

JOURNAL
OF THE
ASSOCIATION OF PUBLIC ANALYSTS

The Analysis of Jersey Seaweeds

by S. A. CASTLEDINE and D. R. A. DAVIES

(Official Analyst's Laboratory, Pier Road, Jersey, C.I.)

Results are given of a survey of the major constituents of various types of seaweed found on the coasts of Jersey. In addition, results are tabulated for certain trace elements, sulphate, chloride and iodine levels and gross β activity. The main interest for this investigation is the assessment of the use of seaweed as a fertiliser, a practice still carried on in the Channel Islands.

Analytical figures on the percentage composition of Cut Vraic (*Fucus*) and Colley (*Laminaria*) were published by F. Woodland Toms, the first Official Analyst of Jersey, in 1905¹. Their chief interest was prompted by the application of seaweeds to the soil, a practice which is still carried on in the Channel Islands. The origin of the use of seaweed as a fertiliser of the land is lost in antiquity². Further, seaweeds have been used as cattle meal in Norway since experiments were commenced in 1917, a meal known as Algit being made from the *Laminariae* and Neptun from the *Fuci*².

Deposits of calcareous algae known locally as Maerl and botanically as the red alga *Lithothamnion* are dredged up off the north coast of Brittany. This is ground and sold commercially as a magnesian limestone. Beds of this alga have recently been found off the south east coast of Jersey. Results on a sample from this source are included in this paper. Figures on limpet shells which were separated from the coralline alga are included for comparison.

As many of the seaweeds may only be collected at periods of low water, sampling was carried out in the spring and autumn. Most of the samples were taken from an area removed from any outfalls.

Initial determinations carried out in 1971 were concerned with the major constituents of agricultural interest. Spring and autumn samples of representatives of the *Fuci* and *Laminariae* were included along with a few red algae and a representative of higher plants *Zostera* which was growing in the same area.

Further determinations were carried out on samples collected in the winter of 1972 in order to obtain information on the level of a number of trace elements. In addition, sulphates, chlorides and iodine levels were recorded as well as gross β activity of the oven-dry powdered samples.

Two varieties of green algae (*Chlorophyta*) were included along with the brown algae (*Phaeophyta*), the red algae (*Rhodophyta*), the coralline alga *Lithothamnion* and limpet shells. In addition, separate analyses were carried out on the stipe and thallus of three of the *Laminariae*.

Procedure

Samples were thoroughly rinsed in sea water to remove adhering sand and then shaken to remove drops of sea water. They were transported to the laboratory in polythene bags, and after identification and classification, initially air-dried in porcelain dishes and subsequently in an oven at 105°C. Primary grinding was carried out in a pestle and mortar, followed by treatment in a Glen Creston hammer mill.

Standard methods of analyses³ were used for nitrogen and chlorides. Iodine was determined by the method of the A.O.A.C.⁴, and the gross β activity by an "infinite depth" method⁵, using potassium chloride A.R. as a standard. In the latter experiments, the results were expressed in pico-curies of potassium 40 per gramme. For the remaining determinations the samples were ashed in platinum dishes in a muffle at 500°C, using hydrogen peroxide as an ashing aid. After weighing the ash, it was taken up in hydrochloric acid (50 per cent.), evaporated to dryness to fix any silica, re-treated with 50 per cent. hydrochloric acid and then filtered to remove insoluble matter. The solution was then made up to volume. Aliquot portions were taken for the determination of phosphates and potash by standard methods³. Sodium was determined by flame photometry and calcium, magnesium and trace metals by means of the Unicam SP 90 Atomic Absorption Spectrophotometer using the methods given in the Unicam manual⁶.

Discussion

Table I gives a comparison of spring and autumn samples including moisture figures on the wet samples; the other figures are expressed as percentages of the oven-dry samples.

In general the results for spring samples are higher than those for autumn samples. Whereas the phosphate figures are rather low, most of the samples are rich in potash. Further, the calcium and magnesium contents may well be significant in the case of additions of seaweeds to acid soils deficient in these elements. The figures also confirm some of the opinions expressed by Toms¹ in 1905.

Table II gives the major constituents for samples taken in the winter of 1972 and Table III includes some trace elements determined on these samples.

Agriculturally the *Laminariae* which occur in profusion in the deeper waters are the most valuable as a source of potash, the stipe containing rather more than the thallus. They are also a richer source of iodine.

The red algae were found to be relatively richer in nitrogen and *Lithothamnion* was found to be mainly composed of calcium and magnesium carbonates, whereas limpet shells were mainly calcium carbonate. Of the *Fuci*, *Ascophyllum* appears to contain most iodine.

TABLE I
COMPARISON OF THE MAJOR CONSTITUENTS OF SEAWEEDS IN THE SPRING AND AUTUMN OF 1971

Type	Location	Date	Moisture per cent.	N	P ₂ O ₅	K ₂ O	Na ₂ O	CaO	MgO
				per cent. on oven dry sample					
<i>Fucus Vesiculosus</i>	La Coupe	26.2.71	77.2	2.5	0.57	4.76	5.12	1.59	1.25
		4.11.71	67.7	1.1	0.21	3.30	3.88	2.82	1.18
<i>Fucus Serratus</i>	La Coupe	26.2.71	74.4	3.0	1.0	6.96	5.88	1.75	1.48
		4.11.71	78.9	1.5	0.31	5.28	5.44	1.71	1.21
<i>Ascophyllum Nodosum</i>	La Coupe	26.2.71	80.8	1.3	0.21	2.92	4.56	1.74	1.29
		4.11.71	71.3	0.9	0.14	3.50	4.62	1.61	1.24
<i>Laminaria Saccharina</i>	La Coupe	26.2.71	96.8	2.5	0.73	7.08	4.36	3.38	1.68
		4.11.71	68.5	1.3	0.51	4.20	3.28	1.37	0.87
<i>Laminaria Digitata</i>	La Coupe	26.2.71	85.8	2.4	0.69	9.84	6.92	2.50	1.65
		4.11.71	74.7	0.9	0.20	4.42	4.40	1.31	1.05
<i>Gigartina</i>	La Coupe	26.2.71	71.0	3.3	0.67	5.85	7.74	3.84	1.64
		4.11.71	64.1	3.1	0.49	2.64	5.40	7.05	1.70
<i>Rhodomenia</i>	La Coupe	26.2.71	86.7	3.5	1.05	21.0	4.19	0.77	0.60
		4.11.71	75.0	2.1	0.40	5.12	2.78	3.32	0.69
<i>Plocamium</i>	La Coupe	26.2.71	88.2	2.8	0.55	1.62	14.50	6.52	1.71
		4.11.71	88.5	3.3	0.43	2.08	12.70	8.27	1.74
<i>Furcelloria</i>	La Coupe	26.2.71	77.6	3.9	0.30	15.80	6.80	1.69	2.44
		4.11.71	71.3	2.4	0.29	5.26	6.46	3.78	1.56
<i>Zostera</i>	La Coupe	26.2.71	74.4	2.5	0.69	3.96	7.25	4.93	1.58
		4.11.71	84.4	2.0	0.51	3.80	9.16	3.81	1.94

TABLE II
MAJOR CONSTITUENTS OF SEAWEED IN THE WINTER OF 1972

Seaweed	Location	Date	Ash	Acid Insoluble Ash	N	P ₂ O ₅	K ₂ O	CaO	MgO	Na ₂ O	SO ₃	Cl
<i>per cent. on oven dry sample</i>												
CHLOROPHYTA												
<i>Codium</i>	Grouville	9.12.72	53.3	2.70	1.80	0.271	1.36	2.00	2.71	22.4	3.70	26.5
<i>Ulva</i>	La Coupe	8.12.72	49.1	4.49	2.76	0.346	2.63	3.01	4.65	13.4	8.94	
PHAEOPHYTA												
<i>Halidrys</i>	Grouville	9.12.72	26.7	0.34	1.60	0.241	7.08	1.66	1.13	5.32	3.84	7.74
<i>Laminaria Saccharina (Thallus)</i>	La Coupe	8.12.72	23.5	0.36	1.88	0.863	7.16	1.21	1.10	4.67	2.69	6.95
<i>Laminaria Saccharina (Thallus)</i>	Grouville	9.12.72	17.8	0.14	1.82	0.595	5.17	1.15	0.84	4.06	2.18	5.32
<i>Laminaria Digitata (Thallus)</i>	La Coupe	8.12.72	32.0	0.59	1.75	0.490	7.97	1.60	1.64	7.15	2.64	9.96
<i>Laminaria Digitata (Stipe)</i>	La Coupe	8.12.72	39.7	0.50	1.34	0.331	14.10	2.91	1.52	6.45	1.80	13.30
<i>Laminaria Cloustoni (Thallus)</i>	La Coupe	8.12.72	17.3	0.14	1.93	0.530	4.82	1.10	0.98	3.97	2.06	4.55
<i>Laminaria Cloustoni (Stipe)</i>	La Coupe	8.12.72	34.9	0.20	1.50	0.379	12.80	2.26	1.28	5.60	2.04	11.00
<i>Laminaria Cloustoni (Thallus)</i>	Grouville	9.12.72	31.8	0.12	1.61	0.334	11.10	1.81	1.40	5.44	3.16	9.73
<i>Laminaria Cloustoni (Stipe)</i>	Grouville	9.12.72	33.8	0.22	2.05	0.331	12.90	2.36	0.95	4.83	2.24	10.25
<i>Fucus Serratus</i>	La Coupe	8.12.72	26.1	0.42	1.90	0.524	5.79	1.73	1.44	5.73	3.96	6.66
<i>Fucus Vesiculosus</i>	La Coupe	8.12.72	22.8	0.45	1.60	0.458	5.18	1.43	1.30	5.58	4.30	5.35
<i>Fucus Spiralis</i>	La Coupe	8.12.72	26.5	0.88	1.63	0.254	5.04	1.46	1.44	5.82	7.26	4.99
<i>Pelvetia</i>	La Coupe	8.12.72	27.1	1.91	1.72	0.202	3.73	1.44	1.55	6.52	9.48	4.26
<i>Ascophyllum</i>	La Coupe	8.12.72	22.7	0.88	1.41	0.244	3.38	1.71	1.39	5.16	4.46	4.56
<i>Ascophyllum</i>	Grouville	9.12.72	21.9	0.13	1.60	0.288	3.98	1.69	1.31	5.00	4.32	4.20
RHODOPHYTA												
<i>Gigartina Stellata</i>	La Coupe	8.12.72	23.7	0.30	3.00	0.486	2.63	0.75	1.12	6.83	9.88	4.46
<i>Rhodomenia</i>	La Coupe	8.12.72	33.6	1.08	3.36	0.934	12.10	1.40	0.82	5.01	1.42	6.13
<i>Porphyra</i>	La Coupe	8.12.72	43.0	13.30	3.87	0.780	4.61	0.89	1.34	8.33	3.18	12.30
<i>Polysiphonia</i>	La Coupe	8.12.72	27.8	1.10	3.96	0.394	5.63	0.74	1.06	6.30	6.92	7.86
<i>Polyides Caprinus</i>	La Coupe	8.12.72	36.1	1.37	3.65	0.400	9.58	0.94	1.30	7.44		
<i>Lithothamnion</i>	Gorey		95.3	2.84	0.08	0.110	0.14	45.90	5.18	0.91	0.67	0.53
<i>Limpet Shells</i>	Gorey		97.5	2.99	0.05	0.058	0.13	50.40	0.24	1.07	0.24	0.43

TABLE III
TRACE ELEMENTS IN SEAWEED IN THE WINTER OF 1972

Seaweed	Location	Date	Fe	Cu	Zn	Ni	Co	Pb	Cr	Mn	I	Gross β
												Activity $\mu\mu$ Curies per gramme
CHLOROPHYTA												
<i>Codium</i>	Grouville	9.12.72	343	6	8	20	3.4	9	2	20	94	1.33
<i>Ulva</i>	La Coupe	8.12.72	2,110	6	18	20	2.6	10	9	26		
PHAEOPHYTA												
<i>Halidrys</i>	Grouville	9.12.72	161	5	17	10	2.0	9	1	4	954	45.3
<i>Laminaria Saccharina (Thallus)</i>	La Coupe	8.12.72	98	8	24	9	2.0	32	1	4	3,760	34.2
<i>Laminaria Saccharina</i>	Grouville	9.12.72	91	4	24	16	1.8	5	3	4	2,530	15.5
<i>Laminaria Digitata (Thallus)</i>	La Coupe	8.12.72	168	6	51	23	1.6	6	5	5	5,390	52.8
<i>Laminaria Digitata (Stipe)</i>	La Coupe	8.12.72	140	10	26	28	2.0	6	9	4	2,820	86.3
<i>Laminaria Cloustini (Thallus)</i>	La Coupe	8.12.72	112	15	47	16	1.8	6	7	3	3,270	27.3
<i>Laminaria Cloustini (Stipe)</i>	La Coupe	8.12.72	119	11	44	26	2.6	6	9	4	2,650	77.8
<i>Laminaria Cloustini (Thallus)</i>	Grouville	9.12.72	140	6	54	24	2.0	13	3	4	3,140	70.9
<i>Laminaria Cloustini (Stipe)</i>	Grouville	9.12.72	168	11	47	28	2.4	7	14	10	2,930	252.0
<i>Fucus Serratus</i>	La Coupe	8.12.72	413	12	82	23	4.0	11	24	103	613	39.2
<i>Fucus Vesiculosus</i>	La Coupe	8.12.72	119	5	56	19	4.0	5	4	63	502	36.9
<i>Fucus Spiralis</i>	La Coupe	8.12.72	175	5	38	10	2.8	8	3	35	436	29.2
<i>Pelvetia</i>	La Coupe	8.12.72	252	6	25	19	1.8	6	2	12	383	23.0
<i>Ascophyllum</i>	La Coupe	8.12.72	105	3	56	7	1.6	5	4	18	1,100	20.3
<i>Ascophyllum</i>	Grouville	9.12.72	49	5	48	6	2.0	6	2	29	1,210	21.2
RHODOPHYTA												
<i>Gigartina Stellata</i>	La Coupe	8.12.72	196	10	25	12	1.4	6	1	9	609	19.57
<i>Rhodomenia</i>	La Coupe	8.12.72	504	18	33	14	2.4	16	1	13	142	81.92
<i>Porphyra</i>	La Coupe	8.12.72	734	7	37	11	2.4	4	2	22	53	33.40
<i>Polysiphonia</i>	La Coupe	8.12.72	790	6	173	15	6.1	6	2	14	1,807	30.57
<i>Polyides Caprinus</i>	La Coupe	8.12.72	1,150	18	35	52	2.0	11	2	18		
<i>Lithothamnion</i>	Gorey		2,570	6	10	26	7.2	41	14	149	139	1.48
Limpet Shells												
	Gorey		1,790	6	6	28	7.6	38	22	26	149	1.85

The green algae are of lesser importance, the relatively high chloride content of *Codium* being another disadvantage. The cobalt figures in most cases are rather higher than those reported by Smales *et al.*⁷ and are more in accord with Lunde⁸ in the case of *Ascophyllum* and of *Fucus Serratus* and *F. Spiralis*. The high manganese figures for *F. Serratus* is also in line with that found by Lunde.

Laminaria Hyperborea mentioned by Lunde is identical with *Laminaria Cloustoni*. According to Dickinson⁹ the latter name should be abandoned in favour of the former to comply with International Rules of botanical nomenclature.

Whereas the presence of trace elements appears to be essential for optimum plant growth, certain elements, such as zinc, copper, and lead, can present serious hazards when present in excess¹⁰. Heavy rates of application of certain sewage sludges to land may create these hazards. However comparison of the trace element figures obtained with seaweeds indicate a considerable margin of safety in the case of the latter.

Smales *et al.*¹¹ use the term "enrichment factor" for the ratio of the concentration of an element in seaweed to that of sodium, compared with the same ratio for seawater. Table IV gives the enrichment factor of a number of trace metals relative to sodium for a few of the seaweeds together with enrichment factors of sulphates and iodine relative to chlorides. Discrimination in most cases against the sodium and chloride ions could be an important factor from the agricultural angle. Figures for sea water are taken from Barnes¹² and Cox¹³.

TABLE IV
ENRICHMENT FACTORS OF SOME TRACE ELEMENTS IN SEAWEED RELATIVE TO CHLORIDE AND SODIUM

TYPE	SO ₃ /Cl	I/Cl	K/Na	Ca/Na	Mg/Na	Cu/Na	Mn/Na	Fe/Na
<i>Codium</i>	1.2	134	1.8	2.3	0.8	223	126	2.2
<i>Porphyra</i>	2.2	164	16	2.7	1.1	700	374	12.5
<i>Fucus Serratus</i>	5.1	3,490	5.5	7.6	1.6	1,740	2,540	10
<i>Lithothamnion</i>	4.8	9,960	4.5	1,270	37.0	5,490	23,200	400
<i>Ascophyllum</i>	8.5	9,160	19.2	8.4	1.8	484	494	2.9
<i>Laminaria Digitata</i>	2.3	20,500	32.7	5.7	1.5	698	99	3.3
<i>Limpet Shells</i>	4.8	13,200	3.6	1,190	1.5	4,670	3,440	237

The Authors acknowledge the assistance of Miss K. Syvret and Miss M. Taylor for the collection and preparation of the samples and in the routine analytical determinations. They also thank Senator Cyril Le Marquand, President of the Finance and Economics Committee of the States of Jersey, for permission to publish this paper.

References

1. Toms, F. W., "Notes on Farm Chemistry in Jersey". C. P. du Parcq, 23 Halkett Place, St. Helier, Jersey, 1905.
2. Newton, L., "Seaweed Utilisation". Sampson Low, 25 Gilbert Street, London W1, 1951.
3. "The Fertilisers and Feeding Stuffs Regulations, S.I. 1960, No. 1165". H.M.S.O., London, 1960.

4. "Official Methods of Analysis of the Association of Analytical Chemists", 11th Edition. Association of Official Analytical Chemists, Washington, D.C., 1970.
5. The Technical Manager (Chemical Services), "P.G. Report No. 403 (W) of the United Kingdom Atomic Energy Authority (Production Group)", H.M.S.O. London, 1962.
6. "Pye Unicam Method Sheets; SP 90, Series 2 Atomic Absorption Spectrophotometer". Pye Unicam, York Street, Cambridge.
7. Smales, A. A., *et al.*, *Analyst*, 1957, **82**, 75.
8. Lunde, G., *J.Sci.Food Agric.*, 1970, **21**, 416.
9. Dickinson, C. I., "British Seaweeds". Eyre & Spottiswoode, London, 1963.
10. Berrow, M. L., *et al.*, *J.Sci.Food Agric.*, 1972, **23**, 93.
11. Smales, A. A., *et al.*, *Analyst*, 1955, **80**, 37.
12. Barnes, H., *Analyst*, 1955, **80**, 573.
13. Cox, R. A., *New Scientist*, 1959, **6**, 149, 518.