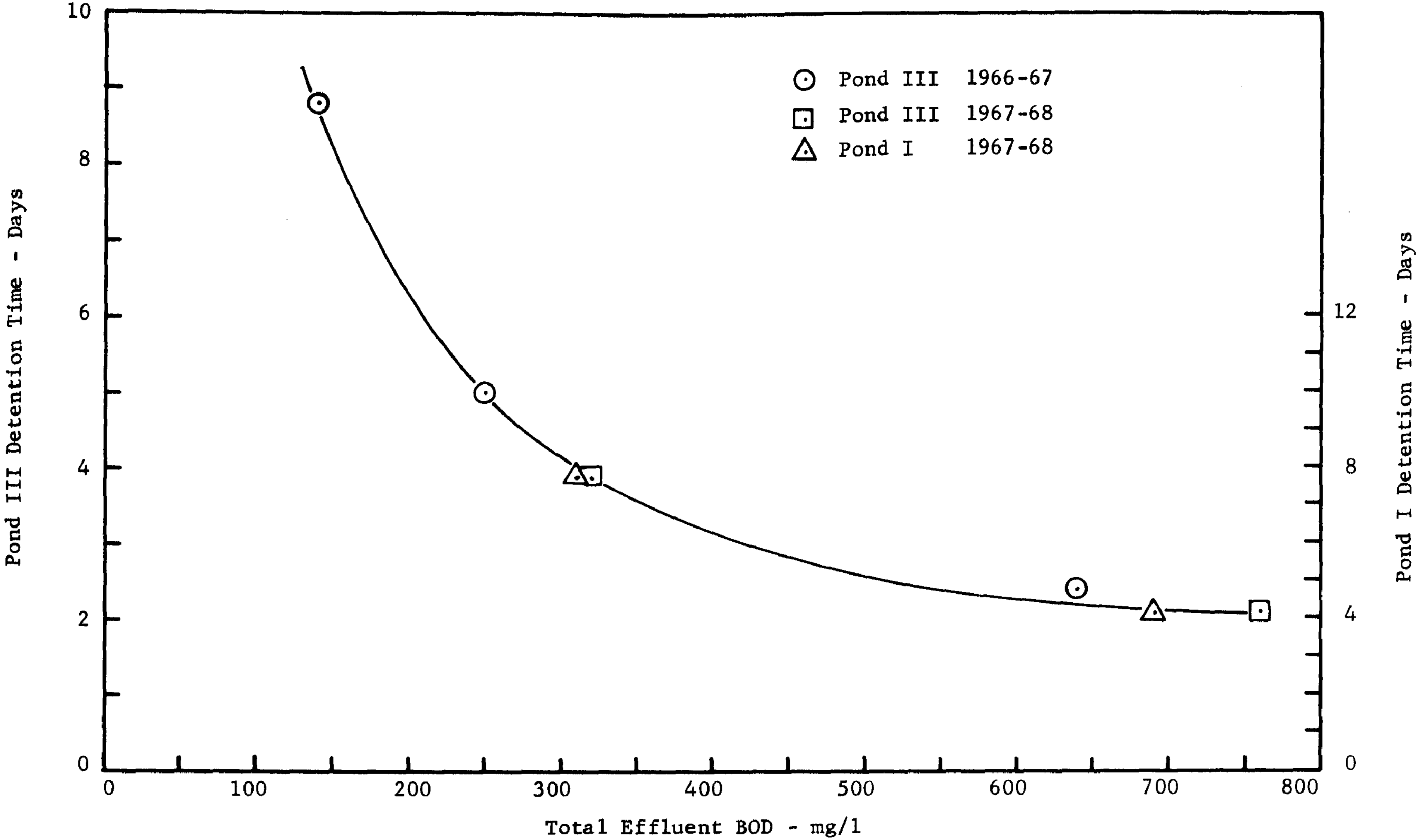

Figure 2 INFLUENCE OF DETENTION TIME ON EFFLUENT BOD

1. BOD of clarifier influent = 2700 mg/l.

2. BOD of clarifier effluent = 1700 mg/l. (Thirty-seven percent reduction by clarifier.)

3. Overall BOD_5 reduction = 90% (effluent BOD = 270 mg/l).

4. Aerators installed at $500/HP (amortized across 10 years at 6 percent).

5. Cost of aerator maintenance at 2%/year of installed cost.

6. Aerators add 2 lbs O_2/HP-hr.

7. Oxygen requirements of waste = 1.2 lbs/lb BOD applied.

8. Power costs $0.01/KW-hr.

9. Total land costs based on $1000/acre of lagoon surface (yearly cost of 6%).

10. Aerobic ponds installed (lined) at $10,000/acre (10 years - 6%).

11. Anaerobic ponds installed (lined, covered, and mixed) at $16,000/acre (10 years - 6%).

12. Waste plant operates 300 days/year, 24 hours/day.

A series of annual charges were calculated using these assumptions for various combinations of anaerobic-aerobic loadings to achieve the effluent BOD_5 concentration of 270 mg/l. Other costs were assumed to remain relatively constant for a given size plant regardless of type of treatment used. On Figure 3 is shown the annual charges in $1,000/yr/mgd treated. Any combination of anaerobic reduction and aerobic reduction, shown directly opposite will reduce the BOD from 1700 to 270 mg/l. Arriving at the desired endpoint by aerobic ponds only (84% reduction) results in a cost of about $48,000/year per mgd treated, whereas, anaerobic ponds removing 35% of its influent BOD followed by aerobic ponds reducing it to 270 mg/l results in a cost of about $39,000. The important point from this preliminary analysis is that a combination anaerobic-aerobic system appears at this time to result in an overall cost lower than either of them separately. This is true despite the relatively poor BOD removals obtained by the anaerobic pond and the higher installed cost of anaerobic ponds.

Discussion

The pilot plant study on secondary treatment of potato processing wastes is being continued during the 1967-68 processing season. Due to the late arrival of the 5 hp aerator the anaerobic-aerobic lagoons in series were only operated about one-half of the 1966-67 season. The 10 hp aerator for the third lagoon did not arrive until the end of last processing season.

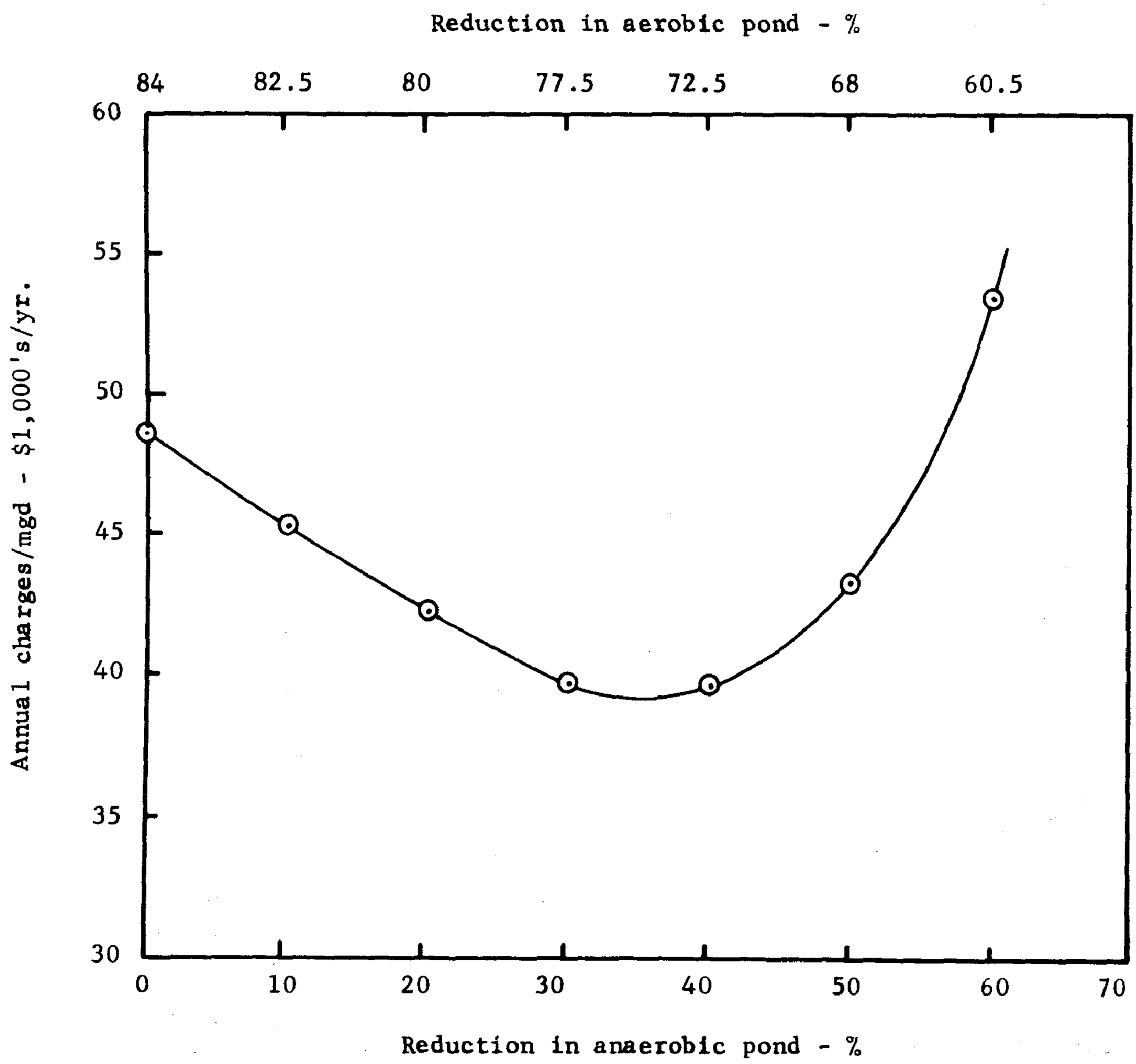

Figure 3 PRELIMINARY ESTIMATE OF ANNUAL CHARGES

Based on the data collected thus far, a BOD_5 reduction of at least 90 percent is feasible with primary clarification followed by anaerobic and aerobic ponds in series. Preliminary findings indicate that loading rates in the range of 10 to 20 pounds of BOD_5 per 1000 cu. ft./day can be applied to the lagoons to achieve the desired removals. The BOD_5 removal varied from 12 to 25 percent across the anaerobic pond and from 87 to 88 percent across the aerated pond at these loading rates. Efficiencies across the anaerobic-aerobic ponds in series ranged from 88 to 91 percent BOD removal. Coupled with an average of 40 percent removal by the primary plant, this results in a total BOD removal in excess of 90 percent.

Based on last season's data, the combination of high BOD removals with substantial increases in suspended solids across the aerobic lagoon indicate that inorganic nutrient levels were not limiting to growth of required organisms to accomplish treatment. As a result of this solids increase, the overall suspended solids reduction was relatively poor--ranging from 50 to 75 percent. In order to increase the suspended solids reduction to 90 percent or higher, secondary clarification will be needed. This should also increase overall BOD removals.

A volatile acids: alkalinity ratio above 0.8 did not seem to affect the removals in the anaerobic pond. Short detention times and fluctuating loading conditions contributed to the inhibition of methane production. The purpose of the anaerobic cell was to carry out the first stage of anaerobic fermentation and hydrolize some of the more complex organics to simpler forms more amenable to aeration. The effectiveness of this cell cannot be evaluated until all the results from the parallel aerobic lagoon study are obtained. Mixing the contents and covering the anaerobic pond with styrofoam did, however, increase its effectiveness by holding the temperature drop to a minimum and preventing sludge deposits from accumulating in the pond.

Foaming in the aerated cell has been an intermittent problem. At the small scale of the pilot lagoons it is not a major nuisance, but a full-scale lagoon may require some means of preventing foaming.

The cost analysis presented is based on rough assumptions and the annual charges derived from it are subject to gross adjustment. The figures do, however, provide an idea of the relative weight to be applied to removals in the anaerobic or aerated cells.

This processing season should provide the necessary pilot plant data for formulation of design parameters for lagooning potato wastes.

Preliminary conclusions drawn from the information gathered during this period include:

1. The BOD_5 in potato wastes can be reduced by greater than 90 percent by primary clarification plus anaerobic-aerobic lagoons in series.
2. Mixing of the contents of the anaerobic lagoon appears necessary for proper operation of the anaerobic-aerobic system.
3. Covering the anaerobic lagoon will reduce the temperature drop and help control odors.
4. Secondary clarification for removal of suspended solids will be required following an aerobic lagoon.
5. Foaming may cause operation difficulties in full-scale aerobic lagoons, but can be controlled by proper design.
6. Preliminary cost estimates show that a combination of anaerobic-aerobic lagoons may result in a lower cost than either anaerobic or aerobic treatment separately.

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OTHER TREATMENT METHODS FOR POTATO WASTES

by

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The potato processing industry in the Pacific Northwest has for several years been gathering and developing information for use in the design of effluent treatment processes. During these years, we have learned much about potato process effluents and their treatability by most conventional and some unconventional means. No panacea has been found from the standpoints of cost, end-product, odor, noise, etc. It would be a tragic mistake to now discontinue the search for better processes and process modifications; however, it appears that in some cases time has run out and current knowledge and technology must be applied to solve severe pollution problems.

This paper considers knowledge currently available or being developed which is applicable to the design of activated sludge and biological filtration processes. The tube settler technique for removal of suspended solids from effluent flows is also discussed.

Activated Sludge

The homogenous activated sludge process in its various forms has probably received as much study regarding its applicability to the treatment of potato process effluents as any other biological process. This process has been widly applied to a great variety of wastes with success. The general conclusion of these studies has been that the activated sludge process is capable of producing a high quality effluent.

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It is logical that this process was the first selected by the U. S. Department of Interior for research on and development of processes applicable to the secondary treatment of potato process effluents. The activated sludge research and development plant currently under design for the R. T. French Company of Shelley, Idaho will demonstrate the full-scale performance of the activated sludge process; locate deficiencies and, we hope, remedy these deficiencies; develop more complete design criteria; and establish capital and operating cost data.

Figure 1 is a preliminary perspective view of the R. T. French system. Table 1 lists the pertinent criteria used in the design of the biological treatment facilities. The proposed system is being designed to accommodate an average daily flow of 1.25 mgd, including both lye peel process water and silt water flows.

The 16-foot deep aeration basins will be of earthen construction with interior embankment slopes of two horizontal to one vertical. The basins will be lined with plastic or rubber sheet because of local soil conditions and anticipated erosion. Influent may be discharged to either one or both basins through submerged header systems. Recycled sludge will be returned to the basins through separate lines. Effluent will be removed through outlet boxes along one side of each basin. Inlet and outlet arrangements are being designed to assist in making the aeration basin contents as homogeneous as possible. Floating mechanical surface aerators will be used to enable repositioning of the oxygen supply and mixing sources as required to meet operational and testing needs.

The secondary clarifier will be of conventional design. The sludge removal mechanism will be a multiple-port hydraulic device to enable rapid sludge removal and operation at high recirculation rates.

An aerobic digester will be used to further stabilize the waste activated sludge prior to its disposal to a mechanical clarifier-thickener, along with the plant silt water. The digester will have a concrete ring wall to 4 feet below the water surface. The earthen slope from the bottom of the ring wall will terminate at the 12-foot water depth. A self-cleaning tube settler will be used to concentrate the waste activated sludge within the aerobic digester, reducing the required digester volume five times.

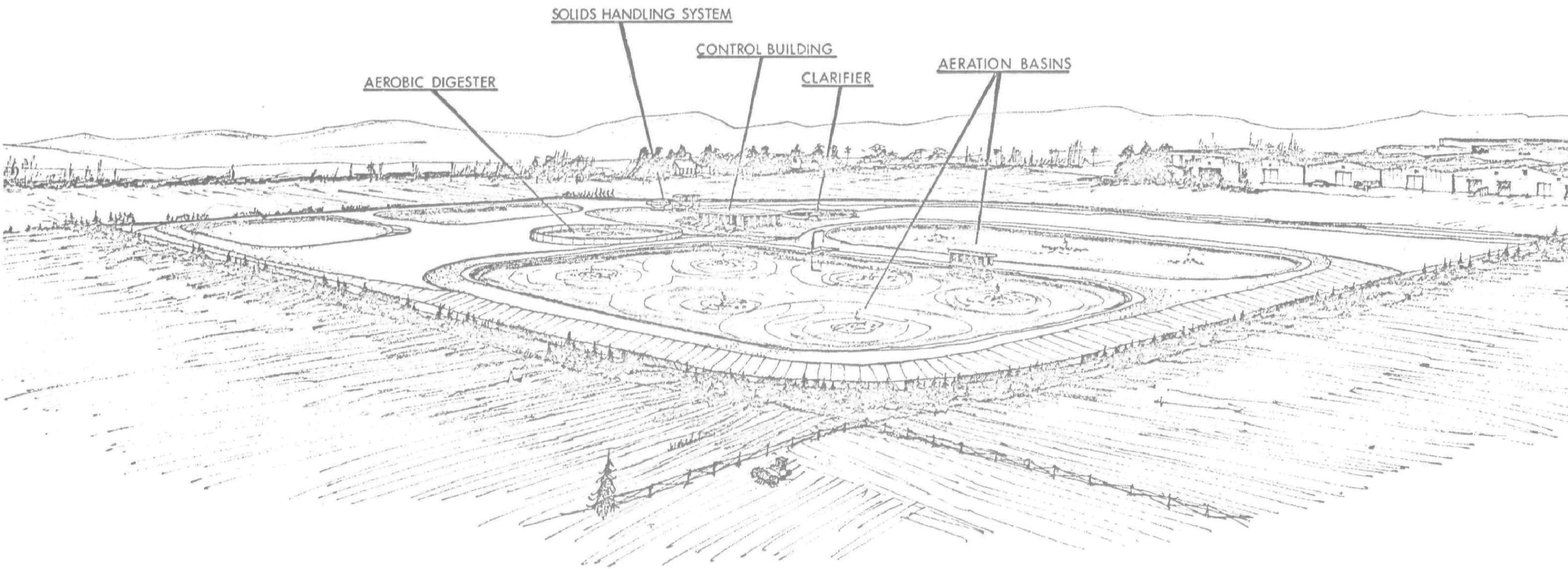

FIGURE 1

R.T. FRENCH COMPANY
SHELLY, IDAHO
PERSPECTIVE VIEW

PROPOSED TREATMENT SYSTEM

CORNELL, HOWLAND, HAYES & MERRYFIELD
SEATTLE CORVALLIS BOISE

CH2M

Table 1

R. T. French Company
Shelley, Idaho
General Design Criteria
Proposed Activated Sludge System

Item	Criteria
Aeration Basins	
Basin No. 1 detention time	24 hrs.
Basin No. 2 detention time	48 hrs.
Total detention time in parallel	72 hrs.
BOD Loading (lbs/lb. mlvss*)	
Basins 1 and 2 at 4,000 mg/l mlss	0.13
Basin 1 only at 2,000 mg/l mlss	0.80
Equipment	Floating - pump type mechanical surface aerators
Clarifier	
Surface overflow rate (gal./ft./day)	650
Detention time	1.17 hr.
Max. recirculation ratio	0.7
Mechanism type	Multiple port hydraulic suction
Aerobic Digester	
Solids content	2%
Thickening equipment	Tube settlers
Tube settler overflow rate (gal./ft.^{2}/min.)	0.50
Aeration device	Mechanical
Total solids age**	15-25 days

* Mixed liquor volatile suspended solids
** Includes sludge age in aeration basins

Digested or undigested waste activated sludge will be pumped to the mechanical silt water system. The waste sludge will be settled, thickened, and hauled to the disposal with the silt. Clarified liquid from the silt water system will be discharged to the aeration basin influent.

The treatment facilities are scheduled for start-up in September, 1968. Data will be collected throughout the 1968-69 campaign. The data collected is to be analyzed and placed in the final report form prior to 31 December 1969. It is anticipated that the most difficult problems to be encountered during the research and development program will be related to cold weather and solids dewatering and disposal.

Biological Filtration

Biological filters are classified according to the applied hydraulic and organic loadings. On this basis there are three general classifications: low-rate filters, high-rate filters, and super-rate filters. In general, as organic loadings are increased on biological filters, the BOD removal efficiency decreases.

Low-rate and high-rate filters generally use rock media, while a prefabricated plastic, tile, or wood media with controlled configuration is generally used in the construction of super-rate filters. Because of the extremely large volume of filter media needed and consequent cost of the media and support structure required, low-rate and high-rate filters have not found much acceptance in the treatment of high-strength, high-volume industrial wastes. Approximately 20 cubic feet of rock media per pound per day of BOD applied is required in the high-rate filter system.

The super-rate filter is capable of assimilating much more organic matter per unit volume of media than is a conventional rock-filled, high-rate filter. This greater capacity is due in part to the greater surface area per unit of filter volume. In addition, the high-rate filter process often employes recirculation of the underflow from the secondary clarification system. This tends to maintain a high biological solids content within the liquid flow through the filter and the clarification system which follows. As a result, the high-rate filter system is somewhat related to the activated sludge process. Design of a super rate biological filtration system must be based on knowledge of both activated sludge and biological filtration processes, and with the realization that, at present, treatment efficiency cannot be accurately predicted without prior pilot plant study.

Pilot plant data using the Dow Surfpac media on lye peel process effluent(1) indicates that it is possible to remove approximately 300 pounds of BOD_5 per day per 1,000 cubic feet of media volume at BOD_5 loadings of between 400 and 1,000 pounds per 1,000 cubic feet of media. The BOD_5 removal indicated includes that obtained in secondary clarification. Efficiencies experienced in the treatment of food processing effluents have generally been greater than those experienced on other substrates. No valid relationship was established between percent BOD removal through the filter and recycle rate during the subject pilot plant study. Chipperfield (2) reports that above a minimum hydraulic loading, which he refers to as the "minimum wetting rate," BOD removal is not enhanced but is actually decreased somewhat. Germain(3) has theorized that when treating domestic wastes the BOD removal efficiency is not increased with increased recirculation rates since the detention time within the filter on each pass is proportionally lower with the number of passes. Disagreement still exists on the role of recirculation in BOD removal efficiency and systems designed should provide substantial flexibility in recirculation capability for this reason. Recirculation should be sufficient to reduce the pH of lye peel effluents below 8.5 prior to discharge onto the filter.

Presently, there are numerous manufacturers of prefabricated super-rate filter media. To this author's knowledge, no good comparisons of the various materials available have been made to date. Any comparison should include BOD removal efficiency, depth to which media is self-supporting, estimated service life of the media, the cost of providing bottom and side structural support and housing, and the cost of the media itself. The cost of plastic media is currently estimated at approximately $2 per cubic foot, while redwood media is available at approximately $0.70 per cubic foot.

Some of the general advantages and disadvantages of super-rate filter systems when compared to homogeneous activated sludge systems in the treatment of potato process effluents are as follows:

<u>Advantages</u>

1. Lower temperature loss through the process.
2. Lower power costs.
3. Lower total operating costs.
4. Reduced waste biological solids separation and handling problems.

Disadvantages

1. Lower organic removal efficiency.
2. Less absorption of shock loads.
3. Greater probability of problems related to nutrient deficiency and pH variations.
4. Greater risk of odor production.

Tube Settlers

The removal of suspended matter from liquid flow is an integral part of most effluent treatment systems. Numerous primary clarifiers of conventional design presently serve the potato processing industry. Secondary clarifiers of conventional design are in the planning stage.

The conventional clarifier is either rectangular or circular and generally has a side-water-depth of 6 to 12 feet. The clarifier basin is usually continuously cleaned of settled solids by mechanical means. Loadings to primary clarifiers are usually from 800 to 1,000 gallons per square foot of surface area per day (0.555 to 0.695 gpm per square foot). Loadings to secondary clarifiers will be from 500 to 800 gallons per square foot of surface area per day (0.347 to 0.555 gpm per square foot).

Recently there has been developed what may well prove to be the most significant advance in the modern history of sedimentation. The recent development of tube settlers is a practical application of the tray sedimentation theory presented by Hazen(4) over 60 years ago.

Figure 2 shows the self-cleaning tube settler pack as developed and marketed by Neptune-MicroFLOC Corporation. Alternate rows of tubes having 60-degree slopes from horizontal are sloped in opposite directions to provide the structural rigidity of the poly-vinyl-chloride (PVC) tube pack shown. The individual tubes in the tube pack shown are approximately 39 inches long and 2 inches square. The tube packs are placed side-by-side to provide the required settling area.

Each tube within a tube settler acts as an individual settling basin. A single tube 39 inches long, 2 inches square, and inclined at a 60-degree angle with the horizontal will theoretically have

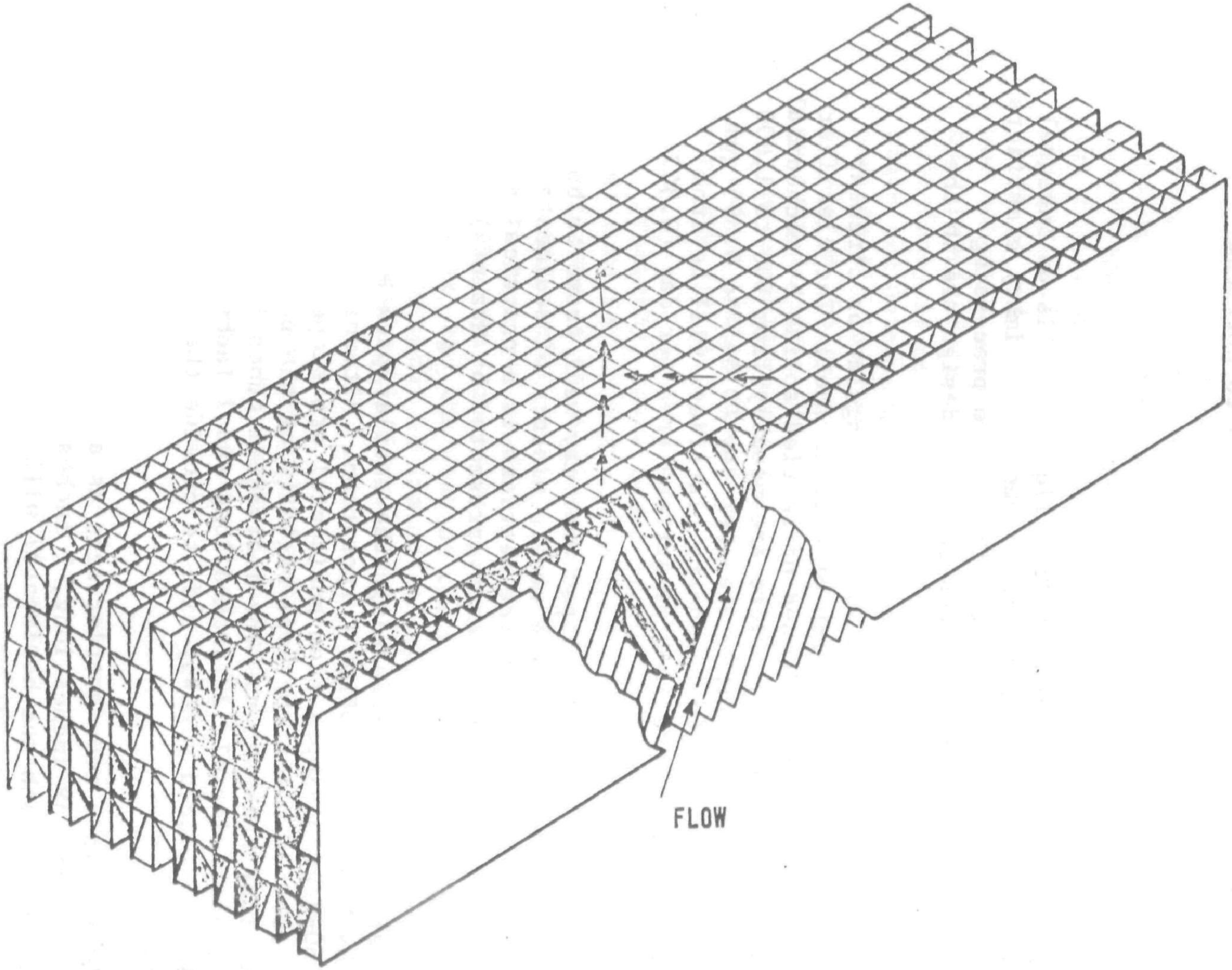

FIGURE 2

R.T. FRENCH COMPANY SHELLY, IDAHO

SELF-CLEANING TUBE
SETTLER PACK

CORNELL, HOWLAND, HAYES & MERRYFIELD
Engineers and Planners
SEATTLE CORVALLIS BOISE PORTLAND
CH2M

the same removal efficiency as will each 2-inch wide segment of a rectangular clarifier having a 78-foot length and an 8-foot depth. Since a tube pack contains several layers of tubes, the theoretical capacity per unit of area is extremely high. In practice it appears that the self-cleaning tubes can be operated at rates of 2.0 to 2.5 gpm per square foot of top surface area when used for secondary clarification of liquids containing 3,000 mg/l of suspended solids. This rate is over 400 percent of that generally used in the design of conventional secondary clarification systems.

Solids which settle from the liquid being clarified slide down the lower surface of the tube and out of the settling zone. The solids which fall from the tubes must be removed by hydraulic or mechanical means.

The self-cleaning tube packs can be placed in existing or new clarification basins, when specially designed outlets are used, or may be installed in reaction vessels such as aeration basins. When installed near the surface of a clarifier, the solids falling from the tubes can be removed by the standard solids removal mechanisms. When installed in an aeration basin, the solids are generally removed from beneath the tubes by liquid currents.

The tube settlers are now being marketed for use in water and wastewater treatment. Only limited operational data is now available. As previously mentioned, expectations are that self-cleaning tube settlers will be used in concentrating waste activated sludge at the R. T. French secondary effluent treatment facilities. A pilot unit is also now being installed to serve as a secondary clarification device in the joint Idaho Potato Processors Association, Federal Water Pollution Control Administration, pilot anaerobic-aerobic studies at Burley, Idaho. Full-scale application of tube settlers should be preceded by pilot plant studies or at least a review of operating results obtained in similar applications. Caution should be used if the waste contains large solids, stringy material, and substantial concentrations of grease.

Summary

A full-scale activated sludge system being designed to treat potato process effluent has been discussed. This system, to be financed by the U. S. Department of Interior and the R. T. French

Company of Shelley, Idaho as a research and development project, will answer many remaining theoretical and practical questions regarding activated sludge in this application. Super rate biological filtration is a second aerobic treatment process which should be considered when selecting a system to meet current pollution abatement needs. The tube settler, a new application of basic sedimentation theory, could and should be considered for use in primary and secondary treatment systems.

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SPRAY IRRIGATION TREATMENT

by

Frank C. Haas[1]

The American Potato Washington plant is located about 6 miles southeast of the town of Moses Lake and started operation in the fall of 1965.

Recognizing that disposal of waste water was a major problem in operating a potato processing plant, American Potato started a feasibility study upon which a decision could be made regarding the location of a plant in Washington state. From past experience in Idaho, it was known that the disposal of waste water must be given primary consideration in both the design and location of a processing plant.

Due to the cost and complexity of a primary and secondary waste treatment facility, it was decided that spray irrigation would be less costly than conventional treatment. A literature search revealed that numerous companies were using spray fields for disposal water and several of these were visited to determine how these spray fields were designed and operated.

Description of the Plant Waste Systems

There are three main sources of waste water from the plant: 1) the sanitary sewer which discharges into a septic tank and then into an underground drain field, 2) potato fluming and washing water which is low in COD (600 to 1200 ppm), and 3) process waters which have been in contact with peeled potatoes and these waters have a high COD content (2000 to 3000 ppm). The wash and flume

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[1] American Potato Company

water is screened in the plant over 20-mesh Linkbelt vibrating screens to remove vines, small pieces of potato, and trash. The screened water is then pumped to one of two settling basins of 18,000 cubic feet capacity in which most of the silt and dirt settles out. Settling time in this basin is several hours or more and the water overflows into a concrete sump. Water from our fresh pack fluming and washing operation also discharges into the same settling basin.

The process water before it is pumped out of the plant is screened on a Dorr-Oliver DSM 40-mesh screen to remove peel and small chips. This water is then pumped to the same sump as the washing and fluming water.

The concrete sump is equipped with two 700 gpm 100 psig head vertical pumps which discharge into the main buried spray field header and then to the laterals and sprays. Pump operation is controlled by means of level controls in the sump so that one or both pumps are continuously operating.

Spray Field

The spray field is approximately 120 acres and is about 3000 feet long and 2200 feet wide. This width varies because of the irregular shape of the land. An 8" buried line runs the length of the field and has 52 rizers to which the 3" laterals are connected. These laterals are above grade and are each 40' long. Each rizer is equipped with one sprinkler nozzle. Nozzles have 3/16" openings except for the end nozzle on each lateral which has a 11/32" opening. Since small pieces of peel and potato are present in the waste water, these collect in the ends of the laterals and are discharged through the larger end nozzles. It has been found that when using the smaller size nozzles at the end of the laterals, the nozzles plugged frequently.

The total waste flow rate to the spray field is about 840 gpm, or about 1.2×10^6 gallons/day. This includes primary washing and fluming water as well as process water. This is equivalent to 0.35" of precipitation per day or an annual precipitation of 100" per year. The temperature of the spray water is 90 to 100°F. Well water temperature is 69 to 70°F.

Normally, five laterals are in operation at one time and operate continuously for 24 hours, after which the next five laterals are used. The movement of laterals and sprinkling area thus progresses down the length of the field until the end of the field is reached, at which time the laterals are brought back to the head end of the field and the sprinkling process is repeated. The average precipitation is any one 24-hour period for a given area is about 3.5". Therefore, it takes about 10 days to make a complete rotation of the field. During the summer months while the plant is down and plant water usage is low, water is obtained from an irrigation ditch so that the cover crop does not die out due to lack of water. This water flows via ditches to the spray field sump and is also sprayed onto the field. We are putting 5 to 6 million pounds of organic solids on the field per season.

Winter Operation and Problems

The end nozzles on each lateral are changed for water operation from 11/32" to 1/2". This increases the velocity in the last section of lateral and reduces the possibility of freezing. Although this change of nozzle size reduces freezing problems, it increases the water flow rate so that the area covered by the end nozzle tends to pond. Of course, if a nozzle plugs, the line freezes, and if the end nozzle freezes, the last 40' section of lateral will also freeze in time since there would be no water flow through this section. If a lateral freezes, the pipe ruptures or the sections are forced apart at the joints.

If tall weeds or grass are near the laterals, they may collect enough ice to completely cover a section of lateral. If so, it is necessary to chip and break the ice away to move the lateral.

Ground Cover

The ground cover is a mixture of grasses and alfalfa, which is cut, cured, and baled. This is done twice per year, but should probably be done more often--4 or 5 times a year. Gerber's in Minnesota has found that "quack" grass is a very good crop for spray fields. Grazing of livestock has not been tried since stock will compact the ground. They also rub against the nozzles and rizers and break them off.

Land

The spray field is not completely flat, but rather sloping and rolling so the field was contoured at 4' intervals to reduce run off and prevent the forming of large ponded areas. The surface soil is loam with 2 to 4' of top soil followed by a broken layer of caliche and gravel about 1' thick with sand below this. Six or seven feet beneath the surface, the subsurface is compacted clay mixed with sand. At one location, a perched water table was found 6 or 7' below the surface. We have not investigated the subsurface conditions since the preliminary survey, and do not know if this perched water table has increased in size or if it has moved closer to the surface. At the start of this season, the field was subsoiled and we have found this has greatly increased the percolation rate. At this time, it is believed that this should be done at least once a year before the start of each processing season.

Costs

The initial capital investment for the spray field, sump, pumps, and silt settling basin was about $30,000 without the land.

The total operating costs for the spray field are $40,000/year. This includes three laborers who are assigned full time to the spray field, plus supervision and maintenance costs.

Both the initial cost and operating cost of a spray field are considerably cheaper than any other complete treatment if sufficient area is available at a reasonable cost. In addition, the problems associated with spray fields are simpler and easier to correct than those associated with a conventional primary and secondary treatment system.

Odors

The spray field has been relatively odor-free, since most of the bacterial action is aerobic. However, when ponding occurs and the bacterial action is anaerobic, the odor increases.

The silt settling pond is also relatively odor-free while in operation, but the silt and dirt must be removed every 3 to 6 weeks. It is during these times that there is a real odor problem, but fortunately, it is of short duration.

Test Spray Field

We have installed a small spray field at our Blackfoot plant to study the feasibility of spray field disposal in Idaho. This was put in operation the first of February this year, so we do not have any very cold weather experience with this system. However, we have sprayed at temperatures of 5 to 10° above zero and have found the sprays operate satisfactorily at these temperatures. The ice formed a layer 3 to 5" thick on the spray field, but as the ice melted, we had very little runoff or ponding. We are presently applying water at a rate of 1/4 to 1/2" per day and the ground is absorbing this water rate very well except for a strip about 6' wide that is completely bare--no grass or alfalfa. In this bare area, the water tends to pond.

POTATO WASTE TREATMENT

RESEARCH NEEDS

by

H. S. Smith[1]

I What is research?

A. Basic. Discovery of hitherto unknown facts and their interpretation to explain mechanisms or observed events.

B. Applied.

1. Organization and incorporation of products of basic research into a useful system; after first time becomes development and refinement.

C. Research, development and consulting often confused.

1. Large amount of research covers ground already researched.

a. Lack of familiarity of researcher with prior work.

b. Inability or unwillingness to recognize basic facts and the universality of their application regardless of superficial concepts and terminology of different disciplines or fields of application.

2. Much of what is termed research should be the job of competent development engineer or designer who know field and can relate already available knowledge to problem at hand.

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[1]Dean, University of Idaho

II Kinds of information needed to solve industrial waste treatment problem.

A. With respect to specific problem.

1. Define and minimize problem.

2. Treatment objectives; how much treatment is needed?

3. "Fill-in" information needed to apply existing technology.

4. Develop new technology when existing technology is inadequate.

5. Optimization of treatment system.

B. With respect to general problem.

1. Improved understanding of treatment process mechanisms.

2. Prediction models for various unit operations and processes.

3. Continuing search for new and better processes.

C. Assembly and organization of information into form applicable to problem may - or may not - involve research.

III Source and character water borne potato processing wastes (Maxson)

A. Washing

1. Largely inorganic clay and silt.

2. Low water use if recirculated: 0.02 gal/pound.

3. Little oxygen demand

B. Peeling

1. Steam

2. Lye

3. Low water use: 0.08 gal/pound

4. High oxygen demand: 6000 mg/1 COD

5. High pH and cation concentration if lye process used.

C. Trimming

1. Low water use: 0.02 gal/pound

2. Low oxygen demand: 193 mg/1 COD

D. Slicing

1. High water use: 0.43 gal/pound

2. Medium oxygen demand: 845 mg/1 COD

E. Blanching

1. High water use: 0.55 gal/pound

2. High oxygen demand: 7300 mg/1 COD

F. Final processing with corresponding minor waste.

G. Overall average and characteristics

1. Water: 2.00 gal/pound processed

2. Oxygen demand: 6000 mg/1 COD

3. 50% COD removable by plain sedimentation.

4. After settling.

a. 1.6% (17,000 mg/1) dissolved solids.

b. Dissolved solids 38% (6500 mg/1) nitrogeneous compounds; about 1000 mg/1 nitrogen on basis of protein.

c. BOD/N ratio on order of 3:1; plenty of nitrogen <u>if</u> in available form.

d. Trace nutrients probably satisfactory for biological synthesis.

IV Existing applicable technology

A. Preliminary treatment

1. Wash water silt removal by sedimentation.
2. Main waste screening

B. Primary treatment

1. Plain sedimentation.
2. Flocculation and sedimentation.
    a. Without chemicals
    b. With chemicals
3. Centrifugation.

C. Secondary treatment

1. Biological
    a. Aerobic
    b. Anaerobic
2. Land methods; irrigation
3. Chemical for selective component removal and recovery.
    a. Protein coagulation and filtration.
    b. Ion exchange for amino acid recovery.

D. Tertiary treatment

1. Adsorption
2. Foam fractionation
3. Ion exchange
4. Filtration

E. Utilization or disposal of recovered solids

1. Sources

a. Preliminary treatment; peels, trimmings

b. Primary treatment; primary sludge

c. Secondary treatment; excess cellular and biologically inert solids from biological treatment.

2. Use for by products; cattle feed base

3. Further disposal

a. Biological; sludge digestion

b. Physical; dewater, incinerate, landfill, etc.

V Information needed to approach specific problem

A. Define and minimize problem

1. Cited volumes and COD concentrations are typical "as is" values.

2. Can production process be controlled to minimize the volume of waste and/or the amount of contaminants?

a. All process performance a function of time; time a function of treatment unit size and flow rate ($t = \frac{V}{Q}$); reduce volume of waste and reduce unit size for given time; reduce cost.

b. Reduce contaminant quantity; reduce load on secondary and tertiary system; reduce capital and operating cost.

c. Even if contaminant amount cannot be decreased reduction in waste volume and corresponding concentration of contaminant usually results in higher rate of contaminant removal per unit volume of treatment facility; can lead to economical stage treatment when high quality effluent required.

3. Waste that can be prevented at source does not require treatment! Research begins within the processing plant.

B. How much treatment is needed?

1. Receiving stream capacity to assimilate some mass of contaminant implied by water quality standards.

2. How much assimilative capacity available to a given industry?

3. Unless answer clear research is needed to determine level to which industry must treat.

a. No use to fly an SST when an F-27 will do the job.

b. Probably involve more political than technological decisions. Who gets first call on the stream capacity?

C. What "fill in" information is needed to apply existing technology.

1. Sedimentation - preliminary and primary. Principles well understood but need data to apply.

a. Settling velocities of particles in non-flocculent regime - silt removal. Need this for rational design.

b. Settling characteristics of particles in flocculent regime - primary treatment. Can't really design without this.

2. What are effects of preflocculation? Can primary efficiency be significantly improved?

a. Plain flocculation without chemicals.

b. Flocculation with chemical coagulants.

3. Biological secondary treatment

a. General questions

(1) Is nutrient balance O.K.?

(2) Is nitrogen present in a useable form?

(3) Are there inhibiting components?

(4) What is the BOD rate constant compared with other wastes?

b. Aerobic treatment; available models

(1) What are the rate constants for BOD removal?

(a) Log growth

(b) Declining growth

(2) What are the oxygen uptake rate constants?

(a) For BOD

(b) For active fraction of biological sludge mass-cell respiration.

(3) What are the active mass growth rate constants?

(a) Synthesis

(b) Auto-oxidation

(4) What are the settling characteristics of the mixed liquor solids?

c. Anaerobic treatment; empirical basis

(1) Heat inventory

(2) Notion of "balance condition".

(3) Volumetric and/or organic loading at which balance between volatile acid and methane production is achieved for continuous operation- with and without sludge return.

(4) Volatile acid concentration at balance condition - for operation control

(5) Cation concentration at balance condition - for operation control.

(6) What is the concentration of active anaerobic biological mass that exists at balance condition resulting from given loading?

(7) What is the effluent quality corresponding to any given balance condition?

d. Combined anaerobic-aerobic systems. General questions related to quality of anaerobic effluent resulting from any given balance condition. Same questions must be answered for the aerobic stage as in the case of single stage aerobic treatment.

e. Liquid-solids separation of biological reactor effluent.

(1) By gravity-sedimentation

(2) Centrifugation

(3) Floatation

(4) Solids characteristics as they relate to these unit operations must be ascertained.

f. Ultimate disposal of excess synthesized cellular material - waste sludge.

(1) For aerobic digestion - same kind of information as needed for basic aerobic process.

(2) For anaerobic digestion - same kind of information is needed for basic anaerobic process.

(3) For physical disposal - whatever characteristics are pertinent.

(a) Solids concentration

(b) Dewatering characteristics

(c) Heat value

(d) Concentration of constituents of interest.

4. Other secondary and tertiary treatment possibilities need same kind of "fill in" information. Can be obtained by persons well informed to ask proper questions. No new concepts are involved, only new applications.

D. Is the need for new technology to solve problems unadequately covered by available Technology?

1. Each previously described unit operation can be continuously refined by research, but,

2. Do gaps in present technology preclude attack on problem with confidence?

a. Unit operations described and others similar afford sufficient tools to proceed now.

b. Must conclude that problem solution need not wait for new technology to be produced by research.

3. New technology will come in future. Treatment systems can be modified to incorporate, if feasible.

E. Optimization of treatment system.

1. What combination of unit processes will achieve degree of treatment most effectively?

a. From standpoint of cost

b. From standpoint of operating dependability

2. How should load be distributed among the unit processes comprising the system?

3. Economic base for comparison

a. Industry - shorter amortization period and tax situation favors minimum investment even if higher operating cost.

b. Municipal - longer amortization period and no tax effect favors higher investment to reduce operating cost.

c. Industry - municipality relationship will affect basis of economic optimimization.

4. Must consider available operating skill.

V What are questions of general concern to treatment technology that might bear on this problem?

A. Better understanding of mechanisms of various unit processes

1. Leads to identification and quantitative understanding of factors entering into process so can

a. Design and operate closer to real process capability - reduce the "factor of ignorance" or "shrink the black box".

b. Better prediction of behavior under conditions different than those for which empirical performance prediction is based,

2. Such questions include

a. Affect of environmental conditions on process capability

b. Process limiting factors such as

(1) Nutrient levels

(2) Temperature

(3) pH

(4) Oxygen concentration

(5) Concentration of limiting constituents

(6) Hydraulic rates

c. Actual biological, physical or chemical mechanisms at work in each unit process.

B. Prediction models needed to replace empirical approaches

1. Reasonably useful models are available for sedimentation, aerobic biological treatment and several tertiary processes.

2. No useful models yet available for anaerobic biological process.

3. Need much work on the coefficients and factors needed to apply models to a wide range of waste conditions.

C. Always need for continuing search for new and better methods but must face existing need to get on with present solutions using available techniques. Improve or modify systems when application of new methodology becomes feasible.

VI So what are research needs?

A. Seems that there is a sufficient kit of tools already available to make significant attack on potato waste treatment without having to wait for further generalized basic research!

1. Classical engineering attack will go a long way.

a. Identify problem

b. Assemble necessary information

c. Analyze information

d. Decide

e. Act

2. Gaps in information and insight needed to apply existing technology for which field scale experience is needed.

a. Demonstration projects operating under field conditions.

b. Use of available "know how" to interpret operating experience. "Know how" exists as evidenced by literature; not widespread, may need to be especially recruited.

c. This is more development and consulting than research, but the researcher must be involved to help interpret.

3. Better design for process environmental control can now be done with present understanding even though not fully quantified. Incorporate control in system to allow operation over a range; let actual operation determine absolute value;

a. pH

b. Temperature

c. Cell mass concentration

d. Oxygen concentration

e. Recirculation and mixing

f. Etc.

B. Real research needs appear concerned with matters generally applicable to all industrial waste matters; not unique to potato wastes.

1. Better prediction models especially for anaerobic biological treatment and some tertiary processes.

2. More precise values for the model factors

3. Better knowledge of waste character effect on value of model factors

4. More quantitative information on effect of water quality parameters on use of receiving stream.

5. Combination of these and related questions into systems analysis approach.

6. First time demonstration of unique process combinations.

FUTURE GROWTH OF THE POTATO PROCESSING INDUSTRIES

by

Ray W. Kueneman[1]

In order to assess the future of the potato processing industry, I think it is very interesting to go back and review how this industry has developed. The history of the potato reflects one of the real contributions the New World has made to every population growth, practically speaking, in the world.

The potato made its first contact with European civilization when the Spanish Conquistadors started their invasions into South America somewhere along in the 1550's. These invaders found quite an advanced civilization that was led by the Incas who ruled the continent of South America from Patagonia up into what is now Mexico.

There was one pertinent factor that was important to the ability of these people to rule such a vast area. Their military forces, in all their contacts with the various areas, carried on their communications by the use of "runners", who were able to cover vast distances during the day and pass on information to the next command post or area, where the message could be relayed by additional runners. Military forces could be dispersed as a result of this rapid form of communication. Both the runner and the military forces were able to carry lightweight emergency food supplies, which consisted largely of potato, a product called "Chuno". The potatoes were indigenous to the high altiplano of South America. Farmers harvested their crops, boiled them, and placed them on reed mats to dry. Since these crops were harvested in what was their harvest season in the autumn, cold weather was

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prevalent at night, especially at these high altitudes. The boiled product would freeze at night and then during the day would dry. This alternate freezing and drying process led to a product that could be crumbled into a fine powder and carried in a pouch by the runner or soldier. By adding water to it, they could reconstitute it into a form of meal which would sustain them on their forced marches. This product still persists in South America and has had a dramatic influence on life there.

The first mention we find of potatoes coming into Europe is through the records left by the Monk, Hieroymas Cordan, who mentions that potatoes were placed on Spanish ships returning to Spain, in ballast, and that they were very useful as a foodstuff. However, when these potatoes arrived in Spain, the clergymen warned the populace that these were heathen vegetables not mentioned in the Bible; and it took a lot of convincing to bring about the use of potatoes in Europe.

Frenchmen planted them in botanical gardens and regarded them as a curiousity, and refused to put them on the table. However, little by little, farmers recognized potatoes as a good food. They spread to England, then to Ireland, and to much of Europe.

There are a number of interesting points in history where we find mention of the use of potatoes. Frederick, The Great, promoted potatoes as a food for his peasants and issued an edict that he would "cut off the nose of any peasant not raising the required acreage".

The War of the Bavarian Succession in 1778, entitled, "The Kartoffelkreig," was a war between the Germans and Austrians. The final battle, which was decisive, was over stores of potatoes located in farmers' fields.

Antoine Parmentier campaigned for the acceptance of potatoes as a food in France. He enlisted the aid of Marie Antoinette, who wore blossoms in her hair; and due to her influence, the court chefs created court dishes. As a result, the potato began to get greater acceptance as a food in France. It was calculated at this time that a single acre of potatoes could support a family of six to eight, and a cow, for a year. So you can see, it was a very important crop indeed, and a valuable contribution from the New World.

Potatoes became a field crop in Ireland some time before 1660 and were popular with the Irish farmers because they protected against the loss of other foods--they would store well in the ground and would survive the rains. Lady Montgomery, who had extensive farms in County Downs, Ireland, in the 1760's provided land for her people to raise potatoes for food, and flax for clothing. By 1780, it was reckoned in Ireland that a 280-pound barrel would provide a week's supply of food for a family, at the rate of five to eight pounds per head per day, served three times a day. As a result of this almost enforced diet, our present potato became known as the Irish potato. This nomenclature, of course, was reinforced by the great potato blight in 1848, when the crop failed and over half the Irish population immigrated to the United States.

In 1719, potatoes were introduced into the Colonies at Londonderry, New Hampshire, which was an Irish colony. Some of the farmers there thought the potatoes were bad, by some, good. By 1740, they had pretty generally spread through the colonies. Today, potatoes represent about 20% of all the vegetables in the United States.

We think, in this country, we are very large users of potatoes; but I would like to give you some figures which probably could be updated from the information I have, but they are interesting indeed. In 1963, the world crop of potatoes represented some 262,700,000 metric tons of potatoes, distributed as follows:

Country	Metric Tons Growth
U.S.S.R.	69.7 million
Poland	37.8 million
West Germany	25.1 million
East Germany	13.3 million
U.S.A.	12.5 million

Other countries followed along with varying amounts; however, the first five mentioned were the predominant producers of potatoes in 1963.

It is interesting to examine what Poland was doing with their potatoes at that time. This was presented in a paper on Waste Utilization at New Brunswick, Canada. Poland raises about seven times the U.S.A. production. It consumes as fresh potatoes some 6.5 million metric tons, feeds about 23.3 million metric tons, uses about 5.4 million metric tons for seed. Industry, as starch and alcohol, utilizes 3.2 million metric tons. They export about 100,000 metric tons. Storage loss is calculated at about 3.5 million metric tons.

I think, with this little background of the past, we can turn towards the subject I have been asked to speak on, "The Future Growth of the Potato Processing Industries". This is a symposium on potato waste treatment, directed towards a cure for an alarm we have in this industry. We should not forget the real nature of the problem. I think it is appropriate to discuss the cause as well. The cause in this case is certainly the potato industry. The future growth is such a tremendous factor in this field that it must impose a tremendous sense of urgency for problem solving on all who are working in this field. I hope to transfer some of this urgency to you.

I have been involved in some phase of the "Potato World" since about 1940. The requests for talks on the future of potato processing have been many. I have acceded to some of these requests. Each time one reviews what has been said in the past, cuts, culls, and steals a bit, and in general updates what has been prophesied, said, and guessed at in the past, I am sure this is standard operating procedure with those who continue to work and to discuss continuing problems in their field.

In preparing for today, I followed this familiar pattern, I confess, with a little complacency and a touch of smug satisfaction, let us say. After all, potato processing has grown into a giant; and it is nice to see one's predictions come true, and to continue to be a part of it--and then the bomb fell!

The growth of the industry in the past two decades has been little short of phenomenal, and various kinds of expertise, good and bad, informed and otherwise, has been exerted in the past, projecting the future growth. However, a DuPont computer analysis which appeared in the December, 1967, issue of "Quick Frozen Foods" is a key to the bomb I referred to above. This projection cannot be ignored because it imposes some tremendous parameters to the problem we are discussing.

Dan Pichulo of DuPont and "Quick Frozen Foods" magazine pumped the potato picture into the DuPont computer memory bank, as one of a series of projects on the frozen food industry. Fortunately, the frozen food industry, through its association efforts, has had a good set of records and provided adequate data. Let us look at these projects now, so the enormity of the future problems will give you the same sense of urgency that hit me.

This joint study is one of the fortuitous circumstances that comes along once in awhile where the right kind of statistical data exists in sufficient quantities to lend itself to this type of analysis. The industry is new enough and accurate records exist, to permit this study to be made with a great deal of reliability, in my estimation.

DuPONT STUDY--FROZEN POTATOES--1966-1976

(In analyzing some of the points on the DuPont study, we find it is convenient to look at just frozen potatoes for the period, 1966 to 1976. The data projects the following information.)

1966	1976	% Increase in Value & Poundage
$319,657,000	$871,670,000	270 (value)
1,459,633,000 lbs.	3,926,140,000 lbs.	248 (poundage)
7.41 lbs. per capita	18.2 lbs. per capita	146

The population will increase from about 200 million in late 1967 to 218 million by the end of 1977. Thus, we get a 248% poundage increase with a 9% population increase. Frozen potato products must indeed be popular.

In view of the past growth, these numbers may be on the cautious side. When one translates them to the problem, the size of the task is indeed enormous. Are these projections reasonable? If we review the past, on the figures that were used, I think we can see what I am talking about.

ARE THEY REASONABLE AS PROJECTIONS? A REVIEW OF THE PAST

Year	Million Pounds	
1953	70.7	
1954	85.2	
1955	128.9	
1956	189.7)-	Almost double
1957	219.8)	
1958	269.4)-	Almost four times
1959	371.0)	
1960	551.4)	
1961	579.1)	
1962	761.6)-	Over 600% net increase in the past decade from 1956 to 1966
1963	861.5)	
1964	1,117.8)	
1965	1,218.5)	
1966	1,459.6)	

Therefore, by past performance, we can accept these DuPont forecasts as reasonable, in my opinion. An actual summary of the DuPont projection is as follows:

Year	Poundage Processed (Billion)	Per Capita
1967	1.66	8.35
1968	1.88	9.38
1969	2.11	10.44
1970	2.36	11.53
1971	2.61	12.64
1972	2.87	13.76
1973	3.13	14.88
1974	3.40	16.00
1975	3.68	17.11
1976	3.92	18.20

By 1965, potatoes represented more than 50% of all frozen vegetables. By 1976, it is projected that potatoes will represent more than all other frozen vegetables by 50%, and will represent about 10% of all frozen foods.

It is interesting to look at the distribution of frozen potato products in a typical year; and we can take our Association figures for 1966 to 1967, as a process year.

DISTRIBUTION OF A TYPICAL PROCESS YEAR
1966-67

Retail French Fries	421,000,000 pounds
Institutional French Fries	862,000,000 pounds
Other Frozen	176,000,000 pounds
TOTAL	1,459,000,000 pounds

POUNDS PER CAPITA (USDA-1960)

Year	Pounds per Capita	Processed
1910	198.0	
1940	123.0	1.9
1948	104.9	
1952	102.0	
1960	109.0	34.8

What do all of these trends show, as far as the problem is concerned? One thing quite simply. We will have more waste to handle. Obviously, potatoes cannot be the scapegoat or fall guy in this picture. All ways of life that contribute to waste will have to stand and be counted. All segments of society will have to pay their share, and somewhere in the "accounting scheme", this cost will have to be reckoned with.

Potato processing, with its relative newness and potential expansion, and its long operating season, is a convenient tool to study, to seek efficient and economical solutions to the problems of all waste in an orderly, progressive manner. I must stress this lest we inadvertently kill the goose that lays the golden egg. The processed potato industry has grown because the costs to the consumer have been kept down to the point where the public can afford to buy them. Production costs are accurately kept and reckoned with, to the fourth decimal place; and very often are only the lesser fraction of the final cost to the ultimate consumer. Sales, distribution, transportation, etc., all take their toll in the final cost. This is the way of life today.

One reason we are here is to further our knowledge, attack the problem, and find feasible, economical solutions on where we stand. The cost of capital expenditures can easily run 20% or higher of the total plant investment of a potato processing unit, depending upon the size of the plant, degree of cleanup required, and other factors. At this time, this essentially nonproductive cash flow can be a deterrent and a restrictive factor in the future program of the industry. I feel that an appreciation of these factors which led to the growth and progress made to date, has been largely contributed by our Western group. We must recognize the progress this group has made in the past and will continue to make. We must appreciate that no single segment of society can be singled out to contribute at an accelerated rate, our of proportion to others. Progress must be made on all fronts. Given an equal shot of time and "fruits of advance," I am sure the potato industry will keep pace.

The figures I have presented thus far represent but one segment of the potato industry, primarily frozen French fries. If we examine the 1965-66 season, we get an idea of what is happening to the trends in the total industry.

1965-66 SEASON

Crop	233,283,000 cwt.
Processed (39 1/2%)	92,283,000 cwt.
Fresh and other	141,000,000 cwt.

WHAT HAS TRANSPIRED IN THE LAST DECADE?

1956 dehydration used	3,200,000 cwt.	
1965 dehydration used	20,000,000 cwt.	(625% increase)
1956 frozen used	4,300,000 cwt.	
1965 frozen used	32,000,000 cwt.	(746% increase)

If we convert DuPont's figures of 3.96 billion to hundredweight, as fresh potatoes, we find we will be using 99 million for frozen in 1977, as compared to 32 million hundredweight in 1965. We will also use 49.5 million cwt. for dehydration, as compared to 20 million in 1965. Without accounting for any other processed usage, we will use 148 million cwt. in these two processes alone. If the loss in processing to be handled runs 25%, as it does generally today, we will be handling 37.1 million cwt., or 1.85 million tons, or about 40% of the total potatoes we processed in all forms during the 1965-66 season.

This, gentlemen, is what I meant earlier when I referred to the bomb.

If we are to use the knowledge and experience we are currently developing, we must cope with the 25% waste I have referred to. We must lessen it, convert it to other usable forms for man or animal, and offset the cost of capital and production to do it.

I have mentioned only two forms of processing and indicated how they are to grow. These trends point to increases in all other forms of processing. This useful knowledge must be shared and extrapolated to other forms of the whole processed food industry, and society as a whole. My mind refuses to convert these figures to our yardstick, BOD, population equivalents, or other measuring devices that are in use now because of the magnitude of the numbers, which to me are staggering.

The pressure of world increase in population and food requirements are constantly being studied and deliberated in various world councils. The problems are not limited to the U.S.A. alone, they are worldwide. Trends and habits in the United States are being paralleled in every civilized country in the world; and I suggest to you gentlemen that we have a worldwide problem.

Thank you!

GENERAL DISCUSSION

Jackson:

I have sat here today and reflected on how things were about 10 years ago in the potato waste field. I have the distinct opinion that we've come a long ways. I shudder to think of some of the things we were talking about then. We had all kinds of wild ideas and we still need a few today.

Dean Smith mentioned that basic research wasn't so popular anymore. It's still popular among a great segment of the universities but it is not so popular among the federal government supporting agencies. The federal government is now interested in the solution to problems and the application of knowledge and I think that future support is going to come heavily from that sector. It will not necessarily be expended in the university, although if the university can qualify in engineering applications it will probably receive support. Dean Smith also mentioned that we should try chemical flocculation. Well, as some of you know, this was one of the first things tried by the potato association at the R. T. French plant and it met with some success. We have also been given a rundown on foam fractionation. My predecessor at this university 15 years ago was interested in coagulating potato protein and he was using ion exchange to try to recover amino acids.

I would like to suggest that in our discussion here, we look ahead a little bit. Dean Smith has outlined to us some research procedures and engineering applications all the way from start to finish. How about a few "blue sky" ideas. I think it would be proper to finish the meeting by looking ahead rather than going back over details.

I'd like to start by pointing this out to you: I think the biggest waste problem comes from the potato peel itself, the method of getting the peel off. Other wastes with the big chunks, etc., are easily removed. The potato peeling is really the main problem. Can you suggest some other way of peeling the potato or modification of present peeling methods to minimize the waste?

Dostal:

Research is being done in this area by ARS in Albany, California, and they have a pilot plant going there on a semi-dry peeling process. I know several of the people in the audience have been down to see this. It processes about 500 pounds per hour and has been operating intermittently for about the past year.

Jackson:

We are somewhat acquainted with the Albany people. What they are doing is not what they wanted this university to do when they were negotiating a contract. Had they gone this way, I'm sure we would have been glad to go down that road. Anybody else got any exotic ideas on peeling?

Comment:

The main problem would be that there is too much loss. These potatoes are peeled deeper than necessary. What do you do with the caustic and steam?

Jackson:

I'm sure this is true from the standpoint of loss of the potato itself but how would this alter waste treatment costs when you look at the process as a whole, including utilization of the peel material. Could you for instance modify peeling and have a more useful or more valuable byproduct.

Kueneman:

I'd like to digress for a minute on this peeling. When you have traveled around through the years as I have, you find a lot of "blue sky" ideas. During World War II there was a little dehydration plant that came up with what someone in the war department thought was absolutely the best idea in the world. I went down to take a look at it. He had gathered up a bunch of old batteries, salvaged the plugs, and had a controlled dip in a molten pot of lead. Believe me, it peeled potatoes. There was no question about it, it was fabulous!

We've talked about the research at Albany where after the potato is dipped under defined conditions of caustic concentration, temperature and time it is exposed to a high heat level under catalytic burners. Then the material is flaked off before any water is applied or it is scrubbed or brushed.

There has been a great deal of work done in considering the potato as a suitable food for the production of Torula yeast either for human use directly or as a byproduct for animal feeding. Quite a bit of work has been done on this in Sweden and other places. Our friends at the New Brunswick Symposium pointed out that the Polish people were working on various phases. Of course, we know that everybody in Scandenavia is producing lots of alcohol. There are some other organic acids, so this leads to some "blue sky" thinking, and I think we all need to be doing it.

It's been pointed out that we're taking off too much by conventional systems but it always comes back to the same thing that Dean Smith pointed out. How long does it take to pay off and what can you do on utilization of materials?

Jackson:

Certain segments of this research the industry can't do but the universities can and that was one reason I brought up the peel problem. But if you were to look at the overall economics now that you have to do something in waste treatment you might modify procedures somewhat. Of course, we grew Torula yeast here at this university 18 years ago and I once approached a starch manufacturer in Southern Idaho with this. He pointed out the capital investment and said, "Son, if I had $200,000 I wouldn't be in the potato starch business".

Smith:

Didn't the paper industry find out several years ago that they could glut the world yeast market in about a month?

Kueneman:

That's right. I talked to some of those people the other day and they were giving me some of their conversion ratios that they make this material with.

At the present time we're converting a lot of peel waste into beef and there's been a lot of debate as to whether that's the most efficient means of converting the waste to protein.

Smith:

What about greater use of the solids as animal feed. Now I'm thinking of the biological solids. These are carbon, nitrogen, phosphorus, calcium sources and usually present a very real problem of ultimate disposal.

Filbert:

There was some work done on feeding activated sludge from a domestic waste treatment plant. They found that cattle, chickens, and hogs would accept this up to a point. Actually there are quite a few vitamins available in the activated sludge or waste biological solids. You can mix about 2 percent of activated sludge with other feed and have it acceptable to the animals. They don't like it too well unless you hide it.

Dugan:

I might as well throw in a plug for the Richmond Field Station (Sanitary Engineering Research Laboratory, University of California). About two years ago they did some work on using potato waste to grow algae and it grew algae very well. Studies showed that animals: chickens, poultry, sheep, and cattle, would accept the algae up to about 25 percent. Several papers have been written on this work.

Jackson:

If you can get into the food and drug field you know the cost per unit is a lot higher so this might be one way to go.

Dugan:

This has another factor too. It produces a very high quality effluent. Once you grow algae and remove the algae you produce a very high quality effluent.

Jackson:

We don't want to go to much "blue sky". How about a few more specifics. One thing I didn't hear mentioned much today and I would think this would be an important factor in the kinds of treatments other than the irrigation that you're talking about and that's the microbiology. One man mentioned you have to take some time to get the methane formers growing. Isn't there an easier way of doing it than relying on chance or are we going to suggest that we embark on a strong program of studying in this field if we're going to use anaerobic methods?

Question:

How about if you burn the waste by aspirating the waste water into a flame such as an oxygen acetylene flame as an example but maybe there's a cheaper source of fuel than that? The heat and steam produced could be used in the plant.

Jackson:

That might be a good way to produce steam but you would have to produce steam to recover costs. Tom Binford would like to add to this and tell us about the Dorr-Oliver calcinor I'm sure.

Binford:

It's cheaper to feed it to cattle.

Jackson:

The comment was made back aways that for some reason anaerobic treatment made aerobic treatment more susceptible. I don't know what this meant. What I'm leading you up to here is I'm trying to get some more ideas on the fundamental process involved. Why should anaerobic treatment bring about this effect?

Filbert:

This has some reference to K factors, synthesis and oxidation. Acids and some of the smaller molecules are removed faster in synthesis than some of the other molecules. You actually find that if you take a waste that contains proteins, carbohydrates and other materials and add a culture of organisms that some materials will be utilized faster than others. Basically, it's the size and complexity of the molecules. We have also found that you generally get better removals with biological filtration of food processing wastes than you do with pulp and paper wastes because of the molecular size.

Jackson:

Are you suggesting that anaerobic treatment shortens the molecule, chops it in half, or makes a different kind of molecule with different reacting characteristics?

Smith:

He said that the acids that are the intermediate products to methane formation are just inherently simpler than the starches, lipids, and proteins you started with.

Dostal:

In regard to the plant at Albert Lea, Minnesota it's fairly certain that this same process would work on potato wastes. In the developmental work done at the University of Minnesota a half dozen industrial wastes were fed to the anaerobic contact process at different times.

Thus far in our work on aerobic and anaerobic-aerobic lagoons very little effort has been expended on solids removal from the effluents. Most lagoons in operation today can obtain good organic reductions, as high as 80 to 90 percent, if designed and operated properly. The effluents do contain a large amount of suspended solids. As a result the capital and direct operating costs have been about 50 percent of those of more conventional treatment processes such as activated sludge since there are no sludge handling and disposal costs. In many locations this practice will have to be altered. That is, these suspended solids will have to be removed also. Then we'll be in a new ball park dollarwise and we'll have to go back and look more closely at some of these other processes such as the anaerobic contact process.

Binford:

Speaking of basic research there needs to be more research done on characterizing the original waste. How many or what kind of amino acids are in there? What kind of protein? Are there any lipids? You may find entirely different ways of treating these individually.

Jackson:

I'm sure this is a problem. The more one knows about a material the better off he is.

Paul M:

If you know something about biochemistry, in this matter of anaerobic versus aerobic digestion, oxygen in a system will tend to slow down the breakdown of starch to different carbohydrates and so an anaerobic system will break down the starch much quicker. This in essence will take it mainly to your organic acids and some more easily degradable compounds which in turn can be treated. So from a biochemical standpoint the use of anaerobic digestion would have a theoretical advantage.

Jackson:

If it works, it must.

Kueneman:

In answer to the question on what do we know about composition of the waste we go back to Dean Smith's approach and use what is available. Eastern Research Laboratory is programming on a computer 28 amino acids found in potatoes. Amino acid studies have been done on several different potato varieties and much of this information is available in the literature.

Furgason:

One of the problems we're faced with here is that we're not talking about a particular material, we're talking about a whole variety of things depending on the time of year you process, how long the potatoes have been in storage, how long it has been in the process stages and so on. So you can't talk about a particular amino acid concentration or starch concentration, or sugar concentration and I don't know if even averages make much sense. You just have to work with what you have. You can't depend on keeping the concentrations constant.

Kueneman:

The only constant in this is change.

Jackson:

Are there any last words? Deans always have the last word.

Dean Smith:

One point I had in my outline that I think I skipped over because the fire whistle blew, is that I would strengthen Ray's remark that there is a lot of information available on amino acids and so forth. We are at the point where the demonstration kind of thing that you're undertaking here in Idaho is likely to pay the most immediate results on things that can be used. Some of you have got a job to do and it has to be solved immediately. We're going to keep on working in the laboratory and we're going to come and ask for research support. We'll feed the information into the hopper, but it takes a step before you go out and blanket the country with a treatment process of this kind or that kind and I believe this is the point where we now are. More power to you on the kind of thing you're doing on the demonstration project, as it has been described. I would only hope that you can bring into these demonstration projects some of what we know about the mechanisms. Hopefully these curves can be explained by what's happening inside the individual processes. This is, I think, where we are on the matter of application of research. We're here today to get a job done and keep our enforcement people happy and the fishermen.

Jackson:

I might conclude on an optimistic note. It was once said when I used to work in the paper industry that sometime in the future we would be pulping the wood not for the fiber but for the other half of the tree which is a wealth of a supply of organic materials, principally lignin. I'm sure that our petroleum supply is not going to last forever, and so I would suggest that at sometime in the future we might be growing and processing the potato for the peel with the dehydrated materials as a byproduct.

Fergason:

Once again on behalf of the college of engineering, the FWPCA and the other participants, I'd certainly like to express my appreciation for the people in the audience, especially to the people who gave papers and others participating in this Symposium. I hope you'll go home with some new thoughts in mind and continue the excellent progress which I think has been made in potato waste treatment.