# ANALYSES OF THE CONSTITUENTS OF THE FLAX PLANT,

## AND OF THE SOILS ON WHICH THE PLANTS HAD BEEN GROWN.

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The daily increasing extent to which flax is cultivated by the farmer, necessarily directed the attention of chemists to the analysis of this plant, soon after the importance of the mineral constituents, strangely neglected for a considerable period, had been generally acknowledged by the scientific agriculturist.

We owe to Sir Robert Kane two excellent papers, containing the analyses both of the ashes of different specimens of flax, and of the soils on which they had been cultivated.* These specimens had been grown principally in Belgium and Holland, where the greatest care is taken in preparing and manuring the land. The analyses which we intend to communicate in the following pages, were made with different specimens of Russian growth. They were supplied to us by Dr. Hofmann,† under whose guidance we have worked throughout.

The localities from which we have obtained our specimens of Flax, are the Russian districts known as Esthonia or Estland, Livonia or Lievland, Courland, and Lithuania. The first of these districts, with the second and third mentioned, are situated on the eastern shores of the Baltic; the fourth, Lithuania, is the only inland country.

These countries extend from 48° to 60° north latitude, and from 22° to 28° east longitude.

The plan we adopted for the preparation of the ash, was the following:—A handful of stems, after being inflamed, were held over a porcelain dish, and allowed to burn gently. The ashes collected in the dish by this process, in one or two instances, were remarkably white; however, in order to free them still more from the remaining carbon, they were placed, small quantities at a time, in a platinum dish over a gentle gas flame. In this manner also the sulphides, formed in the process of combustion, were entirely reconverted into sulphates. This conversion was proved by experiment previous to analysis. In order to hasten the latter part of the process, the Lithuanian and Estland ashes were burned with protoxide of mercury.

The general analyses were performed in the usual manner:—the experimental numbers in Table I. show the quantities of substance employed, the results from which are exhibited in Table II.

* Philosophical Magazine, vol. xxxi. p. 43.

† I am indebted for these specimens to the kindness of Mr. Arthur Marshall, of Leeds, who had them sent from Russia for analysis, being originally intended to supply the material for a continuation of Sir Robert Kane's researches; and it was only in consequence of Sir Robert's other avocations preventing him from following up the investigation any further, that Mr. Marshall sent them to the Laboratory of the Royal College of Chemistry.—*Dr. A. W. Hofmann.*

# TABLE I.

| | Lievland. | | Courland. | | Lithuanian. | | Estland. | |
|---|---|---|---|---|---|---|---|---|
| | I. | II. | I. | II. | I. | II. | I. | II. |
| | grm. | grm. | grm. | grm. | grm. | grm. | grm. | grm. |
| Quantity of ash employed for the general analysis | 4·7076 | 4·6640 | 5·3100 | 1·2953 | 6·1526 | 5·8256 | 4·4630 | |
| Whole amount of the hydrochloric acid solution | 324·0300 | 197·5950 | 293·495 | 293·495 | 242·5620 | 206·9200 | 280·7400 | |
| Hydrochloric acid solution employed for the alkalies | 17·5040 | 16·8415 | 24·2960 | 27·4094 | 28·8473 | 28·1370 | 20·3340 | 23·9870 |
| Hydrochloric acid solution employed for sulphuric and phosphoric acids | { 27·8896<br>29·1392 } | 30·7767 | 26·6230 | { 27·1031<br>27·2480 } | 27·4080 | 28·0232 | { 22·7710<br>22·6950 } | 23·0280 |
| Hydrochloric acid solution for sesquioxide of iron, lime, and magnesia | 30·2702 | 30·7767 | { 31·7940<br>19·9430<br>31·7940 } | { 21 9975<br>19·2260<br>27·5790 } | { 28·8495<br>28·4630 } | 25·4352 | { 28·0500<br>22·7700 } | { 25·8150<br>19·7130 } |
| Quantity of ash employed for the estimation of chlorine | 2·0813 | 1·3249 | ·8360 | .................. | 1·0017 | ............ | 1·3159 | .................. |
| Quantity of ash employed for the estimation of carbonic acid | ·8532 | ·8875 | ·7023 | ·8097 | ·8017 | ·7480 | ·9680 | ·8418 |
| Quantity of the plant dried at 100° C. for the estimation of the amount of ash | 6·0140 | 5·4247 | 1·4577 | .................. | 3·3575 | ............ | 2·4930 | .................. |

## TABLE II.

| | Lievland. | | Courland. | | Lithuanian. | | Estland. | |
|---|---|---|---|---|---|---|---|---|
| | I. | II. | I. | II. | I. | II. | I. | II. |
| | grm. | grm. | grm. | grm. | grm. | grm. | grm. | grm. |
| Silicic acid | 0·3098 | 0·3260 | 0·3590 | 0·0868 | 0·2850 | 0·2597 | 0·2010 | ...... |
| Sand and charcoal | 0·3240 | 0·0128 | 0·1485 | 0·0331 | 0·0750 | 0·0689 | 0·1145 | ...... |
| Mixed chlorides of potassium and sodium | 2·6678 | 2·6492 | 2·8690 | 2·8736 | 3·1279 | 3·1203 | 2·3332 | 2·3349 |
| Bichloride of platinum and potassium | 8·7439 | 8 6829 | 8·1660 | 8·1734 | 8·8082 | 8·7819 | 5 3430 | 5·3521 |
| Chloride of sodium | ...... | ...... | 0·3778 | 0·3797 | 0·4407 | 0·4409 | 0·7030 | 0·7001 |
| Sulphate of baryta for sulphuric acid | 0·6369 | 0·6382 | 0·7222 | 0·6692 | 0·4299 | 0·5047 | 0·5424 | ...... |
| Pyrophosphate of magnesia for phosphoric acid | 0·6492 | 0·6504 | 0·5512 | 0·5601 | 1·0257 | 1·0394 | 0·9710 | 0·9813 |
| Phosphate of sesquioxide of iron | 0·1338 | 0·1333 | 0·1477 | 0·1413 | 0·1513 | 0·1459 | 0·1252 | 0·1301 |
| Carbonate of lime | 1·4451 | 1·4314 | 1·8998 | 1·9077 | 1·9832 | 1·9955 | 1·8913 | 1·8814 |
| Pyrophosphate of magnesia for magnesia | 0·8028 | 0·7324 | 0·9046 | 0·8801 | 0·8818 | 0·9592 | 1·3006 | 1·2817 |
| Chloride of silver | 0 0409 | 0·0277 | 0·0320 | ...... | 0·0692 | ...... | 0·0487 | ...... |
| Carbonic acid | 0·1500 | 0·1550 | 0·1300 | 0·1500 | 0·1830 | 0·1700 | 0·0750 | 0·0650 |
| Amount of ash left on incineration | 0·2532 | 0·2240 | 0·0530 | ...... | 0·0773 | ...... | 0·1020 | ...... |

These numbers correspond to the following composition per cent.

I.—LIEVLAND FLAX ASH.

The stems, upon incineration, gave in average 4·1292 per cent. of ash. Composition of the ash directly found :—

| | I. | II. | MEAN. |
|---|---|---|---|
| Potash - - - - | 35·0670 | 34·8588 | 34·9629 |
| Lime - - - - - | 17·1892 | 17·1833 | 17·1862 |
| Magnesia - - - | 6·2197 | 6·3278 | 6·2738 |
| Sesquioxide of iron - | 0·9235 | 0·9286 | 0·9260 |
| Chloride of potassium | 1·0849 | 1·0201 | 1·0525 |
| Phosphoric acid - - | 8·8048 | 8·8224 | 8·8136 |
| Sulphuric acid - - | 4·5097 | 4·6012 | 4·5554 |
| Silicic acid - - - | 6·5812 | 6·9216 | 6·7514 |
| Carbonic acid - | 17·5914 | 17·4648 | 17·5281 |
| Sand and charcoal - | 0·6788 | 0·3425 | 0·5106 |
| | 98·6502 | 98·4711 | 98·5605 |

The above numbers, after deducting sand and charcoal, which are considered but as accidentally present, and also carbonic acid, give the following composition per cent. :—

| | |
|---|---|
| Potash - - - - - | 43·42 |
| Lime - - - - - - | 21·35 |
| Magnesia - - - - - | 7·79 |
| Sesquioxide of iron - - - | 1·15 |
| Chloride of potassium - - - | 1·31 |
| Phosphoric acid - - - - | 10·94 |
| Sulphuric acid - - - - | 5·66 |
| Silicic acid - - - - - | 8·38 |
| | 100·00 |

II.—COURLAND FLAX ASH.

The stems, upon incineration, gave in average 3.6358 per cent. of ash. Composition of the ash directly found :—

| | I. | II. | MEAN. |
|---|---|---|---|
| Potash - - - - | 29·6786 | 29·5988 | 29·6387 |
| Soda - - - - - | 2·9640 | 2·9433 | 2·9536 |
| Lime - - - - - | 20·1184 | 20·0355 | 20·0769 |
| Magnesia - - - | 6·1111 | 6·2123 | 6·1617 |
| Sesquioxide of iron - | 0·9038 | 0·8646 | 0·8842 |
| Manganese - - | trace | trace | trace |
| Chloride of sodium - | 1·5562 | 1·5562 | 1·5562 |
| Phosphoric acid - - | 6·5948 | 6·7027 | 6·6487 |
| Sulphuric acid - - | 4·6647 | 4.3220 | 4·4933 |
| Silicic acid - - - | 6·7027 | 6·7604 | 6·7316 |
| Carbonic acid - - | 18·5106 | 18·5253 | 18·5179 |
| Sand and charcoal - | 2·5559 | 2·7966 | 2·6762 |
| | 100·3608 | 100.3177 | 100·3390 |

Per-centage after deducting sand, charcoal, and carbonic acid :—

| | |
|---|---|
| Potash | 37·44 |
| Soda | 3·74 |
| Lime | 25·39 |
| Magnesia | 7·71 |
| Sesquioxide of iron | 1·13 |
| Chloride of sodium | 1·94 |
| Phosphoric acid | 8·31 |
| Sulphuric acid | 5·89 |
| Silicic acid | 8·45 |
| | 100·00 |

## III.—LITHUANIAN FLAX ASH.

The stems, upon incineration, gave in average 2·3023 per cent. of ash.

Composition of the ash directly found :—

| | I. | II. | MEAN. |
|---|---|---|---|
| Potash | 27·5459 | 27·4770 | 27·5114 |
| Soda | 2·3055 | 2·3065 | 2·3060 |
| Lime | 18·0526 | 18·1648 | 18·1087 |
| Magnesia | 5·6794 | 5·5154 | 5·5974 |
| Sesquioxide of iron | 0·7991 | 0·7710 | 0·7850 |
| Chloride of sodium | 2·8115 | 2.8115 | 2·8115 |
| Phosphoric acid | 10·5868 | 10·8972 | 10·7420 |
| Sulphuric acid | 2·6755 | 2·8137 | 2·7446 |
| Silicic acid | 4·6346 | 4·4532 | 4·5439 |
| Carbonic acid | 22·8302 | 22·7272 | 22·7787 |
| Sand and charcoal | 1·2190 | 1·1828 | 1·2009 |
| | 99·1401 | 99·1203 | 99·1301 |

Per-centage after deducting sand, charcoal, and carbonic acid :—

| | |
|---|---|
| Potash | 36·61 |
| Soda | 3·06 |
| Lime | 24·09 |
| Magnesia | 7·45 |
| Sesquioxide of iron | 1·04 |
| Chloride of sodium | 3·75 |
| Phosphoric acid | 14·30 |
| Sulphuric acid | 3·65 |
| Silicic acid | 6·05 |
| | 100·00 |

## IV.—ESTLAND FLAX ASH.

The stems, upon incineration, gave in average 4·0914 per cent. of ash.

Composition of the ash directly found :—

| | I. | II. | MEAN. |
|---|---|---|---|
| Potash | 23·1083 | 23·0432 | 23·0757 |
| Soda | 7·5111 | 7·5323 | 7·5217 |
| Lime | 23·8567 | 23·6070 | 23·7318 |
| Magnesia | 10·6274 | 10·4718 | 10·5496 |
| Sesquioxide of iron | 0·9115 | 0·9363 | 0·9239 |
| Chloride of sodium | 1·5069 | 1·5069 | 1·5069 |
| Phosphoric acid | 13·8098 | 13·9642 | 13·8870 |
| Sulphuric acid | 4·1678 | 4·1678 | 4·1678 |
| Silicic acid | 4·4815 | 4·4815 | 4·4815 |
| Carbonic acid | 7·7559 | 7·7215 | 7·7387 |
| Sand and charcoal | 2·5878 | 2·5878 | 2·5878 |
| | 100·3247 | 100·0203 | 100·1724 |

Per-centage after deducting sand, charcoal, and carbonic acid :—

| | |
|---|---|
| Potash | 25·70 |
| Soda | 8·37 |
| Lime | 26·41 |
| Magnesia | 11·74 |
| Sesquioxide of iron | 1·02 |
| Chloride of sodium | 1·67 |
| Phosphoric acid | 15·47 |
| Sulphuric acid | 4·64 |
| Silicic acid | 4·98 |
| | 100·00 |

From the foregoing analyses, the following comparative table has been made, from which it will be readily seen, in what points the ashes of these different specimens agree in composition :—

| | Lievland. I. | Courland. II. | Lithuanian. III. | Estland. IV. |
|---|---|---|---|---|
| Potash | 43·42 | 37·44 | 36·61 | 25·70 |
| Soda | — | 3·74 | 3·06 | 8·37 |
| Lime | 21·35 | 25·39 | 24·09 | 26·41 |
| Magnesia | 7·79 | 7·71 | 7·45 | 11·74 |
| Sesquioxide of iron | 1·15 | 1·13 | 1·04 | 1·02 |
| Manganese | — | trace | — | — |
| Chloride of sodium | — | 1·94 | 3·75 | 1·67 |
| „ potassium | 1·31 | — | — | — |
| Phosphoric acid | 10·94 | 8·31 | 14·30 | 15·47 |
| Sulphuric acid | 5·66 | 5·89 | 3·65 | 4·64 |
| Silicic acid | 8·38 | 8·45 | 6·05 | 4·98 |
| | 100·00 | 100·00 | 100·00 | 100·00 |

We also append, in a tabular form, the results of Sir R. Kane's analyses of this plant, taken from his paper, read before the Royal Dublin Society, on the 6th of April, 1847.

To facilitate comparison, we have re-calculated these analyses after deducting the carbonic acid.

| | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| | Courtral District. | | Antwerp District. | | | | |
| | Heestelt. | Escamaffles. | Hammezog. | Not named. | District in Holland. | Dublin. | Armagh. |
| Potash | 9·69 | 30·62 | 26·67 | 28·62 | 21·35 | 11·78 | 6·60 |
| Soda | 24·16 | none | 16·88 | 0·48 | 12·65 | 11·82 | 6·61 |
| Lime | 19·37 | 22·04 | 22·15 | 21·19 | 21·30 | 14·85 | 23·67 |
| Magnesia | 4·34 | 4·45 | 4·70 | 4·05 | 3·50 | 9·38 | 4·22 |
| Sesquioxide of iron | 5·66 | 2·03 | 1·31 | 2·53 | 2·74 | ...... | 14·10 |
| Alumina | 0·56 | 0·58 | 0·86 | ..... | 1·67 | 7·32 | ...... |
| Manganese | trace | trace | trace | ...... | ...... | ...... | 1·12 |
| Sulphuric acid | 7·93 | 8·33 | 8·18 | 13·43 | 11·22 | 3·19 | 9·30 |
| Phosphoric acid | 14·10 | 15·78 | 10·66 | 12·19 | 12·82 | 13·05 | 7·29 |
| Silicic acid | 3·85 | 4·54 | 3·20 | 3·36 | 6·18 | 25·71 | 0·94 |
| Chloride of sodium | 10·34 | 11·63 | 5·49 | 14·15 | 6·57 | 2·90 | 26·15 |
| | 100·00 | 100·00 | 100·00 | 100·00 | 100·00 | 100·00 | 100·00 |

On comparing the results of our analyses with those of Sir Robert Kane, we find at once that the general features of both are identical, although, as might be expected, discrepancies present themselves respecting the individual constituents. In the ashes, both of the Belgian and of the Russian specimens, we meet with a very large amount of alkali (nearly 40 per cent.): the quantity, too, of phosphoric acid is very considerable (from 10 to 15 per cent.). Our analyses then furnish a further proof that flax must be classed among the most exhausting crops, for the amount of valuable mineral substances which we remove from the soil in this plant considerably exceeds the quantity which is generally extracted from it in the form of wheat or corn.

From a statement of Mr. Mac Adam,* it appears that one rood of land yields about 12·7 cwt. of recently-pulled flax plant. If we take this number as the basis of calculation, and the average per-centage of ash at 3·53 lbs., of alkalies at 39·58 lbs., and of phosphoric acid at 12·51 lbs., we find that a flax crop removes from a rood of land not less than 19·87 lbs. of alkalies, and 6·28 lbs. of phosphoric acid; on

* Royal Agricultural Journal, vol. viii., p. 361.

the other hand, we have learnt from the researches of Mr. Way,* that a rood of land, which has served for the cultivation of wheat, loses (an average taken from a great number of analyses) about 7·5 lbs. of alkali and 6·9 lbs. of phosphoric acid. These figures show that the amount of phosphoric acid in the flax crop closely approaches that of the wheat, whilst the latter extracts only about half the quantity of alkali which we find in the former. Hence, it would appear that a flax crop is at least as exhausting as a crop of wheat.

There is, however, one striking point of dissimilarity between the cultivation of wheat and that of flax, and we are indebted to Sir Robert Kane for having for the first time brought this point under the notice of the farmer in a forcible manner—viz.: that while the mineral ingredients which we remove from our fields in wheat, or cerialiæ in general, become constituents of food, and enter in this manner into a circulation, from which, even under very favourable circumstances, they return to the soil only after the lapse of some time; the woody fibre of flax, as a necessary preliminary to its being used by man, is separated to a considerable extent from those very mineral substances which are so essential for its successful growth. This mineral matter, when economized in a proper manner by the farmer, may be returned to his field to keep up the equilibrium of its fertility.

The vegetation of the flax plant resembles in this respect the growth of the sugar-cane, from the culture of which, we expect a material consisting entirely of atmospheric constituents. The inorganic substances taken up by the plant are only instruments used in its production, which should be as carefully preserved as tools in a manufactory, and will then do further duty in promoting the elaboration of future crops.

The analysis of the flax ash suggests a few remarks respecting an interesting feature in the nature of ashes generally, which was first noticed by Professor Liebig in his celebrated Agricultural Chemistry. On comparing the composition of the ashes of specimens of the same plant, cultivated under different circumstances, he observed, that, notwithstanding very considerable discrepancies in the constitution, the entire basic power of the different bases, united with a certain class of acids, for instance the organic acids, remained constant for different specimens of the same plant: or, in other words, the basicity of an oxide being measured by its oxygen, the total amount of oxygen contained in the bases forming organic salt, was found to be identical in the different specimens. The views respecting this typical basicity, which Liebig pointed out in a few instances, and only

* Royal Agricultural Journal, vol. vii. p. 593.

for the salts of organic acids, were afterwards extended by other chemists. Indeed, the total amount of oxygen contained in the form of basic oxides seems to vary only within narrow limits for different individuals of the same class of plants. Sir Robert Kane has calculated the quantity of oxygen in the bases of his flax ashes, the constancy of which certainly seems to support this view; our analyses lead to a similar conclusion, as may be seen from the following figures:—

| Name of the ash. | Quantity of basic oxygen in 100 parts. | Name of the ash. | Quantity of basic oxygen in 100 parts. |
|---|---|---|---|
| Heestert - - | 16·95 | Lievland - | 16·80 |
| Escamaffles - | 14·00 | Courland - | 17·89 |
| Hamme Zog - | 17·71 | Lithuanian | 17·12 |
| Unknown district | 13·36 | Estland - | 17·86 |
| Holland - - | 15·83 | | *Mean* 17·42 |
| Dublin - - | 16·36 | | |
| Armagh - - | 15·68 | | |
| | *Mean* 15·68 | | |

The composition of several wheat-ashes, as resulting from Mr. Way's analysis, likewise appears to be favourable to this view.*

| | | | |
|---|---|---|---|
| Specimen No. 1. | Hopetoun wheat - - | 11·64 | per cent. |
| " No. 2. | Creeping wheat - - | 11·52 | " |
| " No. 3. | Red straw white wheat - | 11·02 | " |
| " No. 4. | Hopetoun wheat, No. 2 - | 11·94 | " |
| " No. 5. | French wheat - - - | 12·59 | " |
| " No. 6. | Egyptian wheat - - | 12·19 | " |
| " No. 7. | Odessa wheat - - - | 12·08 | " |
| " No. 8. | Marianople wheat - - | 14·46 | " |
| " No. 9. | Hopetoun wheat, No. 3 - | 12·89 | " |
| " No. 10. | Red straw white wheat - | 11·53 | " |
| " No. 11. | White wheat - - - | 12·24 | " |
| | *Mean* | 12·19 | |

The argument, however, drawn from these ashes, is of minor importance, the discrepancies in their composition being far less conspicuous than in the former cases.

The number representing the basic power of the sum of the metallic oxides in the ash varying within trifling limits, it is but a

* Royal Agricultural Society Journal, vol. vii. p. 666.

natural consequence that we should likewise find a certain constancy in the acidity of the total amount of acids. Without going into detail, a glance at the tables will show, indeed, that a replacement of the acids occurs to a certain extent. Whenever the amount of carbonic acid, which represents the organic acids, diminishes, we find the quantity of inorganic acid, as sulphuric and phosphoric, increases, and *vice versâ*.

Our attention was next directed to the soils upon which the different specimens of flax had been grown, samples of which, through the kindness of Mr. Marshall, had likewise been forwarded to Dr. Hofmann.

These soils all gave a brownish colour to boiling water, owing to a portion of the organic matter being soluble in that menstruum.

The following table shows the behaviour of these soils with solvents:—

| | Lievland. | Courland. | Lithuanian. | Estland. |
|---|---|---|---|---|
| Soluble in water, Inorganic matter | 0·0864 | 0·1700 | 0·1528 | 0·1497 |
| Soluble in water, Organic matter | 0·2290 | 0·3125 | 0·4417 | 0·4578 |
| Total ... ... | 0·3154 | 0·4825 | 0·5945 | 0·6075 |
| Soluble in hydrochloric acid ... | 7·2596 | 6·9166 | 7·2433 | 8·7119 |
| Insoluble residue ... ... ... | 92·4250 | 92·6009 | 92·1622 | 90·6806 |
| | 100·0000 | 100·0000 | 100·0000 | 100·0000 |

The following tables contain the details of the individual determinations:—

TABLE I.

| | Lievland. | Courland. | Lithuanian. | Estland. |
|---|---|---|---|---|
| | grm. | grm. | grm. | grm. |
| Quantity of soil employed for general analysis ... ... ... | 20·0480 | 22·3010 | 18·5560 | 22·9480 |
| Amount of the hydrochloric solution ... ... ... ... | 270·0400 | 232·3550 | 324·1250 | 263·98 |
| Hydrochloric solution for alkalies | 64·1800 | 67·4600 | 74·3800 | 56·1600 |
| Hydrochloric solution for sulphuric acid ... ... ... | 58·0350 | 65·2700 | 69·9400 | 45·53 |
| Hydrochloric solution for phosphoric acid, sesquioxide of iron, alumina, lime, and magnesia ... ... ... ... | 84·3700<br>73·4400 | 69·7700 | 75·9150 | 88·7600<br>50·9400 |
| Hydrochloric solution for the sesquioxide of iron ... ... | 23·8400 | 46·9195 | 60·7950 | 22·1800 |
| Quantity of soil for chlorine ... | 13·2600 | 11·3701 | 11·6611 | 14·4190 |
| Quantity of soil for total amount of organic matter ... ... | 7·5850 | 4·9130 | 5·6485 | 7·3205 |
| Quantity of soil for total amount soluble in water ... ... ... | 164·8400 | 205·1700 | 228·2350 | 104·6100 |

TABLE II.

| | Lievland. | Courland. | Lithuan. | Estland. |
|---|---|---|---|---|
| Residue | 18·5294 | 20·7465 | 17·1003 | 20·8094 |
| Mixed chlorides of potassium & sodium | 0·1684 | 0·1757 | 0·1839 | 0·1738 |
| Bichloride of platinum and potassium | 0·5217 | 0·3758 | 0·5255 | 0·4419 |
| Chloride of sodium | 0·0091 | 0·0609 | 0·0236 | 0·0388 |
| Sulphate of baryta for sulphuric acid | 0·0999 | 0·0543 | 0·0784 | 0·8897 |
| Pyrophosph. of magnesia for phosph. acid | 0·0448 | 0·0190 | 0·0234 | 0·0577 |
| Sesquioxide of iron and alumina | 0·6214 | 0·9477 | 0·9864 | 0·9250 |
| Sesquioxide of iron | 0·3624 | 0·5300 | 0·5911 | 0·4537 |
| Carbonate of lime | 0·1504 | 0 3113 | 0·1494 | 0·3237 |
| Pyrophosphate of magnesia for magnesia | 0·1103 | 0·1075 | 0·0918 | 0·2228 |
| Chloride of silver for chlorine | 0·0150 | 0·0071 | 0·0123 | 0·0280 |
| Amount of soil left after ignition | 7·2120 | 4·7150 | 5·4031 | 6·9645 |

From the former tables we obtain, by calculation, the following amounts of constituents of 100 parts in the soils :—

| | Lievland. | Courland. | Lithuan. | Estland. |
|---|---|---|---|---|
| Potash | 0·5011 | 0·3241 | 0 5466 | 0·3726 |
| Soda | ...... | 0·1320 | 0·0452 | 0·0480 |
| Lime | 0·3751 | 0·7816 | 0·4930 | 0·7955 |
| Magnesia | 0·2006 | 0·1304 | 0·1805 | 0·3619 |
| Alumina | 1·1919 | 1·8731 | 2·1418 | 2·0102 |
| Sesquioxide of iron | 1·8076 | 2·3767 | 3·1900 | 2·0206 |
| Manganese | trace | trace | trace | trace |
| Chloride of sodium | 0·0455 | 0·0247 | 0·0421 | 0·0790 |
| Sulphuric acid | 0·1539 | 0·0880 | 0·1206 | 0·1618 |
| Phosphoric acid | 0·1399 | 0 0538 | 0·0805 | 0·1597 |
| Organic matter | 4·7176 | 4·0300 | 4·3442 | 4·8630 |
| Insoluble residue after deducting organic matter | 91·0634 | 89·4872 | 88·4724 | 88·2364 |
| | 100·1966 | 99·3016 | 99·6619 | 99 1087 |

The insoluble residue constituting the greater portion of the soil, was fused with carbonate of potash. The following are the experimental numbers :—

| | Lievland. | Courland. | Lithuania. | Estland. |
|---|---|---|---|---|
| Amount of residue employed | 0·9790 | 1·2955 | 0·8620 | 0·9780 |
| Amount of hydrochloric acid solution obtained | 82·35 | 213·9450 | 270·3300 | 91·9300 |
| Amount of hydrochloric solution for the determination of sesquioxide of iron and alumina | 17·11 | 26·9730 | 29 5835 | 30·1800 |
| Amount of hydrochloric solution for the determination of lime | ...... | 27 7520 | 26·0968 | 26·1700 |
| Amount of silicic acid obtained | 0·852 | 1·1353 | 0·7958 | 0·8930 |
| Amount of sesquioxide of iron and alumina obtained | 0·0260 | 0·0106 | 0·0023 | 0·0210 |
| Amount of carbonate of lime obtained | ...... | 0·0061 | 0·0015 | 0·0120 |

The insoluble residues, upon calculation, yield the following results per cent.

| | Lievland. | Courland. | Lithuania. | Estland. |
|---|---|---|---|---|
| Lime - - - - - - | traces | 1·8727 | 0·8778 | 2·0120 |
| Alumina - - - - - - | 11·6270 | 6·1145 | 2·2452 | 5·7549 |
| Sesquioxide of iron - - - | traces | traces | traces | traces |
| Phosphoric acid - - - - | traces | traces | none | traces |
| Silicic acid - - - - - | 79·3424 | 81·5000 | 85 0938 | 80·5676 |
| | 90·9694 | 92·6224 | 88·2168 | 88·3345 |

In all the four soils we find, comparatively speaking, considerable quantities of alkali, especially potash, and also of phosphoric acid. They closely resemble the Belgian soils analysed by Sir Robert Kane, as may be seen from the tables, which we borrow from Sir Robert's paper :—

| | Heestert. | Escamaffles. | Hamme Zog. | Not named. | Holland. |
|---|---|---|---|---|---|
| Potassa - - - - - | 0 160 | 0·123 | 0·068 | 0·151 | 0·583 |
| Soda - - - - - - | 0·298 | 0·146 | 0·110 | 0·206 | 0·306 |
| Lime - - - - - - | 0·357 | 0·227 | 0·481 | 0·366 | 3·043 |
| Magnesia - - - - - | 0·202 | 0·153 | 0·140 | 0 142 | 0·105 |
| Alumina - - - - - | 2·102 | 1·383 | 0·125 | 0·988 | 5·626 |
| Sesquioxide of iron - - | 3·298 | 1·663 | 1·202 | 1·543 | 6·047 |
| Manganese - - - - - | trace | trace | a trace | no trace | trace |
| Chloride of sodium - - | 0 017 | 0·030 | 0·067 | 0 009 | 0·023 |
| Sulphuric acid - - - - | 0·025 | 0·017 | 0·013 | 0·026 | 0·023 |
| Phosphoric acid - - - | 0·121 | 0·152 | 0·064 | 0·193 | 0·159 |
| Organic matter not driven off at 100° per cent. - - | 3·123 | 2·361 | 4·209 | 3·672 | 5·841 |
| Clay - - - - - - | 14·920 | 9·280 | 5·760 | 4·400 | 17·080 |
| Sand - - - - - - | 75·080 | 84 065 | 86·797 | 88·385 | 60·947 |
| | 99·703 | 99·600 | 99·975 | 100·081 | 99·783 |

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