Soils appear to be barren, or more or less unproductive, -

1 When they contain something inimical to vegetation.

2 When they are deficient in one or more constituents which enter into the organization of the living plant

3 When they contain too large a preponderance even of a valuable ingredient, such as organic matter, sand, lime, and even clay

4. When there is but a thin layer of soil resting on the bare rock.

5. When the land is thin, and rests on an impervious and very thick clay subsoil, or on subsoils containing something injurious to vegetation.

6. When they are badly drained.

7. When they are affected by a bad climate.

The subject in each of these several divisions is treated of in great fullness by the able experimenter. To follow our author into minute details would occupy too much space, and would not, after all, be suitable to the unscientific reader, for whose benefit chiefly this article is intended.

I. *Soils are barren or unproductive when they contain something injurious to vegetation.*

A ready way of ascertaining whether a soil contains an injurious substance is to put a strip of litmus paper in contact with wet earth, and if the blue paper turn rapidly red, it is a clear indication that the soil contains something injurious to plant-life. Good soils have no effect upon red or blue litmus paper, or if any, they produce a slight alkaline reaction, and change the blue colour to a red. The acid reaction is caused by an excess of organic acids (humic), or the presence of small quantities of sulphate of iron—green vitrol.

Bisulphide of Iron, or iron pyrites, is commonly found in unproductive soils in which green vitrol is present. "The simultaneous occurrence of these two compounds is explained by the fact that green vitrol is the result of the oxydation of iron pyrites in contact with air and moisture, the iron of the iron pyrites becomes converted into peroxide of iron, and the sulphur into sulphuric acid, which, combining together, produce sulphate of iron or green vitrol. Even as small a proportion as one-half per cent. of green vitrol renders a soil almost barren; and on land containing little more than one per cent, nothing whatever can grow."

Unproductive soils often contain considerable quantities of protoxide of iron, with scarcely any red peroxides, indicating poor cultivation, which may often be remedied by draining and deeper culture, thus opening up the soil to the admission of air. Protoxide of iron gives a bluish-grey or dark-green colour so common to many unproductive clays, but a change from blue to a reddish brown, which better cultivation induces, indicates the transformation of protoxide into peroxide of iron, a condition more favourable to vegetation. The existence of large quantities of protoxide of iron in the soil surely indicates the absence of deep and thorough culture, which would allow of free access to the air, with the oxygen of which the salt has a powerful affinity.

Chloride of Sodium, (common salt) and the nitrates of potash and soda, sometimes occur in proportions injurious to vegetation, although when used in proper quantities they are, (the two latter especially), powerful manures. Peaty soils when dried consist principally of organic matter, but in a state the most unfavourable to the growth of plants, and they are therefore without artificial treatment, proverbially unproductive. From a number of analysis of such soils made by one author, the following one from near Bridgewater, England, is suggestive.

ANALYSIS OF PEAT LANDS.

	Dried at 212°
*Organic matter (abounding in humic acids)	97.760
Oxides of iron and alumina	.536
Carbonate of lime	.855
Magnesia	144
Potash	.131
Soda	.065
Phosphoric acid	.053
Sulphuric acid	.051
Silica	.405
	100.000
*Containing nitrogen	1.428

This soil, in its natural state, contained 88 per cent. of water. The trifling amount of mineral matter, especially phosphoric acid, with the great excess of organic acids, rendered it unproductive. Draining, marling, and the application of quick lime in large doses, neutralize the humic acids, decompose the peaty or vegetable matter, and bring it into a state adapted to the growth of crops.

AN ANALSIS OF SOIL FROM THE HAARLEM LAKE, IN HOLLAND.

	Dried at 212°
*Organic matter and water of combination	14 71
Oxides of iron and alumina	9.27
Sulphate of protoxide of iron (green vitriol)	.71
Bi sulphate of iron (iron pirites)	71
Sulphuric acid united with oxide of iron as basic sulphate of iron	1 03
Sulphate of lime	1.72
Magnesia	.73
Phosphoric acid	.27
Potash	.63
Soda	.32
Chloride of sodium	.09
Insoluble silicious matter (clay)	69.83
	100.00
*Containing nitrogen	.62
Equal to ammonia	.63

It will be seen from the above that this soil abounds in all the mineral elements which enter into the composition of the ashes of plants, and is rich in phosphoric acid, and contains a sufficient portion of organic matter, yielding on decomposition more than ½ per cent. of ammonia; but the amount of sulphate neutralizes all its useful properties, rendering it unproductive.

This land came into the hands of an enterprising Englishman; it had previously received only a very shallow cultivation, producing scanty crops. The first deep ploughing was followed by still more diminished crops, and a heavy dressing of farm-yard manure, instead of improving matters, made them rather worse; for even the deep rooted weeds ceased to grow, and only the surface varieties maintained themselves. In this dilemma the proprietor applied to Dr. Voelcker, who subjected the soil to a careful analysis.

"The preliminary examination showed at once that there was present some injurious substance, for the wetted soil strongly discolored the blue litmus paper. The acid reaction I found was caused by sulphate of iron, and I succeeded in detecting sulphide of iron, or iron pyrites. As long as the land was left unploughed, the latter constituent was not brought to the surface, and most of the iron existing there originally was no doubt gradually removed into the subsoil by the rain, which accounts for the better crops when the subsoil was unstirred. By deep cultivation, the sulphide of iron was turned up, and air admitted into the soil more freely, which had the effect of oxydizing the iron pyrites, and changing it into green vitriol. As the avoidable mineral elements and soluble salts in the land were already rather in excess of the amount which is beneficial, the drossing of farm-yard manure, containing a good deal of soluble matter, could only aggravate the evil."

In this case, a heavy dressing of lime was recommended, and its application attended with complete success. The lime decomposed the sulphate of iron, and uniting with the liberated sulphuric acid produced gypsum—a useful fertilizer—and to oxide of iron, which occurs in all fertile soils. Since green vitriol, as well as iron pyrites, sometimes occur in subsoils, care should be taken to test the subsoil, before the operation of subsoil ploughing is commenced, for such injurious matters, which it is better not to bring to the surface. Another soil reclaimed from the sea on the coast of Hamptox, was analyzed, and found to contain nearly one and half per cent, of green vitrol, which rendered it perfectly sterile. Its composition was very similar to that reclaimed from the Haarlem Lake, and it was restored by similar means.

COMPOSITION OF A COMPLETELY BARREN SOIL FROM SANDY, IN BEDFORDSHIRE.

	Dried at 212°.
Organic matter and water of combination	4.27
Oxides of iron and alumina	3.84
Phosphoric acid	.09
Sulphate of lime	.85
Magnesia	.96
Potash and soda	.47
Sulphate of iron (green vitriol)	1.05
Sulphide of iron (iron pyrites)	.56
Insoluble siliceous matter (chiefly sand)	87.91
	100.00

"Here, again, we find sulphate as well as sulphide of iron in appreciable quantities. A portion of the field was so completely sterile, that not a weed nor a single blade of grass could be seen on it. Tested with litmus paper, this soil showed a strong acid reaction, and when heated in a platinum capsule, gave off pungent fumes of sulphurous acid. Soils in a healthy condition, it may be remarked, when heated, do not give off pungent vapours, smelling like those of a lighted sulphur match. This is itself a tolerable sure sign of the presence of injurious iron compounds.' The colour of this soil was almost black, yet it will be seen that it contained but a small proportion of organic matter. Its colour was therefore due principally to the finely divided sulphide of iron, a small portion of which under those conditions will impart a dark grey colour, and obnoxious qualities to a large mass of soil. Where such dark soils occur the air is sometimes charged with fœted vapours, smelling faintly like rotten eggs. This smell is produced by the action of carbonic acid of the air upon the black sulphide of iron in the soil, disengaging sulphuretted hydrogen gas, a substance alike injurious to vegetable as animal life.

"All saline matters which are very soluble in water are injurious to vegetation, when they occur in the soil in too large a proportion. The practical question is, What is too large a proportion? An answer has been given lately to this question in the highly interesting scientific experiments on the nutrition of plants, by Professor Knop, of Leipsic, who found that solutions containing in all not more than 1 part of soluble mineral matter to 1000 parts of water are fully as strong as liquids should be from which plants are to derive food and grow luxuriantly. In solutions stronger than this, plants either grow languidly or die altogether, although the same mineral substances are employed which, in a highly diluted state, are most active promoters of vegetation. If such be the case with solutions, my own experience leads me to infer that the soil itself should not contain more than 1-10th per cent. of such soluble substances, and therefore that soils which contain several per cent. of common salt, nitrate of lime, or chloride of potassium, are unfit to maintain vegetable life in a healthy state."

The following analysis of a barren soil impregnated with salt and nitrates is highly instructive:

Moisture	10.66
*Organic matter	4.84
Oxides of iron and alumina	11.28
Phosphoric acid	2.35
Equal to bone earth	(5 08)
Carbonate of lime	5.21
Nitrate of lime	2.32
Containing nitric acid	(1.62)
Chloride of sodium	11.61
Chloride of potassium	2.31
Insoluble siliceous matter	49.22
	100.00
*Containing nitrogen	.24
Equal to ammonia	.29

"We have here a large proportion of common salt, and also chloride of potassium and nitrate of lime, two salts still more soluble in water than chloride of sodium. The nitrate of lime is evidently a product of the oxydation of animal matter, the presence of which in this curious soil is distinctly evidenced by the simultaneous occurrence of phosphate of lime (bone earth) in considerable quantities. We have here presented to us a true nitre-earth, which, valuable as it is unquestionably when applied as a manure, is far too rich in saline constituents to be cultivated like an ordinary soil."

In concluding this section of the subject, the following brief summary of the various matters and conditions which render soil barren or unproductive, may be serviceable fo the reader.

(*a*) Superabundance of organic (humic) acids.

(*b*) Sulphate of iron (green vitriol), even when present in the soil in small quantities.

(*c*) Sulphide of iron (iron pyrites), and especially finely divided black sulphide of iron, which, in the smallest proportions, is most obnoxious to plants.

(*d*) Abundance of protoxide of iron, and absence of peroxide, indicating a bad physical condition of the land.

(*e*) Chloride of Sodium, (common salt) in proportions of one-tenth per cent. and upwards.

(*f*) Nitrates and all soluble saline matter, in quantities exceeding small fractions of 1 per cent. of the whole mass of soil.

(To be Continued.)