ERRATA.

FOR SEPTEMBER ISSUE.

P. 4. Para 3 should read:—

Mr. McFarlane mentioned similar work done at his factory where the dimensions of the gooseneck are smaller than in several other distilleries. The approximate velocity of the vapour at the base of the gooseneck was some 2.5 times that in Mr. Floro's still. He found that the total time from boiling to running rum was 16% of the total against Mr. Floro's 11%. He had carried out experiments with regard to preheating the retorts by means of steam coils and had saved some 15 minutes on the cycle. He had figures similar to those of Mr. Floro for time cycle and steam consumption using a wash heater and retort coils and had found a saving of time of about 15 per cent. With regard to preheating, he had found that a 4" coil in the loading vat, heated with condensate from the still, was sufficient to raise the temperature of the wash to 114°F. and it had been possible to increase this to 120°F. at times. The possibility of utilising the waste heat in dunder should not be overlooked as it was possible that, with modern heat exchangers, some 85% of the waste heat might be recovered. In the event of raising the temperature of the wash to the vicinity of 150°F. it would be necessary to use a closed system and it was probable that considerable time and steam would be saved.

Page 5: Under Mr. Springer's remarks, the second and third sentences to read as follows:—

"In the review of his patent there was a short description of the process which involved the addition of ½% of sodium chloride to hot dunder, followed by electrolysis. The resultant generation of chlorine would accelerate the reduction of the biological oxygen demand of the dunder."

P. 8 — 3 lines from bottom of page.
'much higher' should read 'high'.

P. 9 — 1st line.
'determinations' should read 'figures'.

2nd line after word 'figures'
insert 'but he had compared the results'

P. 15 — 5th line from top,
delete word 'per' before unconverted'

6th line from top,
'unconverted' should read 'converted'.

THE J. A. S. T. QUARTERLY

(Thirty-first Issue, March, 1945)

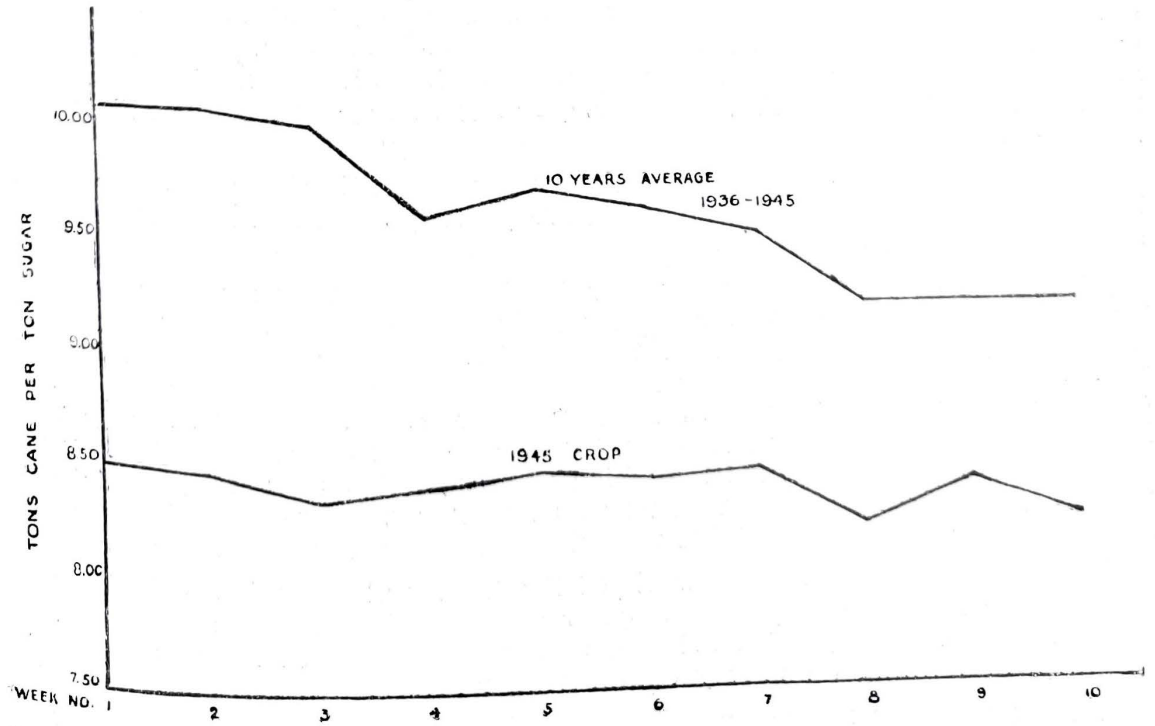
Vol. VIII. March, 1945. No. 3.

EDITORIAL

The 1945 Crop is being affected by the cold droughty weather of the past few months. These factors are undoubtedly depressing sugar cane yields. This depression is, however, being offset to some extent by the good juice purities that are being obtained. While this is partly a result of the weather it is also due to the increased planting of improved varieties, of which B.34104 is an outstanding example. The graph printed below shows a comparison between the weekly average tons of cane per ton sugar for the ten year period 1936-1945, and for the 1945 crop up to the end of March. We are glad to be able to show figures at this low level for the present crop and we hope that with continued improvement in field and factory the ten year average will, in future years, progressively decrease.

Members will be interested to see in this issue a photograph of the new premises of the Sugar Research Office, which were opened on February 12th 1945. These premises were acquired in view of the expanding activities of the Sugar Research Office. The provision of a laboratory, in particular, will greatly aid the Sugar Technologist and his staff.

The Sugar Research Office staff has recently been augmented by the appointment of Mr. W. Ryle-Davies to the position of Office Manager. Mr. Ryle-Davies needs no introduction to the Industry having held office as Honorary Secretary of this Association for over a year. We take this opportunity of congratulating him on his appointment.



Data showing the weekly number of tons cane required to make a ton of sugar averaged over the 10 year period 1936-45 and for the 1945 crop. (Calculations are based on the returns of those factories operating between the end of January and the end of March.)

Mr. Barnes accordingly moved "that this Conference recommends that the Sugar Manufacturers' Association endeavour through contact with the All-Island Cane Farmers' Association to secure more regular and constant deliveries of farmers' canes in accordance with the requirements of the factory to which those farmers are registered." The motion was seconded by **Mr.** Calder and was adopted unanimously by the meeting.

The meeting adjourned for lunch at 12.45 p.m.

The Afternoon Session of the Conference resumed at 2.15 p.m., when the Chairman asked Mr. J. G. Davies to give a short summary of his papers on Dunder Disposal. Mr. Davies proceeded to outline the main points brought out in his papers which had already been circulated to members. These papers are given below:—

METHODS OF DUNDER DISPOSAL — A BIBLIOGRAPHY.

J. G. DAVIES
(Sugar Technologist, Sugar Research Office.)

I. Introduction:

The disposal of dunder from Jamaican distilleries is at present causing considerable concern. No specific reference to the disposal of rum distillery, and especially pot still, dunder can be found in the literature. The experiments at present in progress at Bernard Lodge are therefore of the nature of breaking new ground. The type of fermentation and of still equipment commonly used locally is such that it is probable that the content of organic acids and of the constituents containing aldehyde and ketone groups would be higher in Jamaican dunder than in dunder origination from a pure culture alcohol fermentation and distillation in a continuous still.

The appended bibliography of the available literature is an attempt to present to the Jamaican industry an account of what has been suggested or done elsewhere. Admittedly, in some cases, no local application is possible. But it is immediately apparent that much time, money and effort will be necessary before the local problem is solved.

II. Composition of Dunder, Slop, or Vinasse:

The term "dunder" as used in Jamaica seldom appears in the literature. The alcohol-exhausted effluent from the still is generally called "slop" in the Americas and Great Britain, or "vinasse" on the continent of Europe. To confuse further the terminology, some of the other West Indian Islands use the word "lees".

In order that a picture may be obtained of the type of material which is to be dealt with, the following analyses are quoted from the references named. No comparable analyses for Jamaica dunder have been discovered.

Hoover and Burr (25) report a typical analyses of cane molasses slop to be:—

Total Solids	71053 p.p.m.
Fixed Solids	15364 "
Volatile Solids	55689 "
B.O.D. 5-day	28700 "
B.O.D. 20-day	45000 "
Oxygen consumed	29747 "
Suspended Solids	40 "
Total acidity	4500 "
pH	4.5

The 5-day B.O.D. is the official method of estimating the biological oxygen demand of an effluent. The equipment for this determination is at present not available in Jamaica. The determinations carried out for us by the Agricultural Chemist are, strictly, "oxygen consumed". All materials do

not show such a small difference between 5-day B.O.D. and oxygen consumed as the analyses quoted above.

Marasimha Iyengar (28) reports some analyses of three samples of slop:

	Sample A	Sample B	Sample C
Sp. Gravity at 26.5° C.	1.032	1.035	1.030
Acidity, as gr. H_2SO_4 /litre	0.76	0.8	0.65
Potash, %	0.588	0.62	0.65
Phosphate, %	0.113	0.13	0.12
Nitrogen, %	1.01	1.12	1.05
Sugars, %	0.04	0.06	0.05
Ethyl alcohol, %	0.004	0.005	0.004
Evap. residue, %	6.0	6.7	6.5

Nelson and Greenleaf (39) add an interesting contribution to our knowledge of the organic acids in distillery slop. They state that slop from a cane molasses alcohol distillery contains considerable quantities of formic, acetic, succinic, tricarballylic and lactic acids, a small amount of aconitic acid and only a trace of citric acid. The original molasses was found to contain no succinic or tricarballylic acids and very little lactic acid. They therefore conclude that succinic and lactic acids are the products of fermentation, and that tricarballylic acid is formed by the reduction of aconitic acid.

According to Peck and Deerr (10), the composition of the slop constituents is:—

K20	14.43%
Nitrogen	0.97
Nitrogen in yeast	8.12
Phosphate in slop	0.48
Phosphate in yeast	4.59

III. Disposal by Evaporation or Incineration:

Judging by the literature, this appears to be the method which is most favoured as a disposal method. For distilleries attached to small sugar factories with an unbalanced heat economy, it means an even greater consumption of extra fuel. Apart from that, appreciable capital expenditure is necessary. The general scheme is to remove a greater part of the water by multiple effect evaporation and to dispose of the syrup residue by one of several methods; for example, by incineration. Hind (1) has patented a process in which the dunder is neutralised, and after concentration it is mixed with bagasse. N—I Spiritus Mij and Jacometti's patent (2) states that the evaporated residue is treated with alkali to form hygroscopic salts, or evaporation is carried to dryness to form a powder. Either end-product is then disposed of by spraying on a road surface or is worked up with other road building materials. Humbolt (3) emphasises that a multiple effect evaporator for this purpose must be constructed with copper tubes and tube sheets A vacuum evaporator is unsatisfactory. It is better to operate as a pressure evaporator with steam at 45 lbs. per sq. inch in the first calandria, so that the last body can supply heat to the still. A further advantage of this system is that if the equipment is properly designed, the incrustation will be deposited away from the heating surface and the operating and steam costs are lower. The product at a density of 36 to 40 Be, can be disposed of by self-incineration or by spraying into a brisk fire with a good draught.

Dymond (15) summarises various methods of disposal and states that during evaporation H2 and CO2 are formed. The former affects copper and both form a gas film. In America, 20 gauge stainless steel is employed for evaporator construction. Also, the liquid can be pretreated by spraying it at 205° F into steam at 100 lbs, per sq. inch pressure. This has the effect of liberating the H_2S and CO and precipitates calcium sulphate. Meynier (4) says that at Societe de Sucreries Bresiliennes, Sao Paulo, it is not possible to dispose of the slops by adding it to composts or direct to the fields. He suggests that concentration without calcination is worth considering, since calcination destroys the nitrogenous matter. A suitable but costly evapora-

ting plant connected with the stills would concentrate the liquid to one-third of the bulk, or to about 25° Brix. Luhder (6), working in a potato distillery, concentrates the slops in a two stage vacuum evaporator, with forced circulation by pump. The product contains 20% dry substance. It is mixed with enough previously dried slop, bran or corn meal to make fodder, so that the mass can be shovelled into a drum drier. The moisture is there reduced to 14%. The method is said to be economical.

Strohal (7) describes a process in which the slops are evaporated to dryness, mixed with 1.5% calcium cyanide, dried at 110° C. and powdered to form fertiliser. Vogelbusch (8) states that in a modern but expensive furnace, the slops of 15° Be may be burnt without any appreciable quantity of fuel. The potash is then recovered. The waste gases are used in a waste gas boiler, resulting in the production of 250—300 kg. steam per 100 litres of spirit. Alternatively, concentration may be conducted to a density of 32° Be, in which case the initial cost and the costs of operation and maintenance are more favourable. The steam consumption of the distillery can be reduced by heating the column with vapour from the slop evaporator. Williams (5) points out that the same condition arises in British Guiana, where the slops also cannot be returned to the fields due to the odour. He advocates disposal by the Porion furnace. According to his calculations, 100 tons molasses would produce 4 to 4.5 tons charred ash, containing 20% potash.

Owen (9) is also in favour of the Porion oven to bring the material to a dry state. He suggests that the amount of water to be evaporated can be reduced by setting the wash at a higher density. Leite (16) states that the Porion furnace has been abandoned at Santa Terejinha, Brazil, in favour of pumping the liquid after evaporation through injection nozzles into a bagasse fired furnace. The furnace ash then contains 40% potash and is an excellent fertiliser. Raffinerie Tirlemontoise have a patent (11) for a furnace which occupies little space, has a large capacity and is easy to operate. Incineration takes place by injecting the slops through atomizing nozzles into a previously heated combustion chamber. Ash collects in a pit below and the heat is used for generating steam in a boiler.

Srinivasan (12) describes a process in which a triple or quadruple effect evaporator is followed by a Porion furnace. The charred mass is lixivated with water, filtered and evaporated to dryness. The residue contains 30 to 40% potash. He is an advocate of the Reich process (12). In the Reich process, the aim of which is to reduce steam consumption, the fermented wash is de-alcoholised in an evaporator. The alcohol is recovered in the calandria condensate and the concentrated slop withdrawn from the last vessel is incinerated. Joint research in Taihoku and in Formosa (13) has resulted in recommending the evaporation of the slops, which are then dried in the sun on concrete floors and ground to a powder, or sufficient powdered bagasse is added to yield a dry mass suitable for transportation. Brown's patent (14) specified continuous filtration through cloth followed by liming and a second filtration. The filtrate is then acidified and concentrated.

IV. Destructive Distillation:

Humbolt (3) states that in practice, destructive distillation is not simple. Acetic acid, methanol and acetone are recovered. The mass loses water and then becomes semi-fused, later solid and very hard before carbonizing. A mass two feet thick requires to be heated to 800° C. to produce carbonization, because the temperature at the centre is then only 275° C. These high temperatures are destructive on plant material and wasteful of heat. In a distillery making 22,000 gallons alcohol per day, the permanent gases are burnt under the retorts, and the tars either distilled or also burnt. Large amounts of ammonia are easily recovered together with the aliphatic derivatives. In Guillissen's patent (17), the slop is subjected to pyrogenous continuous distillation in the presence of excess alkali metal base at atmospheric pressure and a temperature below 600° C. The Distillate is treated for the recovery of nitrogen and acetone. Non-oxidising gases are separated at low temperature and returned to the distilling apparatus. Nouvelles Industries Chimiques, Soc. Anon. have a similar patent (18), in which slops are mixed with lime and sawdust. Distillation takes place at 350° C. in a

metal retort with stirring gear. Guignard has patented a process (19) which specifies destructive distillation under vacuum in the presence of water. The water is gradually and continuously introduced during the entire process with agitation. The temperature is 450° to 650° C. Finally, Barbet's patent (20) states that the slops are concentrated until the boiling point is 125° C.

The heated liquid is then subjected to a sudden high vacuum which causes vigorous evaporation. The resulting vapour carries over glycerine.

V. Chemical Methods:

Pittman and Bottons describe a patented process (21) in which slops are treated with bentonite leaving a liquid with 2.5% total solids. The clarified liquid is then evaporated. Hoover and Burr (25) state that chemical treatment is unsatisfactory but it may be of value as a preliminary step to anaerobic fermentation. The following chemicals were used: lime, alum, ferric sulphate, sulphur dioxide, chlorine, tri-sodium phosphate, clay and kieselguhr. Snell and Fain (22) working on laundry wastes, found that by adding 360 p.p.m. of commercial alum sulphate and 114 p.p.m. of sulphuric acid a substantially clear effluent was produced. The oxygen consumed was reduced 90%. Sanborn (23) describes five methods for the disposal of vegetable cannery wastes. They are (a) Screening, (b) chemical precipitation, (c) biological filtration, (d) impounding lagoon, and (e) municipal disposal plant. As regards (d), he suggests the addition of sodium nitrate to control odours. This addition satisfied 20% of the initial 5-day B.O.D.

VI. Bacterial Activity:

Littlefield (24) is of the opinion that provided sufficient time is allowed for passage through a filter, an almost complete oxidation of the organic matter is effected once a suitable bacterium is established. This applies to steep-water, pot-alo, spent lees and wash waters. Hoover and Burr (25) diluted some filtered slop to 2000 B.O.D. and passed it through an activated lathgrid trickling filter. The slop lost 90% of the oxidizable matter, running at the rate of 1 Mn. gallons per acre per day. Intermittent sand filters are of low capacity and clog up. A coke breeze, intermittently-fed filter, four feet deep gave good results. At a flow of 200,000 gallons per acre per day, the B.O.D. was reduced by 98%. The filter started promptly without inoculation. Sewerage or sludge extract can be used if the filter does not function after being dosed. Boruff and Bushwell (26) are of the opinion that converting slops to fertiliser or fodder or removing potash, organic acids or glycerine fails to nett a reasonable profit. They suggest that the hot waste containing 3-4% solids and 0.2% organic acids should be fermented thermophilically in order to produce fuel gas at low cost. They calculate that the yield per 1000 gallons is 2400 cu. ft. of gas, and 58-72% of the organic matter is gasified in two to six days. The residue is a stable inoffensive sludge and a liquid which can be discarded to a sewer or stream. Cosculluela (27) describes a process similar to that for which Munro (40) installed a plant at Bernard Lodge. The process (27) is to dilute the slop with four times its volume of water after which it is received in a sedimentation tank. The diluted dunder is then innoculated with ammonifying bacteria. Vigorous fermentation is said to set up after four days, and the pH rises from 4.0 to 7.0 to 8.0. After fermentation is completed, no putrescible matter is present and the liquid is filtered through beds of foundry slag or charcoal. The efficiency of the process is certified by the sanitary authorities in Cuba. Marasimha Iyengar (28) refers to Cosculluela's process. Jensen (29) outlines the method used in the Slegelso yeast factory in Denmark for the disposal of slops. Anaerobic fermentation is set up by a special culture of bacteria, the optimum temperature of which is 35° C. Gas is produced at the rate of 1000 to 1500 cubic metres per day. The gas consists of methane, carbon dioxide and hydrogen. The calorific value is 5000 kg. calories per cubic metre. It is used under the boilers. After the anerobic fermentation, the liquid passes through a system of ponds in which further fermentation occurs. It is then sent to a biological filter. The effluent of the filter is diluted with a large quantity of water and run to waste in a stream. A possible disadvantage is the production of hydrogen sulphide from the sulphates in the molasses. Buswell and Lebosquet (30) state that pilot plant experiments

on the purification of grain slops by anaerobic fermentation confirm laboratory experiments. The effluent from anaerobic fermentation is diluted with five times its volume of trickling filter effluent. It can be established on a trickling filter running at the rate of 250,000 gals. undiluted digestion liquor per acre per day. The high nitrogen content of the recirculated filter effluent prevents odour nuisance. There is a small amount of sludge, which contains calcium and magnesium phosphates.

VII. Irrigation Water:

The only reference to the disposal of dunder in irrigation water is a mention by Dymond (15) who records the practice in Mauritius. The dunder is first limed before mixing with the water. It may or may not be settled.

VIII. Stock Feed:

Besides Luhder (6), see III, whose final product is for stock feed, Broughton's et al (31) suggest that the solid matter in the slops should be seperated and dried to form a dark brown, fine slightly bitter tasting meal. It contains moisture, 7.43%; nitrogen as protein, 31.37; fat 3.47; fibre, 9.25; nitrogen free extract, 36.55; and ash, 11.93. Too high a proportion cannot be used without lowering the palatability, but 8.1 is readily eaten by hogs. Goldschmidt's patent (33) concerns the separation of the yeast cells, nitrogenous and other material by centrifuging. It is then mixed with bran or linseed cake to form a fodder. Cuker's patent (34) appears to be very similiar.

IX. Fertiliser:

Leite (16), Strohal (7), Williams (5), Meynier (4) and Vogelbusch (8) have been mentioned, see III. Cerasoli has a patent (32) in which the molasses distillery residue is mixed with Kieselguhr or phosphorite or calcium sulphate to form a fertiliser. Metzl (35) advocates heating the residue to about 70° C. with an equal weight of superphosphate. It is then further heated to 130° C. for the complete expulsion of water and the organic acids set free in the first heating. Hinchy (36) describes some preliminary experiments in which heaps of trash or bagasse are treated with the sludge and allowed to ferment. The heaps are turned at intervals.

X. Manufacture of Briquettes:

Moore and Myers (37) state that a 2½ oz. briquette can be made in a plunger press at 7000 lbs. per sq. inch. It consists of 93% 8-mesh anthracite dust and 7% slop evaporated to 33 Be. The briquettes are baked at 600° F. for not less than ten minutes. A combination of asphalt, sodium carbonate, calcium chloride and sulphur makes an excellent binder with concentrated slops.

XI. Electrolytic Treatment:

Brockman (38) has recently described a patent in which the hot unscreened distillery slop is electrolysed. About one half percent of common salt is added. The current per sq. ft. of electrode surface is 30 amp. D.C., or 4 volts, 150 amps. A.C. The liquid may be re-cycled.

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INVESTIGATIONS INTO DUNDER DISPOSAL IN JAMAICA

J. G. DAVIES,
Sugar Technologist, Sugar Research Office, Sugar Manufacturers Association (Ja.) Ltd.

I. Introduction:

The disposal of dunder in Jamaica has now become an issue of the greatest urgency. The rum industry is fully aware of its obligations, and intensive investigations are proceeding. On the other hand, and because of the particular nature of dunder, no method applicable to the local industry has yet been found. The Jamaica rum industry is different from any other in the West Indies. While in the other islands, rum or alcohol is made in a comparatively small number of large distilleries, here the reverse is true. Hence a method of disposal involving heavy capital outlay and a technical staff would defeat the object in view, because the cost would be too great for the size of the average Jamaica distillery.

In order that the local industry and authorities may be fully aware of the magnitude of the problem which confronts them, a bibliography of available literature was prepared and circularised. The bibliography has been presented as a separate paper.

It will be noted from the bibliography that possible disposal methods fall into three main classes. They are: (1) Chemical engineering, (2) Chemical and (3) biological.

Chemical engineering methods include evaporation, incineration, destructive distillation, etc. They are more applicable to large centralised distilleries, because the initial and operating costs are high. For the majority of Jamaica distilleries, the methods could be considered only as a very last resort.

Chemical methods are based upon attempts to remove the noxious constituents by precipitation, with or without subsequent treatment. It is not surprising that in the case of molasses dunder the methods have failed. The raw material for rum manufacture, molasses, is unlike the raw material

for, say, whiskey manufacture. Molasses is the end product of sugar manufacture. As such it has already undergone the processes of liming, heating, subsidisation, evaporation and boiling. Hence the constituents of molasses are those of the original juice which are unaffected by these treatments, and as such must be relatively stable. It is unlikely therefore that any commercially applicable chemical method would be successful. Such has been found to be the case by Hoover and Burr (see Bilbliography (25) page 20). Experiments have also been conducted locally with the same negative result.

Biological methods aim at changing the noxious constituents of the dunder by means of anaerobic fermentation. The anaerobic method advocated by Coscuelluela (See Bibliography (27) page 20), which has been tried at Bernard Lodge, has so far failed to produce the necessary results.

In irrigated areas, dunder may be disposed of in the irrigation water without apparent harm to the cane or soil provided the degree of dilution is great enough. The method is recorded as being used in Mauritius (see Bibliography, Dymond (15) page 21), and is being tried locally in the appropriate districts.

Comparatively few of the Jamaica sugar estates enjoy the benefits of irrigation. Therefore as far as the disposal of dunder is concerned an application of one of the three other methods must be adopted, Of these and in spite of the present experience, the biological method seems the one best suited to local conditions. It was presumably on this ground that Bernard Lodge installed their anaerobic fermentation plant. The plant was the first built in the island before the Sugar Technology section of the Sugar Research Office had come into being. When the section did begin to function, the Bernard Lodge plant therefore provided a logical starting point for investigation. Since then two other estates have constructed plants. The work at present being conducted at these three estates will now be described.

II. Investigations in Jamaica.

The effluent discharged by a factory or distillery is judged by health authorities as acceptable or not, by means of its chemical analysis. The two most important values are the biological oxygen demand (B.O.D.) and the suspended solids, both expressed as parts per million. In Great Britain and the United States, maximum allowable values have been declared. At present, the Jamaica authorities have made no such declaration, and investigators are therefore somewhat in the dark as to what to aim at.

Before the Sugar Research Office commenced its work on this problem, it enlisted the aid of Mr. R. F. Innes, Senior Agricultural Chemist, and of Dr. L. Grant of the Bacteriological Laboratory. Discussions were also held with Dr. K. Leigh Evans and Dr. L. E. Arnold.

(A) Bernard Lodge:

The Bernard Lodge plant has been fully described by Munro (see bibliography (40) page 20).

(1) Pig Manure:

At the time of construction, it was proposed to start the anaerobic fermentation by means of pig manure. This was the material recommended by Coscuelluela. It was used during the initial run of the equipment and for the first series of experiments.

After the plant had been operating continuously for some days, samples were collected and analysed; the results were:

Effluent from filter	.....	6,305 B.O.D.
Effluent after mixing with irrigation water	.....	134 B.O.D.

In view of these results, it was thought that perhaps the organism had not yet attained its maximum activity. Also the degree of dilution and other operating factors were not yet under full control. Thus a month later, further samples were collected and analysed with the following results:

Diluted dunder into anaerobic tank	....	1,900 B.O.D.
Effluent from filter	.....	1,700 B.O.D.

The effluent had the appearance of dunder, but lacked the unpleasant smell. Suspicion then arose as to whether the culture from pig manure was in fact capable of reducing the B.O.D. of Jamaica pot-still dunder. A fresh culture of pig manure was set up in a puncheon. Fermentation proceeded slowly. The plant was shut down and the anaerobic tank emptied. The tank was then filled with fresh pond dunder. The contents of the puncheon, after fourteen days, were added. No attempt was made at continuous operation, for which purpose the plant had been designed. A static test was conducted in order to provide information upon the ability of the organism to decrease the B.O.D. and the rate at which this occurred. The experiment lasted seven days. The initial and lowest B.O.D. values observed were:—

	B.O.D. per 1° Brix.*		
	Initial	Lowest	Days
Pig manure organisms	3,000	1,930	3

Vigorous fermentation was observed after the first day, but it was considerably less after the second. From the third to the seventh day the B.O.D. value increased.

Laboratory experiments were then set up to determine whether the addition of nutrient, the provision of better anaerobic conditions by oil-sealing, or a preliminary but expensive chemical treatment would produce the required results. The effect was negative in each case.

Meanwhile a volume of fresh dunder equal to half the capacity of the tank had been added and the results observed. There was no change in the B.O.D. value after three days.

This suggested possibility that the drop in B.O.D. initially observed was not due to the organism attacking the oxygen demanding constituents of the dunder, but that they were merely converting the organic matter introduced with the pig manure. However, the results so far from the practical point of view were that, even under static conditions, pig manure organisms had proved incapable of reducing the B.O.D. value of pot-still dunder. The second experiment explained the reason for the results observed during the initial operation of the plant.

During the course of the experiments with pig manure organisms at Bernard Lodge, samples had been submitted to Dr. Grant for bacteriological analysis. He succeeded in isolating anaerobic bacteria. These bacteria were introduced into dunder under laboratory conditions. Few signs of active fermentation were observed. Dr. Grant concluded that the organisms were unsuitable.

It was therefore apparent that, both as a result of the experiments at Bernard Lodge and of Dr. Grant's laboratory observations, the B.O.D. value of Jamaica pot still dunder could not be reduced by pig manure organisms.

It has been stated that the Bernard Lodge disposal plant was designed and erected for continuous operation. In view of the results just described, it became apparent that the first requirement was to discover an organism which could achieve the desired decrease in B.O.D. value. Since the Bernard Lodge plant was designed for anaerobic fermentation, other sources of anaerobic organisms were sought and tested. All the subsequent experiments so far conducted have been carried out without any flow of liquid through the anaerobic tank. The aim has been to establish conditions as near ideal as possible. If, as has not yet occurred, an organism was discovered which proved satisfactory, then the factors governing its industrial application could be determined subsequently.

As a result of the above considerations, four other sources of anaerobic organisms have been tested. Each experiment lasted from ten days to a month.

(ii) **Dunder pond muck:**

The western end of the pond at Bernard Lodge in which the diluted dunder is stored, appeared to be in a state of active fermentation. Occasion-

*Note: B.O.D. values are henceforth quoted as per 1° Brix in order to eliminate the effect of dilution.

ally large sods of earth would appear at the surface, showing that fermentation was taking place in the earth bottom of the pond with the evolution of gas.

Some of the muck from this part of the pond was added to fresh diluted dunder in the anaerobic tank. A slow fermentation took place for nine days during which time the B.O.D. value decreased. During the next nine days, the B.O.D. value rose and fluctuated. The initial and lowest values were:—

	B.O.D. per 1° Brix		
	Initial	Lowest	Days
Dunder pond muck	3,550	2,670	9

(iii) **Soil from beneath dry cow pats:**

Some soil taken from beneath dry cow pats was collected and added to a puncheon full of dunder. Fermentation was slight. After fourteen days, the contents were added to the anaerobic tank filled with fresh pond dunder. The B.O.D. value fell fairly rapidly after one day, showed no change after two days, then rose and fluctuated up to the eleventh day when the experiment was discontinued. The results were:—

	B.O.D. per 1° Brix		
	Initial	Lowest	Days
Dry cow pat soil	4,250	2,000	1—2

(iv) **Cesspit effluent:**

Cesspit effluent was added to dunder in a puncheon. A scum formed with a ring of whitish bubbles round the rim. The whitish bubbles developed during the course of fourteen days, after which time the anaerobic tank was pitched with the liquid. The results were:—

	B.O.D. per 1° Brix		
	Initial	Lowest	Days
Cesspit effluent	2,880	860	13

After the thirteenth day, the B.O.D. value rose and fluctuated. There was no appreciable change after fifty-six days.

(v) **Putrefying pit liquid:**

A drum of putrefying pit liquid was obtained from the distillery of Cambridge Estate, Trelawny, by permission of the owner. It was added to the anaerobic tank full of fresh pond dunder. There were few signs of active fermentation, but the B.O.D. value fell fairly consistently. The experiment is in progress at the time of writing this report. The results are:—

	B.O.D. per 1° Brix		
	Initial	Lowest	Days
Putrefying liquid	1,875	810	25

In the above experiments ((i) to (v)) it will be noted that the initial B.O.D. per 1° Brix fluctuated a good deal. This is due to the fact that the sample was taken after the material containing the organism had been mixed with the liquid in the anaerobic tank. It therefore includes organic matter contained in that material.

(vi) **Bernard Lodge Pond:**

In (ii) above, it was reported that part of the pond appeared to be in a state of active fermentation. In order to expedite the experiments for which the disposal plant was necessary, a series of laboratory experiments was set up. In these, raw dunder was cooled, diluted to 1.0, 2.0, 4.0 8.0 and 12.0° Brix. pond muck added to each in a cylinder and oil-sealed. The cylinders have now been left untouched for five months. The contents will be analysed early next year. The aim of this experiment is (i) to determine whether the organisms which naturally occur in the pond require a long period of time to be fully effective, and (ii) to determine the effect of dilution.

(vii) **Aeration:**

Dr. Leigh Evans suggested that simple aeration of the raw untreated dunder might be beneficial. A preliminary laboratory experiment was conducted. The stem of a Buchner funnel was plugged with filter paper to act

as a wick. Some dunder diluted to 2° Brix was placed in the funnel and allowed to drip slowly into a beaker beneath. This was repeated four times. The initial B.O.D. was 7,700 and the final 8,150. The increase was probably due to evaporation. Although the result was disappointing, the possibilities of aeration are to be more fully explored when the sugar technology section possesses its own laboratory, equipment and trained staff.

(B) **Caymanas:**

At Caymanas Estate, two sets of ponds each of 375,000 gallons capacity have been bulldozed. The idea is to use each set alternatively. At a flow rate of 10,000 gals. per day, the effluent could remain in the ponds for 37.5 days.

Shortly after construction, Mr. McFarlane, Chief Chemist, reported some encouraging results. A series of weekly samples were then taken by Mr. McFarlane for the Sugar Research Office with the following results:—

Week	B.O.D. per 1° Brix	Remarks.
0	23,300	Soil wash present.
1	2,500	More dunder added.
2	2,560	
3	5,350	After hurricane rains.
4	900	
5	1,750	
6	1,660	

Heavy rains and flooding terminated the experiment.

On the basis of some analyses previously conducted by Mr. McFarlane. it is apparent that the initial reading was made up of about 2,700 B.O.D. due to the dunder itself and the rest due to organic matter in the drainage water. The increase at the end of the third week was likewise probably due to organic matter washed down by the hurricane rains.

It is deeply regretted that results comparable to the ones reported earlier were not observed. The samples were taken from the same pond.

(C) **Innswood:**

Innswood has constructed a large circular pond, about 7—8 feet deep and divided it into two quarters and one a half section. The original idea was to use it as a settling pond, but the partitions leaked and could not be mended until the out of crop season.

Meanwhile Mr. E. Mackenzie, Distiller, has been conducting some small scale experiments involving filtration. While undoubtedly the dunder is of improved clarity after treatment, the B.O.D. decreased from 2,970 per 1° Brix to 2,280 per 1° Brix. Filtration is expensive but Mr. Mackenzie is continuing his experiments with every encouragement from Mr. Campbell, the Manager and with the co-operation of the Sugar Research Office.

III. Summary of Jamaica Experiments to Date:

It is apparent from the above that no distillery is yet in a position to dispose of its dunder in an innocuous state. Three distilleries have spent money and time in attempting to find a solution. The Sugar Research Office has conducted a considerable amount of investigation with the facilities at its disposal. The position will be eased somewhat for the staff of the Sugar Research Office when a fully equipped laboratory and staff are available. Fulfilment of this requirement is being pursued, but building and appartus delivery difficulties have arisen.

IV. Further Possibilities:

From many points of view, a biological disposal method is the one best suited to Jamaican conditions. Whether or not the method is to be based upon aerobic or anaerobic fermentation remains to be seen. The problem therefore still boils itself down to the need for discovering a suitable type of organism. Dr. L. Grant has been good enough to start enquiries from authorities in the United States. Other possible local sources will be investigated.

Jamaican distilleries are seasonal in their operation. It is not therefore necessary that the plant should be of the continuous operation type, such as is required for sewage disposal. Where land is available, a large pond could be excavated by bulldozing, and the dunder stored in it until the end of crop. The organism could then be introduced and left for five to six months if necessary.

Where ample water is available, an acceptable B.O.D. value might be obtained by simple dilution. But the standard declared by the local Health Authorities would control the degree of dilution necessary.

Recently, a patent has been issued in the United States for an electrolysis process. Copies of patents cannot be posted outside the mainland during the present emergency, hence the applicability of the method to the local problem cannot be examined.

Contact has been established with Prof. J. L. Simonsen, Director of the Colonial Products Research Council. It is hoped that a solution suitable for the local distilleries may be forthcoming.

V. Acknowledgements:

Appreciation is recorded of the assistance obtained from Mr. R. F. Innes, Senior Agricultural Chemist and the staff of his laboratory in conducting the chemical analyses, from Dr. K. Leigh Evans, Dr. L. E. Arnold and Dr. L. Grant of the Government Bacteriological Laboratory and for their sustained interest and advice, and from the staffs of the distilleries concerned, with special mention of Mr. J. Munro, Manager of Bernard Lodge. The greater part of the work reported in this paper was conducted at Bernard Lodge, and therefore without the initiative of the United Fruit Company in erecting the plant it would not have been possible.

The Chairman now declared the papers open for discussion.

Mr. Innes said that in his opinion, it was necessary to modify the views now held in regard to dunder disposal. The Health Authorities should state their requirements — that is, the degree of purity that should be preserved in streams or rivers into which effluent was discharged, depending on the accepted use of such waterways. In other countries, this was done, i.e. the minimum dissolved oxygen content, and the amount of sludge, acidity and bacteria were defined according to the use to which the water would be put. The dissolved oxygen of water in a normal stream carrying no oxidisable load remained near the saturation point, approximately 8.5 parts per million at 25° C. Any departure of the stream from that figure of 8.5 would be in proportion to the load which it carried of impurities to be oxidised. In the U.S.A. for the preservation of fish life in the Ohio and its tributaries, the stream should not contain less than 5 parts per million of dissolved oxygen at any one time, though a lower standard was acceptable for water used for domestic purposes only, and a still lower oxygen content was allowed for industrial purposes. The pH of the streams into which dunder was likely to be discharged was high and the danger arising from undue acidity was, therefore, small.

It was common to use minnows for ascertaining whether a discharge of dunder was effecting pollution or not, but this was not considered a satisfactory test for ascertaining whether such water would support wild life.

In his opinion, before any further investigations were made, the natural purifying ability of the various water courses into which discharge was to be made should be assessed. The flow of rivers during the dunder discharge season and the minimum dissolved oxygen content of the water should be recorded, so that the amount or rate of dunder discharge into any stream at different rates of flow, or at different oxygen contents, could be gauged. The industry would then be in a better position to discuss with the Health Authorities, the degree of purification of dunder that would be required.

He stated further, that in regard to the electrolytic method, on figures supplied by Mr. Floro, at Frome, about one million pounds of dunder were produced in 2½ days, which at 33,000 parts B.O.D. meant that every 2½ days, approximately 16 tons of electrolytic oxygen had to be produced. This would be a very expensive undertaking.

Mr. Barnes said that he wished to deal with the administrative aspect of the problem rather than the technical. The investigations which were proceeding should be continued with vigour, and much had been accomplished. But whatever the results of the enquiries outlined by Mr. J. G. Davies and his co-workers might be, they had to consider the problem from the point view of the laws of the Island.

Three laws existed dealing with the subject, and the latest passed recently, the Wild Life Protection Law, No. 46 of 1944, assented to by the Governor on November 16, contained provisions which, when effective, would so far as could be seen, prohibit the discharge of any kind of factory effluent, including dunder, into any place, where it might endanger any fish. The question was a much greater one than the treatment of dunder.

Consideration was at present being given to the establishing of other industries which would discharge effluent to perhaps a greater extent than the manufacture of sugar or rum and in fact, a Food Yeast Factory was actually being erected.

Under the Water Law, provision was made for the recognition of prescriptive rights, which in some cases had been established by costly legal process. An amendment to the Public Health Law had then been passed which enabled effluent to be discharged into a stream only under a permit issued by the authority administering that Law. Now the Industry was faced with a new control which appeared to ignore any previous ones. The actual effect of this when it came into force would be to prohibit entirely, the discharge of any type of effluent directly or indirectly into any water containing fish. There was no definition of effluent, nor were any standards laid down. The relevant Section 10 of the Law read:—

1. "Notwithstanding anything to the contrary every person who causes or knowingly permits to flow or puts or knowingly permits to be put, whether directly or indirectly, into any harbour, river, stream, canal, lagoon or estuary, containing fish, any trade effluent or industrial waste from any factory shall be guilty of an offence against this section and shall, upon conviction before a Resident Magistrate, be liable to a fine not exceeding two hundred and fifty pounds or to imprisonment with hard labour for any period not exceeding twelve months.

2. No proceedings shall be instituted in respect of any breach of the provision of sub-section (1) of this section committed within twelve months or such further period as the Governor in Privy Council may determine from the date of the coming into operation of this Law."

Until the Governor had decided to proclaim the Law it was not in operation, and even after that there was provision for delayed action of the section which affected the interests of the Sugar and Rum Industries. The grave danger was however clearly apparent. It was not perhaps realised that the terms "effluent" and "industrial waste" were, in the absence of definitions and standards, so comprehensive as to preclude the discharge of condenser water, floor washings, and any waste material into water containing fish of any kind.

He understood that there were certain legally established safeguards in the United Kingdom, including consideration of the various interests involved amongst which were the industries carried on in any particular district, and that those moderated the force of the Law in regard to the discharge of trade effluent into streams. No such provisions appeared in Law 46 of 1944, though the permit system under the Public Health Law did enable such matters to be taken into account.

The value of our industries, now the most important in the Island, and their effect on the welfare and economy of the whole population, demanded that a carefully balanced view of everything involved in such drastic control, including workers, manufacturers and consumers of our products — must be carefully considered and weighed before any control or restriction affecting

those interests was introduced. It was the desire of the West Indies Sugar Company Ltd., and indeed of the whole industry, to reduce pollution by effluent to a minimum.

Mr. Barnes said that in his opinion, a formal resolution should be forwarded to the Sugar Manufacturers' Association making definite recommendations as to what action should be taken in the matter.

Mr. Elder cited what he considered to be a unique experience at Serge Island where during 1944, distillery effluent had been discharged into the estate irrigation system. The Government Health Authorities were invited to give the necessary certificate of approval, but after several months no reply had been received. He was of the opinion that this showed that the authorities did not themselves know what their requirements were.

Mr. Whitaker stated that Gray's Inn Central Factory planned to conduct all their factory effluent by means of a canal to the nearest point on the coast for discharge into the sea. Blue print plans and complete details of these proposals were sent to Government for approval some months previously but no reply had yet been received.

Mr. Croucher asked whether Mr. Penning could give any information concerning his experience of treatment of dunder in other countries.

Mr. Penning stated that he had experience only of modern distilleries where the effluent or lees could in some cases, after dilution, be used to good advantage, as a fertilizer. However, he had no experience of any effluent of the same qualities as Jamaica dunder and was not sanguine as to whether any satisfactory solution could be found for its economic disposal.

Mr. Cuthill was of the opinion that judicious negotiations would go a far way in smoothing out difficulties. He felt that if Government could be shown that the Industry was exerting considerable effort in attempting to solve the disposal problem, the law in question would in all probability not be enforced. He felt that the legislative measure now enacted had come about because there had been a general public feeling in the past, that the industry was making no effort to solve the dunder disposal problem.

Mr. McFarlane suggested that the bacteria being used might possibly be identical to those in use in other countries, but that the lack of success might be caused by unsuitable conditions of culture. He asked whether the bacterial action had been investigated under varying conditions of pH of the wash.

Mr. J. G. Davies replied that some simple experiments had been conducted and that a more thorough investigation would be carried out when equipment and facilities were available.

Mr. Barnes then submitted the following resolution which was seconded by Mr. P. Bovell and passed unanimously:—

RESOLVED: "That this Conference earnestly recommends that the Sugar Manufacturers' Association continues to pay close attention to the problem of disposal of factory and distillery effluent, including dunder, and that amongst other things, strong representations be made to Government in regard to the effect upon our Industry of the 'Wild Life Protection Law' when it comes into operation in its present form.

The Conference urges that action be taken to secure legal definition of the nature and quality of factory effluent which will be permitted to be discharged having regard to the use to which streams or other points of discharge are put.

It is further recommended that the investigational work now being conducted be continued as vigorously as possible."

The President then asked Mr. R. V. Holme to present a brief summary of his paper on "Weed Control" which had already been circulated to members. Mr Holme proceeded accordingly to outline the more important points of his paper which is shown below:—