CEYLON COFFEE SOILS AND MANURES.

A Report

TO THE

CEYLON COFFEE

PLANTERS' ASSOCIATION.

BY

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ARRIVAL IN CEYLON.

UNDER an arrangement with the Ceylon Planters' Association to remain in the Island some two or three months as Analytical Chemist, I arrived in Colombo from Galle on the 17th November, 1877. Before leaving Southampton in the "Pekin" I had despatched my cases of analytical apparatus by the "Eldorado," and was glad to find that they had duly reached their destination in safety.

Upon calling on Mr. H. S. Saunders, the then chairman of the Association, I was informed, however, that it had been arranged for me to make an extensive tour through the principal coffee districts, previous to the commencement of my analytical duties in Colombo.

Fresh from Europe, unacquainted with the character of the natives, with no experience of the conditions of travelling up country during monsoon weather, and being a perfect stranger to all I should meet, it will be admitted that the prospect of continuous travelling in all kinds of weather for some seven or eight weeks did seem a formidable undertaking. However, as the tour had been fully arranged, there was nothing for me to do but to endeavour to meet the engagements already made. Fortunately, the Indian pony selected for me by the chairman proved admirably adapted to the estate paths, and carried me bravely along the main roads.

The weather after the first two weeks was also favourable, while the hearty welcome I met with from the planters soon made me feel quite at home in their snug bungalows.

The few days spent in Colombo previous to starting, were employed in calling upon some of the firms to whom I had letters of introduction. The editor of the *Observer* very kindly furnished me with a map of the planting districts, and several interesting pamphlets written in connection with the leading enterprise of the Island.

A room in the clock tower at the gas works was placed at my disposal as most suitable for a temporary laboratory, and the cases of chemical apparatus were carefully conveyed thereto, and the necessary internal fittings were selected, and it was arranged that everything should be completed by the time of my return.

TOUR UP COUNTRY.

The following is a brief account of my tour, and includes the names of estates visited, or at least passed through; the time allowed was much too short to admit of making any stay beyond a few hours at most on any estate. The names, however, will enable any one acquainted with the districts to observe the route pursued.

Nov. 21st.—Left Colombo by the morning train for Kandy, where I remained two days, during which I visited the Botanical Gardens at Peradeniya, and had an interview with Dr. Thwaites.

Early on the 23rd Mr. Hugh Fraser drove me into Matale, and being chairman of the district Association entertained me that night at Kandenewera, and the next day placed a horse at my disposal (my own not having yet arrived), introduced me at the planters' meeting, and afterwards rode with me through the district. We had some very bad weather, and I had ample opportunities of observing the ill-effects of wash, the roads being flooded and the native paddy fields being broken up and completely disorganised in many localities.

Portions of the following estates were visited:—Hunasgeria, Kandenewera, Suduganga, Ettapolla, The Glen, Borders, Asgeria, Hampshire, Wiltshire, Aloowihare, Opalgalla, Oodelamana, Damboolagalla, Poengalla, Pitakanda.

When passing through Rattotte we paid a visit to the lime kilns, and observed that very fair lime for agricultural purposes could be prepared by burning the native limestone.

Returned to Kandy by the afternoon coach on the 27th, and spent the evening with Mr. Philip, the secretary of the Association, who gave me much useful information respecting the route arranged for me.

Nov. 28th.—Left Kandy by morning train for Gampola. Here I had to engage a conveyance to Nawalapitiya, railway communication being interrupted in consequence of a slip in one of the cuttings. At Nawalapitiya Rest House found my horse and attendant awaiting my arrival. In the afternoon made a short excursion into Dolosbage district at the suggestion of a few planters, Mr. Mercer, of Blackwater, at whose bungalow I was to have stopped the night, being down in Colombo. I found the roads in Dolosbage very rough, and as the afternoon advanced heavy rain so increased the mountain streams that we were compelled to stop for the night at Hillside.

Nov. 29.—Next morning rode through Barnagalla to Windsor Forest with its tea plantation; Saint Rumbold, where the steep faces were thatched with grass; Oregalla, and then back to Nawalapitiya Rest House.

Nov. 30th.—Ambagamuwa, spending the night at Abergeldie, where Mr. Blacklaw invited several planters to meet me. Indeed I was expected the day before, and should have pushed on to Waterwelle instead of returning to Nawalapitiya, but my programme was not sufficiently definite on this point. While in this district I secured a sample of the clay subsoil for future analysis. In the course of conversation I suggested that great benefit would probably result from well forking the surface on all land inclined to be stiff.

Dec. 1st.—Planters' meeting in Dickoya at Norwood Store. Several resident proprietors present; made a few remarks in reference to the practical value of analyses of soils and manures. Mr. Walker (the chairman) put me up for the night at Del Rey; and on 2nd, walked up to Tientsin, whence we obtained a view of the Patana land in the distance—quite a change after seeing so much coffee in the Dickoya Valley. In the afternoon rode over to Glencairn, and on to Blair Athol for the night.

Dec. 3rd.—Through Blair Athol Gap and visited Brownlow, Bunyan, Queensland, Bloemfield, New Brunswick, Cruden, Glenagie, Deeside, Gangawatte, Mousakelle, and, lastly, Nyanza, where I stopped the night. When the moon appeared, the view from the bungalow of the Adam's Peak mountain range of forest was very grand.

Dec. 4th.—Meeting of the Maskeliya Planters' Association at the Hospital. On the way there passed through Eccleston, Leaston, Bittern, Laxapani, Adam's Peak, Avoca. After the meeting (25 members present) returned to Bunyan bungalow for the night; and on the following (5th) day ascended Adam's Peak in company with Mr. Fleming, starting at 6 a.m., and being back in time for a late tiffin at 3 p.m. The weather was wet and unfavourable for obtaining a good view. From the summit of the Peak, however, we obtained several magnificent bunches of rhododendron blossoms; also fragments of the rock for analysis at some future date. After tiffin at Bunyan bungalow pushed on for Stockholm, having arranged to spend the night with Major Tranchell.

Dec. 6th.—Walked over Stockholm estate; afterwards rode through Dickoya to Hatton bungalow.

Dec. 7th.—Visited Errol, Poolbank; afterwards rode over the ridge, and entered Dimbula, and after viewing the picturesque Devon Falls reached Mount Vernon, the residence of Mr. Cantlay (secretary to the Dimbula Association) with whom I remained for the night, walking over the estate early next morning.

Dec. 8th.—Attended district meeting held at Lindula; about 30 members present. On the way there made a short stay at Middleton, where I had the pleasure of making the acquaintance of Mr. Ballardie; the evening was spent at Ritnageria.

Dec. 9th.—After morning service rode up the Wallaha Valley with Mr. B. Laurie, going as far as Bambrakelly, and returning to Ritnageria for the night.

Dec. 10th.—In company with Mr. Humphreys, called on Mr. Elphinstone, the laird of Logie, and had a good walk over that estate, as well as the adjoining one of Belgravia; also inspected the cattle shed with its special arrangement of the cattle on a lattice floor, with the pigs in the basement. Such an arrangement must make the manure very concentrated, the cattle having no litter whatever, the liquid droppings passing directly into the piggery, while the solid excrements are removed by coolies at least twice a day.

Dec. 11th.—Left Ritnageria for Langdale, and was fortunate in finding Mr. E. Heelis at home. I should have been sorry to have missed doing so, Mr. Heelis being one of the few men in Ceylon I was previously acquainted with, having met him in London.

Travelling from Langdale to Newera Elliya, quite alone as regards European company—my horsekeeper being the only attendant—I can scarcely say what route was pursued; a somewhat irregular one, I believe, a certain bridge having been washed away. I must have been very near Abbotsford, and much regret I did not know in time that my route lay in so close proximity to it, or I should certainly have called and spent some hours in order to visit the estate of a man who has done so much for Ceylon as Mr. Ferguson.

Arrived at the club, Newera Elliya, where I met a few planters, among whom being Mr. Gibbon. The night was passed at Kandapolla.

Dec. 12th.—Returned to Newera Elliya, and proceeded for Wilson's bungalow, calling on the way at Hakgala Gardens, where Mr. Thwaites showed me the cinchona plantations, and afterwards his very interesting collection of butterflies and moths, stuffed animals, birds, snakes, &c., the finest natural history collection, I believe, in Ceylon. Had a grand view of the low country in the distance as I rode down to Wilson's bungalow.

Dec. 13th.—From Wilson's bungalow to Badulla. During my ride had a good opportunity of observing the grass lands of the Patana soils, and patches of native coffee.

Dec. 14th.—Visited Spring Valley, but heavy rain prevented an extended tour, which was deferred therefore till after the meeting at Badulla on the next day.

Dec. 15th.—Some 20 members present at the meeting; very heavy weather in the afternoon; Mr. Mackenzie drove me up to Oodoowere, where I remained for the night, and met Mr. Le Cook.

Dec. 16.—Visited Oetumbe, one of Mr. Tytler's estates; also passed through Mayvel Haina. At the time of my visit much sickness was prevalent in this locality. I rode through a set of coolie lines (huts) where I was informed 80 coolies had died in two months. The lines were badly situated near a swamp, the water used was doubtless impure from organic contaminations.

Dec. 17.—Spent the day walking over portions of Spring Valley; terracing of a substantial character was being carried on systematically, a regular gang of coolies being daily told off for this particular work. The expense was considerable, but the results already obtained were decidedly satisfactory. The cattle sheds, and wire rope arrangements for the conveyance of grass and manure were duly inspected. On so extensive an estate, the use of such wire ropes for the purpose of connecting the several divisions will be a great saving of labour in the matter of carrying manure. The bungalow being situated about two miles from the cattle-shed and stores by the regular estate path, and perched on the top of the hill, Mr. Rettie, the superintendent, seemed strongly in favour of establishing the telephone as a means of communcating rapidly with the stores and the assistants of the other five divisions of the estate.

Dec. 18th.—Proceeded to Madulsima, via Mousa Galla, from which bungalow a magnificent view is to be had of the low country in the distance. Three days previous to my visit a young planter, Goodeve, had died there of jungle fever, contracted during a recent stay in the low country.

The estate path leading to Passera Rest House was too steep and rough to ride down. From the Rest House to the twenty-second milestone on the government road, the route lay through some fine scenery with forest land, some of which was being opened up for coffee; saw plenty of jungle fowl constantly running across the road. Mahadowa was reached just as it was getting dark.

Dec. 19th.—Attended meeting of Madulsima and Hewa Elliya Planters' Association heldin Galoola store; on the way there passed through Cordadova and Uvakelle. Eighteen members present at the meeting; made a few remarks in reference to the use of manures, in the course of which recommended the more extended application of lime. A social evening was spent at Mr. Reed's bungalow.

Dec. 20th.—Visited Doomo, Battawatte, Forest Hill, and parts of Uvakelle, remaining for the night at the charmingly situated bungalow on Verelle Pattine, where Mr. Garioch had invited several planters to meet me.

I was informed that Madulsima was the district in which the presence of the now too well known leaf disease (*Hemileia Vastatrix*) was first observed. There was nothing in the outward appearance of the soil which was specially different to soils of other districts, and as no samples were sent me for examination I am unable to say whether the chemical analysis would reveal any peculiarity of composition.

Dec. 21.—Returned to Badulla, passing through Ahnie Malle, Amanadowa, and Deyanewatte; at the latter I had the pleasure of a long chat with Mr. Henry Cottam, who regaled me with a cup of his coffee-leaf tea so-called, being really an infusion of young coffee-leaves previously dried and prepared after the manner of tea leaves. The beverage had a somewhat strong flavour and slight medicinal taste, but otherwise was quite palatable and really refreshing after a hot afternoon ride. In appearance this prepared coffee-leaf closely resembled ordinary black tea.

Dec. 22nd.—From Badulla to Haputale, reaching the celebrated Kahagalla estate for the night. Found the fresh bracing air at Bandarewella Rest House very agreeable after the hot long ride through the hilly Patana lands. This Rest House commands a splendid view of the Patana fields near Wilson's bungalow. Its healthy situation and climate would make the locality a favourite resort for Colombo residents in the event of railway communication being available.

Dec. 23rd.—Found the early morning air outside Kahagalla bungalow positively quite cold; walked over the estate, which has an excellent sloping face towards the west. Observed the rich dark looking character of the soil, evidently due to the presence of vegetable organic remains. I would here remark that in some Ceylon soils the dark—almost black—colour which is very apparent during wet weather, is due rather to the presence of impure graphite and insoluble silicates containing protoxide of iron.

Gonamotava, with its boulders of dark rock, and the adjoining Nayabedde estate were also walked through, called at Leangawella, but found Mr. Mitchell was absent. Pushed on for Ampittiakanda, where the night was passed at Mr. Shelton's well-appointed bungalow.

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Dec. 24th.—Visited the estate, and then proceeded to Meeriabedde, where I remained; during the night over three inches of rain fell.

A few days previous to my arrival in Huputale very high winds had prevailed in the district, so that I had numerous opportunities of seeing the effect of wind on exposed situations; some of the trees were almost leafless while the drains were choked from the accumulation of fallen leaves.

Christmas Day.—Visited Coslanda, and in one of the cattle sheds noticed that the maana grass was cut into chaff, and in this form was used as litter for the cattle. If cut into lengths of from three to four inches, the practical results would, I think, be equally satisfactory and the expense for labour less.

However, the plan of cutting up coarse maana grass is decidedly an improvement, as it permits more perfect saturation by the urine, and of the manure heap being more readily turned over, as well as more perfect distribution when finally applied to the coffee. Rode through Lemastota and walked over Wiharegalla in company with Mr. A. Orchard; examined certain patches of coffee, where the trees were dying gradually. In most instances the roots and rootlets were destroyed by the ravages of white bug, occasionally associated with the presence of a species of white ant, while the soil when dug up had a damp sour smell, very different from the peculiar fresh odour of soil in a healthy mechanical condition.

Mr. Orchard had very wisely introduced some drains with a view of intercepting the water, which possibly permeated the subsoil during its passage from the upper portion of the estate.

During my tour through the Island, I observed frequently, isolated spots, generally in steep land adjacent to a watercourse, where the coffee was dying, and where, I believe, an *accumulation*, or the *passage* of water through the subsoil, was the chief cause, the remedy being intercepting drains properly arranged.

The evening was spent at Mr. Glenny's hospitable bungalow, Haldummulla, where some eighteen planters were invited to the Christmas dinner, and a most pleasant gathering it was.

Dec. 26th.—Spent the morning going over Kalupahani, examining the patches where coffee was dying out. Here again proper drainage and application of lime would be of great benefit. I regretted I was unable to remain some days and go more fully into the examination of these patches of dying coffee, but my programme was fixed and I could make no further stay, so after looking over portions of Blackwood rode up to Needwood bungalow, the residence of Mr. Macphail, chairman of the Huputale Planters' Association.

Dec. 27th.—Walked over Haldummulla estate in the morning, afterwards attended district Association meeting, held at the Rest House; 18 members present.

Dec. 28th.—Again visited Haldummulla estate, spending the morning walking over the interesting portions, and examining the patches where the coffee was dying. In the afternoon departed for Bellaloya, where there is one of the most charmingly situated Rest Houses in Ceylon.

Here certainly there should never be any difficulty in getting the bath so necessary after a long ride or walk, for the house stands on the banks of a river of clear flowing water.

Dec. 29th.—Rode to Balangoda and afterwards to Palmadulla.

Dec. 30th.—Proceeded to Rakwane, reaching the Rest House shortly after mid-day, where I met the chairman, Mr. O'Dowd, Mr. Brabazon, the secretary, and other members of the district Association. The evening was spent at Springwood.

This being the last coffee district on my tour, and the weather being favourable, I was able to visit most of the characteristic estates as follows:—Springwood, Barra, with its thriving tea plantation, Glen Alva, Ben Lomond, The Boyne, Golden Grove, Martin's Town, Everton, Rangwelletenne, Dundonell, Palamcotta, Nahaveena, Aigburth, with its apparently extra rich soil, Lauderdale, Carlton Hill, Deveronside, Gilgarron, Caledonia, Vegeria, Ellengowan, Gongalla, famous for its rock and large coffee trees, Colonna, and some other properties.

The last night of the old year was passed at Mr. Hawkin's bungalow, Martin's Town; a most pleasant evening was spent in the company of several planters. The three following days were spent in visiting the above-named estates. The district meeting took place on the 4th at the Rest House, and on the 5th I left for Palmadulla and Ratnapora, reaching Colombo on the evening of the 8th.

Hitherto Rakwane as a district appears to have been neglected, but I do not see why it should continue to be so. Certainly the natural crop-producing properties of the locality, as a whole, are apparently quite equal to those of most districts. The great drawback, no doubt, has been the distance from Colombo, and the difficulty of getting a ready command of coolie labour.

With improved means of transit, such as good cart roads and eventually railway communication with Colombo, viâ Ratnapora, Rakwane, as a coffee and tea district, will doubtless successfully compete with the present more popular new localities.

During my up-country tour, whenever a thermometer was hung in the verandah of the bungalow, I took the opportunity between six and seven in the morning of observing the temperature, and it may be of interest to know that the average temperature varied from 64 deg. to 69 deg. Fahrenheit. These observations chiefly refer to the new districts of Dickoya, Maskeliya, Dimbula, and portions of Matale.

RETURN TO COLOMBO.

On my return to Colombo, preparations were at once made to commence the analytical work which I had engaged to undertake during my stay in the Island. My tour through the coffee districts had introduced me to a great number of practical planters, many of them men of several years' residence in Ceylon, and in the many social evening gatherings at the different bungalows, I had every opportunity of gaining much useful information connected with the details of coffee-planting; information that will doubtless be of great use when reporting upon soils drawn from the districts visited, or when suggesting the manures most desirable to apply. I had frequent personal experience of the difficulties of transport in many districts, and daily during my tour saw the damage done by wash on steep land where the drainage was insufficient. I can therefore realise the important obstacles which hinder very materially the systematic application of the necessary manure, while at the same time I can understand that the selection of the most suitable manure, and a knowledge of the best season to apply it, are in themselves points of vital importance to the success of most estates. It is true that there are numerous properties which, having a gentle sloping face, with a favourable aspect and moderate annual rainfall, have produced good crops during a succession of years without any manure, and with no system of surface drainage. Such instances are no doubt familiar to most Ceylon men. I could mention several which I visited, and upon which I saw some magnificent coffee.

But such estates are the exception, on the majority draining with judicious manuring is absolutely necessary. Planters know this very well now, though twenty years since probably such operations would have been considered too costly in the matter of labour. Indeed, coffee planting has been conducted too much as a speculation, rather than as a permanent investment. A shrewd man opened an estate as a venture on doubtful land, and took a few crops off with profit, then sold it to a new comer, who in his turn passed it on to someone else, the estate getting more neglected every year. On the other hand, a really good estate not suffering from wash would continue to yield handsome returns year by year, and if sold would invariably fetch a higher price each time it exchanged hands. But it was quite a lottery. I venture to say, that there are hundreds of acres at present in coffee that had much better have been left in forest; I allude specially to steep faces, and quartz ridges exposed to wind. Where there are boulders of granite rock, rich in felspar, or similar potash constituent, the land may be steep with advantage, but coffee will scarcely do on an almost perpendicular face exposed to the baking rays of a tropical mid-day sun, following most likely a night of drenching rain. No system of drains, be they however closely arranged, can avail on such land, In future it would be well to allow all these portions to remain as reserve forest, which in many instances will also prove a shelter from wind. I make these remarks by way of cautioning planters against expecting any adequate return from the application of expensive manure upon land so situated. It will be better to expend such manure upon land really capable of yielding a satisfactory return.

ANALYTICAL WORK.

From the 10th January, until the beginning of April, my time was fully occupied in analysing samples of manure, cake, limestone, &c., selected for me by the Colombo sub-committee of the Association. Most of the results of these analyses have already been published, but it will probably be convenient to planters to have them arranged in a collected form for future reference.

COMPOSITION OF WHITE AND BLACK OR BROWN CASTOR CAKES.

	1 White.	2 White.	3 Black.	4 Brown.	5 Brown.	6 Brown.
Moisture	10.19	9.18	9.98	9.28	9.08	7.60
Oil	11.57	14.47	4.03	4.83	8.76	9.20
*Albuminous Compounds	48.62	44.56	28.01	27.87	28.44	27.43
Digestible Fibre, Mucilage, &c. &c., ...	11.56	11.26	18.84	22.37	21.09	21.89
Woody Fibre (Cellulose)	8.16	9.85	28,22	28.01	27.09	27.76
†Mineral Matters (Ash)...	9.90	10.68	10.92	7.64	5.54	6.12
	100.00	100.00	100.00	100.00	100.00	10.000
*Containing Nitrogen ...	7.78	7.13	4.48	4.46	4.55	4.39
† { Containing Sand ...	2.07	3.32	5.05	3.02	.58	.96
† { Valuable portion of Ash	7.83	7.36	5.87	4.62	4.96	5.16

The above results at once indicate that white castor cake is much superior as a manure to black or brown castor. The great superiority consists in the larger percentage of nitrogenous compounds, also a higher proportion of valuable mineral constituents—such as phosphates of lime, magnesia, and alkaline potash salts. Another advantage associated with white castor is that the proportion of woody fibre is much less, at least 20 per cent. In the specimens of brown or black castor a great deal of this fibre is due to the presence of husks from the original seed, and which are naturally of little value as a manure. The quantity of oil is much larger, it will be observed, in the white castor, but this does not make the cake any more valuable as an immediate plant fertiliser.

For all practical purposes a determination of the quantity of nitrogen in samples of castor cake is all that is necessary in order to judge of the quality as a manure, for a glance at the above analyses will show that the higher percentage of nitrogen is associated with the smallest quantity of woody fibre, and at the same time the most available ash. By available ash I mean the quantity of mineral constituents left after deduction of the sand from the total ash.

All cakes applied directly to the soil as manure, should be reduced by grinding to a fine state of division in order to secure more perfect distribution when mixed with the soil; if ground so that the meal will pass through sieves having holes one-sixteenth of an inch in diameter, it would, I believe, be sufficiently fine. Planters no doubt prefer to buy their cakes and bones separately, and to mix them on the estates in the proportions they may think best adapted to the particular soil or climate of the district. On large estates possessing suitable appliances for crushing and mixing, in connection with water power, this may be done with advantage: but on all small properties such operations will be more thoroughly and more economically carried out by the Colombo firm representing the estate; or the crushed cake, either alone or mixed with bones, could be purchased directly from a firm having mills specially adapted for crushing cakes, bones, &c.

As to the important question of using white or brown castor as a manure, I should consider the former at least 30 per cent. more valuable, so that for long distances it will probably be decidedly the most economical. This is assuming that it contains from 7 to 7½ per cent. of nitrogen, as compared with 4½ per cent. in brown or black castor. Indeed, white castor cake must be considered as a very rich and exceedingly stimulating manure, useful no doubt after an attack of leaf disease, but only to be used with caution, and generally in union with some manure containing phosphates of lime, such as bones or superphosphate. In most cases ½ lb. of white castor will be a large enough dose per coffee tree, but this point should be left to the judgment of the superintendent, or better, to that of the visiting agent, who naturally has great opportunities for observation, riding as he does three or four times during the year through a great number of estates.

I venture to suggest that under the stimulating influence of a climate like Ceylon, small and more frequent applications of manures will be decidedly the safest, most economical, and much less likely to temporarily exhaust the tree's natural productive properties.

COMPOSITION OF MISCELLANEOUS CAKES.

	Dombo.	Sur-goorgie	China Bean.	Rape.	Gingelly.	Poonjam.
Moisture	10.16	10.80	11.60	12.36	9.78	10.34
Oil	13.20	1.83	7.63	5.03	7.50	8.74
*Albuminous Compounds ...	18.87	33.87	40.87	33.19	30.37	25.75
Mucilage and digestible Fibre	31.67	19.59	2 .19	28.78	27.12	43.75
Woody Fibre (Cellulose) ...	17.50	18.17	6.24	8.44	12.21	4.90
†Mineral Matters (Ash) ...	8.60	15.74	6.28	12.20	13.02	6.52
	100.00	100.00	100.00	100.00	100.00	100.00
*Containing Nitrogen	3.02	5.42	6.54	5.31	4.86	4.11
†Containing Sand	3.00	9.06	.38	4.56	4.41	2.50

The names attached to the above analyses are those given me with the respective samples. A careful examination of the analytical results will enable the planter to ascertain those best adapted for purposes of manure; my remarks in reference to castor cake being equally applicable to these cakes.

Rape cake similar to the above will be found a useful substitute for white castor, provided it can be obtained at from 20 to 25 per cent. less cost in Colombo. A somewhat inferior quality of rape cake is largely used in France as a manure for beetroot with very satisfactory results. In analyses of cakes it is desirable that the proportion of sand should be stated separately rather than be included under the general term of mineral matters. By such an arrangement the proportion of valuable ash constituents can at once be distinguished from the useless portion (sand). Thus Surgoorgie cake, although containing 15.74 per cent. of total ash constituents, really only has 6.68 of valuable material, the remainder 9.06 consisting of sand. This large amount of sand may be due to care lessness in harvesting the seed from which the cake was made, or a portion of it may have been purposely added. Certainly any quantity of sand above 4 or 5 per cent. should be objected to, and a corresponding deduction made from the price of the cake. China bean cake and gingelly, when obtained in fresh condition, would be best employed first as a cattle food; the high price of cocoanut poonac should induce the trial of other and less expensive cakes as feeding materials. Such a price as 120 rupees per ton for ordinary cocoanut poonac is altogether out of proportion to its comparative value as a food for cattle, when linseed cake of good quality can be obtained at 80 or 90 rupees per ton.

In the following table of analyses I have included two samples of linseed cake for comparison with samples of ordinary and cheekoo-made poonac.

COMPOSITION OF SAMPLES OF COCOANUT POONAC COMPARED WITH LINSEED CAKE.

	1	2	3	4	5	6
	Native Cheekoo Cake	Hydraul. Press Cake	Hydraul. Press Cake	Hults-dorf Mills Cake	Bombay Linseed Cake	Calcutta Linseed Cake
Moisture	13.04	12.40	13.98	10.14	8.86	9.56
Oil	10.93	8.57	10.01	8.67	12.99	10.50
*Albuminous Compounds	18.87	19.56	19.19	20.94	30.25	29.12
Mucilage, Digestible Fibre, &c....	43.06	41.09	44.28	41.21	29.77	36.25
Woody Fibre (Cellulose)	6.30	8.32	5.68	8.58	10 65	9.13
†Mineral Matter (Ash)...	7.80	10 06	6.86	10.46	7.48	5.44
	100.00	100.00	100.00	100.00	100.00	100.00
*Containing Nitrogen ...	3.02	3.13	3.07	3.35	4.84	4.66
†Containing Sand	2.02	4.88	1.82	4.32	2.20	1.14

It would appear first from the above results, that the native cheeko-made cake No. 1 is the richest in oil and fat, and is generally the more profitable feeding cake as compared with the hydraulic press made cakes. Naturally, the superior mechanical appliances used in the latter instance, enables the maker to extract a larger quantity of oil than the native mills are able to do, the cake being poorer in oil in proportion. It would appear to be only a question of extra pressure, for it will be noticed that cake marked No. 3, although press-made, contains 10 per cent. of oil, and is very nearly equal in general feeding properties to No. 1.

Now let us turn to the linseed cakes. No. 5, marked Bombay, is, as we should have expected from its name, superior to Calcutta cake, and contains 2 per cent. more oil, and in round numbers 12 per cent. more albuminous (or flesh-forming) compounds than No. 1, the best of the cocoanut cakes. It is surprising that with the well-known reputation as a feeding material which linseed cake occupies in England, its value should have remained hitherto comparatively unappreciated in Ceylon. Doubtless the use of cocoanut cake, dating back as it does

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for years, has prejudiced the introduction of any foreign cake; also possibly for draught cattle linseed cake may not be so suitable, but on the estates with an elevation varying from 2,000 to 5,000 feet, it will, I am sure, prove a most welcome addition to the daily allowance of guinea-grass, especially during a continuance of wet weather when the grass is naturally not so nutritious in character. I understand that Messrs. Dunlop and Co., of Colombo, have already imported small quantities of the cake, and have no doubt that it will be used with economy on estates instead of the ordinary cocoanut poonac.

Apart from the question of feeding properties, linseed cake is very much superior as regards the residue passed off as manure, for it contains from 1.50 to 1.75 per cent. more nitrogen than the average of the four samples of cocoanut cake, and as the most recent experiments of Mr. Lawes show that practically nine-tenths of the total nitrogen present in feeding materials is recovered afterwards in the manure, it follows that viewed simply as a food for making manure, it must be at least 25 to 30 per cent. more valuable, assuming that moderate care is taken to protect the manure from loss by exposure to heavy rainfall.

I am somewhat surprised that cotton cake is also, like linseed, at present so little used in Ceylon. Only one sample was sent to me for analysis, of which the following are the results:—

COTTON SEED POONAC (CRUSHED).

Moisture	8.16
Oil	18.37
*Albuminous (flesh-forming) compounds	19.93
Digestible Fibre, Mucilage, Sugar, &c.	31.43
Indigestible Woody Fibre (Cellulose)	17.17
†Mineral matters (Ash)	4.94
	100.00

* Containing Nitrogen	3.19
† Containing Sand	.70

This is a sample of whole cotton seed, or generally called undecorticated. It was coarsely crushed, and was sent to me for analysis rather as a manure, but the high percentage of oil suggests that it would be most profitably employed first as a feeding material in small quantities of ½ lb. per day, for, on account of the somewhat large amount of indigestible fibre, it would not be advisable to give more, especially in the case of young stock. A mixture of ½ lb. linseed cake and ½ lb. cotton cake would be very suitable for cattle. For pigs I should not think this cotton cake would be desirable, cocoanut poonac being much better adapted.

I apprehend that there is no sufficient demand in Ceylon to attract, at remunerative rates, importation of cake made from Egyptian cotton seed from which the husk has been removed, otherwise a meal made from decorticated cake would be applicable as a food for pigs. It contains 16 per cent. of oil and 40 per cent. of albuminous compounds.

SAMPLES OF BONE DUST AND STEAMED BONES.

	1 Australian Bone Dust.	2 Australian Bone Dust.	3 Australian Bone Dust.	4 Indian Fine Dust.	5 Indian Bone Dust.	6 Leechman's Steamed Bones.
Moisture	7.30	5.95	5.10	7.20	7.85	15.40
*Organic matters ...	29.87	31.01	29.55	25.30	24.25	16.45
†Phosphoric Acid ...	18.05	19.05	21.50	24.25	24.75	24.90
Lime	27.10	30.01	31.41	32.36	.47	33.60
Magnesia Alkalies ... Fluorine and Carbonic Acid	10.63	10.10	8.79	6.49	5.83	7.70
Sand	7.05	3.88	3.65	4.40	4.85	1.95
	100.00	100.00	100.00	100.00	100:00	100.00
*Containing Nitrogen ...	3.08	3.01	3.12	3.69	3.30	2.48
Equal to Ammonia ...	3.75	3.65	3.79	4.48	4.01	3.01
†Equal to Tribasic Phosphate of Lime	39.40	41.58	46.94	52.94	54.03	54.36

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I am informed that it is only within the last few years that Indian bones have been imported into Ceylon, and that Australian bone dust was the form in which bones were generally used. I conclude samples 1, 2 and 3 fairly represent the average composition of such bones, as I have every reason to believe they were sent to me direct from the cargo in bulk. Of the three samples, No. 3 is evidently the best, as it contains the most phosphate of lime and nitrogen. Australian bones contain apparently more organic matter than Indian bone dust, but such organic matter is less rich in nitrogen, the element which is generally recognised as determining the commercial value of organic substances when purchased as a manure. I find, however, that the organic matter in the Australian bone dust is soluble in water to a very much larger extent than is the case with Indian bones, as will be noticed from the following :—

	No. 1. Australian.	No. 4. Indian.
Organic Matters, soluble in water ...	10.50	1.10
Containing Nitrogen	1.27	.18

Soluble nitrogen compounds may be fairly assumed to be twice as valuable as nitrogen compounds insoluble in cold water, for all purposes where an immediate plant fertiliser is required. Consequently, although containing somewhat less total nitrogen, I should consider Australian bone dust fully equal to Indian in the matter of *nitrogenous organic matter*, and further, that provided both kinds were reduced to the same mechanical condition of fineness, Australian bone dust would produce a more immediate effect as a coffee manure, though its permanency will not be as great as in the case of Indian dust, similar to No. 4, which is richer in total nitrogen, and contains also upwards of 12 per cent. more phosphates of lime than Australian bone dust as represented by No. 1 sample. When in Ceylon I suggested that bones should be applied in a finer mechanical condition; indeed, during my tour I was sorry to notice a great waste of expensive manure from careless application, the bones were much too coarse, and were not properly covered in the soil. On one estate I saw some bones, actually in the drains. Next in importance to crop time comes the season when manure is applied, when the constant personal supervision of the superintendent is of the greatest importance in the interests of the estate.

Before I left the Island several samples of ground Indian bones of excellent quality were sent me for examination. The following is an analysis of one of these samples:—

INDIAN BONE MEAL.

Moisture	8.15
*Organic Maters	27.30
†Phosphoric Acid	24.20
Lime	31.72
Magnesia Alkalies, &c., &c.	5.89
Sand	2.74
	100.00
*Containing Nitrogen	3.66
Equal to Ammonia	4.44
†Equal to Tribasic Phosphate of Lime	52.83

The fine state of division of this meal may be understood from the fact that the whole of it passed through a sieve having holes ⅛ of an inch in diameter, and 90 per cent. of it through a (one-sixteenth) 1-16th inch sieve. Some planters who happened to call on me whilst engaged in the analysis, stated that they had never seen such finely-ground bone dust used hitherto on the estates. With the above results, as regards analysis and mechanical condition, planters will be able in future to ascertain whether their lots of bone dust are of equally good quality.

Indian bone dust is not liable to deterioration during transit up country, or from exposure to rain, to anything like the same extent as would be the case with Australian bone dust, for the reason already stated, namely, that it is so much harder, and almost the whole of it is insoluble in water. Hence Indian bones can be very materially improved in condition by being mixed in layers with cattle dung in a heap, which should be turned over occasionally during the two or three months allowed for decomposition.

Australian bones, on the other hand, consisting as they do of steam bones and partially fermented raw bones, are more suitable for direct application to the coffee as soon as received on the estate, and should moreover be well protected from rain previous to being used, otherwise the soluble nitrogen compounds, shown to be present in considerable quantity, are liable to be washed out.

No. 6.—LEECHMAN'S STEAMED BONES.

This consisted of a fine meal, apparently dry, but on analysis found to contain 15.40 per cent. of water lost at a temperature of 212° Fah. Compared with the other samples arranged in the same list this amount of water appears high, but it is present as hygroscopic moisture constitutionally incorporated in the material, rather than as accidental or surface moisture.

If, however, allowance is made for the small amount of sand; in fact, if we deduct 5.10 per cent. (the difference between sand in No. 1 and 6) from the 15.40, the water determination is not at all excessive. A high percentage of water is not to be encouraged, but in all manufactured manures there must naturally be from 10 to 15 per cent., and water present in the form in which it occurs in these steamed bones, is of importance in materially promoting the decomposition of the valuable phosphate of lime. Certainly hygroscopic moisture is more useful than sand, weight for weight, as a constituent for manures intended for naturally light soils in a tropical climate.

The phosphate of lime it will be noticed is present in high proportion as compared with the Australian bones, and if the moisture were reduced in the steamed bones, the comparison should be still more favourable. It is in the organic matter that the results are not quite so satisfactory, and after making due allowance for the fact that two-thirds of the nitrogen compounds are present in a form readily soluble in water, and consequently at once available as plant food, it would be desirable to use a mixture of ground castor cake and steamed bones rather than apply the latter alone. By using such a mixture the total nitrogen in the manure applied would be increased, and the relation between organic and mineral fertilising elements more in accordance with the required composition of a coffee manure. As a prepared manure, I was very favourably impressed with this sample of steamed bones submitted to me during my residence in Colombo. Its chemical composition, as stated in the analysis, would warrant a valuation midway between Australian and Indian bones, but considering the rough coarse condition in which the latter were used on many estates (often in pieces an inch long), I have no hesitation in saying that the steamed bones as examined by me would be superior even to the Indian bones in producing crop and a satisfactory return for outlay. But in the fine grinding of bones I apprehend great improvement will be made as soon as the true economy of a finely prepared manure is fully recognised by planters, who will be prepared to submit to a slight increase in cost involved by the necessary erection of special grinding machinery and improved steaming apparatus.

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FISH MANURES.

Valuable and very stimulating as the best specimens of this manure must be considered to be, it appears decidedly probable, judging at least from a personal examination of numerous samples submitted to me officially on behalf of the Planters' Association, and privately by individuals, that adulteration by means of the addition of sand is carried on largely by the original native collectors of the fish. In some samples the amount of sand has been as much as 62 per cent. of the whole material. The following analyses represent four samples:—

	No. 1. Fish Manure.	No. 2. Whole Dried Fish.	No. 3. Patent Fish Manure.	No. 4. Massey's Carbonised Fish Manure.
Moisture	5.24	13.12	23.60	9.76
*Organic Matters	31.18	43.40	13.32	55.63
†Phosphoric Acid	5.24	8.70	5.71	12.75
Lime	6.20	10.19	9.42	13.44
Alkaline Salts .. .. Magnesia, Carbonic Acid }	3.37	5.49	3.27	5.39
Sand	48.77	19.10	4.68	3.03
	100.00	100.00	100.00	100.00
*Containing Nitrogen ..	4.01	5.84	4.25	7.42
Equal to Ammonia ..	4.87	7.09	5.16	9.01
†Equal to Tribasic Phosphate of Lime, &c. ..	11.44	18.99	12.48	27.83

I conclude that No. 1 must be taken as a fair average sample of the fish manure usually imported, and if so, half of it consists of sand; consequently it is not suitable as a manure to be purchased for estates situated at any considerable distance from a railway station. When I consider the question of the valuation of manures it will be appropriate to refer to this kind of fertiliser, inasmuch as the point planters have to consider is the comparative quantities of nitrogen and phosphates which are offered for a certain price per ton of the material. Even with 50 per cent. of sand this fish manure may be an economical one, if the price is moderate and the cost of transit within reasonable limits.

No. 2 seems to represent what ordinary whole dried fish (about the size of sprats) should consist of. A certain amount of sand will naturally adhere to the fish, collected as they are on the sandy shore for the purpose of being dried. It would be a reasonable arrangement between buyer and seller to guarantee 20 per cent. as the maximum limit of sand allowed to be present.

No. 3.—This is called a patent fish manure, but is practically simply a mixture of some cake, containing a low percentage of nitrogen (probably poonjam poonac), with damp fish previously freed from extraneous sand and cut up into small pieces. The mixture, as received, was in a damp partially fermented condition. Its commercial value is but little above that of No. 1.

No. 4.—MASSEY'S CARBONISED FISH MANURE.

I was informed that only a small quantity of this material had been made at the time of sending the sample. Why the term "carbonised" was applied is not so important to ascertain, as the fact that the composition of the sample analysed satisfactorily indicates that the material is a most concentrated and stimulating manure, only to be used in small quantities at a time. It consists of small wafer-like scales of fish, evidently carefully washed to remove excess of sand and afterwards partially dried. If such a material can be prepared at a moderate cost it would command a ready market in Europe and yield a remunerative return for original outlay. Indeed I am informed by Messrs. Arnott Brothers, of London, that fish manure is actually being imported in Liverpool from India. There should be a market for all such valuable fertilisers much nearer India, and one would fairly assume that Ceylon would be a large purchaser. Of course being a manufactured article much of its present high quality would depend upon care being taken to keep up the standard of purity and freedom from extraneous dirt, sand, &c.

Valued commercially, I should place this above the best specimens of white castor cake, for in addition to containing as much nitrogen, it yields 28 per cent. of phosphate of lime, in a form soon rendered available as plant food. The thin wafer-like particles would decompose in the soil more rapidly than ordinary bonedust.

COMPOST MANURES.

The collection and subsequent use as manure of all animal and vegetable refuse matters is undoubtedly worthy of every encouragement. In a hot climate the daily removal of all such accumulations is a sanitary precaution essentially necessary to the preservation of health, while the economical manufacture of the said refuse into valuable manure is decidedly an element of thrift. During my residence in Colombo certain specimens of such compost manures were submitted for analysis and report; the results in most cases were against the materials being profitably used for transit up country, though in the immediate vicinity of the town or a few miles by rail they might all be usefully employed.

The two principal drawbacks in their composition were the high proportions of sand and water—the former it would be difficult to get rid of when once collected, though with proper care the amount might be reduced in the original accumulation. The water, however, during most of the year could be expelled by simply exposing the mass to the action of the sun. The process would be greatly facilitated by the admixture of some finely ground powder like ground coral, for instance, which by dividing the damp particles of matter would cause a larger surface to be presented to the drying influence of the sun.

The following results represent the composition of the manure prepared by Mr. Grinlinton :—

GRINLINTON'S NEW COMPOST MANURE.

Moisture (lost at 212° Fah.)	7.25
*Organic Matters	31.20
Carbonate of Lime	32.49
Lime (Caustic Lime)	2·42
Tribasic Phosphate of Lime	3.40
Carbonate of Magnesia	2.47
Chloride of Potassium	.66
Chloride of Sodium	1.69
Sulphate of Lime	.98
Oxides of Iron and Alumina	2.09
Insoluble Siliceous Matters	15.35
	100.00
*Containing Nitrogen	2.93
Equal to Ammonia	3.56

I believe this material, as represented by the above analysis can be used with advantage on coffee estates, within moderate distances of railway stations. Formerly, I understand, this compost manure was sent out in a very damp condition, but by mixing the latrine refuse with ground coral, and exposing the mixture to the drying influence of the sun, the proportion of moisture has been reduced to reasonable limits, and we have a manure which contains as much organic matter (containing nitrogen) as is usually present in average samples of bonedust, while at the same time one-third of its weight in round numbers consists of finely ground coral. The phosphate of lime is only present in small quantities it is true, and this fact suggests the desirability of employing a mixture of bones with this compost.

As a manufactured article of course all depends upon the guaranteed quality being kept up, and the valuable constituents maintained in proportion indicated by the above analysis.

My report is in reference to the sample submitted to me, and it remains for planters who may wish to test the quality from time to time, to call in the assistance of the resident analyst, should there be a competent one available.

It is most necessary to bear in mind the importance of using a material as a drier for compost manures, that is itself really valuable as a fertiliser. Such a substance ground coral appears to be, and is eminently better adapted than quick lime, which would rather tend to cause a most abominable smell as the result of chemical action on decomposing animal organic matters.

I commend the employment of ground coral as a most valuable drying material in the manufacture of really economical compost manures, and have no doubt that Grinlinton's compost, if it maintains the above quality, will give satisfactory results as a coffee manure used in conjunction with bones.

THE USE OF LIME.

During my tour, I was very much astonished at the small value apparently attached to the use of burnt lime, prepared either from coral or from some of the numerous local deposits of magnesian limestone, which very fortunately occur in irregular masses interspersed among the prevailing granite formations of the Island. At home the value of lime upon all arable soils is so fully recognised by practical agriculturists that it would be unnecessary to enter at any length into a discussion of its merits. At the request of the Planters' Association I addressed a short note upon the use of lime in some form as a desirable manure for coffee, and I have reason to believe that it will in future be much more extensively employed.

Lime is a necessary constituent of all permanently fertile soils, for it is a requisite element of the ashes of plants. It assists in rendering both the organic and inorganic portions of soils available as plant food. On all flat land rich in organic vegetable remains, lime will be found especially valuable for improving the physical as well as the chemical condition of the soil. Sir Samuel Baker in his book ("The Rifle and Hound in Ceylon") mentions in reference to Newera Eliya, that "an absence of lime in the soil, and the cost of applying it artificially prohibit the cultivation of all grain, and restrict the produce of the land to potatoes and other vegetables." The analyses of upwards of 50 samples of Ceylon coffee soils drawn from different estates, would incline me to think that the great huntsman need not have limited his remarks to the neighbourhood of Newera Eliya, when speaking of the poverty of the soil as regards lime.

The difficulty of applying lime artificially is one which is fast disappearing under the annual extension and improvement in the means of transit; good roads, railway extension, and plentiful labour supply, will soon enable the planter to obtain burnt lime at a moderate cost, say 1s. per bushel delivered on the estate.

I am told that ordinary burnt lime applied at low elevations (by which I assume anything under 2,000 feet) has been found too stimulating. This fact should rather be taken as a positive proof of its quickening efficacy at once indicating the powerful action upon the previously dormant qualities of the soil. With the alternations of heavy rainfall, followed by tropical heat, the effect of burnt lime, naturally is very powerful, so that caution must be used, and a far smaller dose applied than would be considered sufficient according to English modes of application.

Again, chalk as used at home, although not so immediately apparent in its results, is far more permanent than quick lime, and it is for this reason that I have recommended ground coral instead of ordinary slaked lime as being more suitable on naturally light soil, possessing little organic vegetable matter (humus).

Of course such ground coral should be obtainable at a reasonable price, not exceeding that paid per ton for ordinary burnt coral. Whether this can be so obtained is a matter of enquiry. It should be remembered that burnt lime on exposure to the air rapidly absorbs carbonic acid, changing the caustic lime into carbonate of lime, so that ultimately there is a recurrence to the original formation. Consequently where neutralisation of organic acids (sourness of soil) is the object, caustic lime freshly made should be scattered over the surface and forked in at once. While on naturally light soil, lime that has been allowed to stand some weeks after slaking with water, will be more suitable (in the absence of ground coral) as a general surface dressing where the object is the supply of necessary plant food. Dr. Voëlcker in his interesting paper "On Lime in Agriculture" (Journal of the Bath and West of England Society, vol. xiii., 1865) directs special attention to the important functions which the judicious application of lime effects, not only in rendering the mineral constituents of the soil available as plant food, but also in actually retaining all the more valuable elements of fertility.

It follows that the frequent dressing of coffee with cattle dung should be accompanied with a certain quantity of lime in some form, otherwise the full benefit of the nitrogenous manure will not be obtained, especially as the soil is naturally so poor in lime.

In the following tabulated form I have arranged the analyses of specimens of Ceylon limestone, which is evidently magnesian limestone associated with more or less quartz crystals, and insoluble silicates. I have also included a specimen of the coral as imported in Colombo, which is afterwards burned in kilns by the native lime burners, who are compelled to carry out their process at a certain distance beyond the boundaries of the Colombo municipality.

	1	2	3	4	5	6
	Aberdeen Estate Ambagamua	Eldorado Estate Rakwane	Rangwelletenne Estate Rakwane	New Quarry Moray Boundary Maskeliya	Hunasgeria Matale	Coral Colombo
Moisture	Trace	.22	.18	.16	.18	.52
					Organic matter	1.94
Carbonate of Lime ...	60.73	61.20	96.24	54.98	54.01	92.40
Carbonate of Magnesia	18.45	32.07	Trace	43.10	42.02	Trace
Oxide of Iron & Alumina	.65	.90	.88	.17	.70	.75
Quartz and Insoluble Silicates	20.17	5.30	2.14	1.59	3.09	2.01
					Sulphate of Lime	.68
Alkalies, Sulphuric Acid Chlorine, &c.	Trace	.31	.56	Trace	Trace	1.70
	100.00	100.00	100.00	100.00	100.00	100.00

No. 1.—White crystalline limestone, evidently a species of dolomite associated with a somewhat high quantity of quartz. Having visited the estate where this stone is found, I have had an opportunity of inspecting the kiln employed for burning it. It was very simple in construction and produced lime which readily crumbled into a fine powder, so that the quartz is only objectionable as regards the increase of so much useless matter to be

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carried with the genuine lime. It might be used with advantage on all estates in the immediate neighbourhood, though it would be scarcely suitable for transit any distance.

No. 2.—This is also magnesian limestone, of better quality, containing carbonate of magnesia in the place of quartz, as compared with No. 1.

No. 3.—Calcareous spar, tinged with green and dotted with particles of plumbago. Broken into pieces and exposed to atmospheric influence it becomes brittle, and can easily be reduced by grinding to a fine powder, in which condition it would be of great value for agricultural purposes. When calcined, the lime so produced would be equal to the best quality of Colombo burnt coral. Whether this specimen represents a small or large deposit will, I apprehend, be an important question for the proprietor to ascertain; there can be no doubt of its usefulness if there is any quantity obtainable.

Nos. 4 and 5 are very similar in composition, although representing magnesian limestone from different localities.

No. 6.—This sample of coral was in the condition of powder, being so finely ground that 87½ per cent. readily passed through a sieve having holes 1-32 of an inch in diameter. It may be considered sufficiently fine for all practical purposes. As already mentioned, it should be obtained at a price not exceeding that paid for ordinary Colombo lime (burnt coral), otherwise it will be more economical to purchase the latter, which contains from 65 to 70 per cent. of available caustic lime, while in ground coral, similar to No. 6, we have but 51.74 per cent. lime, which is in union with 40.66 per cent. carbonic acid, forming the 92.40 per cent. of carbonate of lime as stated in the analysis.

There are certain conditions, however, favourable to the use of ground coral, which may be briefly mentioned.

1.—It can be ground by the different firms at their own mills to any degree of fineness, whereas the burning of coral is at present a monopoly in the hands of the natives, and must be conducted outside the town boundaries under special regulations on account of the unpleasant carbonic acid fumes evolved during the process.

2.—Ground coral forms a most useful drying material for mixing with compost or similar damp manures.

3.—It can be sent up country in bags and exposed to heavy rainfall without any appreciable deterioration in quality, whereas if freshly burnt Colombo lime (not already slaked by addition of water) be sent up in bags and is exposed to rain or be kept any length of time in a damp place, the bulk becomes increased from the absorption of moisture, and as a consequence the bags are burst and a loss is incurred.

4.—It can be used with greater safety and with more permanent, though less immediate, results on light quartzy soils deficient in organic matter. For on such land quick lime (burnt coral) applied in any quantity would be too strong, too exhaustingly stimulative.

Of course I am fully aware that ground coral furnishes a very ready means of adulterating fine bone dust, but so far as my experience enables me to judge, I apprehend that no respectable firm in Colombo would risk its reputation by any such wilful adulteration. The presence of coral, though ever so finely ground, can at once be detected by adding a little muriatic or sulphuric acid to the sample of bone dust. If genuine, only a small amount of effervescence will be noticed, as there is but little carbonate of lime in good bones, and what there is, is so intimately blended and associated with the organic

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structure of the bone that the disengagement of carbonic acid takes place gradually.

Any violent and extensive effervescence should be considered decidedly unfavourable in samples of bone meal.

In recommending ground coral to the notice of Ceylon planters, I had in view certain practical results obtained from the use of carbonate of lime in the form of finely divided particles of shells.

During a tour in Cornwall some years since I was struck with the local custom of mixing sea-sand with cattle manure, and allowing the combined heap to remain two or three months before application to the land. At Bude a very extensive trade is carried on annually by sending sea-sand loaded in barges into the interior of the country by means of the district canal.

Believing that such sand must consist of something more valuable than quartz in a fine state of division, I examined a sample of the sand obtained from a barge already loaded, and the following are the results of the analysis:—

SAND FROM BUDE, CORNWALL.

Water lost at 212° Fahr.	.90
Combined Water	1.94
Carbonate of Lime	50.21
Carbonate of Magnesia	2.26
Tribasic Phosphate of Lime	.28
Sulphate of Lime	.71
Chloride of Sodium	.18
Potash	.23
Soda	.39
Oxide of Iron	2.46
Alumina	1.54
Insoluble Siliceous Matters (fine quartz)	38.90
	100.00

It will be observed that this sand contains in round numbers half its weight of carbonate of lime, also that, including the iron, alumina, and sand, there is upwards of 40 per cent. of worthless constituents, and yet it is found practically economical to apply as manure. It is well to bear this in mind when considering the question of purchasing fish manure in Colombo for the coffee up country.

The following analysis of a specimen of limestone is interesting, inasmuch as it shows how the quality varies even on the same estate :—

GRANITIC LIMESTONE FROM ELDORADO ESTATE, RAKWANA.

Water	.86
Oxide of Iron and Alumina	3.83
Potash	.41
Soda	·77
Magnesia	1.99
Carbonate of Magnesia	5.58
Carbonate of Lime	65.53
Silica and Insoluble Silicates	21.03
	100.00

This was very hard to break into pieces, and even after burning would require to be slaked at once by the addition of water, in order to obtain a fine powdery condition. On account of the large quantity of siliceous matters, it would only be economically available in the immediate locality, where, however, it might be used with advantage for compost heaps and for dressing the surface previous to forking. It would not, however, be suitable for building purposes.

The native process of burning limestone appears to be conducted with the smallest possible amount of fuel. Such economy may do very fairly in the case of coral, which is almost entirely composed of carbonate of lime (see analysis), but is scarcely adapted for the perfect calcination of the exceedingly hard, dense rock, such as magnesian limestone.

I had numerous opportunities during my tour, and subsequently in the laboratory at Colombo, of examining samples of lime prepared from such mountain limestone (dolomite) and always found small particles of the undecomposed rock. The following is an analysis of one specimen of such lime:—

LIME PREPARED FROM HUNASGERIA LIMESTONE (No. 5.)

Moisture	7·25
Caustic Lime	27.38
Caustic Magnesia	19.54
Carbonate of Lime	20.50
Carbonate of Magnesia	16.23
Oxide of Iron and Alumina	1.15
Potash, Soda, Sulphuric Acid, &c.... ...	1·10
Insoluble Siliceous Matters	6.85
	100.00

This was made from No. 5 specimen previously referred to (see analysis) under limestone.

A certain proportion of the carbonates present is no doubt due to absorption of carbonic acid from the atmosphere, but at least one-fourth of the whole mass consists of the undecomposed rock present in small granular particles.

I believe it will be found an economical advantage to increase the quantity of fuel when making lime from such a quality of limestone.

ANALYSIS OF GAS LIME FROM COLOMBO GAS WORKS.

Moisture	16.96
*Organic Matters	2.92
Carbonate of Lime	61.70
Caustic Lime	7.01
Sulphide of Lime	1.71
Sulphide and Cyanide of Iron	2.40
Magnesia, Alkalies, &c., &c.	4.40
Insoluble Siliceous Matters	2.90
	100.00

*Containing Nitrogen	.30
Equal to Ammonia	.36

Before the publication of this analysis in the Colombo papers by the manager of the gas works, I was very frequently asked respecting the value of gas lime as a manure, there being generally an opinion that it was specially rich in ammonia, but the results of a very careful analysis at once shows that the value of gas lime is not on account of the quantity of ammonia which it contains, as there is really only a trace, and the small quantity of nitrogen exists chiefly as cyanogen, only ultimately becoming converted into ammonia upon decomposition in the soil. The value of the gas lime, represented by the above analysis, consists in the large amount of carbonate of lime in a minute state of division, the carbonate being the result of absorption of carbonic acid by the original Colombo lime used to purify the coal gas.

If the 7.01 of caustic lime still unaffected by the coal gas be calculated into the equivalent of carbonate we have 12.51, which, added to the 61.70, represents 74.21 per cent. carbonate of lime in the wet sample, which contains nearly 17 per cent. of water. But I found by actual experiment in Colombo that if this damp lime be exposed in a thin layer on the ground to the drying influence of the mid-day sun for a few hours, the percentage of moisture was reduced to 3.66, and the dry sample would show the following composition :—

Moisture	3.66
Carbonate of Lime	71.58
Caustic Lime (equal to Carbonate of Lime 14.73) ..	8.25
Other constituents	16.51
	100.00

In England gas lime is always wet and cannot be dried naturally by exposure to the sun, which is not available except during a limited period of the year for such purposes, consequently it is not appropriate to compare such lime with the quality that could be easily prepared at the Colombo Gas Works by carefully drying the spent lime as above described.

There should be no difficulty in disposing of all such dried gas lime guaranteed to contain not more than 4 to 5 per cent. water. On naturally light soils I should consider it more suitable than ordinary Colombo burnt lime, which would be too strong and stimulating.

It is superior to ground coral as a manure, because it consists of artificially prepared carbonate of lime, and such a compound will be found more bulky, less stable in constitution, and consequently more easily decomposed and rendered available as plant food.

The commercial value of Colombo gas lime when used as a manure, should be influenced by the proportion of water which it may contain, and also by its mechanical condition as regards fineness.

With only 5 per cent. of water and in a nice finely divided condition, it should command a higher price (for reasons just mentioned) than ground coral. Compared with ordinary Colombo lime it is not so easy to express a decided opinion, because the latter will, I apprehend, vary considerably in the respective proportions of water, caustic lime, and carbonate of lime, which different lots may contain.

Thus the amount of fuel used in calcination, the care taken, and the time occupied in the process, also the amount of water used for slaking (probably the largest possible quantity will be added), and lastly, the time since the lime was first burned, and the extent to which it may have been exposed to the carbonating influence of the atmosphere—all these circumstances will affect the value of Colombo lime. In fact it would not be desirable to attempt to fix a definite value to a material, which by a little manipulation on the part of the maker can be made to vary so much in composition.

In making purchases of Colombo lime, the aid of the resident chemist might very well be called in to determine the proportions of water, caustic lime, and carbonate of lime. In other words, lime should be sold subject to a guarantee of quality, and this can be easily ascertained by means of a few analyses of different lots. There may not be any very great difference in the average quality, except as regards the amount of water, of which the maker will endeavour to add as much as possible, whereas the purchaser will desire as little as possible.

When intended to be sent any distance, quick or unslaked lime should be bought, the water being added as soon as the material reaches the estate, care being taken to use only as much water as is necessary to cause the lime to crumble into a fine powder. If too much water is used the whole becomes a paste, in fact mortar. Planters should certainly purchase in Colombo unslaked lime and add the water themselves.

On slaking, lime increases in bulk, and the richness of it can be determined by noting the quantity of water which a given weight or measure of lime will absorb, without becoming a paste. Good lime should increase from 2½ to 3 times its bulk upon slaking.

During transit lime should be protected from the rain. In a tropical climate it should be used with caution, and certainly in much less quantity than is usually done by English farmers.

DEPARTURE FROM COLOMBO.

I had intended leaving Ceylon on the 15th March, and by such an arrangement I should have more than fulfilled my three months' term of residence as Analytical Chemist to the Ceylon Planters' Association. But as a considerable time had been occupied by my tour up country, and as I was desirous of completing as many analyses of the various specimens of manures, feeding cakes, limestones, &c., as possible, I made arrangements to defer my departure till the end of April. It was generally understood when I returned from Rakwane in January, that the analyses of all soils sent me should be deferred till my return to London, as such analytical work would require considerable time and careful attention. Consequently all such samples which reached me during my residence in Colombo were carefully packed in zinc-lined cases for shipment to London.

In reply to the request of several planters who desired information as to the best method of taking soil for analysis, I drew up a form containing special instructions, and also certain questions which the senders of samples were requested to answer as far as possible and agreeable.

The answers were most courteously and carefully given, and proved of great assistance in enabling me to understand the general natural peculiarities of the respective soils. For the convenience of planters who may wish at any future time to send samples of soil for analysis, I now append the said instructions:—

DIRECTIONS FOR TAKING SAMPLES OF SOIL FOR ANALYSIS.

Having selected a piece of ground where the soil appears uniform in composition, take a cubic foot of the surface soil, or a large spadeful to the depth of one foot, from at least six places from the selected spot; mix the six portions thoroughly together in some central place, and send about 5 lbs. in a clean tin or wooden box. Each sample of soil should be numbered, and the box marked with the name of the estate in black letters. Samples should not be taken from recently manured ground, and where manure holes have been made in past years, great care must be taken to avoid such when drawing samples.

For comparison it will be very useful to send a sample of good coffee soil, which should be specially marked. Information is requested in reply to the following questions respecting the land from which the samples are taken :—

1. The elevation and average rainfall.
2. Situation as regards sun, wind, &c.
3. General appearance and character of the subsoil.
4. What kind of drainage.
5. Number of years in coffee.
6. What manure, and what quantity has been used per acre; also the effect of same?
7. Is there any natural peculiarity about the soil?
8. What are the average crop returns per acre?
9. What is the natural tendency of the soil as regards production of wood, leaf and crop?
10. State any general particulars respecting the past history and present condition of the soil, that may be considered desirable.

In the following analyses of soils the replies of the superintendents who forwarded the samples will be noticed, in order to make the analytical results of greater practical use for those who may wish to compare them with any analyses they, at any time may have made of other soils.

The room in the Clock Tower at the Gas Works was, I believe, one of the most suitable that could possibly have been selected. It was lofty (some 15 feet high), with four large windows shaded by jalousie. The room was about 20 feet square, and having a window on each side, there was always a current of air passing through the laboratory. The temperature at 8 a.m. was generally 82° Fah., which gradually rose to 88° or 90° as the day proceeded. A damp atmosphere with the thermometer at 90° Fah. is not the most comfortable for working in, especially such work as making analyses, in which the consumption of a considerable amount of coal gas was requisite.

The months of February and March had been rather hotter than usual, and it was with feelings of considerable pleasure that I found myself once more in the train, early in April, bound for the Coffee districts, in order to pay a short visit to a portion of Ambagamuwa, generally known under the name of Lower Dickoya, and in which the general character of the soil is fairly friable, and very different to that which has been associated by some, as the normal peculiarity of ordinary Ambagamuwa soil.

Having had opportunities of seeing a good deal of this district I think it would be but fair that I should state decidedly that there is no reason, in my opinion, why Ambagamuwa should be classed as consisting entirely of stiff soil.

There are certain parts undoubtedly in which the soil partakes of a stiffish clay; but the characteristic feature is confined to certain localities, which, unfortunately, being not far from the main road, have led travellers to carry away an opinion generally unfavourable to the district. But such an opinion is, I apprehend, incorrect of the district as a whole.

With due attention to draining, surface forking and liming, combined with the advantages of easy transit for manures (which the extension of the railway will secure), even the stiff parts can be very materially and profitably improved.

Having seen all my samples of soil, some 50 in number, carefully packed for shipment, also my chemical apparatus for which no one seemed inclined to make any offer, I left Colombo on the 24th April, by the night coach for Galle, and returned to London, viâ Bombay, Venice and Paris, and reached Folkestone on the 31st May, shortly after the foundering of the German Iron-clad *Grosser Kurfurst.*

My cases containing the soils, &c., did not arrive till the end of June, when they were delivered from the "Eldorado," the same ship, singular to mention, which took them out in the preceding October.

ANALYSES OF SOILS.

A careful analysis of a soil requires much more time than is generally supposed. It frequently happens that certain operations have to be performed two or three times before the analytical results can be considered to satisfactorily represent the correct composition.

The determinations of phosphoric acid, nitrogen and potash require special care and delicacy of manipulation.

In the following analyses attention was directed to secure as far as possible comparative results, the quantities of acid and alkali used, being in each case the same, as well as the time allowed for acting upon the prepared sample.

ANALYSES OF CEYLON COFFEE SOILS, SENT BY THE DIMBULA PLANTERS' ASSOCIATION.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.	No. 9.
Elevation (about)	4,000 ft.	4,500 ft.	4,000 to 4,300 ft.	4,800 ft.	4,200 ft.	4,500 ft.	4,100 ft.	4,400 to 4,800 ft.	3,200 ft.
Average rainfall annually	120 in.	Not known	Average of district	110 in.	Average	Not taken	About 170 in	100	Not taken
Aspect	Eastern	Eastern	Eastern	South	Westerly	South	Eastern	South Eastern	Westerly
Situation as regards wind	Not much exposed	No remark	Not affected in either monsoon	..	Very slight by S.W. monsoon	N.E. monsoon about a month	Slightly exposed	Very slight	Not affected
Number of years in Coffee	28	10	3 to 14	4	7	6	9	4 to 6	10
Water lost at 212° F.	2.980	3.704	7.734	5.950	6.142	5 848	10.120	5.050	3.680
*Organic matter and water of combination	13.852	12.573	13.988	13.444	20.460	15.682	13.360	16.440	8.380
Oxides of iron and traces of manganese	7.128	11.018	10.610	9.265	9.910	9.728	8.837	9.080	4.530
Alumina	18.472	14.382	13.190	12.108	15.912	11.550	11.738	9.191	4.993
Lime	.084	.055	.085	.136	.154	.168	.070	.154	.350
Magnesia	.171	.078	.180	.118	.144	.144	.063	.081	.216
Potash	.096	.072	.110	.173	.104	.106	.082	.091	.115
Soda	Trace	.053	.053	.075	.021	.057	.050	.015	.062
Phosphoric acid	1.14	.101	.115	.099	.211	.124	.051	.102	.147
Sulphuric acid	.092	.109	.091	.097	.105	.103	.055	.081	.003
Chlorine	.003	.002	.002	.006	.003	.008	.017	.007	.006
Carbonic acid	Trace	Trace	Trace	Trace	Trace	Trace	Trace	Trace	Trace
Silica soluble in alkali	3.120	3.360	3.670	2.305	3.765	3.380	.960	.540	2.720
†Insoluble silicates	53.888	54.493	50.172	56.224	43,069	53.102	54.597	59.168	74.798
	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000
*Containing nitrogen	.160	.171	.213	.265	.403	.317	.203	.347	.219
†Containing quartz	21.200	13.120	20.650	17.197	14.645	17.790	14.020	17.680	26,800

The following remarks of the senders of the above soils will doubtless prove interesting:—

"No. 1.—The subsoil is brown in appearance, gritty in character, and is mixed with soft stone.

"Surface drainage.—No manure has been applied so far as I am aware. There is nothing peculiar about the soil, except that it has been exceedingly washed. It has been little cultivated, and is generally rather weedy. Most of the surface soil has been carried away by wash and scraping. Average crop, 2 to 3 cwt. per acre.

"No. 2.—There is little difference between the surface and subsoil. Not many natural ravines on this part of the estate, but a great many surface drains have been cut. Little or no manure has been applied. No special peculiarity about the soil is observable. In reply to question 9, want of young wood and the dying off of old branches, with a good deal of leaf disease. The coffee, when young, bore very heavily, and has not had sufficient manure applied to it. Average crop, 5 cwt. per acre.

"No. 3.—The subsoil is slightly clayey.

"Surface drainage.—The drains being 50 feet apart, running *across* the hill. The sample sent represents a mixture of 8 specimens of soil, drawn respectively from coffee 14, 12, 7, 6, 5, and 3 years old.

"Various manures used; cattle-dung very little. Castor, Poonac, Cocoa-nut Poonac, Rape Poonac, and the results so far, appear to have been quite as good from the portion manured with *Rape*, as from anything put in. Average crop for the last 8 years, 6½ to 7 cwt. per acre.

"No. 4.—The subsoil is very similar in appearance to the sample sent (surface), slightly more reddish, perhaps. No drains have been cut on this field. It is a long gentle slope, with small natural ravines; has never been manured. The soil is, I believe, a good coffee soil. There are large boulders on the upper part of the field, but in the piece from which sample is taken, the stones are much smaller in size. Where the coffee is sheltered from the wind, the trees produce plenty of wood, leaf, and crop. For the year 1877 the crop was 5 to 6 cwt. per acre.

"No. 5.—The general appearance of the subsoil is generally good, light, and friable.

"No manure has yet been applied; the surface of the land is undulating, but sufficiently flat to admit of any style of application of manure. The soil is generally like the ordinary soil of the district. During the dry months, the growth of new wood is wonderfully great. Average crop, nearly 7 cwt.

"No. 6.—Subsoil appears good; the roots of the coffee penetrate 2 to 3 feet into it.

"No drainage (artificial) on the slope from which the soil was taken. No manure ever applied on this portion of estate. In the dry months the soil is rendered hard, and cracks up a good deal. Always lots of wood, leaves drop off a good deal; branches and stems rather slight for six-year-old coffee. Crop returns as near as possible 4½ cwt. gathered up to date, March, 1878.

"No. 7.—The land has a steep face. 1 lb. of a mixture of 2 parts rape cake, and 1 part of steamed bones, has been applied per tree with very good results, 1876. A good crop-producing soil.

"No. 8.—Subsoil generally free. In places mixed with small stones and gravel.

"Being well drained (open drains), there is very little wash. The whole estate has been manured, bones, poonac, and cattle manure principally. No peculiarity about the soil, but slightly above the average quality. Average crop, about 7 cwt. per acre. All the wood bears, the climate being favourable. For a young estate, a considerable quantity of manure has been applied; and, having been drained from the commencement, not much soil has been washed away.

"No. 9.—Sheltered from the morning sun by a precipice at the back. The ground is free from wash. Bones and rape 1 lb. per tree applied with good results, 1876. The sample sent represents a mixture of 8 different lots taken from a portion of the estate underlying a ridge of limestone rock.

"Produces very weedy coffee. Sample taken during dry weather, rain not having fallen for some time previously. The land was originally heavy forest. Average crop, about 6 cwt. per acre."

Such then are the replies which have been furnished in connection with the above Dimbula soils, and they are of much interest when considered together with the analyses.

All the soils are of a general light brown colour varied with a red tinge which deepened into chocolate in the case of damp samples.

The proportion of water found in the samples varies considerably, but this is chiefly due to accidental circumstances depending on the amount of moisture which the soil contained at the time the sample was taken, and also on the drying influences to which it was exposed during transit.

Small samples in wooden boxes contained less water than larger samples, and the soils sent in tin cases were damper than those in wooden boxes. No. 7 is a notable instance of this peculiarity of dampness being associated with enclosure in tin case, while No. 1 represents how a naturally stiff soil, may be dried during transit under special conditions.

I have already written a separate report on each of the above soils, so that I will now simply confine my remarks to certain general statements.

Taking these soils as a class, they may be considered as some of the best I have received from Ceylon, more especially as regards the proportions of nitrogen, phosphoric acid, and in certain instances, potash and lime, all of which are constituents of important fertilising value.

No. 5 soil is prominently rich in phosphoric acid and nitrogen, containing the largest amount of the former constituent I have yet found in Ceylon coffee soil.

Of course I must assume the specimen sent fairly represents the estate, otherwise the results are only misleading and unsatisfactory, for on all estates there are specially fertile spots, near the Bungalow for instance, or the coolie lines, where the coffee receives constant dressings of manure in the form of various refuse matters. On the other hand this same soil contains a decidedly large quantity of alumina, which, associated as it is, with a similar high per centage of organic matter and combined water, would lead to the opinion that this soil was possibly somewhat stiff and damp for coffee during certain seasons.

The results of some 50 analyses of Ceylon soils rather indicate that the most suitable for coffee, are those in which the iron and alumina together, do not exceed 15 to 18 per cent., though naturally there are exceptions to this general rule. For instance, in districts where the rainfall is comparatively small and the elevation low, a higher per centage of iron and alumina is quite reasonable, and, moreover, is I know (from special analyses) quite favourable to the production of large trees.

Further, oxide of iron, if present in the condition of peroxide, or red oxide, which gives the red colour to the earth, may exist with advantage to the extent of 20 or 30 per cent., being an excellent fixer of ammonia and generally useful as an absorbent of fertilising constituents. Some of the richest English soils are those which are distinguished for their red colour.

Generally the alumina in good soils is about 2 to 3 per cent. more than the oxide of iron, though I have one specimen of soil (to which I shall allude again) in which the iron is twice as much as the alumina, and as I should expect was associated with good coffee.

In fact the proportion of peroxide of iron may be high with advantage, but not the alumina.

Red stiff soils may be rendered useful coffee land, but from poor yellow clay not much permanently good results can, I fear, be expected.

The small crops mentioned in respect of No 1 may be due to some extent to the alumina being so very much in excess of the iron, and also to the damage done by wash. For although the phosphoric acid is present in fair proportion in this soil the amount of original surface mould is doubtless small, and we have an indication of this in the comparatively small amount of nitrogen.

A high per centage of nitrogen does not of itself alone prove the land to be a suitable one for coffee, indeed, too high an amount is rather a bad sign, for it would show the presence of organic or peaty matter in higher proportion than that which is favourable to coffee.

But the quantity of nitrogen does very clearly indicate the probable state of the land *as regards exhaustion of the original forest mould by reason of wash,* so that, excepting certain special instances of red iron soils in which no great amount of undecomposed organic matter can long exist in a tropical climate (consequently but little organic nitrogen), it may very fairly be assumed that a low per centage of nitrogen in Ceylon soils, generally gives reliable information respecting damage by wash.

Lime in all these soils is very low, the only exception being No. 9, which is taken from a spot situated at the base of a limestone rock. I was unable to determine any appreciable amount of carbonic acid in this, or any of the soils, so that doubtless the lime originally present as carbonate (or bicarbonate if in any kind of solution) has been decomposed by the humic acid of the organic matter in the soil.

The much higher quantity of lime in No. 9 is of considerable interest, and also of practical importance as evidence of the value of the close proximity of limestone.

Upon the remaining eight soils it would be desirable to apply lime in some of the numerous forms in which it may be obtained. With the comparatively high proportion of alumina present in these soils the application of freshly slaked burnt lime, can be used, either that obtained from burning the local magnesian limestone or Colombo lime. The dressing in the former case can be about 1½ to 2 lbs. per tree and in the latter about 1 lb.

With the exception of No. 4, the potash does not appear in the analyses in any very large amount, but I apprehend that the disintegration of the insoluble silicates must furnish a considerable supply not only of potash but of other equally important elements. I am aware, from personal inspection of the rocks during my tour, that this process of decomposition or weathering goes on to a marvellous extent in a climate like that of Ceylon, subject to rapid alternations of heavy rainfall and tropical heat, and it follows that, provided the soil is of similar composition, the amount of oxidation will be greatly influenced by the exposure to the local effects of climate. It will be noticed that No. 4, which contains the most potash, faces the south, has the highest elevation, and a moderate rainfall of 110 inches.

For the information of those who may wish to compare these Ceylon soil analyses with those made by other chemists, I wish to mention that in each case the soil taken for the determination of iron, alumina, lime, magnesia, potash, and soda, was treated directly with a definite quantity of standard acid and that the soil was not previously burned before treatment with acid. The latter method is frequently employed especially where there is much organic matter present, but is not generally desirable. The effect of burning the soil is to produce a partial decomposition of the insoluble silicates, so that on subsequent addition of the acid a larger quantity of soil is dissolved. In my analyses I have endeavoured to ascertain the relative proportions of the important elements which are naturally available, and in order to show to what extent different results may be expected by adopting a different method of analysis, I have appended the following comparative partial analyses of two coffee soils—

	Soil treated directly with acid.		Soil first burned and then treated with acid.	
	A.	B.	A.	B.
Oxides of Iron	6.798	5.891	6.815	5.948
Alumina	6.502	4.429	11.765	8.152
Lime	.266	.263	.336	.264
Magnesia	.153	.054	.306	.057
Potash	.139	.057	.178	.084
Soda	.020	.031	.023	.029

In these results the effect of previously burning the soil can be ascertained at a glance. The difference is most marked in the case of the alumina and potash. Soil A represents an estate recognised as a good one in Haputale, so that No. 4 must be considered as certainly comparatively rich in respect of potash.

Let me here say that in comparing the analyses of Ceylon soils, or indeed those of any tropical country, with the analyses of soils from other parts of the world, due allowance must be made for the well-known stimulating effects of climate. Soils which on analysis show perhaps a somewhat low amount of the important elements when compared with European soils, are nevertheless, comparatively rich when placed side by side with other soils drawn from less favoured localities in the same district.

We must compare Ceylon soils with each other, or at least with soils from countries subject to similar climatic influence—certainly not with those drawn from a temperate zone. Practical planters thoroughly understand that a stimulating climate *more* than compensates for apparent deficiency in the soil. As regards the supply of potash, no doubt the application of potash salts in small quantity at frequent intervals, will be found economically advantageous, especially after a sharp attack of leaf disease; but I believe potash is most profitably supplied indirectly in materials like cattle dung, poonac, or a mixture of ashes with artificial manure, such as dissolved bones, or superphosphate.

Several complete coffee manures are now prepared in which potash salts to the extent of 10 to 15 per cent. are incorporated. Such manures can be used in union with the more bulky materials.

Ashes have been used by Mr. Elphinstone and other Ceylon planters, with marked advantage, and the benefit derived therefrom must be considered to be due to the combined efforts of very finely divided carbonate of lime and carbonate of potash.

It is well to remember that potash salts are soluble in cold water with great ease, and that the supply of any excessive quantity beyond that which the soil immediately is capable of rendering useful as plant food, is really practically lost, as it is carried away with the drainage water.

Again, the natural supply of potash from the gradual decomposition of the insoluble silicates is very considerable. Soil A, for instance, contains 2.00 per cent. potash, which it must be allowed is present in a form not liable to be washed out, for the subsoil is doubtless equally rich in this insoluble form of potash. On the other hand, the surface soil in which the valuable nitrogen compounds are contained, *is* liable to be washed away, and we know that we cannot expect any nitrogen from the subsoil.

It appears, therefore, in any system of manuring, that the safest and most economical plan is to supply nitrogenous organic matter and phosphate of lime; the former on decomposition will furnish nitrogen and a supply of carbonic acid, which latter will materially hasten the disintregration of the silicates, and the natural production of available potash; while phosphates are most essential where the seed or berry is the chief object of attainment in the crop.

From the results of modern research in the branch of agricultural chemistry, it would appear that plants possess the power of assimilating the potash naturally present in the soil, with much greater readiness than they can the nitrogen and phosphate of lime. Consequently in practice it is found most profitable to confine the artificial supply to the latter, and only to add a small quantity of potash under special circumstances; but I will allude to this point more fully in the chapter on coffee manures.

The magnesia and soda determinations in these soils do not call for any special remark.

Phosphoric acid is one of the most important constituents to be noticed, for the presence of ·14 to ·25 per cent. is to be observed always associated with permanently good coffee estates; there may be some few exceptions, thus where good coffee has been produced on new estates the soil of which on analysis does not show any high percentage of phosphoric acid, no doubt the supply is sufficient in such cases for *immediate requirements*, and the stimulating climate has forced the tree to make the most of the natural resources. But on estates which have yielded good crops for upwards of twenty years, I have invariably found a high percentage of this constituent.

The accurate determination of it is, however, one of the most delicate operations in the analysis of a soil requiring considerable previous experience on the part of the chemist, otherwise the results will be only of doubtful value.

Again, a high percentage of clay in the soil may vitiate the natural fertilising effects of an apparently favourable quantity of phosphoric acid, thus making a decided instance of an exception to the general rule. But this fact should be noticed and allowed for by the chemist in making his report. This has been done in the case of the alumina in No 1, and the remedy will consist in more thorough forking, so as to improve the mechanical condition and by means of aëration render the fertilising elements available.

Indeed, with the exception of No. 9, all these soils would be very much benefited by forking, not during wet weather, but in the intervals of dry days succeeding rain, in fact in showery weather, when the land is neither too dry nor too wet, neither too hard nor too soft for the coolie to work readily. There is a proper time for forking as well as for every other planting operation, and practical men of experience will know when it should be best done on each variety of soil.

Sulphuric acid in all these soils is present in the usual small proportion common in Ceylon coffee soils; an increase of it in the form of hydrated sulphate of lime, as supplied in superphosphate of high quality, will be doubtless of considerable advantage.

Chlorine, as in all inland soils, is present only in small quantity, No. 7 being the only exception, and in this soil it is not present in any abnormal quantity, considering its exposure to the north-east monsoon and a somewhat high rainfall, which, being impregnated with saline matter, would account for the larger quantity of chlorine probably present as common salt.

Carbonic acid was not found to be present in appreciable quantities, though in very minute proportions it is no doubt associated with the decomposing organic matter.

The presence of a high percentage of *soluble silica* would be of importance in the consideration of soils suitable for sugar-cane. In reference to coffee, however, I believe it is one of those points which will vary with the particular situation of the estate, as regards climate and composition of soil. I have examined soils from estates known to be good for coffee, in which a comparatively low percentage of silica soluble in standard alkali solution has been found upon analysis. For instance, No. 8, which contains the least, is certainly very far from being a poor coffee soil when we consider the high percentage of original forest mould still present, witness the amount of nitrogen and the percentage of organic matter and combined water. I should consider it *one* of the best of these nine, most of which, however, contain a high proportion of nitrogen, and compare very favourably with average coffee soils in this respect.

This determination of silica soluble in alkali, is also one which I should expect to vary in the analyses of the same soil by different chemists, since the results will depend upon the strength of the alkali solution used, and the time allowed for digestion. The object is to obtain comparative results, and this being so, it does not matter if one chemist finds more or less in a particular soil than another who employs a different strength of solution, &c. It will be greater in cases where the soil is first burned previous to treatment with standard acid, as I have described when noticing the proportions of alumina.

Generally from 2 to 5 per cent. will, according to the process I have adopted, represent the amount usually associated with good coffee soils, and I am inclined to think that in wet exposed localities, a low percentage will be more favourable, and in dry localities a rather high proportion.

A glance at the analytical results shows that the soluble silica varies from .540 in No. 8 to 3.765 in No. 5. The proportion of insoluble silicates, including quartz, appears pretty uniform except in No. 5, where in consequence of the high amount of organic matter and combined water, the figures are low, while in No. 9, for opposite reasons the figures are high.

We may judge whether a soil is stiff or light from a comparison of the relative proportions of those constituents which appear in large quantity, but should carefully compare the analytical determinations of the components which appear only in small quantity, if we wish to judge of the probable fertility as regards crop. Thus nitrogen, phosphoric acid, potash, and lime are the important elements which we should take note of in these analyses.

As regards nitrogen it will be noticed that the figures vary from .160 in No. 1, an estate which has suffered from wash, to .403 in No. 5, which is remarkably high, and being present in the form of rich vegetable mould not simply as peat, it must be considered as indicative of a presumably good coffee soil. Nos. 1 and 2 are the only soils in which the nitrogen is present in the usual average amount, as compared with those of estates which have been under coffee upwards of ten years. All the other seven soils contain above the average.

In some soils which have been much neglected or washed, only .06 or even less nitrogen has been found.

I would, however, remark that the amount of nitrogen is not always a certain indicator of fertility, though in most cases it does afford a tolerably sure guide as to the probable quantity of valuable surface soil still left. I have one remarkable red soil containing over 30 per cent. of iron as peroxide, which has only .080 per cent. nitrogen and yet produces, I believe, excellent coffee. In this soil, possessing evidently great powers of oxidation, no large amount of organic nitrogen could be expected to remain long as such, but it would rather be easily rendered available as plant food. I should add further that this red soil contains the high proportion of .147 phosphoric acid.

Thus it is apparent that it would be most rash and unfair to lay down any fixed standard of nitrogen as an indication of a good coffee soil—though a moderately high amount may generally be considered a favourable sign, as pointing to the absence of any great amount of waste from previous wash.

Quartz, the last item in the analyses, represents approximately the proportion of quartz crystals found in the soils. This presence of crystals of irregular size is a very marked characteristic of Ceylon coffee soils—I have found as much as 50 per cent. in special samples—and though so large a proportion can scarcely be considered generally desirable, yet I frequently find as much as 30 to 35 per cent. present in some of the best coffee soils.

There can be little doubt that the presence of quartz in moderate quantity is decidedly advantageous, as it prevents soil otherwise naturally stiff from becoming too stiff and impervious for coffee, which delights in a loose friable soil.

In these Dimbula soils, the quartz varies from 13.120 in No. 2 to 26.800 in No. 9, the latter containing twice as much as the former, while the other soils show intermediate quantities.

In each case this determination of quartz was arrived at by mechanical treatment, the insoluble matter being ground lightly with the aid of a pestle and mortar and a good supply of water.

Having now briefly reviewed the principal points in these analyses, it may be acceptable if I offer a few suggestions in reference to the manures most suitable.

It is the part of the analytical chemist to make a careful analysis of the soil, and to point out the constituents which are specially deficient, or are specially required, in order to enable such soil to produce profitably any particular crop.

He may go further, and, having found out the special requirements of any individual soil, as far as analysis and previous experience enables him to do, may suggest the particular form or condition in which the required constituents should be supplied.

But, for many reasons, it is generally desirable to offer such an opinion rather in the form of a suggestion. Let me explain what I mean. The chemist makes an analysis of a soil, and states quantitatively the relative amounts of the important elements. Having done so, he mentions those which he believes should be increased by artificial means, and further suggests the form in which these constituents had best be added; but he will do well not to limit the form or condition in which they are to be supplied, because local considerations of market price or cost of transit, of which he may be imperfectly informed, would suggest to the practical planter a different character of manure to that which the chemist had recommended.

The great question which the planter is called upon to decide is how to supply the required elements in the most suitable form, and at the cheapest cost. In the chapters on coffee manures and their valuation, I will endeavour to show how this can best be secured. But to proceed. Soils 1 and 2 will be much improved by increasing the supply of nitrogen, phosphoric acid, lime, and potash.

If cattle manure is available, the most economical dressing will be a basket of dung and ½ lb. of slaked lime per tree; otherwise, a mixture of—

Per tree.
¼ lb. steamed bones (Leechman's).
½ lb. rape or castor poonac (finely ground).
¼ lb. high-class superphosphate, 44 per cent. of soluble phosphate (Lawes').

Forking the surface and application of lime being carried on as a separate operation.

As already frequently mentioned in my private reports, it will be found more economical to apply small dressings about every two years, than larger ones at longer intervals.

Now 1½ lbs. per tree, or (at 1,200 trees) 16 cwt. of concentrated manure per acre, appears to be too strong a dressing, and is naturally calculated to be too stimulating in a tropical climate.

Nos. 3, 4, and 7, containing a higher percentage of nitrogen than Nos. 1 and 2, will not stand so much in need of an artificial supply of this element; and consequently, the treatment as regards manuring may be slightly altered, in so far as the quantity of cake used, which can be reduced to 4 ozs. instead of 8 ozs. per tree, also a smaller quantity of cattle manure. In the case of No. 7, the quantity of bones might be increased. No. 5

soil, if the analysis fairly represents the estate, appears to be quite capable of producing good crops of coffee for many years, and the application of lime over the surface, followed by careful forking, would be the only necessary expense I would suggest.

In Nos. 6 and 8 I think that nitrogenous manures, such as cakes, may be dispensed with, and that steamed bones and superphosphate, with occasional liming, will be generally the most advisable application, the quantities of each being ½ lb. of the former to ¼ lb. of the latter. No. 9 analysis shows us what effect the proximity of limestone rock may be expected to produce upon the composition of the soil immediately underlying. The amount of lime is fully twice that found in any of the other soils, and as .10 may be taken to represent one ton per acre, extending to the depth of 6 inches, we can understand that this soil contains 1½ tons more lime than any of the others. Comparatively, therefore, this soil is decidedly rich in lime, and does not, as a coffee soil, require lime to be specially added in any large quantity. The phosphoric acid is also present in high proportion, while the nitrogen is fully above the average of most estate soils. This is from an estate in Dimbula well known as a good plantation, and it is certainly of practical interest to notice to what extent the analytical results confirm or agree with the actual condition as regards production of coffee. This is essentially a light friable soil, with a relatively high proportion of quartz, and I apprehend that any hygroscopic material will be valuable as a manure. It appears that bones and rape have been used with advantage. I would suggest some bulky manure should be used if possible. A small basket of decomposed pulp, with ¼ lb. steamed bones, would be a suitable application per tree; or if no compost manure is available, the following mixture may be used every two years:—

Per tree.
¼ lb. steamed bones.
¼ lb. ground rape cake.
¼ lb. high-class super 44 per cent. soluble phosphate.

This (No. 9) is a naturally light soil, and contains the most quartz—certainly an instance in which it would be most unwise to employ a heavy dressing of a highly nitrogenous character. It is stated that this land does not suffer much from wash, and this agrees with the favourable proportion of nitrogen. The sample, be it remembered, is a mixture of eight specimens, taken from different parts of the estate, portions of which are sandy, and others of a peaty nature.

I have not specially suggested fish manure or similar mixtures in these remarks, because they are, I fear, subject to great variation in quality, requiring a corresponding alteration of quantity to be used, but the planter can, with the aid of the valuation tables contained in this report, see whether at the market price such can be more profitably used than those already recommended.

(Leechman's) Steamed Bone Meal, Ground Rape Cake, and (Lawes') Super. 44 per cent., are materials which may be considered of uniform composition, and not likely to vary much in price, thus offering a convenient standard of comparison.

In concluding the remarks upon these soils, it may be as well to bear in mind that they have been made in reference to the samples submitted to me. Whether these fairly represent the several estates will depend upon the care taken in selection of the specimens by the senders.

The nitrogen varies considerably, but is above the general average in seven instances; while in two, it is fully equal to that found in most estates ten years in coffee.

The ready production of wood and leaf will generally be associated with the presence of *available* nitrogen in the soil. From ·200 to ·300 appears to be the average nitrogen in permanently good coffee land. Of course much depends on the condition in which such nitrogen exists, whether it is in a form suitable or available as plant food. A higher percentage than ·400 may be positively injurious, if it be produced from very hygroscopic organic matter. One remarkable example of such a condition was afforded me in the analysis of a soil, which after being kept some weeks in an office in Colombo, contained over 26 per cent. of water lost at 212 Fahr.; this soil was suffering from white bug at the roots.

Again, as pointed out, a low percentage of nitrogen does not always imply inability to throw out plenty of new wood. (See the case of the specially ferruginous soil, containing only ·080 per cent.)

The varying proportions of phosphoric acid I have drawn attention to, and would say that a careful determination of phosphoric acid may be of great use in forming an opinion of the permanent fertility of coffee soils, but such determinations will require great care and delicacy, being really the most difficult operation in an ordinary soil analysis.

Potash does not stand specially high in any of the nine, but nevertheless appears in most cases sufficient, so far as it is possible to judge by comparison with the analyses of soils carefully selected from several good coffee estates.

Finally the application of lime, and surface forking, will be generally of great benefit upon all except No. 9, which is chemically and physically different from the others.

ANALYSES OF MASKELIYA SOILS.

ANALYSES OF COFFEE SOILS SENT BY THE MASKELIYA PLANTER'S ASSOCIATION.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
Elevation (about)	3,900 ft.	4,200 ft.	3,500 ft.	4,300ft.	4,000 to 4,300 ft.	4,000 to 4,200 ft.
Average annual rainfall	..	140in.	190in.	..	160	150
Aspect	Flat land Eastern	South	Wstrly.	Fairly good.	North east.	South-west.
Situation as regards wind	No Wind to harm.	Not much Wind.	..	Not much Wind.	Exposed	..
Number of years in coffee	5	3	4	4	2 to 6	4 to 7
Water lost at 212° F. ..	6·480	4·050	3·180	4·390	3·670	2·170
*Organic water and combined water ..	16·140	15·300	11·690	10·680	10·920	10·520
Oxides of Iron and traces of Manganese	10·876	21·753	10·423	11·783	9·290	9·743
Alumina	15·474	15·372	10·927	9,920	7·110	10·382
Lime	·234	·070	·070	·084	·168	·084
Magnesia	·298	·018	·126	·153	·175	·090
Potash	·125	·129	·082	·072	·062	·077
Soda	·054	Trace	·011	·071	·040	·081
Phosphoric Acid	·083	·070	·025	·028	·070	·032
Sulphuric Acid	·027	·007	·034	·013	·015	·010
Chlorine	·014	·012	·008	·002	·005	·003
Carbonic Acid	Trace	Trace	Trace	Trace	Trace	Trace
Silica soluble in Alkali ..	5·600	Trace	Trace	2·520	1·120	·820
†Insoluble Silicates ..	44·595	43·219	63·424	60·285	67·355	65·988
	100·000	100·000	100·000	100·000	100·000	100·000
*Containing Nitrogen ..	·267	·117	·133	·128	·187	·138
†Containing Quartz ..	2·640	13·280	28·710	15·890	23·360	21·500

The following answers were sent in reply to the official questions:

"No. 1.—Taken from flat land, evidently alluvial deposit, the sub-soil being very similar in character though lighter in colour. The land being flat, the only drainage is by means of natural downward percolation. Average crop about 5 cwt. The general tendency of the soil is to produce sufficient wood and leaf, but not enough crop. No manure yet used.

No. 2.—The subsoil is gritty and of a light colour. The slope is 30°, with several natural ravines. No manure has been applied.

The soil seems to be composed in a great part of rotten stone of a ferruginous nature and colour. The growth of wood and leaf is slow.

No. 3.—The subsoil is a free, open, sandy clay. Usual drainage, the drains being cut in connection with natural ravines. Oldest coffee four years old. Manured with bones and poonac in the proportion of 2 of cake to 1 of bones. One lb. of mixture per tree with good results, also capital results from cattle manure. Average crop returns 3 to 4 cwt. per acre. When the trees have large crops they die out unless assisted by manure.

No. 4.—Aspect fair. Not much wind. Subsoil stiff; drainage fairly good. No manure as yet. Too young an estate to say what the average crop may be considered. Slow as regards production of wood and leaf.

No. 5.—The sample of soil sent is a mixture representing the average soil from three estates. North-easterly aspect. Monsoon blowing right across the land. Precipitous range of hills at the back. Natural ravines, some very steep and abrupt, cut up the land into sharp spurs. From 2 to 6 years in coffee. No exact estimate as to crop can yet be given, but the results so far have been poor. No manure applied.

No. 6.—Subsoil red, free and gritty. Bones and poonac used with fair results as regards wood, but deficient in crop. No special peculiarity about the soil. Average crop, say from 3 to 4 cwt. per acre."

The above remarks furnish the only information given in reference to these samples of Maskeliya soils, which, as a class, are not quite equal to the Dimbula soils sent me. Whether these samples fairly represent the average soil of the district is quite another question. Possibly they were selected as being new estates, and that information was wished as to the manures most suitable.

I may state that the analyses were carried out on the same plan as adopted in the case of the Dimbula and other Ceylon coffee soils.

The water shown in the results represents that found in the samples as received. The variation in the several soils is to some extent due to accidental circumstances, depending on the state of the weather and the condition of the soil when the specimen was taken.

The organic matter and combined water in Nos. 1 and 2 is very similar in quantity, but differs in quality; the former containing relatively much more organic matter and less combined water than the latter, in which the high percentage is largely due to water of hydration associated with the iron and alumina.

In Nos. 3, 4, 5, and 6 the proportions of organic matter and combined water are very uniform and agree with the nitrogen determinations. In No. 5 the relative proportion of organic matter is somewhat higher, and it will be noticed that the nitrogen is higher, while the iron and alumina is smaller, consequently less water of combination.

Iron and Alumina are present generally in tolerably equal proportions, and in four of the soils iron is in excess of the alumina, and is so far a favourable condition, especially being, as it is, present as peroxide. No. 2, indeed, stands out very prominently in this respect, but unlike the remarkable ferruginous Rakwane soil is not associated with a correspondingly high proportion of phosphoric acid. However, though doubtless able to retain the ammonia furnished by rain to a considerable extent, the amount of nitrogen present in the form of organic matter is, as we should expect, but small, the soil being subject to such complete oxidation, as shown by the presence of so much peroxide of iron.

Lime.—Only in No. 1 soil (which is certainly the best) does the lime appear in any appreciable quantity. In Nos. 2, 3, 4 and 6 it is present in the small quantity common to most estates of average richness. No. 5, though, approaches No. 1 in its quantity of lime, and stands second as regards the nitrogen.

Magnesia is highest in the soils, Nos. 1 and 5, which contain the most lime.

Potash is present in fair quantity, in Nos. 1 and 2, though rather low in Nos. 3, 4, 5, 6.

As noticed in the Dimbula analyses, the highest percentage is found in the estate with a south aspect, in this case No. 2.

Soda is present in varying proportions as usual, and does not call for any special remark.

Phosphoric Acid is present in the highest proportions in soils 1, 2, and 5, and may be considered as existing in fair average quantity, but in the other soils it is decidedly low. All six will, however, be greatly improved by the application of phosphate of lime in some form.

Sulphuric Acid as usual is also in small quantity.

Chlorine in Nos. 1 and 2 is somewhat high. In the former, the superintendent states in his remarks that the land is flat, and that the only drainage is by means of downward percolation. It is reasonable to suppose that the amount of saline salts which are carried inland during the monsoon must be considerable, and that when the land is flat, and of an alluvial character, we should expect to find a correspondingly high amount of chlorine retained in the soil. No. 2 soil also shows a somewhat high percentage. No special importance is to be attached to the varying quantities of chlorine in these soils, they can scarcely produce any marked effect in the degree of natural fertility.

Silica soluble in a standard solution of Alkali.—The variations under this heading are very marked in these Maskeliya soils, from a mere trace up to 5.6 per cent. From the numerous analyses I have lately completed, I am inclined to believe that the presence of large coffee trees is generally associated with a high proportion of soluble silica in the analytical results, though I would by no means infer that good coffee cannot be grown upon soil showing, on analysis, only 1 per cent., or possibly less, of soluble silica.

Insoluble Silicates.—A glance at the analytical figures would indicate that soils Nos. 1 and 2 differ from the others very considerably as regards insoluble matters.

Nitrogen is fully high in No. 1, fairly so in No. 5, and a somewhat low average in the remainder.

Quartz varies very much, as will be noticed. No. 1, the most alluvial, contains the least, and No. 3, which has a westerly aspect, and is washed with 190 inches of rain annually, shows the most. I do not, however, consider that the amount of quartz furnishes any reliable information as to the suitableness or otherwise of land in reference to coffee cultivation. A rather high percentage is, as a matter of fact, generally concurrent with good coffee land.

Manures.—From the preceding remarks it will be gathered that the elements which are most required to be supplied to these soils will consist of nitrogenous organic matter, phosphate of lime and some potash salts, in the case of the last five soils. For No. 1, systematic surface forking after application of lime will be the most desirable treatment, and if any manure is used, a mixture of fine bone dust and superphosphate in equal parts will be most economical, at the rate of ½ lb. per tree.

Upon the remainder, cattle manure and fine bone dust would be a very desirable dressing, in order to increase the quantity of those constituents which have been shown to be most required.

As previously mentioned, it is more convenient that the chief requirements of a soil should be ascertained by careful analysis, and pointed out for the guidance of the planter, but that the latter should choose the particular form in which these necessary elements should be supplied. If no cattle manure is available, resource must be made to some other bulky manure, such as pulp or compost of collected leaves mixed with soil. Should neither of these be obtainable, the following mixture per tree will be appropriate :—

½ lb. ground rape, or white castor cake.
¼ lb. fine bone dust.
¼ lb. high class super, 44 per cent. solnble.

Bones in a fine state of division may fairly be considered as the crop producer, containing, as they do, nitrogen, phosphoric acid and lime, with a small quantity of alkaline salts, but as usually applied I fear they are not generally in sufficiently finely divided condition to be readily available, consequently poonac is used to supply nitrogen in a quicker form as plant food; and superphosphate in order to furnish phosphate of lime, previously rendered soluble by treatment with sulphuric acid. It is simply as an immediate source of phosphates that super is recommended, and naturally where cost of transit has to be considered, only the concentrated superphosphates, containing a high percentage of soluble phosphate, are to be selected. In England, 25 per cent. is practically the most economical, but for the Colonies 40 to 44 per cent. of soluble phosphate is the more useful quality of superphosphate, cost of transit being the important feature, which indicates that the more concentrated quality is really, under such circumstances, the cheapest.

The only soils on which manure had been applied were Nos. 3 and 6, and on these bones and poonac had given very satisfactory results in the case of the former, but were only partially so in the latter.

On No. 3, cattle manure had given capital results also. This is very natural; the chief difficulty will be to get enough of it, and at reasonable cost. When two systems of manuring both give good results, we should choose the cheapest. In fact, the theory of successful manuring consists in ascertaining what elements are required by a soil to produce certain crops, and then to supply these materials in the most suitable and cheapest form.

GOOD COFFEE SOILS.

Probably the most practical way of definitely ascertaining what should be the chemical composition of really good coffee soils, will be to take samples of soil from estates recognised as good ones for each particular district, and to submit these samples for careful analysis.

It is only natural to conclude that the majority of the soils sent me for examination do not represent the highest quality of coffee land.

The proprietors of estates on which the soil is particularly rich are quite satisfied with the results of the annual crops, and think that any analysis of the soil in their case is quite unnecessary. I quite agree with them.

Fortunately, however, I have obtained by special application, specimens of such high-class coffee soil; and also, thanks to certain planters who have complied with my request to send samples of known good soil, other examples have been furnished, notably by the Dimbula Association, so that I have had the advantage of making careful comparative analyses; and the results obtained have been most useful when making suggestions as to the improvement of the other soils.

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The following are selected as samples from old estates still bearing.

EXAMPLES OF GOOD COFFEE SOILS FROM OLD ESTATES.

	No. 1. From Badulla District.	No. 2. From Haputale.
Elevation above sea level	About 4,500 ft.	4,700 feet
Average annual rainfall	70 to 80	70 inches
Aspect	Western exposure	Faces West
Situation as regards wind...	...	Not exposed.
Number of years in Coffee	35	40
Water lost at 212 F.	6.790	3.850
*Organic Matter and combined Water ...	10.280	8.750
Oxides of Iron and traces of Manganese	5.778	6.798
Alumina	7.447	6.502
Lime	.168	.266
Magnesia	.146	.153
Potash	.091	.139
Soda	Trace	.020
Phosphoric Acid	.166	.185
Sulphuric Acid	.062	.062
Chlorine and Carbonic Acid	.005	.004
Silica, soluble in Alkali	2.520	2.820
**Insoluble Silicates	66.547	70.451
	100.000	100.000
*Containing Nitrogen	.224	.213
** { Containing Quartz	29.760	20.120
** { Containing Potash	1.196	1.941

The superintendent's replies are as follows in reference to the above soils.

"No. 1.—Subsoil free and open. Surface drainage, and that only within the last three years. About thirty-five years in coffee, and no manure, so far as I am aware, has been applied to the part from which this was taken. No special apparent peculiarity about the soil, except that it is intersected with large gneiss boulders and a large number of smaller stones. Crop returns, about 8 cwt. per acre for the last five years. Always an abundant supply of wood, leaf, and good crops.

No. 2.—Subsoil red in appearance and gravelly in character; sample taken from a large plot in the middle of the estate, which has a gentle slope. About forty years in coffee, but no manure used. No special apparent peculiarity about the soil; it is of a dark, rich looking colour and is of good depth. Crop about 10 cwt. per acre per annum. There is an equal abundance of wood, leaf and crop."

Such is the information I have received from the senders. No. 1 soil was sent at my own request, being taken from an estate visited during my tour, and with the fine appearance of the coffee I was much struck. No. 2 was sent me by the Haputale Association, and also represents an estate personally viewed.

The elevation, aspect and rainfall, are similar in each case, and it will be noticed that the annual rainfall is certainly very moderate, apparently indicating that a fall of about 70 inches of rain is decidedly favourable to the permanency of coffee. Although it is not stated that No. 1 is from steep land, I believe the general feature of the estate is eminently so, but the presence of boulders of gneiss rock prevents any great damage from wash. No. 2. represents a gentle slope. A glance at the analyses at once shows how similar also these soils are in their chemical composition; the total iron and alumina amounts to 12 per cent. in No. 1, and to 13 per cent in No. 2, indeed, were it not for the slightly higher percentage of moisture in the former (doubtless due to conditions of soil at the time of taking the sample) the quantities would be almost identical. The soils are, it will be noticed, taken from different districts, and have been 35 and 40 years respectively in coffee without receiving any manure. These facts speak for themselves, and prove most assuredly that soil and climate are very important elements in considering the permanency of coffee estates. It is equally necessary to notice how rich both these soils are in phosphoric acid, containing quite double the quantity I found in most estates of average fertility.

Nitrogen is high and remarkably similar in both samples, as is also the case with the figures for soluble silica determined with standard alkali solution. Potash is less in No. 1 which contains the most quartz, but in both cases the insoluble silicates contain an abundant supply of this alkali, so necessary to the production not only of the bean, but also (as will be seen from future analyses) of the leaves and young wood. The insoluble silicates would be much closer in amount were the samples previously submitted to equal drying conditions.

In order to exhibit more clearly the retentive properties of different samples of soil, equal quantities of the following specimens were kept under similar atmospheric influences, namely, at a temperature of 50° F. for three whole days, or seventy-two hours consecutively, and the moisture retained in each then determined by drying weighed amounts of each soil at a temperature of 212° F.

Moisture in air-dried samples of soil :—

No. 1.	Badulla	soil	.... 3·177	per cent.	moisture.
No. 2.	Haputale	"	.... 3.474	"	"
No. 1.	Maskeliya	"	.... 5.205	"	"
No. 5.	Dimbula	"	.... 5.872	"	"
No. 8.	"	"	.... 4.496	"	"
No. 9.	"	"	.... 3.137	"	"

It will be seen that the Badulla and Haputale soils above referred to, are very similar as regards the property of retaining moisture, and that had the samples analysed been previously subjected to the same drying influences as just described, the results as regards water lost at 212° F. would have been similar. The soils which retain 5 per cent. contain also corresponding high quantities of iron and alumina, and are evidently stiffer and more retentive in character.

No. 8 occupies an intermediate position, while No. 9 closely agrees with the results of the first two soils.

From 3 to 6 per cent. would appear to represent the average variation of moisture, retained in small quantities of soil that have been air dried by exposure to the drying influences of a temperature of about 50° F.

I will conclude my remarks upon the two selected soils, by observing that detached limestone rocks are present on the estate represented by No. 2, which is the richer of the two in lime. The determination of potash, as usually made, would appear to indicate the amount of the future supply to be expected from the disintegration of the insoluble silicates by atmospheric influence; as well as to give useful information concerning the proportion already available, for it will be seen upon reference to the analyses that No. 2 contains the most potash in both conditions.

The comparatively high percentage of phosphoric acid which distinguishes both these soils is very important to notice, as such richness very materially contributes to the continuous production of crops or seed. In the Dimbula analyses similar high equivalents of the same element were found, and generally at once indicated the comparative merits of each soil as regards crops. Ceylon coffee soils are not remarkable for their special richness in phosphoric acid, but wherever a higher amount is present, whether as apatite or chemically associated with the ferric oxide, in such cases superior coffee producing properties is naturally the consequence. Very great care has been taken with the determination of phosphoric acid in order to secure comparative results; similar quantities of soil and acid being always employed. As I have already mentioned, it is one of the most delicate operations in a soil analysis, and unless every care be taken, the results obtained may be positively misleading.

In these two soils, the high percentage of phosphoric acid found cannot be due to the presence of phosphates derived from bones, no manure having been used, and planters will not be surprised at this, for Haputale and the coffee districts beyond Badulla, are certainly not localities where artificial manure to any extent has yet been used, simply because transit costs too much at present.

In selecting these analyses as representative of good coffee land, I by no means wish to infer that they should be considered as the best of all the soils received from Ceylon. My object in bringing them before the notice of planters was simply because the samples are from estates that have been in coffee thirty-five and forty years respectively; consequently the analysis of such soils would give the most reliable and practical information as to the chemical composition of good coffee soil, and as such I trust the analytical results will be of value.

In both soils there is upwards of 20 per cent. of quartz crystals, which no doubt contribute to render the land friable and naturally suitable to coffee.

DYING OUT OF COFFEE TREES.

Among the soils sent me privately by different planters, several samples are described as representing soil on which coffee has actually died out, or has commenced to do so, if such an expression may be allowed.

For instance, on one estate the superintendent writes:—"The coffee commenced to die out some twelve years since. The appearance of the trees is that of a gradual dwindling away as if from want of natural supply of plant food." Whether the samples submitted to me for analysis fairly represented the affected plots is a point which entirely depends on the judgment of the taker of the samples. As a chemist I can only report upon the soils as submitted to me, and if the analysis does not show the presence of injurious compounds, so much the better, as there is then the prospect that the evil element or cause is one due to accident, the ravages of insects, or to some physical defect in the subsoil.

During my tour I personally examined several spots of land on which this dying out of the coffee trees was very apparent, but in the general appearance of the soil there was nothing specially remarkable, except that in many cases black ironstone seemed to abound on the surface, and probably extended equally into the subsoil. When in Haputale, I was much struck with the presence of this large quantity of ironstone on these spots, and a sample of soil said to be taken from a spot where the coffee had commenced to die twelve years ago was sent by the Haputale Association for my examination, but no unusual amount of iron was present, and the general chemical composition of the soil was equal to that of most Ceylon estates which have been in coffee twenty or more years.

Although the analysis has been already published it may be convenient to give the details here.

SOIL UPON WHICH COFFEE TREES ARE SAID TO HAVE DIED OUT.

Hygroscopic Moisture ...	1,900
*Organic Matter, and Combined Water	6,800
Oxides of Iron and trace of Manganese	5,891
Alumina...	4,429
Lime	263
Magnesia	.054
Potash	.057
Soda	.031
Phosphoric Acid	.147
Sulphuric Acid...	.065
Chlorine...	.002
Silica, soluble in Alkali	.740
†Insoluble Silicates	79.621
	100.000

*Containing Nitrogen	.149
† Containing Quartz	32.360
† Containing Potash	.927
† Containing Soda	.684

The superintendent's answers are as follows:—

"Elevation, 3,000 feet above sea level; annual rainfall, about 77 inches; estate lies east and west, with a southerly exposure, getting the sun all day and is a good deal wind-blown: subsoil black in appearance, nineteen years in coffee, no manure used, a great deal of rubble ironstone mixed with the soil; crop returns about 6½ cwt. per acre. The coffee commenced to die out 12 years ago on parts of the estate."

Now I must assume that the sample was carefully taken, and represents the bad batches, but if it does, where is the large quantity of rubble ironstone? The analysis really shows less iron and alumina than was found in one of the best soils of the district.

Phosphoric acid stands out very satisfactory as compared with ordinary estates. Lime is also present in fair proportion, but the nitrogen is somewhat low. The water retained in the air-dried soil is under 2 per cent., while the quartz is high, so that the retentive properties are not up to the desired average specially necessary, as the land is subjected to the baking influence of the sun during the whole of the day. The amount of potash presumably available is very small, and upon making a fusion of the insoluble silicates, and determining the potash contained in an insoluble form, it will be noticed that the proportion is much less than that usually present.

I was unable to detect the presence of anything injurious to coffee. The iron was in the form of peroxide, showing the soil, as sent, was well aërated, and I cannot suppose that such oxidation of the iron compounds could have taken place during transit. Should, however, future samples of soil upon which coffee has died, be sent me for examination, it would be advisable to enclose the same in a clean wide-mouth bottle, which should be well corked, sealed, and packed between sawdust or straw in a small wooden case. Provided the soil is thoroughly mixed previously, one pound would be sufficient to send for analysis.

As far as can be gathered from the analytical results above recorded, the only apparent cause of such dying out is a deficiency of potash in the soil. But if so, the process must be a very gradual one, whereas instances of coffee trees having gone quite out in a single year are doubtless familiar to planters. Possibly the failure may be due rather to accidental causes, and if so, it is certainly so far satisfactory. Naturally, personal and continued observation must determine this point. A practical planter on the spot will be able to ascertain whether the damage is not rather due to the ravages of insects, or possibly fungoid growth generated by peculiar atmospheric influences. One opinion held by many, is, that subsoil wash at a varying distance below the surface impoverishes the soil, and carries off moisture which in in moderate quantities is required by the tap-root for support during the dry weather.

On one estate, deep open drains at close intervals were being cut, with a view of intercepting underground flow of water, and the result is no doubt apparent by this time.

It is stated that Guinea grass grows very well on ground where the coffee trees had died, if so, this fact proves that there is nothing generally injurious to vegetation. The presence of prosalts of iron in any considerable quantity would be injurious, as would also sulphuret of iron, instances of which I have had personal experience.

From what I saw during my visit, I am bound to say that I fear scarcely a representative sample of the particular spots has been sent me, and consequently my

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examination of such soil must, for the present, be considered incomplete.

Dr. Voelcker has already reported upon a sample of soil sent him from one of these patches on another estate; he was unable to find anything peculiar about its composition, his opinion being, I believe, that the necessary elements should be supplied by manure. His analysis, however, is said to represent the important constituents as present in the following proportions in the soil from the dead patches of coffee.

Nitrogen	·32	per cent.
Phosphoric Acid	·36	„
Potash	·20	„

I certainly must say, in reference to the second item, that ·36 is unusually high for phosphoric acid, even in the best coffee soils of Ceylon, or of any other country, and it is to be feared there must be some mistake, possibly in the sample sent.

HIGH PERCENTAGE OF IRON NOT NECESSARILY INJURIOUS TO COFFEE.

During my tour I visited an estate in Rakwana remarkable for its peculiar ferruginous soil, the surface seemed literally to consist of pieces of broken pebble like ironstone, and the subsoil extending to a considerable depth was apparently similar in character. Further the coffee flourished best on these specially red portions of the estate, affording, in fact, a most practical illustration that a high percentage of iron in a soil is not necessarily injurious, provided such iron be as peroxide (ferric oxide), and not as protoxide or sulphide of iron.

It is scarcely necessary to state this, as agriculturists are well acquainted with the fact that some of our best English soils are those distinguished for their bright red colour. A glance at the following analysis will however show that this soil is specially rich in phosphoric acid, which no doubt is of great importance, when we consider the natural fertility of the land. I much regret that the samples sent me by the proprietor, just as I was on the point of leaving Colombo, were unaccompanied by the usual replies respecting elevation, rainfall, and aspect; however, as the estate is peculiar for its red soil, most planters in the district will be able to ascertain such particulars.

FERRUGINOUS SOIL FROM RAKWANA.

	No. 1. Surface Soil, or 1st foot.	No. 2. Subsoil. or 2nd foot.
Moisture, lost at 212° F.	2.080	1.700
*Combined water, with little organic matter	11.450	8.700
Peroxide of iron	34.425	
Alumina	15.546	
Lime	.070	
Magnesia	.045	
Potash	.043	
Soda	.083	
Phosphoric acid	.147	.147
Sulphuric acid	.051	
Chlorine...	.002	
Silica, soluble in alkali	Trace	
Insoluble silicates	36.058	
	100.000	
*Containing nitrogen	.080	.053

In reference to the quantity of alumina, it may be stated that the percentage would not have exceeded 7 per cent. had the determination been made in the usual way, but that in order the more completely to separate the large quantity of iron, the portion of soil originally treated with acid, was ignited, and again exhausted with hydrochloric acid, and, as previously pointed out, the proportion of alumina appearing in the analysis is always much higher, when the soil has been previously burned before treating with standard acid.

The principal point of interest in this analysis is the large quantity of peroxide of iron associated with a high percentage of phosphoric acid, which latter is evidently not accidentally present, for it will be noticed that the subsoil, representing the second foot of soil, is equally rich in this respect. The occurrence of phosphorus in iron ores is fully recognised, and the determination of the exact quantity is of the greatest importance in considering the value of different ores for smelting purposes. In such instances the smaller the quantity the better, as malleable iron made therefrom is less liable to fracture. For agricultural purposes on the other hand a high percentage distinguishes essentially rich red soils from poor ones.

The potash and nitrogen are small, but as regards the latter no large amount of organic matter can long remain unoxidised in a soil so perfectly aërated as this one evidently is. But peroxide of iron has the power of retaining ammonia to a considerable extent, and doubtless a portion of the nitrogen is present as such. The subsoil also possesses this property, for there cannot be much organic matter as humus present at such a depth, and yet we find nitrogen in a quantity but little less than that found in the surface soil. It is well to consider the character and quality of the nitrogen compounds as well as the quantity. A peaty soil containing possibly as much as 1 per cent. of nitrogen would be of small agricultural value, while (.10) *one tenth* per cent. in some soils may, under certain climatic conditions, be indicative of a comparatively high degree of fertility.

The manure most economical on such land would be composts of cattle dung, pulp, and lime.

CEYLON WOOD ASHES.

Anxious as planters now are to obtain manure for their coffee trees, it is much to be feared that a large proportion of the valuable ashes, produced by the burning of the original forest, are practically but only very partially utilised for future requirements. Mr. Elphinstone who has had considerable experience in the application of wood ashes, furnished me with certain samples and requested that the analyses should be sent him on my return to London. These analyses he very kindly published for the general advantage of planters, and I take the opportunity of reproducing them with certain additional remarks.

Nos. 1 and 4 are specimens of pure wood ashes sent from different estates, and obtained, I apprehend, from the combustion of different kinds of wood.

No. 2 represents ashes as generally used, containing a larger proportion of charcoal associated with siliceous impurities chiefly due to the admixture of soil.

No. 3 represents some of the surface soil after the application of ashes.

COMPOSITION OF WOOD ASHES FROM HOLYROOD ESTATE, G. H. D. ELPHINSTONE, ESQ.

	No. 1. Wood ashes, marked pure.	No. 2. Ashes, as used.	No. 3. Top soil and ashes.
Water lost at 212° F.	3.05	3.05	3.95
Carbonaceous matter and Combined water	14.58	18.69	21.09
Oxides of iron and alumina	7.42	18.75	18.01
Phosphoric acid	Trace	Trace	Trace
Carbonate of lime	48.86	10.15	2.60
Sulphate of lime	2.24	Not determined	Trace
Magnesia	3.64	2.20	1.05
Potash	1.71	1.35	.54
Soda	.41	.56	.21
Chlorine	.14	Trace	Trace
Insoluble siliceous matter	17.95	45.25	52.55
	100.00	100.00	100.00
	lbs.	lbs.	lbs.
Weight per bushel	31½	53	69
Approximate value per bushel	5¾d.	3¾d.	1½d.

COMPOSITION OF WHITE WOOD ASHES, NEW PENYLAN ESTATE.
G. H. D. ELPHINSTONE, ESQ.

Water lost at 212° F.	7.87
Carbonaceous matter and Combined water	13.17
Oxide of iron and alumina	16.70
Carbonate of lime	30.80.
Sulphate of lime	3.19
Phosphoric acid	Trace only.
Carbonate of Potash	21.46
Carbonate of soda	1.06
Magnesia	2.59
Chlorine	.46
Insoluble siliceous matters	2.70
	100.00
Weight, per bushel	22½ lbs.
Approximate value per bushel	15½d.

In appearance 1 and 4 were similar, being both white and in a fine powder, but it will be seen that No. 4 is very superior in quality, containing 21½ per cent. of carbonate of potash, in addition to a large quantity of carbonate of lime in a state of powder.

A glance at the analytical results shows that the only constituents which are valuable as manure in these ashes, consist of the potash and lime salts which exist in the state of carbonate; and the former being readily soluble in cold water is liable to be washed away, while the latter, though but slightly soluble, yet being in such a fine state of division, and having consequently a low specific gravity, it would certainly be very readily swept away by wash on moderately steep land.

How very necessary, therefore, to endeavour to retain these valuable constituents by forking the surface, and either actually cover in the ashes or at least loosen the soil sufficiently, so that, the particles may be washed into the land rather than be altogether carried off it.

If planters, when opening an estate, paid due attention to the future requirements of the crop, it is probable that no reasonable expense would be spared to retain these important fertilisers, and that the original extra outlay for labour would be incurred.

Unfortunately capital in many cases is wanting, and the planter hopes to sell the estate after a few seasons of good crops; he has, therefore, no permanent interest in the property.

It will be noticed that phosphoric acid is not present in appreciable quantity in any of the four samples. No doubt, by employing the delicate molybdinum process specially adapted to determine phosphoric acid in soil analysis, certain definite quantities could be ascertained, but the proportions so found would not be sufficient to in any way affect the fertilising value as a manure, for to do so, phosphates must be present in such proportions as to be readily determined by the ordinary method used in the analyses of manures.

As wood matures, the proportions of potash and phosphoric acid decrease, while that of lime increases, so that the ash of old wood is not so valuable as that made from young branches, leaves, &c., in which phosphoric acid and potash usually largely abound.

Now certain trees secrete phosphates only in a comparatively limited extent, and it is very probable that No. 4 represents the ash made from new wood derived from such trees. Also that No. 1 represents the ash of old wood. These are points upon which Mr. Elphinstone would doubtless be able to give interesting information. Samples 1, 2, 3, were sent from Holyrood Estate, Dimbula, and No. 4 from New Penylan, Nawalapitiya.

The amount of insoluble siliceous matters, due to admixture of soil, is considerable in the three first samples, and it follows that ashes of such a quality could not be economically carried any distance to adjoining estates, for the iron, alumina, and unburnt charcoal, which go far to make up the remainder of the composition, would certainly not be considered in any way necessary to the improvement of the soil.

No. 4, on the contrary, must be considered as a concentrated potash manure, as it contains this salt in a much larger quantity than would be found in any economical artificial fertiliser.

I apprehend that no considerable amount of so valuable a material is to be had, but certainly if so obtainable, it is the cheapest form in which potash can be applied in the district. In addition to the potash, the lime, which it contains, will be of great value as a manure, especially as it is in such a fine powdery state naturally suitable for assimilation as plant food.

The weight per bushel of each specimen varies considerably, and it will be of practical use to notice that the *lighter the weight*, the *more valuable* the ashes. The value attached is only an approximative and comparative one, being rather under the actual value than over, when the present high rate of cart-hire is considered.

The best way of applying ashes will be in union with pulp, or similar bulky manure, as it is most essential that there should be uniform distribution of so concentrated a material.

Now that I am referring to ashes, I would ask whether it would not be an advantage to burn all weeds collected on estates, rather than bury them in immense holes, as now generally done.

Farmers always burn the couch grass when the weather is anything at all favourable, and only cart it into heaps along the headlands of the fields when they are obliged to do so through pressure of circumstances;

but, in the latter case, the couch is mixed subsequently with quick-lime, and made into compost heaps for future use, whereas no use whatever is made of the tons of weeds removed from Ceylon coffee estates every year. Even with hand weeding a certain quantity of rich surface soil must adhere to the roots of the weeds, and is at present practically lost; whereas, if the coolies were paid for the weeding in proportion to the quantity gathered and brought to a central spot for future drying and burning; the insoluble silicates of the adhering soil would be decomposed during the process of combustion; and, in addition to the fertilising elements derived from the weeds, we should have a considerable quantity of potash liberated, and rendered available as plant food.

In a very practical paper on "Paring and Burning," published in the Royal Agricultural Society's Journal, in 1858, Dr. Voelcker has given some valuable information respecting the composition of vegetable ashes.

When it is remembered that a tendency to produce weeds in large quantities, may be taken as a general rule to indicate considerable natural fertility in a soil; it follows that on good, but previously neglected estates, the economical treatment of weeds must be a question well worth the consideration of the planter.

No doubt, unless the compost heaps are very well prepared, the vitality of the weeds, or rather of any seeds attached, will not be destroyed, and there would be danger from possible future germination.

The ammoniacal salts derived from the fermentation of cattle dung would be best calculated to effect this destruction. In the absence of dung, sulphate of ammonia sprinkled over the weeds, and the whole made into a heap and covered with soil, would probably be the next best plan.

The question of burning the weeds would be more satisfactorily settled if the average quantity of ash, produced from the combustion of a known weight, was first carefully ascertained, and the composition of these ashes afterwards determined by means of chemical analysis. It would give me much pleasure to undertake the latter at some future time.

If the weeds, however, are burned, the organic matters, including the nitrogen compounds, are destroyed and practically lost as future manure, the only satisfaction being that the vitality of the weed is also destroyed, while the residue in the form of ash (or mineral elements) is rendered at once available as plant food.

COFFEE PULP.

I was unable to obtain any very decided opinion during my tour as to the true merits of pulp as a manure; some planters had obtained good results, while others attached very little value to it. Probably their opposite opinions were due rather to the different conditions under which the pulp had been applied. When allowed to remain in a large heap below the pulping house for some months, exposed both to rain and wash from the stream near which it lies, we cannot expect such a material to be a very stimulating manure, for the soluble matters must have been washed away, leaving little more than woody fibre (cellulose), together with a small quantity of insoluble nitrogen compounds.

Probably too, the whole mass will contain 80 parts of water in every 100 of pulp, so that transit for any distance would not be economical.

In the following analysis the pulp was obtained immediately after separation from the seed. I am indebted to Mr. Alexander Hebenton, of Badulla, for a supply of fully ripe and very fine cherries, which were sent to me when in Colombo. They were enclosed in a clean tin case, and being forwarded by post reached their destination in excellent fresh condition.

Immediately on receipt, the pulp was carefully removed from the bean, and the respective weights determined.

	By weight.
Beans (with mucilage attached)	57·83
Pulp	38·98
Water lost during stripping	3·19
	100·000

And 1,428 cherries weigh in round numbers 100 ozs.

The pulp was afterwards sun-dried, then completely dried at a temperature of 212° Fah., and placed in a well corked bottle for future analysis on my return to London.

I have calculated the results of the analysis for the pulp in its natural wet state, in order to arrive at the practical value of such a material as a manure.

ANALYSIS OF COFFEE PULP IN THE NATURAL STATE.

Water		78·310
Soluble organic matters	Soluble in cold water	6·543
Soluble mineral matters (ash)	Soluble in cold water	1·201
Insoluble organic matters		13·317
Insoluble mineral matters (ash)		·629
		100·000
Nitrogen (contained in the organic matter) ..		·330
Total amount of ash, 1·880, consisting of		
Potash		·874
Soda		·031
Lime		·184
Magnesia		·037
Ferric oxide		·029
Phosphoric acid		·084
Sulphuric acid		·062
Chlorine		·047
Carbonic Acid		·410
Silica		·072
		1·830

The pulp from well ripened cherries would appear to contain a considerable quantity of saccharine matter,

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mucilage, and similar constituents, readily soluble in cold water, and associated therewith, at least two-thirds of the mineral matters.

It must be remembered that the sample of pulp, represented by the above analysis, was prepared in the most favourable manner, being removed by hand from the fresh cherry, consequently is much richer than would be the case under ordinary circumstances where the pulp would be allowed to remain in a heap, and the greater part of the mineral constituents, including the potash, would be washed out.

The most practical way of treating pulp would be to mix it wherever possible with cattle dung, which has a higher fermenting power. In cases where this is not possible, composts should be made with a liberal supply of burnt lime, which will effect the neutralisation of any excess of acid resulting from the decomposition of a material, containing much carbon and water, and but little nitrogen. I can quite understand that if employed alone, the results as a manure, have not been very beneficial to the coffee, but as a vehicle for mixing with concentrated materials like superphosphate or bones it will be of great use, as well as for composts.

In whatever form it may be ultimately employed I would strongly recommend that it should be removed from the action of flowing water, and be placed under cover day by day as the pulping process is proceeded with.

Coffee pulp is evidently much inferior to ordinary farmyard manure (see future analyses) which may be represented as containing in natural state—

Nitrogen	·55
Phosphoric Acid	·25
Lime	·70
Potash	·50

Thus it will be seen that only in the quantity of potash is pulp superior, and as the greater part of even this, is liable to be washed away, it follows that one ton of good cattle dung is probably worth as much as two tons of pulp, indeed practically it is worth more, for the cost of application has to be added, which would be twice as much in one case as in the other.

CATTLE MANURE.

It is quite unnecessary if not superfluous to say anything in favour of this manure, its merits as a general fertiliser for all crops has been long since determined, but there are one or two points connected with its production and subsequent use, upon which a few remarks may be made.

Ferguson's Directory, 1878, contains a very able article upon "The true way to keep Cattle for Food and for Manure." The writer, who is evidently an experienced planter, states that "Ceylon is perhaps the only country where *manure* is the sole end and object of stock-keeping, and Ceylon is a most fortunate country if the operation will pay, even when coffee is above 100/ per cwt."

The author adds: "there seems to me but one solution of all these complications, and that is, to make *the stock pay for their food in beef*, and have the manure over and above."

Certainly this is the way to make manure profitably; but can it be done? and if it cannot, then does it pay to keep cattle? Doubtless this question has been seriously and anxiously considered over and over again by planters, who have at length come to the conclusion, namely, that of the two alternatives, it is decidedly the best.

At present, in the absence of railway extension, the cost of getting a ton of bone-dust or cake from Colombo on to the estate is enormous; indeed, for certain localities, the expense is almost prohibitive. In some districts the cost of cart-hire from Colombo is stated to be Rs.100 per ton, so that, by the time a ton of manure reaches the estate, it has cost in all some £15 to £18, a price which is only allowable in the case of special concentrated manufactured manures intended for mixing with bulky materials before application. It is not surprising, therefore, that resort was made to the keeping of cattle and pigs, as a means of manufacturing on the spot, a manure well known to be the most permanent as well as suitable for most crops, and certainly free from any worthless adulteration.

Unfortunately, however, in too many instances, such manure, which has entailed a large outlay to make, is allowed to remain several months before being applied. Large sums of money have been spent by proprietors in the erection of expensive cattle-sheds, in the purchase of cattle and cake; and yet, when the manure has been made, it is left rotting in a heap, sometimes entirely exposed to the combined action of sun and rain, and nearly always liable to depreciation by drainage.

I regret to state it, but frequently during my tour did I notice a dark stream wending its way from the manure heap to the nearest watercourse.

It is unnecessary to point out that such dark fluid contains most valuable fertilising constituents. Voelcker, in his capital paper on "Farm-yard Manure," mentions that the drainings of dung-heaps are more valuable than the urine of domestic animals, such as the cow, horse, pig, &c. Coolies probably dislike carrying manure for many reasons, and it requires considerable energy on the part of the resident superintendent to carry out this application of cattle manure at regular and frequent intervals.

I am aware that manuring is a process that must be performed when labour is available, and consequently can only be done at certain times of the year. Naturally the supply of labour is essentially one of the important elements which influences the prosperity or failure of a coffee estate. Not unfrequently cases have been known in which the fruit has been allowed to rot on the trees for want of sufficient hands to pick. What I wish to suggest is, that, if cattle are kept as a source of manure, every possible effort should be made to get the dung put out at intervals of every four to six months at the most, and at least that the heaps should be protected from rain by a covering of soil well hardened down to resist water.

Professor Wolff, in the following analyses, represents the composition of farm-yard manure in three different stages of condition :—

PERCENTAGE COMPOSITION OF FARM YARD MANURE.

		Fresh.	Moderately Rotten.	Thoroughly Rotten.
	Water*	71.0	75.0	79.0
	*Organic Matter	24.6	19.2	14.5
	Ash (Mineral Matter)	4.4	5.8	6.5
		100.0	100.0	100.0
Mineral Matters excluding Carbonic Acid.	Potash	.52	.63	.50
	Soda	.15	.19	.13
	Lime	.57	.70	.88
	Magnesia	.14	.18	.18
	Phosphoric Acid	.21	.26	.30
	Sulphuric Acid	.12	.16	.13
	Chlorine	.15	.19	.16
	Silica	1.25	1.68	1.70
	*Containing Nitrogen	.45	.50	.58

These analyses show the changes that dung undergoes during fermentation. Weight for weight, well fermented dung is more soluble than fresh, as it is more concentrated and contains a larger quantity of nitrogen and ash constituents in a form more soluble or more readily available as plant food. During decomposition the organic matter becomes resolved into carbonic acid and water, the ash constituents at the same time increasing as the manure becomes concentrated.

If, however, dung is exposed to the action of rain and suffers loss by drainage, there will be much waste of nitrogen and ash constituents.

There can be little doubt that in common practice, both at *home* as well as *abroad*, large quantities of valuable manure are annually lost from exposure to the effects of weather. This loss is specially great where there is a limited supply of straw, in other words where litter is scarce and not sufficient for the proper absorption of the liquid; also where the manure heap is exposed to heavy rain associated with intervening periods of tropical heat, causing rapid fermentation. From the published reports of the Surveyor-General the annual rainfall in Ceylon would appear to vary immensely. No general average return, applicable to coffee estates as a whole, can be practically fixed, though an average may be arranged for each district, subject of course to special variations due to exceptional seasons. For instance, on some estates upwards of 200 inches are recorded as having fallen during one year, of which 7, 8, 9, and even more inches fell during 24 hours on certain occasions. Again, on other plantations, only 60 to 90 inches per annum are recorded. Certain districts are distinguished as comparatively dry, others have a moderate rainfall, and others again have too much rain. Elevation, situation and general exposure to monsoon weather, have a very decided effect on the annual rainfall of each estate, great differences being experienced within a radius of a few miles.

Probably 100 inches is a low average for the majority of estates, but this is more than three times that of the annual rainfall of England, and falling, as it does in heavy showers, cannot fail to damage manure heaps which are left exposed. Certainly when manure is the only object of cattle establishments, every possible means should be taken to prevent loss from drainage.

The quality of the dung depends on the quality of the food consumed, and also upon the character of the stock kept, as well as on the skill displayed in the arrangement of the sheds. Full-grown animals, whose weight is constant, as for instance oxen in work, or better still, fattening stock, make more valuable manure than young growing animals or cows yielding milk, because in the former, most of the nitrogen and phosphates pass off in the manure, not being required for assimilation, except in so far as to replace a constant waste of tissue. In the case of fattening stock whose weight does increase, the materials such as fat, starch, mucilage, &c., abstracted would not be of any practical value as manure, while the proportion of nitrogen and ash removed would be somewhat less than in the case of draught oxen. It follows, therefore, that full-grown stock are the most profitable descriptions that planters can keep. Where cart roads are opened upon an estate, oxen can be employed during the day, and the work done will contribute to pay for their keep. A certain number can afterwards be fattened and killed, the surplus meat being served out to the coolies in lieu of a certain proportion of the weekly allowance of rice.

No doubt rice is a suitable food for coolies when living an indolent life in their native villages at a low elevation, with a high temperature, but when engaged in hard work on Ceylon coffee estates at an elevation of 3,000 to 5,000 or 6,000 feet above sea level, in a damp climate, with the thermometer ranging from nearly freezing point to 120° F. (or higher) in the sun, it appears desirable that they should receive a more nitrogenous diet, and should get meat twice a week during certain times of the year. The stories I have heard from superintendents respecting the disinterment of the carcases of animals that had died from disease, but which the coolies were only too glad to stew with their curry and rice, sufficiently indicate the natural craving for animal food under special climatic conditions.

Where cattle are kept, it is usual to have also a certain number of pigs, which are housed in close proximity to the cattle sheds, but at a somewhat lower level, so that the manure and litter from the former can be turned over every day into the piggery, to be more thoroughly trodden down and saturated with urine.

It is well to recollect, however, that an excessive quantity of a poor watery fluid is by no means a desirable feature in the pig dens (as they may be called). Fermentation proceeds most favourably at a temperature of above 80° F., and this cannot be constantly attained at high elevations when the dens are almost flooded with water. I well remember a visit to one shed where the poor brutes (pigs) were up to their knees in water, and seemed in a wretched condition from the bad repair of the roof, which allowed the rain to pour in. Notwithstanding the miserable state of the shed, the animals managed to keep their faces specially clean, and an examination of the feeding troughs, showed a very poor watery liquid containing some poonac. It was impossible for them to drink all the liquid for the sake of the trace of poonac, but they licked each other's faces in order to get the particles of meal which adhered.

The following table, taken from Mr. Lawes' statement respecting the fattening of animals, will be of interest in comparing the relative merits of cattle *v.* pigs as a source of manure:—

100 TOTAL DRY SUBSTANCE OF FOOD SUPPLY.

		In Increase in Weight.	In Manure.	In Respiration.
Oxen.	Nitrogenous Substances ...	.8	29.1	57.3
	Non-Nitrogenous Substances	5.2		
	Mineral Matters	.2	7.4	...
		6.2	36.5	57.3
Pigs.	Nitrogenous Substances ...	1.7	14.3	65.7
	Non-Nitrogenous Substances	15.7		
	Mineral Matters	.2	2.4	...
		17.6	16.7	65.7

It will be observed that for a given weight of dry substance consumed, oxen void more as manure, and expend less in respiration than pigs. Now, as *most* of the nitrogen and ash constituents of the food are practically recovered in the manure, while the elements absorbed by the animal, or lost during respiration, consist chiefly of carbonaceous matter and water, it follows that weight for weight, the excrements (liquid and solid) of oxen are not so valuable as those of pigs. Further, if the composition of the various kinds of food given to fattening-animals is known, we can determine beforehand how much nitrogen, phosphoric acid, and potash, existing in the food, will be recovered in the manure produced. For this purpose the following analyses made by Dr. Voëlcker are introduced.

COMPOSITION OF FEEDING CAKES OF AVERAGE QUALITY.

	1 Linseed.	2 Decorticated Cotton Cake.	3 Gingelly.	4 Cocoa-nut Cake.
Moisture	13·62	9·28	12·56	8·97
Oil	13·96	16·05	5·38	11·44
*Albuminous compounds (Flesh forming matters). ..	28·87	41·25	32·81	20·75
Mucilage, sugar, digestible fibre	25·43	16·45	20·31	39·41
Woody fibre (cellulose) ..	12·72	8·92	21·08	14·27
†Mineral matter (ash) ..	5·40	8·05	7·86	5·16
	100·00	100·00	100 00	100·00
*Containing nitrogen	4·62	6·58	5·25	3·32
†Containing sand	·64	..	1·20	·51

No. 1. Is a good sample of average linseed cake made from carefully harvested seed, as shown by the small quantity of sand present. It has not been too hard pressed, since there is nearly 14 per cent. of oil present, and is consequently in excellent condition for feeding purposes.

No. 2. Is a specimen of decorticated cotton cake made from shelled seed, hence the small quantity of fibre, as compared with that found in cake made from the whole seed, in which there is often upwards of 20 per cent. of fibre.

The analysis compares most favourably with that of ordinary poonac (No. 4) and indicates that the cake is in fact an exceedingly rich feeding material, for it contains 16 per cent. of oil and 41 per cent. albuminous (flesh forming compounds). As a general cake for cattle this is somewhat too concentrated if used in any quantity, but if ground into meal and given with water it will prove a useful pig food. I am not, however, aware whether this kind of cake has been used on estates, it is very different from that sent me in Colombo and already reported on.

No. 3. This cake which is made from the pressed oily seed of *Guizotea Oleifera* appears to have been made from cleaner seed than the sample reported on when in Ceylon, for notwithstanding a higher percentage of fibre the sand is much less.

No. 4. Is a good sample of cocoa-nut poonac and is very similar to those analysed by myself in Colombo.

In England it was formerly imported for the purpose of adulterating linseed cake, or the manufacture of an inferior quality of feeding stuff.

It will be observed from these four analyses that linseed cotton and gingelly cake, if in fresh condition, can be used with advantage instead of ordinary poonac, as in each case the amount of nitrogen is much higher. The market price of the various cakes is of course subject to considerable variation, depending on the supply and demand, as well as on other important considerations, but the comparative value of the manure made from the consumption of a ton of each, can be very fairly calculated. In the following table which was published by Mr. Lawes in his paper, contained in the Journal of the Royal Agricultural Society, second series, vol. x., part 1, we have the calculated value, *as manure*, which the various feeding-stuffs would produce, assuming the whole of the fertilising constituents could be incorporated with the soil *without loss*.

What this loss consists of, and how materially it may be reduced by careful management has already been mentioned.

VALUE OF THE MANURE FROM FEEDING STUFFS.

No.	Description of Food consumed by Stock.	Money value of the Manure from one ton of each Food.		
		£	s.	d.
1	Cottonseed Cake, decorticated	6	10	0
2	Rape Cake	4	18	6
3	Linseed Cake	4	12	6
4	Cottonseed Cake, undecorticated ...	3	18	6
5	Lentils	3	17	0
6	Beans	3	14	0
7	Tares	3	13	6
8	Linseed	3	13	0
9	Peas...	3	2	6
10	Indian Meal	1	11	0
11	Locust Beans	1	2	6
12	Malt Dust	4	5	6
13	Bran...	2	18	0
14	Coarse Pollard	2	18	0
15	Fine Pollard	2	17	0
16	Oats...	1	15	0
17	Wheat	1	13	0
18	Malt...	1	11	6
19	Barley	1	10	0
20	Clover Hay...	2	5	6
21	Meadow Hay	1	10	6
22	Bean Straw...	1	0	6
23	Pea Straw	0	18	9
24	Oat Straw	0	13	6
25	Wheat Straw	0	12	6
26	Barley Straw	0	10	9
27	Potatoes	0	7	0
28	Parsnips	0	5	6
29	Mangold Wurzel	0	5	3
30	Swedish Turnips	0	4	3
31	Common Turnips	0	4	0
32	Carrots	0	4	0

Cocoa-nut cake is not included in this list unfortunately, but its manurial value would be about half that of decorticated cotton cake, which stands at the top of this list of feeding materials.

Naturally, therefore, no large outlay in ordinary poonac should be incurred for stall-fed cattle or for pigs; it will be more profitable to purchase cakes containing a higher percentage of nitrogen with an equal quantity of oil as compared with native poonac (cocoa-nut), namely, linseed, or decorticated cotton cake. At first the animals may not like the change, if so, mixtures of these cakes may be employed to educate their palate.

When palm-nut kernel cake, made from the kernel of the oil palm (*Elaïs Guinensis*) was first introduced as a meal for sheep some eighteen years since, Mr. Coleman, then Professor of Agriculture in Cirencester College, informed me that the animals positively refused to eat it, but afterwards became so fond of it that they would not touch any other kind of meal.

In cattle establishments where the animals are stall-fed, regular supplies of artificial grass will have to be provided, thus, Guinea grass for oxen, Mauritius grass for pigs, and Maana grass to be cut up into small litter for both descriptions of stock.

It is absolutely necessary to have a good supply of these three kinds of grass, also that the estate should be rather under stocked than over, for the better the animal is kept, the better the quality of the manure. Half-starved cattle make very poor manure, since a much larger proportion is abstracted from the food in order to supply waste of tissue.

At the same time cake should be only employed as an auxiliary, when the quality of the grass supplied is poor, or the quantity limited, in fact at certain seasons of the year only. It cannot pay to give cattle any quantity of cake which is obtained at great expense—and which is subject to a certain varying loss of *manurial* elements during its passage through the animal—unless *meat* as well as *manure* is intended to be made.

In giving cake as a feeding material we are converting a concentrated manure, containing three, four, five or six per cent. of nitrogen, into a bulky one like dung, which at most does not contain more than .60 per cent. nitrogen. It is best, therefore, to keep stock on grass as much as possible, and if they will do without cake, so much the better. Bulky manure naturally is well adapted to coffee, but to be economical it must be applied within reasonable distance of the sheds, and it follows that for the more distant parts of the estate purchased manures should be directly applied. It may be convenient here briefly to consider the comparative advantages of using cake in its natural *fresh* condition, or after being *fermented* in a heap.

The following analysis represents the composition of some cotton cake that had been damaged by water during the voyage to London from America :—

DAMAGED OR FERMENTED COTTON-SEED CAKE.

Water	35.26
*Organic matters soluble in water	15.09
** ,, ,, insoluble ,, ...	42.75
Mineral matters (ash) soluble in water	5.12
,, ,, insoluble ,, ,, ...	1.78
	100.00
*Containing nitrogen (in the form of ammonia)	1.42
**Containing nitrogen (in form of organic compounds) ...	3.27
Total	4.69

This cake was quite unfit for food, and was in a state of decomposition, only requiring a summer temperature to be accelerated into rapid fermentation. Originally when shipped the proportion of water would not have exceeded 10 per cent., so that 25 per cent. of water had been since absorbed, thus increasing the bulk of the material at the expense of its quality as regards percentage of nitrogen.

In the fresh state with 10 per cent. water, the quantity of nitrogen would have been 6½ per cent. (which agrees with the average in decorticated cotton-cake); whereas, it now only contains 4.69. In fact, valuable material to the extent of 25 per cent. has been replaced by water Consequently, if equal weights of *fresh* and *fermented* cake were separately applied as manure, it is only reasonable to expect that the results in future crop would be decidedly in favour of the former, for the very simple reason that it is 25 per cent. richer in fertilising matters.

No doubt the presence of an appreciable quantity of ammonia in the fermented sample would produce a more immediate effect on the trees, in the same manner that rotten dung is more immediately effective than fresh, but the permanent results would certainly not be so great as if fresh cake were used.

It is quite true that English agriculturists attach a much higher value to nitrogen compounds soluble in water than to those which are insoluble, or only rendered soluble after decomposition, thus, sulphate of ammonia, nitrate of soda, &c., are twice as valuable as dried blood, shoddy, and similar organic refuse materials.

The principal reason why this is the case must be due to the fact that the season during which vegetation proceeds actively, is *at home* limited to certain months of the year, and the object of farmers is to supply the elements of plant food in a form at once available at the particular period when the natural functions of the plant enable it to extract the greatest quantity of fertilizing material.

Hence the great advantage of the use of dissolved bones and mineral superphosphate, as opposed to the old practise of applying raw bones. Also the practice of top dressing corn crops in the spring with nitrate of soda and similar manures readily soluble in water.

Farmers are naturally anxious to get immediate results, and therefore apply manures which act on the growing crop, the seed being planted in spring and the harvest gathered in August, a large proportion of the unabsorbed manure left in the land is lost by drainage during the following winter months; this loss is especially great as regards the soluble nitrogenous portion of manures, phosphates being retained in the soil to a much greater extent. (Voëlcker's Paper on the Composition of Land-drainage Waters. "Journal of the Royal Agricultural Society," 1874.)

In Ceylon, with a climate eminently stimulating, associated with a heavy annual rainfall, it is most important in manuring a shrub like coffee, that the nitrogen should be applied in a condition *insoluble* rather than *soluble*, so that the effect may be as gradual as possible, hence nitrogen in the form of cake, fish, &c., will be more desirable than in a soluble form such as ammonia salts, guano, or nitrate of soda.

The cake will absorb moisture and become decomposed after application quite rapidly enough, the only exception perhaps, being after a severe attack of leaf disease, when a dose of guano, especially dissolved guano, combined with supherphosphate, will be of special service in resuscitating the exhausted energy of the tree.

But to return to the question of cattle manure, I would suggest that breeding establishments should be introduced on estates contiguous to patana lands, where the young stock might be reared, grazing during the day. The matured stock should be transferred to estates for draught purposes and subsequently stall-fed and killed, moderate fattening being encouraged by the use of some cake in addition to grass. On all properties at a high elevation, with a heavy rainfall, a certain quantity of meat should be supplied the coolies, and a deduction made from the weekly allowance of rice, thus making the production of flesh a means of reducing the cost of keep.

Cattle sheds to be *scattered* over the estate rather than *concentrated* in one particular spot, this would lessen the expense for the carriage of grass and in the application of the manure. The litter to be cut in lengths of not less than four to six inches, which would be sufficiently small for all purposes of absorbing the urine, while it would very materially facilitate the subsequent manipulation of the dung. When maana grass is given for litter in lengths of a yard (as I have frequently seen) much unnecessary trouble is involved in turning over manure heaps, as the stems of full-grown grass are nearly as hard as dried wood from the large percentage of siliceous woody fibre which they contain. It would be well to keep maana cut down pretty close, and not allow it to attain full growth previous to being used for litter, indeed if this were done the chaffing process might be omitted.

The question of labour will make the application of manure to depend frequently on local circumstances, but as a rule after crop naturally is the best time. If the cattle are stall-fed and the grass chaffed, the manure might be allowed to remain accumulating till a depth of three or four feet is formed, and then be applied direct to the coffee, or at least carried out on to the estate and made into heaps conveniently arranged for subsequent application.

Coolies do not like carrying manure, and it requires considerable and constant energy on the part of the Superintendent in order to secure the due performance of such work, as well to get the manure properly mixed with the soil in its final distribution round each tree.

Great expense is incurred in the erection of cattle sheds and the purchase of stock, and yet, too often, the manure which has cost so much is allowed to remain in a heap, month after month, waiting a convenient season for application, moreover, it is frequently exposed to rain and nearly always to a certain loss from drainage.

If dung cannot be applied when ready it should be covered over with soil, and the heap so arranged that rain shall readily run off its sloping sides. At present it seems probable that far too long a time is allowed for the rotting of the manure. As just mentioned this is not necessary in Ceylon to anything like the same extent it is at home, first, because the climate being hotter, fermentation proceeds much more rapidly and the same result is attained in a shorter time; secondly, because the greater solubility of *rotten* dung as opposed to *fresh* is not so necessary for coffee as it is for spring sown crops requiring plant food in a form at once available.

Certainly for coffee any extra advantage which would ensue from the use of dung thoroughly rotten, is more than counterbalanced by the loss incurred through drainage during the months that the heap has been lying exposed to weather.

The large capital invested in the manufacture of cattle manure, must make the consideration of the best mode and time of applying the same one of the most important questions which planters having stock will be called upon to decide. It would be very desirable that some experiments should be carried out, with a view of obtaining really reliable information in reference to the best times for application, and the comparative advantages of the same.

Systematic application after crop would appear the plan generally most economical, but during special seasons, and for particular portions of the estate, later dressings will no doubt be found of great advantage.

Again, as to the quantity applied to each tree, planters seem very undecided, and I have myself seen dung applied in small baskets similar to those used by road pioneers, and at other times in much larger ones.

Though frequent enquiries were made during my tour, it was impossible to get any details as to the quantity applied per tree—probably 10 to 20 lbs. each will represent the limits of variation.

Taking the lowest (10 lbs.), and assuming 1,200 trees, we have 12,000 lbs. per acre, and as ordinary dung contains in round numbers 75 per cent. of water, each tree would receive 2½ lbs. of dry matter, associated with 7½ lbs. of water.

At present I have not had any opportunity of analysing a sample of cattle and pig manure as usually made on the estates, but it is reasonable to suppose that lime at least will be present in smaller quantity than is the case in ordinary farm-yard manure as made at home. Possibly, also, the other important elements will be present in slightly smaller proportion. But for the sake of comparison with other manures, we will assume that the following figures fairly represent the average quality.

100 LBS. OF CEYLON CATTLE AND PIG MANURE.

Nitrogen	.55
Phosphoric acid	.25
Potash	.50
Lime	.45
	1.75 lbs.

Now let us compare the quantities of the above constituents which are supplied per acre by the use of 10 lbs. of dung per tree, as opposed to the employment of ½ lb. fine bone dust with ½ lb. ground rape cake, which is a mixture frequently used, I believe, for coffee. The composition of the bone dust and rape cake is assumed to be as follows, as regards the principal constituents:—

	Fine Bone dust. In 100 parts.	Rape Poonac. In 100 parts.
Nitrogen	3½ ...	5¼
Phosphoric Acid	24 ...	2½
Potash	1 ...	2
Lime	32 ...	

Assuming that there are 1,200 trees to the acre, we may expect the above constituents will be supplied as follows:—

MIXED CATTLE MANURE *versus* BONES WITH POONAC.

Quantity per acre.	Cattle manure, 12,000 lbs.	Fine bone dust, 600 lbs.	Ground Rape Cake, 600 lbs.
Nitrogen	66	21	31½
Phosphoric Acid	30	144	15
Potash	60	6	12
Lime	54	192	12
Total... ...	210 lbs.	363 lbs.	70½ lbs.

It will be observed that cattle manure supplies 66 lbs. of nitrogen against 52½ in the mixture of bones and poonac, and 60 lbs. of potash against 18 lbs., but that only 30 lbs. of phosphoric and 54 lbs. of lime are afforded against 159 lbs. and 204 lbs. respectively. Consequently dung is chiefly valuable as a source of nitrogen and potash, so that when the soil requires phosphoric acid, bones, or concentrated superphosphate will be the most convenient form of application.

Bones will at the same time supply a large proportion of lime, and if a larger dressing is required, it can be supplied by a separate dressing of slaked lime. It follows that bones can be used with great advantage as an addition to cattle manure, and that on soils naturally deficient in phosphoric acid and lime, ordinary dung applied by itself continuously will scarcely be sufficient to meet the natural requirements of coffee on these particular soils.

Most English soils contain a higher proportion of phosphate of lime than I found in Ceylon coffee soils, and yet it has been shown by practical experience that the use of mineral manures, containing phosphate of lime in a condition readily soluble in water, is more effectual in the production of crop than ordinary farm-yard manure; this is especially so in the case of root crops. It is therefore only reasonable to suppose that a moderate dressing of some phosphatic manure, combined with cattle dung, or a similar nitrogenous material like rape or castor poonac, will be equally beneficial for coffee. Where cattle and pigs are kept, I would therefore recommend that bones, superphosphate, or at least slaked lime should be used with the dung, otherwise the trees, though looking well as regards production of leaf and wood, may be deficient in the matter of crop.

Nitrogenous manures used alone, and in a tropical climate, are unduly stimulating, and contribute rather to the premature exhaustion of the natural supply of the mineral elements necessary for crop.

WHAT KIND OF MANURE DOES COFFEE REQUIRE?

Now that we have considered the composition of the soils and manures, it is desirable to ascertain as far as possible the general character of the manures most suitable for coffee. Let us first enquire what are the organic and mineral elements necessary to the production of *wood*, *leaf*, *pulp*, and *seed*.

As regards the composition of coffee branches no analyses are at present available, but of the other items I have made an examination. The following is an analysis of parchment coffee which was obtained from some cherries sent me from the district of Badulla. The amount of moisture present is possibly high, as compared with average estate coffee received in Colombo, but on this point future analyses must decide. The sample was very carefully prepared, the beans being separated from the pulp, allowed to remain in contact with water the necessary time, well washed in fresh water, afterwards dried by exposure to the sun, and then enclosed in a well corked bottle and shipped with the samples of soil. The analysis is only a partial one as regards the proportions of the different organic constituents. Sugar, albumen, tannin, caffeine, cellulose, mucilage, &c. are included under one heading. The separate determination of each would be of interest in comparing different qualities and varieties of coffee, but is not necessary for our present purpose. The quantity of nitrogen contained in the total organic portion has, however, been very carefully determined, as well as the respective quantities of the important mineral constituents. The analysis has been made with a view of ascertaining to what extent coffee exhausts the soil.

COMPOSITION OF PARCHMENT COFFEE FROM BADULLA.

Water	13.31
Fat	10.97
*Gum, Sugar, Tannin, Albumen, Caffeine, Woody Fibre, &c.	72.42
†Mineral Matters (Ash)	3.30
	100.00
*Containing Nitrogen	1.47
†Consisting of—	
Potash	1.349
Soda	.065
Lime	.193
Magnesia	.219
Phosphoric Acid	.260
Sulphuric Acid	.076
Carbonic Acid	.921
Chlorine	.028
Silica	.094
Oxide of Iron...	.095
	3.300

It will be noticed that there is nearly 11 per cent. of fat and 1½ per cent. of nitrogen present in every 100 parts by weight of this parchment coffee, also that in the ash constituents potash stands out very prominently and that phosphoric acid exists in larger quantity than either lime or magnesia.

Carbonic acid is present as the result of the combustion of organic carbonaceous matters in the presence of basic salts.

An analysis of the coffee pulp (in which the seed is enclosed) has already been given, and I will now introduce the analysis of some very fine and apparently healthy coffee leaves, also from the neighbourhood of Badulla.

COMPOSITION OF PARTIALLY-DRIED COFFEE LEAVES.

Water lost at 212° F.	9.750
*Organic Matters, soluble in water...	23.760
Mineral Matters (Ash) „ „	3.890
†Organic Matters, insoluble in water	58.890
Mineral Matters (Ash) „ „	3.710
	100.000
*Containing Nitrogen	.994
†Containing Nitrogen	1.678
Total ...	2.672

Total Mineral Matters (Ash) = 7.600.

Consisting of—	
Potash	2.078
Soda	.483
Lime	1.689
Magnesia	.919
Phosphoric Acid	.352
Sulphuric Acid	.261
Carbonic Acid...	.995
Chlorine	.082
Oxide of Iron...	.100
Silica and particles of Quartz	.641

It will be noticed that the nitrogen in these partially-dried (sun-dried) coffee leaves amounts to 2.672 per cent. while the seed (commonly called bean) only contains 1.470 per cent. Also that the leaves contain 2.078 potash and .352 phosphoric acid as against 1.349 potash and .260 phosphoric acid contained in the parchment coffee. Hence if equal weights are taken in each case, sun-dried leaves are more exhausting in the important elements than ordinary parchment coffee. Consequently it follows that exposure to wind tends to exhaust the productive powers of an estate in a very serious degree; a fact which practical planters fully recognise.

Now what is the average weight of a coffee leaf, and how many leaves should there be on an average coffee tree? In a recent letter in the *Ceylon Observer* the number of leaves is assumed to be 2,000, but I am inclined to think that these figures are somewhat high, at least for most estates of less than ten years' standing.

During my residence in Colombo, three parcels of apparently healthy leaves were sent me from essentially different estates, and the following are the respective weights, ten leaves being in each case selected for comparison.

At the same time ten leaves, evidently affected by *Hemileia Vastatrix*, were taken from three other parcels representing the corresponding estates.

WEIGHT OF FULLY-MATURED COFFEE LEAVES FROM THREE ESTATES.

In natural green state.	No. 1. 10 Leaves.		No. 2. 10 Leaves.		No. 3. 10 Leaves.	
	Healthy.	Diseased.	Healthy.	Diseased.	Healthy.	Diseased.
Water ...	96	70	112	79	188	128
Dry portion ...	51	50	65	51	87	76
Total weight in grains ...	147	120	177	130	275	204

As far as possible the healthy and diseased leaves selected from the respective estates were of similar size, so that the difference in the actual weight is due rather to the ravages of the fungus than to difference in size. But it will be noticed that the general character of the leaves differs considerably. Those from No. 3 estate were exceptionally large, and although I see from my notes that these diseased ten leaves were suffering from a very severe attack, yet the total weight exceeds very considerably the weight of the ten healthy leaves from Nos. 1 and 2 estates. On the other hand, the general character of the leaves from No. 1 would lead to the conclusion that they represented a low average of fully-matured coffee leaf, and that either they were exceptionally selected from young trees, or that the fertility of the estate was of an inferior quality.

For practical purposes, therefore, it will be more satisfactory to select the leaves from No. 2 estate as our representative sample. Accordingly, if we take 9.75 per cent. as the amount of water in partially-dried healthy coffee leaves, and 11.98 per cent. as the amount in diseased leaves (see future analyses), the respective weights of these leaves from No. 2 estate will be as follows:—

COFFEE LEAVES FROM NO. 2 ESTATE, MARCH 19TH, 1878.

	10 Healthy Leaves.*		10 Diseased Leaves.	
	In natural state	Partially dried	In natural state	Partially dried
Water	112	7	79	7
Dry portion ...	65	65	51	51
Weight in grains	177	72	130	58

Now we will assume that 200 fully matured and healthy leaves are dropped during the year by each tree, though where the trees are exposed to wind the number will be much higher; also assuming that the number of diseased leaves are inconsiderable where manuring is efficiently carried out, we have at the rate of 1,200 trees per acre, 240,000 leaves, which from the above table would weigh in the partially-dried state 1,728,000 grains or (7,000 grains = 1 lb.) 247 lbs. in round numbers.

Again in the analysis of coffee pulp we found that 100 parts by weight of ripe cherries yielded 57.83 parts of beans (with mucilage attached) and 38.98 parts of pulp, allowing 3.19 parts for water lost during stripping.

Further, I find by experiment that the above weight of fresh damp beans, when properly washed and

* Consequently each leaf in its natural fresh green state weighs about 18 grains, and when partially dried about 7 grains.

afterwards sun-dried gave 35.87 parts by weight of ordinary parchment coffee as prepared on the estate. Consequently 100 lbs. of ripe cherries may be fairly taken to represent in round numbers 36 lbs. of parchment, 39 lbs. of pulp (natural state), and 25 lbs. of water (with the saccharine mucilaginous coating originally attached to the bean).

Assuming the average yield of coffee per acre to be 7 cwt. (784 lbs.) of parchment, we should have 849 lbs. of pulp.

With this estimate of a really good crop, according to present circumstances we may proceed to ascertain, with the aid of the analyses already furnished, what are the proportions of the important elements removed respectively by the seed, pulp, and leaf.

CONSTITUENTS REMOVED PER ACRE BY AN AVERAGE CROP OF COFFEE, ASSUMING 7 CWT. OF PARCHMENT FROM 1,200 TREES.

	Seed.	Pulp.	Leaf.*	Total.
	7 cwt. Parchment = 784 lbs.	Fresh Pulp = 849 lbs.	Partially dried. 240,000 leaves = 247 lbs.	Weight = 1880 lbs.
Water	104.3	664.8	24.0	793.1
*Organic Matters	653.8	168.7	204.2	1026.7
Mineral (Ash) Matters	25.9	15.5	18.8	60.2
lbs.	784.0	849.0	247.0	1880.0
*Containing Nitrogen	11.5	2.8	6.6	20.9
The Ash Consists of—				
Potash	10.6	7.5	5.2	23.3
Soda	.5	.3	1.2	2.0
Lime	1.5	1.5	4.2	7.2
Magnesia	1.7	.3	2.3	4.3
Phosphoric Acid	2.1	.7	.9	3.7
Sulphuric Acid	.6	.5	.6	1.7
Chlorine	.2	.4	.2	.8
Oxides of Iron	.7	.2	.2	1.1
Silica	.7	.6	1.6	2.9
Carbonic Acid	7.3	3.5	2.4	13.2
lbs.	25.9	15.5	18.8	60.2

* Probably 200 leaves for each tree is much too low an average, but the necessary connection can easily be made for large trees having 1,000 to 2,000 leaves.

The above table enables us to form an idea of the relative proportions, in which the important elements of plant food are required for the production of a good crop of coffee. Doubtless 7 cwt. per acre of parchment would be a small crop when compared with the returns of good estates in the earlier days of Ceylon plantations, but at the present time it would be considered, I apprehend, a *bumper* crop, thankfully accepted by many proprietors. Of course if the pulp is preserved from rain action and is returned after fermentation to the land; also if the leaves are collected and returned too, the total quantity of ingredients removed from the estate is very much reduced, and coffee as a crop cannot be considered as specially exhausting. Even if the pulp is not returned and the leaves are allowed to be carried away till they choke the drains and cause extra damage by wash, still, if the above figures are accepted, coffee is not so exhaustive as an ordinary crop of turnips or wheat, for the latter remove in round numbers about 4,000 lbs. of dry matter per acre, whereas in the above table 1,087 lbs. only is abstracted, and of this there is but 60 lbs. of ash or mineral ingredients as against 364 lbs. in the case of turnips and 189 lbs. in the case of wheat.

Again if the nitrogen (20.9 lbs.) be deducted from the organic or combustible matter (1,026.7 lbs.) the remainder (1,005.8 lbs.) when resolved into its primary elements consists chiefly of carbon and oxygen with a small proportion of hydrogen. Of these, oxygen and hydrogen are derived originally in the form of water from the soil through the roots of the tree. Carbon is probably derived almost entirely from the atmosphere through the leaves under the influence of light. Indeed, not only the leaves but all the green portions of the plant would appear to possess the power of extracting carbon from the carbonic acid of the atmosphere, which after being absorbed through the cuticle (or thin vesicular membrane covering the external surface), is decomposed, oxygen being evolved and carbon retained.

Nitrogen, on the other hand, will have to be furnished through the medium of the soil to the roots, and though considerable quantities of nitric acid and ammonia are no doubt naturally supplied to the soil by means of rain (this being probably specially the case in damp tropical climates), still the greater portion of the nitrogen must be artificially supplied by judicious manuring. According to Bonsingault the ordinary atmosphere is incapable of supplying nitrogen in sufficient quantity for the vigourous growth of plants. Practically, therefore, at least the full amount of nitrogen removed should be returned in some form, and so far as I am able to judge from my visit to Ceylon, *nitrogen* in an *insoluble form* as in *cake*, *fish manure*, and *cattle dung*, will be more suitable for coffee than in a soluble form, as in nitrate of soda, sulphate of ammonia, or similar highly soluble nitrogenous manures.

The total amount of nitrogen removed per acre is 21 lbs. in round numbers, and if we select white castor cake containing 7 per cent. of nitrogen, exactly 300 lbs. will be required, and at 1,200 trees this would represent 4 ozs. (¼ lb.) for each tree.

If rape cake, containing 5 per cent. of nitrogen, be used, 420 lbs. per acre or about 5½ ozs. per tree will be required. When the composition of the cake as regards nitrogen is known, the calculation of the required quantity per tree can be easily made for the different kinds of cake. White castor has been selected on account of its greater richness in nitrogen as compared with rape or brown castor so that a saving may be effected in cart hire, a much less quantity of the former being required to supply the necessary nitrogen as just indicated.

Let us now proceed to notice the constituents present in the ash, as stated in the table. Potash is by far the largest item, there being 23⅓ lbs. out of 60 lbs. of total ash, and if the mineral theory of Liebig was to be followed, we should make it the most important element in all coffee manures, but I need not mention that this theory has been found to be inconsistent with practical experience, indeed its fallacy is now generally admitted, though agriculturists must always feel grateful to the great German chemist for having directed attention to the composition of the ash of plants, and so opened up a field for future scientific investigation into the general composition of the organic as well as mineral constituents of farm crops.

There are three important reasons why potash should not be supplied in large quantities in coffee manures.

1st.—All potash salts, whether as nitrate, muriate, carbonate, or sulphate, are readily soluble in cold water, and are therefore liable to be washed away before they can be assimilated by the roots of the tree.

2nd.—Plants appear to possess the power of abstracting potash from the soil itself to a much greater extent than they do the other important mineral elements.

Thus an average crop of turnips, 17 tons per acre, remove in the roots and leaf about 150 lbs. of potash, 74 lbs. of lime, 50 lbs. of sulphuric acid, and 53 lbs. of phosphoric acid, and yet the manures used do not contain any appreciable quantity of potash, but consist almost entirely of phosphate and sulphate of lime in a condition readily soluble in water. I am referring now to the artificial manufactured manures prepared in thousands of tons every year, and which, under the name of superphosphate and dissolved bones, are the recognised fertilisers for turnips and swedes. Indeed every district in England now has its own sulphuric acid and manure manufactory.

3rd.—From my analyses of the insoluble silicates (see Badulla aud Haputale soil analyses) of good coffee soils, there appears to be a practically inexhaustible supply of potash, which will be rendered available for plant food, as the soil becomes disintegrated or decomposed by atmospheric influences.

For the above reasons, then, it will be desirable that potash salts when applied to coffee in Ceylon should be employed in but small quantities, and should be always mixed with some more bulky manure. I should consider 4 per cent. of potash the utmost that a good coffee manure intended for Ceylon should contain. On most estates it is not potash that is required by the soil, but a cheap source of bulky nitrogenous manure (cattle dung, composts of pulp with cake), and a moderate supply of phosphate and sulphate of lime.

But to proceed, let us examine the other elements found in the ash.

Soda calls for no special remark.

Lime comes next in importance to potash, and appears specially prominent in the ash of the leaf, there being 4.2 lbs., as compared with 5.2 lbs. of potash. Bearing in mind the small proportion of lime usually present in the soils of most estates, there is every reason to believe that an artificial supply in some form (either as phosphate of lime, sulphate of lime, or slaked lime in composts) will be attended with satisfactory results. Lime is undoubtedly a necessary constituent of all permanently fertile soils, and although coffee does not appear to require a large quantity for the production of seed, pulp, and leaf, still we must not place too great confidence in the analyses of the ash, but be guided rather by practical experience.

Magnesia is present in varying proportions. In the seed or bean it exists to a greater extent than lime, there being 1.7 lbs. against 1.5 lbs. of lime, but in the leaf there is only 2.3 lbs. against 4.2 lbs., while in the pulp there is but .3 lbs. against 1.5 lbs. of lime.

The presence of magnesia seems to be associated with land naturally suitable to coffee; some Jamaica soils sent me for analysis a few years since contained upwards of 2 per cent. of magnesia, and had been in coffee upwards of 70 years. In several Ceylon soils I have found nearly .50 per cent. ($\frac{1}{2}$ per cent.) generally associated with a high percentage of potash, and in these samples mica was evidently present in considerable proportion.

Magnesia appears to be a normal constituent of these soils, and will not require to be added artificially; plants apparently are capable of abstracting a sufficient supply from the soil itself. So far as I am aware magnesia is not specially added to manufactured manures, at least judging from published results, as well as from the fact that samples representing some 40,000 tons, which are annually submitted to me for analysis, do not contain any appreciable quantities of magnesia. Indeed for agricultural purposes, magnesia in the form of sulphate of magnesia (Epsom salts) is only used directly for adulterating sulphate of ammonia by fraudulent exporters, who thus are able to obtain large profits at the expense of the purchaser, and to the detriment of honest and well-known firms. It would be advisable that samples of sulphate of ammonia should be taken at the time of shipment as a preventative to this fraud.

Phosphoric Acid appears from the table to be present in the ash in but small proportion, but it will be gathered from my remarks under the head of potash, that we must not place too much reliance on proportions of certain elements as represented by an analysis of the ash, for, as shown in the case of turnips, and indeed of root crops generally, soluble phosphate of lime and sulphate of lime are unquestionably the most efficient artificial fertilisers, notwithstanding the relatively small proportion in which phosphoric acid appears in the analysis of the ash. In coffee, as in other crops, I apprehend it will be sound policy to take advantage of known facts, and to follow the example of English farmers in using superphosphate in combination with bones (steamed if possible) to a moderate extent. Ceylon coffee soils, as a class, are decidedly poor in phosphoric acid as well as in lime, and it is an interesting and very practical result of numerous soils analyses recently made, that the soils from really good estates are always much richer in phosphoric acid than those from poor ones. Indeed certain plantations that have been in coffee upwards of 30 years, are richer in this respect than those that have been only just planted. It would be well therefore to use a small quantity (¼ lb. per tree) of steamed bones or high-class super, together with cattle, or a similar bulky nitrogenous manure.

Sulphuric Acid, as an important constituent, has already been referred to in the preceding remarks.

Chlorine, *Oxide of Iron*, and *Silica* do not require any special comment, except that in reference to the last-named, the relatively high proportion present in the ash of the leaf is to some extent due to minute particles of quartz, which, in the form of fine dust, had become mechanically attached to the external surface of the leaves, and with the aid of a microscope the crystals of quartz could easily be distinguised.

Carbonic Acid, the last item, also does not call for any special notice. Its presence in the ash of plants is a necessary consequence of the combustion of the carbonaceous materials which enter so largely into the composition of the various organised tissues of the vegetable substance. During the process of combustion, carbon becomes converted into carbonic acid, and in the presence of lime, magnesia, potash, and soda, becomes chemically combined with these constituents, forming carbonates of these several salts, provided that other more powerful mineral acids (sulphuric and hydrochloric) are not present in sufficient quantity.

WHAT ARE THE MOST SUITABLE MANURES FOR COFFEE ?

Since my return to London this question has been frequently asked me by men interested in coffee estates. In reply I have asked, what is the composition of your soil; what is the elevation of the estate and annual rainfall; what are the local facilities for obtaining manure, and lastly, but certainly very far from being the least in importance, what distance is the estate from Colombo, or rather from any railway communication ? It is scarcely possible to lay down any general rule on this important subject of manuring. The theory of successful manuring consists, as I have already stated, in first finding out what coffee requires; secondly, what the soil requires to make it suitable to coffee, and thirdly, to apply the requisite materials in the cheapest and most suitable condition. My views on these different points have, I trust, been made sufficiently apparent during the preceding pages of this report. The analyses of the various samples of soil have had my most careful personal attention, so that I have had ample opportunities of ascertaining the natural peculiarities and requirements of each. The composition of the seed (bean) pulp and leaves of coffee have also been chemically examined as well as the manures at present used in Ceylon. On the majority of estates the application of manure is advisable, not so much because coffee as a crop is specially exhausting, but rather in consequence of the local conditions under which the crop is grown, being in themselves exhausting, thus the damage caused by *wash* is the great element in the exhaustion of Ceylon estates. The steep character of the land, associated with a heavy rainfall varying from 100 to 200 inches per annum must naturally tend to the rapid removal of the rich surface soil. The introduction of surface drains carried across the hillside at a distance of 36 to 40 feet apart has done much to mitigate the evils of wash. Wherever possible, terracing in lines across the ridge will do much additional good, provided draining be carried on simultaneously. Those who have never visited Ceylon estates during heavy weather, cannot form any practical idea of the disastrous effects of wash. So heavy are the showers of rain, and so steep the nature of the land, that mountain streams that can be crossed on stepping-stones under ordinary circumstances become impassable for horses after an hour's rain.

During my tour I saw sufficient to understand what is meant by *wash*, and fully agree with those practical planters who believe it true economy to spend money in draining and terracing new estates. The outlay of £20 per acre in such operations may seem a large original expense, but if the land be naturally rich and suitable to coffee it will be the most economical permanent improvement that a proprietor could undertake. The retention of the original forest mould is the cheapest form of supplying manure to the young trees. Now the amount of such virgin mould present in the surface soil can be generally gathered from the percentage of nitrogen as shown on analysis, and in good soils there is generally from .150 to .350 per cent. of nitrogen, associated with .120 to .200 of phosphoric acid, and as .100 per cent. may be taken to represent one ton of the constituent per acre extending to a depth of about 9 inches, it will readily be understood that the apparently small difference indicated by the comparison of the analyses of soils do really represent substantial practical differences in the quality of the respective soils.

Let us see what a difference of .100 per cent. of nitrogen in a soil analysis may represent. First, it represents 1 ton of nitrogen per acre for an average depth of 9 inches; and secondly, if we take white castor containing 7 per cent. of nitrogen it (.100 per cent.) represents 14¼ tons of this cake per acre, and as this material could scarcely be obtained on the estate for less than £10 per ton, we have £142 10s. as the equivalent of .100 of nitrogen in every 100 parts of air-dried soil. Of course there may be too much nitrogen in a soil, as for instance when there is much peat present, which is very different in fertilising value to the rich forest soil of new estates. But the above figures will be of use in comparing the analyses of different soils. Again, as regards phosphoric acid; one ton of this constituent would be supplied by four tons of steamed bones similar to Leechman's, which could not be obtained on most estates for less than £10 a ton, so that four tons of steamed bones per acre, or £40, represents .100 per cent. of phosphoric acid in a soil analysis. In the natural process of exhaustion nitrogen is the element that is first reduced in quantity, and it follows that manures of a nitrogenous character, such as cattle manure, cake and fish are the materials that should be first applied. This remark is specially applicable to estates which suffer or have suffered from wash, because the available nitrogen exists almost entirely in the original surface soil, the subsoil may contain an ample supply of the important mineral elements, but it cannot be rich in nitrogen. Again, under the present system of keeping the estate free from weeds the soil is exposed to the baking influence of the sun, as well as to the effects of heavy rain. Also a high percentage of iron, which if in the form of peroxide is generally a healthy feature, still its powerful oxidising effect upon all organic vegetable matters, tends very materially to exhaust the natural supply of nitrogen, though the soil no doubt is compensated to some extent by the presence of a mineral, like ferric oxide, well known to possess the property of retaining ammonia (doubtless specially present in the rain of tropical countries) to a very considerable extent. All these points would incline me to believe that nitrogen must stand first as the material to be supplied, and mineral substances, as phosphoric acid, lime, potash, should follow in order to permanently improve the soil.

THE VALUATION OF MANURES.

The market price of manures and feeding cakes, as of other materials, must be largely influenced by the demand and supply.

This being so it is not desirable that analytical chemists should undertake to attach any *fixed* money value to such materials.

It is the duty of the chemist to make a careful and impartial analysis, and to leave the question of price to be mutually settled between the merchant and planter. Only these parties are usually acquainted with the special conditions of sale, the amount to be added for extra credit, or the deduction in the case of cash payment. These points naturally affect the actual cost of the manure to the purchaser.

At the same time it is only reasonable that the analyst should be asked to state his opinion respecting the comparative merits of different kinds of manure, and to say how far the agricultural value is likely to be influenced by the presence or absence of certain elements; in fact to translate the possibly obscure analytical statements into the plain language of £ s. d.

It is only in compliance with the request of planters that the following *comparative* valuation table of the several important constituents has been included in this report, and as such I trust it may be of use in the selection of manures.

Before proceeding to the valuation, let us enquire what are the important elements of manures.

Nitrogen and phosphate of lime are the most important constituents to be considered in the valuation of manures. It is the proportion in which these are present in different materials that should influence the difference in price, though, of course, under special circumstances of soil and climate other constituents must naturally have a most powerful additional effect.

Let us briefly examine the analytical statements of an ordinary analysis.

Water is an unavoidable ingredient, and exists in varying quantities and conditions. Many animal and vegetable substances are exceedingly hygroscopic, containing water in high proportion without any appearance of dampness, thus in the numerous kinds of poonac there is generally from 10 to 12 per cent., and I have found much more in cake that has been kept in a damp temperature; on the other hand, certain substances, such as sugar, sand, &c., would be rendered very wet by the presence of 4 or 5 per cent. of water only.

As mentioned when treating of steamed bones, hygroscopic moisture in moderate proportions, not exceeding 15 per cent. is, in my opinion, not objectionable when the manures are intended for light soils.

Organic matter is the general term used in analyses for all substances subject to decay, or decomposition by heat; thus wool, cotton, hair, sawdust and bark are all forms of organic matter, but they possess very different manurial values. The practical value is found to depend on the richness in nitrogen, and it is therefore usual in analyses to state separately the proportion of this constituent existing in the organic matter, for a high percentage of the latter is not necessarily an indication of superior quality. For instance, cotton, sawdust, and bark are of little value as manure, except, of course, mechanically in keeping the soil open, and for the retention of moisture to be given up during dry weather as the tree may require it.

Sulphate of Lime is present in superphosphate* and dissolved bones as a necessary consequence of the action of the sulphuric acid, which is added to render the phosphate of lime soluble.

The value of this sulphate of lime on soils poor in this constituent is considerable, but being generally associated with the presence of soluble phosphate a separate valuation is not necessary.

Carbonate of Lime, as a constituent of manufactured manures in England, would have decidedly a low value

* The name superphosphate is given to manures containing *mineral* phosphate of lime, rendered soluble by addition of acid.

inasmuch as the climate being naturally cold it cannot be decomposed rapidly enough to be of any value during our short period of vegetable growth, though when mixed with cattle dung, as done in Cornwall (see analysis of sea sand), it has a practical fertilising value. As a material for mixing with composts derived from town refuse, it will be most useful in Colombo and other localities, where a supply of ground coral can be obtained. The value per unit of carbonate of lime can easily be ascertained by dividing the price per ton by 92, the number of units in 100 parts of ground coral.

Alkaline Salts is a general term applied to salts of soda and potash when the respective amounts are not separately determined. Soda in the form of common salt can be purchased for agricultural purposes for about 30s. per ton in London, more or less, according to quality. It is therefore purchased separately, and should not form a considerable proportion of the more expensive manufactured manures. When, however, the alkaline salts consist chiefly of potash, their value is of real importance, and it is desirable that the actual percentage of potash should be stated, as it may be present as sulphate, muriate, or nitrate, which contain potash in different proportions.

Magnesia is present only in small quantities in most manures, and in the ash of cakes. *Insoluble siliceous matters*, like water, is a constant though unavoidable constituent, but the quantity should be as small as possible in all concentrated manures intended for use on estates situated at a long distance from the railway, and to which the cost of transit is an expensive item. In fish and compost manures sold at a low price, and intended for use on estates within a few miles of the railway, no special objection should be raised on account of a somewhat high percentage of sand, provided the remainder is really worth the cost of the whole bulk, though, of course, the less sand the better.

We now come to the most important constituents of manures:—

Firstly, Nitrogen, which is the most valuable ingredient of the organic matter of cakes, and is present in varying proportions in the various tissues of animal and vegetable substances; it is also the valuable element in ammonia salts and nitrate of soda, in both of which it is present in a form readily soluble in cold water, and is consequently, as an immediate plant fertiliser, more valuable than when present in an insoluble condition, as in bones, cakes, &c., in which it only gradually becomes available as decomposition proceeds.

Secondly, Phosphate of Lime, which, like nitrogen, may also be present in a soluble and insoluble form with an intermediate stage known as precipitated phosphate, which latter, however, is not generally recognised as a separate form, being rather included as a superior quality of insoluble phosphate. The mechanical condition, as regards fineness of division, should influence the money value of all phosphatic as well as nitrogenous manures. Thus, raw Indian bones, though of high quality as regards composition, yet, in large coarse pieces will not be so immediately valuable for manure as an ordinary sample of Australian bones possibly decidedly inferior in actual richness in phosphate and nitrogen.

This question of mechanical condition must be mutually settled between buyer and seller, especially as many large planters may prefer to grind their cakes or bones themselves. Probably 10 to 15 Rs. per ton will more than cover the expense of grinding to a moderate degree of fineness say an ⅛ (eighth) of an inch size. In the following table, however, I have assumed that the materials are purchased as imported, so that the cost of grinding must be added when necessary.

In analyses it is usual to represent the composition of 100 parts of the material, and it is therefore a convenient method of valuation to attach a value to each unit of the important constituents, and these multiplied together represent the value in one ton of the particular material. The different constituents treated in this way and the money values added together, give the total value of a ton of the manure. No attempt is made to attach a money value to feeding cakes intended for cattle. Upon this point more definite information is wanted, and experiments are now being carried on at Woburn under the direction of the Royal Agricultural Society. The value of the residue from cakes consumed by cattle, however, will be gathered from the table of the various feeding materials already given (page 100). The following valuation refers to substances directly applied as manure.

COMPARATIVE VALUE IN COLOMBO OF MANURIAL CONSTITUENTS.

(Assuming a Rupee to represent 1s. 8d.)	Per Unit. Rs.	C.
Nitrogen in a soluble and highly concentrated form, as in Sulphate of Ammonia, containing 20 per cent. of nitrogen	15	0
Nitrogen in a soluble but less concentrated form, as in fermented Bones and Cakes	10	0
Nitrogen in an insoluble though easily decomposed form, as in Dried Blood, Cake and Fish	9	0
Nitrogen in an insoluble and less concentrated form as in Raw Bones, &c.	8	0
Phosphate of Lime, as soluble Phosphate, 40 to 50 per cent. in Superphosphate	3	0
" " insoluble Phosphate in Guano and Fish ...	1	50
" " insoluble Phosphate in Raw Bones ...	1	0
Potash, in Manures	2	0
Valuable Ash (Ash less Sand) in Cakes	—	75
Caustic, or Burnt Lime	—	50
Ground Carbonate of Lime, as in finely-ground Coral	—	25

Let us take a few examples of the manures (page 21) analysed, and calculate the comparative value by the above table.

AUSTRALIAN BONE DUST, NO. 1, AS IMPORTED.

						Rs.	C.
				Rs.			
Nitrogen ...	(soluble)	1.27	per cent. at	10	per unit	12	70
"	(insoluble)	1.81	" "	8	"	14	48
Phosphate of Lime	"	39.40	" "	1	"	39	40
				Per ton		66	58

RAW INDIAN BONES, NO. 4.

Nitrogen ...	(soluble)	.18	at	10	per unit	1	80
"	(insoluble)	3.41	"	8	"	27	28
Phosphate of Lime	"	52.94	"	1	"	52	94
						82	02
			Deduction for Cost of grinding			10	0
				Per ton		72	2

As imported Indian bones are not sufficiently small to be used with advantage, it would be necessary that they should be ground into meal, and the cost of this operation must be allowed for in making any comparative valuation. Australian bone dust, so far as I am able to judge from the samples sent me, is in a better mechanical condition, so that although it will be improved by grinding, yet such an operation is not necessary to anything like the same extent as in the case of Indian raw bones.

LEECHMAN'S STEAMED BONE MEAL.

				Rs.		Rs.	C.
Nitrogen ...	(soluble)	1.68	at	10	=	16	80
"	(insoluble)	.80	"	8	=	6	40
Phosphate of Lime	"	54.36	"	1	=	54	36
					=	77	56
Addition on account of fine mechanical condition						10	00
				Per ton		87	56

This is really a manufactured manure and in a capital mechanical condition, being in fact quite a meal very different to ordinary bone dust. I was most favourably impressed with the general character of this material as a manure for coffee, and before leaving Colombo had an opportunity of visiting the Hultsdorf Mills and inspecting the process of the special manufacture. The manure in bulk, as prepared ready for sale, appeared fully equal in quality to the sample sent me for analysis.

Let us next take a few examples of cake used directly as manure.

Nitrogen compounds in cakes, though not present in a form soluble in cold water, are much more rapidly decomposed and rendered subject to fermentation than the nitrogen compounds existing in bones, consequently a higher rate per unit is attached.

WHITE CASTOR CAKE AS IMPORTED.

No. 1 Analysis.

			Rs.	C.			Rs.C.
Nitrogen	7.78	at	9	0	per unit	=	70.02
Valuable Ash	7.83	"	—	75	"	=	5.87
					Per ton		75.89

WHITE CASTOR CAKE, NO. 2.

			Rs.	C.			
Nitrogen	7.13	at	9	0	per unit	=	64.17
Valuable Ash	7.36	"	—	75	"	=	5.52
					Per ton		69.69

RAPE CAKE AS IMPORTED.

			Rs.	C.			
Nitrogen	5.31	at	9	0	per unit	=	47.79
Valuable Ash	7.64	"	—	75	"	=	5.73
					Per ton		53.52

In these last three examples of cake no allowance has been made for reducing the poonac to a fine powder as strongly recommended in my report to the Association last year (1878). The cost will be much less than in the case of Indian bones, and possibly planters can get such grinding done on the estate with the aid of water-power. If, however, the cake is ground previous to sale, a fair allowance should be added to the above comparative valuation.

Next, let us take the examples of fish manure (page 26).

FISH MANURE, NO. I ANALYSIS.

			Rs.	C.		Rs. C.
Nitrogen	4.01	at	9	0	per unit =	36.09
Phosphate of Lime	11.44	„	1	50	„ =	17.16
						53.25
Deduction for 28.77 of Sand—above 20°/₀						15.32
					Per ton	37.93

Obviously some deduction must be made on account of the excessive quantity of sand present (48.77 per cent.) because the above rates of valuation have been attached to the units of nitrogen and phosphate of lime, on the assumption that the remaining constituents either enter directly into the composition of these items, and are therefore included in the valuation, or at least that they have a certain manurial value decidedly above that of ordinary sand.

If fish manure is to be used on estates the amount of sand in the same must be reduced very considerably. Some samples sent me contained as much as 60 per cent., and I was informed that 20 per cent. might be expected in average lots. With proper attention the proportion might be reduced to much less, I should think ; however, we will assume 20 per cent. as the present limit, consequently in the above example there is 28.77 in excess. Now if the valuable portion of one ton is represented by Rs. 53 C. 25, and if this value be divided into 100 parts we can readily deduct for the excessive quantity of sand at the rate of 28.77 per cent. from the total cost of one ton. Namely, if 100 parts cost Rs. 53.25, what should we deduct for 28.77 parts of simply worthless material ? This calculation gives Rs. 15 cents 32, which, deducted from Rs. 53.25, leaves Rs. 37.93 as the comparative value, allowing 20 per cent. as the limit for sand, but as I have just mentioned this limit seems too high, and therefore if a lower percentage be arranged for, a greater reduction in proportion can easily be made. Be this as it may, there should be some limit of sand guaranteed when fish manure is purchased, otherwise unnecessary expense will be incurred in the cost of transit for a material (sand) which is quite useless as a fertiliser.

The next example shows us what a highly concentrated manure can be prepared from fish.

MASSEY'S CARBONISED FISH MANURE, NO. 4 ANALYSIS.

(Page 26.)

			Rs. C.			Rs. C.
Nitrogen	7.42	at	9 0	per unit	=	66.78
Phosphate of Lime	27.83	„	1 50	„	=	41.74
				Per ton		108.52

When the sample of this manure was sent me, I was informed that only a small quantity had been made, but by this time no doubt the manufacture of this material has been greatly increased, and provided the superior quality is kept up there should be a large demand.

In attaching a comparative value to the various compost manures it will be necessary to consider the quantity of lime present in forms other than as phosphate of lime, because the proportion of the latter must necessarily be small, though carbonate and sulphate of lime will very possibly be present in much larger quantities than is usually the case in ordinary phosphatic manures. Nitrogen can be valued at 9 Rs. per unit, and carbonate and sulphate of lime be regulated by the local market price of these constituents. Compost made from town refuse matters will be subject to considerable variation in value, depending on the state of the weather, the character of the refuse, the quantity and quality of the ingredients subsequently added to improve the final product. It is therefore not desirable to attempt to attach even a comparative value to a material liable to such great variation in quality. With proper attention a very useful manure may be made from town refuse mixed with ground coral and bone dust, and with the aid of the resident analyst planters can ascertain the exact quality of different mixings.

Very possibly, in consequence of a reduced demand for manures, the values given in the preceding calculations may be above the present market price for the several materials, and if so, of course so much the better for the planter. I would repeat that the above table has been prepared simply as a comparative one, by which the planter may be assisted in the selection of the materials, which may be offered from time to time as manure for coffee, and as such I trust it may be of use.

GENERAL REMARKS.

Bones, cake, and superior qualities of fish manure are the materials which are best calculated to be economically used as coffee fertilisers. Also composts whenever the estates are sufficiently near to a railway to allow of the application at a moderate cost.

High-class superphosphate, containing about 44 per cent. of soluble phosphate, will be a most valuable substitute for the phosphates contained in bones whenever an immediate effect is required, as for instance in cases of leaf disease, but it should always be used in conjunction with cattle dung or cake, so that nitrogen, as well as phosphate, may be supplied.

The following analysis of a special superphosphate prepared by Messrs. Lawes, London, represents the composition of the quality I would recommend for this urpose.

LAWES' SPECIAL SUPERPHOSPHATE.

Moisture lost at 212° F.	10.20
*Monocalcic Phosphate or Bi-phosphate of Lime	28.09
Insoluble Phosphate of Lime	.50
Hydrated Sulphate of Lime	59.76
Magnesia and Alkaline Salts	1.25
Silicious Matters (Sand)	.20
	100.00
*Equal to Tribasic Phosphate of Lime, rendered soluble by Acid...	43.99

The advantages of this manure consist in the large quantities of phosphate of lime and sulphate of lime, which are present in a form readily soluble, and consequently at once available as plant food.

This solubility of the otherwise insoluble phosphate of lime, has been effected by the action of sulphuric acid which decomposes the original material into the above constituents. Planters who have attempted at great cost to import sulphuric acid may be interested to learn that this super has absorbed, during the process of manufacture, half its weight of commercial sulphuric acid, and that associated with the soluble phosphate of lime there is sufficient free acid to fix 1¼ per cent. of ammonia.

This material is now being exported to the West Indies, there to be mixed with fish manure with a view of supplying soluble phosphate, and at the same time fixing any volatile ammonia.

In a special report I have recommended this manure for shipment to Ceylon, as being, in my opinion, one of the most economical that can be supplied for future mixing with steamed bones, which naturally contain a considerable proportion of soluble nitrogen compounds in the form of volatile ammonia salts as carbonate and sesquicarbonate. This manure contains only a mere trace of sand, is in a finely divided state, and in excellent dry condition suitable for shipment. The 10 per cent. of water which is present as a necessary consequence of the use of the acid, is very low for a manufactured manure, in fact it does not exceed the quantity found in average samples of poonac. I understand that it is sold under a guarantee of quality as shown by analysis of samples taken at the time of shipment, and can be sent in double bags or casks, as arranged by purchasers, the price of the manure being £6 5s. per ton in London.

Provided the manure is protected from exposure to rain during transit, double bags will do, and will be more convenient to move, as well as cheaper, than casks or barrels.

Sulphate of Ammonia.—Among the manures imported into Ceylon, this material must be used with great caution, as it is a most concentrated nitrogenous ingredient, containing from 24 to 25 per cent. of ammonia, and being readily and completely soluble in cold water, is naturally liable to be washed away if exposed to rain. It is most extensively used in mixed manures for corn crops in Europe, but for reasons previously given, its chief use in Ceylon will be, I apprehend, as a material for hastening the decomposition of composts made of green vegetable matter; indeed I believe it has already been employed for this purpose, with advantage by experienced planters.

For some years the demand in the London market has so increased that it now costs some £20 a ton in bulk, with every prospect of a higher figure.

If shipped it had better be packed in puncheons, as bags would be quite unsuitable.

It is sold guaranteed to contain 24 per cent. of ammonia, and samples are usually drawn at the time of shipment for analysis as to the exact quality, and as a check against adulteration by admixture of sulphate of magnesia (Epsom salts) which, from similarity in general appearance, is sometimes added by dishonest firms.

Containing 24 per cent. of ammonia, and offered at £20 per ton, each unit of ammonia would represent 16s. 8d.; consequently each unit less than 24 per cent. would amount to a considerable money loss when several tons are shipped.

Planters frequently inform me that in sending manures from Europe, they want a *complete* coffee manure, containing the necessary constituents already mixed in suitable proportions. They do not wish to run the risk of any subsequent mixing in Colombo and are willing to pay a somewhat higher price for a fertiliser which can be sent direct to the estate in casks or double bags. If so there are several excellent special coffee manures prepared by well-known firms, such as Ohlendorff, Lawes, Odams, &c., &c.

Dried Blood.—It is a matter of suprise that dried blood in a finely ground state should not have been offered as a cheap source for supplying nitrogen to the soils of estates which have suffered from wash. In a finely ground powder, dried blood would make a most excellent material for mixing with steamed bones. It contains, as usually sold, 12 to 13 per cent. of nitrogen and about 14 per cent. of hygroscopic moisture. Possibly it may have been used already, indeed, in its crude state it forms an ingredient of Mr. Grinlinton's compost, but as a finely ground powder, I would strongly recommend a trial, and have no doubt that large quantities could readily be obtained from India, as samples have been offered in London.

Having now considered the properties of the various manures, and pointed out the elements which should influence the selection of the most economical, I would in conclusion recommend that due allowance should be made for the cost of cart hire, because, where the distance is considerable, the expense for transit will be nearly as much as the original cost of the manure.

Indeed, we should calculate, by means of the figures in the table, the actual cost on the estate of each unit of nitrogen and of phosphate of lime respectively, and make a selection of those materials which supply these constituents in the cheapest form. Again, in reference to the use of cattle manure, *versus* a mixture of bones and poonac, the table constructed will be useful in forming an opinion as to the special dressing best adapted to the requirements of any particular estate. Some soils being more deficient in nitrogen than others will require a more liberal supply of this element, and so also in reference to the mineral elements such as phosphoric acid, lime, potash, and magnesia. It is quite impossible to lay down any general rule for the application of manure, but certain principles may be foreshadowed as a guide.

For instance, on estates where the trees make plenty of wood and leaf, nitrogenous manures are not so requisite as a good supply of mineral constituents in an available form. On the other hand, on washed estates nitrogen is essentially necessary, hence the great value of cattle dung in all such cases, but it should be used moderately and be followed next year by a dressing of steamed bones wherever possible.

On young estates capital will be most economically expended in draining and terracing rather than in the application of manure which would tend to unduly stimulate the growth of the tree; this would be specially so if cattle manure or cake were used alone. On naturally poor soil or in situations exposed to wind, it would be rash to attempt to grow trees of large size by the application of expensive manures. Small compact trees topped at about 2 feet 6 inches will be the most suitable in such cases.

Coffee as a crop is not exhausting in itself, but the conditions under which it is produced tend to impoverish the soil. Wind, wash, and exposure to the baking influence of a tropical sun, are the elements which produce premature exhaustion of the soil.

In the original forest these elements are practically inoperative, the surface soil being protected by reason of dense, overhanging foliage which naturally breaks the force of wind and rain, and effectually keeps off the sun's rays. It appears desirable, therefore, that in exposed situations coffee trees should be planted at closer intervals than where the natural conditions are more favourable, and that being of smaller size they should be arranged more closely for mutual protection. The retention of the original surface soil should be the great endeavour of the planter, for it is by far the cheapest form of manuring.

LEAF DISEASE (HEMILEIA VASTATRIX).

The natural history and general fungoid character of this disease have already been very fully described by Thwaites, Berkeley, Hooker, Abbay, and more recently in a very able report by Mr. Morris, Assistant Director of the Botanical Gardens, Peradeniya, who has devoted much time to the careful examination of the disease in its different stages.

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Personal examination of the fresh leaves taken day by day from the trees is naturally the only way to understand the special peculiarities of this fungoid pest. The microscopical examination of the dried leaves is scarcely satisfactory and is insufficient to trace the progress of the disease.

Various reports upon this *leaf disease* have from time to time been made, that of the Rev. M. J. Berkeley published in the *Gardeners' Chronicle* for November 6th, 1869, being probably one of the earliest. This report was made in reference to some leaves sent by Dr. Thwaites from Ceylon, and which afterwards formed the subject of an article in the journal of the Linnean Society under the name of Hemileia Vastatrix.

Any general review of the history of leaf disease since its first appearance would occupy too much space to be included in this report, more especially as up to the present no practical remedy has been established as a specific against its ravages, though flowers of sulphur have been used with advantage.

It is a matter of surprise, and certainly of regret, that no systematic and carefully-conducted series of experiments should have been instituted long since, with a view of obtaining satisfactory results by the use of flowers of sulphur, sulphide of calcium, quicklime, or certain special mixtures of these or other substances, which could be obtained at a sufficiently cheap rate to admit of being used on a large scale. Planters want a practical remedy rather than an elaborate description of the disease. If the ravages have really been so extensive as to effect in a marked degree the annual production of coffee, surely it would be but reasonable to expect that Government should come forward and take some official steps to ascertain what remedial measures should be have been deprived of the rich surface soil from continued wash, suffer more than the new districts.

When leaf disease has fully developed itself, there can be no doubt that planters are quite right in looking upon judicious manuring as the only means of restoring the vital energy of the tree in as short a space of time as possible.

Again, withered leaves should be considered quite worth the expense of collection and making into a compost with burnt lime.

For instance, compare the analyses of cattle manure and pulp with these partially-dried leaves, the former contains only from .50 to .60 of nitrogen in every 100 parts, and the latter (pulp) only .33 per cent.

It is an economical operation to make manure of coffee leaves rather than allow them to increase the wash by choking up the drains.

Exceptionally bad seasons and excess of moisture in the atmosphere and in the soil, have doubtless contributed to make the attack of the Hemileia more severe in its effects. It is for this reason and also on account of the natural poverty in lime of granitic soils, that I ventured, when in Ceylon, to recommend the more extensive use of lime in some of the numerous conditions in which it can be obtained. The scattering on the surface of well burnt lime at the rate of ½ lb. per tree in the case of Colombo burnt coral, or 1 lb. in case of the mountain dolomitic lime, and the subsequent forking of the surface to allow of penetration, will be found a great improvement as a preventive measure.

There is no great novelty about such an operation, but it does not appear to have been sufficiently recognised as a desirable one to be tried.

In the opening up of new land at home, *liming* is one of the primary operations considered necessary.

As regards any direct antidote or specific against leaf disease, some reliable experiments should be conducted before any united action can reasonably be expected from planters as a body, and at the present low price of coffee it is quite certain that if any remedy is attempted it must be a cheap one, or otherwise it cannot be practically carried out.

In the early stages, when the filamentous threads are external only affecting the stem and primary branches, the plan of white-washing the stem and branches with a solution of Colombo lime (freshly burnt) will be a very simple operation.

It is a very common practice to lime wash apple trees at home after this manner.

Next, as regards the use of sulphur, in order to destroy the spores immediately they attack the leaves.

Fumigation, though the most perfect and energetic form of application, is attended with so many practical difficulties, and to a certain extent with the possibility of positive damage to the tree, that I shall not stop to consider the most desirable means of application, especially as my views on the subject have already been published in the *Ceylon Observer*, April 2nd, 1879, being contained in a letter to the Secretary of the Ceylon Company, dated February 28th, 1879.

If fumigation were practically applicable, I apprehend it would long since have been adopted by the hop growers of Kent and Sussex, and in the vineyards of France and Spain.

But in reference to the use of sulphur in the form of a fine powder there is every opportunity for making numerous experiments in respect of the quantity, the quality, and the time of application.

1st.—Probably at least 2 ozs. per tree or (1,200 trees per acre) 150 lbs. per acre will be required to give the trees a thorough dressing, but on this point, as well as to ascertain whether the above dressing should be applied in one or two operations with an interval of some days between, future experiments, and the size of the trees, must decide.

2nd.—*As regards quality* caution should be exercised in purchasing low-priced flowers of sulphur. Of course planters will be anxious to obtain it as cheap as possible, but unless the sulphur is genuine and in a very fine state of division, it will be unreasonable to expect any satisfactory result. Where carriage is such an important item the difference of £2 or £3 in the original price of the best quality, as compared with second or third rate sulphur, should influence the selection of the best, so that what is carried up at such expense should be really good. The great advantage of flowers of sulphur over specimens of *ground* native sulphur consists in its purity and minute state of division.

I find by experiment that the finer sifted and more minute the particles of sulphur the less the specific gravity. The following results of the respective weight of an imperial pint of three qualities of sulphur will be of use in comparing samples.

	Price per ton in barrels, London.		1 pint filled loosely.		1 pint shaken down.	
	£	s.	ozs.	grains.	ozs.	grains.
Flowers of Sulphur, 1st quality	12	15	11	37	13	221
" " 2nd "	10	15	12	61	14	389
Powdered Sulphur Vivum (black)	7	—	15	427	19	169

Flowers of sulphur obtained by the sublimation of the native ore and subsequent sifting is decidedly the most effective, the weight of an imperial pint being about 11 ozs. when filled loosely and not more than 13½ ozs. when carefully shaken down during filling. Of course the finer the powder the more readily is the sulphur decomposed under the influence of heat, and converted into sulphurous acid.

3rd.—*Time of Application.* This will depend upon the particular period when the attack may appear, and naturally the application must then be carried out. The leaves should have their surface moist in order the more perfectly to retain the powder, hence when there is dew or after a shower of rain will be most suitable time. On slopes exposed to the morning sun the dew will not remain long, consequently but little available time can be calculated on, and it will be necessary to concentrate the whole of the available labour upon the operation in the early morning.

In showery weather a much larger acreage can be gone over. The flowers of sulphur are very irritating to the sensitive mucous membrane of the eye, so that the coolies should keep well to windward of any breeze that may exist, or their eyes will suffer. Various descriptions of blowers will no doubt be devised by Messrs. Walker, of Kandy, for the rapid and equal distribution of the powder, so that this important point may confidently be left to the ingenuity of the firm.

Lime, prepared from freshly burnt Colombo coral, should be tried either separately or, as I have already suggested in combination, in equal parts, with flowers of sulphur.

As a suitable manure to stimulate the tree suffering from the Hemileia a mixture of white castor cake, steamed bones, and superphosphate in equal parts and about ¾ lb. of the mixture per tree will be found generally an economical dressing, or 10 lbs. of cattle dung and ¼ lb. of steamed bones. Fish manure of good quality applied alone will also be a suitable restorative application, as it contains both nitrogen and phosphate of lime in a form readily available as plant food. But to apply any of these profitably, an improvement in the price of coffee as well as railway extension will be necessary.

WHITE BUG AT THE ROOTS OF COFFEE TREES.

Among the soils analysed during my stay in Ceylon was one on which the trees were suffering from the ravages of the well-known "white bug," many of the small rootlets being almost covered with these minute bugs. The soil was of dark peaty description, and although it had been kept in a wooden box in an office in Colombo for upwards of three weeks, the quantity of water retained amounted to over 26 per cent. without giving the soil the appearance of being damp.

SOIL IN WHICH "WHITE BUG" ATTACKED THE ROOTS.

Water expelled at 212° F.	26.340
Organic Matter and Combined Water	15.660
* Oxide of Iron	3.806
Alumina...	7.200
Lime	.414
Magnesia	.620
Potash	.173
Soda	.024
Phosphoric Acid	.140
Sulphuric Acid...	.014
Silicates soluble in Alkali	2.140
† Insoluble Silicates	43.469
	100.000
* Containing Nitrogen	.434
† Containing Quartz	15.540

It will be noticed that there is a high percentage of nitrogen, while the proportions of iron and alumina are low, so that the greater part of the 15.660 consists of organic peaty matter which is naturally very hygroscopic in its character and no doubt accounts for the large amount of water retained in the soil.

Thorough draining and opening up of the land, combined with liberal doses of burnt lime would be the best remedy. This is an instance where any manure like cattle dung or cake would be unnecessary, as the supply of nitrogen is already more than sufficient.

Though no samples of soil were sent me officially by the Matale Association, I have received several from private individuals, who, I presume, will have no objection to the publication of the results, (provided numbers are substituted for names of the estates,) and thus be the means of contributing additional information respecting Ceylon soils.

These analyses are also specially interesting on account of the large proportion of manganese which some of the soils contain. The presence of manganese even in small quantities, as .40 to .60 per cent., is rather a sign of natural fertility in a soil. In the sugar soils of Queensland it exists to such an extent that a distinct colour is imparted to the sugar produced in certain localities.

COFFEE SOILS FROM MATALE.

	1	2	3	4	5	6
Water	1.670	1.230	3.775	[illegible].025	3.160	8.220
* Organic Matter and Combined Water ...	6.660	6.020	6.006	8.075	7.670	10.760
Oxides of Iron...	11.103	12.236	9.789	15.975	7.024	14.856
Oxides of Manganese ...	.980	1.501	Traces.	Traces.	.905	3.850
Alumina	7.747	8.639	11.886	13.275	8.421	14.476
Lime	.224	.098	.420	.056	.070	.126
Magnesia	.306	.262	.126	.261	.234	.468
Potash	.221	.241	.096	.106	.178	.149
Soda	.039	.010	Trace.	.030	.049	.032
Phosphoric Acid	.121	.083	.204	.014	.057	.115
Sulphuric Acid...	.020	.017	.017	.051	.048	.089
Chlorine	.002	.001	Not determined	Not determined	.015	.019
Silicates soluble in Alkali	4.540	5.580	8.525	9.925	4.600	7.360
† Insoluble Silicates ...	66.367	64.082	59.156	50.207	67.569	39.480
	100.000	100.000	100.000	100.000	100.000	100.000
† Containing Nitrogen ...	.106	.080	.058	.066	.080	.154
* Containing Quartz ...	11.340	20.080	38.070	30.975	31,940	16.040

It must not be considered that the above soils are representative of Matale as a district. They were sent from individual estates, some of which had been remarkable in past years for large trees and heavy crops, and with proper care and suitable manure will certainly produce good results again.

A careful examination of the above analytical figures, and a reference to my remarks on the Dimbula soils will indicate the points in which these soils require attention.

AMBAGAMUWA CLAY.

During my tour a sample of this clay was personally selected for future analysis.

The specimen represents a layer some 3 or 4 feet thick and about 1½ to 2 feet below the surface. In its natural damp, plastic condition the colour is of a pale brown, but on being dried by exposure to the sun, the colour becomes yellow, and on analysis gave the following results :—

COMPOSITION OF AMBAGAMUWA CLAY (AIR-DRIED SAMPLE).

Water lost at 212° F.	2.580
*Combined Water and a little organic matter ...	20.220
Oxides of Iron (chiefly as Hydrated Sesquioxide) ...	22.206
Alumina	30,356
Lime	.084
Magnesia	.063
Potash	.077
Soda	.094
Phosphoric Acid	Traces
Sulphuric acid and Chlorine	Not determined
Silicates soluble in Alkali	3.120
Insoluble Silicates	21.200
	100.000
*Containing nitrogen...	.048

The analysis indicates that this must be a very stiff impervious clay, always to be avoided in the selection of suitable coffee land. The proportions of alumina, iron, and combined water are far too high for a friable soil to be expected.

There is really very little organic matter present as the greater part of the 20.220 consists of water of combination which is chemically associated with the oxides of iron and alumina. On ignition at a gentle heat the clay assumes a bright red colour, due to the fact that this water of combination is driven off and the oxide of iron becomes converted into anhydrous ferric oxide. Burning would no doubt improve the physical condition of this clay, though under present circumstances it would scarcely be practicable.

The clay in its natural state is certainly not suitable to coffee, and would scarcely be for tea or cinchona either, indeed, if such layers of clay are found at about two feet from the surface it may explain the dying away in patches of cinchona succirubra on certain estates.

FUSION ANALYSES OF CEYLON ROCKS.

Among the samples brought home, I have a large collection of specimens of representative rocks personally selected during my tour, and the analyses of which I shall hope to complete during my leisure time.

In order to make such analyses practically useful in the selection of the stone most suitable for terracing, it would be desirable that specimens of the rocks, with the analyses attached, should be deposited in the Colombo Museum; by this means planters would have a convenient opportunity of comparing pieces of rock from their own estates with specimens of known composition.

The following analyses (by fusion in the usual manner) of three specimens have been completed for insertion in this report.

B is a specimen of light coloured Granulite.
G " " Garnetiferous Gneiss.
H " " Dark metamorphic rock.

FUSION ANALYSES OF CEYLON ROCKS.

	B.		G.		H.
Silica...	70.06	...	60.81	...	72.59
Alumina	14.71	...	16.34	...	13.08
Ferric Oxide (Peroxide) ...	2.70	...	1.05	...	Not determined.
Ferrous Oxide (Protoxide)...	4.20	...	9.66	...	4.15
Lime	2.93	...	5.44	...	2.63
Magnesia	.67	...	3.02	...	1.43
Potash	1.57	...	1.90	...	4.32
Soda	2.04	...	1.06	...	1.47
Phosphoric Acid	.21	...	.25	...	.09
Sulphur	.2	...	—	...	—
Loss on ignition	.12	...	.05	...	.42
	99.50	...	99.58	...	100.18

The above analyses were made by the usual process of fusion with alkali, &c., but in order to ascertain the extent to which the several specimens, when finely ground, were decomposed by acid (as in the ordinary analyses of soils); equal quantities of each of the powdered rocks were digested with a measured quantity of muriatic acid for a given time with the following results.

PORTION SOLUBLE IN ACID OF STANDARD STRENGTH.

	B.		G.		H.
Lime...	.588	...	1.204	...	.252
Magnesia	.234	...	.486	...	.418
Oxide of Iron and Alumina	4.550	...	6.150	...	3.001
Alkalies, &c., &c.,... ...	Not determined	...	—	...	—
	5.372	...	7.840	...	3.671

Specimen G, which contains the most lime and iron, shows the highest proportions of these elements soluble in acid, and B, though containing about the same quantity of lime as H, nevertheless exhibits a larger proportion of this element soluble in acid.

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It is reasonable to expect that this degree of solubility extends to the other constituents of the three rocks, and that the weathering action bears a certain relation to the solubility in acid. In other words, that some practical opinion as to the readiness with which rocks are decomposed and their ingredients rendered available as plant food, may be formed from the extent to which the powdered rock is affected by acid. Further, that for terracing we require a rock rich in lime, potash, &c., and at the same time readily weathered or decomposed. The latter we can judge to some extent from the general appearance of the rock, as for instance the formation of a deep reddening of the surface in proportion as the iron compounds become oxidised from a state of protoxide to that of peroxide (which gives the red colour to the earth).

From the above analyses and general appearance of the rocks, specimens B and G appear more suitable for terracing than the one marked H, which, though richer in potash, is apparently much less easily decomposed by the action of the weather.

With these remarks I beg to conclude this report, and in doing so must express my regret that I have been unable to complete the same at an earlier date.

ANALYTICAL LABORATORY,
79, MARK LANE, LONDON,

June 10th, 1879.

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