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DICTIONARY OF FERTILIZERS AND FERTILIZER TERMS

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Greenkeeper's Fertilizer Dictionary

In this number of the Bulletin there are listed and defined a large number of terms used in the fertilizer trade. Greenkeepers and members of green committees are constantly asking the Green Section for the meaning of these terms. Such a dictionary of fertilizer and fertilizer terms should accordingly prove to be a handy reference for any one charged with the purchase of fertilizers for golf courses. It is also recommended that a good book on elementary chemistry, such as is used in high school or college, be obtained. A book of this kind will be of assistance in acquiring a general understanding of some of the simpler chemical reactions entering into the behavior of the various fertilizer materials. It will be noted from the list that is given in the dictionary that there is a large assortment of fertilizer materials to choose from. Many of these, though of chief interest for farm use, are occasionally of value on golf courses also, while others are especially suitable as turf fertilizers.

In spite of the apparently large number of fertilizers described in this Bulletin the list is by no means complete. Unfortunately a number of the materials which are occasionally used on golf courses, and possibly some of the materials that are frequently used, have been overlooked or omitted because of lack of space. It will be noted that the general policy in the Bulletin has been to refer chiefly to the elementary materials used in fertilizers and to avoid special trade names except to refer the reader to the fundamental ingredients contained in the fertilizers with trade names. A large number of the fertilizers sold under trade names for special golf course use have been included, but here again the list unfortunately could not be made complete. In considering any fertilizer it is well to recognize that its fertilizer value may vary considerably in different lots of the same material. The wide range in the percentage of plant food contained in some of the materials listed shows clearly why it is essential that the percentage of plant food be considered in each case. In this connection it is advisable for anyone concerned with the purchase of fertilizers, particularly those sold under trade or brand names, to apply to his State Department of Agriculture or State Experiment Station for a report on the inspection of commercial fertilizers. Such reports are usually published annually, and contain analyses of all fertilizers on the market in the state, together with other information of considerable value.

In the list of fertilizers given on the following pages it will be noted that the fertilizer trade gives special emphasis to waste materials and to by-products of industrial plants and constitutes an economical outlet for many such materials. Frequently golf courses are able to obtain such wastes at no greater expense than that involved in hauling material from its dumping place to the golf courses. Analyses are given on page 102 of some typical waste products, but there are many others which may have been omitted but which may be worthy of consideration by some golf clubs.

The information presented in this number has been obtained largely from various publications of the United States Department of Agriculture, state agricultural institutions, and the National Fertilizer Handbook. No one can choose wisely from the large assortment of fertilizers now on the market unless he has some understanding of the fundamentals of fertilizing practice. A few of these fundamentals are reviewed in the March and May numbers of the Bulletin.

Dictionary of Fertilizers and Fertilizer Terms

Acid fish. Acidulated fish scrap. Acidulated fish tankage. See *fish scrap.*

Activated sewage. Activated sludge. See *sludge.*

Alkali.—A term popularly used to include any compound which will neutralize acids, such as compounds of soda, potash, lime, and ammonia. When an alkali comes in contact with an acid a chemical reaction takes place and a salt is formed. If the alkali caustic soda, for instance, reacts with nitric acid, a salt is produced which is called nitrate of soda. Similarly the alkali ammonium hydroxide combines with sulphuric acid to form another well-known salt of the fertilizer trade, sulphate of ammonia.

Alumina, Al_2O_3, aluminum oxide.—A common ingredient of clay and other substances in the soil. It sometimes becomes injurious to turf on acid soils. It occurs in small quantities in phosphate rock, along with other impurities such as iron. Superphosphate made from rock high in alumina and iron is wet and sticky and is therefore not as desirable as a superphosphate made from rock low in these two materials. Many contracts for rock to be used in the manufacture of superphosphate demand that the rock contain less than 4 per cent of iron and alumina as oxides.

Alunite.—A mineral containing aluminum and potash. The potash is insoluble in water until the mineral is roasted. It occurs in large deposits in Utah and other western states.

Ammonia, NH_3.—Ammonia is 82.25 per cent nitrogen and 17.75 per cent hydrogen. It occurs free as a gas with a well-known odor but in fertilizers it is in combination with other chemicals. Frequently the odor of ammonia can be plainly detected in the vicinity of piles of animal manures, particularly poultry manure. The odor of ammonia in such places indicates that much of the value of the manure is being lost in the nitrogen escaping in the form of ammonia gas. Grass ordinarily responds quickly to fertilizers containing nitrogen in the form of ammonia. In the United States most of the ammonia is produced as a by-product of coke ovens or gas plants. During the process of making coke from coal, gas containing ammonia is driven off. The ammonia is usually removed from the gas by washing it with water or by bringing it in contact with sulphuric acid to form sulphate of ammonia. Ammonia is now made in large quantities by a synthetic process, in which nitrogen from the air is combined with hydrogen, under high pressure and temperature and under certain other favorable conditions.

Ammonia, liquid anhydrous.—Dry ammonia gas compressed into liquid form. It is usually handled in heavy steel cylinders or special tank cars designed to withstand high pressure. If the pressure is released it will return to its original form of a gas. If mixed with water in the proper proportions and under proper conditions, ammonia liquor or ammonium hydroxide is formed. The principal use of liquid anhydrous ammonia has been in refrigeration, but of late it occasionally has found its way into the fertilizer industry.

Ammonia liquor, NH_4OH.—Ammonia gas is readily absorbed in water. Commercial grades of this liquor generally contain from 25 to 30 per cent of ammonia gas. The solution is strongly alkaline and is valuable in the fertilizer industry for its action with acids, with

which it unites to form salts; for example, with sulphuric acid it forms the salt sulphate of ammonia.

Ammonia salts. See *nitrogen.*

Ammoniated superphosphate.—A product containing superphosphate and nitrogen compounds, but without potash. Many compounds containing nitrogen and phosphorus are now being used on golf courses.

Ammonium chloride, NH_4Cl, sal-ammoniac, muriate of ammonia.—Manufactured by evaporating a definite mixture of ammonia and hydrochloric (muriatic) acid. As a fertilizer it is similar to sulphate of ammonia; but since muriatic acid is more expensive than sulphuric acid, ammonium chloride is seldom used as a fertilizer. The effect of the chlorine residue resulting from the use of this fertilizer has not been thoroughly tested on turf. This fertilizer contains about 26 per cent of nitrogen.

Ammonium citrate $(NH_4)_3C_6H_5O_7$.—This salt is important not as a fertilizer but as a means for testing fertilizer. It is used in the determination of the insoluble phosphoric acid in superphosphate and other fertilizers. A fertilizer sample to be tested is washed with water to remove the water-soluble phosphoric acid (P_2O_5), the residue is treated with a neutral solution of ammonium citrate according to prescribed methods, and the phosphoric acid which is not soluble in this solution is defined as insoluble phosphoric acid. The total phosphoric acid less the insoluble proportion is called "available" phosphoric acid in fertilizer literature. The so-called available phosphoric acid is regarded as the important part, since it is supposed to be the only portion which the plants can use.

Ammonium nitrate, NH_4NO_3.—The residue from the evaporation of a definite mixture of ammonia and nitric acid. In recent years it has been manufactured extensively in Europe by a process utilizing nitrogen from the air. It is a good nitrogenous fertilizer for turf, containing half of its nitrogen as ammonia and half as a nitrate, but is not extensively used as a fertilizer because of its danger as an explosive and a fire hazard. There is a process to overcome its undesirable features in which ammonium nitrate and sulphate of ammonia are mixed in definite proportions to form a double salt (see *Leunasalpeter* and *Montansalpeter*). Pure ammonium nitrate contains 35 per cent of nitrogen.

Ammonium phosphate. See also *Ammo-Phos* and *Leunaphos.*—There are two types of ammonium phosphate which are of importance as fertilizers, mono-ammonium phosphate $NH_4H_2PO_4$, and di-ammonium phosphate $(NH_4)_2HPO_4$. Either of these is a good turf fertilizer, but the former especially contains too much phosphorus for the amount of nitrogen to be suitable for exclusive use for turf on most soils. As an occasional fertilizer or as an ingredient of mixed fertilizers for turf, however, they can both be used to advantage.

Mono-ammonium phosphate is made by evaporating a definite mixture of ammonia and phosphoric acid. The pure salt is made by using purified ingredients, whereas the crude salt, which is used for fertilizer, is made by the same method except the unpurified ingredients are used. (This crude material contains about 11 per cent of nitrogen and 48 per cent of available phosphoric acid.)

Di-ammonium phosphate is made by adding the proper proportions of ammonia to a solution of mono-ammonium phosphate. The pure

salt contains 21.05 per cent of nitrogen and 53.35 per cent of phosphoric acid.

Ammonium sulphate $(NH_4)_2SO_4$. See *sulphate of ammonia.*

Ammonium sulphate-nitrate. See *Leunasalpeter.*

Ammo-Phos. See also *ammonium phosphate.*—A trade name for a commercial grade of ammonium phosphate commonly used as a fertilizer on golf courses. It is manufactured in two grades, one of which contains about 11 per cent of nitrogen and 48 per cent of available phosphoric acid and the other about 16 per cent of nitrogen and 20 per cent of available phosphoric acid. The latter is equivalent to a mixture of 800 pounds of the former with 1,200 pounds of sulphate of ammonia.

Analysis.—The percentage composition of a fertilizer as expressed in terms of nitrogen or ammonia, phosphoric acid, and potash in their various forms. In most states the nitrogen is expressed directly as nitrogen (N) but in a few states it is expressed in terms of ammonia (NH_3). To meet the requirements of the different states the manufacturers express the percentages of nitrogen in terms of both nitrogen and ammonia. In stating the content of a fertilizer it is customary in most parts of the United States to give the nitrogen first, the phosphoric acid second, and the potash last. In a few of the southern states however the phosphoric acid content is given first and the nitrogen second. Therefore a 12-6-4 fertilizer in most parts of the country means that the fertilizer contains 12 per cent of nitrogen, 6 per cent of phosphoric acid, and 4 per cent of potash. The same set of figures in certain southern states however would mean 12 per cent of phosphoric acid, 6 per cent of nitrogen, and 4 per cent of potash. This important difference should be kept in mind by those who purchase fertilizers in the states where the exceptional order is in use. For the purpose of complying with state laws the analysis of most fertilizers will be found stamped on the bag or printed on a tag.

Anhydrous ammonia. See *ammonia, liquid anhydrous.*

Apatite.—A mineral composed chiefly of calcium phosphate. It is occasionally used for fertilizer but rarely on golf courses.

Artificial manure. See *manure.*

Ash. See *bone ash, coal ashes, hardwood ashes,* and *wood ashes.*

Association of Official Agricultural Chemists (North America).—A group of Federal and state analytical chemists charged with the official control of fertilizers, soils, cattle feed, dairy products, human food, medicinal plants, drugs, and other materials connected with agricultural industry. For further information see the Bulletin for March, 1931, page 62.

Available.—A term used in the trade to designate that part of the plant food in a fertilizer which is in such a form that it can be taken into plants through the roots as distinguished from that part which is so locked up chemically that plants can not use it. Plant food of the latter class is called unavailable. Due to certain chemical or biological changes that take place in soil some of the plant foods may be changed from unavailable to available, or the reverse. Plant foods in such materials as peat, leather scrap, and phosphate rock are considered unavailable because plants can not absorb and use them until they have been broken down by a long process of decay or by treatment with certain chemicals. Such materials in the crude state when

added to the soil can not be expected to release to turf the food they contain for several years and their food is therefore classed as unavailable. Other fertilizers, such as sulphate of ammonia, urea, Ammo-Phos, nitrate of soda, and the like, contain plant food which plants can use almost immediately and their food elements are therefore designated as *quickly available.* Some plant foods in fertilizers can not be used by plants immediately, but after a relatively short time decomposition renders them available; these fertilizing materials are designated as *slowly available* or by a similar term to indicate that the plant food can not be used immediately but becomes available in time. Agricultural chemists have devised certain laboratory tests to determine the quantities of plant food that are classed as available and those which are not available in fertilizers.

Barnyard manure. See *manure.*

Base goods (dry).—Generally mixtures of several fertilizer materials (usually superphosphate) with materials containing ammonia or potash, or both. As such they are not generally used as fertilizers, but after curing are used as a base in mixing fertilizers.

Base goods (wet).—A term commonly used in the fertilizer trade to designate a material made by treating phosphate rock and some material containing nitrogen with sulphuric acid. Hair, leather, beet residues, scrap fur, wool waste, and such, are the materials containing nitrogen which are used most frequently. The same equipment is used in its manufacture as in the making of superphosphate. Garbage tankage is often added to the base after the heating process to assist in the drying of the base and to increase the availability of the tankage. Materials containing potash are sometimes used in making base goods. Treatment of material containing nitrogen with sulphuric acid converts part of the inactive nitrogen into a highly available form. The addition of phosphate rock neutralizes the sulphuric acid and gives a solid product that can be handled by fertilizer-mixing machinery.

Basic slag, Thomas slag, Thomas phosphate.—The by-product of the manufacture of steel, by the Thomas process, from iron ores and pig iron containing phosphorus. It is used frequently as a farm fertilizer and is occasionally used on golf courses, particularly on fairways. If finely ground it provides phosphoric acid economically. It contains liberal amounts of lime in a form which is not readily available. It contains 10 to 25 per cent of phosphoric acid and 40 to 50 per cent of calcium carbonate.

Bat guano. See *guano.*

Beet sugar residue. Beet slop.—A liquid by-product from the manufacture of beet sugar. It is not used directly as a fertilizer but is combined with phosphate rock and sulphuric acid by the method described under base goods. Beet sugar residue contains 3 to 6 per cent of nitrogen and 8 to 10 per cent of potash.

Bird guano. See *guano.*

Blood.—Dried blood is a by-product of slaughterhouses. The poorer grades of blood are used in fertilizers. Dried blood is quickly available and is a good stimulant for grass. Its use on golf courses has been somewhat restricted in recent years because cheaper fertilizers containing nitrogen in quickly available form have been demonstrated to produce the desired results much more economically

than dried blood. It may contain 8 to 14 per cent of nitrogen. Under the official definition of the Association of Official Agricultural Chemists, "Dried blood is the collected blood of slaughtered animals, dried and ground, and containing not less than 12 per cent of nitrogen in organic form."

Blood and bone. See *blood*, also *bone*.—A mixture of blood and bone which in the past was used to some extent on golf courses. Its analysis varies widely, depending on the proportion and qualities of the blood and bone used in making the mixtures. It averages about 6 per cent of nitrogen and 12 per cent of phosphoric acid.

Bone. See also *dissolved bone* and *precipitated bone*.—It is claimed that the fertilizer industry began when animal bones were ground up and applied to soil. Ground animal bones still play an important part in the fertilizer industry in spite of the fact that much larger quantities of superphosphate are now used for supplying phosphoric acid. A good supply of bones comes from the junk collectors, small slaughterhouses, and butchers. Large quantities of bones are steamed to extract the material from which glue is made, and the steamed bones are then ground for fertilizer. The steaming process removes about half of the nitrogen and therefore the steamed bone contains less nitrogen than the raw bone. Large quantities of bones are also used in the production of bone black for use in refineries. In the trade the phosphoric acid contained in the various forms of bone is frequently referred to as *bone phosphate of lime* or *BPL*. To convert BPL into terms of percentage of phosphoric acid, multiply by .458. See also *calcium phosphate*.

Bone ash.—A grayish white ash obtained from burning bones. This material is not extensively produced and little is used as a fertilizer. It contains practically no nitrogen but is high in phosphoric acid, containing 30 to 38 per cent.

Bone black.—Charcoal from heated bones, prepared in a manner similar to that of making coke from coal. It is used for refining sugar, oil, and other materials, and is more expensive than bone meal. After it has served its purpose in the refineries it is sold to fertilizer manufacturers. It is seldom used on golf courses except in mixtures. Bone black contains about 1.5 per cent of nitrogen and 30 to 36 per cent of phosphoric acid.

Bone meal (raw).—Ground bones of animals. The finer the grinding the more rapidly the material decomposes in the soil and becomes available as a plant food. This fertilizer has been used for many years on golf courses and is still widely used, particularly on fairways. It is often applied alone or as an ingredient of mixed fertilizers. Being slowly available, it is a good fertilizer to mix with the top layer of soil in preparing a seed bed. It contains 2 to 6 per cent of nitrogen and 14 to 27 per cent of phosphoric acid.

Bone meal (steamed).—This is obtained by boiling out some organic matter from the bones of animals. This organic matter is mostly glue, which is dissolved in the process of boiling, leaving behind the calcium phosphate. The fertilizer ingredients in steamed bone meal are more rapidly available to plants than in raw bone meal. Like raw bone meal, it is a common golf course fertilizer, particularly for fairway use. Much of the nitrogen is removed from bones in the steaming process and as a result steamed bone meal has a lower nitrogen

content than raw bone meal. It contains 2 to 4 per cent of nitrogen and 16 to 40 per cent of phosphoric acid.

Bone phosphate. See *calcium phosphate.*

Bone phosphate of lime. See *bone.*

BPL. See *bone.*

Bran. See *waste.*

Brand or brand name.—A term, design, or trade mark used in connection with one or several grades of fertilizer, or a specific designation applied to an individual fertilizer.

Brewers' grains. See *waste.*

Borax, $Na_2B_4O_7$, sodium tetraborate.—Needed in minute quantities for plants but if present in excess it is toxic. Because of its toxicity the United States Department of Agriculture has ruled that potash salts or fertilizer materials must not contain more than .5 per cent of borax, and that fertilizer mixtures must not contain more than .1 per cent unless plainly marked on the container. Sometimes borax is used on manure piles to control flies, and the use of manure thus treated should be avoided on golf courses.

Brimstone. See *sulphur.*

Calcium, Ca.—The element calcium does not occur pure in a native state but is widely distributed in nature in combination with other elements, as for instance in limestone. Calcium is needed for plant growth. It is supplied to growing plants ordinarily in some form of lime.

Calcium carbonate, $CaCO_3$, carbonate of lime.—A common substance found in materials such as limestone, marble, and oyster shells. These are ground for use on soil. The comparative value of these various forms is affected by the fineness of the particles. The carbonate form of lime is not as chemically active as the hydrated form (calcium hydroxide) but is used on golf courses to satisfy the lime requirement of the soil. Calcium and magnesium in lime are the elements which determine its ultimate effectiveness as a means of reducing acidity. Pure calcium carbonate contains 56 per cent of calcium oxide, which is equivalent to 40 per cent of pure calcium.

Calcium cyanamid, $CaCN_2$.—A compound containing calcium, carbon, and nitrogen. Commercial cyanamid is made by passing nitrogen over a heated mass of calcium carbide. Pure calcium cyanamid contains 35 per cent of nitrogen. The commercial product sold as cyanamid is a mixture of calcium cyanamid and calcium hydroxide. It contains 14 to 25 per cent of nitrogen and 10 to 15 per cent of calcium oxide.

Calcium hydroxide, $Ca(OH)_2$, hydrated lime.—The product of the action of water on calcium oxide (quicklime). Considerable heat is evolved when the calcium oxide unites with water. This process is called slaking. The slaked lime or calcium hydroxide when exposed to the air takes up carbon dioxide from the air and becomes air-slaked lime or calcium carbonate. Calcium hydroxide is more active than ground limestone (calcium carbonate) and contains more calcium. Seventy-four pounds of hydrated lime contains as much calcium as 100 pounds of ground limestone. Hydrated lime is frequently used when lime is required on a golf course, but since it is likely to injure

turf if used in excess or soon after an application of fertilizer containing ammonia it should be handled with care.

Calcium nitrate, $Ca(NO_3)_2$, nitrate of lime, lime nitrate.—A white salt formed by combining a definite mixture of lime or limestone with nitric acid. It is a source of nitrogen in the nitrate form but thus far has not been generally used on golf courses in the United States. It absorbs water readily and therefore must be shipped in containers that exclude moisture. The commercial calcium nitrate used as a fertiiizer contains about 15 per cent of nitrogen and 28 per cent of lime (calcium oxide).

Calcium oxide, CaO, lime, burned lime, quicklime. See also *lime.* Made by heating limestone, marble, oyster shells, and other forms of calcium carbonate to a temperature sufficient to drive off the carbon dioxide. It requires 100 pounds of limestone (calcium carbonate) to make 56 pounds of calcium oxide or 74 pounds of calcium hydroxide.

Calcium phosphate, $Ca_3(PO_4)_2$, bone phosphate of lime, phosphate of lime, tri-calcium phosphate.—This salt of calcium and phosphoric acid is the form in which phosphoric acid usually occurs in nature in phosphate rocks and bones. Superphosphate is manufactured by treating ground rock phosphate with sulphuric acid. As a result the following phosphates are formed: *mono-calcium phosphate,* $CaH_4(PO_4)_2$, water soluble; *di-calcium phosphate,* $CaHPO_4$, citrate soluble; *tri-calcium phosphate,* $Ca_3(PO_4)_2$, insoluble; free phosphoric acid, H_3PO_4, water soluble.

Calcium sulphate, $CaSO_4$, sulphate of lime.—The calcium salt of sulphuric acid which may be formed by the action of sulphuric acid on lime or calcium phosphate combined with water. It occurs in nature as *gypsum,* which see.

Caliche. See *nitrate of soda.*

Calnitro.—Trade name of a German product made by combining ammonium nitrate with carbonate of lime. It contains about 20 per cent of nitrogen and 35 per cent of carbonate of lime.

Calurea.—Trade name of a German product made by combining synthetic urea and calcium nitrate. It contains about 34 per cent of nitrogen and about 14 per cent of calcium oxide.

Carbon dioxide, CO_2.—A gas formed by the burning in the presence of air of any material containing carbon, such as coal. The carbonates are formed by the combination of carbon dioxide with lime, soda, and other alkalies. It is replaced in its salts by the stronger acids, such as sulphuric and phosphoric, similar to the manner in which a weak alkali, such as ammonia, is driven out of its salts by stronger alkalies, such as soda or lime.

Carbonate of lime.—Lime in the form of calcium or magnesium carbonate, such as limestone, marble, oyster and clam shells, and marl.

Carbonate of potash, K_2CO_3.—A material with a strong alkaline reaction usually recovered from plant ashes, molasses residue, wool washing, beet sugar residue, cottonseed hull ashes, and other ashes. As a crude chemical it is sometimes used in the manufacture of special grades of fertilizers not often used on golf courses. The residues from which it is prepared, such as beet sugar, cottonseed hulls, and other ashes, are frequently used for the carbonate of potash they contain. The potash content of these materials ranges from 15 to 65 per cent.

Carbonic acid, H_2CO_3.—A weak acid formed by dissolving carbon dioxide in water. It occurs in soils as the result of the carbon dioxide given off by animals and plants being dissolved in the soil water.

Carnallite. See also *potash.*—A material from which commercial muriate of potash is usually extracted. It contains about 13.5 per cent of actual potash.

Castor bean pomace.—The remains of the castor bean after the oil has been pressed out. It is commonly used as a fertilizer for golf turf. It gives results similar to those obtained from cottonseed and similar meals. Due to the claim that it has insecticidal properties it is occasionally preferred as a fertilizer on golf courses where insect pests are troublesome. It contains 4.5 to 6 per cent of nitrogen, 1.5 to 2 per cent of phosphoric acid, and .5 to 3 per cent of potash.

Cement dust.—A by-product in the manufacture of cement. It contains 6 to 9 per cent of potash.

Charcoal.—Practically pure carbon produced by burning wood in a limited supply of air. It is not a fertilizer but is occasionally used on golf course turf. It contains no nitrogen but traces of phosphoric acid and potash.

Charred peat. See *peat.*

Chile saltpeter. See *nitrate of soda.*

Chloride of potash. See *potassium chloride.*

Chlorides, muriates.—Salts of chlorine in combination with a metal or alkali. They are formed by the action of hydrochloric (muriatic) acid on an alkali or metal.

Chlorine, Cl.—A gas which when combined with hydrogen forms hydrochloric (muriatic) acid. When combined with a metal or alkali it forms chlorides (muriates), the most common of which is table salt (sodium chloride). Chlorine is commonly used in swimming pools and general water supplies for purification purposes. When used on grass in excess it is toxic, but the small quantities used for water purification are not sufficient to injure turf when chlorinated water is used for watering.

Coal ashes.—The residue from the burning of either hard or soft coal. It sometimes contains wood ashes. It is not regarded as a fertilizer but is used frequently on golf courses in constructing drainage lines or in mixing with stiff soils to improve the texture and drainage. Coal ashes contain traces of phosphoric acid and potash.

Cocoa shell meal.—Ground husks of cacao seeds. Its fertilizer constituents are slowly available. It contains 1 to 3 per cent of nitrogen, .5 to 1.5 per cent of phosphoric acid, and 2.5 to 3.5 per cent of potash.

Coffee grounds. See *waste.*

Colloidal phosphate. See also *phosphates.*—A soft, finely divided phosphate, with more or less clay and silt. It is a by-product of mining rock phosphate in Florida. It contains phosphoric acid in the form of tricalcium, iron, and alumina phosphate. According to the methods of analysis used by state control chemists phosphoric acid in these forms is classed as unavailable. It varies in composition but usually contains the equivalent of 20 per cent of phosphoric acid.

Commercial mixed fertilizers.—Mixtures of various fertilizing materials. Many of these mixtures are sold under trade names which

indicate that they are intended for some special purpose, such as *turf special, fairway special* and similar names. In many instances these names are meaningless. Fertilizers sold under identical trade names sometimes vary widely in their compositions and formulas. Mixed fertilizers should be purchased on the basis of the plant foods they contain rather than on the basis of special names. In most states the laws require that the manufacturer of a mixed fertilizer state its content of nitrogen, phosphoric acid, and potash. Some states require that the kind of materials used in preparing the fertilizer be stated also.

Complete fertilizer.—Mixed fertilizer containing all three of the important fertilizer elements (nitrogen, phosphoric acid, and potash) in appreciable amounts.

Concentrated tankage. See also *stick.*—The product from a special treatment of dried stick. It contains about 11 per cent of nitrogen.

Cotton waste. See *waste.*

Cottonseed meal.—The residue after the extraction of oil from the meats of cotton seeds by means of steam and hydraulic pressure. The meal is extensively used as cattle feed, but that which is off color or of inferior grade is sold as a fertilizer. It is commonly used as a golf course fertilizer when the price is favorable. It has given good results as a fertilizer for turf on both putting greens and fairways. It contains 3 to 8 per cent of nitrogen, 2 to 3 per cent of phosphoric acid, and 1.5 to 2 per cent of potash.

Cow manure. See *manure.*

Cyanamid.—Trade name for a commercial *calcium cyanamid* (which see).

Di-ammonium phosphate. See *ammonium phosphate.*

Di-calcium phosphate, $CaHPO_4$. See *precipitated bone* and *precipitated phosphate.*

Dissolved bone.—Produced by treating ground bone with sulphuric acid. It contains 1.5 to 4 per cent of nitrogen and 14 to 24 per cent of phosphoric acid.

Distillery waste.—The residue remaining after fermented molasses has been distilled. This residue is a liquid containing considerable potash and some nitrogen which may be recovered by evaporation. Distillers' grain is the residue of the distilled liquors from corn, rye, and other grains, and contains about 3.5 per cent of nitrogen, .5 per cent of phosphoric acid, and a trace of potash.

Dolomite.—A mineral composed chiefly of carbonates of calcium and magnesium. It may be used for neutralizing acid soils in the same way that lime is used. True dolomite contains about 30 per cent of calcium oxide and 22 per cent of magnesium oxide.

Double superphosphate.—A manufactured product resembling superphosphate in appearance but containing 2½ to 3 times as much available phosphoric acid. In its manufacture phosphoric acid is used in treating the rock phosphate, instead of sulphuric acid as used in the preparation of superphosphate. It is commonly employed in making mixed fertilizers, especially those of the higher grade. It contains 40 to 50 per cent of available phosphoric acid.

Driconure.—A trade name for a dried and pulverized mixture of cow manure and moss peat.

Fairway. Fairway fertilizer. Fairway special. See *commercial mixed fertilizers.*—Trade names for mixed fertilizers claimed to have some special merit for fairway use.

Feathers. See *waste.*

Feldspar.—A mineral containing silica and alumina with potash, soda, or lime. It is seldom used as a fertilizer.

Felt-hat factory waste. See *waste.*

Ferric oxide, Fe_2O_3, oxide of iron.—Found in phosphate rock and widely distributed in nature. Its action in the soil is similar to alumina. Superphosphate containing more than 4 per cent of oxide of iron becomes sticky.

Fertilizer formula. See also *analysis.*—The Association of Official Agricultural Chemists has adopted the following definition: "The term *fertilizer formula* shall be interpreted as expressing the quantity and grade of crude stock materials used in making a fertilizer mixture. For example: 800 pounds of 16-per-cent superphosphate, 800 pounds of 9-20 tankage, and 400 pounds of sulphate of potash-magnesia."

Fertilizer grade. See *grade.*

Fish guano.—Fish scrap.

Fish scrap.—Waste material from canneries, such as non-edible fish and offal, which are cooked by steam and the oil removed under pressure. The pressed material is then ground. In this form it is often used as a fertilizer on golf courses, either alone or in mixed fertilizers. It contains 3 to 10 per cent of nitrogen and 5 to 20 per cent of phosphoric acid.

Acidulated fish tankage, acid fish, and *acidulated fish scrap* are fish scrap treated with sulphuric acid. They contain 4 to 6.5 per cent of nitrogen and 3 to 6 per cent of phosphoric acid.

Floranid.—A trade name for *urea,* which see.

Formula, fertilizer. See *fertilizer formula.*

Garbage tankage.—Produced from waste household food materials. The garbage is steamed and pressed to remove water and some of the grease. More grease is then removed by extraction with naphtha. The residue is then dried and ground. It is comparatively slowly available as a fertilizer but due to its high organic content is a valuable material for composting. It contains 1 to 4.5 per cent of nitrogen, 1 to 6 per cent of phosphoric acid, and .5 to 2.5 per cent of potash.

Gashouse tankage, spent oxide.—A by-product remaining after the removal of sulphur compounds from illuminating gas. Although it often contains 5 to 10 per cent of nitrogen it contains also substances which are poisonous to plants and it should therefore not be used on golf courses.

Glauconite. See *greensand.*

Grade.—A term used to express the minimum guarantee of the total plant food expressed in terms of nitrogen, available phosphoric acid, and water-soluble potash. Fertilizers are commonly classified in three grades according to the following percentages: low-grade or low-analysis, below 20 per cent; medium-grade or medium-analysis, 20 to 30 per cent; high-grade or high-analysis, over 30 per cent.

Thus ½ ton of 16-8-8 fertilizer, which would be considered a high-grade fertilizer, contains the same amount of plant food as 1 ton of 8-4-4, or a low-grade fertilizer. The advantages in the high-grade fertilizers are lower handling, hauling, and storage costs at the plant and destination, reduction in freight costs, fewer bags needed, and economies in distribution. In using high-grade fertilizers careless application to fine turf may cause damage by burning due to the high concentration of fertilizers.

Grape pomace.—The residue after the juice has been pressed from grapes. It may be used on golf courses as a source of organic material for composting purposes. It contains about 1 per cent of nitrogen and small amounts of phosphoric acid and potash.

Grass clippings.—Grass removed from putting greens as they are cut. These clippings may be used to fertilize the approaches by scattering them on the turf, or they may be used as an ingredient of compost piles. Clippings from an ordinary bent green contain about 4.5 per cent of nitrogen, .5 per cent of phosphoric acid, and 3 per cent of potash.

Green manure.—A term applied to crops of such plants as rye, clover, vetch, cowpeas, and soybeans, which are plowed or disked into the soil while still green in order to supply the soil with organic material. Green-manure crops can be used to advantage on golf courses in preparing the topsoil before the course is planted to seed for permanent turf and also in soil beds where soil is being prepared for top-dressing. Legumes used as green-manure crops add large quantities of nitrogen to the soil because these plants are able to assimilate the nitrogen directly from the air and combine it with other materials in a form that can later be used by turf grasses.

Greensand, glauconite.—A hydrated silicate of iron and potash not recommended as a fertilizer since the potash is not available without special treatment.

Guano.—Deposits of the droppings and dead bodies of birds and bats; found in districts where there is no rain. Some of the deposits are of a surprisingly large extent. The material varies considerably in its plant-food value. It is a quickly available organic fertilizer and can be used to advantage on golf courses. On account of the variation in analyses of different samples it should be purchased on the basis of analysis. It contains .4 to 13.5 per cent of nitrogen, 10 to 35 per cent of phosphoric acid, and a trace to 4 per cent of potash. Fish guano is *fish scrap*, which see. See also *whale guano.*

Gunpowder sweepings. See *waste.*

Gypsum, $CaSO_4 2H_2O$, land plaster. See also *calcium sulphate.*—A combination of calcium sulphate and water. It is valuable as a preservative for manure since it aids in retaining the ammonia. It can be utilized for this latter purpose by golf clubs which store large quantities of fresh manure. Gypsum has been used occasionally on golf courses for direct application to turf but its value for such purpose is questionable. Any addition of calcium in this form should not be regarded as a substitute for lime since gypsum does not neutralize acids as does lime.

Hair.—Waste from tanneries. It is used in making nitrogenous tankage and wet base goods. It is too slowly available to be suitable

as a fertilizer. It can be used to advantage in making compost. It contains on the average about 9 per cent of nitrogen.

Hardsalt, hartsaltz. See also *potash.* A salt similar to kainit. It is composed of widely different proportions of muriate of potash, magnesium sulphate, and sodium chloride. It contains about 16 per cent of potash.

Hardwood ashes. See also *wood ashes.*—The ashes from the burning of hardwood. They have little value on turf except when the soil is deficient in potash. They contain from a trace to 14 per cent of potash before they have been leached.

Hare waste. See *waste.*

Hay.—Grass cut from the rough and other waste places around the golf course. This grass can be used to advantage as an ingredient of compost piles or by rotting down into artificial manure (see *artificial manure,* under *manure*) or by mixing in compost. Average hay contains about 1.5 per cent of nitrogen, .5 per cent of phosphoric acid, and 1.5 to 2 per cent of potash.

Hen manure. See *manure.*

High-analysis fertilizer. See *grade.*

Hoof and horn meal.—A meal resulting from the processing, drying, and grinding of hoofs and horns. It contains 10 to 15.5 per cent of nitrogen in a slowly available form and 1 to 2.5 per cent of phosphoric acid.

Horse manure. See *manure.*

Humic acid.—Acid derived from the decay of organic material.

Humus.—Decomposed organic matter in the soil.

Hydrated lime. See *calcium hydroxide* and *lime.*

Hydrogen, H.—A highly inflammable gas and an essential element of all acids. It is usually made by passing steam over hot coke. Of importance to the fertilizer industry in the manufacture of synthetic ammonia.

Hydrogen ion concentration. See *pH.*

Hygroscopic.—Ability or tendency to absorb or condense moisture from the air.

Imhoff sewage sludge. See *sludge.*

Incomplete fertilizer.—Mixed fertilizer in which one of the three important fertilizer elements (nitrogen, phosphoric acid, and potash) is contained in less than 1 per cent.

Inorganic.—A term used to designate substances belonging to the mineral kingdom as distinguished from the organic substances, which are derived from living organisms. In this class are included the various carbonates and also all compounds which do not contain carbon. Sulphate of ammonia, nitrate of soda, superphosphate, lime, and muriate of potash are common examples of inorganic fertilizers.

Iodine, I.—An acid-forming chemical element occurring in the Chilean nitrate deposits and in seaweeds.

Iron, Fe. See *ferric oxide.*

Kainit. See also *potash.*—A potash salt containing potassium and sodium chlorides and sometimes sulphate of magnesia. It occurs in irregular deposits and is usually of a reddish color. Most of the kainit

on the market at present is a mixture of carnallite and sylvanite or hardsalt with sodium chloride. It contains 11 to 22 per cent of potash.

Kali-ammon-salpeter, potassium ammonium nitrate.—A trade name for a mixture containing one-half of its nitrogen in the nitrate form and one-half in the form of ammonia. The mixture is made with the object of reducing the hygroscopic property of the ammonium nitrate. It contains about 16 per cent of nitrogen and 27 per cent of potash.

Kalkammon.—A mixture of ammonium chloride and calcium carbonate which contains about 17 per cent of nitrogen.

Kalk-ammon-salpeter. Same as *Calnitro,* which see.

Kelp.—A species of seaweed which has a wide distribution. At one time it was extensively harvested in order to obtain potash. Kelp from the Pacific coast ranges higher in potash content than that found on the Atlantic coast. Kelp contains 1.5 to 3.5 per cent of nitrogen, 1 to 2 per cent of phosphoric acid, and 15 to 20 per cent of potash.

Land plaster. See *gypsum.*

Leaf mold.—Partially decomposed leaves from woodlands or from piles of leaves stacked up to decay. Such material is often available on golf courses and is useful for mixing with soil in compost piles or soil beds. It is largely organic matter and contains 1 to 3 per cent of nitrogen and traces of phosphoric acid and potash.

Leather.—Scraps and shavings of leather are used in making base goods or nitrogenous tankage. They are sometimes ground. They are slow to decay and become available, but can be used in compost piles and soil beds. Scrap leather contains 5 to 12 per cent of nitrogen.

Leaves.—Gatherings from the golf courses or woods used as an ingredient of compost piles or rotted down into artificial manure (see *artificial manure,* under *manure*). Leaves contain about 1 per cent of nitrogen, .5 per cent of phosphoric acid, and 1 per cent of potash.

Lecco.—One of the *commercial mixed fertilizers,* which see.

Leucite.—A mineral containing aluminum and potassium silicates. The potash may be rendered soluble by special treatment.

Leunaphos. See also *ammonium phosphate.*—A trade name for a mixture of di-ammonium phosphate and sulphate of ammonia. It contains about 20 per cent of nitrogen and 20 per cent of available phosphoric acid.

Leunasalpeter. See also *ammonium nitrate* and *Montansalpeter.* —A trade name for a double salt made from sulphate of ammonia and nitrate of ammonia. Approximately ¼ of the nitrogen is in the nitrate form and ¾ in the ammonia form. It is not explosive nor is it very hygroscopic, as is true of nitrate of ammonia. It contains about 26 per cent of nitrogen.

Lime.—In the fertilizer trade the term *lime* applies to calcium oxide, calcium hydroxide, and calcium carbonate in the crude form, or their equivalent in magnesium compounds. The term however is applied primarily to *calcium oxide,* which see. Lime occurs commonly in nature in the form of limestone, marble, shells of mollusks, marl, and other natural deposits. Some years ago lime was used in excess on golf courses where no other fertilizers were used. This abuse led to a reaction against lime and for a time its use was greatly

restricted. Recent tests have shown that lime plays an important function in grass culture but that its excessive use or avoidance is harmful. Generally on golf courses lime is applied in some carbonate form, especially when preparing seed beds. When a quick reaction is desired on turf the hydrated form is preferable. Lime in the hydrated form however is more likely to injure turf than lime in the carbonate form and therefore must be used with greater caution. The more common forms of lime are as follows:

Agricultural lime.—This is an indefinite term which has been used for a number of years but has come into disrepute and is no longer encouraged by the fertilizer trade.

Air-slaked lime.—A lime carbonate produced by exposing quick lime to the atmosphere. The slaking process in the air enables the quick lime to absorb both moisture and carbon dioxide to form calcium carbonate.

High calcium lime products.—Liming materials containing not more than 4 per cent of their total oxides as magnesium oxide.

High magnesium lime products.—Liming materials containing more than 25 per cent of their total oxides in the form of magnesium oxide.

Hydrated or slaked lime.—Crude calcium hydroxide obtained by treating quick lime with sufficient water or steam to combine with its oxides to form hydroxides. During the chemical process of slaking quick lime considerable heat is evolved. It contains 60 to 80 per cent of calcium oxide.

Ground limestone.—A lime carbonate obtained by grinding calcitic or dolomitic limestone. Seventy-five per cent or more should pass a 100-mesh sieve. It should contain the equivalent of not less than 45 per cent of calcium oxide or the mixed oxides of calcium and magnesium.

Ground shell lime.—A lime carbonate obtained by grinding the shells of mollusks. Seventy-five per cent or more should pass a 100-mesh sieve. It should contain the equivalent of not less than 40 per cent of calcium oxide or the mixed oxides of calcium and magnesium.

Marl, ground shell marl.—A lime carbonate obtained by grinding natural deposits of shell marl. Seventy-five per cent or more should pass 100-mesh sieve. It should contain the equivalent of not less than 40 per cent of calcium oxide or the mixed oxides of calcium and magnesium.

Precipitated lime.—A form of carbonate of lime which is ordinarily more variable in its composition than is limestone. It may contain impurities of clay or silty material.

Quicklime, burned lime, caustic lime, lump lime, unslaked lime.—Commercial calcium oxide and magnesium oxide produced by heating natural carbonates such as limestone, marble, shells, and others, until practically all of the carbon dioxide has been driven off. It contains 80 to 95 per cent of calcium oxide.

Waste lime, by-product lime.—Industrial by-products containing calcium and magnesium in forms that will neutralize acids.

Lime nitrate. See *calcium nitrate.*

Lime requirement.—The amount of lime needed to neutralize acids in a soil. The more acid the soil, the higher is its lime requirement.

Limestone. See *calcium carbonate* and *lime.*

Linseed meal.—Produced by grinding the cake which is a by-product when flaxseed is pressed to recover linseed oil. It analyzes about 5.5 per cent of nitrogen, 1.5 per cent of phosphoric acid, and 1.3 per cent of potash.

Liquid stick. See *stick.*

Loma.—One of the *commercial mixed fertilizers,* which see.

Low-analysis fertilizer. See *grade.*

Magnesia, MgO, oxide of magnesium. See also *lime.*—Usually associated with lime; also found in dolomite. Magnesium behaves like calcium in neutralizing acids.

Manganese, Mn.—A soft, reddish-gray metal, widely distributed as the oxide. It plays an important part in plant growth. It is deficient in a few soils, especially in certain parts of Florida, and when added to such soils gives remarkable results. Most golf course soils are however adequately supplied with manganese.

Manure. See also *green manure, pulverized poultry manure, poultry manure tankage,* and *mushroom soil.*—A term used in old agricultural practice for fertilizers in general but now in America generally meaning the excreta of animals with the straw or other bedding material used as an absorbent. Manure is chiefly organic matter and is valuable on golf courses for preparing the soil for planting and for mixing with soil for top-dressing purposes. Some manures contain seeds of many weeds which are undesirable on golf courses; hence care must be exercised in selecting manure, particularly for putting greens. Some have a high water content and consequently a much less fertilizer value than an equal weight of the relatively dry manures. Some by being dried and pulverized are reduced to a form that is convenient for direct application to turf. The fertilizer value of manures varies considerably, depending on the kind of animal from which they are obtained and the type of food consumed by the animal producing the manure, and also on the litter used and the method of storing and caring for the manure after it is collected.

Artificial manure consists of leaves, straw, grass clippings, or similar materials reduced to the form of a manure substitute by the addition of a quickly available source of nitrogen, such as sulphate of ammonia or nitrate of soda, which hastens decay. The process of making artificial manure, known as the *Rothamsted method,* is described on page 167 of the Bulletin for September, 1930.

Some approximate analyses of manures are given in the accompanying table.

APPROXIMATE CONTENT OF MOISTURE, NITROGEN, PHOSPHORIC ACID, AND POTASH OF SOME MANURES

	Moisture per cent	Nitrogen per cent	Phosphoric acid per cent	Potash per cent
Barnyard manure, mixed cow and horse	72.0	trace—1.5	trace—1.0	.5—1.0
Cow manure, dry ground	44.0	1.5—2.0	.5	1.5
Hen manure, fresh	65.0	1.0—2.5	.5—2.0	.5
Hen manure, dry	5.7	2.0	1.5	1.0
Henhouse refuse	12.5	trace—1.0	.5—1.0	trace—1.0
Horse manure	53.0	.5—1.0	trace—1.5	.5—3.0
Horse manure, dry ground	8.5	2.5	2.5	2.0
Sheep manure, fresh	44.5	1.0	1.0	1.0
Sheep manure, dry ground	7.9	2.0—4.0	1.5—2.5	1.0—3.0
Sheep manure, foreign sterilized	3.3	3.0	trace	.5

Manure salts.—These salts are found in French and German deposits as raw salts but they may be obtained as a by-product in the manufacture of muriate of potash. They contain a high percentage of chlorides and 20 to 30 per cent of potash.

Marl. See also *lime.*—Earthy or soft rock deposits rich in carbonate of lime. It has a similar effect to that of limestone when applied to the soil.

Meal. See *cocoa shell meal, cottonseed meal, hoof and horn meal, linseed meal, meat meal, mowrah meal, mustard meal, rapeseed meal, seed meal.*

Meat meal.—Ground meat containing very little bone. It analyzes approximately 10 per cent of nitrogen and 1 to 5 per cent of phosphoric acid.

Medium-analysis fertilizer. See *grade.*

Menhaden.—A small fish from which oil is recovered and the by-product of which is made into fish scrap.

Milorganite.—A trade name for an activated sludge. See *sludge.*

Mixed fertilizers. See also *commercial mixed fertilizer.*—Mixtures of various fertilizer ingredients prepared for special purposes.

Mono-ammonium phosphate. See *ammonium phosphate.*

Montansalpeter. See also *ammonium nitrate* and *Leunasalpeter.*—A trade name for a dry mixture of ammonium nitrate and sulphate of ammonia of which ¼ of the nitrogen present is in the nitrate form and ¾ in the ammonia form. It contains 26 per cent of nitrogen.

Mora meal. Mowrah meal.—The seeds of the Bassia tree are pressed to recover the fat they contain and the resulting cake is ground into mowrah meal. It contains saponin, which makes it unfit as animal feed. It is used to a considerable extent on golf courses as a vermicide. When spread on greens and watered into the soil it causes worms to come to the surface. It also has some fertilizer value, containing 3 to 5 per cent of nitrogen in a slowly available form and about 1 per cent of phosphoric acid and 1 per cent of potash.

Muck. See *peat.*

Muriate. See *chloride.*

Muriate of potash. See *potassium chloride.*

Mushroom soil. Spent mushroom soil.—Discarded soil from mushroom beds. Commercial mushroom beds are filled with manure, to which is added a small proportion of soil. The mushrooms feed on the manure and gradually decompose it, after which the beds are emptied and refilled. Mushroom soil is therefore primarily well-rotted manure but its composition varies to some extent depending on the proportion of soil used in filling the beds. It is used on golf courses like well-rotted manure and is valuable as an ingredient of compost. It ordinarily contains about 1 per cent of nitrogen, .5 per cent of phosphoric acid, and 1 per cent of potash.

Mustard meal.—Ground residue of mustard seeds after the oil has been extracted. It contains about 5 per cent of nitrogen, 1 per cent of phosphoric acid, and 1 per cent of potash.

Naco.—One of the *commercial mixed fertilizers,* which see.

Nebraska potash.—Highly alkaline salts obtained from the evap-

oration of brines in Nebraska. They contain from 20 to 30 per cent of potash, mostly as carbonate and sulphate.

Niter cake.—A product remaining in the manufacture of sulphuric acid by the chamber process, in which nitric acid or nitric oxide is added to complete the oxidation. Niter cake is essentially sodium bisulphate, and contains approximately 35 per cent of sulphuric acid.

Nitrate of ammonia. See *ammonium nitrate.*

Nitrate of lime. See *calcium nitrate.*

Nitrate of potash. See *potassium nitrate.*

Nitrate of soda, $NaNO_3$, Chile saltpeter, sodium nitrate.—The salt formed by a combination of nitric acid and sodium. Until recently it has been obtained in large quantities from deposits on the west coast of South America, chiefly from Chile. Nitrate of soda is the chief ingredient of the mineral *caliche* and is dissolved out of the caliche with water. The water is then evaporated, leaving the nitrate residue, during which process valuable iodides and bromides are recovered. It is now being made synthetically from synthetic nitric acid and caustic soda (NaOH) or soda ash (Na_2CO_3) in the United States and Europe. Some of the synthetic nitrate of soda now on the market has been especially prepared and dried so that it can be distributed readily with fertilizer distributors. Much of the nitrate of soda on the market tends to cake and is difficult to distribute without mixing with other materials. It has been largely replaced by sulphate of ammonia in golf course fertilizing due principally to the fact that nitrate of soda leaves an alkaline residue (soda) in the soil which seems favorable to the growth of certain weeds and clover. Nitrate of soda analyzes about 15 per cent of nitrogen.

Nitrate of soda-potash.—This fertilizer is prepared in much the same manner as nitrate of soda. It is made from a crude Chilean caliche which contains both nitrate of soda and nitrate of potash. It contains 14 to 15 per cent of nitrogen and 10 to 14 per cent of potash.

Nitrates. See also *nitrogen* and *nitrogen cycle.*—The salts of nitric acid formed by its action on metals and alkalies; also metals or alkalies may be combined with nitrogen and oxygen in the proportion of NO_3 to form nitrates. Nitrogen in this form is quickly available to plants.

Nitric acid, HNO_3.—A strong mineral acid which combines readily with metals or alkalies to form nitrates. It is now made synthetically on a large scale for the manufacture of fertilizers and other products. By an elaborate process nitrogen is taken from the air and changed into ammonia, which in turn is combined with oxygen to form nitric oxide, which is dissolved in water to form nitric acid. This process of converting the unlimited supply of nitrogen in the air into nitric acid has had an important bearing on the fertilizer industry in recent years.

Nitrification.—The process whereby different forms of nitrogen in the soil are converted into nitrates by various bacteria or other micro-organisms living in the soil. It is generally supposed that plants can use nitrogen only when it is in the form of nitrates and therefore this process is regarded as of great importance. Nitrification is most rapid when the soil is warm, has sufficient but not too much moisture, and is nearly neutral or alkaline.

Nitrites. See *nitrogen cycle.*

Nitroganic.—A trade name for an activated sludge. See *sludge.*

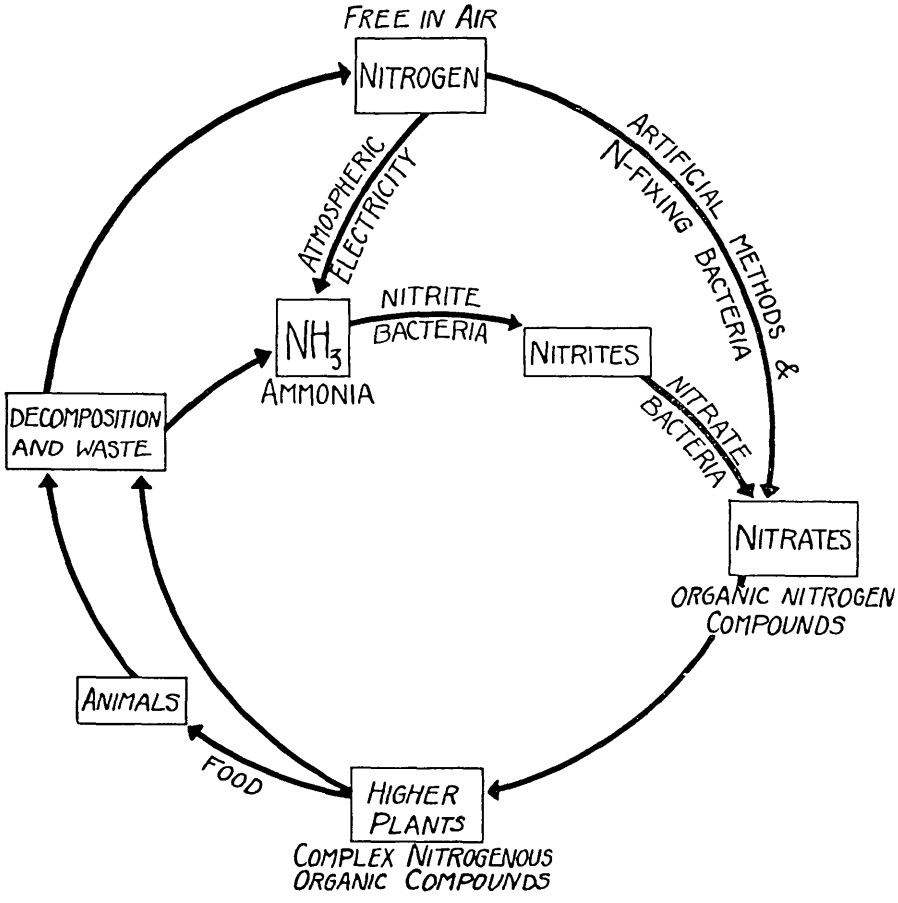
Nitrogen, N.—A colorless, tasteless, and odorless gas, constituting about 4/5 of the atmosphere by volume. It is an inactive gas, combining with other materials only at a high temperature or as the result of the action of certain microorganisms. When it is once combined with other elements it takes part in a large number of chemical processes of commercial importance. In fertilizers it is important in the forms of ammonia, nitrates, and various organic compounds. It is the most important fertilizer element in growing grass for turf purposes. Nitrogen is one of the important ingredients of animal manures and certain minerals used as fertilizers. In recent years nitrogen from the air has been combined with other elements to form nitric acid, ammonia, and cyanamid. The air is liquified and allowed to become warm to distill off the nitrogen and separate it from the oxygen. The nitrogen thus separated is converted into ammonia and nitric acid by a definite chemical process. Fixed nitrogen in fertilizer materials is classified as nitrates, ammonia salts, and organic nitrogenous matter. *Nitrates* consist of one part of nitrogen and three parts of oxygen combined with soda, potash, ammonia, lime, or similar alkalies. Most of the nitrates in the past have come from the large deposits of nitrate of soda in Chile. In recent years nitrates have been manufactured by combining nitrogen from the air with other elements. *Ammonia salts* are combinations of nitrogen with hydrogen and some acid. Most of the ammonia salts used in fertilizers are combinations of some acid with ammonia recovered by gas companies as a by-product of coke ovens. Ammonia salts are now also produced by converting nitrogen in the air into ammonia and absorbing this ammonia in acid. Organic nitrogenous matter includes animal and vegetable materials such as tankage, cottonseed meal, bone meal, fish scrap, and sewage sludge. In these materials the nitrogen is combined with complex organic compounds containing carbon, hydrogen, oxygen, and other elements.

Nitrogen cycle.—The circulation of nitrogen in nature (or the nitrogen cycle) is a provision without which plants and animals would soon starve. This cycle is an example of the chemical law of the conservation of mass, under which no elemental matter is lost even though it may change its form by combination or disintegration.

Free nitrogen of the air may be converted into *nitrates* by the nitrogen-fixing organisms present in the soil, and also by the bacteria which live in tubercles or nodules upon the roots of plants of the legume family. Recently artificial methods have been developed to combine the atmospheric nitrogen with other substances, forming compounds of nitrogen which are available to plants. It seems a needless burden that man must pay considerable for his nitrogen by purchasing it in combination in the form of proteins and other organic substances when the air he breathes contains large quantities of pure nitrogen, but neither plants nor animals other than the nitrogen-fixing soil organisms and certain bacteria that form nodules on the roots of legumes are able to use it in the pure form. However, it is largely in the form of nitrates that nitrogen is taken in by plants and transformed by certain physiological processes into proteins and other organic compounds which in turn serve for nutrition of animals. These compounds of nitrogen finally return to the soil as decomposition products of plants and animals. In this process am-

monia is produced and taken into the soil as such. Here the nitrite bacteria convert it into *nitrates,* which in turn are seized upon by the nitrate bacteria which produce the nitrates. For these bacteria to function properly and efficiently they must have proper soil, moisture, and temperature conditions as well as soil containing plenty of the common plant food elements.

The leguminous plants, such as clovers, alfalfa, beans, and peas, assist in keeping up the combined nitrogen supply by assimilating free nitrogen from the air and storing it in combination with other elements through the medium of certain microscopic organisms or bacteria which live in the nodules upon their roots and take up free nitrogen and cause it to form compounds suitable for plant food.



Diagrammatic representation of the nitrogen cycle

A limited amount of the nitrogen of the air, which is unavailable to plants as such, is converted into ammonia by atmospheric electricity and washed into the soils by rain.

The accompanying diagram illustrates essentially the several steps in the nitrogen cycle, although the actual changes that occur in the complete cycle are much more complex than is indicated by the diagram. There are a great many changes involved in the form of nitro-

gen; but in the final analysis the total amount of nitrogen remains the same.

Nitrogenous materials.—All materials containing nitrogen either in the organic or inorganic form.

Nitrogenous tankage, process tankage.—Waste material obtained from leather, wool, hair, feathers, and such by a process of steaming with or without the use of acids, for the purpose of increasing the activity of the nitrogen. The product is then dried and ground and is a highly available nitrogenous material containing 5.5 to 10 per cent of nitrogen.

Nitrolene.—A trade name for certain base goods containing about 9 per cent of nitrogen. See also *base goods.*

Nitrophoska.—A trade name for a number of highly concentrated complete fertilizers manufactured in Germany by mixing di-ammonium phosphate, nitrate of ammonia, and potash salts. There are four grades of this material offered to the American trade; number 1, containing 15 per cent of nitrogen, 30 per cent of available phosphoric acid, and 15 per cent of potash; number 2, containing 16.5 per cent of nitrogen, 16.5 per cent of available phosphoric acid, and 21.5 per cent of potash; number 3, containing 15.5 per cent of nitrogen, 15.5 per cent of phosphoric acid, and 19 per cent of potash; number 4, containing 15 per cent of nitrogen, 11 per cent of phosphoric acid, and 26.5 per cent of potash.

Organic.—This term was originally confined to materials containing carbon as an essential ingredient originating in living organisms, as distinguished from materials of mineral origin which are referred to as inorganic. The term has been extended to include also carbon compounds of artificial or synthetic origin. It does not include carbonates. Blood, tankage, and manure are common examples of organic fertilizers obtained from animals, whereas urea is an example of an organic fertilizer which is produced in the bodies of animals but is also produced in large quantities by a manufacturing process.

Oxygen, O.—A colorless, tasteless, odorless gas. It occurs in enormous quantities as a free gas in the air, and in combined form it constitutes an important part of water and a large part of the earth's crust. It is an essential constituent of all plant and animal tissues and fluids. The roots as well as the tops of plants require oxygen. It also forms part of most fertilizer materials even though in itself it is not regarded as a fertilizer.

Oyster shell. See *waste.*

Peanut shells. See *waste.*

Peat, muck.—Partly decayed vegetation which has accumulated in swampy land and has been buried in layers under the water. It is regarded as the first stage in the development of coal from plant accumulations. Peat or muck is frequently used on golf courses, particularly on putting greens. It contains 1.5 to 3 per cent of nitrogen, a trace to .5 per cent of phosphoric acid, and a trace to 2.5 per cent of potash, but these are not readily available and are ordinarily of little value as fertilizers. Peat is frequently used as a filler in the preparation of commercial fertilizers. The material is discussed in greater detail in the Bulletin for November, 1929.

Peruvian guano. See *guano.*

pH, hydrogen ion concentration.—A sign used to express the degree of acidity or alkalinity of any solution, soil, or compound. A numeral joined to the term, as in ph 5, indicates the degree. The numeral 7, as in pH 7, is an indication that the material is neither acid nor alkaline but neutral. All values below 7 indicate acidity; the lower the number the higher the acidity. All values above 7 indicate alkalinity; but in this instance the higher the number the higher the alkalinity. The meaning and use of pH are discussed in greater detail in an article in the Bulletin for April, 1930.

Phosphate of potash. See *potassium phosphate.*

Phosphate rock.—This rock occurs in large quantities in many parts of the world. It contains various amounts of phosphorus in the form of calcium phosphate or phosphate of lime. The commercial phosphate rock used in the United States contains 30 to 34 per cent of calcium phosphate.

Phosphates.—See also *collodial phosphate, precipitated phosphate,* and *superphosphate.*—Salts of phosphoric acid which may be formed by combining phosphoric acid with an alkali such as soda, potash, ammonia, or lime. Phosphates of lime and ammonia are the only ones that are used extensively as fertilizers.

Phosphoric acid, P_2O_5.—This acid is seldom used alone but its salts are in general use. The acid itself is never used as a fertilizer but in the trade the practice is to state the amount of phosphorus in any fertilizer in terms of phosphoric acid. Phosphorus in fertilizers occurs in various combinations and the designation of the amount of phosphoric acid is merely for convenience in comparing values of different fertilizers and simply signifies how much phosphorus there would be if it were already in the form of P_2O_5.

Phosphorus, P.—An element which combines with oxygen and hydrogen to form phosphoric acid. It is never used alone as a fertilizer but occurs mixed with other elements in many fertilizers. It is one of the three essential elements used in the preparation of a complete fertilizer. A good turf can not be maintained without phosphorus in an available form. An adequate supply of phosphorus encourages the development of new shoots and therefore tends to induce a matted turf. An excess of phosphorus, on the other hand, sometimes makes grass too yellow and unthrifty.

Picker dirt. See *waste.*

Plaster.—A preparation from *gypsum,* which see.

Pomace. See *castor bean pomace,* also *grape pomace,* also *tung oil pomace.*

Potash, K_2O.—As used in the fertilizer trade potash expresses the equivalent of potassium oxide in the various potash salts. In fertilizers it is usually in the form of muriate or sulphate, but occasionally as the carbonate or nitrate. Potash materials are supplied mostly from the French and German deposits and from refined low-grade materials in California and Spain. The evaporation of sea water confined in prehistoric lakes without outlets is believed to be the source of the French and German salt and potash beds. The continual evaporation and concentration of the sea water washed in by tide and storm through channels from the coast resulted in deposits of vast layers of salts, differing in composition from rock salt to *carnallite,*

kainit, and *hardsalt.* These latter three are used in the manufacture of potash salts for the fertilizer trade.

Potassium, K.—A soft, bright metal, which, in the pure metallic state, has the appearance of lead. It oxidizes rapidly when exposed to air and combines with water to form caustic potash. The pure metal is never used as a fertilizer but its salts are in general use in the fertilizer trade. In the fertilizer trade the amount of potassium contained in a fertilizer is expressed in terms of potash, which represents the equivalent of potassium oxide. It is one of the three essential components of a complete fertilizer. For turf purposes on a great majority of golf courses it is one of the least important of the three essential elements nitrogen, phosphorus, and potash. A small amount of potassium, however, may be advisable in turf fertilizers, especially on soils that are deficient in this element.

Potassium chloride, KCl, chloride of potash, muriate of potash.—A salt which may be made by mixing hydrochloric (muriatic) acid with caustic potash. Most of the natural deposits of potash are in the form of potassium chloride. Muriate of potash for fertilizers contains 48 to 53 per cent of potash.

Potassium hydroxide, KOH, caustic potash.—A very strong alkali which has a corrosive action on the skin and kills plants with which it comes in contact. It is not used as a fertilizer but when combined with acids forms salts which are used for fertilizers.

Potassium nitrate, KNO_3, saltpeter, nitrate of potash.—A salt which may be produced by mixing nitric acid with caustic potash. Small deposits of this salt occur in various parts of the world. It is also manufactured from nitrate of soda and muriate of potash. It is not frequently used as a fertilizer. Pure potassium nitrate contains 14 per cent of nitrogen and 44 per cent of potash.

Potassium phosphate, phosphate of potash.—The potassium salt of phosphoric acid which may be made by the action of phosphoric acid on caustic potash. It is not used much as a fertilizer but it may be developed as a concentrated fertilizer containing phosphoric acid and potash.

Potassium sulphate, K_2SO_4, sulphate of potash.—The potassium salt of sulphuric acid, which may be made by mixing sulphuric acid with caustic potash. Some sulphate of potash occurs naturally in France and Germany, but most of it is made by treating muriate of potash with sulphuric acid or sulphate of magnesia. For fertiizers it is sold on a basis of 90 per cent of sulphate of potash, which is equivalent to 48.7 per cent of potash.

Poultry manure. Pulverized poultry manure. See also *manure.*—A common turf fertilizer obtained from poultry farms or from cars in which poultry is shipped to market. Its nitrogen content varies widely depending on how much soil or litter is mixed with the manure. If not properly handled poultry manure rapidly loses its nitrogen in the form of ammonia. In purchasing poultry manure for turf special attention should be given to its nitrogen content, which may vary from 2 to 6 per cent. It contains 1 to 3 per cent of phosphoric acid and 1 to 1.5 per cent of potash.

Poultry manure tankage.—A pulverized product containing poultry manure from cars in which poultry has been shipped to market combined with blood and offal from slaughtered poultry. Due to the

addition of blood and offal this material has a higher proportion of plant foods than has ordinary poultry manure. It is in common use on golf courses for both fairways and putting greens. Poultry manure tankage contains 6 to 7 per cent of nitrogen, about 3 per cent of phosphoric acid, and 1.5 per cent of potash.

Powder-works waste. See *waste.*

Precipitated bone.—A by-product in the manufacture of glue-stock resulting from the treatment of bones with hydrochloric acid. Lime or limestone is used to precipitate the phosphoric acid. It contains about 40 per cent of available phosphoric acid, mostly in the form of *di-calcium phosphate* soluble in neutral ammonium citrate.

Precipitated phosphate.—A by-product usually obtained from the manufacture of mono-calcium phosphate used in baking powder.

Process tankage. See *nitrogenous tankage.*

Protein. The nitrogen-carrying portion of stock feed. It is not in common use in the fertilizer trade.

Putting green. Putting green fertilizer. Putting green special. See *commercial mixed fertilizers.*—Trade names for mixed fertilizers claimed to have some special merit for use on putting greens.

Quicklime. See *calcium hydroxide* and *lime.*

Rapeseed meal.—A product obtained by grinding the cake resulting from pressing rapeseed in securing rapeseed oil. It contains about 6 per cent of nitrogen, 2 per cent of phosphoric acid, and 1 per cent of potash.

Reverted phosphoric acid.—Term used in the fertilizer trade to designate the phosphoric acid which undergoes certain changes as the superphosphate cures. It is of little practical significance in turf fertilizer practice.

Rothamsted method. See *artificial manure,* under *manure.*

Rough ammoniates.—Scraps of leather, felt, wool waste, fur, hair, and similar organic nitrogenous waste materials not suited for fertilizer material without treatment. Used in manufacturing tankage and wet base goods.

Sal-ammoniac. See *ammonium chloride.*

Salt.—The product of the combination of an acid and an alkali. Many of the common inorganic fertilizer materials are salts produced either naturally or artificially. If the alkali caustic soda, for instance, reacts with nitric acid, the salt nitrate of soda is produced, or if the alkali ammonium hydroxide reacts with sulphuric acid the salt sulphate of ammonia is produced. Common table salt may be produced by treating caustic soda or sodium bicarbonate with hydrochloric acid.

Saltpeter. See *potassium nitrate.*

Seaweed. See *kelp.*

Seed meal. See also *castor pomace, cottonseed meal, linseed meal, mowrah meal, mustard meal,* and *rapeseed meal.*—Seeds of various plants furnish sources of numerous fertilizers. All seeds are rich in nitrogen and many of them contain fat. The fat is pressed out of some seeds for various commercial oils and the residue is ground for use as feed for animals or as fertilizers. Seed meals are used chiefly for the nitrogen they contain, although they carry small amounts of phosphoric acid and potash.

Sewage sludge. See *sludge.*

Sheep manure. See *manure,* also *wool waste.*

Shell lime. See *lime* and *waste.*

Shoddy. See *waste.*

Silica, SiO_2.—This is one of the most abundant of the earth's ingredients. It is insoluble in common acids and is one of the most resistant components of most rocks. Sea sand and quartz are common examples of silica. Silica combines with alkalies to form silicates, which are insoluble in water or weak acids. Large quantities of potash are locked up in the form of insoluble silicates which are not available for plant use.

Silk waste. Silkworm cocoons. See *waste.*

Slag. See *basic slag.*

Sludge. Sewage sludge.—An organic material obtained by the purification of city sewage. The most important kinds are activated sludge and ordinary sludge. Both forms are used extensively on golf courses, particularly as fairway fertilizers. Some sludge is difficult to distribute and is of little value for turf fertilizers. Other sludge, however, is especially prepared as a fertilizer and is in excellent condition for distribution through the ordinary fertilizer distributors. Sludge is also often used as an ingredient of commercial mixed fertilizers. The process of purification determines the nature and kind of sludge obtained as a product.

Activated sludge is raw sewage mixed with approximately 25 per cent by volume of material which has already passed through the purification tanks and has been distributed to large aeration tanks in the bottom of which porous plates are placed and through which air is forced to produce a continuous stream of tiny bubbles. This process is kept up for approximately six hours, after which the aerobic organisms, which live in the presence of air, cause the organic matter to coagulate. This mixture is passed into settling tanks, where the heavy organic material settles to the bottom and the liquid portion flows out at the top. The sediment is then filtered, dried, and screened, producing a good nitrogenous material of satisfactory availability as plant food. Several cities in the United States are producing activated sludge. *Milorganite* is the trade name for the product of the Sewerage Commission of the City of Milwaukee. *Nitroganic* is the trade name of the sludge produced by the City of Pasadena, Calif. The approximate analysis of activated sludge is 4 to 6.5 per cent of nitrogen and 2.5 to 3 per cent of phosphoric acid.

Ordinary or *Imhoff sludge* is sewage run through large settling tanks and subjected to the action of anaerobic bacteria, which live in the absence of air, and allowed to settle. The sediment is then removed and can be used as a fertilizer though for this purpose it is inferior to the activated sludge. The analysis of the Imhoff sludge shows that it contains 1 to 3 per cent of nitrogen and about 1 per cent of phosphoric acid.

Sludge acid.—A by-product of the process of refining petroleum in which concentrated sulphuric acid is used to remove water and impurities. This sludge acid is sometimes used in the manufacture of superphosphate and the resulting product is called *sludge superphosphate,* owing to its characteristic odor.

Sludge superphosphate. See *sludge acid.*

Sodium nitrate. See *nitrate of soda.*

Soot.—Deposits which are primarily carbon from the smoke of coal or wood. Ordinary soot or the so-called "Scotch soot," was at one time used extensively on golf courses but has been almost entirely replaced by more efficient fertilizers. Depending on the position in the flues or chimnies from which it is obtained, soot may contain no nitrogen or it may have as much as 6 per cent or more of nitrogen, about 1 per cent of phosphoric acid, and a trace of potash.

Soybean meal.—The product remaining from processing the soybean for oil. Up to the present little has been used as a commercial fertilizer. It contains about 7 per cent of nitrogen, 1.5 per cent of phosphoric acid, and 2 per cent of potash.

Special fairway fertilizer. Special putting green fertilizer. See *commercial mixed fertilizers.*—Trade names for certain mixed fertilizers claimed to have some special merit for fairways or putting greens.

Spent bone black. See *bone black.*

Steamed bone. See *bone meal (steamed).*

Stick.—The tank water obtained in rendering slaughterhouse tankage, garbage tankage, fish scrap, and such material, is evaporated to a thick syrup which is called *stick.* This material, mixed and dried with such materials as garbage or low grade tankage, is used in the manufacture of *base goods,* which see.

Sulphate of ammonia, $(NH_4)_2SO_4$, ammonium sulphate.—The ammonium salt of sulphuric acid which may be prepared by mixing ammonia with sulphuric acid. Most of the sulphate of ammonia produced in the United States is a by-product of coke ovens. Gas from coke ovens is passed through weak sulphuric acid and the ammonia in the gas combines with the acid and crystalizes out of the solution as sulphate of ammonia. In some coke and gas plants the ammonia liquid is distilled to make it more concentrated and this is combined with sulphuric acid to form sulphate of ammonia. It is also manufactured on a large scale in Europe by combining ammonia, gypsum, and carbon dioxide. Sulphate of ammonia is one of the most commonly used fertilizers on golf courses. It economically provides nitrogen in a readily available form for turf. The ammonia in this salt is used by the grass and the sulphuric acid is left in the soil. This acid residue tends to make soils gradually more acid in reaction. Frequently the acid in sulphate of ammonia is neutralized on golf courses by lime in sand used for compost or by lime contained in water used in sprinkling greens, or directly by applications of lime made deliberately to neutralize any excess of acid in the soil. Some factories are manufacturing sulphate of ammonia in forms which do not lump and are particularly well adapted for distributing dry on turf. The commercial sulphate of ammonia in the United States contains about 20.5 per cent of nitrogen.

Sulphate of lime. See *calcium sulphate* and *gypsum.*

Sulphate of potash. See *potassium sulphate.*

Sulphate of potash-magnesia.—A combination of the salts of potassium sulphate and magnesium sulphate. It is seldom if ever used on golf courses except occasionally in manufactured fertilizers. It contains not less than 25 per cent of potash nor less than 25 per cent of sulphate of magnesia.

Sulphur, S, brimstone.—A bright yellow, hard, brittle, acid-forming element which combines with oxygen and hydrogen to form sulphuric acid. Most of our sulphur comes from Texas and is about 99.5 per cent pure. Sulphur is used frequently as a fungicide and occasionally as a means to make the soil acid. However, its use on golf courses has not been general and invariably has resulted in more harm than good.

Sulphuric acid, H_2SO_4, oil of vitriol.—This acid is prepared from sulphur by burning or roasting it and dissolving the resulting fumes of sulphuric oxide in water by the aid of nitric acid. It is the cheapest acid and therefore is the acid which is most generally in use in the manufacture of fertilizers by commercial processes which require acids. It is used in the manufacture of sulphate of ammonia and in the preparation of wet base goods and other materials for fertilizers.

Superphosphate.—A product made by mixing about equal weights of finely ground phosphate rock and sulphuric acid and carrying them through certain manufacturing processes. The sulphuric acid renders the phosphorus in the phosphate rock available for plant use. The proportion of available phosphoric acid contained in the superphosphate is designated by the grade and it should always be bought on this basis; thus the 20-per-cent grade of superphosphate is much more valuable than the 16-per-cent grade. The available phosphoric acid in superphosphate varies from 14 to 20 per cent. The terms *double superphosphate* and *treble superphosphate* designate other forms of superphosphate, defined under those names.

Sylvanite.—A natural salt of potash found in German and French deposits, containing chlorides of both potassium and sodium. It contains about 16 per cent of potash.

Synthetic materials.—Materials which are built up from separate components by artificial means, especially chemicals which previously were regarded as the product solely of natural processes. Synthetic ammonia is now made in large quantities by combining nitrogen from the air with hydrogen. This synthetic ammonia is used in large quantities in the manufacture of various fertilizer materials, including nitric acid, sodium nitrate, calcium nitrate, ammonium nitrate, sulphate of ammonia, ammonium sulphate-nitrate, ammonium phosphate, urea, and others. The manufacture of such synthetic materials has had an important bearing on the fertilizer industry in recent years and a large part of the fertilizers used on golf courses are these synthetic materials alone or mixed with other fertilizer materials.

Tankage. See also *garbage tankage, gashouse tankage, nitrogenous tankage, poultry manure tankage,* and *whale tankage.*—A by-product obtained from slaughterhouses or other places where animal refuse is obtainable. It is used occasionally for direct application on golf courses and also in large quantities in the manufacture of commercial mixed fertilizers. All kinds of animal refuse are cooked with steam, usually under pressure, to disintegrate the tissue and set free the fat. The fat is removed and the remaining material is pressed, dried, and ground for fertilizer use. A number of special brands of tankage are on the market containing varying amounts of nitrogen. Due to the great variety of materials that make up tankage there is a wide range in the fertilizer value of the different lots. It contains 1 to 11 per cent of nitrogen, a trace to 23.5 per cent of phosphoric acid, and a trace to 1.5 per cent of potash.

Tea grounds. See *waste.*

Thomas slag. Thomas phosphate. See *basic slag.*

Tobacco.—Waste tobacco products are ground and used for fertilizer. Tobacco is sometimes used on golf courses, particularly on putting greens, as an insecticide and vermicide, and as such is claimed to check to some extent the worms and insects harmful to turf. It contains 1 to 5 per cent of nitrogen, .5 to 1 per cent of phosphoric acid, and .5 to 10 per cent of potash.

Treble superphosphate.—A new name recently applied to *double superphosphate,* which see.

Tung oil pomace.—A by-product from seeds of the tung oil tree. The oil is pressed from the seeds and the remaining cake is ground and sold as fertilizer. It contains about 6 per cent of nitrogen, 2 per cent of phosphoric acid, and 1 per cent of potash.

Turf builder. Turf special. See *commercial mixed fertilizers.*—Trade names for certain mixed fertilizers claimed to possess special merit.

Unit.—The unit of plant food is 20 pounds, or 1 per cent of a ton of fertilizer.

Urea, $CO(NH_2)_2$.—A white, crystalline material used occasionally as a fertilizer on golf courses. It has given good results especially when used as a fertilizer for putting greens, but due to its concentrated form it must be used in relatively small amounts. It is now made on a large scale synthetically in Germany by bringing together pure synthetic ammonia and pure carbon dioxide under high pressure and other suitable conditions. Commercial urea used for fertilizer purposes contains about 46 per cent of nitrogen. The nitrogen is in an organic form soluble in water and readily available to plants.

Vigoro. See *commercial mixed fertilizers.* Trade name for a special commercial fertilizer mixture.

Waste.—Waste from industrial plants frequently contains materials that can be used to advantage as fertilizers. Some of these waste materials are used in the fertilizer trade for mixing with other materials (see *base goods, wet*). Many of these materials are rich in nitrogen and are available to golf clubs in limited quantities at a very low cost. Often they are of value only when they can be secured from a nearby source so as to eliminate transportation costs. Plant food in some of these materials is not available to plants until it has been decomposed by organisms in the soil or by acids in some fertilizer manufacturing process. They can, however, be used on golf courses in compost piles or in soil beds, where they will be decomposed and help to furnish organic matter while at the same time adding plant food to the soil. Some of them can be broken down in a manner similar to that used in the preparation of other artificial manures. In the table on the following page are shown the approximate analyses of some industrial wastes and by-products which have fertilizer value.

APPROXIMATE CONTENT OF NITROGEN, PHOSPHORIC ACID, AND POTASH OF SEVERAL OF THE COMMON INDUSTRIAL WASTES AND BY-PRODUCTS WHICH HAVE FERTILIZER VALUE

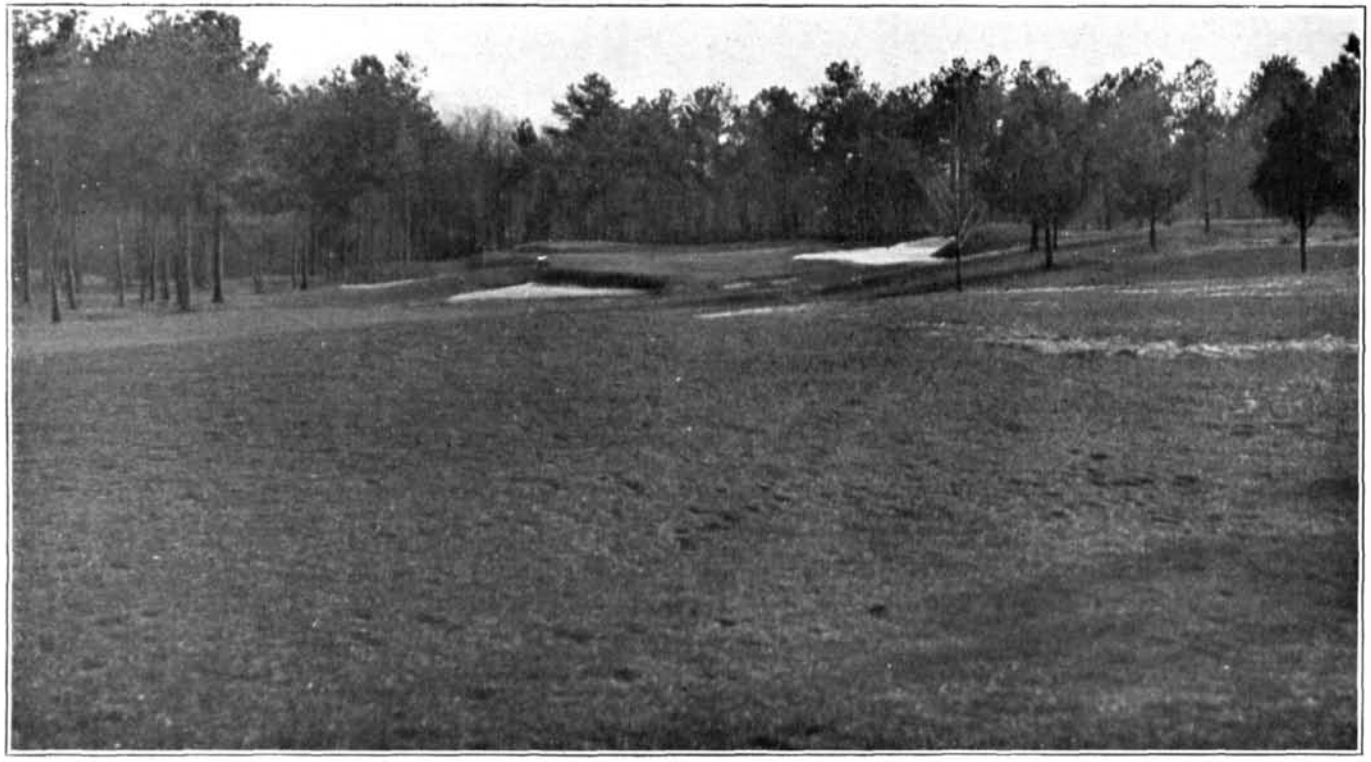
	Nitrogen per cent	Phosphoric acid per cent	Potash per cent
Brewers' grains, wet	1.0	.5	trace
Cocoa-shell dust	1.0	1.5	2.5
Coffee grounds	2.0	trace	trace
Cotton waste from factories	1.0	trace	trace
Feathers	15.0	.....	.....
Felt-hat factory waste	14.0	.....	1.0
Gunpowder sweepings from powder mills	10.0	.....	34.5
Hair	8.0—16.0	.....	.....
Hare and rabbit waste	7.0	1.5—3.0	.5
Oyster shell mound siftings	trace	10.0	trace
Peanut shells	1.0	trace	.5
Picker dirt from cotton mills	1.0	.5	1.5
Powder-works waste	2.0—3.0	.....	16.0—18.0
Raw sugar residue	1.0	8.0	.....
Shoddy and felt	4.0—12.0	.....	.....
Silk (waste)	8.0—11.0	.....	.....
Silk-mills by-product	8.0	1.0	trace
Silkworm cocoons	9.5	1.5	1.0
Tea grounds	2.0—4.0	.5	.5—1.0
Wheat bran	2.5	3.0	1.5
Wheat grain	2.0	1.0	.5
Wool waste	2.0—6.0	trace—4.0	trace—3.0

Whale guano, whale meat, whale tankage.—The ground residue of flesh of the whale after the oil has been extracted. This material is used as a fertilizer and contains 6.5 to 8 per cent of nitrogen and 1.5 to 4 per cent of phosphoric acid.

Wheat bran. Wheat grain. See *waste.*

Wood ashes. See also *hardwood ashes.*—Before the discovery of the potash mines wood ashes formed the principal source of potash. Potash is now available in so many other convenient forms that wood ashes are seldom used on golf courses. Unleached wood ashes are obtained from burning wood that has not been leached and contains more potash than the leached form. The unleached ash contains 4 to 10 per cent of water-soluble potash and 1 to 2 per cent of phosphoric acid.

Wool waste.—The by-product from cleaning raw wool by mechanical processes. It consists of short hair, manure, grease, dirt, and similar waste. It is used chiefly in making base goods but may be used in compost piles as a source of organic matter and nitrogen. It contains from 2 to 6 per cent of nitrogen, from a trace to 4 per cent of phosphoric acid, and from a trace to 3 per cent of potash.



No. 4 hole (149 yards), James River Course of the Country Club of Virginia, Richmond, Va.

The chief difference between a wise man and an ignorant one is, not that the first is acquainted with regions invisible to the second, away from common sight and interest, but that he understands the common things which the second only sees.

Starr King