



## GETTING " OUR " POTASH

By WILLIAM H. ROSS, *Scientist, Bureau of Soils.*

**T**HE growth of all crops depends on the soil and the weather. The weather we always have with us; sometimes it is good, sometimes it is bad, and sometimes it is only fair; but in whatever state we find it we must learn to be content, for we can not change it. It is different with the soil. By faulty cultivation it is possible to make a good soil bad and, conversely, by proper treatment, to make a poor soil fertile.

A soil may be unproductive for many reasons, but the most frequent cause is an inadequate supply of the elements essential for plant growth, one of the most important of which is potassium. This element, probably better known under the trade name of potash, plays a very important rôle in the life processes of the plant. When it is lacking the leaves of the plant are brown and unhealthy and the stems become weak and brittle.

There is no substitute for potash as a food for plants. An adequate supply of it in an available form is absolutely necessary for the production of crops of desirable yield and quality. It enables plants to withstand more effectively the attacks of fungous diseases; it produces fleshy fruits of fine flavor and texture; and it supplies a food element absolutely essential to normal growth.

A suitable system of cultivation will serve in some soils to maintain a supply of potash for the crops; but where the natural supply in the soil is insufficient it is necessary to apply potash from outside sources. Even where there is an

abundance of insoluble potash materials in the soil, it has been found profitable in many cases to apply soluble potash salts.

### Sources of Potash.

The principal ultimate source of all potash salts is a class of igneous rocks known as the feldspar group. By exposure to water and atmospheric agencies these rocks are decomposed and the potash is leached out and is deposited in the soil or carried by streams to the ocean or to inland depressions. When the water into which the potash has been carried evaporates, soluble deposits are formed. The potash liberated from disintegrated rocks is also taken up and stored in plants and may be recovered again when the plant is burned or otherwise treated. There are thus three distinct sources from which potash is obtained: Rocks, salty lakes or soluble deposits, and plant materials.

### Plentiful, but—

Potash is one of the most widespread and abundant constituents of the earth's surface. The tremendous amount in the United States in various forms can be indicated best by a comparison with phosphate. Uncle Sam is said to have the greatest phosphate deposits in the world, but his potash holdings are twenty times as great. These holdings, however, are so widespread and of such low concentration that no deposits anywhere are known to average much over 10 per cent. Furthermore, though some of the combinations in which potash occurs are soluble, the great bulk are not soluble in water—or even in acids.

### From the Rocks.

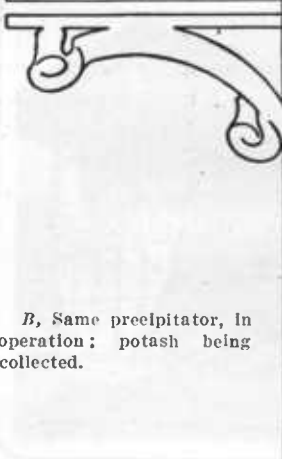
The principal rocks containing potash are feldspar, mica, greensand, leucite, and alunite. The last three are found only in certain localities; the first two are widespread. With the exception of alunite all contain silica as well as potash and are therefore often spoken of as potash silicates.

A great many attempts have been made, both in this country and abroad, to use these mineral rocks directly as fertilizers but without very marked success. Some soils respond to

applications of these minerals, particularly greensand, but owing to their low solubility the results obtained as a rule were scarcely sufficient to justify the expense. It was soon



A, Cottrell precipitator installed at one of the cement plants for the collection of potash-bearing dust. Precipitator not operating; fumes escaping.

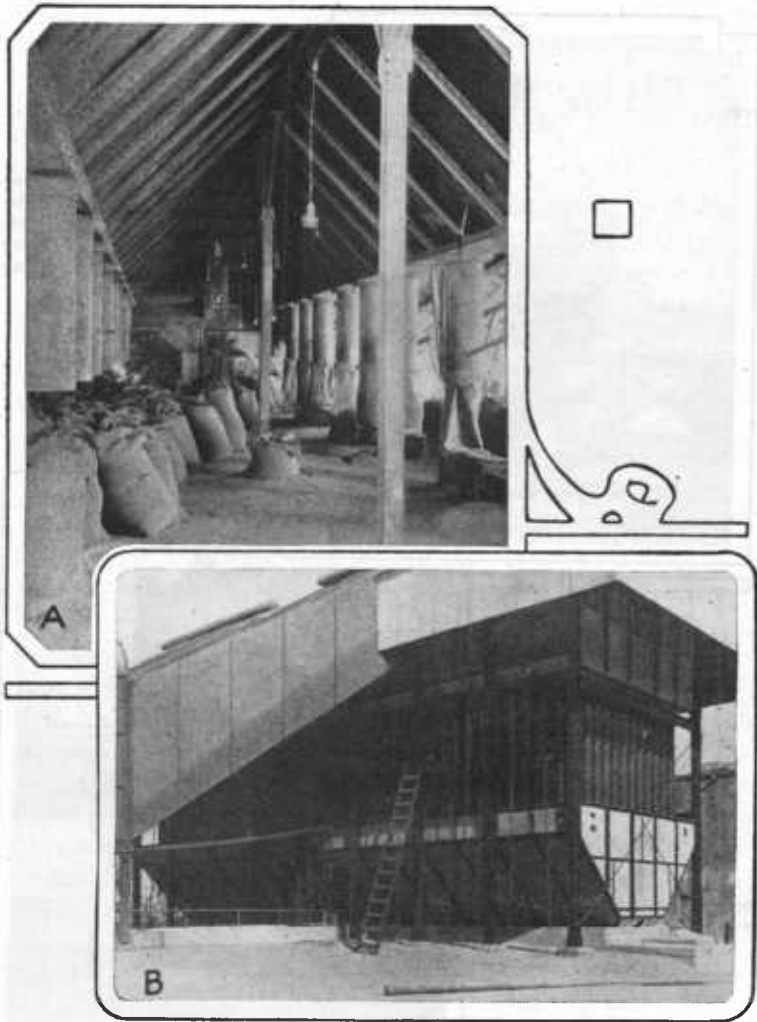


B, Same precipitator, in operation; potash being collected.

Potash from Rock.

recognized that much better results might be expected if the minerals were first treated in some way to render the potash soluble before applying it as a fertilizer. Many processes

have been proposed for decomposing the potash silicates, but the amount of potash that has actually been produced from this source is still very small. The reason for this is entirely



Collecting and Bagging Cement Dust.

*A*, Dust dropping from precipitator into bags. *B*, Close-up view of precipitator, showing pipes in which the dust is deposited.

an economic one. Many of the processes that have been devised are comparatively simple, and several of them make it possible to bring about a quantitative separation of the pot-

ash. If the percentage of potash in feldspar, for example, approached that of phosphoric acid in phosphate rock, the potash problem would long since have been solved. It unfortunately happens, however, that the potash in all silicates is comparatively low, and no mine-run rock has been found anywhere that contains as high a percentage of potash as the deposits of Germany and France in which the potash is already soluble.

It would seem, therefore, that the extraction and recovery of potash from silicate rocks at a price that will compete with the foreign product does not offer much promise, unless the potash is recovered as a by-product in some industry in which these rocks are used as raw materials. It is in this way that most of the potash so far obtained from this source has been prepared.

A study that was made of this subject a few years ago by the Bureau of Soils indicated that the most promising methods for recovering potash from the silicate rocks consist in igniting the rock with lime, as in the manufacture of cement, or in digesting the rock with lime and water under pressure. In the first process the potash is volatilized and passes from the kilns in the process of burning, while in the second it passes into solution during the digestion. In both cases the residue is suited for the manufacture of cement or other building material. At the present time these two processes are both being developed on a commercial scale, and of the numerous methods that were tested out during the war these are the only ones, so far as is known, that are now being operated.

The process of digesting the potash silicates with lime and steam under pressure has been given special attention by the Bureau of Soils, and it has been found possible with pressure, such as can readily be maintained in the industries, to bring about a very high percentage extraction of potash. This process is now being developed on a large scale for the treatment of greensand with the object of producing bricks and other building material in addition to potash, and there is every reason to believe that this will prove a profitable though limited source of potash in proportion as a market is found for the other products.

### From Cement Kilns and Blast Furnaces.

In the survey that was made of the cement industry by the Bureau of Soils it was found that the total potash that escapes from all the plants of the country amounts to about 87,000 tons annually. The maximum actually collected in any one year (1917) amounted to 1,621 tons, which was 5 per cent of the total produced in this country from all sources. In 1919 the production from cement plants dropped to 1,250 tons. The decrease was due to unforeseen difficulties which developed in some of the plants in collecting the potash and in preparing it in a marketable condition. The potash volatilized from some plants was too small in amount to be profitably recovered. In other plants, where the loss of potash was greater, such a quantity of dust was collected with the potash that there was relatively too little potash to justify leaching the material, or shipping it for direct use as a fertilizer. This might be remedied (1) by increasing the proportion of potash volatilized; (2) by increasing the efficiency of the process used for its recovery; (3) by reducing the dust that escapes with it; or (4) by bringing about a mechanical separation of the potash and the dust during the process of collection. Very discouraging results have frequently been obtained in attempts at improvement in these directions. Progress, however, has continued to be made, and recent developments give assurance that the difficulties in the way are not insurmountable, but simply require time and attention for their satisfactory solution.

Potash silicates are not intentionally used in the blast-furnace industry, but are associated in varying amounts with the ore, coke, and limestone used in the charge. In the process of smelting, the lime reacts with the silicates as in the burning of cement, the potash is volatilized and escapes from the furnaces, and the residue or slag is sometimes used in cement manufacture. Potash may, therefore, be recovered from blast furnaces, and the situation with regard to its recovery in this industry is very similar to that outlined for the cement industry. A survey of this industry corresponding to that which was made for cement plants is now being made by the Bureau of Soils. The results obtained in this work and in large-scale experiments now being made at two plants

in this country go to show that the percentage of potash in the dust that escapes from some blast furnaces is higher than that contained in the richest cement dust. However, success here is not dependent alone on the quantity that might be collected. The gases that escape from a blast furnace are combustible and after being freed from dust are used as fuel. In the present wet system for purifying the gases the potash is lost. Large-scale experiments are now being made on the purification of the gases by a dry system in which the potash is recovered with the rest of the dust. If it is demonstrated that the dry process is superior to the wet, then potash will be recovered in all plants in which the new process is installed. It is thus possible that potash at a comparatively low cost may yet be recovered from these furnaces.

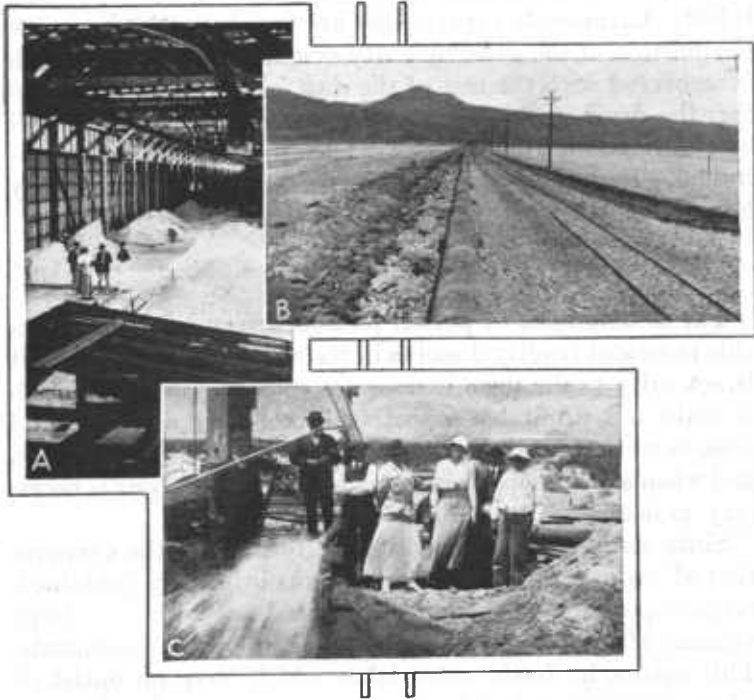
### From the Salty Lakes.

The soluble salts of potash possess a very salty, disagreeable taste and readily dissolve in water. If a natural deposit is not salty to the taste it does not contain sufficient potash to make it a profitable source. The converse does not hold true, however, for there are other materials which are salty, and when a salty deposit is found a chemical analysis is necessary to determine its value.

Since soluble potash deposits are formed by the evaporation of water in which the potash was originally contained, large deposits of this kind are located only where a large volume of water has had an opportunity to concentrate. This occurs in fresh water lakes which have no outlet or where some unusual geological formation has inclosed a body of sea water so that it has ultimately evaporated and deposited the salts which it contained.

The world's largest known potash deposit, that which occurs in Germany and Alsace, is supposed to have been formed in the way last mentioned. According to the accepted view, a large arm of the sea at some period of former times was shut off from the rest of the ocean by a bar of such peculiar formation that the sea water flowed into the bay at high tide but could not flow out. As the water evaporated, more and more was added at each successive high tide until, when the isolation of the bay had become complete, a deposit

of potash and other salts was formed which extended over an area of many square miles and varied to a maximum of 5,000 feet in depth. In the course of time this was covered over with earth and vegetation, and not until 1857 was it recognized that the deposit contained a fertilizer material in the form of potash salts. The richness and extent of the



Potash from Salty Lakes.

*A*, Potash salts obtained from brine at Searles Lake, Calif. *B*, Pipe line through which brine is conveyed from the lake to the plant for evaporation and recovery of potash. *C*, Brine pouring into reservoir at plant.

deposit soon made it the principal source of the world's supply of potash, and this position it still maintains.

A number of relatively small potash deposits occur in this country, but unlike the European deposits all have been formed apparently by the evaporation of what was originally fresh lake water. The most important of these are in western Nebraska; at Searles Lake, Calif., and in the Salduro Marsh, Utah.



These deposits may all be said to represent a geological process that has not yet been completed, inasmuch as the lakes from which the deposits were formed have not yet been evaporated to dryness, but have simply been reduced in each case to a potash-bearing brine of varying concentration. In western Nebraska the brine is distributed in a number of pockets, the largest of which is known as Jesse Lake. When the brine of this lake is evaporated it yields a product containing about 25 per cent of potash. The recovery of the potash is therefore a very simple process and consists in pumping the brine from the lakes, concentrating in special evaporators to about 33 per cent solids, and finally drying in rotary kilns.

The production of potash from these lakes during the five years, 1915-1919, exceeded that from any other source in this country and amounted to 43 per cent of the total. The future of the industry will largely depend on the outcome of experimental work now under way. The product recovered at present consists of a mixture of several salts. By making a separation of the salts it would be possible to produce several materials of value instead of one, and a number of processes with this end in view are now being investigated. It is recognized, too, that the cost of concentrating the brine might be greatly reduced by applying solar evaporation, and as the concentration of the brine as it occurs in the lakes is greatest during the dry season, it is possible that the industry may yet develop into a seasonal one.

The deposit at Searles Lake is the largest known deposit of soluble salts in this country. It resembles those of Nebraska in that the potash is contained in a brine; but the association of salts is different. In the former the potash occurs as the chloride and in the latter as the carbonate and sulphate. The salts in the brine of Searles Lake are also characterized by the presence of a relatively high percentage of a soluble salt called borax. This has been shown to be injurious to crops when applied in fertilizers, and the recovery of the potash for fertilizer therefore involves not only evaporation of the brine but also purification of the potash by crystallization of the recovered salt. A satisfactory process seems to have been developed for this purpose, and the borax in the product that is now placed on

the market amounts to less than 0.5 per cent—a proportion well below the danger point.

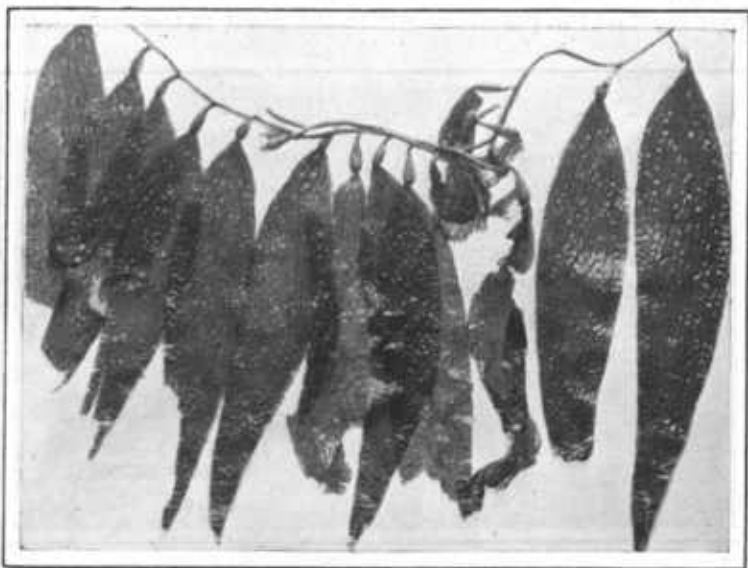
### From Plant Materials.

The earliest potash materials to be used as fertilizers were plant ashes and kelp. These were frequently applied to the soil long before it was recognized that their fertilizing value was due to the potash which they contained. It is now known that all organic materials contain potash, and the quantity present in parts of many plants is much in excess of any other mineral constituent.

The potash in some organic materials is low, but in others the quantity present is sufficient to justify its recovery as a by-product when these materials are used in the industries. The most important of these sources of potash are sugar beets, wood, wool, kelp, and tobacco. With the exception of kelp, none of these products are primarily treated for the production of potash, and only the wastes resulting from their use in the industries are utilized in this way. The total amount of potash that is contained in these wastes is very large, but it unfortunately happens that these wastes are frequently too widely distributed to admit of the economic recovery of the potash. This is best illustrated in the case of the wood wastes. According to estimates that have been made by the Forest Service, the total potash in the ash of the wood burned as waste, together with that used as fuel, amounts to upward of 140,000 tons annually. About 80 per cent of the wood that goes into firewood is used on farms, and it is known that a portion of the ashes is applied as a fertilizer, but owing to the wide area over which wood is burned the greater part of the ash is not recoverable, and it is for this reason that the maximum annual production of potash from this source, under the stimulation of the high prices that prevailed during the war, amounted to only about 600 tons.

Other organic materials, such as kelp and sugar residues, are more localized in their distribution than wood ashes, and during the war these served as important sources of potash. The principal item of expense in the recovery of the potash from these materials has to do with the necessary evaporation of a relatively large volume of water. This is well illus-

trated in the preparation of potash salts as a by-product of beet sugar. It is estimated that the total potash in an average crop of sugar beets in the United States is about 20,000 tons. In the process of manufacture the potash remains in solution and is found in the final molasses. A portion of the molasses is used as feed for stock and the potash values in this case are recovered in proportion as the manurial values



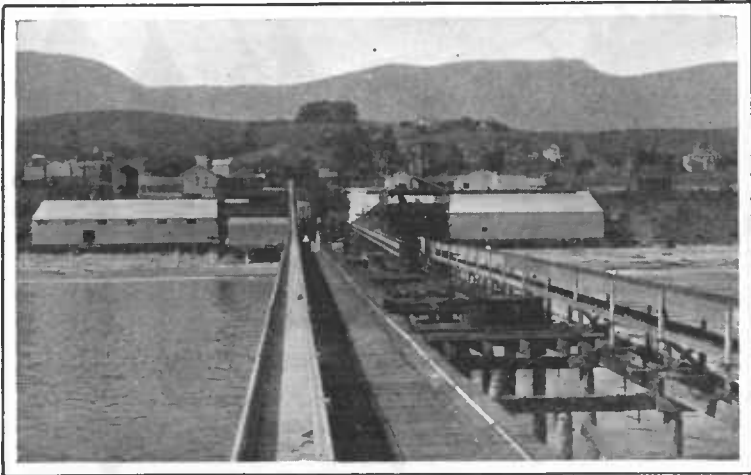
The Giant Kelp of the Pacific Coast.

An organic source of potash. The Bureau of Soils is now obtaining potash from kelp in its plant at Summerland, Calif. During the war kelp was one of the most important sources of potash in this country.

from the feeding operations are utilized. A second portion is used in alcohol production, and the still residues containing the potash are concentrated and used as potash fertilizers. The remaining portion, amounting to about half of the total, is subjected to a treatment known as the Steffens precipitation process, by which the greater part of the sugar still contained in the molasses is precipitated. The filtrate, which is called Steffens waste water, contains the potash, and this may then be recovered by evaporating the solution. In 1919 the production of potash from molasses distillery

waste amounted to 2,792 tons and from Steffens waste water 3,616 tons. The sugar industry thus came next to the saline lakes as a source of potash during 1919, but owing to the cost of concentrating the potash it is doubtful if any further increase in yield of potash will be obtained from this industry unless the waste waters are found to yield other products of value in addition to the potash.

Kelp differs from the other organic sources of potash in that most of the potash occurs in the plant in the same form



Bureau of Soils Potash Plant at Summerland, Calif.

An experimental plant developed to handle 100 tons of wet kelp a day and to produce therefrom 2 tons of potash salts, 1,500 pounds of kelp char, and other by-products.

as it is found in sea water and in many mineral deposits. It also differs from the other organic sources in that potash is the principal product for which the material is harvested. The commercial treatment of kelp for the production of potash salts began in 1915. In 1917 the quantity that was obtained from this source increased to 3,572 tons and in 1918 to 4,804 tons. Shortly after the signing of the armistice, however, all plants working in this field ceased operations, as it was apparently recognized that the processes used would not prove economical under normal conditions. As this result was anticipated, an investigation was

undertaken by the Bureau of Soils in 1917, under special authorization of Congress, with a view to the possible development of a process that would yield products of sufficient value to place the industry on a permanent basis.

The process to which special attention has been given consists in subjecting the dried kelp to destructive distillation. By this treatment such products as ammonia, oils, creosote, and pitch are volatilized, while potash salts, iodine, and active carbon are recovered from the residue. This investigation is still in progress, but the results already obtained give promise that the different products that can be recovered in this way will yield sufficient revenue to enable the main product, potash salts, to be marketed successfully in competition with foreign sources.

### In Case of Emergency.

The production of American potash increased from 1,090 tons in 1915 to a maximum of 54,803 tons in 1918 and then dropped to 30,899 tons in 1919 and to 48,625 tons in 1920. Of the total of 177,000 tons produced during this six-year period, 10 per cent was obtained from insoluble potash deposits, 70 per cent from soluble deposits, and 20 per cent from organic materials. The average annual importation for the six-year period preceding the war amounted to 230,000 tons. This dropped to a minimum of 7,885 tons in 1916, but increased again to about 200,000 tons in 1920, or more than the total produced in this country during the period of the war. Thus, notwithstanding the interest that has been taken in the matter, and the estimated expenditure of \$50,000,000 in capital, we have as yet fallen far short of meeting our potash requirements. It is well to emphasize, however, that the time and effort that have been given to the subject have not been lost. It is possible that potash will shortly be imported more cheaply than it can be produced from most American sources, but the processes that have been developed during the last few years give assurance that in the case of future necessity it can be produced in unlimited quantity as occasion demands.

The value of the 177,000 tons produced in the United States during the war is estimated at \$58,000,000, or about \$46,000,000 in excess of the prewar price. These values and the large importation of 1920 would thus seem to indicate the necessity of further investigations on potash recovery if the cost of domestic production is to compete with that from foreign sources. The importance of this work might well be emphasized, even should it lead to no further advantage than to reduce expenditures in a future emergency.