COURSE
OF
LECTURES ON ORGANIC CHEMISTRY
AS APPLIED TO
MANUFACTURES AND AGRICULTURE.

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LECTURE V.

Analysis of Manure—Table Showing the Relative Value of each Species—Particular Notice of Certain kinds of Manure.

GENTLEMEN,—In my last lecture I explained to you the manner in which you should conduct the analysis of any particular animal substance, and especially of a manure, and I pointed out how you were to determine the exact quantity of nitrogen contained in it; but I then alluded to the elementary composition of the material, and founded my remarks on the supposition that it was necessary to ascertain the exact proportions of carbon, hydrogen, oxygen, and nitrogen. This explains why I recommended you to employ a tube for the chloride of calcium, and the combustion tube of Liebig. However, as our chief object is to ascertain simply the quantity of nitrogen contained in any manure, we may dispense with these instruments and follow the following method of analysis:—

You take a strong glass tube and close it, by heat, at one end; the next step is to dry it, and this may be done by rinsing the tube with a small quantity of warm deutoxide of copper; when any moisture which may be contained in the tube is thus removed, you introduce a small quantity of the bicarbonate of soda; in addition to this you add a layer of deutoxide of copper, and then about six grains of the manure, well dried and mixed with a little deutoxide of copper. Above this mixture you place some copper shavings, perfectly free from oxide, then a fresh layer of oxide of copper, and lastly, you fill the tube with metallic copper. This done, the tube is surrounded with copper leaf, supported by twisting iron wire round it, taking care to leave the part of the tube which contains the bicarbonate of soda free. The combustion tube is then placed in a long furnace and made to communicate at one end with a double branched tube, one branch of which communicates with a vessel containing mercury, and the other with one of Guy-Lussac's small air-pumps. When this tube has been fixed on the combustion tube the air-pump is worked, for the purpose of trying if all the joints are true. When this is ascertained, a receiver, two-thirds full of mercury, is placed erect in the mercury bath and above the extremity of the receiving tube, its upper third being filled with a concentrated solution of potass. The furnace is now filled with charcoal, commencing opposite the part of the tube which contains the deutoxide of copper (the tube containing the soda is to be heated subsequently) and under the influence of heat the organic substance undergoes decomposition; its oxygen and carbon form carbonic acid, the hydrogen unites with oxygen to form water, and passes, with the nitrogen, under the form of vapor, into the receiver containing mercury; the carbonic acid is taken up by the potass; the watery vapor is condensed while the insoluble nitrogen passes to the upper part of the receiver and displaces the fluid. When the operation is terminated, which is known by the gas

ceasing to be disengaged, the extremity of the tube containing the bicarbonate of soda is then heated. The bicarbonate is thus decomposed and emits a considerable quantity of carbonic acid gas, which sweeps along the combustion tube, and carries with it any gases which might have remained there. The above operation having been completed, the solution of potass is carefully shaken in the mercury bath, so as to saturate any carbonic acid which may have been mixed with the nitrogen. If we have any reason to fear that the saturation is not complete, a small piece of caustic potass may be introduced into the solution. The receiver is now removed from the mercury bath, placed in an earthen vessel full of water, and the mercury is removed and replaced by water; all this must be done with very great care. Finally, the gas which now occupies the upper part of the receiver, and is pure nitrogen, is transferred to a small graduated bell to ascertain its volume, &c. When we have obtained the volume we easily get the weight, according to the following formulæ:—

	Temp.	Pressure.	Weight.
1 quart of dried nitrogen	0°	0.76	1.259 grs.
1 (moist)	15°	0.77	1.188 „
1	15°	0.76	1.172 „
1	15°	0.75	1.156 „
1	15°	0.74	1.140 „

The following table exhibits a view of the equivalents of the substances commonly employed as manure:—

Substances.	Nitrog. per 1000.	Equi- valents.
Stable Manure	4.0	10000
Peas	17.9	2223
Millet	7.8	5128
Buck Wheat	4.8	8333
Lentil	10.1	3960
Oats	2.8	14285
Barley	2.3	17390
Rye	1.7	23529
Wheat	4.9	8160
Lower part (0.67) of the straw	4.1	9750
Upper part (0.33)	13.3	3000
Wheaten chaff	8.5	4700
Dried stalks of Jerusalem artichoke	3.7	10810
Top Madia	5.7	7010
Beet	5.0	8000
Potato	5.5	7272
Carrot	8.5	4700
Field weeds	5.3	7547
Furze, leaves and stalk	12.2	3278
Autumn leaves of Oak	11.7	2777
Beech		
Poplar	5.3	7434
Acacia		
Pear-tree		
Heath	17.4	2290
Fucus digitatus	8.6	4650
„	9.5	4211
„ Sacchar. sic	13.8	2890
„	5.4	7400
Brewers' grains	45.1	880
Clover root	1.6	24800
Lupin seeds	34.9	1140
Grape husks	18.3	2185
Pulp of beet root (dry)	11.4	3500
„ (pressed)	3.8	10580
Oyster shells	3.2	12500
Burned sea weed	3.8	10526

Substances.	Nitrog. per 1000.	Equi- valents.
Soot { Coal	13.5	2962
{ Wood	11.5	3478
River mud	4.0	10000
Mari	5.1	7810
Picardy cinders	6.5	6150
Dried muscular flesh	130.4	306
Salt cod	67.0	597
" washed and pressed	168.6	237
{ Dry, soluble	121.8	328
{ Fluid	27.1	1474
Blood { Coagulated and pressed	45.1	886
{ Insoluble and dry	148.7	269
Feathers	153.4	260
Cow hair	137.8	290
Woollen rags	179.8	222
Beet root (worked)	0.9	41365
{ Linseed	52.0	769
{ Coleseed	49.2	813
Cakes { Arachyshypogea	83.3	462
of { Madia	50.6	790
{ Croton	40.2	993
Pulp of potato	5.3	7600
Juice of potato	3.8	10638
Saw- { Acacia	2.9	67459
dust { Oak	5.4	13790
Solid excrement of cow	3.2	12500
" " horse	5.5	7270
Urine { Cow	4.4	9090
{ Horse	2.6	1530
{ Cow	4.1	9750
Mixed { Horse	7.4	5400
Excre- { Pig	6.3	6240
ment { Sheep	11.1	3600
{ Goat	21.6	1850
Common guano	49.7	804
Purified guano	53.9	741
Colombine	83.0	480
Litter from the silk' worm	32.90	1215
Their chrysalides	19.14	2061
Prepared human fæces (Belhoni)	35.5	1020
" " (Monfaucou)	15.6	2560
Horn scrapings	143.6	278
Cockchaffers	32.1	1270
{ Melted	70.2	570
Bones { Moist	53.1	643
{ Fat	62.1	574
Residue of bone glue	5.2	7575
Kitchen stuff	118.7	336
Refiners' black	10.6	3770
Animal black	10.9	3669
Earth at { Limogne	3.2	12618
{ Marville	2.2	18274
{ Boulbene	0.7	55172

The exact values of the different articles mentioned in the above table were determined by analysis which I made for the purpose; it will be necessary, however, to say a few words in explanation of the table.

In the first column you will find the name of the substance employed as manure; in the second column the quantity of nitrogen contained in 1,000 parts of the material; and in the third the number of kilogrammes* required to manure a hectare.†

Our common stable manure has been placed at the head of the table, and taken as a standard. It requires 10,000 kilos. to manure two acres; or, in other words, 10,000 kilos. of a material which contains 4 per 1,000 of nitrogen, will manure the hectare (2.471 English

* The kilogramme is equivalent to 2.205 pounds avoirdupois*

† The hectare to 2.471 acres English.

acres) of ground. The standard then is a hectare, manured with 10,000 kilos. of matter containing 4 per 1,000 of nitrogen. [Thus, 5,000 kilos. of a substance containing 8 per 1,000 would produce the same results, and so on.

There are some few other points in the table which also require notice.

On looking at the relative values of the straw of corn, peas, &c., we find that it contains a very considerable proportion of nitrogen, and we are led at once to ask why this straw is given as food for animals, instead of being employed as a manure; and how it happens that the excrement of herbivorous animals fed on straw contains comparatively so small a quantity of azote. In the first place we may observe that the fodder is dry, while in the excrements it is minutely divided, mixed with a large proportion of water, and has already yielded a portion of its nitrogen for the nutrition of the animal.

If we examine the proportion of nitrogen contained in the solid fæces of man or animals, we shall find that it is almost nothing compared with that contained in their fluid excretions; and this must be so. The food of man and animals can only support life in so much as it furnishes to the different organs the elements which they require for their reproduction. All corn, and the fresh or dried herbs which they eat, contain, without exception, principles that are rich in nitrogen. The quantity of fodder or nourishment that an animal requires diminishes in proportion as the food is rich in azotised principles. The life of a horse may indeed be supported by feeding him on potatoes (which contain little nitrogen), but although the animal lives, he scarcely exists, and gives way under the slightest exertion. We are astonished at the enormous quantities of rice consumed, at each repast, by the natives of India; but we understand this when we remember how little azote is contained in rice.

It is evident that the nitrogen of vegetables and corn which supply nourishment to animals is assimilated by them. When digestion is completed, the excrementitious matter passed by the animals does not contain any azote; or if it does, the small quantity mixed with the fæces is derived from the secretions of the liver or intestinal canal; at all events the excrement contains much less azote than the food consumed.

Human fæces contains a greater proportion of nitrogen than that of any other animal; because man eats, not merely to satisfy a want, but to gratify a passion; hence, he consumes more nitrogen than is necessary for his sustenance, and the excess is found in his fæces.

From what I have said, it is evident that, by simply employing animal manure, we restore to the soil less of azotised matter than has been removed from it by the crop; but, on the other hand, we furnish a greater quantity than the atmosphere could supply. The true scientific problem which the agriculturist has to resolve is, how he can best employ the azotised nutriment of plants contained in human and animal excrement, and also in the *débris* of animals and vegetables which are rich in nitrogen. Unless he knows how to convey it in a proper way to his farm, it is almost worthless; a heap of manure improperly employed is just as useful to his neighbour as to himself, for at the end of a few years nothing will remain but the carbonaceous remnant of putrid vegetable matter; the

whole of the nitrogen will have disappeared under the form of carbonate of ammonia.

You must not forget that the younger the organs of a vegetable are, the more nitrogen it contains; this explains why the upper part of straw is much richer in azote than the lower part. This difference is indicated in our table of equivalents; the upper third (0.33) of the blade contains 13.3 per 1000 of nitrogen; while the lower two-thirds (0.67) contain only 4.1. This important fact, which results from experiments made by myself and M. Boussingault, proves that it is advisable to employ the upper part of the straw only for fodder, and the lower for litter.

On looking at the table you will also see that the straw, or stalks of the leguminosæ (peas, lentils, &c.) is much richer in nitrogen than that of the graminæ (corn, &c.) Every one knows that beans, lentils, &c., are very nutritious. Dwarf peas form the basis of the food of our convicts. The leaves of trees, and particularly those which fall in autumn, contain a good proportion of azote. The different kinds of *fucus*, or sea-weed, which are collected in large quantities along the sea coast, form very excellent manure, especially when mixed with farm-yard dung. For some time back the seeds of the lupin constitute an important branch of commerce in Tuscany; they are sold for five to eight shillings the 200 lbs. The capability of germinating is destroyed by slightly roasting or boiling them in steam. In vine countries the husks of the grape are much employed as manure. Oil cakes, or the residue of the manufacture of oils, by pressure, contain vegetable albumen, gluten, and a small quantity of cellulin. They form an excellent manure, and are the more valuable in proportion as they are freed from oily matter, for oil is a substance unfavorable to vegetation. The cakes should be reduced to powder before being mixed with any other substance. The urine of herbivorous animals, as may be seen in the table, is much richer in nitrogen than their feces; hence, the agriculturist should use every effort to collect so precious a material and not allow it to be wasted, as too many of them do. The quantity of nitrogen contained in the dung of goats and sheep indicates the effect which we may expect from it when mixed with that of the cow, horse, &c., to form the mixed dung of the table.

In alluding to guano a difference has been made between the natural and prepared material; the latter contains 4 per 1000 more of nitrogen, because it has been freed, by sifting, of the vegetable residue and pebbles, &c., with which it is mixed. We know that coal furnishes a certain proportion of carbonate of ammonia, when distilled; this is the reason why coal soot contains more nitrogen than soot derived from the combustion of wood.

Feathers, hair, woollen rags, horn scrapings, &c., contain a very high proportion of nitrogen; but from the tenacity of these materials they are not easily decomposed. Generally speaking their disintegration does not take place before five or six years. Hence, we should chiefly employ them for manuring orchards, vineyards, &c. They follow the progress of vegetation slowly; and if we calculate their slowness of decomposition, their richness in azote, and the quantity required for two acres (*hectare*) of land, we can tell precisely the quantity that is required to obtain, during

six years, the same results as those which would ensue from using annually 10,000 kilos. of common manure. Animal black is obtained by mixing fecal matter with a carbonised earthy powder. It is an excellent manure, and was invented, in 1833, by my associate M. Salmon. The discovery, which resolved two interesting questions, the disinfection of stercoraceous matter, and the production of a manure which might be used without previously undergoing putrefaction, was rewarded with the grand Monthyon prize.

ADDITIONAL

ILLUSTRATIONS OF THE WATER-CURE, AS PRACTISED AT MALVERN.

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Provincial Medical and Surgical Association.

In my last communication I related the treatment of a case of gout, and particularly noticed that the patient suffered much from being almost smothered under a bed. This clumsy and semi-barbarous mode of producing perspiration has certainly the merit of novelty. At least, as far as tradition reaches, we know of nothing precisely similar to this, unless, indeed, we suppose that the custom of smothering unfortunate individuals affected with hydrophobia under a bed, as practised in some districts in this kingdom, may be considered in the same light, and may at an early period have been brought into this country from the forests of Germany by some wandering tribes. The Silesian peasant has extended this treatment to many other diseases, and it has been proposed as a mode of treatment in this highly-civilised country, being recommended by the hydropathists as a certain cure for "various ills which flesh is heir to." Fortunately, however, the water-doctors have not quite succeeded in depriving all the patients who fly to them for succour of common sense, and, therefore, this part of the treatment has *staggered*—literally so staggered some of them—that they could not be enchanted by the wand of the magician.

But to be serious. This said mode of producing perspiration, by putting a patient between a bed and a mattress, which is so frequently had recourse to by Priessnitz and his adherents, is a horrid mode of dealing with an invalid; and if one may believe report, not a few English people rebel against this Germanic custom. Not that the heroes who are engaged in these mountebank performances would ever allow this to transpire, but the truth will ooze out and find its way to the world; that some of the Malvern water-doctor's patients have rebelled against this *novel observance* is certain, whilst others have well nigh paid the debt of nature by imprudently persisting in this extraordinary course.

My object at present will be to reveal to your readers some of the secret performances. And first of all, in order that I may not be supposed to set down aught in malice, I will give verbatim an extract of a letter which has happened to fall into my hands, wherein one of the water-doctor's own patients graphically describes the goings-on at this English Graefenburgh, especially in reference to his own personal experience of what may be appropriately called a