

## **Agricultural chemistry / [George Cox].**

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# AGRICULTURAL CHEMISTRY.

BY GEORGE COX,

AUTHOR OF "SPECTACLE SECRETS,"  
"THE CHEMICAL DELECTUS," &c.

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## PREFACE.

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IN introducing the following pages to aid and assist in the attempts to render Agriculture more deserving the attention and pursuit of enquiring minds, by shewing that the successful cultivation of the soil is dependent upon a higher and better standard of education, the Author is only endeavouring to fill up, at least to a certain extent, a void which has for some time existed. The book may properly be divided into two parts: the first, treats of the properties of those bodies which either enter into the composition of a plant, or affect its condition. In this portion of the work will be found many original practical hints and suggestions for the manufacture and application of manures. The great consumption of soluble silica by the cereals and grasses must render any process which will procure a cheap and abundant supply of that great essential, a valuable addition to agricultural information. Under the head Silica, that information will be found; but it must be borne in mind that it is essentially necessary to employ sand of as



fine a grain as can be obtained. This fertilizer will be found an invaluable agent on those soils which yield a deficiency of straw. The fact that gypsum converts the very soluble carbonate of potash into the nearly insoluble sulphate of potash, will prove a truth worth knowing by those farmers who are in the habit of using wood ashes. The article headed Potash also contains some hints on the application of liquid manure to the land, which it may be worth while to consider before an expense is incurred in purchasing the apparatus necessary for its distribution. It is repeated here, with an increased conviction of its truth, that rain water and irrigation are the best and only necessary forms of applying liquid manure to the land. The nitrogenous phosphate manure mentioned at page 20, is cheap in its manufacture, and an efficient mode of employing urine in a convenient manner. A compost, consisting of equal parts, by weight, of burnt gypsum and putrified urine, well mixed with a third part of bone-dust, made some months ago, has retained all the ammonia of the urine, and is in a state exceedingly well adapted for drill or broadcast. In the chapter on Lime, will also be found some suggestions for the solidification of night-soil, well worthy of immediate attention. The application of night-soil to the land, in a proper form, would doubtless prove a great source of national



wealth. Let a trial be made by the enlightened and intelligent farmer, and a fair and impartial verdict be given. Almost all journals are open for communications of this nature, so that doubt need not exist any longer on the subject. It may be said that there *is no doubt*, as such manure has long been employed with advantage to the speculator, and its efficacy fully established. The answer is, that if its efficacy were admitted, and understood, it would be more generally employed. Now is a good time to give it the trial it demands; and a ton of it, sufficient for six or seven acres of land, can be manufactured at an inconsiderable cost. A hundred weight of gypsum is capable of rendering friable a hundred weight of mixed excrements. When the constitution of other manures is placed by the side of this, the economy of its application must be at once acknowledged. Nearly all the quotations made have been taken from Liebig's celebrated work, entitled "The Chemistry of Agriculture;" and, indeed, it was found impossible to write on the subject at all without going very frequently, and always with profit and satisfaction, to that fountain head.

The second part of the work treats entirely on analysis, and the mode of detecting the various simple and compound bodies which are found in soils, manures, and the ashes of plants. These analyses are



given with entire confidence, as most of the facts are taken from authors of known precision. Mr. Parnell's work, "On Chemical Analyses," is recommended as a great assistance to those who have not sufficient confidence in themselves. A person unacquainted with the first principles of chemistry, cannot, of course, expect to be in a condition to follow out the plans laid down for investigations of this kind. To such an one is recommended the immediate and attentive perusal of some elementary treatise on the subject, and a vigorous effort to make himself perfect in the various modes of manipulation necessary in chemical research. Where great nicety is not required, a chemical analysis is by no means so difficult a matter as many imagine; but, to succeed to any great extent in chemical investigations, great care and caution is always requisite. Earnest endeavours have been made to render "The Agricultural Test Chest," complete for the purpose intended, viz., that of enabling its possessor to successfully undertake analytical investigation connected with agriculture. The only exceptions to its being entirely complete, are the omission of a platinum crucible, a silver crucible, an agate mortar, and a Rose's Argand spirit lamp. Now, the latter would have increased the bulk of the chest too much to render it conveniently portable; and it fortunately happens that it may now be displaced by a smaller lamp,



since the announcement made by Liebig, that fluoride of ammonium is a more valuable and correct agent in disintegrating siliceous minerals, and for calculating the quantity of silica present, than the old method usually adopted. In the *Lancet* of September 7th, the following occurs in one of Liebig's lectures on organic chemistry. "A useful application of fluoride of ammonium has recently been discovered in mineral analysis. Fluoride of ammonium is easily obtained by saturating silico fluoric acid with carbonate of ammonia, and boiling; the hydrated silicic acid separates, and fluoride of ammonium remains in solution. This solution, when in a state of concentration, etches glass, in the same manner as fluoric acid. The fluorine goes off with the silica of the glass as fluoride of silicon. I need scarcely tell you, gentlemen, that such a solution ought not to be evaporated in glass or porcelain vessels, but in evaporating dishes made of lead, silver, or platinum. Fluoride of ammonium is of particular value as a means of rendering minerals containing silica soluble. The usual methods of fluxing are laborious; and, after all, uncertain. By adding dilute sulphuric acid and fluoride of ammonium to the mineral, all the silica is made to separate, and to go off as fluoride of silicon, whilst all the other constituents are obtained in solution, combined with the sulphuric acid."



The other articles omitted, were left out on account of the price, which would necessarily have made the chest at least two guineas higher; and, as they are not necessary in all operations, it was thought better to give the price merely, and then they can be included, if desired by the purchaser. A serviceable platinum crucible is worth from a guinea to 25s. The price of an agate mortar of sufficient size is about 14s., whilst a silver crucible or dish can be had for 10s. If the purchaser of the "Agricultural Test Chest" should not be sufficiently informed of the distinctive character and properties of those bodies most likely to come under his more frequent observation, he had better study the chapter on Qualitative Analysis, before he undertakes a complicated investigation. For instance, let the student precipitate a mixed solution of phosphate of soda and sulphate of soda, with a solution of chloride of barium. If the precipitate be washed and digested in dilute nitric acid, he will find that a portion of it is taken up, and a portion left untouched. He will learn by this that phosphate of baryta is soluble, and sulphate of baryta insoluble in nitric acid. These are the characteristics by which one body is distinguished from another; and, of course, it requires some little acquaintance with these characteristics, to enable an operator, to proclaim, with anything like certainty, what the nature and



composition of a body submitted to his judgment is likely to be.

In conclusion, the author has only to observe, that whatever errors the work may unfortunately contain, he has laboured hard to prevent them being there. There is one circumstance, however, to be considered, viz., that this is the first attempt to give practical men the means of establishing or refuting the opinions of others. Many works have been written on the subject of agricultural chemistry, but none of them have been bold enough to give plans and methods. All act on the suggestions of others, and enlarge and dilate upon acknowledged truths ; but it has been well observed, “one plain and correct mode of analyzing a soil, or the ash of a plant, is worth a hundred pages of mere verbiage and advice”





# AGRICULTURAL CHEMISTRY.

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THE object of this work is not to give a general description of the chemical properties of matter, or to unfold the leading features of each of the fifty-four ultimate elements of which matter under all its various forms is composed,—it is merely an endeavour to render still more popular, those new views, those new principles which have recently been given to the world by that profound philosopher *Liebig*, and which are, from their justice, soundness, and demonstrable truth, destined to displace the shoals of ignorance on which the science of Agriculture has been founded, and to build up a system on the firm foundation of ascertained principles and clearly defined scientific research.

To carry out the objects contemplated by this work, it is proposed to take into consideration the chemical, and other properties of those bodies only, which either enter into the composition of plants, or affect their growth and condition. The number of elements that form the constituents of vegetation is exceedingly small, when compared with the great diversity in their form, colour, taste, and other general physical properties.

We may properly divide these constituents into two kinds, the *organic* and the *inorganic*. The



*organic* constituents, viz. :—woody fibre, gum, sugar, starch, &c., must be again resolved into their original elements:—Oxygen, Carbon, Hydrogen, and Nitrogen. These four elements, and principally the first three, constitute the great mass of vegetation, but they are controlled or governed in their action to a great extent, by the presence of certain mineral constituents; so much so, indeed, that it has become a matter of certainty, that many species of plants could not exist without their presence. The ultimate elements of these *inorganic* constituents are,

|                  |                                                                                                   |                        |
|------------------|---------------------------------------------------------------------------------------------------|------------------------|
| OXYGEN .....     | Oxygen combined with the bodies,<br>named on the left, form those com-<br>pounds placed opposite. |                        |
| Aluminum .....   |                                                                                                   | Alumina                |
| Potassium .....  |                                                                                                   | Potash                 |
| Sodium .....     |                                                                                                   | Soda                   |
| Calcium .....    |                                                                                                   | Lime                   |
| Silicon .....    |                                                                                                   | Silica, or Flint Earth |
| Magnesium .....  |                                                                                                   | Magnesia               |
| Phosphorus ..... |                                                                                                   | Phosphoric Acid        |
| Iron .....       |                                                                                                   | Oxide of Iron          |
| Carbon .....     |                                                                                                   | Carbonic Acid          |
| Sulphur .....    |                                                                                                   | Sulphuric Acid         |
| Iodine .....     |                                                                                                   |                        |
| Chlorine .....   |                                                                                                   |                        |

These elements, under various combinations among themselves, are of the most frequent occurrence in the ashes of plants; indeed, more or less, most of them are always found to be present.

As plants can only obtain their nourishment from the atmosphere and from the soil, it follows that all the elements which a plant may contain, must have been derived from one of those two sources.



Now-a-days, fortunately, the question is completely set at rest; but only a very few years since, it was a question with many as to the origin of the alkalies and phosphates in plants, and various experiments were devised, such as sowing seeds in sand, small shot, and even flowers of sulphur, to ascertain whether or not those matters were formed by the vital power.

### OXYGEN.

OXYGEN is one of the most abundant and widely diffused elements that enter into the composition of the varied mass of matter which constitutes this globe; its action is constant and energetic, and almost all the various changes that ensue in the destruction of existing, and recomposition of new forms of matter, are owing to its unceasing agency. The atmosphere contains twenty-one parts in a hundred of this *gas*, and water consists of eight-ninths by weight of oxygen. To procure the gas, all that is necessary is, to heat the native black oxide of Manganese to redness in an iron retort or bottle, having a copper tube attached to its orifice. The gas is abundantly given off, and may be collected in a gas holder, or any convenient vessel. For the purpose of experiment, however, the best way is to put about half an ounce of chlorate of potash into a green glass retort, and to heat the salt nearly to redness by the application of a large spirit flame, when oxygen is given off most copiously, and of absolute purity; it can be received in bell jars over water, and retained there until wanted. Oxygen gas promotes combustion to an extraordinary degree; if a piece of wood, containing but a spark of fire, be immersed in a jar containing the gas, it immediately bursts into a flame, and burns with astonishing brilliancy. Iron or steel,



likewise, can be made to burn in oxygen gas. The surest mode of proceeding, is to procure five or six lengths of wire, to twist them loosely together, and then to dip the ends in sulphur; on igniting the sulphur, and thrusting the wire into the gas, the iron burns with the most beautiful scintillations; the bell jar ought to be rather broad, and to rest on a deep plate, containing water. Phosphorus burns with a light almost equal to that of the sun; but considerable caution is requisite in handling that substance, and a piece not larger than a pea, should be made use of. Oxygen gas is colourless, tasteless, and inodorous, and is always gaseous when not combined with other ponderable matter. Water dissolves not more than 3 or 4 per cent. of this gas, which seems to be quite sufficient for the respiration of those animals which live in that medium. It combines with all the other simple bodies, forming the most varied classes of compounds. Combined with some of the metals it forms a class of acids, while in combination with other metals it produces alkalies and oxides, or salifiable bases. Oxygen gas is also necessary for respiration: no animal can live in an atmosphere from which oxygen gas has been withdrawn; but though its presence is absolutely necessary to preserve existence, it is, in a state of purity, highly deleterious. The proportion in which it exists in the atmosphere is doubtless the best adapted for all our purposes, and were it to be withdrawn or altered, even to a trifling extent only, no long time would elapse before some monitor would apprise us of what had happened, and, should we neglect these premonitory warnings, the circulation and respiration would become affected, followed by weakness, insensibility, and death, within ten or twelve hours.



The same result happens in respiration as in combustion, viz.:—the disappearance of the oxygen, and the formation of new compounds, according to the nature of the body which happens to be presented to it. “The life of an animal is essentially connected with a continual introduction into its system of the oxygen contained in air; without air and oxygen animals cannot exist. In the process of respiration a certain quantity of oxygen is introduced into the blood by means of the lungs. The air which we respire contains this oxygen, and yields it to the constituents of the blood. The blood of an adult man removes from the air, at each respiration, about two cubic inches of oxygen. A man consumes in twenty-four hours, from ten to fourteen ounces of oxygen, in a year, hundreds of pounds. What then becomes of this oxygen? we take into our bodies, pounds weight of food, and pounds weight of oxygen, and nevertheless the weight of our body either does not increase to any sensible extent, or it does so in a much smaller proportion than corresponds to the food; in certain individuals (in old age) it experiences a continued reduction. It must be obvious, that this phenomenon is explicable only on the assumption that the oxygen and the constituents of the food exercise on each other in the organism a certain action, in consequence of which both disappear from the body. This is actually the case, for none of the oxygen inspired as a gas into the body remains in it; it is separated in the form of carbonic acid and water. The carbon and hydrogen which have combined with the oxygen are derived from the organism; but as these elements of the body are obtained from the food, it may be said that in their final form, all the elements of food capable of uniting



to oxygen are converted in the living body to organized compounds, or what expresses the same thing, they enter into combustion."

The products of this slow combustion are expelled from the body in various ways. The lungs and the skin emit carbonic acid and water, while the bladder and large intestines collect the nitrogenous and saline ingredients. As, then, there exists such an enormous consumption of oxygen by respiration and combustion, with an equivalent production of carbonic acid, how is it that the atmosphere is never found to vary from a constant and invariable ratio in the proportion of its constituents? this question will be answered in a future chapter.

## CARBON.

CARBON is an element that exists under a variety of forms, and enters into numerous combinations, forming highly useful compounds, important to the arts and agriculture; it occurs pure and chrystalized under the form of diamond, the hardest substance in nature; pure plumbago contains from 90 to 95 per cent. of carbon. Charcoal, coke, lamp-black, and ivory-black are all varieties of carbon contaminated with mineral ingredients or animal matter. Carbon is the most fixed and indestructible substance in existence; it is neither attacked by acids or alkalies, and bears the most intense heat of a furnace, in closed vessels, without fusing, or undergoing any alteration. Very pure charcoal may be formed by passing the vapour of turpentine or alcohol through a red-hot tube, when it is deposited in the form of a fine black



powder. The charcoal of commerce is made of wood, the wood is piled into cones of an immense size, and then covered with earth, leaving a few air holes open for the purpose of ignition, which having taken place, the holes are then closed. It is also obtained for the manufacture of gunpowder, by heating wood in large iron cylinders, having conducting tubes attached to them, through which passes a large quantity of inflammable gas, water, tar, and an impure pyroligneous or acetic acid. The latter is collected in large barrels, and, purified of its tar, becomes an article of immense consumption. Putrid water, passed through charcoal and sand, becomes quite sweetened, and perfectly wholesome. Charcoal of wood is also used for destroying colour, but animal charcoal, or ivory-black, is usually preferred. Charcoal possesses a very valuable property for the farmer, that of absorbing ninety times its own volume of ammoniacal gas. "The effect is owing to the peculiarly porous texture of the charcoal, which enables it, in common with most spongy bodies, to absorb, more or less of all gases, vapours, and liquids, with which it is in contact. This property is most remarkable in charcoal prepared from wood, especially in the compact varieties of it, the pores of which are numerous and small. It is materially diminished by reducing the charcoal to powder, and in plumbago, which has not the requisite porosity, it is altogether wanting. It seems that those gases which are most soluble in water are absorbed most freely. For this reason charcoal absorbs vapours more easily than gases, and liquids, than either." Charcoal in a state of powder must be considered as a very powerful means of promoting the growth of plants on heavy soils, and particularly on such as consist of argillaceous earth."



What is the origin of carbon in plants? As the atmosphere and the soil can be the only sources of its supply, it will be well to refer to the general composition of those two media. The atmosphere contains in one hundred parts, twenty-one of oxygen, and seventy-nine of nitrogen, and one part in a thousand of carbonic acid gas. It likewise contains watery vapour, and a certain amount of ammonia. The proportion of the latter has not yet been ascertained, but its existence has been infallibly and incontestibly proved. Oxygen, nitrogen, carbonic acid, and ammonia, then are the constituents of the atmosphere, but soils have a greater diversity in their composition, as will now be shewn.

All soils contain silica, alumina, and lime; indeed, they are to be considered as the basis of all soils, and from the preponderance of any particular ingredient, does it derive its physical character. Magnesia is almost always present in soils, but seldom in sufficient quantity to give rise to any peculiar physical feature; so likewise are certain saline constituents, and lastly, the remains of animal and vegetable matter in a state of decay. It will be proper in this place to give an estimate of the general ratio in which the elements of plants exist in their organism.



Composition of the produce of the land, dried in vacuo, at 212° Fahrenheit:—

|                    | Carbon. | H<br>hydrogen. | Oxygen. | Nitrogen. | Ashes. |
|--------------------|---------|----------------|---------|-----------|--------|
| Wheat.....         | 46.1    | 5.8            | 43.4    | 2.3       | 2.4    |
| Wheat Straw ....   | 48.4    | 5.3            | 38.9    | 0.4       | 7.0    |
| Oats .....         | 50.7    | 6.4            | 36.7    | 2.2       | 4.0    |
| Potatoes .....     | 44.0    | 5.8            | 44.7    | 1.5       | 4.0    |
| Turnips .....      | 42.9    | 5.5            | 42.3    | 1.7       | 7.6    |
| Peas .....         | 46.5    | 6.2            | 40.0    | 4.2       | 3.1    |
| Pea Straw .....    | 45.8    | 5.0            | 35.6    | 2.3       | 11.3   |
| Red Clover Stalk.. | 47.4    | 5.0            | 37.8    | 2.1       | 7.7    |

It will be seen by the above table, that carbon forms, in some of our most valuable edible plants, from above 40 to nearly 50 per cent. of the dried herb, for what is lost by their evaporation is simply water. Now where does all this carbon come from? It is assimilated by the plant, through the agency of its roots and leaves, from the carbonic acid of the atmosphere, and from that also which is generated from the decomposition of humus. That humus could not have been a primary source of the carbon existing in plants, is self evident, for it is a product of vegetation. Whence did the first vegetables derive their carbon? Without question, only from the atmosphere.



It is not denied that manure exercises an influence upon the developement of plants; but it may be affirmed, with positive certainty, that to its carbon is not due the favourable influence which it exercises, because we find that the quantity of carbon produced by manured lands is not greater than that yielded by lands which are not manured. In attempting to explain the origin of carbon in plants, it has never been considered that the question is intimately connected with the origin of humus. It is universally admitted that humus arises from the decay of plants, no primitive humus, therefore, can have existed—for plants must have preceded the humus. Let us put these two questions. What becomes of the immense quantity of carbonic acid generated by respiration and combustion? and how is it, that notwithstanding the continued and enormous consumption of oxygen, the atmosphere at all times—at all seasons—and under every variety of circumstances—contains invariably the same amount? These two questions are easily answered, and in such a manner as satisfactorily to set the question at rest for ever. Animal life is the great consumer of oxygen, and generator of carbonic acid. Vegetable life consumes carbonic acid by assimilating its carbon, and emitting the oxygen, and thus an equilibrium is constantly and harmoniously established. “It is quite evident that the invariable quantities of carbonic acid and oxygen in the atmosphere, must stand in some fixed relation to each other; a cause must exist which prevents the increase of carbonic acid by removing that which is constantly forming; and there must be some means of replacing the oxygen removed from the air, by the processes of putrefaction and combustion, as well as by the respiration of animals. Both these causes are united in vegetable life.”



The true cause is the assimilation, by the vegetable of the carbon of the carbonic acid, and the consequent liberation of its oxygen. For every volume of carbonic acid thus received, the atmosphere regains an equal volume of oxygen. That plants possess the power of decomposing carbonic acid, may be proved in the most easy manner. The leaves, and other green parts of plants, possess this property, independently of the plant itself, for if, after being separated from the stem, they are placed in a bell jar of water, containing carbonic acid, and exposed in that condition to the sun's light, oxygen gas is emitted, and the carbonic acid disappears. "Plants thus improve the air by the removal of carbonic acid, and the renewal of oxygen, which is immediately applied to the use of man and animals. Thus vegetable culture heightens the healthy state of a country so that a previously healthy country would be rendered quite uninhabitable, by the cessation of its cultivation." These changes take place only during the presence of solar light. At night the assimilation of carbon, and the liberation of oxygen, ceases. Without the presence of light, vegetable organization has not the power to decompose carbonic acid.

## HYDROGEN.

HYDROGEN, when uncombined with other matter, always exists in the gaseous state. It is colourless, tasteless, and inodorous, a powerful refractor of light, and is the lightest body in nature. It is neither acid nor alkaline, and water dissolves only



about  $1\frac{1}{2}$  per cent. of its volume. Hydrogen gas is inflammable in the highest degree, and used formerly to be known under the name of inflammable air.

The best mode of preparing it for the purpose of experiment, is to pour some sulphuric acid, diluted with five parts of water, on some granulated zinc, or iron nails, in a glass retort, and to receive the gas in bell jars, over water; or for common purposes it may be received at once into pigs bladders.

Hydrogen gas is a non-supporter of combustion, for a lighted taper may be thrust into a confined volume of it, and it will be extinguished; but if it be previously mixed with half a volume of oxygen gas, or four or five volumes of air, and then ignited, it will explode with tremendous violence. When a jet of hydrogen gas is made to play on a ball of platinum sponge, the metal becomes red hot, and ignites the gas. An elegant lamp is constructed on this principle. A large quantity of heat is evolved during the combustion of hydrogen gas; indeed, the most intense degree of heat yet procurable is obtained by the combustion of hydrogen in oxygen gas. There have been a variety of instruments constructed for the purpose of safely using the gases in a mixed state, but the one proposed by Mr. Hemming seems to be as simple and as safe as any. I would refer the reader to "Dr. Turner's Elements of Chemistry" for that general information which it is so desirable for him to possess, but which it is beyond the scope of this work to furnish; though it has been thought desirable to give a broad outline of the general properties of the matter under consideration.



When two volumes of hydrogen and one of oxygen gas are mixed together and exploded, a total condensation ensues, and water is formed. It is from the decomposition of water that the hydrogen of plants is obtained. "From their generating caoutchouc, wax, fats, and volatile oils containing hydrogen in large quantity, and no oxygen, we may be certain that plants possess the property of decomposing water, because from no other body could the unazotized substances obtain their hydrogen. Water is a remarkable combination of two elements, which have the power to separate themselves from one another in innumerable processes, in a manner imperceptible to our senses, while carbonic acid, on the contrary, is only decomposable by violent chemical action."

The influence of water on vegetation is not confined to its being merely a source of hydrogen, for, indeed, without its presence, many substances necessary for the existence of plants, could not be assimilated.

"However great may be the supply of food in a soil, it will be sterile for most plants, if water be deficient. At certain seasons of the year rain fructifies our fields ; seeds neither germinate or grow, without a certain quantity of moisture. The action of rain is much more striking and wonderful, to the superficial observer, than is that of manure. For weeks and months, the influence which it exerts on the crops, is appreciable."

Water, doubtless, plays a decided part in the growth of plants, by virtue of its elements ; but, at the same time, it is a mediating member of all



organic life. "Plants receive from the soil, by the aid of water, the alkalies, alkaline earths, and phosphates, necessary to the formation of their organs. If these substances, which are necessary for the passage of atmospheric food into the organism of the plant, be deficient, its growth must be impeded. Its proper growth, in dry seasons, stands in exact relation to the quantity of the substances taken up from the soil during the first period of its developement; but on a soil poor in mineral food cultivated plants do not flourish, however abundantly water may be supplied to them."

In all analyses of vegetable matter, the water is previously expelled by exposing the substance intended for examination to a temperature of 212 degrees, till it becomes thoroughly exsiccated. A table is subjoined, for the purpose of shewing the amount of water, contained in different vegetables in their normal state:—

|                | Substance Dried. | Water. |
|----------------|------------------|--------|
| Wheat.....     | 0.855 .....      | 0.145  |
| Rye.....       | 0.834 .....      | 0.166  |
| Oats.....      | 0.792 .....      | 0.208  |
| Potatoes ..... | 0.241 .....      | 0.759  |
| Turnips .....  | 0.075 .....      | 0.925  |
| Beet .....     | 0.122 ... ..     | 0.878  |
| Peas .....     | 0.914 .....      | 0.086  |
| Clover.....    | 0.790 .....      | 0.210  |



Water possesses one peculiar property, which is of great advantage to the farmer, viz:—that of becoming solid, at 32 degrees temperature, and at the same time expanding greatly in bulk. Huge trees are frequently torn asunder, and waterpipes are burst, from the immense force exerted by this expansive power. So, likewise, large clods of earth are frequently mouldered by this means, and a stiff soil, is to a great extent, made more pervious.

## NITROGEN.

NITROGEN, when uncombined, always exists in the gaseous state. It is principally distinguished by its negative qualities, being colourless, tasteless, and inodorous, incombustible, and incapable of supporting combustion. Nitrogen enters into the composition of all the products of the animal kingdom, from the decomposition of which it is given off in combination with hydrogen, under the form of ammonia. Combined with oxygen it forms a variety of compounds, such, for instance, as nitric acid, or aquafortis, laughing gas, and nitric oxide gas, which of itself is completely colourless, but when exposed to the air becomes orange coloured, from imbibing another portion of oxygen. Nitrogen likewise constitutes 4-5ths of the atmosphere, but it appears to act only as a medium for the agency of the more active ingredients, or as a diluent to their too energetic activity.

Nitrogen is prepared for experimental purposes, by burning phosphorus in a confined volume



of air, when the oxygen is withdrawn, by the burning phosphorus, and a fixed body formed, called phosphoric acid. On immersing the vessel in water and opening the orifice, the water rushes in to supply the place of the consumed oxygen, and, dissolving the phosphoric acid, leaves the nitrogen nearly pure.

Plants could not attain maturity without the presence of matter containing nitrogen, and as it has been satisfactorily proved that plants cannot assimilate nitrogen in the simple state, the source of it as an element of vegetation, must exist in another shape, it must be a compound body. Saussure says, "It is certain, from the experiments which have been made on this subject, that plants receive their nitrogen only from such animal and vegetable extracts, or from such ammoniacal vapours as they may find in the soil, or extract from the air."

Does the atmosphere contain a sufficiency of ammonia for the production of the nitrogenous constituents of plants? "All the analyses of atmospheric air hitherto made, have failed to demonstrate the presence of ammonia, although, according to our view, it can never be absent. Is it possible that it could have escaped our most delicate and most exact instruments? The quantity of nitrogen contained in a cubic foot of air, as Ammonia, is certainly extremely small; but, notwithstanding this, the sum of the quantities of nitrogen, from thousands and millions of dead animals, is more than sufficient to supply all those living at one time with this element."

The exact proportion in which ammonia exists in the atmosphere, has not been ascertained,



indeed it varies according to circumstances, but any one may satisfy himself that there it does exist. The small quantity of air usually employed for an analysis, contains so inappreciable a quantity, that it is impossible to prove its presence by the usual tests; but by collecting rain water as it falls, especially after long continued dry weather, we possess ourselves of all that which was diffused previously over a large area, because ammonia is so soluble in water, that it is sure to be taken up by it. Liebig's experiments in the Giessen laboratory have placed the presence of ammonia in rain water beyond doubt. He distilled some hundreds of pounds weight of fresh fallen rain water in a copper still, and on evaporating the first two or three pounds, after adding a very little muriatic acid, a distinct chrystallization of sal ammoniac was obtained. The chrystals had always a brown or yellow colour. It is likewise always present in snow water: chrystals of sal ammoniac were obtained by evaporating in a vessel containing muriatic acid, several pounds weight of snow gathered from the ground in March, when the snow had a depth of ten inches. Ammonia was set free from these chrystals by the addition of hydrate of lime, and the inferior layers of snow contained a decidedly greater quantity than those upon the surface.

“The employment of animal manure in the cultivation of grain, and the vegetables which serve for fodder for cattle, is the most convincing proof that the nitrogen of vegetables is derived from ammonia. The quantity of gluten in wheat, rye, and barley, is very variable, and these kinds of grain, even when ripe, also contain this compound of nitrogen in very different proportions. Proust found French wheat to contain 12.5 per cent. of gluten; Vogel found that



the Bavarian contained 24 per cent.; Davy obtained 19 per cent. from winter, and 24 from summer wheat; from Sicilian, 21, and from Barbary wheat, 19 per cent. The meal of Alsace wheat contains, according to Boussingault, 17.3 per cent. of gluten; that of wheat grown in the Jardin des Plantes, 26.7; and that of winter wheat, 33.3 per cent. Such great differences must be owing to some cause, and this we find in the different methods of cultivation. An increase of animal manure gives rise not only to an increase in the number of seeds, but also to a most remarkable difference in the proportions of the nitrogenous substances, such as gluten." Human urine is a most powerful manure for vegetables rich in nitrogen; but it is astonishing with what facility a manure can be manufactured for any specific purpose. If a nitrogenous phosphate manure is wanted, mix one part of bone dust well with four parts of putrified urine, and solidify the two with well burnt gypsum. Gypsum will be found by experience to be the most valuable and economical agent the farmer can hope to possess. The manure I have just named must be invaluable for clover and peas; and grass land would not pay less for its exhibition. In the *Mark Lane Express* appeared, some months ago, a peculiar statement, to the effect that the writer could never get a crop of wheat from a certain field; the straw was always good, but directly the blossoming time came the whole plant died away. I regret that I had not at the time an opportunity of analyzing that particular soil, as I am persuaded the failure in the formation of the ears arose from the absence of the phosphates necessary for the production of the grain. A plant cannot grow if its proper food be absent, any more than the child or the man can thrive and be-



come vigorous if wholesome sustenance is withheld. How necessary therefore it becomes to make ourselves acquainted with the actual condition and composition of a soil before we endeavour to obtain any species of crop from it. Should the writer of the communication in the *Mark Lane Express* happen to read this book, I hope he will try the nitrogenous phosphate manure I have mentioned, and he will find the result will be satisfactory.

There is one important fact in connection with the employment of ammoniacal salts as manure, which ought to be more generally known, viz., that caustic lime, and wood ashes, decompose the salts of ammonia, and render their base volatile, yet I frequently read of those two substances being mixed with guano! and more especially have wood ashes been recommended by correspondents in the *Sherborne Journal*, and other newspapers circulating in agricultural districts. Nothing can be more erroneous and opposed to reason than the practice recommended. Take the analyses of two samples of guano, from Liebig, and study their composition, the folly of mixing lime or potash with guano will be at once acknowledged. Indeed, smelling-bottles are filled on this very principle. Sal ammoniac, or muriate of ammonia, is well mixed with an equal weight of salts of tartar, or carbonate of potash, and put into a bottle with some perfume; decomposition immediately commences, and a supply of volatile ammonia is constantly at hand till it becomes exhausted.



|                                         | Guano,<br>No. 1. | Guano,<br>No. 2. |
|-----------------------------------------|------------------|------------------|
| Muriate of Ammonia.....                 | 6.500            | 4.2              |
| Oxalate of Ammonia.....                 | 13.351           | 10.6             |
| Urate of Ammonia.....                   | 3.244            | 9.0              |
| Phospate of Ammonia.....                | 6.250            | 6.0              |
| Sulphate of Potash.....                 | 4.227            | 5.5              |
| Sulphate of Soda.....                   | 1.119            | 3.8              |
| Phosphate of Soda.....                  | 5.291            |                  |
| Phosphate of Magnesia and Ammonia....   | 4.196            | 2.6              |
| Phosphate of Lime.....                  | 10.000           | 14.3             |
| Oxalate of Lime.....                    | 16.360           | 7.0              |
| Silica.....                             | 5.800            | 4.7              |
| Loss, consisting of Water, Ammonia, &c. | 22.718           | 32.3             |

If, then, the virtues of guano as a manure are at all dependent upon the salts of ammonia, the addition of wood ashes, or lime to it, will detract from its excellence, just in the proportion that it decomposes those salts, and they amount, on an average, to 30 per cent.

We have now given a description of those elements which form the great mass of vegetable life, viz., their organic constituents, and the sources from whence they are derived; for further and fuller information we can but refer to Liebig. The intention of this treatise is to convey to the reader sound information in a condensed form, to direct his attention to those prominent facts upon which successful and profitable farming must for the future be founded, and to point out in intelligible language to the purchasers of the Agricultural Test Chest, those leading principles which it is for their advantage clearly to understand.



The inorganic or mineral constituents will be treated of in the following order:—

## POTASH AND ITS SALTS.

THAT which is generally known among farmers and the commercial world under the name of potash, is an impure article, brought to this country in immense quantities from Russia and America. It is obtained by burning land plants, lixivating, or washing their ashes, and evaporating the solution to dryness. The ingredients not taken up are for the most part composed of silica and insoluble salts. The article as thus prepared, is a carbonate of potash, and contains sulphate, muriate, and silicate of potash, besides at times numerous other impurities, in considerable quantities.

The potash of chemists is a very different article, and possesses very active properties, being alkaline in the highest degree. The bodies to which the term alkaline is attached, possess peculiar properties. They change the blue juices of vegetables to a green (with the exception of litmus), and the yellow tints they transform to a brown. They possess a very acrid taste, and have the property of rendering oils miscible with water.

The alkalies are four in number, viz., potash, soda, lithia, and ammonia. The first three are called fixed alkalies, because it requires the most intense degree of heat to volatilize them; the last is called volatile alkali, because at the natural temperature it exists in the gaseous state. There are four other bodies



also possessed of alkaline properties, viz., baryta, strontia, and lime very strongly, while magnesia is much less active; but as these bodies possess general properties more nearly allied to the earths, they are generally retained in that list, and are called alkaline earths. The alkalies are powerfully caustic, and combine with acids, forming numerous salts, of immense value to the arts and agriculture. The potash of chemists, called by them pure potash, or caustic potash, is a compound body, composed of a metallic base, termed potassium, and oxygen, in the ratio of 39.15 to 8. Potassium is lighter than water, has a silvery whiteness, and burns with a brilliant flame when thrown into that fluid. The water is decomposed, its oxygen combining with the potassium, forms solution of potash, but with such an intense chemical action, that enough heat is given off to ignite the liberated hydrogen. The hydrogen burns with the characteristic purple colour which all the salts of potash exhibit, when in contact with combustible matter at a high temperature.

Pure potash is obtained by exposing equal parts of slacked lime and pure carbonate of potash, to the action of twelve parts of water, kept boiling for ten minutes, and when the solid matter has subsided, the clear solution is poured off, and evaporated rapidly to dryness in a silver alembic. Pure potash acts powerfully on silica, rendering sand in the space of a few months exceedingly soluble. In the chapter on silica, an excellent method of forming a cheap and valuable manure is treated more fully.

Carbonate of potash, also known under the names of pearl ash, salt of tartar, and salt of worm-



wood, is a product of nearly all land vegetation, and gives origin to a class of plants, called potash plants. The ashes of meadow clover, consist of nearly 40 per cent of the salt of potash and soda; those of maize straw contain 71 per cent; turnips 81.60, beet root 88.00, the tubers of potatoes 85.81, while the potatoe herb contains only 4.20 per cent. In many instances potash is replaced by soda, and lime by magnesia, but this part of the economy of vegetation is yet open to investigation, and perhaps the best mode of enquiry will be to confine our labours to a strict examination of the saline constituents of a similar plant grown under every variety of condition and circumstances. Liebig states, "that very little difference is observed in the composition of the ashes of the same plants even although they are grown on different soils. Silica and potash form invariable constituents in the straw of the gramineæ, and in their seeds there are always present phosphate of potash, and phosphate of magnesia: a large quantity of lime occurs in the straw of peas and in clover. We know further that in certain kinds of plants, the potash is replaced by soda, and the lime by magnesia." As the carbonate of potash under the form in which it is imported into this country may prove a cheap source for its employment as a fertilizer, I should recommend its conversion into a less soluble form, previous to its application to the land. I mixed two ounces of salts of tartar with four ounces of dried gypsum, and making them into a paste with water, left them at rest for about a month. At the end of that time a portion of the mass was pulverized and boiled in pure water, but it displayed not the least alkalinity whatsoever; in fact. when the solution became cool, chrystals of sulphate of potash were plentifully depo-



sited, and the sulphate of lime had become converted into chalk. Sulphate of potash is a much better form too for its exhibition, than the carbonate, as it is a question, whether plants assimilate their potash from the carbonate, and it is likewise a much less soluble salt. Carbonate of potash dissolves in less than its weight of water, while the sulphate requires sixteen times its weight at 60°.

It may not be deemed unimportant to state a few facts here in relation to the application of liquid manure to the soil. The virtues of liquid manures must be evanescent, unless the soil contains a sufficiency of some ingredient to decompose and fix the soluble materials, and if the soil does so, of what use is it to apply the manure in that form? Take putrified urine or the drainings of dunghills mixed with some soluble salts dissolved in that medium. Now, should this manure be sprinkled over land deficient in sulphate of lime, nearly the whole of its ammonia would be lost in the atmosphere, and its other soluble salts left to the mercy of the first shower of rain. The farmer will learn eventually that that form of manure is best which is but just soluble in water, and that any plan which may be proposed in order to effect that object, will be valuable in proportion as it approximates to it. Most persons are unaware of the rapidity with which surplus water percolates the soil, especially on drained lands; consequently, all the soluble materials are carried away; and, what is of more importance, that water which a soil now contains is displaced by the next portion which makes its appearance. No soil can retain more than a certain quantity of water; indeed, the quantity it can retain is governed by its hygrometric power, and its power



of capillary attraction, therefore all surplus moisture must give way to the law of gravitation, and descend lower from the surface. I contend, then, that the more soluble a manure is, the sooner it is liable to be carried beyond the influence of the roots, and that its economy depends materially upon the state of the weather which follows its application. That manures are generally applied in too concentrated a state, I think can be easily shewn, if we may be allowed to refer to nature's operations. It cannot be doubted that rain water exercises a beneficial influence on vegetation, decidedly superior to pump or river water; now this beneficial influence can be attributed only to its containing ammonia, and yet the ammonia it possesses exists in so diluted a state, that the usual mode of testing its presence has to be departed from. "If a pound of rain water contains only one-fourth of a grain of ammonia, then a field of 26.910 square feet must receive annually upwards of eighty lbs. of ammonia, or sixty-five lbs. of nitrogen; for by the observations of Schubler, the annual fall of rain must be about 2.520.000 lbs. This is much more nitrogen than is contained in the form of vegetable albumen and gluten, in 2650 lbs. of wood; 2500 lbs. of hay, or 200 cwt. of beet root, which are the yearly produce of such a field, but it is less than the straw, roots, and grain of corn, which might grow on the same surface would contain."

Plants require an equal and continuous supply of food, for it is not to be doubted that the powers of their organism are limited to a certain capability, and that their functions are not capable of assimilating the elements of which they are composed beyond that limit; therefore to supply them



with an undue proportion, is not only uneconomical but injurious. Look how niggardly nature apparently is in furnishing potash and silica to plants, and yet from such a scanty source, conditions being favourable, they obtain whatever is requisite. All natural manures are highly insoluble in water, and it is only when that agent becomes impregnated with carbonic acid, that those materials become soluble to any extent. Depend upon it the best liquid manure is rain water; it enables a plant to gather from the soil its inorganic constituents, and conveys at the same time a plentiful supply of nitrogen. In the case of wheat crops, I have no doubt it would be much more advantageous to manure the land with two separate applications, the first with the soluble silicate manure, previous to sowing the grain, and the second, about March or April, with the nitrogenous phosphate manure.

I will now go back to the consideration of the best form of applying potash to the soil. If potash only is required to be exhibited, then the mixture of plaster of Paris and commercial potashes made into a paste with water, and suffered to harden, is a very effectual and economical form; two parts of plaster to one of ashes answers well. As was before stated the resulting sulphate of potash is one of the most insoluble salts of potash, and besides, it is more than probable, as will be shewn in a future chapter, that plants obtain their sulphur from the alkaline sulphates.



## SODA.

SODA is an alkali possessed of very similar properties to potash; the former is called the mineral alkali, the latter the vegetable alkali. Soda is also a metallic oxide, being composed of 23.3 parts of a metallic base, sodium, and 8 oxygen. Sodium does not ignite when thrown into water, but intense chemical action ensues if a little nitric acid be previously placed in the water, it then burns most brilliantly, with a yellow flame. Soda is easily distinguished from other alkaline bases by the following characteristics:—1st. It yields, with sulphuric acid, a salt, which by its taste and form is easily recognised as Glauber's salts, or sulphate of soda. 2ndly, All its salts are soluble in water, and are not precipitated by any re-agent. 3rdly, On exposing its salts by means of platinum wire, to the blowpipe flame, they communicate to it a rich yellow colour.

The soda of commerce, known to the Germans under the name of natron, imported into this country from Spain as barilla, and also manufactured largely in Scotland, in the form of kelp, is procured by burning sea weeds, particularly the *Sal Sola* and the *Sali cornia* Herbacea weeds, lixiviating their ashes, and evaporating the solution. The purest barilla always contains sulphates of potash and soda, and chlorides of potassium and sodium. A purer carbonate is prepared by heating a mixture of sulphate of soda, sawdust, and lime, in a reverberating furnace; by the action of carbonaceous matter, the sulphuric acid is decomposed, its sulphur partly uniting with calcium.



and partly being dissipated in the form of sulphurous acid; while the carbonic acid which is generated during the process unites with the soda, and the carbonate of soda is then obtained by lixiviation and chrySTALLIZATION. Pure caustic soda is made from this carbonate by treatment with lime, in exactly the same manner as before described in the chapter on potash.

Common salt is a compound of chlorine and sodium, and is of immense value to the farmer. When salt and slaked lime are mixed together, well covered over, and allowed to remain undisturbed for a few months, they form a valuable compost, especially adapted for lime plants. A partial decomposition ensues, and the compost contains, besides lime and salt, chloride of calcium and caustic soda. In soils deficient of alkaline constituents it would likewise prove a valuable agent; but I should judge it to be of much greater service when applied to peas, clover, and barley, than to any of that class of plants denominated potash plants. It is true, soda does in some cases take the place of potash, for their action is undoubtedly similar, yet an experiment related in page 72 of Liebig (third edition), seems to prove that even sea plants growing on land prefer potash to soda. "Seeds of the *Salsola Kali*, when sown in common garden soil, produce a plant containing both potash and soda; while the plants grown from the seeds of them contain only salts of potash, with mere traces of muriate of soda." If I may venture to surmise, I imagine that the reason why potash exists in greater abundance than soda in land plants, may be owing to the facility with which it can adapt itself to the functions of the plant. If particular functions in plants cannot be carried on without the presence of alkalies,



there must exist in plants a power of withdrawing them from the surrounding medium. Now, whatever that power is, it is probable that it exerts an affinity for potash greater than for soda, for there are many soils which contain a greater abundance of soda than potash, yet there are few ashes of plants that do. Marine plants grow in a medium which contains, I believe, fourteen or fifteen times more soda salt than potash, and the points of contact being so much more numerous, the plant finds a greater facility in assimilating the soda. It is well known that chemical affinities are often destroyed by a large quantity of some less energetic agent being present; as, for instance, a small quantity of sulphate of baryta, by a large quantity of carbonate of potash. It is offered as a suggestion, because should this be found to be the case, the economy of manures will be much more perfect. "The following facts are of the greatest significance and value to agriculture; viz., that the newly developed sprouts, leaves, and buds, or, in other words, those parts of the plants possessing the greatest intensity of assimilation, contain the greatest proportion of alkaline bases; and that the plants richest in sugar and starch, are no less distinguished for their quantity of alkaline bases and organic acids. As we find sugar and starch accompanied by salts of an organic acid, and, as experience proves that a deficiency of alkalies causes a deficient formation of woody fibre, sugar, and starch, and that, *on* the contrary, a luxuriant growth is the consequence of their abundant supply, it is obvious that the object of culture, viz., a maximum crop, cannot be obtained unless the alkalies necessary for the transformation of carbonic acid into starch and sugar are supplied in abundant quantity, and in a form fit for assimilation by plants."



Where an alkali is necessary for the organism of plants to perform their functions, soda will supply the place of potash, and frequently does; the question as to its employment as a fertilizer, is a mere consideration of economy and circumstance; but the mode in which it is to be applied to the soil deserves some little attention. Sulphate of soda is, perhaps, the best form for its exhibition; and where a soil contains a sufficiency of gypsum, common salt will then prove a good manure. Gypsum and common salt are mutually decomposed when they come in contact, and sulphate of soda with chloride of calcium formed. Now, chloride of calcium is one of those salts which attract moisture with avidity from the atmosphere, and is a salt known to be favourable to vegetation; it likewise possesses the power of fixing ammonia, and, in dry seasons, has proved to be an invaluable agent. But where a soil does not contain gypsum in sufficient quantity to decompose the salt, then the best plan is to well mix the salt with double its weight of gypsum, previous to its application to the soil. Damp weather is best suited for applying it, as decomposition does not take place without the presence of water.

“A solution of gypsum, containing common salt or chloride of potassium, such as sea water and the water of most springs, may be viewed as a mixture of an alkaline sulphate with chloride of calcium. From this it must be obvious, that when we furnish to a plant at the same time both gypsum and common salt, we actually furnish, by such a solution, the same materials that we should do if we supplied a mixture of sulphate of soda and chloride of calcium. In order to form the constituents containing sulphur,



that element and the alkali must be retained by the plant, while the chlorine and calcium will be expelled by the roots. We know that this process does actually take place in the case of marine plants.

The other compound of soda, which is of interest to the agriculturist, is the nitrate. Nitrate of soda has been used very extensively for some years, and its influence on grasses and white crops has been clearly decided. The mode of its action, however, on vegetation, has not yet been accounted for, but it certainly is worth every endeavour to fathom it. It is all very well for farmers to exclaim, what is the good of learning the *reason* of a thing, when you know it *will* do it? The good is, that it enables you, perhaps, to accomplish the same object at a less expence. For instance, who now-a-days would go to the expence of transporting to any distance a large bulky material, when it might be condensed into a compass one or two hundred times less, without the loss of a single good property? This condensation is accomplished now in many cases, and it has been effected only because experiment and enquiry discovered first what this bulky material contained, which gave to it its value; and, secondly, the means of separating the valuable elements so as to render them more easy of carriage, and consequently more economical in application. The time has arrived—ignorance cannot put it back, nor obstinacy prevent its advancing—when all who are interested in the produce of the soil, and who would prefer a full yield of its various growths to a lean and scanty harvest, must accept the aid and assistance which science proposes. The demonstrable truths of chemical investigations must displace crude theories and fluctuating opinions, and



the laboratory be regarded as the storehouse from which the agriculturist shall obtain the materials for safely and profitably carrying on the operations of the farm.

### SILICA, OR FLINT EARTH.

THIS compound exists very abundantly as a constituent of soils and rocks. It forms the chief ingredient in sandstones and flints, and rock chrystal may be considered as a specimen of pure silica in a chrystalline state. It is composed of a non-metallic combustible body, termed silicon, and oxygen, in the proportion of 48.4 of the former to 51.6 of the latter. It is very infusible, but melts sooner than lime or magnesia, before the flame of the oxy-hydrogen blow-pipe. It possesses the properties of an acid, and is called by chemists, silicic acid, for it combines with many bases, forming neutral compounds, and displaces carbonic acid by the aid of heat from the alkalies.

The compounds of silica and the alkalies are easily obtained by heating the mixed ingredients till they fuse in a large hessian crucible. The mass heaves and swells up from the emission of carbonic acid, but at last settles down to a smooth transparent glass. The nature of this glass depends materially on the proportions used, but when three parts of alkali to one of sand are employed, the glass becomes completely soluble in water, from which property it has been for many years known under the name of soluble glass. It is from this soluble glass that pure silica acid is obtained, and in the following manner :



to a rather concentrated solution, add muriatic acid to saturation, and then heat the mixture till it becomes dry. The silica remains as an insoluble powder, and has to be well washed with boiling distilled water on a filter, to free it from adhering chloride of potassium. Let it remain on the filter until the drainage is complete, and then put it in an oven to dry, when it becomes fit for any purpose required.

The great importance of silica, or flint earth, to the agriculturist, is the fact, that it is a constituent of many plants, which could not exist without its presence. "The ashes of good meadow hay, consisting of a mixture of the ashes of potash, lime and silica plants, gave in one hundred parts (Haidlen),

|                                 |      |
|---------------------------------|------|
| Silica.....                     | 60.1 |
| Salts of lime and magnesia. .   | 28.6 |
| Salts of potash and soda. . . . | 5.5  |

while the ashes of wheat, oat, barley, and rye straw, contain above 60 per cent of silica."

Silica, in its chrySTALLINE state, or in the form of sand, is quite insoluble in water; and so, indeed, is precipitated silica, when it has been dried; yet, to have formed a constituent part of vegetation, silica must have been presented to the plant in a soluble form. It will be well worth while here to enquire further into the properties of this peculiar earth. "All silicates soluble in water are decomposed by acids. If the solution of the silicate contains silica corresponding to more than 1-30th the weight of the water, the addition of an acid causes the formation of a precipitate of a very gelatinous appearance; but if the solution contains less silica than the above pro-



portion, no precipitate is formed on the addition of an acid, the whole remaining perfectly clear. This circumstance proves that silica, in the state in which it is precipitated by an acid, possesses a certain degree of solubility in pure water; indeed, by washing with water, the gelatinous precipitate of silica formerly alluded to, its volume diminishes, and silica may be detected in solution, by evaporating the water which has passed through. From these facts, we perceive that silica possesses two distinct chemical characters. In the form in which it is separated from a silicate, it possesses quite different properties from those which it has when in the state of sand, quartz, or rock crystal. When sufficient water is present during its separation from a base, to effect its solution, the whole remains dissolved. In certain conditions, silica is more soluble in water than gypsum." The knowledge of such facts as these must eventually place farming on a basis very different from that on which it at present rests. The knowledge gained by merely individual experience, is proved to be "not all-sufficient." That which sound thinking men now require, is the test of trial, guided by well considered experiment, upon rational principles, and a love of truth.

It will be perceived that the mere abundance of silica in a soil, is no guarantee that the soil is capable of furnishing a sufficiency of that earth to a silica plant; the condition, not the amount in which silica exists, is of real importance to the farmer. There can be no doubt, I think, that, provided a sufficiency of phosphates be present, the luxuriance of the straw in the spring must have a material effect on the future crops of grain. The more healthy and vigorous the



stem, the deeper and wider will the roots extend, and consequently a larger surface be obtained for the supply of the wants of the plant after and during the blossoming time. What more important, then, for a grain crop, than that it should be well supplied in the early part of the year with soluble silica, or rather with that earth in a fit state for assimilation. It is true, that some soils contain a sufficiency of silica in the desired state for all required purposes, but a vast deal of otherwise good land is completely exhausted. I will subjoin a cheap and effectual mode of preparing silica for deficient soils, but it has not yet been stated how the silica has been rendered soluble in soils which grow cereal crops. This question remains to be answered.

A casual glance at an old building, whether of stone or brick, will shew at once, that even those hard materials are not capable of withstanding certain influences ; for though the agent may be slow in operation, it is sure in its action, and the hardest granite will eventually yield to its power. "Silica being an acid of a very feeble character, the decomposition of the soluble silicates is effected even by carbonic acid." "We find numerous examples in the inorganic kingdom of a continued and systematic process of decomposition of the silicates contained in the various kinds of rocks. This decomposition is effected by the action of carbonic acid and of water." Polstorff and Wiegmann boiled some white sand with a mixture of nitric and muriatic acids ; and, after completely removing the acid by washing the sand with water, they exposed it, thus purified, to the action of water saturated with carbonic acid gas. After the action of



thirty days, this water was subjected to analysis, and found to contain in solution, silica, carbonate of potash, and also lime and magnesia; thus proving that the silicates contained in the sand were unable to withstand the continued action of water containing carbonic acid, although the same silicates had resisted the short action of aqua regia.

“It is known that felspar is unable to resist the solvent action of water and carbonic acid, although it is scarcely affected by being left in contact with cold muriatic acid for twenty-four hours.” “All minerals and rocks containing silicates of alkaline bases, are incapable of resisting the continued solvent action of carbonic acid dissolved in water; the alkalies, with lime and magnesia, will either dissolve alone, or the former will enter into solution with silica, while the alumina remains behind mixed or combined with silica. In the process of the disintegration of rocks, therefore, the alkalies, potash and soda, lime and magnesia, are dissolved and carried away by water, along with silica and alumina, and the residue gradually lessens in the amount of the alkalies originally present, but as long as the mineral contains a trace of an alkali, or of any base soluble in carbonic acid, water containing that gas continues to exercise an action upon it, and effects a progressive disintegration of its constituents.”

Thus is given a rational explanation of the formation of soils, and of the gradual decay of our structures and monuments, and thus also, for the first time, is given a true solution of the manner in which fallow operates.



“Carbonic acid gas and water, then, are the agents employed by nature to effect these changes, and as carbonic acid and water are continually present in soils, and more particularly in cultivated soils, a supply of flint earth in a soluble state is thus constantly being formed for the wants of the growing plant.”

Almost all soils, indeed all fertile soils, contain alkaline silicates, and these soils have had their origin from the disintegration of rocks acted on by the influences of carbonic acid and water. All cultivated soils are continually losing a percentage of these soluble silicates; but a good farmer would supply, by artificial means, that which is taken away, so as at any rate to keep up a productive equilibrium. Would it not, then, be highly advantageous to him to possess an economical and ready mode of forming these salts? That which is now proposed, is as cheap as it is effectual.

It is a well known fact, that when lime and sand are mixed together, as in the manufacture of mortar, a chemical combination ensues between them, the more intimate according to the length of time elapsed since they came in contact. Caustic potash, that is, potash free from carbonic acid, acts, however, more speedily than lime, and is more especially useful as a fertilizer for general vegetation; but as caustic potash can only be cheaply procured through the agency of lime, the latter is employed to effect its formation from the common potashes of commerce:—Take two parts of fine sand (the finer the better), two parts of quick lime, one part of common salt, and one part of American or other potash, and mix them well together so as to form a stiff mortar. Cover the



mass with anything convenient, so as to protect it from the air, and thus let it continue for some months. At the end of that time it will be found that the silica has been acted on effectually. This can be easily ascertained by mixing a small portion of the compost with equal parts of muriatic acid and water, and then neutralizing the filtered solution with ammonia; a gelatinous precipitate of considerable bulk instantly makes its appearance, which is silica coloured by the presence of iron; or, pour concentrated muriatic acid on a small portion of this compost, and, if the mass be not sufficiently dry for pulverization, let it stand for an hour or two; it will be found to present the appearance of a firm jelly, owing to its combination with the dissolved silica.

This manure will always pay for its distribution on grass lands; and when mixed with 1-8th of its weight of phosphate of lime, in the shape of bone ashes, or even crushed boiled bones, forms the most natural and economical manure for wheat and other cereal crops, since it contains, in a proper form, nearly all the constituents of the ashes of those crops, as will be seen on glancing at the table at the end of the work.

### ALUMINA, OR CLAY EARTH.

ALUMINA, which is the basis of all clays, is a compound body, being composed of a very peculiar metal, termed aluminum, and oxygen, in the ratio of 27.4 of the former, to 24 of the latter. It exists most abundantly, and forms a constituent of every



soil and of every rock. Bricks, pipes, and earthenware are composed of this earth, in a state of greater or less purity; many of the most beautiful gems, likewise, such as the sapphire, the ruby, and the amethyst, consist almost entirely of it. Alum is a compound of alumina, and an alkali united to sulphuric acid.

To procure pure alumina dissolve some purified alum in four or five times its weight of boiling water, and add a slight excess of carbonate of potash. A bulky white precipitate then makes its appearance, which must be allowed to digest for a few minutes, after which it may be collected on a filter, and well washed with hot water, till all soluble materials have passed through. The precipitate has now again to be re-dissolved in pure muriatic acid diluted with water, and re-precipitated with carbonate of ammonia. This precipitate, on being well washed and exposed to a white heat, yields pure anhydrous alumina.

“ Alumina exercises only an indirect influence on vegetation, by its power of attracting and of retaining water and ammonia. It is itself very rarely found in the ashes of plants, but silica is often present, having in most cases entered the plant by means of alkalies. In order to form a distinct conception of the quantities of alkalies in aluminous minerals, it must be remembered that felspar contains  $17\frac{3}{4}$  per cent. of potash; albite, 11.43 per cent. of soda; mica, 3 to 5 per cent.; and that zeolite contains 13.16 per cent. of alkalies. The late analyses of Ch. Gmelin Löwe, Fricke, and Meyer, have also shewn that basalt and clinkstone contain from  $\frac{3}{4}$  to three per cent. of



potash, and from five to seven per cent. of soda ; that clay slate contains from 2.75 to 3.31 per cent. of potash, and loam from  $1\frac{1}{2}$  to four per cent. of potash."

"Pure sand, and pure limestones, in which there are no other inorganic substances except siliceous earth, carbonate or silicate of lime, form absolutely barren soils ; but argillaceous earth always forms a part of fertile soils. Now, from whence come the argillaceous earths in arable land ? what are their constituents, and what part do they play in favouring vegetation ? They are produced by the disintegration of aluminous minerals, among which the common potash, and soda felspars, Labrador spar, mica, and the zeolites, are those which most commonly undergo this change." It is known that the aluminous minerals are the most widely diffused on the surface of the earth ; and, as we have already mentioned, they are never absent from fertile soils ; or, if they should happen to be absent from soils capable of cultivation, this is the case only when certain of their constituents are supplied by other sources. Argillaceous earth must, therefore, contain something which enables it to exercise an influence on the life of plants, and to assist in their developement. The property on which this depends is, that of its invariably containing alkalies and alkaline earths, with sulphates and phosphates. "Thousands of years have been necessary to convert stones and rocks into the soil of arable land, and thousands of years more will be required for their perfect reduction, that is, for the complete exhaustion of their alkalies." The cause of the fertility of aluminous soils, is ably explained by Liebig, and one of the properties mentioned previously is of an exceedingly important nature. I allude to the power it



possesses of attracting ammonia from the atmosphere, and, in a manner, locking it up till a shower of rain liberates it. It is also shewn that the favourable effects of manuring fields with burnt clay, are owing to this property; burnt clay possessing, in an extraordinary degree, the power of fixing ammonia. Bonis shewed that the peculiar odour observed on moistening minerals containing alumina, is partly owing to their exhaling ammonia; indeed, many kinds of gypsum, and some varieties of alumina, pipe clay, for example, emit so much ammonia, when moistened with caustic potash, even after they have been exposed two days, that reddened litmus paper held over them becomes blue. Soils, therefore, containing burnt clay, must absorb ammonia, an action which is favoured by their porous condition; they also, by their chemical properties, prevent the escape of the ammonia once absorbed.

Alumina is easily distinguished from other bodies, by its forming with sulphate of potash, and a little free sulphuric acid, crystals of alum. It is also soluble in a solution of caustic potash; so, too, is glucina; but if the solution be weakened with water and boiled, whatever glucina is present will be precipitated.

### LIME.

LIME is one of the alkaline earths, and is composed of a metallic body, termed calcium, and oxygen. The proportions are 20.5 to 8. It is also known by the name of quick lime, and is obtained by subjecting carbonate of lime in any of its various forms, to a full red heat for a couple of hours. Iceland spar, or Carrara marble, should be employed when



lime in a state of purity is required, but for the purpose of making mortar, common limestone is made use of. Lime phosphoresces powerfully when heated to full redness, and is one of the most infusible substances known, hardly yielding to the flame of the oxy-hydrogen blowpipe. When water is sprinkled on lime, a combination takes place, and the water becomes solidified, while great heat is given off, and a white bulky powder is the result. This is called hydrate of lime, by chemists, but is commonly known under the name of slaked lime.

Lime is soluble to a certain extent in water, but it is a curious fact that cold water holds more in solution than hot water, as may be seen by immersing a phial of the cold solution in some boiling water, when a quantity is precipitated. Lime water turns turmeric paper brown, and converts the blue infusion of cabbage to a green. When lime water is exposed to the air, or breathed into through a tube, a white precipitate soon shews itself, which is a carbonate of lime, similar, indeed, to common chalk.

Carbonate of lime is a very abundant natural production, and exists under a great variety of forms, such as chalk, limestones, marble, and Iceland spar. It is sparingly soluble in pure water, but is taken up readily by carbonic acid gas and water. Daniell has noticed that an aqueous solution of sugar and lime deposits crystals of carbonate of lime on exposure to the air. Sulphate of lime is one of the most important of the salts of lime, and plays a prominent part in agricultural operations. It is an abundant natural production, and is known under the names of gypsum, silenite, and alabaster, according to the physical



features it presents. It is also of extensive use in some of the arts, and is employed under the name of plaster of Paris, for forming moulds, busts, images, &c., but it has to be submitted first to a dull red heat for several hours, to expel the water it contains, and is afterwards ground to a fine powder.

Sulphate of lime is soluble in about 500 parts of water, and the property, termed hardness of water, is generally to be attributed to its presence. Water enters largely into the composition of some bodies, and in many cases becomes solidified; it is thus with well dried plaster of Paris. But for the purpose of explaining to the agriculturist the great utility of this property of burnt gypsum, of consolidating water, as well as for elucidating its other valuable qualities, I purpose inserting in this place some extracts from a letter which appeared in the *Mark Lane Express* during the latter portion of 1843, from Mr. James Coombe. From the trials I have made, I have no hesitation in saying that the plan recommended by that gentleman is decidedly an eligible and successful one.

“What a sound discretion farmers would exercise, were they to depend more upon scientific research and reasoning, than on their own crude notions and traditional reports! Look at the immense annual loss sustained by the system of sewerage adopted in large towns, where, instead of preserving in suitable reservoirs, the urine and excrements, and applying these for the production of more food, they are suffered to be washed away, and a national loss incurred. According to Marcet and Macaire, 100 parts of the urine of a healthy man, are equal to 1,300 parts of the fresh dung of a horse, and to 600



parts of the fresh dung of a cow, in respect to the quantity of nitrogen they contain. In China and Flanders the powerful effects of urine are well known and duly appreciated. Indeed, so much value is attached by the Chinese to the influence of human excrements, that laws of the state forbid any to be thrown away, and reservoirs are placed in every house for their careful collection. No other kind of manure is used for their corn fields. On the assumption (Boussingault) that the liquid and solid excrements of a man amount on an average to only  $1\frac{1}{2}$  lb. daily (5-4ths urine, and  $\frac{1}{4}$  fæces), and that both taken together contain three per cent. of nitrogen, then, in one year, they will amount to 547 lb., containing 16.41 lbs. of nitrogen, a quantity sufficient to supply the necessary nitrogen to 800 lbs. of wheat, rye, oats, or 900 lbs. of barley. Facts of this kind are not to be treated lightly, nor set aside from any feeling of false delicacy. Let the subject be dispassionately examined, and the proposal fairly tested; such as would feel disposed to ridicule it, and disdain to enter into the philosophy on which it is founded, may be fairly numbered among those "who are more nice than wise." Liebig assures us that the quantities enumerated are much more than are necessary to add to an acre of land, in order to obtain, with the assistance of the nitrogen absorbed from the air, the richest crops every year. By adopting a system of rotation of crops, every town and farm might thus supply itself with the manure, which besides *containing the most nitrogen, contains also the most phosphates*. When human excrements are treated in a proper manner, so as to remove the moisture without permitting the escape of ammonia, they may be put into such a form as will allow them to be transported to great distances. This is already



attempted in many towns, and the preparation of night soil for transportation, constitutes not an unimportant branch of industry."

Mr. Coombe's plan accomplishes both objects, viz., the solidification, or removal of the moisture, and the fixing of the ammonia, besides rendering the manure in a much fitter state to be amalgamated with the soil. "In Paris, for example, the excrements are preserved in the houses in open casks, from which they are collected and placed in deep pits at Mont-faucon, but they are not sold until they have attained a certain degree of dryness, by evaporation in the air. But whilst lying in the receptacles appropriated for them in the houses, all their urea is converted for the most part into carbonate of ammonia, the vegetable matters contained in them putrify, all the sulphates are decomposed, and the sulphur forms sulphuretted hydrogen (volatile hydrosulphate of ammonia). The mass, when dried by exposure to the air, has lost the greatest part of its nitrogen along with its water, and the residue, besides phosphate of ammonia, consists for the most part of phosphate of lime and magnesia, together with fatty matters. In other manufactories of manure, the night soil while still soft, is mixed with the ashes of wood, or with earth, and a large quantity of quick lime, and this causes a complete expulsion of all the ammonia of the excrements, depriving them in consequence of all smell. The efficacy of this manure cannot, therefore, depend upon its nitrogen."

Though the amount of nitrogen in a manure may not necessarily have that influence on the *growth*



of a plant which many observers have imagined, and which, perhaps, may not be the case, yet that it possesses an influence on the *product* of the plant is, I think, fully substantiated. A case in point is given by Liebig: "100 parts of wheat grown on a soil manured with cow dung (a manure containing the smallest amount of nitrogen), afforded only 11.95 parts of gluten, and 62.34 of amylin, or starch, whilst the same quantity grown on a soil manured with human urine, yielded the maximum of gluten, viz., 35.1 per cent, or nearly three times the quantity." Enough has been said, at any rate, to shew that human excrements are too valuable to be thrown away, and that any practical plan for rendering them fit for manure, is a grand desideratum, and worthy of a fair trial. The plan recommended in the letter I have been quoting from, is merely to mix the liquid and solid excrements with well dried plaster of Paris, till it forms a consistence that will set, or get hard. Plaster of Paris possesses the valuable property of converting carbonate of ammonia into a fixed salt, and also of consolidating a large bulk of water. It is likewise of considerable value as a manure, and though it is made in this case to act merely as an agent to render another manure fit for employment, yet it must of itself always prove to be a valuable addition to any soil deficient of its presence. "When a field is strewed with gypsum, and then with putrified urine, or with the draining of dunghills, all the carbonate of ammonia is converted into the sulphate, which remains in the soil." Stables, also, if strewed with common gypsum, lose their offensive odour, while all the ammonia is preserved and retained in a condition best adapted for a manure.



“The evident influence of gypsum upon the growth of grasses—the striking fertility and luxuriance of a meadow upon which it is strewed—depends, in some degree, upon its fixing in the soil the ammonia of the atmosphere, which would otherwise be volatilized with the water which evaporates. In order to form a conception of the effect of gypsum, it may be sufficient to remark, that 100lbs. of burnt gypsum fixes as much ammonia in the soil, as 6,250 lbs. of horse’s urine would yield to it, even supposing that the whole of its nitrogen was absorbed by the plants without the slightest loss.” Thus is a plan offered for converting an offensive accumulation into a mine of wealth, and a tangible protection is given to the farmer, which he would do well to avail himself of as a good defence against the many impositions to which he is subjected, from the native and foreign compositions offered to his notice, vamped up as possessing virtues innumerable, and, of course, at prices corresponding to the rare excellences they are represented as possessing. It is quite evident that an inexhaustible supply of the best materials for manuring our fields has been suffered to float away uncared for down our streets and sewers, and that which we have paid large sums for getting rid of, might, by inexpensive arrangements, have been made a source of profit. With respect to the influence it will have on vegetation, it only requires a proper trial to prove its value; and it can always be relied on, because it is uniform in its action.

Phosphate of lime, or bone earth, is another very important compound, forming the solid constituent of bones, in the ratio of fifty-five per cent. It may be procured in a state of purity, by adding a solution of



ammonia to any acid solution of phosphate of lime, when it falls as a white gelatinous powder, and must be well washed with hot water before it is dried. An easy mode of procuring it for the purpose of experiment, is to macerate a few ounces of ivory black in some muriatic acid, diluted with four parts of water; phosphate of lime is then taken up by the air, and pure animal charcoal remains. The phosphate of lime is to be precipitated from its acid solution by ammonia. Phosphate of lime exists also in many minerals; but apatite is the principal source from which it is obtained, and which, as Liebig states, is never absent from fertile soils.

“Plants obtain their phosphoric acid from the soil. It is a constituent of all land capable of cultivation. It has been found in all mineral waters, in which its presence has been tested, and in those in which it has not been found, it has not been sought for. When we consider that sea water contains phosphate of lime in such small quantity that its amount cannot be determined in a pound of water, and yet that from this quantity all the living animals in the sea receive the phosphates contained in their bones and flesh, we must admit that the amount of phosphates in the above-mentioned mineral waters is very considerable. A very few simple experiments point out the manner in which the earthy phosphates, and particularly phosphate of lime, are taken up by the roots of plants. Phosphate of lime is insoluble in pure water, but it dissolves readily in water containing salt, or a salt of ammonia, and in water containing sulphate of ammonia it dissolves as readily as gypsum. It is also soluble in water containing carbonic acid; in this respect it is analogous to carbonate of lime.”



By manuring an acre of land with 60lbs. of bones, we furnish sufficient manure to supply three crops (mangold-wurzel, wheat, and rye) with phosphates; but the form in which they are restored to a soil does not appear to be a matter of indifference, for the more finely the bones are powdered, and the more intimately they are mixed with the soil, the more easily are they assimilated. It is stated in a note (p. 186) of Liebig's work, that seeds steeped in the water from a dunghill, and then dusted with a mixture of twenty parts of fine bone-dust, and one of burnt gypsum, in such a manner as to give each seed a good coating, have given very favourable results. But it would be much better to give the land a good dressing in the first instance. I would suggest here, whether it would not be worth while for the proprietors of glue manufactories, to convert their waste acid liquid into a marketable article, by rendering it of easy carriage. That it would find a sale, at a fair price, is not to be doubted. "In the manufactories of glue many hundred tons of solution of phosphates in muriatic acid are yearly thrown away as useless; it would be important to ascertain how far this solution might be substituted for bones."

I made a solution of bone-dust in muriatic acid, diluted with two parts of water, and when it was nearly saturated with phosphate, I mixed one part of it with two parts of burnt gypsum, and a solid, pulverizable mass resulted. In another experiment, I nearly neutralized the acid solution with chalk, and then solidified it with gypsum; but the mass, on account of the presence of chloride of calcium (muriate of lime), was too deliquescent to keep in a pulverizable form. The mere addition of burnt gypsum, however, to the refuse liquor alluded to above, would be all



which is requisite to give it a convenient form, and would render it a very cheap, and highly useful manure.

### MAGNESIA.

MAGNESIA, like lime, is a metallic oxide, and possesses, though in a weak degree, alkaline properties. It converts the blue infusion of cabbage to a green, and forms a numerous class of salts with the acids. To prepare pure magnesia (calcined magnesia), the carbonate must be exposed to a red heat in a covered crucible, for an hour or two; or, if a small quantity only is operated on, then half an hour will be quite long enough.

The carbonate of magnesia is pretty freely distributed, and, more or less, forms a constituent of most soils. There is a limestone, also, called magnesia limestone, which frequently contains more than forty per cent. of carbonate of magnesia, the employment of which, in its caustic state, has, in many instances, proved highly injurious. When quick lime is distributed over the land, it soon loses its causticity, on account of its great affinity for carbonic acid, which combining with it converts it into chalk. Magnesia, on the other hand, takes a much longer time ere it is converted into the mild carbonate, so that when a limestone contains any considerable quantity of magnesia, it takes so much longer time after it is burnt, to return to its original state. Now, as caustic lime is injurious to actual vegetation, there is great danger in applying it in a state where it cannot lose that noxious quality before vegetation commences.



The only compound of magnesia, which is of any interest to the agriculturist, is the phosphate, which exists largely in seeds, &c.

## PHOSPHORUS. SULPHUR.

PHOSPHORUS has hitherto defied the labours of the chemist to decompose it, and it is consequently classed with the simple bodies. It was first made in Holland, from putrid urine, but was afterwards procured by Scheele from burnt bones, which indeed are now the only source whence it is obtained. Phosphorus is of an exceedingly inflammable nature, and when burnt in the open air, or in oxygen gas, combines with that element, forming dense, white, suffocating fumes of phosphoric acid, which are soluble in water. Phosphorus in the simple state, however, has no claim on the attention of the farmer; but, in the form of phosphoric acid, combined with an earthy or alkaline base, it becomes an invaluable agent in most species of vegetable culture. It must be judiciously applied, however, or else it were better to withhold it. The misfortune among farmers is, that they rely too much upon the good name of an article, without in the first place sufficiently considering all circumstances connected with its operation. Thus bone manure, which is chiefly dependant upon the phosphates it contains, for its beneficial influence, has failed in many cases in which it has been applied, because the soil was deficient in those ingredients which are equally necessary for vigorous and mature vegetation. The fact is, a farmer should possess himself, by some means or other, of a correct knowledge of all the constituents existing in each separate portion of his land; he may then, with certainty of



success, apply the actual food his land may be deficient in for growing any particular species of vegetation; and not only that, but, by ascertaining the nature and amount of the constituents a particular crop may have taken away, the farmer is enabled to calculate, at any time, what any other crop may require, and the expence attendant upon the supplying that which is wanted. Liebig was doubtless right when he prognosticated that manures would eventually have to be procured from the chemist's laboratory. Indeed, something like acting upon this suggestion is evidenced by associations (particularly in Scotland) engaging experienced chemists, to conduct the various manipulations connected with scientific farming,—the proposals made and readily supported for agricultural colleges,—example and model farms, and, above all, the deep interest taken in these various subjects by the intelligent farmer of the present day, which, but a dozen years since, would have been scouted as too abstruse for his purpose, and dismissed as “all very well for the larned folk, who farmed for amusement.”

It must be more economical to prepare manures in a simple, definite form, and afterwards, to mix and combine them, according to the deficiency of the soil and the wants of the growing crop, than to throw into one large heap a mass of heterogeneous materials, which becomes half spoiled before used, and the virtues wasted and destroyed, because no consideration or care is bestowed upon its condition. In his laboratory, however, the chemist possesses the means of separating from each other, all those various qualities on which the virtues of a manure depend. Where is the apology for throwing away any thing of value? and it amounts to the same thing, if you



give to a plant that which it does not require. As manures are now frequently made, a great loss must be sustained, for all is loss which we fail to procure when we possess the means. A farmer has purchased a lot of guano, and, imagining that its qualities will be enhanced by adding to it some wood ashes, he applies it to his land, and wonders, as the season of return comes round, to find that all the boasted qualities of the manure have been grossly exaggerated. The farmer, in fact, has thrown away his money; or, which amounts to the same thing—by destroying the nature of his manure—he has failed to procure that which he would have done had he properly applied it. If a nitrogenous manure is wanted, give it separately, or else locked up, as it were, in combination with some other ingredient which will liberate the ammonia by degrees only, and under favourable circumstances. Or, if the alkalies should be required in combination with a nitrogenous manure, then let them be exhibited in the form of sulphates, as in that shape they lose the power of rendering the fixed salts of ammonia volatile. Phosphate of lime, then, is a valuable manure where it is wanted, but it should never be given unless *it is* wanted.

Sulphur is another elementary body, and is found in immense quantities in the vicinity of volcanos. It exists abundantly in combination with many metals, and is generally procured by heating iron pyrites to redness, in a close vessel, when it sublimes and chrystallizes on the cool part. Though sulphur does not form so prominent a constituent of plants, as many other elements, yet it is essentially necessary to the formation of those principles of vegetables,



which constitute nutriment. "Albumen, fibrine, and caseine, contain sulphur, a circumstance by which they are distinguished from all other component parts of the animal body. This sulphur does not exist in the form of an oxide, such as sulphuric acid, or one of its salts. It is well known that the albumen of eggs emits, during its putrefaction, sulphuretted hydrogen gas, and it is owing to this that rotten eggs possess the property of blackening silver or other metal, with which they may be brought in contact. During the putrefaction of fibrine and caseine, the same gas is likewise generated.

"From what source does the animal body derive these three fundamental components? Unquestionably they are obtained from the plants upon which the animals subsist." Liebig goes on to shew that the sulphur compounds exist in plants in variable quantities, in their roots and seeds, or dissolved in their juices, and that nitrogen is an invariable constituent.

A very exact enquiry into the properties and composition of these substances has led to a remarkable result, namely, that the sulphur compound dissolved in the juices of plants, is, in reality, identical with the albumen contained in the serum of blood and in the white of an egg; that the sulphur compound in the seeds of the cereals, possesses the same properties and composition as the fibrine of the blood, and that the nutritious constituent of peas, beans, and lentils, is exactly of the same nature and composition as the caseine of milk; hence it follows, that plants, and not animals, generate the constituents of blood containing sulphur.



“There also exist certain families of plants, such as the *crucifera*, which contain peculiar sulphur compounds, much richer in that element than the vegetable constituents of blood. The seeds of black mustard, horseradish, garlick, onions, and scurvy grass, are particularly marked in this respect.”

As the sulphur compounds form such an important constituent of nutritious food, it becomes interesting to the farmer to learn the best mode of creating them in the growing vegetables; and, as it was stated that nitrogen, also, was always present in the vegetable compounds containing sulphur, it follows, that the body which contains those elements in a condition best adapted for assimilation, must be the most economical for application to the soil. Sulphate of ammonia is that body. It contains both the sulphur and nitrogen, just in that form best suited for decomposition; as, by the simple removal of the elements of water from the sulphate of ammonia, its sulphur and nitrogen become free, and ready for adaptation. Sulphur, in combination with oxygen, forms two compounds, the sulphurous and sulphuric acids. It is the latter acid, in combination with bases, which is of chief importance to the agriculturist; but as those compounds have been treated of under their respective heads, no further notice of them is required in this place.

## CHLORINE, IODINE, AND BROMINE.

THESE three elementary bodies are very similar in their characters, and form very similar compounds; they all three exist in sea water, and in the



ashes of sea weeds; but the two latter are seldom present in those of land vegetation. The alkaline chlorides, however, are of frequent occurrence, but it is the base only which is assimilated by the plant. The chlorine is expelled in some shape or other, and forms no part of vegetable existence. The compounds of chlorine useful for agricultural purposes, have been treated of in another place. Iodine is a very curious elementary body, existing in the solid form; whilst chlorine, uncombined with other matter, always exists in the gaseous state. Bromine assumes the liquid state, but when exposed to the air it soon evaporates. Methods are given in the proper place for detecting either of the above elementary substances; for though they exist, especially the two latter, in such minute quantities as to create a doubt whether they perform any function whatever in the process of vegetation, yet, as they do form a constant portion of marine vegetation, investigation into their mode of action is desirable.

“When it is considered that sea water contains less than one-millionth of its own weight of iodine, and that all combinations of iodine with the metallic bases of the alkalies are highly soluble in water, some provision must necessarily be supposed to exist in the organization of sea weed, and the different kinds of fuci, by which they are enabled during their life to extract iodine in the form of a soluble salt from sea water, and to assimilate it in such a manner that it is not again restored to the surrounding medium. These plants are collectors of iodine, just as land plants are of alkalies, and they yield us this element in quantities such as we could not otherwise obtain from the water without the evaporation of whole seas.”



*On Qualitative Analysis, or the Art of Testing for the Presence of Bodies ; in contradistinction to Quantitative Analysis, or the Art of Separating one Body from another.*

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### POTASH.

IN testing for the presence of potash, every endeavour must be made to separate all the other bodies which can be expelled or precipitated by the known methods, as it is a matter of delicacy very frequently to shew its characteristic properties, especially when intermixed with foreign bodies. The solution ought to be rather concentrated, and if it contains potash, an alcoholic solution of chloride of potassium causes a light yellow precipitate, insoluble in acid; or a strong solution of tartaric acid throws down, especially when stirred with a glass rod, a white chrySTALLINE precipitate, soluble in alkalis, hydro-chloric, sulphuric, and nitric acids. The moist soluble salts of potash give a faint red or violet colour in the blowpipe flame.

### SODA.

THE detection of soda by the usual modes is impossible, for it does not form a single insoluble compound; it is proved to be present only by removing all foreign bodies, and evaporating the solution nearly to dryness. If chrySTALS form, and they give



the blowpipe flame a yellow hue, the article is known to be soda. This is the only test to be relied on.

### SILICA.

THE presence of silicic acid in a neutral solution is shewn by its producing with muriatic or sulphuric acids a jelly; or, when the mixture is evaporated to dryness, it leaves a residue insoluble in water. The gelatinous precipitate caused by the addition of muriatic acid, when evaporated to dryness, becomes insoluble in nitric acid.

### ALUMINA.

ALUMINA is precipitated by caustic potash in a voluminous mass, which is redissolved by an excess of the precipitant. Carbonate of potash also precipitates alumina, but it is insoluble in an excess of that menstruum. The characteristic test of the presence of alumina is, however, that it forms crystals of alum when sulphate of potash and a little free sulphuric acid are added to its solutions. Hydro-sulphate of ammonia gives a white precipitate of alumina, soluble in potash.

### AMMONIA.

ALL the salts of ammonia are volatilizable without residue by heat, except those having fixed acids, such as the phosphate, borate, &c.; they likewise are all decomposed by caustic potash, evolving the well-



known penetrating odour of hartshorn. A glass rod, dipped in muriatic acid, is an excellent test for the presence of free ammonia, producing a cloud of dense white fumes.

### LIME.

OXALIC acid, either free or in combination with ammonia, is the usual precipitant of lime from its solutions. When the precipitate is ignited, it becomes converted into the carbonate, and, by a continuation of the heat, into caustic lime. Sulphuric acid gives a white precipitate, slightly soluble in water, and the salts of lime communicate a red colour to the flame of alcohol.

### MAGNESIA.

THE presence of magnesia is of easy detection, and the following is the test most usually depended on. To the solution add some phosphate of soda, a precipitate may make its appearance, but, if a little ammonia be now added, and magnesia be present, it is sure to shew itself. The minutest quantity can be discovered in this way.

### CARBONIC ACID.

CARBONIC acid, in the free state, is easily discovered by exposing lime water to its influence, when a white precipitate falls (chalk) which effervesces when acted on by acids. All carbonates efferve-



vesce with acids, and give off their carbonic acid in the gaseous state. As there are many other bodies besides carbonates which effervesce on the addition of acids, the gases ought to be collected and subjected to an examination.

### HYDRO-CHLORIC, OR MURIATIC ACID (CHLORINE).

A NEVER failing agent in separating chlorine from all known bodies, is a solution of nitrate of silver, acidulated with a little nitric acid. If chlorine in any form or shape, and in however minute a quantity, be present in any solution, nitrate of silver separates it in the form of a white curdy precipitate, which is soluble in ammonia, but insoluble in nitric acid. The precipitate blackens by exposure to light.

### HYDRO-BROMIC ACID (BROMINE).

“THE method recommended by Balard for procuring this substance, as well as for detecting the presence of hydro-bromic acid, is to transmit a current of chlorine gas through bittern (the uncrystallizable residue left after chloride of sodium has been separated from sea water by crystallization), and then to agitate a portion of sulphuric ether with the liquid. The ether dissolves the whole of the bromine, from which it receives a beautiful hyacinth red tint, and on standing it rises to the surface.” Solution of potash separates the bromine from its ethereal solution, forming with it two distinct compounds, bromide of potassium and bromate of potash. The bromide of potassium



crystallizes in the form of a cube. Bromate of potash is decomposed at a red heat, with the loss of its oxygen, and bromide of potassium is the result. Concentrated sulphuric acid added to either a bromide or bromate, causes an evolution of bromine, in the form of ruddy fumes, highly suffocating.

### HYDRIODIC ACID (IODINE).

SOLUBLE compounds of iodine, present in the shape of an iodide, may easily be detected, by adding chlorine water to the solution, when iodine is gradually set free, as may be ascertained by applying starch, with which it gives a characteristic blue colour; or the compounds form, with solution of nitrate of silver, a yellow precipitate, insoluble in nitric acid. If the iodine exists in the form of an iodate, then sulphurous acid is to be added, which, deoxidizing the iodic acid, liberates the iodine, which may be detected by starch, as above described.

### NITRIC ACID (NITRATES).

FREE nitric acid, with the addition of hydrochloric acid, dissolves gold. If free nitric acid is suspected to be present in a solution, put a strip of gold leaf into the mixture, and add some hydro-chloric acid, quite pure; should the gold be taken up, nitric acid may almost safely be suspected as the agent. The presence of nitrates is more difficult to be shewn, but hydro-chloric acid added to their solutions causes gold leaf to be dissolved. The same takes place with the



chloric, bromic, iodic, and selenic acids; therefore, the absence of these acids must be previously ascertained. A very delicate test has been proposed by Mr. O'Shaugnessy, founded on the orange red, followed by a yellow colour which nitric acid communicates to morphia. The supposed nitrate is heated in a test tube, with a drop of sulphuric acid, and then a crystal of morphia is added. It is advisable to try the process in a separate tube, with the sulphuric acid alone, in order to prove the absence of nitric acid.

### OXALIC ACID (OXALATES).

As the soluble oxalic salts are the best agents for detecting lime, so is any soluble salt of lime reciprocally the best test for discovering oxalic acid. A dry oxalate heated with sulphuric acid, gives off carbonic oxide and carbonic acid gases; the latter can be withdrawn by lime water, the former is a very inflammable gas. Oxalate of lime is converted into the carbonate by a red heat, as are likewise many other oxalates, but not the alkaline salts.

### PHOSPHORIC ACID (PHOSPHATES).

NITRATE of silver is the best test for discovering the phosphoric soluble salts. It gives a yellow precipitate, which is soluble in nitric acid and in ammonia. With acetate of lead a white precipitate is formed which is soluble in nitric acid, but not so in acetic acid. Solution of magnesia with ammonia, gives a white crystalline precipitate. If the phosphate happens to be insoluble in water, it is better to



fuse it with an alkaline carbonate, when a phosphate of the alkali is formed, which, together with the excess of alkaline carbonate, becomes soluble in water. When made neutral by nitric acid, this solution may be tested with nitrate of silver.

### SULPHURIC ACID (SULPHATES).

SULPHURIC acid, or any soluble sulphate, may be detected by chloride of barium, which gives a white precipitate, insoluble in acids or alkalies, a characteristic by which the presence of sulphuric acid, whether free or combined, may always be recognised. An insoluble sulphate may be detected by mixing it in fine powder, with three times its weight of carbonate of potash, and exposing the mixture in a platinum crucible, for half an hour, to a red heat; double decomposition ensues, and, on digesting the residue in water, filtering the solution, neutralizing the alkali by pure hydro-chloric acid, and adding chloride of barium, the insoluble sulphate of that base falls.

### IRON (OXIDES).

THE salts of the peroxide of iron are easily discriminated from all other bodies. With infusion of nut galls, their solutions give a black precipitate—with yellow prussiate of potash, a prussian blue precipitate—and with sulpho-cyanide of potassium, the solution is converted to a blood red colour. The proto salts of iron (the protoxide) give equally characteristic evidence of their presence. Yellow prussiate of potash gives at first a white precipitate, which



turns blue on exposure to the air. Infusion of nut galls gives no precipitate, but red prussiate of potash is capable of detecting the minutest quantity, which it does by forming a precipitate similar to prussian blue.

### MANGANESE (OXIDES).

HYDRO-SULPHATE of ammonia gives a flesh-coloured precipitate with the proto salts of manganese, which is soluble in excess of the precipitate, as do likewise the salts of the deutoxide; but the precipitates from the latter are insoluble in excess of precipitant. Solution of chloride of lime gives a brown precipitate of peroxide of manganese, if no ammoniacal salt be present.



ON THE ANALYSIS OF SOILS.

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A QUANTITY of soil is put into the hands of the chemist for analysis, and the questions which the reader requires to be answered, are, What is the best mode of procedure? and how shall I set to work, guarding against precipitancy on the one hand, and unphilosophical conclusions on the other? "An examination of the physical characters of a substance must always precede its analysis; it is of great importance to know its density, volatility, combustibility, and solubility. Before proceeding to determine the inorganic constituents of a substance, it is also necessary to ascertain whether or not any organic matter is present, this materially affecting many metals in their behaviour with re-agents. Almost all fixed organic bodies possess the property of becoming blackened or carbonized by heating, out of contact of air. To discover organic matter, therefore, a small portion of the substance should be heated in a glass tube, free from lead, when, in general, blackening will occur, and an empyreumatic odour be developed, if organic matter is present. The tube should be held slightly inclined, and be heated by a spirit lamp. There are, however, a few inorganic bodies, which become black by heating, and, on the contrary, some organic bodies which do not blacken. But there is another characteristic of organic bodies, which, taken with the blackening by heat, may be considered decisive. This is the property they all possess of deflagrating when thrown into fused nitre; a property possessed, too, by a few inorganic bodies, but by none



which also blacken by heating. The two tests conjoined are therefore conclusive" (Parnell.) If the substance be heated *gradually*, the presence of water is also easily ascertained; as, should it be present, it would condense on the sides of the glass tube before carbonization ensues. Turmeric paper will shew whether the condensed water contains ammonia. The quantity of organic matter present may be nearly accurately ascertained, by first expelling the water at a gentle heat in a water bath, and then igniting a known weight in a Berlin ware crucible: the loss of weight will indicate organic matter, or be a near approximation to it. Too much heat, however, must not be employed, lest, if carbonates be present, they should suffer partial or complete decomposition.

The next thing to be done, is to discover what the proper solvent of the substance is, and for this purpose it has to be converted into an impalpable powder. Hot hydro-chloric (muriatic) acid is first tried, then nitric acid, and, if necessary, aqua regia, (nitro-hydro-chloric acid.) Some matters are insoluble in all the above menstrua, and when that is the case, another mode of treatment has to be adopted. One part of the finely powdered mineral, or soil, must be intimately mixed with three or four times its weight of carbonate of potash, or carbonate of soda, and subjected to a red heat in a platinum crucible, till fusion is complete. This, in general, renders the matter completely soluble in hydro-chloric acid, but should it display further obstinacy, it must be mixed with four times its weight of pure caustic potash, and fused in a silver crucible. When alkalies, however, are suspected to be present, in the matter intended for examination, it is evident that some other agency



than an alkali, must be employed to effect the disintegration of its particles, and caustic lime, or carbonate of baryta, is in general made the substitute. An Argand spirit (Rose's) lamp, will in most instances be found sufficiently efficacious to effect the above object, but, if that is not at hand, the operation must be conducted in the following manner. Enclose the platinum, or silver crucible, containing the mixture, in a porcelain crucible somewhat larger than itself, as a protection, and then expose it to the action of a dull red heat, engendered in a small furnace, or chafing dish, or else a clear common fire. When the operation is completed, the mass must be dissolved in hydro-chloric acid, and the process of analysis then commences. We will begin with the analysis of one of those siliceous minerals of frequent occurrence, such as a combination of silica, alumina, and lime, with magnesia, oxides of iron, potash, and soda. Solution in this case has taken place without the aid of an alkali. Evaporate the solution to dryness, and redissolve in dilute hydro-chloric acid, the residue undissolved is silica. Should protoxide of iron be present, ascertain by the red prussiate of potash, and then peroxidize it by adding nitric acid and employing heat. Muriate of ammonia and excess of caustic ammonia added to this solution (*a*), throw down peroxide of iron and alumina. Redissolve in a little hydro-chloric acid, add an excess of potash and boil, the oxide of iron remains undissolved, and the alumina is taken up. Muriate of ammonia reprecipitates alumina. The filtered solution (*a*) must be evaporated, till most of its ammonia is expelled, and while boiling, oxalate of ammonia has to be added. Filter, to separate the oxalate of lime, and convert it into pure lime by a strong red heat; to the filtered



solution add hydro-sulphate of ammonia, and, if manganese is present, it will fall in the shape of sulphuret. Filter again, and destroy the excess of hydro-sulphate of ammonia by evaporation and decomposition by hydro-chloric acid. To a portion of the solution add ammonia and phosphate of soda, if a precipitate falls, it is magnesia, combined with phosphoric acid and ammonia. Evaporate the other portion of the solution to dryness, ignite the residue, and redissolve in a small quantity of water. A strong solution of tartaric acid will throw down crystals of cream of tartar if potash be present, or a strong alcoholic solution of chloride of platinum will precipitate the double chloride, in the form of a light yellow powder. If soda be present likewise, then the residue left from the evaporated solution, after ignition, has to be weighed; tartaric acid removes the whole of the potash, and the soda has to be calculated from the loss of weight.

“There are a few silicates which resist the action of even carbonate of soda and potash. To effect the decomposition of these, caustic potash, to the amount of four or five times the weight of the mineral, must be employed, instead of the alkaline carbonate; and the heating then performed in a silver, instead of a platinum crucible, heated carefully over the spirit lamp, with a circular wick. The crucible must be well closed with its lid, as the escape of water from the hydrate of potash produces violent ebullition, which might cause a serious loss in quantitative analysis. A mixture of one part of hydrate of potash and three of carbonate of soda, is found convenient for this operation, as the fusion may then be performed in a platinum crucible.”



## ANALYSIS OF A MINERAL, OR SOIL, INSOLUBLE IN HYDRO-CHLORIC ACID, AND SUSPECTED TO CONTAIN AN ALKALI.

CALCINE the finely pulverized soil, or mineral, with five or six times its weight of carbonate of baryta, and treat the ignited mass with hydro-chloric acid. Silica remains undissolved. To the solution (*a*) in hydro-chloric acid, add carbonate of ammonia and hydro sulphate of ammonia. Separate by filtration the precipitate from the solution. (*b.*) The precipitate may contain baryta, lime, alumina, and the sulphurets of iron and manganese, for the separation of which from each other we will refer to the next chapter. The solution (*b*) may contain magnesia, alkali, traces of lime, and baryta. Add a solution of oxalate of ammonia, lime and baryta are precipitated; evaporate the solution (*c*) to dryness, ignite the residue, redissolve in water, and add a strong solution of caustic baryta; magnesia is precipitated. The solution (*d*) now contains alkali and baryta; add dilute sulphuric acid, sulphate of baryta is precipitated. The solution has now to be evaporated to dryness, ignited, and redissolved in water; examine for potash and soda as in the preceding article.

## ANALYSIS OF CLAY IRON STONE.

THE powdered mineral is dissolved by boiling in the mixed nitric and hydro-chloric acids; carbonic acid escapes, and there is a separation of silica as an insoluble powder, with perhaps a little alumina. The solution, which contains all the bases, with the ex-



ception of a little alumina, is evaporated to dryness ; the residue is redissolved in diluted hydro-chloric acid, and the solution filtered. Unless the solution is very acid, muriate of ammonia is now added, and afterwards an excess of caustic ammonia, which precipitates peroxide of iron and alumina, with small quantities of protoxide of manganese and magnesia. From the solution filtered from this precipitate, lime is to be precipitated, as oxalate, by oxalate of ammonia, or oxalic acid. The precipitate by ammonia being filtered and washed, is dissolved in a small quantity of hydro-chloric acid. This solution is then boiled with excess of caustic potash, to redissolve the alumina at first precipitated by potash, and the iron remains mixed with small quantities of magnesia and protoxide of manganese. The alumina can be precipitated from its alkaline solution by muriate of ammonia. The precipitate containing the iron has to be redissolved in pure hydro-chloric acid, and the solution carefully neutralized with ammonia ; peroxide of iron is then separated as a succinate, by the addition of succinate of ammonia. The filtered liquid is then to be mixed with that filtered from the oxalate of lime, when manganese is precipitated as sulphuret by hydro-sulphate of ammonia, and magnesia from the filtered solution, as ammonia phosphate, by phosphate of soda with ammonia.

*Parnell's Mode of estimating the Quantity of Carbonic Acid in Carbonates.*

The following paragraph is taken from Mr. Parnell's valuable work on "Chemical Analysis," which is recommended as a safe guide for all those who wish to enter more largely into the philosophy



of chemistry. The apparatus referred to is contained in Cox's Agricultural Test Chest.

“The quantity of carbonic acid contained in all carbonates, which are soluble in muriatic or sulphuric acids in the cold, may be determined by the following simple method:—A known weight of the powdered substance is introduced into a flask similar to that represented in figure 23. The flask should be thin at the bottom, to allow of the application of heat, and have the capacity to contain three or four ounces of water. It is fitted with a cork, which has a perforation to admit a small bent tube, and the latter is connected by means of another cork, with a somewhat larger tube, containing dry fragments of chloride of calcium; the extremity (*b*) of this tube is drawn out so as to be capillary. The small tube (a test tube) within the flask, sealed at one end, is intended to hold hydro-chloric or sulphuric acids, to decompose the carbonates, and is of such length that it will not fall flat on the bottom of the flask, but rests against the side at an angle of about  $45^{\circ}$ , with the bottom so that on inclining the flask all the acid contained in this tube can be made to flow out. The apparatus being arranged, the weighed carbonate is introduced into the empty flask with about half an ounce of water; the small tube (*c*) containing sufficient hydro-chloric or sulphuric acid to decompose the carbonate, is then introduced, taking care that no acid comes in contact with the carbonate, and the flask is closed by the cork attached to the chloride of calcium tube (*a*). The whole apparatus is now weighed, after which the flask is inclined, in order that a little of the acid in the tube (*c*) may flow out, and come in contact with the carbonate, which is repeated until the



latter is completely decomposed. As the evolved carbonic acid gas is dried in passing through the chloride of calcium tube, nothing else than this gas escapes, and the loss in weight of the apparatus at the close of the experiment, is the weight of the carbonic acid required. But as the flask is then full of carbonic acid gas, which is considerably heavier than air, it should not be weighed in its present state. To get rid of the remaining carbonic acid, the flask is very gently heated, so as to fill it with aqueous vapour, and thus drive out the gas, the steam itself not going further than the chloride of calcium tube. On the condensation of the steam, air enters the flask, which, when cold, is in the same condition as it was when weighed before the decomposition of the carbonate, excepting only in the loss of the carbonic acid."

*To determine the Quantity of Phosphoric Acid.*

The great difficulty in determining the quantity of phosphoric acid present in combination, is that it forms so many compounds with the same base. If phosphoric acid existed alone in solution, its amount might be determined directly, by adding to the solution a known weight of pure and freshly calcined protoxide of lead, which must be in excess; and evaporating to dryness; the residue, which is a mixture of phosphate of lead, with the excess employed of oxide of lead, is calcined in a platinum crucible and weighed. The increase on the quantity of protoxide of lead employed, is the amount of phosphoric acid formerly contained in solution.

If the phosphoric acid exist in combination with baryta, then the best mode is to dissolve it in



hydro-chloric acid, and to precipitate the baryta by means of diluted sulphuric acid; from the weight of the precipitated sulphate of baryta, that of the baryta is calculated, which again, deducted from the original weight of the phosphate, gives the amount required of phosphoric acid.

*Estimation of Phosphoric Acid in Soils, Rocks, and Wood Ashes.*

M. SCHULZE has recently proposed a method of determining the amount of phosphoric acid contained in soils, rocks, wood ashes, &c., founded on the insolubility of phosphates of the peroxide of iron, and phosphate of alumina in acetic acid. In soils the phosphoric acid generally exists in the state of phosphate of lime and phosphate of magnesia. If to a solution of these phosphates in acetic acid, a sufficient quantity of a solution of acetate of peroxide of iron be added, all the phosphoric acid may be precipitated in the form of phosphate of peroxide of iron, which may be collected and weighed. Instead of acetate of iron, acetate of alumina may be employed, with the same result. As soils usually contain more peroxide of iron and alumina than is sufficient to combine with the whole of the phosphoric acid they contain, all that is required to be done, in estimating the amount of this acid contained in a soil, is to add excess of ammonia to the solution of the earthy matter in hydro-chloric acid, and to treat the precipitate with acetic acid; nothing but phosphate of the peroxide of iron and phosphate of alumina remains undissolved, and after being weighed, these phosphates may be separated from each other by dissolving the phosphate of alumina in solution of caustic potash.



## ON THE ANALYSIS OF THE ASHES OF PLANTS.

ALMOST every plant, when burned, leaves ashes which commonly contain silica, potash, soda, phosphoric acid, magnesia, sulphuric acid, iron, carbonic acid, and sometimes chlorine, manganese, iodine, bromine, and fluorine.

“A large number of analyses are necessary before a classification of plants, according to the constitution of their ashes, can be accurately made. For the present purpose they may be arranged in three groups:—

- A. Ashes rich in alkaline and earthy carbonates. To these belong woods and lichens, since these contain salts of organic acids.
- B. Ashes abounding in the phosphates of alkalies and earths, as the ashes of seeds.
- C. Ashes rich in silica. The gramineæ and equisetaceæ belong to this group.

This classification is not to be considered more than an approximation. The ashes of the mistletoe, the acorn, and the chesnut, contain both carbonates and phosphates; those of millet, oats, and barley, abound in silica, and might with equal propriety be placed in either the second or the third class.”

Having thoroughly incinerated on a clean iron plate, or in a Hessian crucible, the plant, whose



mineral constituents are to be ascertained, try the solubility of its ashes in water and acids; the more soluble in water the ashes are, the richer are they in the alkaline salts. If they are not very soluble in water, but are taken up by hydro-chloric acid, then the salts of lime and magnesia prevail; but should they prove to a great extent insoluble in water or acid, then silica is the predominant ingredient. Having ascertained the probability of the constitution of the ashes, the first thing to be done, is to free them from soluble and insoluble silica, for which purpose they have to be acted on by hydro-chloric acid, filtered, and then evaporated to dryness. Water added to the residue, takes up every thing except silica which has to be separated, washed, ignited, and weighed; this, added to what was left undissolved in the first operation, gives the amount of silica. Estimate the proportion of carbonic acid by Parnell's apparatus, on another portion of the ashes, (sec p. 72).

Sulphuric acid is to be separated from a known divided portion of the acidulated solution freed from silica, by means of chloride of barium; 100 parts of sulphate of baryta, are equivalent to 34 of sulphuric acid. For estimating the proportion of phosphoric acid, take another known portion of the solution, freed from silica, and neutralize it with ammonia; after which, it must be well acidulated with acetic acid, and a strong solution of acetate of peroxide of iron added to it, as long as any precipitate is formed. This precipitate is phosphate of iron, which must be well washed and dried before it is weighed: 100 parts of the phosphate of iron, are equivalent to 74 of phosphoric acid. If a chloride be present, a fresh portion of the ashes has to be submitted to the action



of hot water and a little nitric acid, and the chlorine precipitated with nitrate of silver. When washed and dried, 100 parts of chloride of silver are equal to  $24\frac{1}{2}$  of chlorine.

I shall quote from a valuable paper, published in the *Lancet*, the mode recommended by Drs. Fresenius and Will, for separating peroxide of iron, and the alkaline earths, from a solution of those ashes rich in carbonates and phosphates. "To a known portion of solution, freed from silica, ammonia has to be added, until the precipitate, which is thereby produced, no longer entirely redissolves; acetate of ammonia is next added, and enough acetic acid to render the solution strongly acid. From the form and appearance of the precipitate it can easily be judged whether it still contains phosphate of lime. If this be the case, more acetic acid must be added. The yellowish precipitate which remains, consists of phosphate of the peroxide of iron; its separation from the fluid is assisted by gentle heating. It is then well washed upon a filter, with hot water, ignited, and weighed. To the filtered solution neutral oxalate of ammonia is added, as long as a precipitate is formed, and the quantity of lime is determined in the usual manner, viz., by ignition, and then weighing the carbonate formed. When it has been shewn by the qualitative analysis, that, beside phosphate of iron, the ash contains peroxide of iron, or oxide of manganese (in which case the presence of earthy phosphates is very rarely detected), the solution, previously to the separation of the lime, should be supersaturated with ammonia, and precipitated by means of sulphuret of ammonium (hydro-sulphate of ammonia), the two oxides being afterwards separated by the known methods. If the ashes



under examination contain earthy phosphates, the solution filtered from the oxalate of lime will contain free acetic acid; if otherwise, there will be free ammonia. It is next somewhat concentrated, rendered ammoniacal, treated with a solution of phosphate of soda, and separated from the precipitate, which is estimated as phosphate of magnesia." For the purpose of estimating the alkalies, all that is necessary is to add baryta water to a portion of the solution till it gives an alkaline reaction, when it has to be gently heated and filtered. Baryta precipitates all the sulphuric and phosphoric acids and peroxide of iron, as well as the magnesia and most of the lime. Wash the precipitate on a filter, till what passes through no longer disturbs a solution of nitrate of silver. The solution and the washings are now to be warmed, treated with caustic and carbonate of ammonia, and allowed to stand until the precipitate becomes heavy and granular. The whole is now filtered, and the solid matter is washed; after which the solution is evaporated to dryness, and the residue heated to redness in a platinum crucible, to expel the ammoniacal salts. What remains, consists of the chloride of potassium or sodium, or, more commonly, a mixture of both. The weight being noted, a little water is added, which mostly leaves undissolved a trace of magnesia. This is collected on a filter, its quantity subtracted from that of the supposed alkaline chlorides, and added to that of the magnesia, as previously ascertained. The quantity of potash is determined by chloride of platinum, in the usual way, and that of the soda by the loss of weight sustained by the withdrawal of the former.

If the ashes are very soluble in water, and the solution remains quiet on the addition of an acid,



the alkaline phosphates are to be looked for. Nitrate of silver in neutral solutions gives the characteristic yellow precipitate, and nitrate of baryta decomposes them by joining its base with their acid, and falling as a heavy white powder, soluble in acids. Nitrate of baryta may sometimes throw down sulphuric acid, unless it has previously been removed, therefore the precipitate must always be redissolved in an acid, when the sulphate (if any) is left untouched. Phosphate of baryta is reprecipitated by neutralizing with ammonia. If the solution should effervesce on the addition of an acid, the alkaline carbonates are present. A mode has been given for estimating both. Iodine and bromine, if present, are easily detected by pursuing Balard's plan (see p. 62). The earthy phosphates are easily separated, by acting on the ash with acetic acid, diluting with water, and then precipitating the phosphates with ammonia. Magnesia in solution is to be precipitated by ammonia and phosphate of soda. "The precipitation of magnesia, by means of phosphoric acid and ammonia, though extremely accurate when well performed, requires several precautions. The liquid should be cold, and either neutral or alkaline. The precipitate is dissolved with great ease by most of the acids, and Stromeyer has remarked that some of it is held in solution by carbonic acid, whether free or in union with an alkali. The absence of carbonic acid should always, therefore, be insured, prior to the precipitation, by heating the solution to  $212^{\circ}$ , acidulating at the same time by hydro-chloric acid, should an alkaline carbonate be present. Berzelius has also observed that, in washing the ammoniacal phosphate of magnesia on a filter, a portion of the salt is dissolved as soon as the saline matter of the solution is nearly all removed, that is



to say, it is dissolved by pure water, hence the edulcorations should be completed by water, which is rendered slightly saline by hydro-chlorate of ammonia."

I have now given a correct and easy method of separating all the constituents of the ashes of plants. It is better, in general, to calculate the proportions of these constituents, as acids and bases, rather than as preconceived combinations. When a vegetable has been subjected to a red heat, some new arrangements among the atoms of its mineral constituents must have taken place, so that we may have no just idea of the real compound which existed in the living plant; besides, it is easy to calculate, if the operator is observant and attentive, what the nature of the combinations are, by watching the action of water and acids on the ash. If the ash be very soluble in water, and does not effervesce much on the addition of an acid, then it abounds in alkaline phosphates. If very soluble, and a strong effervescence is produced on the addition of an acid, then the alkaline carbonates predominate. Should the ash be not very soluble in water, yet dissolve in acids with strong effervescence, carbonate of lime abounds. If, however, it dissolves without effervescence, then the earthy phosphates prevail. If it be indifferently soluble in water and acids, then silica is the characteristic ingredient.

*Analysis of Ashes abounding in Silica, by Fresenius and Will.*

Ashes of this kind, as has been already observed, are generally only partially soluble in acids;



their alkalies, must, therefore, be determined in a separate portion of ash. The chlorine and carbonic acid are determined in the same manner as when the ash is entirely soluble in acids. The quantity of chlorine found in ashes of this class, is, however, probably always somewhat less than it should be, since the alkaline chlorides, when ignited with silica and carbon, undergo a partial decomposition.

### 1. *Estimation of the Silica.*

Pure potash, or soda ley (solution), is poured upon about 60 grains of the ashes, and evaporated to dryness in a platinum or silver dish. The silicic acid compounds are by this treatment dissolved, leaving the sand unaffected. The heat should not be so great as to fuse the mass, or some of the charcoal will be oxidated at the expense of the water of the hydrated alkali. Dilute hydro-chloric acid is poured upon the mass, the whole evaporated, and the silica, charcoal, &c., determined in the manner already described. The acidulous solution, filtered from the insoluble matter is divided into two parts, one is employed for the determination of the sulphuric and phosphoric acids, and the other for that of the peroxide of iron, and the alkaline earths (lime and magnesia) by the methods detailed in the preceding pages.

### 2. *Estimation of the Alkalies.*

A second portion of the ash (say 50 grains) is ignited in a crucible of platinum or silver, with four times its weight of hydrated barytes. The acid solution which remains after separating the silica, &c., is precipitated successively with baryta water and



carbonate of ammonia, the alkalies being then obtained in the state of chlorides. The solution must be evaporated to dryness, so as to obtain the alkaline chlorides in a pure state, and the potash separated from soda in the usual manner.

The *Lancet*, of August 31st, 1844, contains some valuable facts, in a tabular form, which are deserving of careful study. I can only refer to them, as they take up too large a space to be transferred to these pages. That number, however, and several previous ones, will amply repay perusal.

It having been deemed essential to the design of ascertaining the normal constitution of various plants, Professor Liebig, through the favour of the Austrian government, obtained ten different kinds of tobacco grown in Hungary, upon land which had never been manured, but where the same plant had been cultivated for a long time. The results of the analyses are then given, and the report goes on to state: "That the leaves reached us healthy and in a sound state, retaining their green colour. The organic acid combined with the bases we found to be the malic, by the usual method of testing that acid." The tables shew that plants of the same kind, grown upon the same soil, yield ashes differing but little in composition. "The proportion of bases combined with organic acids is, so far as their oxygen is concerned, very nearly the same; in the Debreczyner leaves, the amount of lime is nearly the same as in the Banat leaves; whilst the potash in the latter is scarcely two-thirds the amount in the former, and at the same time the quantity of magnesia is double. The Funfkirchner leaves, in four cases, contained scarcely one-third



of the potash found in the Debreczyner leaves, but the quantity of lime is increased nearly 50 per cent. It is evident these and other differences seen in the tables, depend upon the quality of the soil as respects the bases it contains, and afford a beautiful confirmation of the law of mutual displacement of bases, as laid down by Professor Liebig.

The ashes of seeds, so far as their composition is known, consist, like those of the blood of man and other animals, principally of the phosphates of the alkalies, and alkaline earths. The curious fact, moreover, has lately been observed, that the phosphoric acid is not in all seeds combined with the same number of equivalents of fixed bases. Analyses conducted by ourselves, and under our superintendence, shew that peas, beans, hogs' beans, (that is, the leguminosæ), and the seeds of the conifera (the pines), contain tribasic phosphates. The seeds of the cerealia (rye, wheat, millet, buckwheat, and also hemp and linseed) contain, on the other hand, bibasic phosphates. This relation is maintained, also, when the seeds are grown in different localities. The solution of ashes containing tribasic phosphates, gives a yellow precipitate with nitrate of silver, even if made immediately after ignition; whilst that of those containing bibasic phosphates, gives a pure white precipitate." Some valuable tables again follow, and the statement concludes by observing, "that it is of great importance that analyses should be made of the ashes of the most widely differing plants, and also those of the same kind of plant grown on very different kinds of soil. This can only be accomplished, however, by the persevering cooperation of many chemists. The example given above, shew how beautiful and fertile in their



consequences are the results obtained by ash analysis, and we hope that, by means of the methods we have described, the work will be greatly facilitated."

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## ANALYSIS OF GUANO.

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THE value of guano as a manure, must be estimated according to its richness in the salts of ammonia, and the earthy and alkaline phosphates. If a genuine guano should happen to prove deficient in the salts of ammonia, we may expect to find a corresponding increase in the amount of the phosphates. Its deficiency in ammoniacal salts is to be attributed to age, and consequent long exposure to atmospheric influence, which gradually dissipates its more volatile ingredients, while the relative amount of its fixed ingredients must increase. To ascertain with accuracy the amount of ammonia and nitrogenous compounds convertible into ammonia, which guano contains, is not by any means a difficult proceeding; it is based upon the well known property which potash possesses of displacing ammonia from all its combinations, as well as converting all organic nitrogen into that peculiar compound. Put 200 grains, or any certain quantity of guano into a small tubulated retort, having a tube funnel passing through a cork in the tubulure; the extremity of the funnel must reach almost to the bottom of the retort, and be drawn out



nearly to a capillary just large enough to allow a liquid to flow through. Adjust the retort to a receiver containing dilute hydro-chloric acid, allowing the beak of the retort just to touch, but not to dip under the surface of the liquid. A strong solution of potash is now to be poured through the funnel into the retort, and heat applied to distil the ammonia; if necessary, more solution of potash must be added, till all the ammonia is driven over into the receiver. The solution of muriate of ammonia in the receiver, has now to be continually evaporated in a water bath to perfect dryness, and carefully weighed; 100 grains of muriate of ammonia, indicate  $31\frac{1}{2}$  grains of pure ammonia. The oxalic, muriatic, uric, and phosphoric acids, are those generally found in combination with the ammonia. Treat the residue in the retort with an excess of dilute nitric acid, and digest for a couple of hours, frequently shaking. The mixture, then, is to be filtered, and the insoluble matter washed with warm distilled water, whilst on the filter; the filtered washings are to be added to the acid solution, which now contains, besides the earthy and alkaline phosphates, oxalate of lime. Render the solution (a) slightly alkaline with ammonia, the earthy phosphates are precipitated with the oxalate of lime; macerate the precipitate in acetic acid, the earthy phosphates are redissolved, and the oxalate of lime is to be separated by filtration. The acetic solution is to be rendered slightly alkaline with ammonia, the earthy phosphates which are reprecipitated, are to be washed, dried, and weighed. The solution (a), from which the earthy phosphates and the oxalate of lime have been separated, is to be rendered neutral with dilute nitric acid, and solution of nitrate of baryta added as long as turbidness is produced. The preci-



pitate which falls, is a mixture of the phosphate and sulphate of baryta, which must be washed with warm distilled water. To separate the phosphate from the sulphate of baryta, add an excess of dilute nitric acid; the phosphate is dissolved, and the sulphate left behind as a powder insoluble in acids or alkalies. Precipitate the phosphate from the nitric solution by ammonia: 100 parts of the dried phosphate, indicate 25 parts of phosphoric acid, which must have existed in combination with potash or soda, or perhaps both. For the purpose of research, and where exceeding accuracy is required, the reader is referred to (p. 74) for the truest method of determining the amount of phosphoric acid; but for commercial and agricultural purposes, the mode just given can safely be depended on, as the results obtained are sufficiently accurate for sale or purchase, or for application as a manure.

As guano always contains a large quantity of moisture, some persons may perhaps drive off this moisture before they submit it to a chemical investigation, but this should not be done, because, at the temperature necessary to drive off the moisture, a large quantity of ammonia must be expelled along with it. Another point of importance to be observed is to be careful to separate any oxalate of lime, from the earthy phosphates, as the former is comparatively inert; acetic acid does this effectually, as oxalate of lime is insoluble in that menstruum. The uric acid is obtained by boiling a portion of the guano with an excess of solution of potash made rather weak, filtering the solution quickly, and while hot, evaporating to a small bulk, and then precipitating the uric acid, by hydro-chloric acid. The pre-



cipitate had better be redissolved in a solution of potash, evaporated to a concentrated form, and then left to chrystallize. Let the chrystals be first washed in cold distilled water, then dissolved in boiling water, with the addition of a little more potash, then evaporated to concentration, and finally precipitated by muriatic acid; uric acid is the product.

The object of this little work is to assist the farmer in *his* investigations, and though exceeding accuracy is decidedly necessary in purely scientific research, the same degree of exactness is not requisite in the applications of science to commercial pursuits. When a farmer purchasees a lot of guano, he does not modify his price for that article according to the actual per centage of its valuable ingredients; he would give just the same if it contained 30 or 32 per cent of ammonia, 18 or 20 per cent of phosphates; therefore, it becomes a matter of importance to inform him, that it is only in cases of exact research, that chemical investigations become difficult, and require labour and patience.

Subjoined is Dr. Ure's plan for the analysis of guano, as published by him in the "Journal of the Royal Agricultural Society."

#### *Dr. Ure's Plan of Analysis.*

1. In every case I determine, first of all, the specific gravity of the guano, which I take by means of spirits of turpentine, with a peculiar instrument contrived to render the process easy and precise. If it exceeds 1.75 in density, water being 1.0, it must



contain sundry impurities, or has an excess of earthy phosphates, and a defect of azotized animal matter.

2. I triturate and digest 200 grains of it with distilled water, filter, dry the insoluble matter, and weigh it.

3. The above solution, diffused in 2,000 gr. measures, is examined as to its specific gravity, and then with test-paper, to see whether it be acid or alkaline.

4. One half of this solution is distilled along with slaked lime in a matrass connected with a small quintuple globe condenser, containing distilled water, and immersed in a basin of the same. As the condensing apparatus terminates in a water trap, no part of the ammonia can be lost; and it is all afterwards estimated by a peculiar meter, whose indications make manifest one hundredth part of a grain.

5. The other half of the solution is mixed with some nitric acid, and divided into three equal portions.

*a*, the first portion, is treated with nitrate of barytes, and the resulting sulphate of barytes is collected, ignited, and weighed.

*b*, the second portion, is treated with nitrate of silver, and the resulting chloride of silver ignited and weighed.

*c*, the third portion, has a certain measure of a definite solution of ferric nitrate mixed with it, and then ammonia in excess. From the weight of the precipitated subphosphate of iron after ignition, the known amount of oxide used being deducted, the



quantity of phosphoric acid in the soluble portion of the guano becomes known.

*d*, the three above portions are now mixed, freed by a few drops of dilute sulphuric and hydrochloric acids from any barytes and silver left in them, and then tested by nitrate of lime for oxalate of ammonia. The quantity of oxalate of lime obtained determines that point.

6. The last liquor filtered, being freed from any residuary particles of lime by oxalate of ammonia, is evaporated to dryness and ignited, to obtain the fixed alkaline matter. This being weighed, is then dissolved in a little water, neutralized with acid, and treated with soda-chloride of platinum. From the quantity of potash-chloride of platinum which precipitates, after being filtered, dried, and weighed, the amount of potash present is deducted; the rest is soda. These bases may be assigned to the sulphuric, hydrochloric and phosphoric acids, in proportions corresponding to their respective affinities.

7. The proportion of organic matter in the above *solution* of guano is determined directly by evaporating a certain portion of it to dryness, and igniting. The loss of weight, minus the ammonia and oxalic acid, represents the amount of organic matter.

8. A second portion of a solution of the guano is evaporated to dryness by a gentle steam-heat, weighed, inclosed in a stout well-closed phial along with alcohol of 0.825, and heated to 212 deg. After cooling, the alcoholic solution is decanted or filtered clear, evaporated to dryness by a single heat, and



weighed. This is urea, which may be tested by its conversion into carbonate of ammonia, when heated in a test-tube or small retort. In this way I have obtained from Bolivian guano 5 per cent. of urea: a certain proof of its entire soundness.

9. *Analysis of the insoluble matter.*—One-third of it is digested with heat in abundance of borax-water, containing 1-100 of the salt, filtered, and the filter dried by a steam-heat. The loss of weight indicates the amount of uric acid, which is verified by supersaturating the filtrate with acetic or hydrochloric acid, thus precipitating the uric acid, throwing it upon a filter, drying, and weighing it. This weight should nearly agree with the above loss of weight, the small difference being due to soluble organic matter, sometimes called geine and ulmic acid. The uric acid is evidenced,—1, by its specific gravity, which I find to be only 1.25, as also that of the urate of ammonia; 2, by its affording fine purple *murexide* when heated in a capsule along with nitric acid, and then exposed to the vapour of ammonia from a feather held over it; 3, by its dissipation when heated, without emitting an empyreumatic odour.

10. Another third of the solid matter is distilled along with half its weight of slaked lime and ten times its weight of water, in the apparatus already described, and the ammonia obtained from it estimated.

11. The remaining third having been ignited, is dissolved with a gentle heat in weak hydro-chloric acid, and the remaining silica and alumina washed on a filter, dried, and weighed. To the hydrochloric



solution, dilute sulphuric acid is added, and the mixture is heated till all the hydrochloric acid be expelled, and the greater part of the water. Alcohol of 0.850 is now poured upon the pasty residuum, and the whole, after being well stirred, is thrown upon a filter. The phosphoric acid passes through, as also magnesia in union with sulphuric acid. The sulphate of lime, which is quite insoluble in spirits of wine, being washed with them, is dried, ignited, and weighed. From the weight of sulphate of lime, the quantity of phosphate of that earth that was present becomes known.

12. Ammonia in excess is now added to the filtrate, which throws down the granular phosphate of ammonia and magnesia. After washing and drying this powder at a heat of 150 deg., its weight denotes the quantity of that compound in the guano.

13. To the filtered liquor (of 12), if a little ammonia be added, and then muriate of magnesia be slowly dropped in, phosphate of ammonia and magnesia will precipitate, from the amount of which the quantity of phosphoric acid may be estimated.

14. The proportion of oxalate of lime is determined by igniting the washed residuum (9), and placing it in an apparatus for estimating the quantity of carbonic acid given off in dissolving carbonate of lime. The apparatus, either Fig. 1 or 2, described in my little treatise on alkalimetry, will serve that purpose well. I have rarely obtained more than  $\frac{1}{2}$  gr. of carbonic acid from the insoluble residuum of 100 gr. of good guano; and that corresponds to less than  $1\frac{1}{2}$  per cent. of oxalate of lime in the guano. Sometimes



no effervescence at all is to be perceived in treating the washed residuum with acid after its ignition.

15. The carbonate of ammonia in guano is readily determined by filtering the solution of it in cold water, and neutralizing the ammonia with a test of alkalimetical acid. (See the Treatise on the Alkalimeter above referred to.)

16. Besides the above series of operations, the following researches must be made to complete our knowledge of guano. The insoluble residuum (of 10.) which has been deprived by two successive operations of its uric acid and ammonia, may contain azotized organic matter. It is to be therefore well dried, mixed with four times its weight of the usual mixture of hydrate of soda and quick lime, and subjected to gentle ignition in a glass or iron tube closed at one end, and connected at the other with an ammonia-condensing apparatus. The amount of ammonia being estimated by a proper ammonia-meter, represents the quantity of azote, allowing 14 of this element for 17 of ammonia, being the potential ammonia corresponding to the undefined animal matter. In a sample of Peruvian guano, I obtained 5 per cent. of ammonia from this source.

17. The whole quantity of ammonia producible from guano is to be determined by gently igniting 25 grains of it, previously well dried, and then mixed with ten times its weight of the mixture of hydrate of soda and quicklime (2 parts of the latter and 1 of the former). The ammonia disengaged is condensed, and measured as above described.



18. The ready-formed ammonia is in all cases determined by distilling a mixture of 100 grains of slaked quicklime, condensing the disengaged ammonia, and estimating it exactly by the meter.

19. The relation of the combustible and volatile to the incombustible and fixed constituents of guano is determined by igniting 100 grains of it in a poised platinum capsule. The loss of weight denotes the amount of combustible and volatile matter, including the moisture, which is known from a previous experiment.

20. The insoluble matter is digested in hot water, thrown upon a filter, dried, and weighed. The loss of weight is due to the fixed alkaline salts, which after concentrating their solutions, are to be investigated by appropriate tests—1. nitrate of barytes for the sulphates; 2. nitrate of silver for the chlorides and phosphates; and 3. soda-chloride of platinum, for distinguishing the potash from the soda salts.

21. The insoluble matter (of 20) is digested with heat, in dilute nitric or hydrochloric acid, and the whole thrown upon a filter. The silica which remains on the filter is washed, ignited, and weighed. The lime, magnesia, and phosphoric acid, which pass through in solution, may be determined as already pointed out.

22. I have endeavoured to ascertain if muriate of ammonia be present in guano, by evaporating its watery solution to dryness, and subliming the residuum; but I have never obtained a satisfactory portion of sal ammoniac; and therefore I am inclined



to think there is little of it. The quantity of chlorine to be obtained from guano is too inconsiderable to lead to a suspicion of its presence except in combination with sodium and potassium. Phosphate of soda is also a doubtful product—but if present, it may be obtained from the saline matter (of 20) by acidulating it with nitric acid; precipitating first with nitrate of barytes, next with nitrate of silver, taking care to use no excess of these two re-agents, then supersaturating the residuum with ammonia, and adding acetate of magnesia, when the characteristic double phosphate of this earth should fall, in case phosphate of soda be present.

By the preceding train of researches, all the constituents of this complex product may be exactly disentangled and estimated: but they manifestly require much care, patience, time, and dexterity, as also a delicate balance, particularly in using the appropriate apparatus for generating the potential ammonia, and for measuring the whole of this volatile substance, separated in the several steps of the process. It may be easily imagined how little confidence can be reposed in many of the analyses of guano, framed, I fear, too often with the view of promoting the sale of an indifferent, or even a spurious article of commerce.



## ON THE ANALYSES OF URINE,

(From the "*Traité de Chimie*" of Berzelius).

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THE substances to be looked for are—uric acid, albumen, colouring matter of the bile, urea, phosphate of lime, phosphates of the alkalies, lime, sulphuric acid, phosphoric acid, fibrine, caseous matter, hydrochloric acid, mucus, free acid and alkali, and sugar. The following are the re-agents to be used, with their applications :

1. Nitric acid. This is employed to detect uric acid, urea, albumen, and the colouring matter of the bile. It is known whether uric acid is present by adding a few drops of nitric acid to half a pint of urine, and allowing it to stand for twelve hours, when uric acid will be deposited on the sides of the vessel. To detect urea, evaporate the urine to 1-8th of its original bulk, and add half its reduced volume of nitric acid; when, either immediately or on standing a short time, crystals of nitrate of urea are deposited. Nitric acid gives a fleecy white precipitate with albumen, which is soluble in caustic potash after being washed, and is not reprecipitated by acetic acid.

2. Ammonia precipitates the phosphate of lime, held in solution by the free acid of the urine.

3. Lime water shews the presence of alkaline phosphates, by the precipitation of phosphate of lime which it produces.



4. Oxalate of ammonia is employed to precipitate the lime contained in urine. If ammonia is afterwards added, the ammoniacal phosphate of magnesia may be precipitated. Should no precipitation take place, add a solution of phosphate of soda, to ascertain whether this is owing to the absence of magnesia, or that of phosphoric acid.

5. Acetate of baryta is used to indicate sulphuric acid. The urine must be slightly acidulated with acetic acid.

6. Neutral acetate of lead may precipitate the chloride and the phosphate of lead, which may be distinguished as follows: chloride of lead dissolves to a considerable extent in hot water, acidulated with hydrochloric acid, which are again deposited in white acicular crystals, as the solution cools. Chloride of lead, also, fuses at a temperature below redness, and forms, as it cools, a semitransparent mass. Phosphate of lead is soluble in solution of potash, and likewise in most acids, but it is not so in acetic acid.

7. Solution of alum causes a troubling in urine that contains albumen or fibrine in solution.

8. Bichloride of mercury gives no precipitate in acidified urine, unless albumen or caseous matter be present.

9. Infusion of gall nuts, or tannin, precipitates at least two constituent principles, viz., mucus, and the extractive matter, which last is also precipitated by acetate of lead.



10. Red and blue litmus papers are used to detect free acid and alkali.

11. Yeast is employed to discover the presence of sugar in urine, by exciting the vinous fermentation.

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### ANALYSES OF THE ASHES OF SOME PLANTS, BY DE SAUSSURE, 1805.

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*A.* THE ashes were treated with water, and the parts soluble in it were introduced into the calculations in the second and following columns.

*B.* The residue remaining undissolved in the last operation, was dissolved in nitric acid and evaporated to dryness; the portion now insoluble in water was silica.

*C.* By precipitating the solution obtained in *B*, with prussiate of potash, the iron and manganese were obtained, the amount of iron supplied by the re-agent being subtracted in the calculation.

*D.* By a further precipitation of the solution with ammonia, the earthy phosphates were obtained, (lime and magnesia.)



*E.* By treating this precipitate with caustic potash, neutralizing it with an acid, and precipitating it with ammonia, the earthy phosphates mixed with alumina (phosphate) were procured.

*F.* By a further precipitation of the liquid *D* with carbonate of soda, and by continued boiling, the earthy carbonates were obtained.

*G.* The difference of the products of these various operations, when compared with the total weight of the ashes analyzed, expressed the small per centage lost, and the quantity of salts with alkaline bases which were not dissolved by the first treatment with water.

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According to the second mode of procedure, which Saussure considers to be the most exact, the ashes containing alkaline phosphates were analyzed.

*a,* The ashes were dissolved in nitric acid, the lime and magnesia separated as phosphates, the liquid evaporated to dryness and heated to redness with the addition of charcoal. The residual salts were now saturated with acetic acid, dried, and treated with alcohol; the phosphates and sulphates of potash and chloride of potassium were left behind.

*b,* The residue was taken up by water and mixed with acetate of lime. The residue being dried and heated to redness, was treated with acetic acid (*c*), and the portion not dissolved was estimated as pure phosphate of lime, from which it was assumed that 100



parts corresponded to 129 parts of phosphate of potash.

The solutions (*a*) and (*c*), and also that remaining after the precipitation with acetate of lime, were evaporated and heated to redness; the residue was weighed, and the chlorine and sulphuric acid estimated, and calculated as chloride of potassium and sulphate of potash, by subtracting the two latter salts, and also the potash calculated from the phosphate of lime, from the weight of the whole residue, the quantity of potash not existing as phosphate of potash was obtained. As Liebig states, neither of these two methods can be considered accurate in the present day, yet they are of value to those who may consult Saussure's tables of the constituents of the ashes of plants, because the sources of error can now be perceived, and the result of those errors rectified.

"Alumina is said by many chemists to be found in vegetable ashes. De Saussure states that the ashes of the bilberry, the pine, and the oleander, contain 17.5, 14.8, and 28.8 per cent. of alumina, but he mistook the phosphates for alumina, because when he made other analyses to determine the amount of the phosphates, he found no alumina, or only a faint trace of it."



| 100 parts of the Ashes<br>of Plants. | Trifolium<br>Pratense<br>Clover. | Lucerne<br>Clover. | Sainfoin. | Havana<br>Tobacco. | Bean Straw. | Pea Straw. | Fir Wood. | Fir Bark. | Fern. | Wheat<br>Straw. | Barley<br>Straw. | Potatoe<br>Straw |
|--------------------------------------|----------------------------------|--------------------|-----------|--------------------|-------------|------------|-----------|-----------|-------|-----------------|------------------|------------------|
| Carb. Potash . . . . .               | 12.72                            | 23.47              | 9.93      | 6.18               | 13.32       | 4.16       | 11.30     | 2.95      | ..    | ..              | 16.0             | 4.69             |
| Carb. Soda . . . . .                 | 13.52                            | 8.16               | 17.16     | 19.4               | 16.06       | 8.27       | 7.42      | ..        | ..    | ..              | ..               | ..               |
| Carb. Lime . . . . .                 | 38.21                            | 41.61              | 32.55     | 51.38              | 39.50       | 47.81      | 50.94     | 64.98     | 24.8  | 9.6             | 12.5             | 43.68            |
| Silica . . . . .                     | 5.43                             | 2.26               | 2.79      | 8.26               | 7.97        | 7.81       | 13.37     | 17.28     | 73.0  | 71.5            | 57.0             | 29.81            |
| Phosphate Lime . .                   | 11.970                           | 11.80              | 15.37     | ..                 | 6.43        | 5.15       | 3.43      | 5.03      | 1.0   | 2.3             | 7.75             | 5.73             |
| Phosphate Magnesia                   | 6.79                             | 0.91               | 3.98      | ..                 | 6.66        | 4.37       | 2.90      | 4.18      | ..    | ..              | ..               | ..               |
| Earthy Phosphates . .                | ..                               | ..                 | ..        | 9.04               | ..          | ..         | 1.75      | 2.42      | ..    | ..              | ..               | ..               |
| Magnesia . . . . .                   | 4.16                             | 6.41               | 9.11      | 7.09               | 1.02        | 4.05       | 5.60      | 0.93      | ..    | ..              | 3.5              | 3.76             |
| Sulphate Potash . . .                | 3.08                             | 2.23               | 3.27      | ..                 | 3.24        | 10.75      | ..        | ..        | 0.70  | ..              | ..               | ..               |
| Chloride Sodium . .                  | 1.67                             | 2.27               | 3.87      | 8.64               | ..          | 4.63       | ..        | ..        | ..    | ..              | ..               | 2.28             |
| Phosphate of Iron . .                | 1.24                             | 0.81               | 0.64      | ..                 | 3.49        | 0.90       | 1.04      | 1.04      | ..    | ..              | 0.25             | 1.30             |
| Phosphate of Soda . .                | ..                               | ..                 | ..        | ..                 | ..          | ..         | ..        | ..        | ..    | ..              | ..               | ..               |
| Phosphate of Potash                  | ..                               | ..                 | ..        | ..                 | ..          | ..         | ..        | ..        | ..    | 13.0            | ..               | ..               |
| Silicate of Potash . .               | ..                               | ..                 | ..        | ..                 | ..          | ..         | ..        | ..        | ..    | ..              | ..               | ..               |
| Sulphate Soda . . . .                | ..                               | ..                 | ..        | 7.39               | ..          | ..         | ..        | ..        | ..    | ..              | ..               | ..               |
| Chloride Potassium.                  | ..                               | ..                 | ..        | ..                 | ..          | ..         | ..        | ..        | ..    | 3.2             | 0.5              | ..               |







|                                         | Human<br>Urine. | 150 parts<br>of Human<br>Feces dried | 100 parts<br>Horse<br>Dung. | 1000 parts<br>Horses'<br>Urine. | 100 parts<br>Ashes of<br>Cow Dung. | 682 parts<br>Cows'<br>Urine. | Guano. |
|-----------------------------------------|-----------------|--------------------------------------|-----------------------------|---------------------------------|------------------------------------|------------------------------|--------|
| Water.....                              | 933.0           | ..                                   | ..                          | 940.0                           | ..                                 | 650.0                        | ..     |
| Urea.....                               | 30.10           | ..                                   | ..                          | 7.                              | ..                                 | 4.0                          | 3.24   |
| Phosphate Lime....                      | 1.00            | 100.0                                | 5.0                         | ..                              | 10.9                               | ..                           | 9.94   |
| — Magnesia                              | 1.65            | ..                                   | 36.25                       | ..                              | 10.0                               | ..                           | 4.19   |
| — Ammonia                               | 3.71            | 4.0                                  | ..                          | ..                              | ..                                 | ..                           | 6.25   |
| Sulphate Potash....                     | 17.14           | ..                                   | ..                          | ..                              | ..                                 | 6.0                          | 4.22   |
| Animal Matter and<br>Ammoniacal Salts.. | 1.              | ..                                   | ..                          | ..                              | ..                                 | ..                           | ..     |
| Uric Acid .....                         | 3.16            | ..                                   | ..                          | ..                              | ..                                 | ..                           | 1.11   |
| Sulphate Soda.....                      | 2.94            | 4.0                                  | ..                          | ..                              | ..                                 | ..                           | 5.29   |
| Phosphate Soda....                      | 4.45            | ..                                   | ..                          | ..                              | ..                                 | ..                           | ..     |
| Chloride of Sodium..                    | ..              | 8.0                                  | ..                          | 9.0                             | ..                                 | ..                           | ..     |
| Carbonate of Soda..                     | ..              | 16.0                                 | 40.0                        | ..                              | 63.7                               | ..                           | 5.80   |
| Silica .....                            | ..              | ..                                   | 18.75                       | 11.0                            | 1.5                                | 3.0                          | ..     |
| Carbonate Lime....                      | ..              | ..                                   | ..                          | 24.0                            | ..                                 | ..                           | ..     |
| Hippurate Soda....                      | ..              | ..                                   | ..                          | 9.0                             | ..                                 | 15.0                         | ..     |
| Chloride Potassium..                    | ..              | ..                                   | ..                          | ..                              | ..                                 | 4.0                          | ..     |
| Muriate Ammonia..                       | ..              | ..                                   | ..                          | ..                              | ..                                 | ..                           | 6.50   |
| Carb. Potash .....                      | ..              | ..                                   | ..                          | ..                              | 8.5                                | ..                           | ..     |
| Perphosphate Iron..                     | ..              | ..                                   | ..                          | ..                              | 3.1                                | ..                           | ..     |
| Sulphate Lime.....                      | ..              | ..                                   | ..                          | ..                              | ..                                 | ..                           | 13.35  |
| Oxalate Ammonia ..                      | ..              | ..                                   | ..                          | ..                              | ..                                 | ..                           | 16.36  |
| Oxalate of Lime....                     | ..              | ..                                   | ..                          | ..                              | ..                                 | ..                           | ..     |



## EXPLANATION OF THE USES OF THE APPARATUS ACCOMPANYING THE TEST CHEST.

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1. THE Retort Stand, a very handy instrument for supporting retorts, capsules, flasks, &c., when containing matter to be subjected to heat. It is exceedingly useful for small distillations, evaporations, and many other necessary processes.

2. The Large Porcelain Capsule is used for evaporating solutions to a smaller bulk, or for driving off mere excess of water. It is likewise indispensable in the manufacture of many saline compounds, in continual demand by the earnest experimenter.

3. Test Tubes are indispensably necessary in so many operations, that the chemist would now be really at a loss without their aid. Their principal use is for holding small portions of liquids, to be tested by re-agents; they are also used for observing the action of heat on earths, minerals, and many other bodies.

4. A Test Tube Stand for supporting the tubes in an upright position.

5. A Berlin-ware Mortar, which in many cases may supersede an agate mortar. It is for the purpose of effecting a fine division of a mineral or soil intended for chemical examination.



6. Berlin-ware Crucibles and Cups, for the various purposes of ignition, fusion, &c. They resist a very high temperature, and may very safely supersede the platinum crucible in many cases. They must never be introduced naked into the fire, but always enclosed in a Cornish or Hessian crucible. For very accurate research, however, recourse must be had to a platinum crucible, but for all the ordinary purposes of agricultural enquiry, a good clear fire, or small chafing dish, and the Berlin crucible, will be found quite sufficient. If too much heat is not employed, soils and minerals may safely be fused with the alkaline carbonates. The smaller cups are for igniting precipitates, previous to their being weighed, &c. &c.

7. The Glass Spirit Lamp will be found a ready and convenient mode of applying heat in many operations, where a temporary strong flame is wanted. It is particularly useful in tube and small flask operations.

8. Berlin Test Tubes, free from lead, for subjecting substances in a dry state to the action of heat. They are likewise well adapted for boiling liquids in, or for heating small quantities of mineral substances with acids.

10. Scales and Weights, adjusted with great accuracy, for the purpose of weighing substances before and after a chemical operation.

10. Parnell's Apparatus for determining the quantity of carbonic acid in soils, ashes, &c. (See page 72).



11. An Apparatus consisting of a Retort, Funnel, and Receiver, for determining the quantity of ammonia in guano, and any species of manure, saline compounds, &c. &c. (See page 93).

12. A Water Bath is essential in all cases of evaporation, where the application of a temperature beyond  $212^{\circ}$  would be injurious to the experiment. It is also exceedingly useful in many cases of exsiccation.

13. Small Retorts, for procuring gases, effecting small distillations, &c. They are made of green glass, so as to resist the temperature necessary for procuring oxygen.

14. Glass Rods, for stirring solutions or testing with a drop of liquid.

15. Glass Tubing, useful for many blowpipe operations besides those mentioned in the treatise.

16. Two Small Flasks, for effecting solutions in water, acids, &c. They will be found useful in many cases where it is necessary to observe the action of heat. The experimenter should always have at hand a number of clean Florence flasks; they are as useful vessels as any the chemist possesses.

17. Funnels, for guiding liquids from one vessel to another; their chief use is for supporting filters, &c.

18. Filter Paper, of a superior quality, which burns without leaving a large residue of ash.



19. Test Papers of blue litmus and turmeric, and red litmus; these are indispensably necessary for shewing the state a liquid is in. If a solution be alkaline, it changes the yellow turmeric to a red brown, and the red litmus to its original blue. If it be acid, it will convert the blue litmus to a red colour. These papers are always used to ascertain the state a solution is in before the application of re-agents or tests.

20. Platinum Foil, for shewing the presence of foreign matter in solutions when evaporated. A delicate indication of the presence of any salt which is not volatile, is afforded by evaporating a few drops to dryness on a piece of clean platinum foil, a minute trace of the salt causing a very perceptible stain, which could not occur with pure distilled water.

21. Platinum Wire, for holding small portions of matter to be exposed to the blowpipe flame, for ascertaining the colour of the flame, &c.

22. The Blowpipe, in the hands of an experienced operator, is an invaluable instrument. It is introduced into the chest as a means of discriminating the alkalies by the colour of the flame.

23. A small Berlin Capsule, for evaporating small quantities of liquids.

24. Watch Glasses, exceedingly well adapted when very minute portions of a liquid are to be left for spontaneous evaporation.

25. Argand Oil Lamp, for heating vessels, such as retorts, capsules, flasks, &c. &c.



26. Precipitating Glasses, made conical, so that by being larger at the bottom than at the top a precipitate is not obstructed in its passage through the fluid in which it is suspended.

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### LIST OF TESTS.

#### *3 oz. Stoppered Bottles.*

|                            |      |
|----------------------------|------|
| Nitric acid                | pure |
| Hydrochloric acid          | pure |
| Strong acetic acid         | „    |
| Strong solution of ammonia | „    |
| Solution of caustic potash | „    |
| Carbonate of potash        | „    |

#### *2 oz. Stoppered Bottles.*

|                             |      |
|-----------------------------|------|
| Dried chloride of calcium   |      |
| Carbonate of soda,          | pure |
| Sulphuric acid              | „    |
| Carbonate of ammonia        | „    |
| Acetate of peroxide of iron | „    |
| Oxalate of ammonia          | „    |
| Phosphate of soda           | „    |
| Yellow prussiate of potash  | „    |

#### *1 oz. Stoppered Bottles.*

|                                  |      |
|----------------------------------|------|
| Caustic lime                     | pure |
| Acetate of baryta                |      |
| Red prussiate of potash          |      |
| Solution of nitrate of silver    |      |
| Solution of tartaric acid        |      |
| Hydro-sulphate of ammonia        |      |
| Solution of succinate of ammonia |      |
| Solution of chloride of platinum |      |



Sulphuric ether  
Solution of caustic baryta

*1 oz. Shouldered Boxes.*

Acetate of lead  
Alum  
Bruised galls  
Chloride of barium  
Nitrate of baryta  
Muriate of ammonia  
Oxalic acid  
Pure carbonate of baryta  
Nitrate of potash  
Oxide of manganese  
Barilla  
Potashes  
Granulated zinc  
Chlorate of potash  
Sulphate of potash

*In small Bottles.*

Morphia  
Bichloride of mercury  
Potassium  
Sodium



## DIRECTIONS

FOR DETECTING THE USUAL IMPURITIES OF RE-AGENTS,

*(Taken from Parnell's Chemical Analysis),*

TOGETHER WITH

## A PRICE LIST

OF THE

LEADING CHEMICALS AND APPARATUS USED IN  
EXPERIMENTAL AND ANALYTICAL CHEMISTRY.

*Sulphuric Acid* should leave no residue when evaporated to dryness on a piece of platinum foil, neither should it render water turbid when mixed with four or five times its bulk of that fluid, if it does, it contains sulphate of lead. If wanted pure and in a diluted state, the diluted acid will answer, on suffering the precipitate to subside; but to obtain the concentrated pure acid, the diluted solution must be evaporated till the desired strength is obtained. Impure oil of vitriol is sometimes redistilled to free it from adventitious matter, but the above method is most to be recommended.

*Hydrochloric, or Muriatic Acid*, should be colourless (iron and organic matter), and not produce a precipitate with salts of baryta (sulphuric acid); neutralized with ammonia it ought not to become black on the addition of hydro-sulphate of ammonia, (iron). It may be obtained pure by diluting commercial muriatic acid until of the specific gravity 1.11 and distilling. Of this density it distils without gaining or losing strength.



*Nitric Acid* should not leave a fixed residue on evaporation. It should not give precipitates with chloride of barium (sulphuric acid), nor with nitrate of silver (chlorine). If it contain these impurities, add a little nitrate of silver, and distil.

*Oxalic Acid* is impure if it deliquesces, or leaves a fixed residue on ignition. Its crystals should be colourless, and their solution should not give a precipitate with salts of baryta. This acid is easily purified by repeated crystallizations.

*Binoxalate of Potash* is sometimes adulterated with bitartrate and bisulphate of potash. If the former, it will become of a black colour when heated with sulphuric acid, and evolve sulphurous acid. Bisulphate of potash is detected by a salt of baryta.

*Oxalate of Ammonia* when heated should not leave any incombustible residue.

*Tartaric Acid.* The usual impurities of tartaric acid are sulphuric acid and a salt of lime. A moderately dilute solution should not produce in salts of baryta a precipitate insoluble in nitric acid; nor should oxalate of ammonia cause a precipitate after the acid has been neutralized by ammonia. Tartaric acid must be purified by recrystallization.

*Potash.* Solution of caustic potash is usually contaminated with carbonate of potash, sulphate of potash, and chloride of potassium. If it contain carbonate of potash, it effervesces when saturated with an acid. After being neutralized with nitric acid, it ought not to give a precipitate with nitrate of



silver (chlorine), nor with nitrate of baryta (sulphuric acid).

*Ammonia* frequently contains muriate, carbonate and sulphate of ammonia, chloride of calcium, and sometimes, but very rarely, a trace of oxide of tin. The solution should be limpid and colourless (organic matter); neutralized with nitric acid, it should neither be precipitated by nitrate of silver, nor by chloride of barium, and should leave no fixed residue on evaporation.

*Carbonate and Bicarbonate of Potash.* The impurities are alkaline sulphates and chlorides, silica, and alumina. The tests of purity are, after being neutralized with nitric acid, nitrate of silver (chlorine), and a soluble salt of baryta (sulphuric acid). If the neutralized solution, when evaporated to dryness, and the residue treated with water, leave white flocks, or a gelatinous substance undissolved, this is silica. If alumina be present, the neutralized solution will give a white precipitate with carbonate of ammonia. Bicarbonate of potash should not precipitate sulphate of magnesia in the cold.

*Carbonate of Soda.* Besides sulphates and chlorides, this may contain an alkaline sulphuret, sulphite, or hyposulphite. When neutralized by an acid, the gas evolved should be quite inodorous, and no white precipitate of sulphur should be produced.

*Carbonate of Ammonia.* Impurities and means of detection are the same as those for ammonia.



*Nitrate of Silver.* Its ordinary impurities are a salt of copper and nitrate of potash, the former is detected by the solution assuming a blue colour when an excess of ammonia is added. The whole of the silver being precipitated by hydrochloric acid, the filtered liquor should not afford a fixed residue on evaporation (nitrate of potash).

*Chloride of Barium and Nitrate of Baryta.* Their impurities are chlorides of calcium and of strontium, nitrates of strontia and of iron. The dry salts, moistened with alcohol, should not burn with a red flame; they should not deliquesce in the air, nor produce a blue precipitate with yellow prussiate of potash.

*Sulphuretted Hydrogen* may be said to be the most important of all re-agents. For purposes of qualitative analysis, it may be kept in solution in water; the solution being made with distilled water, which has been recently boiled to expel air, (as the oxygen of the air decomposes sulphuretted hydrogen when in solution), and preserved in carefully closed bottles. In the absence of sulphuretted hydrogen water, and when a small quantity only of the re-agent is required, it is conveniently applied by generating the gas in a test tube, moistening a piece of paper with the solution to be tested, and holding the latter within the tube. Sulphuret of iron, if pure, is more convenient for making this gas than sulphuret of antimony, as the former does not require the application of heat.

*Hydro-sulphate of Ammonia* is easily prepared by transmitting sulphuretted hydrogen gas



through solution of ammonia, until no more of the former is absorbed. It should be preserved in well stoppered bottles, which do not contain lead.

*Muriate of Ammonia.* Its ordinary impurities are sulphate of soda, sulphate of ammonia, and chloride of sodium. It should sublime without residue, and a salt of baryta should produce no precipitate in its solution.

*Acetate of Lead.* Its impurities are acetate of lime, and acetate of iron. The whole of the lead being separated from its solution by sulphuretted hydrogen, no precipitate should be produced in the filtered solution by ammonia, hydrosulphate of ammonia (iron), nor by oxalic acid (lime).

*Proto-chloride of Tin.* Its ordinary impurities are salts of iron and of lead. Hydro-sulphate of ammonia should entirely redissolve the precipitate it occasions in the solution of protomuriate of tin. If a black insoluble residue remains, this is either sulphuret of iron, or sulphuret of lead.

*Chromate of Potash* occasionally contains some sulphate of potash, this is detected by the precipitate produced in the solution by nitrate of baryta not being entirely soluble in free nitric acid. Chromate of baryta is soluble, but sulphate of baryta is insoluble in nitric acid.

*Acetate of Baryta.* Its ordinary impurity is chloride of barium, this is detected by nitrate of silver, which if moderately dilute affords no precipitate with acetate of baryta.



*Iodide of Potassium.* Its common impurities are carbonate of potash and alkaline chlorides; its solution should not effervesce with acids. To detect any chloride, the following method may be followed:—precipitate the solution completely by nitrate of silver, add excess of ammonia and filter. If any chloride of silver has formed, this is now in the filtered liquid, held in solution by ammonia, and may be precipitated by nitric acid; but as iodide of silver is not perfectly insoluble in ammonia, a faint turbidity on adding nitric acid to the filtered ammoniacal solution may always be expected.

## PRICE LIST.

|                           |                |                            |         |
|---------------------------|----------------|----------------------------|---------|
| Acid, Acetic, strong      | 1s oz.         | Baryta, pure chrystal      | 2s oz.  |
| ..... useful              | 2d „           | .... pure                  | 1s 6d „ |
| .... Gallic               | 10s „          | .... Acetate, pure         | 8d „    |
| .... Hydrochloric, pure   | 2d „           | .... Carbonate, pure       | 4d „    |
| ..... common              | 4d lb.         | .... Muriate, pure         | 6d „    |
| .... Nitrous anhydrous    | 6s oz.         | ..... common               | 3d „    |
| .... Nitric, pure         | 4d oz.         | .... Nitrate, pure         | 6d „    |
| ..... common              | 1s & 1s 6d lb. | ..... common               | 3d „    |
| .... Oxalic, pure         | 6d oz.         | Borax, pure                | 3d „    |
| .... Succinic             | 5s „           | Bromine                    | 4s 6d „ |
| .... Sulphuric, pure      | 2d „           | Calcium, Chloride, fused   | 6d „    |
| ..... common              | 3d lb.         | Charcoal, Animal, pure     | 4d „    |
| .... Tartaric, pure       | 6d oz.         | Copper, Black Oxide        | 1s „    |
| Alcohol, per pint         | 3s             | Flux, black or white       | 6d „    |
| Æther, Pyroligneous, or   |                | Iodine, pure               | 2s „    |
| wood naptha, for burning, |                | ..... common               | 1s 6d „ |
| per pint                  | 1s 6d          | Iron, peracetate, Sol.     | 1s 6d „ |
| Æther, Sulphuric          | 6d oz.         | .... Sulphate, pure        | 2d „    |
| Ammonia. strongest        | 4d „           | .... Sulphuret             | 8d lb.  |
| .... Benzoate             | 4s „           | Lead, Acetate, pure        | 3d oz.  |
| .... Carbonate, pure      | 3d „           | .... Chloride              | 6d „    |
| .... Hydrosulphate Sol.   | 6d „           | .... Nitrate, pure         | 6d „    |
| .... Muriate, pure        | 4d „           | Lime, pure                 | 6d „    |
| .... Oxalate              | 8d „           | Mercury, Bichloride        | 6d „    |
| .... Succinate            |                | .... Proto Nitrate Chryst. | 1s „    |



|                           |            |                            |           |
|---------------------------|------------|----------------------------|-----------|
| Mercury, Nitrates, common | 6d oz      | Potassium, Bromide         | 4s 6d oz. |
| Microcosmic Salt          | 1s 6d „    | ..... Iodide, pure         | 2s „      |
| Phosphorus                | 1s 6d „    | Selenium                   |           |
| Platinum, Chlor Sol.      | 1s 1s 6d „ | Silica, pure, precipitated | 2s 6d „   |
| ..... Foil and Wire       |            | Silver, Acetate, pure      | 8s „      |
| Potash, pure caustic      | 2s „       | .... Cyanide               | 6s 6d „   |
| ..... Sol. pure           | 6d „       | .... Nitrate, pure         | 5s 6d „   |
| ..... Carbonate, pure     | 6d „       | .... Oxide                 | 8s „      |
| ..... com.                | 1s lb.     | Sodium, per grain          | 1½d       |
| ..... Chlorate            | 4d oz.     | Soda, pure caustic         | 2s 6d oz. |
| ..... Hydriodate, pure    | 2s „       | .... Carbonate, pure       | 3d „      |
| ..... nearly pure         | 1s 6d „    | .... Hypo-sulphite         | 6d „      |
| ..... Prussiate, yellow   | 4d „       | .... Phosphate, pure       | 6d „      |
| ..... red                 | 1s 6d „    | Tin, Proto-chloride Sol.   | 6d „      |
| ..... Silicate            | 8d „       | Test Papers, a sheet       | 1d        |
| ..... Binocalate          | 6d „       | Zinc, granulated           | 6d lb.    |
| Potassium                 | 1½d gr.    | .... Foil                  | 3d oz.    |
| ..... Cyanide             | 1s 6d oz.  |                            |           |

## CHEMICAL APPARATUS.

|                                 |              |                                   |                 |
|---------------------------------|--------------|-----------------------------------|-----------------|
| Adapters, for connecting re-    |              | Bottles, Flint glass, round       |                 |
| torts,                          | from 1s      | stoppered,                        | from doz. 4s 6d |
| Air jars, cylindrical, nested   | 8s 6d        | ..... Washing, for cleaning       |                 |
| .... single                     | from 1s      | filters and precipitates with     |                 |
| .... bell-shaped, plain,        | from 1s      | hot water                         | 3s              |
| ..... stoppered                 | 2s 6d        | Bottle (Clarke's) for testing     |                 |
| ..... brass capped              | from 3s      | with sulphuretted hydrogen        | 3s              |
| ..... graduated                 | from 3s 6d   | Bath (Water) for evaporations     |                 |
| Alkilimeters, accurate          | 6s           | and desiccations,                 | 1s to 5s 6d     |
| Blowpipes                       | 6d to 5s     | Balance, chemical, and weights    |                 |
| .... Black's recom.             | 1s 6d 2s 6d  | from                              | 42s             |
| Blowpipe Apparatus and Tests,   |              | ..... common                      | from 3s 6d      |
| complete, for travelling        | 21s          | Bladder and ferrule               | 2s              |
| Bottles, Test, made from drawn  |              | Caoutchouc, in sheets             | 1s              |
| tube, plain                     | doz. 2s 6d   | Connecting pieces, each           | 10d             |
| ..... stoppered                 | 7s           | Crucibles (Berlin) of all shapes, |                 |
| Bottles, Woulfe's, with two or  |              | from                              | 8d each         |
| three necks                     | 2s 2s. 6d 3s | ..... English, Hessian,           |                 |
| Bottles, Specific Gravity, from |              | black lead, platinum, silver,     |                 |
| 250 grains to 1000 grains,      |              | &c.                               |                 |
| plain 1s to 1s 6d; stoppered,   |              | Cubic inch tubes, graduated to    |                 |
| 2s 6d 3s 6d 5s                  |              | 100th                             | 4s and 5s       |



|                                                                                                                                                                                |                                                                                    |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|
| Chemical Test Chests, complete,<br>especially adapted for a<br>learner from 7s 6d to 42s                                                                                       | Minerals, for analysis from 6d                                                     |
| Drop Tubes, or Pipettes, from<br>3d to 1s                                                                                                                                      | Mercurial Troughs from 1s 6d                                                       |
| Dishes, Evaporating, of Wedg-<br>wood, enameled iron, &c.,<br>all prices and sizes                                                                                             | Mineralogical Cases, with tests,<br>apparatus, and specimens,<br>complete from 4?s |
| ..... Berlin-ware, strongly<br>recommended as not liable to<br>crack or stain, and far more<br>durable from 5d to 9s                                                           | Mortars, Agate from 5s                                                             |
| Eudiometers from 8s to 12s                                                                                                                                                     | ..... Composition 1s 3d                                                            |
| Filtering Paper, strong and po-<br>rous, and leaves but little ash<br>in burning, 1s 6d per quire                                                                              | ..... Glass 9d                                                                     |
| Filtering Rings from 3d                                                                                                                                                        | ..... Steel crushing 14s                                                           |
| Flasks, green and flint glass,<br>from 1oz. upwards, for solu-<br>tions and digestions                                                                                         | ..... Berlin, Porcelain 1s                                                         |
| Funnels, glass ribbed, from 3d,<br>with long necks, bent or<br>straight from 4d                                                                                                | Platinum Spoons 1s 6d                                                              |
| Furnaces of all kinds, from 10s 6d                                                                                                                                             | ..... Forceps 3s                                                                   |
| Glasses Beaker, German, Bohe-<br>mian, and tumbler shaped,<br>smooth with thin bottoms,<br>strongly recommended by all<br>German chemists, single or<br>in nests from 1s to 3s | Pneumatic Troughs from 4s 6d                                                       |
| Gas Holders                                                                                                                                                                    | Precipitating Glasses 6d                                                           |
| Hydrometers, glass 5s 6d to 21s                                                                                                                                                | Retorts, cast iron, wrought iron,<br>&c. 9s                                        |
| Lamps, Argand, Oil from 6s                                                                                                                                                     | ..... earthenware 8d                                                               |
| ..... Argand Spirit (Rose's)<br>from 9s                                                                                                                                        | ..... porcelain 2s 6d                                                              |
| ..... Glass (Spirit) ground<br>caps 2s 3d                                                                                                                                      | ..... tube of green glass 1s                                                       |
| ..... Tin (Oil) with three<br>wicks and copper chimney,<br>useful and economical 3s                                                                                            | ..... flint glass 7d                                                               |
| ..... Tin Blowpipe, self-act-<br>ing Spirit 6s                                                                                                                                 | Receivers, flint glass 9d                                                          |
| Ladles, iron, from 6d                                                                                                                                                          | Retort Stands 1s 3d to 21s                                                         |
| Liebig's Apparatus for organic<br>analysis                                                                                                                                     | ..... iron, with three<br>rings, very useful 7s 6d                                 |
| Measure Glasses from 1s to 3s 6d                                                                                                                                               | Scale of Equivalents, Cuff's 5s 6d                                                 |
| Magnets from 6d                                                                                                                                                                | Scales and Weights                                                                 |
|                                                                                                                                                                                | Stills, copper and tin                                                             |
|                                                                                                                                                                                | Syphons, glass from 1s 6d                                                          |
|                                                                                                                                                                                | Syringes, condensing and ex-<br>hausting from 7s                                   |
|                                                                                                                                                                                | Stop Cocks, best make 3s                                                           |
|                                                                                                                                                                                | Test Chests, of all sizes<br>7s 6d 12s 21s 30s                                     |
|                                                                                                                                                                                | Test Glasses from 7d                                                               |
|                                                                                                                                                                                | Test Tubes from 2s doz.                                                            |
|                                                                                                                                                                                | Thermometers, in great variety                                                     |
|                                                                                                                                                                                | Tubes, earthenware and Wedg-<br>wood                                               |
|                                                                                                                                                                                | ..... bulb, for boiling, &c.<br>from 6d                                            |
|                                                                                                                                                                                | Tube glass, from 2s lb.                                                            |
|                                                                                                                                                                                | Tongs, Crucible from 9d                                                            |
|                                                                                                                                                                                | Urinometers, single and in sets                                                    |
|                                                                                                                                                                                | Wetter's Safety Tubes 2s                                                           |
|                                                                                                                                                                                | Watch Glasses 2s doz.                                                              |
|                                                                                                                                                                                | Weights, Decimal                                                                   |







## NOTES.

*Guano.*—Although the remoteness of the island of Ichaboe, its uninhabited and desolate appearance, together with the exposed and dangerous nature of its situation, would seem to be sufficient reasons for Europeans to avoid approaching it, yet a knowledge of the treasured manure to be found there, has been sufficient to call forth as much energy and enterprising speculation as would an unlimited invitation to the gold mines of Peru; indeed, the trade in guano has been as profitable to many adventurers as freights of the precious metals would have been; and the dismal patch of land has to these successful traders become a magic spot, a golden island. But all is not gold that glitters, and those officers and seamen who flattered themselves that they had made a gold-dust discovery, when the glittering sands of the place met their astonished eyes, found, to their mortification, after having toiled to fill every bag, cask, and spare vessel with the treasure, that it would not bear the touchstone of chemical examination; the alchemists and chemists, though armed with crucible and blowpipe, not having a philosopher's stone, were compelled to report that all their experiments ended in smoke.



Sir Humphrey Davy procured some guano, which he remarks was used extensively in South America, and on the sterile plains of Peru, as an excellent fertilizer. His experiments, in 1805, were upon guano of similar quality to that which we now obtain unadulterated from Ichaboe ; he reports it as a brown powder, it blackened by heat, and gave off strong ammoniacal fumes ; treated with nitric acid, it afforded uric acid.

Mr. Warrington read a paper at the British Association, on the chemical constituents of guano. There was no novelty in the remarks, but it gave rise to an interesting discussion, in which professor Liebig took an active part. The latter gave it as his opinion, that it was a mere assumption that uric acid added to the value of guano, *because its action on the soil had never been studied*. He, however, recommended agriculturists to experiment with it. He also mentioned a singular fact, recently discovered in his laboratory, that plants near the sea shore contain a very large proportion of soda, shewing that this alkali may in part re-place potash. He also remarked that many plants were known to contain potash without soda, but that the converse had never yet occurred.

Not less than 600 vessels sailed in the summer of 1844 for the African coast, in search of the new manure. The thickness varies from 30 to 40 feet, but a few feet of the surface consists of the skins of birds, carcasses of seals, &c. The crew set to work and convey the precious manure in bags and barrows along a jetty erected with the vessels' spars, planks,



and yards, into a boat, and thence to the ship; the vessels lie about 300 yards from the shore, and the surf is very heavy, so that the jetty becomes a matter of necessity.

In an account of the European settlements in America, published in 1760, it is stated that "Guinea pepper, agi, or, as it is called by us, Cayenne pepper, is a very great article in the trade of Peru, as it is used all over Spanish America in almost every thing they eat. In the vale of Arica, they export to the annual value of 600.000 crowns. The district which produces this pepper is but small, and naturally barren; its fertility in pepper, as well as in grain and fruits, is owing to a species of very extraordinary manure brought from an island called Iquiqua. It is a sort of yellowish earth, of a fetid smell, generally thought to be dung of birds, because of the similarity of the scent—that feathers have been found very deep in it, and that vast numbers of sea fowl appear upon that and all the adjacent coasts."

Mr. E. Culver, who made three or four trips to Ichaboe, in 1843-4, brought me specimens of guano, and also of the *gold dust* which refused to support the brilliant encomiums bestowed upon it, and confessed itself to the chemist as simple mica. He found many carcasses of seals, as well as of pelewes and other birds, which cluster in clouds on the island at certain seasons of the year, and considered the entire of these accumulations or guano, would barely last eighteen months, at the rate they were clearing it away. They often run great hazards on this unprotected coast; two vessels were wrecked, several lost their anchors, and put to sea without them, four men



were drowned from boats capsizing, mutinies were of daily occurrence, and greedy selfishness triumphed over order and fair play; those who came first were not always first served, and still greater violence was anticipated when the French and other foreign speculators arrived to claim their share of the treasure.

Captain Isemonger, of the brig *Africanus*, forwarded to England an account of the capture and destruction by the Moors of several of the crews of the ships *Margaret* and *Courier*, both of London, while in search of guano at the island of Arguin. One man was shot through the head, and the captain and crew were treated with great cruelty, and condemned to be sold as slaves; but about two months after their capture, after four more men had been killed, Captain Isemonger, having received intelligence of their disastrous condition, sailed up to the island, and, by paying a heavy ransom, rescued the remnant of the unfortunate party from hopeless slavery. The adulterations practised, and trash vended under the magic name of guano, have been very justly exposed in the *Agricultural Gazette*, and other papers. A quantity sold at £12. per ton, was analyzed, and found to contain not one per cent. of ammonia, not a trace of urea, minute quantities of alkaline sulphates and phosphates of lime. The largest estimate which could be made of the real guano, amounted to three per cent., including feathers, which however appeared to have belonged to pheasants and sparrows, which had never winged their flight from England.

*On Lime.*—Dr. Playfair states, that the efficacy of limestones as a manure, depends on the phos-



phate of lime, silicate of potash, and 'magnesia it contains. When iron is present as a protoxide, it acts as a poison to plants, but in the state of peroxide it has a twofold benefit,—as food for the plant, and as a retainer of ammonia, a gas so essential to vegetation.







# A GLOSSARY

## OF CHEMICAL TERMS.

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*Absorption.* The sucking up of a liquid, or the condensation of a gas, within the pores of a body.

*Acidulate.* To render slightly acid. Chemists generally make use of the acetic, nitric, or muriatic acids, when they wish to render a solution acidulous.

*Aeriform.* A body is said to be aeriform when it exists in the gaseous state.

*Affinity Chemical.* A term used to express a propensity which certain bodies have to combine with each other.

*Albumen.* A peculiar product, common to the vegetable and animal kingdoms, which coagulates on the application of heat. The white of eggs and the serum of blood is albumen in nearly a pure state.

*Analysis Chemical.* The separation of a compound body into its most simple or elementary parts, or the division of a body into certain definite compounds,



the known composition of which afford such correct evidence as to render further proceedings unnecessary.

*Anhydrous.* A body is said to be anhydrous when it contains no water, either of adhesion, composition, &c.

*Argillaceous.* A term descriptive of those earths which contain a predominance of clay, or alumina.

*Calcareous.* A term made use of indicating chalky and lime compounds.

*Capillary Attraction.* The power which liquids possess of ascending in tubes of exceedingly minute diameter. If a lump of sugar is held *above* yet just in contact with water, the fluid will be found to be rapidly sucked up. This is owing to the porous texture of the sugar, which contains an infinite number of small tubular spaces.

*Caustic.* A peculiar property which certain bodies possess of attacking and corroding animal matter.

*Combustible.* A body which gives off heat and light when entering into combination with other matter.

*Concentrate.* To render into a smaller space the active properties of certain compounds.

*Condensation.* To bring nearer together the particles of a body, or to change the condition of vapours by converting them into liquids.



*Deflagration.* The oxidizement of a body by fusion with nitre, or any other matter capable of giving off oxygen.

*Deliquescence.* The property which a body possesses of attracting and absorbing moisture from the air. Many salts become liquid on exposure to the air.

*Digestion.* The immersion of solid matter in a liquid for a continued period of time, either with or without the application of heat.

*Distillation.* A process for separating the volatile parts of a body from the more fixed, and preserving them both in a state of separation.

*Efflorescence.* The property which certain chrystals have of losing their water of chrystallization on exposure to the air.

*Element.* Simple, undecomposable matter.

*Empyreuma.* A peculiar, indescribable, and disagreeable smell, arising from the burning of animal and vegetable matter in close vessels.

*Evaporation.* A driving off excess of moisture by the application of heat.

*Exsiccation.* The act of drying moist bodies. It is sometimes applied to the separation of the water of chrystallization from saline compounds, &c., and of water from vegetable matter.

*Filtration.* The separation of liquid from solid



matter, by allowing the former to pass through bibulous paper, supported on a funnel.

*Fusion.* The state of a body which was solid at natural temperature, and is now rendered liquid by heat.

*Gluten.* A product of the vegetable and animal kingdom. The value of wheaten flour depends on its presence, that being the peculiar nourishing principle.

*Hydrates.* Those substances which form an intimate union with water, and render it a component part. Slacked lime is an hydrate of lime.

*Hygrometric.* The existence of water in the air or other substances, not in a state of combination, but merely as interspersed particles.

*Ignite.* To set on fire, or bring to a red heat.

*Incineration.* The burning of vegetable matter for the sake of its ashes. It is applied to the burning of land and marine plants for the sake of their alkalies.

*Isolation.* The existence of matter in a free or uncombined state.

*Liquefaction.* Matter passing from the solid to the liquid state.

*Lixivation.* The solution of an alkali or a salt in water, or some other fluid, to form a lixivium.

*Menstruum.* The fluid in which a solid body is dissolved.



*Mineral.* Any natural substance of a metallic, earthy, or saline nature, whether simple or compound, which is not a direct product of the organization of animals or plants, is deemed a mineral.

*Neutralize.* Acid and alkalies, when brought into contact, are destructive of certain properties which are peculiar to each. Thus acids lose their acidity, and alkalies their acridity, and a compound is formed possessing the properties of neither. It is called a neutral compound.

*Oxidizement.* The operation by which a substance is made to combine with oxygen.

*Precipitate.* The pulverulent matter which frequently forms on the addition of one liquid to another, consequent on a new arrangement of their particles.

*Precipitant.* That which is added to a solution to cause the formation of precipitates. Nitrate of silver is the precipitant for chlorine and its compounds.

*Re-agents.* Substances which are added to solutions, or applied to matter to discover their composition.

*Refractory.* A term applied to earths and metals, that are either infusible, or require a great degree of heat to melt or change them.

*Saturation.* The impregnation of a fluid with a substance till no more can be imbibed.



*Sublimation.* A process by which certain volatile substances are raised by heat, and again condensed by cold into a solid form.

*Test.* A term applicable to those bodies employed in chemical manipulation to discover the constituents of a compound.

*Volatility.* A property of some bodies which disposes them to assume the gaseous state.

THE END.



## INDEX.

- ACETIC acid, manufacture of, from wood, page 9  
 Acid, phosphate liquor, how to render available, 5  
 Agriculture, importance of gypsum to, 44  
 Alkalies, peculiar properties of the, 23  
     ..... the presence of, necessary for vegetable existence, 31  
     ..... the mode of applying, an important consideration, 32, 28  
 Alkaline earths, 24  
 Alkaline silicates, essential to fertility, 39  
 Alumina, the properties of, 41  
     ..... mode of procuring pure, 41  
     ..... modes of testing for, 60  
     ..... how to discover, 60  
 Aluminous soils, fertility of, 42  
 Ammonia, condensation of, by charcoal, 9  
     ..... the presence of, in the atmosphere, proved, 19  
     ..... average annual quantity of, distributed by rain water, 27  
     ..... modes of testing for, 60  
 Ammoniacal manures, important fact concerning the employment of, 21  
 Animal charcoal, 9  
     ..... mode of procuring pure, 50  
     ..... life, action of, on the atmosphere, 12  
     ..... products, existence of nitrogen in all, 17  
 Animal manure, number of seeds increased by the use of, 20  
 Analysis qualitative, 59—66  
     ..... how to conduct an, 67—70  
     ..... of a mineral suspected to contain an alkali, 71  
     ..... of clay iron stone, 71  
     ..... of the ashes of plants observations on the, 77  
     ..... of ash, mode of procedure in, 77  
 Argillaceous earths, composition of, 42  
 Artificial manures, most safely to be relied on, 54, 55  
 Ashes, estimation of silica in, 82  
     ..... alkalis in, 82  
     ..... analysis importance of, 84  
     ..... of plants, Saussure's mode of analyzing the, 98  
 Atmosphere, influence of vegetation on the, 13  
     ..... permanent existence of ammonia in the, 10  
     ..... composition of, 10—12  
     ..... invariable composition of the, 12  
 Boussingault, on the value of mixed excrements, 46  
 Bone earth, pure, 50  
     ..... dust, experiment with, 51  
 Bones, value of as manure, 51  
 Bromine, presence of in marine plants, 58  
     ..... test for distinguishing, 62  
 Burnt clay, action of, 43



- Carbon, properties of, 8  
 ..... origin of in plants, 10, 11  
 ..... assimilation of from the atmosphere, 11
- Carbonic acid, experiments with plants, 13  
 ..... action of on soils, 38  
 ..... the influence of alkalies in effecting the conversion of, 31  
 ..... how to distinguish, 61
- Carbonate of lime, great varieties of, 44
- Carbonates, Parnell's mode of estimating the quantity of carbonic acid in, 72
- Caustic lime and magnesia, 52
- Chalk, formation of from lime water, 44
- Charcoal, action of on gases, 9  
 ..... manufacture of, 9
- Chemical affinity, influence of quantity on, 31
- Clays, alumina the basis of all, 40
- Combustion, brilliant increase of, by oxygen, 5, 6  
 ..... and respiration, identity of, 7
- Constituents of crops, require to be known, 54
- Coombe, Mr. James, on the manufacture of human excrements as manure, 45
- Crucifera, peculiar compounds of the, 57
- Culture, beneficial influence on health, 13  
 ..... the object of, 31
- Disintegration, powerful agency of carbonic acid in affecting, 37, 38, 39
- Dunghills, carelessness in making, 54
- Economical manure for wheat crops, 40
- Estimation of the alkalies in soils, 71
- Excrements, how manufactured for manure at Paris, 47
- Experiments with oxygen, 6  
 ..... on the growth of the *Sal sola Kali*, 30
- Fallow, operation of, 38
- Farming, scientific information necessary for successful, 36, 45
- Felspar, decomposition of, 38  
 ..... easily effected, 37
- Food, conversion of, in the body, 8
- Formation of soils, 38, 39
- Fructification, water the great cause of, 15
- Gluten, influence of animal manure on the increase of, 20
- Graminea, potash and silica always present in the straw of the, 25  
 ..... seeds of the, always contain phosphates, 25
- Guano, composition of two samples of, 22  
 ..... the folly of mixing lime with, 22  
 ..... value of, as a manure, 48  
 ..... and lime, wood ashes, &c. &c., 21  
 ..... analysis of, 85—95  
 ..... observations on the value of, 85  
 ..... estimation of ammonia in, 85  
 ..... estimation of earthy phosphates in, 86  
 ..... estimation of alkaline phosphates in, 87  
 ..... Sir Humphrey Davy's experiments on, 120



- Guano, Professor Liebig's remarks at the British Association, 120  
 ..... proceedings at Ichaboe, 121
- Gypsum, the value and importance of, 20--45  
 ..... action of salt on, 32
- Gypsum, a cheap and efficient source of converting night soil into manure, 48  
 ..... value of as a manure, 48
- Human excrements, the importance of preserving, 46--48  
 ..... carefully collected by the Chinese, 46  
 ..... Mr. Coombe on the manufacture of, as a manure, 48  
 ..... urine, the comparative strength of, 48  
 ..... the employment of, in China and Flanders, 46  
 ..... qualitative analysis of, 96--98
- Humus, source of, in soils, 12
- Hydrogen, properties of, 13  
 ..... experiments with, 14  
 ..... a source of intense heat, 14
- Insolubility of natural manures, 28
- Iodine, constant presence of in sea plants, 58  
 ..... how to shew the presence of, 63  
 ..... sea plants, collectors of, 58
- Iron, oxides, how to distinguish between them, 65  
 .... how to separate from manganese, 72
- Liebig, on the application of mixed excrements, 46
- Light, influence on vegetation, 13
- Lime, caustic, how obtained, 43  
 ..... its cause of fertility explained, 46  
 ..... tests for discovering, 61  
 ..... consolidation of water by, 44
- Liquid manure, on the application of, 26
- Magnesia, properties of, 52  
 ..... how to distinguish, 61
- Magnesian limestone, 52
- Manganese, tests for distinguishing, 66
- Manufacture of soluble silica as a manure, 39, 40
- Manure, its influence not owing to carbon, 12  
 ..... human urine, a most powerful, 20  
 ..... economy in the application of, 27, 28  
 ..... peculiar mode of applying bone dust, 51  
 ..... on the application of, 51  
 ..... too great solubility objected to, 26
- Minerals, importance of aluminous 41, 42  
 ..... bountiful distribution of aluminous, 42  
 ..... to discover the proper solvent of, 68
- Muriate of lime, its action on soils, 32
- Muriatic acid, test for discovering, 62
- Nature, necessity for studying the laws of, 27
- Nitrate of soda, its influence on certain crops, 33
- Nitric acid, beautiful test for, 63, 64



- Nitrogen, peculiar properties of, 17  
 ..... how to prepare, 17  
 Nitrogenous compounds, essential to vegetation, 18  
 ..... phosphate manure, on the application of to wheat crops, 21  
 ..... manures, their influence on the products of plants, 20, 48  
 ..... manures, on the application of, 21
- Organic matter, how to discover in soils, 67  
 Oxalic acid, test for discovering, 64  
 Oxygen, its abundance and diffusion, 5  
 ..... active and increasing agency of, 5  
 ..... how to procure, 5  
 ..... action of, on food in the organism, 7  
 ..... vegetation the grand source of, 12  
 ..... gas, essential for respiration, 6
- Phosphate of lime, frequent presence of, in minerals, 50  
 ..... peculiar properties of, 59  
 ..... indiscriminate use of, 53  
 Phosphates, earthy and alkaline. necessary for the formation of grain, 120  
 Phosphorus, origin and properties of, 53  
 Phosphoric acid, how to discover, 64  
 ..... mode of estimating the quantity of, in soils or the ashes of platts, 75
- Phosphoric acid, quantitative analysis of, 74  
 Pipe clay, 43  
 Plants, organic constituents of, 4  
 ..... ultimate elements, 4  
 ..... controlling power of the mineral constituents of, 4  
 ..... sources of nourishment for, 4  
 Plants, composition of, dried in vacuo, 11  
 ..... large proportion of carbon in, 11  
 ..... source of hydrogen in, 15  
 ..... relative proportion of water and dry matter in various, 16  
 ..... source of nitrogen in, 18  
 ..... on the supply of food to, 27  
 ..... influence of gypsum on the growth of, 49  
 ..... origin of phosphoric acid in, 50  
 ..... frequent presence of chlorine in, 58  
 ..... negative influence of alumina on, 41  
 Potash, mode of procuring, 23  
 ..... pure, mode of procuring, 24  
 ..... replacement of by soda, 25  
 ..... carbonate of, abounds in certain plants, 25  
 ..... cheap conversion of the carbonate of potash into the sulphate, 25  
 ..... best mode of detecting, 59  
 ..... silicate of, 34  
 Potassium, properties of, 24
- Salt and lime, as a manure, 30  
 Scientific knowledge, essential for good farming, 33  
 Sea water, remarkable constitution of, 58  
 Silica, composition of, 34



- Silica, how to discover, 60  
     .... mode to obtain pure, 35  
     .... an essential constituent of  
     grass and cereal crops, 35  
     .... important as a manure, 37  
     .... properties of, 35  
     .... solubility of, in water, 36  
     .... easily rendered fit for assi-  
     milatation, 37  
 Siliceous mineral, analysis of a,  
 69  
 Snow water, production of sal  
 ammoniac from, 19  
 Soda, how to detect, 59  
     .... on the manufacture of, 29  
     .... replaced by potash, in the  
     ashes of plants, 30  
     .... best form for exhibiting, 32  
 Sodium, properties of, 29  
 Soils, composition of, 10  
     .... a certain quantity of water  
     always retained by, 26  
     .... necessity of analyzing, 53  
     .... mode of detecting ammonia  
     in, 68  
     .... or minerals, the presence of  
     water discovered in, 68  
 Soluble silica necessary for white  
 crops, 37  
     .... silicate manure, applied to  
     wheat crops, 40  
 Stables, purified by gypsum, 48  
 Sulphate of ammonia, valuable as  
 a manure, 57  
     ..... procured by  
     means of gypsum, 48  
 Sulphur, mode of procuring, 55  
     ..... an essential constituent  
     of many vegetable products,  
     55  
     ..... compounds of, plants  
     identical with certain,  
 Sulphuric acid, how to discover,  
 60  
 Tables of the composition of the  
 ashes of plants, 101—102  
     ..... of the composition of ma-  
     nures, 103  
 Vegetation, the influence of mi-  
 neral constituents on, 16  
 Water, composition of, 15  
     ..... necessary for the assimi-  
     lation of matter by plants, 15  
     ..... the beneficial influence  
     of its expansive properties on  
     soils, 17  
     ..... rain, experiments to de-  
     tect ammonia in, 19  
     ..... beneficial influence of, 27  
     ..... the best liquid manure, 28







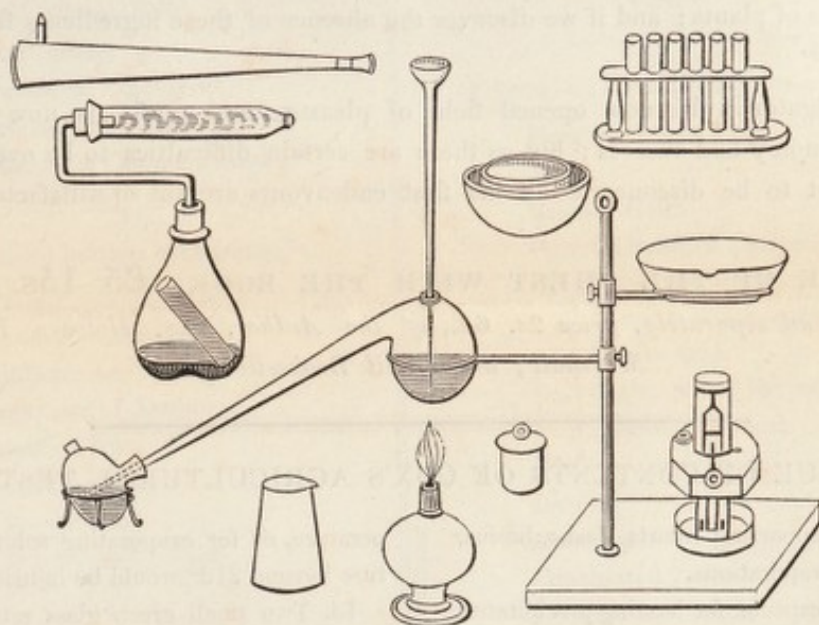








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