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CHEMICAL ANALYSIS OF PRECIPITATION IN IRELAND 1966-1975

by

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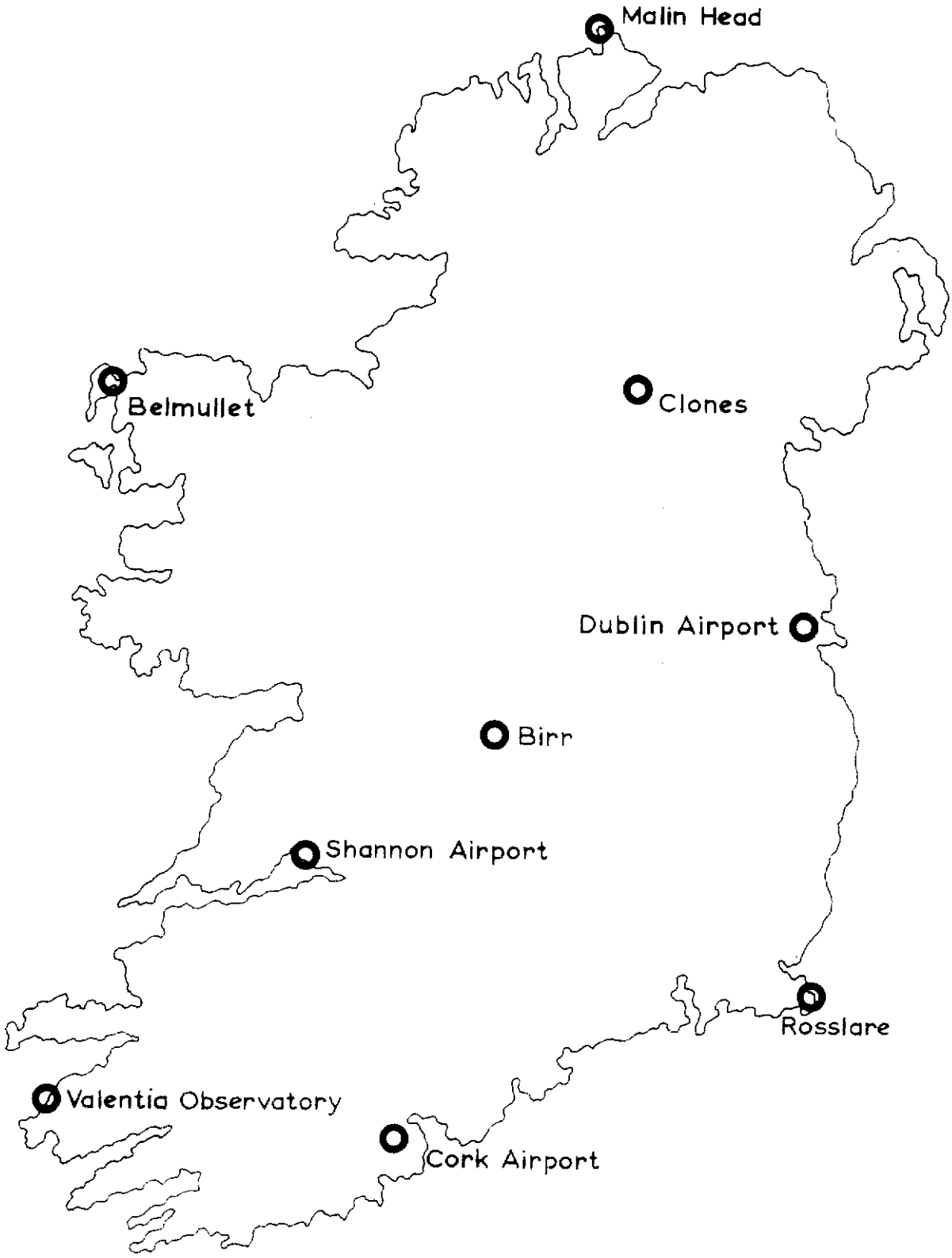

Frontispiece: Network of rain and air sampling stations.

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1. Introduction

At nine of the Irish synoptic stations, precipitation samples are collected throughout each month; these are sent to the Meteorological Service Laboratory for analysis for several trace constituents and for measurement of certain parameters. The results of these determinations are published in the Monthly Weather Report, Part I, as Table 9. This paper presents these results in summarised form, for the period 1966-1975 inclusive. The results for the 5-year period 1962-1966 have been discussed in an earlier paper (Tierney, 1967 /1/).

In operating this programme of monthly sampling and analysis of precipitation, the Meteorological Service is participating in a long-term international project, involving a network of observing stations co-ordinated by the Meteorological Institute of the University of Stockholm and known as the International Meteorological Institute (IMI) - network.

The network was set up in 1956/57 to study the chemical composition of precipitation and air, as a contribution to the scientific work for the International Geophysical year (I.G.Y.) 1957-1958. The network continued to function after the I.G.Y. ended. The content of the Meteorological Service programme is determined by the requirements of this network.

In 1970, the World Meteorological Organisation requested its members to participate in a world-wide network of Regional and Baseline Stations for the measurement of Background Air Pollution. In this programme which is also based on monthly samples, the list of parameters to be measured includes all of those already specified in the I.M.I. programme. Valentia Observatory was selected as a Regional Station, and since July 1970, the results for this station contribute to the W.M.O. programme as well as to the original I.M.I. programme.

Since 1957, the I.M.I. has from time to time changed many of its recommended analysis procedures, introducing more sophisticated instrumental techniques. The changes were made chiefly to save time and labour in dealing with large numbers of samples, but were also directed towards enhancing the accuracy of analysis. No significant changes have been made in the analysis procedures used in the Meteorological Service. Accordingly in the 10-year period reviewed here, all the results were obtained by using the same methods of sampling and analysis. They thus form a homogeneous series with only minor changes of sampling sites at two of the locations.

In this paper only the results of the precipitation analyses are dealt with. Air chemistry values will be the subject of a future study, when more data have been accumulated.

It should be borne in mind that because they are located at meteorological stations, the sampling sites are representative of coastal and rural locations rather than industrial or urban areas. The results should be considered therefore as affording information on "background" values in precipitation.

It is to be expected that in a island country such as Ireland, where most of the rainfall originates from air-masses which have passed over extensive ocean areas, the contribution from the sea to the trace constituents in precipitation would be significant. An attempt has been made to provide a quantitative estimate of the mean contribution from that source to some of the trace constituents. The average "excess" arising from sources other than the sea has also been computed. Some features of interest in the monthly and yearly values are discussed.

2. Location of Sampling Stations

The positions of the nine sampling stations are shown in the frontispiece map. At each of these the sampling cabinet is set up either in or near to the Main Instruments enclosure. The following notes give some additional information on the sites.

Malin Head. Latitude 55° 22'N Longitude 07° 20'W

Collector in Main Instruments enclosure. Enclosure Ht. above MSL:-20m.

The nearest town is Carndonagh (10 Km to SSW) which has a population of about 1200, with no significant pollution - producing industry. The collector is 200-300 m from the open sea. No change of site in the period 1966-1975.
Classification:- Coastal Station

Belmullet. Latitude 54° 14'N Longitude 10° 00'W

Collector in Main Instruments enclosure. Enclosure Ht. above MSL:-9m.

The station is approximately 1½ Km. West of Belmullet, a town with a population of about 750 and no significant pollution-producing industry. The collector is less than 100 m from the shore of Blacksod Bay. No change of site in the period 1966-1975.
Classification:- Coastal Station

Valentia Observatory. Latitude 51° 56'N Longitude 10° 15'W

Collector in Main Instruments enclosure. Enclosure Ht. above MSL:-9m.

The station is approximately 1 Km. SW of the town of Cahirciveen, which has a population about 1800, and no significant pollution-producing industry. The collector is about 150 m from the shore of the estuary. No change of site in the period 1966-1975.
Classification:- Coastal Station

Rosslare. Latitude 52° 15'N Longitude 06° 20'W

Collector in Main Instruments enclosure. Enclosure Ht. above MSL:-23m.

The station is 11 Km SE of Wexford, which has a population of about 13,500 and has mixed light and medium industry. The collector is about 100 m from the shore. No change of site in the period 1966-1975.

Classification:- Coastal Station

Shannon Airport. Latitude 52° 41'N Longitude 08° 55'W

Collector in Main Instruments enclosure. Enclosure Ht. above MSL:-14m.

The station is situated at Shannon Airport, near the terminal building. It is about 3 Km distant from Shannon Town (mainly residential population, 5000 approx.) and about 25 Km from Limerick City, which has a population of about 65,000. In the Industrial Estate, near the Airport there is a concentration of light industry; in Limerick City there is both light and medium industry. A cement factory lies 16 Km ESE of the station. The collector is about 1 Km from the shore of the Shannon Estuary. A minor change, to a position about 130 m south of the original site, was made on 6/5/1969.

Classification:- Semi-Coastal Station

Dublin Airport. Latitude 53° 26'N Longitude 06° 15'W

Collector in Anemometer Enclosure. Enclosure Ht. above MSL:-68m.

The station is situated 9-10 Km North of Dublin City centre, and the present site is on the perimeter of the airfield. The population of Dublin City is about 750,000; there is extensive industrial activity in the Dublin area with mixed, mainly light, industry within 2-3 Km of the airport. From January 1966 to 31st December 1972, the collector was situated in the main instruments enclosure, close to the operational area where there was a number of very localised pollution sources (car park, incinerator etc.); from 1st January 1973 it has been in the Anemometer enclosure, about 1 Km West of the original site. The collector is about 3 Km distant from the Irish Sea.

Classification:- Semi-Coastal

Cork Airport. Latitude 51° 51'N. Longitude 08° 30'W.

Collector in Main Instruments enclosure. Enclosure Ht. above MSL:-153m.

The station is 6-7 Km South of Cork City centre. Cork has a population of about 140,000, with both heavy and light industry in

the City and environs. (Power generation, steel fabrication, chemical factory). There is an oil refinery (Whitegate) 20 Km East of the station. The site is about 11 Km from Cork Harbour and about 16 Km distant from the open sea.

Collection of precipitation at this station began in 1971; only a five-year record is available. No change of site since 1971.
Classification:- Semi-Coastal Station

Clones. Latitude 54° 11'N Longitude 07° 14'W.

Collector in Main Instruments enclosure. Enclosure Ht. above MSL:-87m.

The station is situated about 800 m from the centre of Clones, a town with a population of about 2,000, with little local industry. The site is almost equidistant from the nearest points on the West and East coasts (about 60 Kms).
Classification:- Inland Station

Birr. Latitude 53° 05'N Longitude 07° 53'W.

Collector in Main Instruments enclosure. Enclosure Ht. above MSL:-70m.

The station lies 2 Km East of the centre of Birr, a market town, with a population of about 4,000, with only light industry. The site is about 70 Km from the nearest point on the West coast and about 120 Km from the East coast. No change of site in the period 1966-1975.
Classification:- Inland Station

At four of the stations - Malin Head, Belmullet, Valentia and Rosslare - the sites of the precipitation collectors are very similar - all less then 30 m above MSL, and all less than ½ Km from the sea-shore. Shannon Airport, on the estuary, 14 m above MSL is certainly semi-coastal; but Cork Airport, 11 Km from the shore and 153 m above MSL, and Dublin Airport, 3 Km from the shore and 68 m above MSL are marginal cases. Birr and Clones, at 87 m and 70 m above MSL and at least 60 Km from the shore in any direction, are clearly inland stations, with comparable exposures.

3. Sampling and Analysis Procedures

(a) Sampling Procedures

At each station, an insulated cabinet in the enclosure accommodates the apparatus for both air and precipitation sampling. The cabinet has an almost flat roof, which stands about 1.5 metres above ground level; a polythene funnel 15-18 cms in diameter, mounted on the roof, is connected by a latex tube and vented stopper to a 2-litre polythene bottle inside the cabinet. The funnel is fitted with a spiked guard-ring, to prevent birds perching on it; a plug of glass wood, renewed periodically, is tamped lightly into the neck of the funnel to keep the sample free from gross contaminants (flies, leaves or twigs etc.).

The collection period is from 1200 GMT on the 1st day of each month to 1200 GMT on the 1st day of the following month. The collecting bottles are cleaned and steamed before issue to the station and are kept capped until put in place in the cabinet. With the funnel size used, one such bottle will hold the catch from about 100 mms of rain, but a fresh bottle is always inserted when the rainfall in the month reaches 80-90 mms. A fresh bottle is always fitted at 1200 GMT on the 1st of each month even if the current bottle is apparently empty. Bottles removed from the cabinet are capped at once. The funnel is not washed or cleaned at any time, although leaves and twigs which may collect in it are removed, care being taken to avoid handling the collecting surface. To prevent the sample from freezing, a thermostatically-controlled 40W bulb, blackened to reduce the possibility of algal growth, is mounted inside the cabinet.

The amount of rainfall in the collecting period 1200 GMT on 1st to 1200 GMT on 1st of following month is determined from the official raingauge in the instruments enclosure.

The precipitation collection procedure described, while simple to operate and maintain, has certain shortcomings. Since the funnel is always uncovered, in dry weather, particles settling from the atmosphere or blown by the wind will be deposited in it; the soluble part of such deposition will be washed down into the sample by subsequent rainfall. Thus each sample for a month contains both those substances originally present in the rain as it fell and those which are washed down from the surface of the funnel.

In warm dry weather, with an open collector, there is the risk of evaporation from the sample, which would increase the concentration of the dissolved elements. Despite the guard-ring, bird droppings may occasionally give rise to contamination on an uncovered collector. Finally at coastal stations in windy conditions, there is always some direct deposition of sea-spray droplets or of dry salt particles on an uncovered funnel, whether precipitation is occurring or not.

For these and other reasons, the I.M.I. Network and the W.M.O. Background Air Pollution Programme both now recommend that precipitation sampling be effected by automatic collectors, which are closed tightly in dry weather and open only on the onset of precipitation, closing again as soon as the precipitation ends. At Valentia an automatic collector of this type has been designed and constructed and has been undergoing field trials. In due course, such collectors will replace those now in use at all stations of the Meteorological Service network.

However, since open collectors of the type in use 1966-1975, collect both wet and dry deposition, they furnish useful data on the total deposition on an area, and it will be desirable, even after the automatic collectors have been introduced, to run both systems side-by-side for some time for comparison and evaluation.

(b) Analysis Procedures

The methods of analysis are based on those originally recommended by the I.M.I. [2] with some minor modifications. Samples are analysed, as a routine, for:- Electrical Conductivity; Hydrogen (pH); Sulphur (as Sulphate); Chloride; Ammonium - Nitrogen, Nitrate - Nitrogen, Sodium, Potassium, Calcium and Magnesium; acidity or alkalinity.

The methods for analysis of different properties and chemical elements, with units of measurement used, are as follows:-

Electrical Conductivity (Micro-Siemens per cm) is measured on a resistance bridge, using a suitable conductivity cell; the cell constant is first determined with a Potassium Chloride solution of known strength. 20°C was the reference temperature for all measurements.

Electrical conductivity provides a measure of the total ionic concentration of the soluble ions present in the sample. Since, in general, non-determined ions occur only in extremely small amounts, an electrical conductivity value can be calculated from the other analysis results, using the formulae given in [2].

pH. (pH units) is determined by standard pH meter.

SO_4 - S (milligrams per litre) is determined by conductometric titration, using Barium Trichloroacetate.

Cl (milligrams per litre) is determined by conductometric titration, using Silver Nitrate.

NH_4 - N (milligrams per litre) is determined by a colorimetric procedure. The colour is developed by addition of Nessler's reagent after distillation of the samples with Sodium Hydroxide.

NO_3 - N (milligrams per litre) is obtained by a colorimetric determination. Devarda's Alloy is added to the residue of the ammonium distillation to reduce the nitrate to ammonia. Nessler's Reagent is then added to the redistillate.

Na, K, Ca (milligrams per litre). These are determined by flame photometer, using standard filters. The Calcium value is adjusted to allow for Sodium interference.

Mg, Ca (milligrams per litre). These are determined by E.D.T.A. titration. The method used is a slight modification of that developed by Lott and Cheng, [3], using Eriochrome Black T and Calcon as indicators. In most cases, satisfactory agreement is obtained between the flame photometer value for Calcium and that obtained by this method.

Acidity and Alkalinity (micro-equivalents per litre). An Alkaline titration to pH 5.6 is used.

The International Meteorological Institute, Sweden, organised a number of interlaboratory calibration and comparison tests for participating laboratories in the period 1966-75. Samples containing in known concentrations (not disclosed to the laboratories) most of the constituents for which regular determinations are made were sent to each participating laboratory for analysis. The results of the Meteorological Service analyses of these were generally satisfactory. A similar test was organised in 1974 by the U.S. Environmental Protection Agency on behalf of the W.M.O. The results from the Meteorological Service Laboratory in this case also were all found to be well within the acceptable levels.

4. Computation of Means and Presentation of Data

4.1. For the trace constituents in precipitation for which analyses are made, the concentration is expressed in mg/L (milligrams per litre). Since 1 mm of rain, falling on an

area of 1 square metre yields 1 litre of water, for a monthly sample, the concentration of a substance in mg/L multiplied by the corresponding rainfall in mms (millimetres) gives the weight in mgs. of that substance deposited on 1 square metre. Thus for each month and each substance for which a concentration in mg/L has been determined, the weight in mg/m^2 deposited by precipitation can be readily calculated.

It must be remembered that the concentration of a substance in mg/L, determined from the analysis of a monthly sample is itself a mean value. The total sample collected comprises a number of individual "subsamples" resulting from the individual rainfall events in the collection period, together with a contribution from dry deposition.

A simple arithmetic mean of concentration is influenced by extreme values (low with large rainfall amounts, unduly high with small rainfall amounts); it was, therefore, decided to use precipitation-amount-weighted mean values of concentration in mg/L. For each station, a set of 120 values (60 in the case of Cork Airport) of concentration in mg/L was available for most of the trace constituents, i.e. 10 values for each month.

4.2. Computations of Mean Values and Depositions

4.3. Monthly

For each set of 10 months (e.g. the January's in 1966-75), the concentration in mg/L of a particular element for each month was multiplied by the corresponding rainfall amount in mms, giving ten values of deposition, mg/m^2. The sum of these ten deposition values was divided by the sum of the corresponding rainfall amounts in mms, giving the weighted mean value of concentration mg/L, for the month.

The Mean Deposition (D) is the arithmetic mean of the ten deposition values.

4.4. Yearly

For each station, the 12 values of deposition in each year were summed and the total divided by the rainfall amount in mms for the year, giving a weighted mean concentration, in mg/L, for the year.

The sum of the 12 deposition values in each year is the yearly deposition.

4.5. Overall Mean Value

The overall mean value of concentration, mg/L, is the sum of the 120 deposition values divided by the total rainfall in the 10-year period. The overall mean value of yearly deposition is the arithmetic mean of the ten yearly deposition amounts.

4.6. Computation of "Excess" deposition

4.6.1. The contribution from the surrounding seas to the constituents found in precipitation samples is most pronounced at Coastal stations but is evident even in those furthest inland. The composition of sea-water is practically constant; Appendix III shows the quantities of the relevant elements, and the ratios of their abundance, taking Sodium as 1. The assumption is commonly used for this purpose, that these ratios remain unaltered when sea-water or sea-salts are included in precipitation samples. It is thus possible, given the amount of one constituent which is assumed to originate solely from the sea, to estimate the amount of others from that source. "Baseline" constituents used for this purpose may be Chlorine, Sodium or Magnesium. It has been found that in precipitation samples, the ratio of Chlorine to Sodium is often lower than the theoretical ratio 1.8:1; this is considered to occur from a loss of Chlorine due to disassociation. A full series of

Magnesium determinations was not available for all stations, so it was decided to use the Sodium values as the baseline from which to calculate the amounts of various constituents (S, K, Ca,) deposited from marine sources. However, several checks, using Chlorine and Magnesium values as "baselines" gave results close to those derived from the Sodium figures.

By subtracting the calculated value of the mean deposition of "Sulphur from the sea" for any period, from the total deposition of Sulphur, as analytically determined, in the same period, the amount of the "excess" Sulphur, (i.e. of other than marine origin) was obtained. Similarly "excess" values, both on a mean monthly and a yearly basis were calculated for Calcium and Potassium.

Finally, the tables show the "excess", where computed, as a percentage of the total deposited from all sources.

4.7. A table of mean monthly rainfall for each station, and a table of yearly rainfall totals at each station during the period have been given as Appendices I and II respectively for easy reference.

5. Comments on Results

General remarks on some features of the tabulated results are given here. The Chloride, Sodium, Magnesium, Potassium and Calcium ions are not generally regarded as pollutants; Sulphate and Nitrate ions are generally considered to contribute to the acidity of precipitation; pH is an indicator of the acidity of the sample. Electrical conductivity is almost linearly related to the total dissolved salts in precipitation.

5.1. Electrical Conductivity (Micro-Siemens per cm.)

Table 1 shows mean values of conductivity for each station for each calendar month, and the maximum and

minimum values which occurred in that month in the period. The mean values are the arithmetic means of the 10 values determined (5 at Cork Airport) in the period for each month. Isopleths are given for each month in Figure 1. There is a pronounced peak value in March at all stations, and the minimum values occur in July-August, with conductivity rising again to a second, generally lower peak in November-December.

Table 1(a) shows, for each station, the mean value of conductivity in each year over the period, obtained as the arithmetic mean of the 12 monthly values, together with the maximum and minimum values recorded in the year. These are illustrated in Figure 1(a). Except at Malin Head, where apart from the year 1970, there is a more or less steady decline, and at Rosslare, where a less-well-marked decline appears, the values do not show any significant trend.

Figure 1(b) gives isopleths of mean conductivity over the whole period 1966-1975. While this retains the "saucer" shape referred to by Tierney [1], with high values around the coasts and low values in the centre of the country, there is an overall drop in conductivity, particularly at coastal stations, compared with the period 1962-1966. At Malin Head and Rosslare the drop is approximately 33%, at Belmullet and Valentia about 15%, at Dublin and Shannon Airports about 12%, with the inland stations, Clones and Birr, showing decreases of 4% and 17% respectively.

This figure illustrates well the considerable influence of the sea on the constituents in precipitation.

5.2. Chloride and Sodium (Cl and Na)

These two are by far the most abundant ions in sea-water (see Appendix III) and are also generally the chief constituents in Irish precipitation samples, even at inland stations. In sea-water the Chlorine/Sodium ratio is 1.8:1, in precipitation samples it can vary widely; Tierney [1]

has suggested that the effects of sea-spray can adjust the ratio upwards towards 1.8:1 particularly at coastal stations.

In Table 2, the weighted mean concentration (mg/L) and the mean deposition (mg/m^2) are given for each station, for each calendar month, for both Chlorine and Sodium. The table also includes the mean Cl/Na ratio for each month. Figure 2 illustrates the month-to-month variations in concentration and deposition at each station. The seasonal pattern, high in Winter, low in Summer, shows clearly, for both concentration and deposition, but the maximum concentrations occur at almost all stations (Cork Airport is the exception) in March, with the greatest depositions occurring in November and January.

Table 2(a) gives the weighted mean concentration (mg/L) and the total deposition for each year in the period at each station, for both Chlorine and Sodium. Except at Malin Head, where there is a more-or-less steady decline in both concentration and deposition (arrested briefly in 1970 and 1974), the values do not show any very significant trend. Figure 2(a) illustrates this.

A peak value occurred in 1974 at most stations; there were strong westerly winds on a number of occasions in the early part of this year. The block diagrams emphasise the difference between the magnitudes of the deposition at coastal and inland stations. It is noteworthy that Dublin Airport - a semi-coastal station by location - receives only slightly more Chlorine and Sodium than the inland stations at Birr and Clones. It would appear that the influence of the Irish Sea at this station is small, due to the relative infrequency of strong easterly winds and the short trajectory of the East wind over the sea.

The overall values of concentration of Chlorine and of Sodium show a decrease, of the same order as that noted for conductivity, from those for the period 1962-1966.

5.3. Sulphur (S)

Sulphur in precipitation is mainly in the form of sulphates. Both natural sources (the sea, volcanic activity, rock weathering etc.) and human activities (burning of fossil fuels, industrial processes etc.) contribute sulphur to the atmosphere. Over Ireland, except along the East coast, the sea is the principal source of sulphur in precipitation. The tables show the mean concentration of sulphur (mg/L), the total weight of sulphur deposited (mg/m^2), the weight of sulphur (mg/m^2) estimated to have originated from other than marine sources, and the latter as a percentage of the total. The estimates of the "excess or non-marine" sulphur have been made by deducting from the total the amount of the Sulphur calculated to have come from the sea by using the Sulphur/Sodium ratio in sea-water.

Table 3 gives the concentration, total deposition, "excess" deposition and percentage for each station for each calendar month. Figure 3 shows the concentration and the deposition for each month. At the coastal stations the similarity to the Chlorine and Sodium graphs is obvious both for concentration and deposition, and at these the "excess" is a relatively small part of the total. At Cork, Dublin and Shannon the "excess" can range, in Summer, up to 80-90% of the total. This arises more from the decrease of the contribution from the sea in Summer than from variation in the "excess", although in that season some increase in dry deposition could be expected.

Table 3(a) gives for each station, for each year in the period, the mean concentration, the total deposition of sulphur, the estimated "excess" deposition and the latter as percentage of the total. Figure 3(a) illustrates the year-to-year variation in both concentration and deposition. Malin Head shows a fairly steady decrease over the 10-year period, Rosslare a less definite one; Dublin Airport shows a steady increase up to 1972 (the change of site away from the centre of operations may be significant) with a sharp

drop in 1973 followed by a steady increase. At other stations there is little significant variation.

While the figures again reveal the "saucer" pattern - high along coasts, low in centre - the values of total Sulphur deposition at Shannon, Cork, Dublin and Rosslare appear to arise as much from land sources - possible the nearby towns and cities - as from the sea. Some of the "excess" may originate from sources such as the exhalation of H_2S from extensive inter-tidal mud-flats. Average total yearly deposition of Sulphur ranges from 535 mg/m^2 (5.35 Kg/ha or 4.8 lbs/acre) at Birr to 2338 mg/m^2 (23.38 Kg/ha or 21 lbs/acre) at Malin Head.

Compared with the 1962-1966 period the overall total concentration of sulphur shows a decrease similar to that in the conductivity and Chlorine and Sodium values, most noticeable at coastal stations.

5.4. Nitrogen (NO_3 and NH_4)

In precipitation samples, Nitrogen is determined both for Ammonia compounds (NH_4 - nitrogen) and Nitrates (NO_3 - Nitrogen). The concentration of nitrogen in sea-water, in either of these forms is extremely low (see Appendix III) and the contribution from this source is too small and too variable to permit any reliable estimate of its amount. The contribution from agricultural sources (use of fertilisers etc.) must be considered as well as that from industrial sources.

5.4.1. NO_3 - Nitrogen

In Table 4, mean values of the concentration (mg/L) of Nitrogen as NO_3 are given for each station for each calendar month, together with mean values of the deposition (mg/m^3). These are illustrated by Figure 4.

Table 4(a) and Figure 4(a) give the same kind of information on a yearly basis.

The monthly values show that at Malin Head, Belmullet and Valentia, the maximum concentration occurs in May; this is also the case at Clones, and at Birr it occurs in April. At these five stations the maximum deposition also occurs in April, but there is only a small month-to-month variation throughout the year. At Shannon and Dublin Airports, and at Rosslare and Cork, there is no clear-cut seasonal pattern and both concentrations and depositions are somewhat higher.

The yearly values show little change except at Dublin and Shannon Airports, where sharp increases occurred in the years 1973-1975.

5.4.2. NH_4 - Nitrogen

Tables 4(b) and 4(c) give respectively monthly and yearly data for NH_4 - nitrogen, and these are illustrated in Figures 4(b) and 4(c).

The monthly data show no significant pattern at any station. Values at Malin Head, Belmullet, Valentia, Rosslare and Birr are low, with almost uniform deposition throughout the year; considerably higher values are found at Shannon Airport, Dublin Airport, Cork Airport and rather surprisingly Clones, but the occurrence of peak values is quite irregular.

The yearly data present much the same picture. At Malin Head, there is a decline; at Belmullet, Valentia, Rosslare and Birr there is no significant trend. At Dublin, Shannon and Cork Airports, and Clones a fairly steady increase has been occurring from 1971 onwards.

5.5. pH

The accepted equilibrium value of pH in precipitation samples is 5.6, slightly acidic, because of dissolved carbon

dioxide. Since pH is the negative logarithm of the hydrogen ion concentration, a simple arithmetic mean cannot be used. Each pH value was converted to its equivalent hydrogen ion concentration, this was multiplied by the rainfall value appropriate to the sample, the products were summed, the sum divided by the sum of the rainfall amounts involved and the resulting hydrogen ion concentration was reconverted to a pH value.

Table 5 and Figure 5 give for each station the mean pH value, calculated as above, for each calendar month, together with the maximum and minimum value of pH determined in each month in the ten-year period. No seasonal pattern can be discerned.

Table 5(a) and Figure 5(a) give the same kind of data on a yearly basis. At Birr and Shannon Airport the values are almost all slightly above or just below pH 6.0, at Belmullet the mean fluctuates slightly around pH 5.6, and Valentia is similar with a rather wider range of fluctuation. At Malin Head the mean remained about pH 5.1 up to 1973 but has increased to pH 5.5 - 5.6 in 1974 and 1975. Cork and Clones also fluctuate around pH 5.0, with a tendency to more alkaline values in recent years. Dublin Airport shows most variation, the mean value rising from pH 4.8 in 1966 to pH 5.9 in 1972 and declining thereafter to pH 4.7 - 4.8 in 1974 - 1975. (The change of site from January 1973 is probably a significant factor in this case). Rosslare is the only station which exhibits a fairly consistent lowering of mean pH, from pH 5.2 in 1966 to pH 4.7 in 1975. This decrease cannot be attributed to an increase in sulphur deposition, since at Rosslare, in recent years, both the total sulphur and the "excess" sulphur deposited have been declining, as have also the nitrogen amounts deposited.

Table 5(b) shows the frequency of occurrence of pH values at each station over the 10-year period. Except at Rosslare, there is no evidence of a tendency to lowering pH values over the 10-year period.

5.6. Potassium (K)

Table 6 gives monthly values of mean concentration (mg/L), mean total deposition (mg/m^2), mean "excess" deposition (mg/m^2), and the latter as percentage of the mean total deposition. Figure 6 illustrates this table.

The shapes of the graphs for the coastal stations and for Birr and Clones are very similar to those for Sodium and Chlorine (Figure 2); at the airports there is little resemblance. The deposition diagrams show that only at Cork, Dublin, and Shannon Airports is there a significant excess of Potassium, but no pattern is evident for this excess.

Table 6(a) gives the same data on a yearly basis, illustrated by Figure 6(a). Both Malin Head and Rosslare show the decline already observed in Sodium, Chlorine, and Sulphur; at the other stations, except the airports, the deposition diagrams show little change either in the total amount or the "excess". The increased "excess" at Shannon Airport from 1972 onwards may possibly arise from industrial processes.

5.7. Calcium (Ca)

Table 7 gives monthly values of mean concentration (mg/L), mean total deposition (mg/m^2), mean "excess" deposition (mg/m^2) and the latter as percentage of the mean total deposition. Figure 7 illustrates these data.

For the coastal stations, and Birr and Clones the graphs of concentration are very similar to those for Sulphur (Figure 3). At the three airports the resemblance is less marked. The deposition diagrams show that the amount of "excess" calcium, is relatively constant throughout the year, and that the calcium from marine sources accounts for the seasonal pattern in the total. At the inland stations and the airports the "excess" calcium accounts for up to 95% of the total, while at the coastal stations it ranges, on average, from 45% to 75%.

Table 7(a) and Figure 7(a) provide similar data on a yearly basis. Both Malin Head and Rosslare show a fall in concentration and deposition; at Cork, Valentia, Belmullet and Clones there is little change. Shannon Airport shows an increase up to 1969, followed by a fall to well below the 1966 level, Birr shows a tendency to increase from 1970 on, and Dublin Airport exhibits a steady rise from 1966 to 1972 (change of site in January 1973 away from centre of operations), dropping sharply in 1973 to $\frac{1}{4}$ of the 1972 level and rising slightly thereafter.

The Dublin Airport figures bear out the widely held view that Calcium is the element in precipitation samples which is most affected by dry deposition. Much of the "excess" at Dublin and Shannon airports may arise from the "dusting" of the extensive concrete surfaces while at inland stations liming for agricultural purposes may have some influence.

5.8. Magnesium (Mg)

The method used (EDTA titration) for Magnesium determination has the disadvantage that a large volume (500 mls) of sample is required. Consequently, in Summer months the sample is frequently insufficient to enable the analysis for Magnesium to be carried out by this method.

Table 8 gives the mean monthly concentration (mg/L) and mean monthly deposition for Magnesium for the stations Malin Head, Belmullet, Valentia, Rosslare and Cork Airport, with a few values for other stations, illustrated by Figure 8. The graphs and deposition diagrams are almost identical with those for Sodium (Figure 2).

Table 8(a) and Figure 8(a) provide similar data on a yearly basis. Again the resemblance to the Sodium graphs and diagrams is noticeable. Since, like Sodium, Magnesium may be considered to originate almost exclusively from the sea, this similarity is to be expected.

5.9. Acidity/Alkalinity

Acidity/Alkalinity determinations have been made on precipitation samples since August 1971; before then only the alkalinity was measured. For the years 1972 to 1975, yearly mean values of acidity or alkalinity have been calculated, by multiplying each monthly value, in micro-equivalents per litre, acid or alkaline - by the corresponding rainfall amounts in mms. From the 12 results so obtained in each year, the nett acidity or alkalinity was determined and a mean value, in micro-equivalents per litre, was computed.

Table 9 and Figure 9 show these yearly mean values. The relationship between the measured pH of a precipitation sample and the acidity or alkalinity value (determined with reference to pH 5.6) is not a simple or straightforward one. Nevertheless, in most cases, the year-to-year variations shown in Figure 9 are somewhat similar to those of mean pH (Figure 5(a)) for the same period, with best agreement when pH values are below 5.6.

6. Discussion

At all stations, but most markedly at those on the Western and Southern coasts, the mean electrical conductivity in precipitation for the period 1966-75 is lower than the mean for the period 1962-1966. The reduction in those substances which come mainly from the sea, most pronounced at coastal stations, suggests that the influence of the sea on precipitation chemistry has been less in 1966-75 than in 1962-66.

This may be in some measure due to the decline in the strength and/or frequency of westerly winds since the agitation of the ocean surface by winds is the chief mechanism by which the sea-derived constituents are introduced into the atmosphere. This decline would also reduce the transport of spray and salt direct from the sea to collectors at coastal stations. During the period 1966-75, at almost all stations the wind direction was from the sector 150° to 320° inclusive (SSE through W to NW approx.)

on about 70% of the occasions, so that it is in this sector that a fall in wind strength would have most effect. At almost all stations there has been a small drop in mean wind strength, compared with the period 1962-66 and the average number of days with gales has also dropped. In an element so variable as wind strength, a ten-year period is too short to permit any inference to be drawn about a trend.

As regards the general variation in the concentration of the constituents of precipitation during the period, it is suggested that at Malin Head the decrease is related to a reduction in the surface wind strength. At Cork Airport, Dublin Airport and Shannon Airport the changes are mainly in those constituents, such as Sulphur and Calcium, in which an increased local contribution either as wet or dry deposition, may be a factor. At Rosslare the principal change is a gradual fall in pH to a more acidic value, for which no simple explanation appears. At Belmullet, Birr, Clones and Valentia there is little overall change.

The expected Winter-Summer pattern - high-low-high - in concentration in precipitation is more defined at coastal stations and for electrical conductivity, Sodium, Chlorine and Magnesium. Rosslare, Dublin Airport and Clones have the highest frequency for acidic pH values. The greatest "excess Sulphur" values occur at Dublin Airport and Shannon Airport.

It is hoped that the general introduction of automatic open-and-shut rain collectors will provide further information in precipitation chemistry analysis.

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TABLE 1 : ELECTRICAL CONDUCTIVITY - μS/cm (MICRO-SIEMENS/cm)

MEAN MONTHLY AND MONTHLY MAXIMUM AND MINIMUM VALUES, 1966-75

STATION		J	F	M	A	M	J	J	A	S	O	N	D
MALIN HEAD	MEAN	165	225	262	192	136	97	86	68	102	146	240	218
	MAX.	218	380	600	280	238	245	129	112	187	252	606	420
	MIN.	104	117	115	116	88	48	45	40	57	62	118	112
BELMULLET	MEAN	193	205	217	132	117	92	80	62	95	138	165	213
	MAX.	360	410	494	177	189	148	151	112	135	232	254	446
	MIN.	126	119	61	70	62	41	40	26	56	73	61	100
VALENTIA	MEAN	120	129	131	79	62	55	39	34	85	64	131	124
	MAX.	340	200	255	138	104	93	68	57	168	106	500	231
	MIN.	54	45	55	30	35	34	24	20	52	27	39	60
ROSSLARE	MEAN	138	176	192	152	107	117	46	54	100	124	109	137
	MAX.	223	491	318	530	225	225	73	88	181	232	280	276
	MIN.	72	64	76	70	54	47	25	31	60	79	64	75
SHANNON AIRPORT	MEAN	80	88	115	102	95	89	77	53	82	59	95	115
	MAX.	104	126	200	193	190	284	174	124	207	85	219	200
	MIN.	47	44	52	44	52	23	23	16	37	28	45	42
DUBLIN AIRPORT	MEAN	109	111	135	82	80	75	52	67	61	106	82	91
	MAX.	169	200	185	117	150	180	84	174	187	218	167	208
	MIN.	58	63	80	50	28	41	33	19	25	40	35	42
CORK AIRPORT	MEAN	69	62	73	61	48	63	28	25	56	56	44	74
	MAX.	96	98	82	70	62	104	37	35	135	74	68	96
	MIN.	55	41	60	47	37	31	21	17	25	43	28	48
CLONES	MEAN	47	61	76	60	46	34	28	26	47	38	53	58
	MAX.	68	83	102	106	70	84	50	60	200	51	94	151
	MIN.	29	35	46	36	22	15	12	12	15	17	29	28
BIRR	MEAN	46	65	84	51	38	49	30	28	34	31	37	54
	MAX.	80	108	150	84	82	142	47	50	67	45	108	114
	MIN.	24	41	39	27	19	17	15	16	18	15	20	21

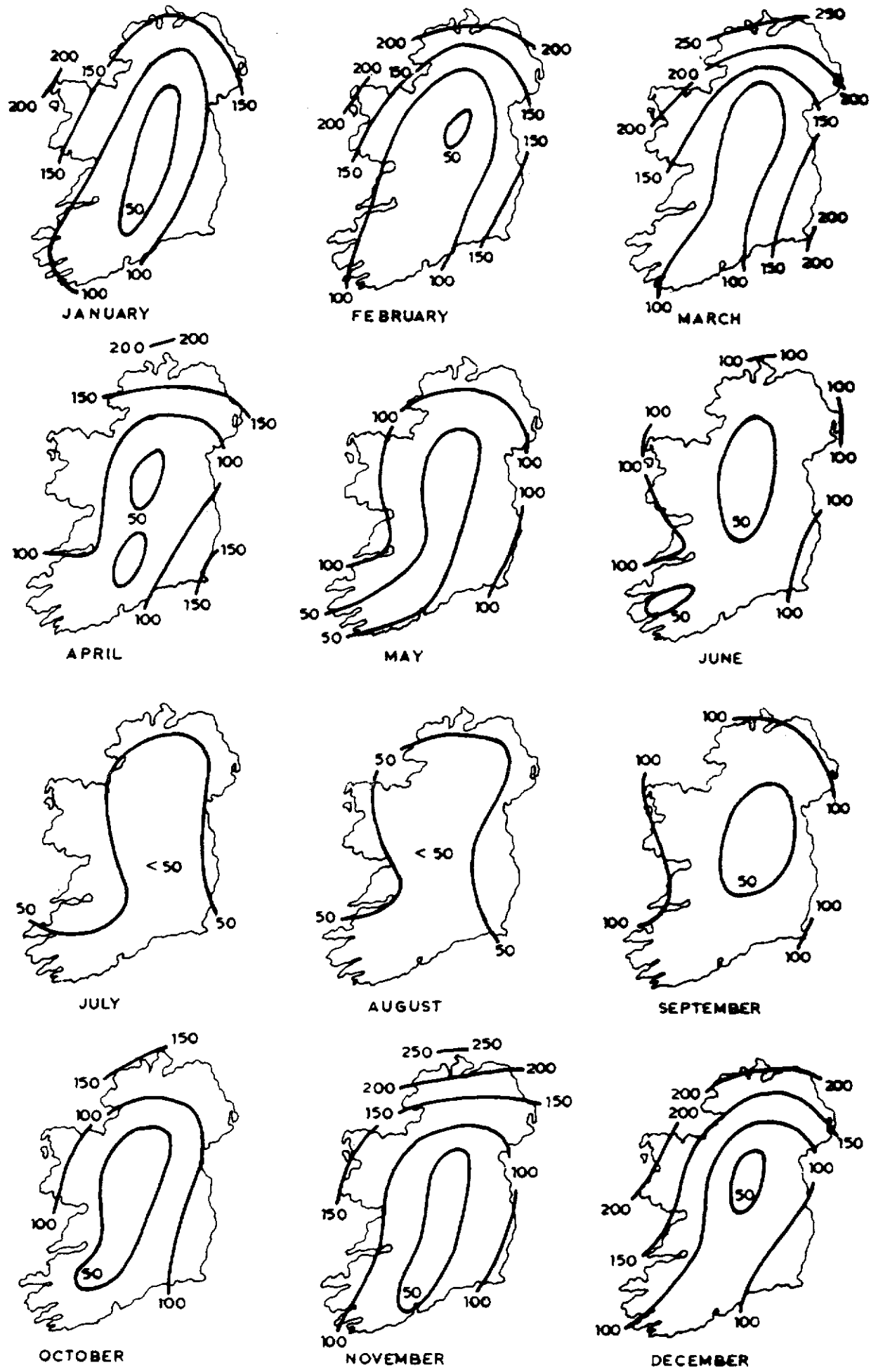

Fig. 1. Electrical conductivity (µS/cm) mean monthly values.

TABLE 1(a) : ELECTRICAL CONDUCTIVITY - μS/cm (MICRO-SIEMENS/cm)

YEARLY MEAN VALUES, 1966-75 INCLUSIVE, WITH MAXIMUM AND MINIMUM VALUES FOR EACH YEAR

STATION		1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	Overall
MALIN HEAD	MEAN	231	212	149	155	184	154	137	135	135	125	161
	MAX.	606	600	290	264	315	286	330	380	252	245	606
	MIN.	48	89	51	76	70	53	40	44	44	47	40
BELMULLET	MEAN	125	163	126	127	135	152	152	145	170	129	142
	MAX.	254	494	235	174	234	446	232	410	351	200	494
	MIN.	34	34	40	48	69	26	61	41	95	66	26
VALENTIA	MEAN	117	110	66	77	71	84	95	71	119	67	88
	MAX.	500	255	163	166	141	200	212	180	340	152	500
	MIN.	24	20	26	28	24	30	28	36	25	27	20
ROSSLARE	MEAN	147	160	103	140	137	111	99	94	98	120	121
	MAX.	285	530	226	491	318	216	181	164	164	225	530
	MIN.	65	27	38	39	25	37	36	34	31	50	25
SHANNON AIRPORT	MEAN	93	96	69	82	79	88	115	110	67	76	88
	MAX.	219	200	162	126	132	192	207	284	135	190	284
	MIN.	20	55	36	47	28	40	45	38	16	28	16
DUBLIN AIRPORT	MEAN	69	79	73	89	86	99	115	66	114	84	88
	MAX.	167	185	125	218	150	169	200	138	208	180	218
	MIN.	33	32	36	36	35	53	49	19	35	27	19
CORK AIRPORT	MEAN						52	58	48	62	56	55
	MAX.		NOT	AVAILABLE			98	135	76	96	104	135
	MIN.						17	26	25	23	21	17
CLONES	MEAN	46	41	38	49	49	58	56	41	48	53	48
	MAX.	102	88	90	92	84	151	200	83	106	96	200
	MIN.	17	17	12	21	19	20	18	16	12	23	12
BIRR	MEAN	48	48	43	43	53	44	43	38	46	49	46
	MAX.	114	150	108	72	97	79	67	88	98	142	150
	MIN.	15	16	17	24	22	20	16	15	19	22	15

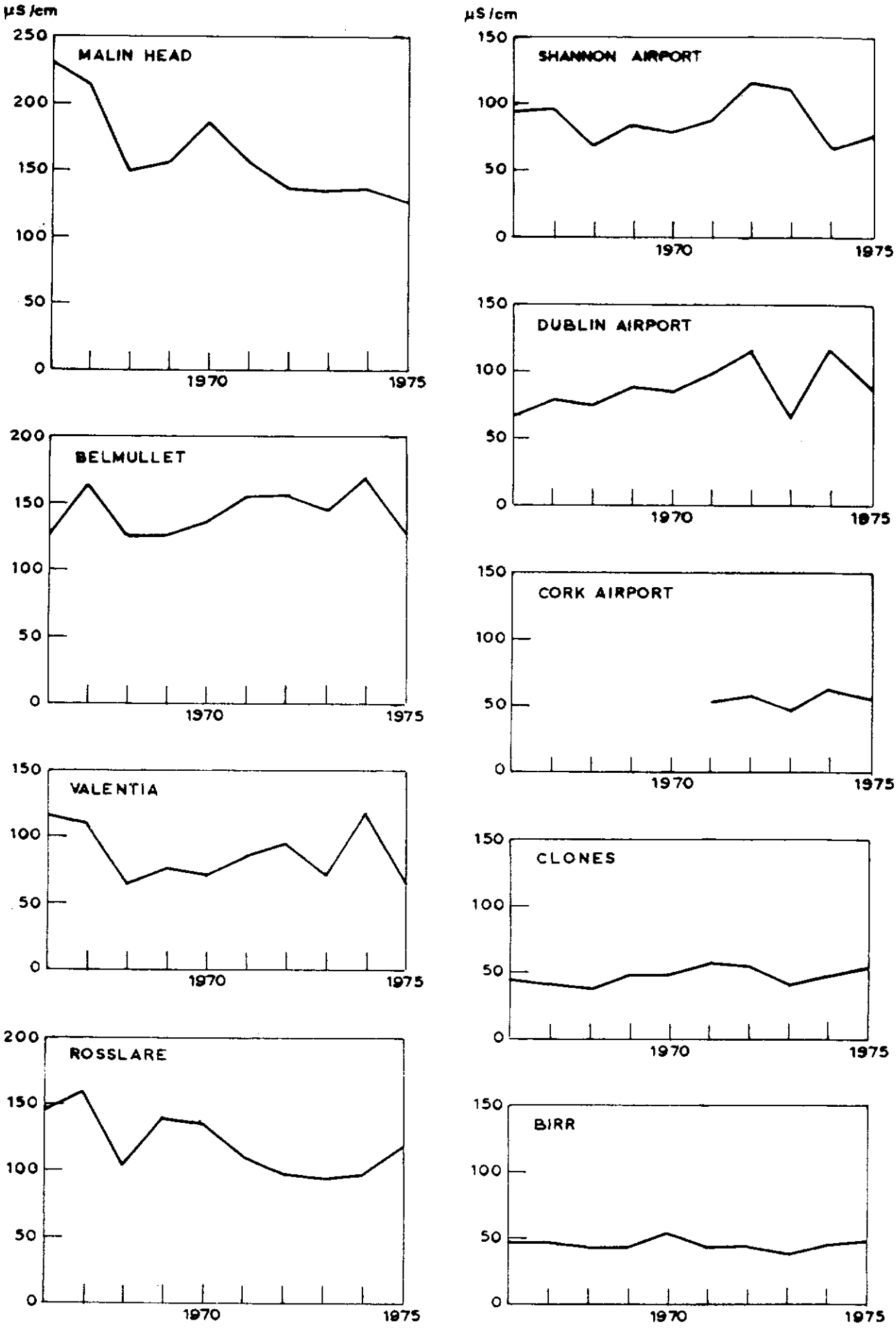

Fig. 1(a). Electrical conductivity yearly mean values.

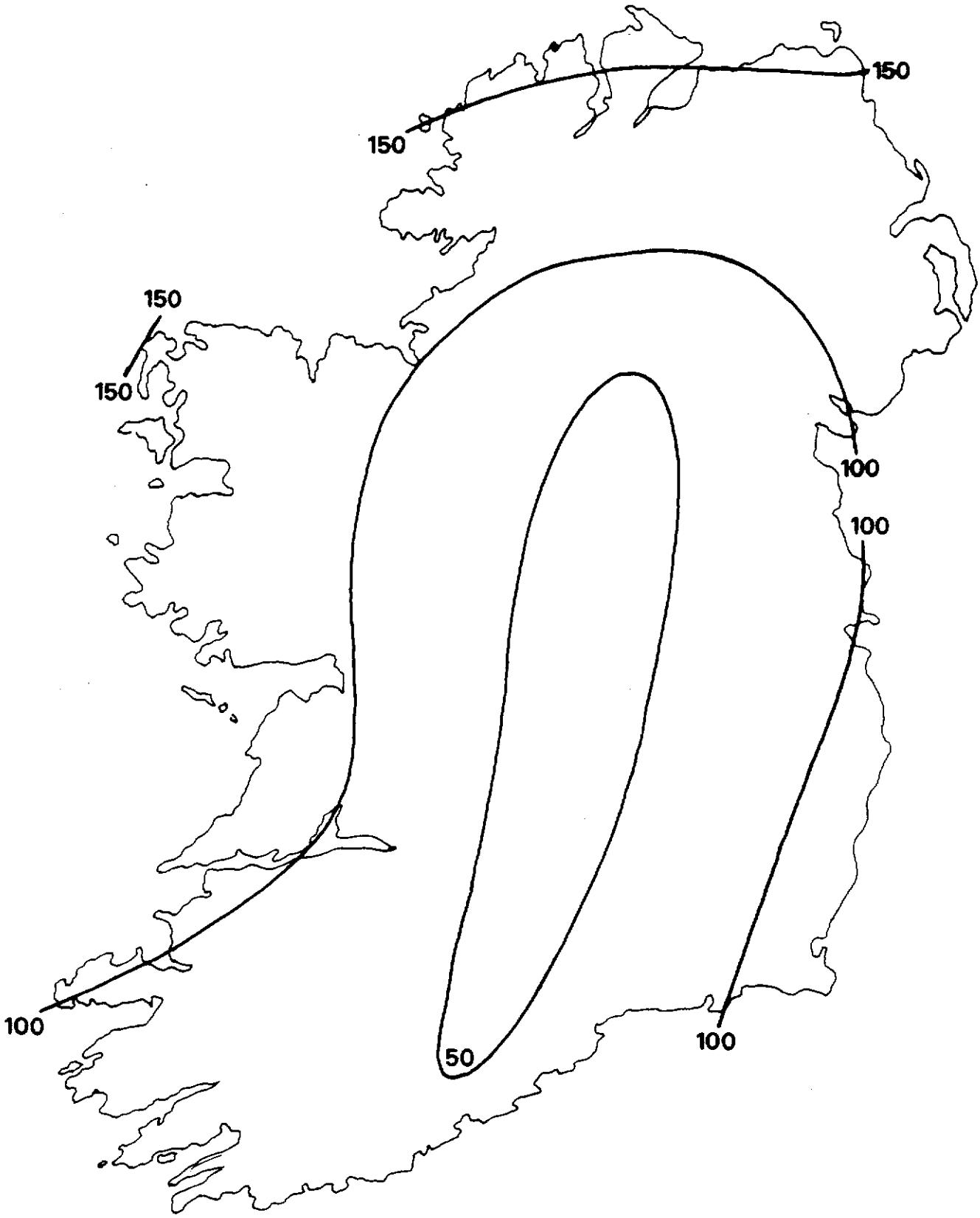

Fig. 1(b). Electrical conductivity (µS/cm) overall mean values.

TABLE 2 : CHLORINE (Cl) AND SODIUM (Na) - MEAN MONTHLY VALUES 1966-75 incl.

C = Mean (weighted) concentration, mg/L.
D = Mean deposition, mg/m^2.

STATION		J	F	M	A	M	J	J	A	S	O	N	D
MALIN HEAD	Cl (C	34.8	48.2	67.6	38.1	24.2	14.1	13.6	11.2	16.7	32.5	54.3	53.1
	Cl (D	3774	3955	5130	2196	1502	884	892	915	1602	3450	6953	5341
	Na (C	20.6	28.5	39.3	22.9	14.4	8.5	8.7	6.7	10.2	18.9	31.6	31.0
	Na (D	2233	2336	2986	1321	893	537	570	548	980	2011	4042	3112
	Cl/Na Ratio	1.69	1.69	1.72	1.66	1.68	1.65	1.56	1.67	1.63	1.72	1.72	1.72
BELMULLET	Cl (C	47.3	47.1	52.8	24.5	21.5	14.7	13.4	10.0	18.9	29.2	36.0	47.5
	Cl (D	5865	4404	3639	1362	1307	966	836	851	2085	3204	4618	5141
	Na (C	27.5	27.5	31.1	15.6	13.8	9.3	8.6	6.7	11.6	17.6	21.0	28.0
	Na (D	3409	2573	2141	869	841	609	536	570	1282	1929	2698	3025
	Cl/Na Ratio	1.72	1.71	1.70	1.57	1.55	1.59	1.56	1.49	1.63	1.66	1.71	1.70
VALENTIA	Cl (C	30.0	26.1	29.3	12.4	10.5	7.4	4.4	4.2	18.9	11.4	22.4	24.0
	Cl (D	5755	3398	2008	1037	970	497	308	405	2351	1463	3341	2944
	Na (C	17.7	15.6	18.2	7.8	6.6	4.8	3.3	3.0	11.4	7.0	13.1	14.5
	Na (D	3405	2034	1245	652	610	325	230	290	1415	893	1951	1773
	Cl/Na Ratio	1.69	1.67	1.61	1.59	1.59	1.53	1.34	1.40	1.66	1.64	1.71	1.66
ROSSLARE	Cl (C	27.5	31.6	34.6	23.8	16.6	13.5	4.7	6.2	16.1	20.1	20.9	23.9
	Cl (D	3320	2267	1527	1454	1097	515	313	444	1270	1595	2032	1707
	Na (C	16.2	18.6	20.5	13.9	10.0	8.5	3.1	4.0	9.4	11.9	12.3	13.9
	Na (D	1957	1332	905	848	659	324	205	285	738	946	1197	990
	Cl/Na Ratio	1.70	1.70	1.69	1.71	1.67	1.59	1.53	1.56	1.72	1.69	1.70	1.72
SHANNON AIRPORT	Cl (C	12.4	15.0	21.2	13.5	12.0	6.0	5.3	3.1	8.6	8.1	13.2	18.0
	Cl (D	1224	1165	1146	736	733	326	300	235	807	659	1446	1483
	Na (C	7.3	9.0	13.0	9.0	7.7	4.3	3.9	2.5	5.6	5.2	8.2	11.0
	Na (D	725	702	702	492	468	230	220	184	528	424	900	909
	Cl/Na Ratio	1.69	1.66	1.63	1.50	1.57	1.42	1.36	1.27	1.53	1.56	1.61	1.63
DUBLIN AIRPORT	Cl (C	14.0	13.2	16.8	6.5	6.0	2.8	2.0	3.2	2.8	7.4	8.1	10.4
	Cl (D	1089	709	673	412	383	133	113	188	207	432	563	654
	Na (C	8.3	7.9	10.2	4.8	4.2	2.1	2.3	2.7	2.0	5.3	5.3	6.5
	Na (D	644	426	408	303	270	98	127	159	152	308	373	407
	Cl/Na Ratio	1.69	1.66	1.65	1.36	1.42	1.36	0.89	1.18	1.36	1.40	1.51	1.61
CORK AIRPORT	Cl (C	13.8	8.4	8.3	5.2	3.5	3.5	1.3	1.9	4.5	5.8	5.4	10.8
	Cl (D	2679	829	432	246	392	135	106	152	502	647	476	954
	Na (C	8.1	5.4	5.2	3.3	2.6	2.7	1.2	1.5	2.9	3.5	3.6	6.5
	Na (D	1568	532	269	155	292	101	98	115	326	390	314	577
	Cl/Na Ratio	1.71	1.56	1.61	1.59	1.34	1.33	1.09	1.32	1.54	1.66	1.52	1.65
CLONES	Cl (C	5.9	7.4	10.7	5.8	2.8	1.8	1.6	1.2	2.0	4.4	8.5	7.4
	Cl (D	572	554	608	338	201	126	100	92	163	358	770	555
	Na (C	3.9	4.4	7.2	4.0	2.0	1.4	1.1	1.1	1.9	2.9	5.0	4.6
	Na (D	376	326	409	233	146	94	68	82	151	231	453	347
	Cl/Na Ratio	1.52	1.70	1.49	1.46	1.37	1.35	1.46	1.13	1.08	1.55	1.70	1.60
BIRR	Cl (C	6.0	8.7	12.0	4.1	3.0	2.2	1.4	1.3	2.6	3.3	4.4	7.9
	Cl (D	520	457	522	222	194	101	84	85	196	263	372	529
	Na (C	4.1	5.6	7.8	3.2	2.5	2.4	1.6	1.7	2.4	2.4	3.0	5.2
	Na (D	350	293	339	170	161	111	96	108	179	192	252	347
	Cl/Na Ratio	1.49	1.56	1.55	1.31	1.21	0.91	0.88	0.79	1.09	1.37	1.47	1.52

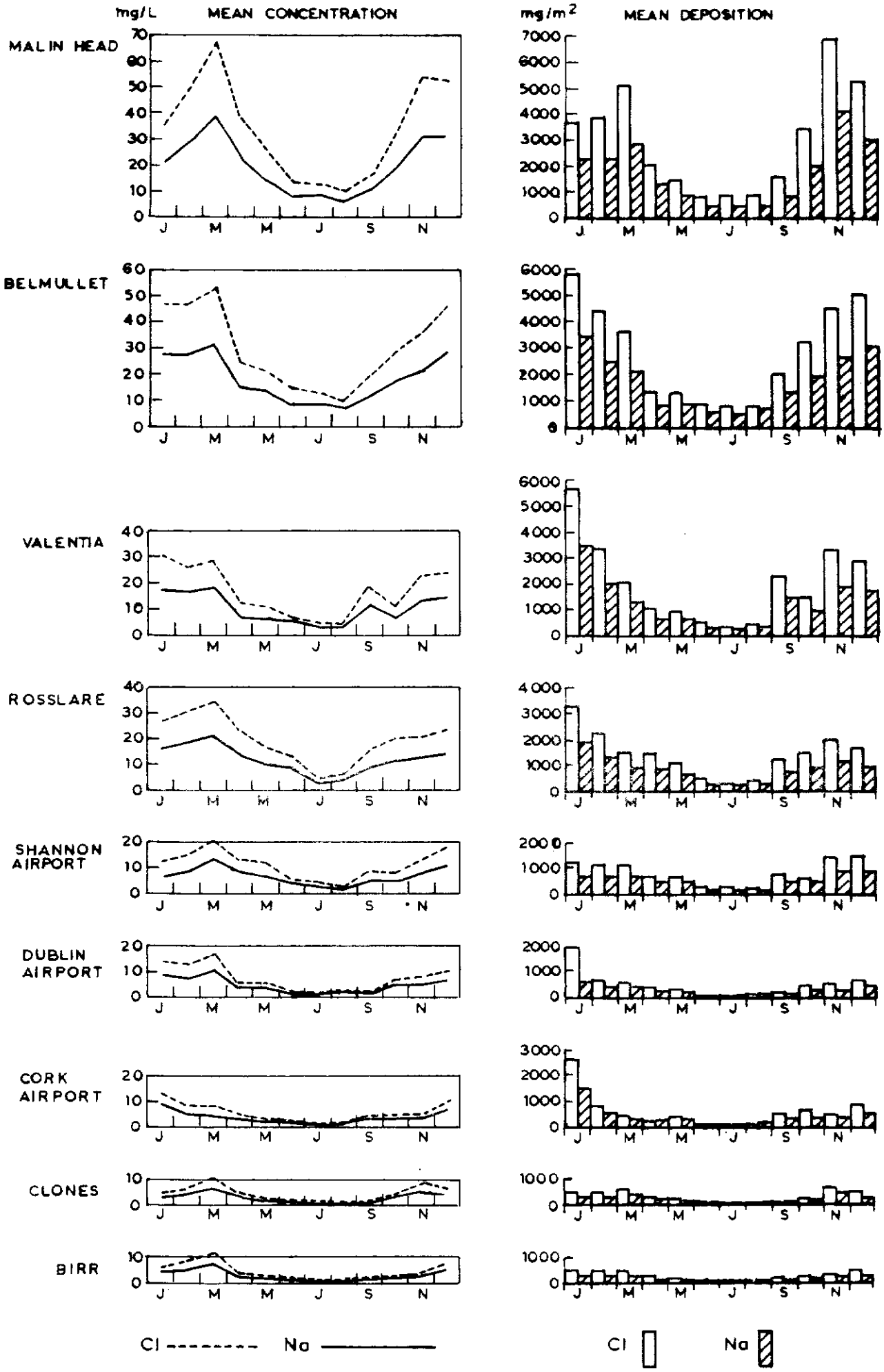

Fig. 2. Chlorine and Sodium mean monthly values

TABLE 2(a) : CHLORINE (Cl) AND SODIUM (Na) - YEARLY VALUES 1966-75 incl.

C = Mean (weighted) concentration, mg/L, over the year.
D = Total deposition, mg/m^2, over the year.

STATION		1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	OVER ALL
MALIN HEAD	Cl (C	61.9	45.5	34.4	34.6	39.3	29.2	24.9	27.0	30.7	23.0	35.6
	Cl (D	63768	56662	33512	36454	44338	28906	24054	28043	30310	19879	36593
	Na (C	35.8	26.7	19.8	19.9	22.9	17.4	15.1	16.0	18.7	14.6	21.0
	Na (D	36900	33169	19299	20989	25803	17223	14581	16650	18494	12581	21569
	Cl/Na Ratio	1.73	1.71	1.74	1.74	1.72	1.68	1.65	1.68	1.64	1.58	1.70
BELMULLET	Cl (C	31.2	36.4	31.8	27.7	28.2	31.6	31.9	29.6	41.3	28.1	32.0
	Cl (D	37734	41595	33340	24792	33370	29144	30756	32243	50337	26752	34276
	Na (C	18.1	21.4	18.6	16.6	16.5	19.5	20.0	17.7	24.6	17.2	19.1
	Na (D	21911	24464	19458	16467	19594	17977	19286	19255	29987	16421	20482
	Cl/Na Ratio	1.72	1.70	1.71	1.70	1.70	1.62	1.60	1.67	1.68	1.63	1.67
VALENTIA	Cl (C	19.8	23.0	13.7	14.3	12.7	16.2	18.9	14.6	34.0	13.0	18.5
	Cl (D	27886	31037	19920	16173	17671	15959	28661	17902	53910	15654	24477
	Na (C	11.7	13.8	8.2	8.9	7.8	9.9	11.9	8.5	20.4	8.1	11.2
	Na (D	16460	18612	11957	10125	10816	9753	18041	10495	32288	9698	14824
	Cl/Na Ratio	1.69	1.67	1.67	1.60	1.63	1.64	1.59	1.71	1.67	1.61	1.65
ROSSLARE	Cl (C	28.1	24.6	19.5	23.2	20.6	16.6	16.5	13.6	19.7	16.4	20.2
	Cl (D	32412	22483	16700	17561	17025	12277	15662	12005	18607	10688	17542
	Na (C	16.3	14.6	11.5	13.4	12.3	10.1	10.1	8.0	11.7	9.8	12.0
	Na (D	18807	13342	9820	10186	10145	7437	9655	7064	11030	6378	10386
	Cl/Na Ratio	1.72	1.69	1.70	1.72	1.68	1.65	1.62	1.70	1.69	1.68	1.69
SHANNON AIRPORT	Cl (C	15.4	17.2	11.4	9.6	10.6	9.2	14.5	9.3	10.2	5.9	11.4
	Cl (D	15008	15227	10706	7930	9927	6492	12975	8745	10778	4806	10259
	Na (C	9.4	10.4	6.7	6.4	6.9	6.3	8.9	6.1	6.5	4.2	7.2
	Na (D	9157	9200	6251	5264	6462	4459	7988	5729	6888	3445	6484
	Cl/Na Ratio	1.64	1.66	1.71	1.51	1.54	1.46	1.62	1.53	1.57	1.40	1.58
DUBLIN AIRPORT	Cl (C	8.0	7.9	7.9	8.2	7.2	7.5	10.1	4.9	8.9	5.4	7.7
	Cl (D	8176	6207	6211	5854	5126	4452	6767	3340	6293	3137	5556
	Na (C	5.0	4.8	5.0	5.0	4.5	4.5	6.6	4.4	6.3	4.5	5.1
	Na (D	5058	3776	3928	3583	3215	2682	4452	3028	4441	2610	3677
	Cl/Na Ratio	1.62	1.64	1.58	1.63	1.60	1.66	1.52	1.10	1.41	1.20	1.51
CORK AIRPORT	Cl (C	NOT AVAILABLE					5.6	7.5	4.1	10.7	5.5	6.9
	Cl (D						5198	8755	4622	13632	5545	7550
	Na (C						3.4	4.7	2.7	6.4	3.7	4.3
	Na (D						3205	5571	3029	8154	3732	4738
	Cl/Na Ratio						1.62	1.57	1.53	1.67	1.49	1.58
CLONES	Cl (C	5.6	5.3	3.6	4.8	4.9	4.6	4.4	4.6	6.0	5.5	5.0
	Cl (D	6530	5242	3359	4097	5001	3087	3891	3822	5745	3604	4438
	Na (C	3.5	3.2	2.3	3.2	3.3	3.3	3.1	3.1	3.6	4.0	3.3
	Na (D	4069	3224	2182	2713	3364	2232	2748	2558	3424	2638	2915
	Cl/Na Ratio	1.60	1.63	1.54	1.51	1.49	1.38	1.42	1.49	1.68	1.37	1.53
BIRR	Cl (C	5.8	6.3	4.4	3.8	4.3	4.4	4.6	3.1	5.1	3.1	4.6
	Cl (D	5551	5181	3909	2380	3442	2715	3404	2365	4368	2117	3543
	Na (C	4.0	4.0	3.0	3.0	3.8	3.4	3.6	2.3	3.4	2.6	3.4
	Na (D	3780	3307	2720	1874	3093	2117	2646	1715	2972	1762	2598
	Cl/Na Ratio	1.47	1.57	1.44	1.27	1.11	1.28	1.29	1.38	1.47	1.20	1.36

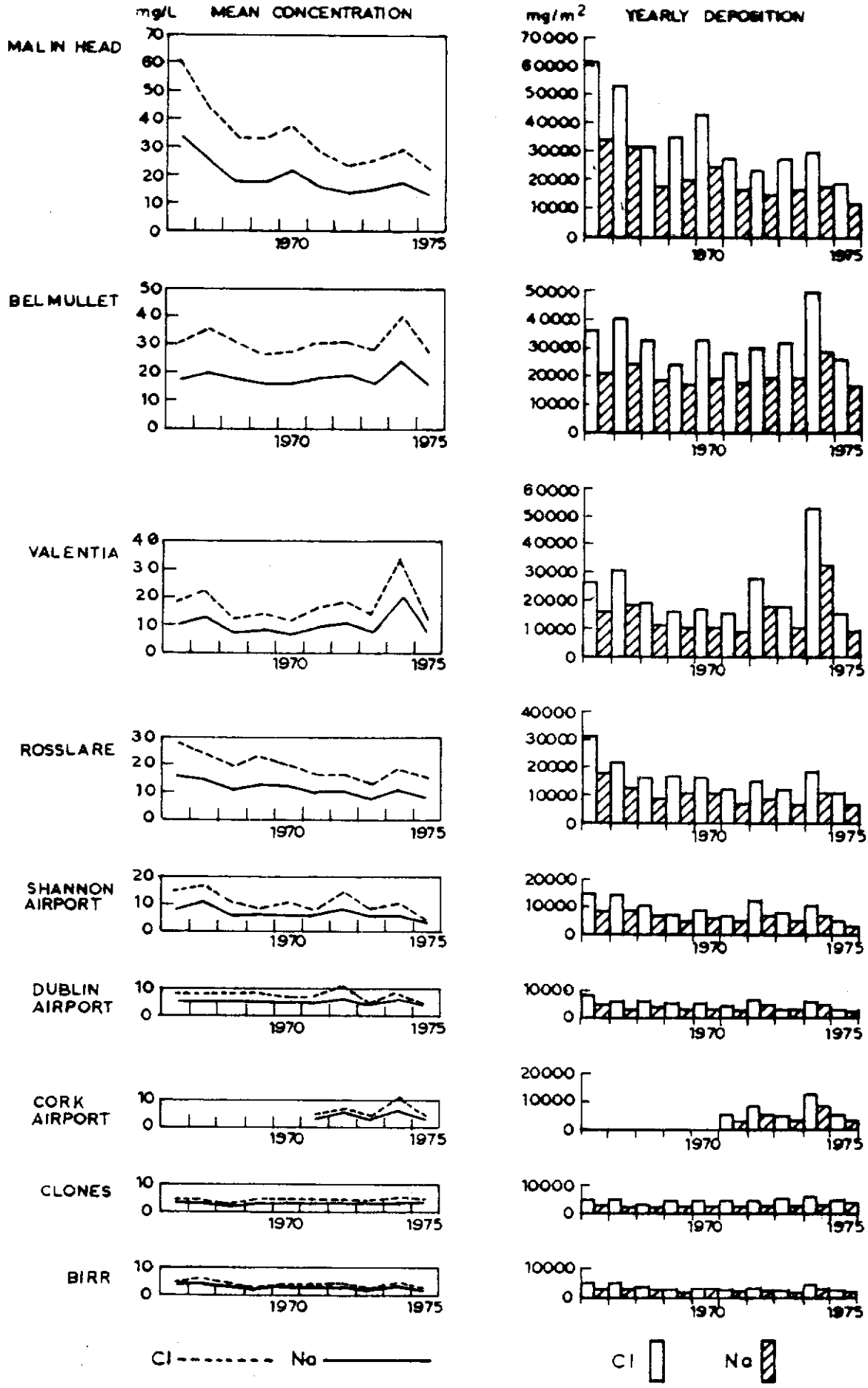

Fig. 2(a). Chlorine and Sodium yearly values.

TABLE 3 : SULPHUR - MEAN MONTHLY VALUES, 1966-1975

C = Mean (weighted) concentration of S, mg/L
D = Mean deposition of sulphur, mg/m^2, from all sources
d = Mean calculated deposition of sulphur from other than marine sources, mg/m^2
% = d expressed as percentage of D

STATION		JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
MALIN HEAD	C	2.21	3.03	3.81	2.65	2.15	1.49	1.22	0.99	1.26	1.89	3.09	3.00
	D	239	249	289	153	134	94	80	81	121	201	395	302
	d	51	53	38	42	59	49	32	35	39	32	55	41
	%	21.3	21.3	13.1	27.5	44.0	52.1	40.0	43.2	32.2	15.9	13.9	13.6
BELMULLET	C	2.46	2.59	3.03	1.96	1.80	1.43	1.35	0.85	1.26	1.83	2.13	2.69
	D	305	243	209	109	109	94	84	72	139	200	273	291
	d	19	27	29	36	39	43	39	24	31	38	46	37
	%	6.2	11.1	13.9	33.0	35.8	45.7	46.4	33.3	22.3	19.0	16.8	12.7
VALENTIA	C	1.60	1.63	1.84	1.26	1.03	0.92	0.86	0.67	1.21	0.95	1.34	1.53
	D	308	212	126	106	95	62	60	65	151	122	200	188
	d	22	41	21	51	44	35	41	41	32	47	36	39
	%	7.1	19.3	16.7	48.1	46.3	56.5	68.3	63.1	21.2	38.5	18.0	20.7
ROSSLARE	C	1.78	2.38	2.84	2.16	1.71	2.24	0.93	0.87	1.30	1.52	1.52	1.73
	D	215	170	125	132	113	89	63	61	102	121	148	124
	d	51	58	49	61	58	62	46	37	40	42	47	41
	%	23.7	34.1	39.2	46.2	51.3	69.7	73.0	60.7	39.2	34.7	31.8	33.1
SHANNON AIRPORT	C	1.52	1.51	2.05	2.12	1.93	1.75	1.77	0.98	1.19	0.99	1.44	1.71
	D	151	117	111	116	117	95	100	73	112	81	158	141
	d	90	58	52	75	78	76	82	58	68	45	82	65
	%	59.6	49.6	46.8	64.7	66.7	80.0	82.0	79.5	60.7	55.6	51.9	46.1
DUBLIN AIRPORT	C	2.89	3.25	3.83	2.47	2.56	2.06	1.55	1.55	1.47	2.61	2.12	2.41
	D	225	175	132	156	163	96	87	91	110	152	148	151
	d	171	139	99	131	140	88	76	78	97	126	117	117
	%	76.0	79.4	75.0	84.0	85.9	91.7	87.4	85.7	88.2	82.9	79.1	77.5
CORK AIRPORT	C	0.89	0.98	1.44	1.91	1.02	1.72	0.82	0.65	0.76	1.12	0.85	1.25
	D	174	97	75	90	114	65	67	51	84	126	75	111
	d	42	52	52	77	89	56	59	41	57	93	49	62
	%	24.1	53.6	69.3	85.6	78.1	86.2	88.1	80.4	67.9	73.8	65.3	55.9
CLONES	C	1.04	1.27	1.61	1.30	1.25	0.94	0.78	0.63	0.72	0.72	0.95	0.99
	D	100	94	92	76	91	65	49	48	58	58	87	75
	d	68	67	58	56	79	57	43	41	45	39	49	46
	%	68.0	71.3	63.0	73.7	86.7	87.7	87.8	85.4	76.8	67.2	56.3	61.3
BIRR	C	0.60	0.95	1.39	0.98	0.72	0.74	0.60	0.44	0.44	0.49	0.57	0.84
	D	51	50	60	53	46	34	36	28	34	39	48	56
	d	22	25	32	39	32	25	28	19	19	23	27	27
	%	43.1	50.0	53.3	73.6	69.6	73.5	77.1	67.9	55.9	59.0	56.3	48.2

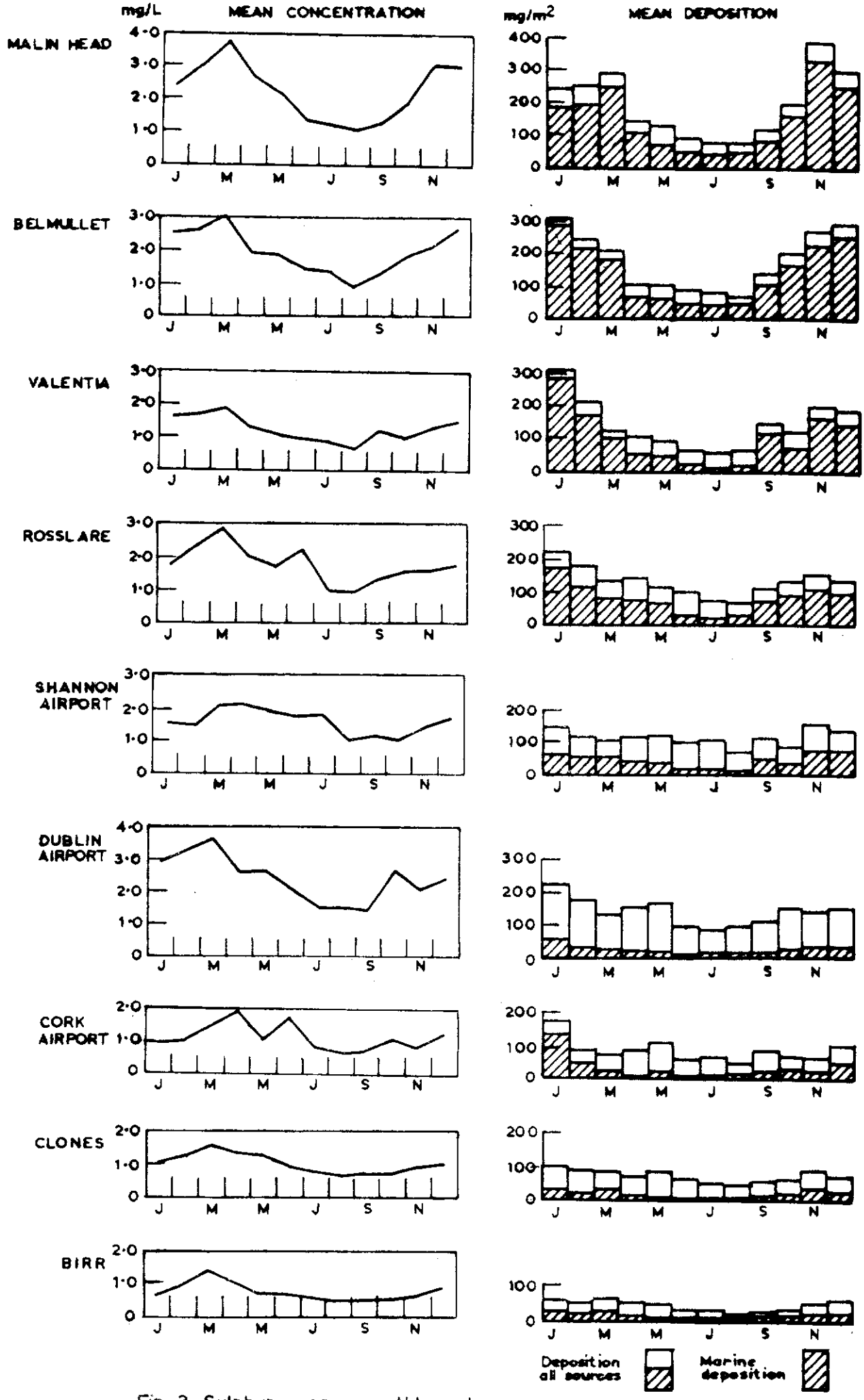

Fig. 3. Sulphur mean monthly values.

TABLE 3(a) : SULPHUR - YEARLY VALUES, 1966-1975

C = Mean (weighted) concentration of sulphur, mg/L, over the year
D_y = Deposition of sulphur from all sources, mg/m^2, over the year
d_y = Calculated deposition of sulphur from other than marine sources, mg/m^2, over the year
% = d_y expressed as percentage of D_y

STATION		1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	OVER-ALL
MALIN HEAD	C	3.47	2.62	2.20	2.57	2.54	2.15	1.76	1.63	1.94	1.68	2.28
	D_y	3574	3265	2144	2702	2865	2129	1704	1688	1859	1450	2338
	d_y	474	479	523	939	698	682	479	289	306	393	526
	%	13.3	14.7	24.4	34.8	24.4	32.0	28.1	17.1	16.5	27.1	22.5
BELMULLET	C	1.96	2.10	1.85	1.99	1.84	1.98	2.19	1.94	2.25	1.71	1.98
	D_y	2368	2404	1938	1980	2180	1824	2109	2117	2742	1629	2129
	d_y	527	349	304	597	534	314	489	500	223	250	409
	%	22.3	14.5	15.7	30.2	24.5	17.2	23.2	23.6	8.1	15.3	19.2
VALENTIA	C	1.39	1.38	0.90	1.22	1.06	1.22	1.35	1.09	1.84	1.20	1.28
	D_y	1948	1867	1317	1385	1481	1203	2046	1339	2922	1448	1696
	d_y	565	304	313	535	572	384	531	457	210	633	451
	%	29.0	16.3	23.8	38.6	38.6	31.9	26.0	34.1	7.2	43.7	26.6
ROSSLARE	C	2.22	1.89	1.62	1.98	1.82	1.72	1.43	1.29	1.29	1.51	1.69
	D_y	2560	1723	1385	1501	1504	1272	1357	1133	1219	987	1464
	d_y	980	602	560	645	652	647	546	540	293	451	592
	%	38.3	34.9	40.4	43.0	43.4	50.9	40.2	47.7	24.0	45.7	40.4
SHANNON AIRPORT	C	1.42	1.27	1.20	1.46	1.46	1.81	2.07	2.01	1.21	1.44	1.53
	D_y	1390	1123	1124	1202	1378	1283	1852	1898	1276	1181	1371
	d_y	621	350	599	760	835	908	1181	1417	697	892	826
	%	44.7	31.2	53.3	63.2	60.6	70.8	63.8	74.7	54.6	75.5	60.2
DUBLIN AIRPORT	C	1.77	2.07	2.01	2.56	2.56	3.33	3.50	1.58	2.01	2.34	2.32
	D_y	1795	1626	1589	1823	1831	1970	2347	1087	1413	1368	1685
	d_y	1370	1309	1259	1522	1561	1745	1973	833	1040	1149	1376
	%	76.3	80.5	79.2	83.5	85.3	88.6	84.1	76.6	73.6	84.0	81.7
CORK AIRPORT	C	NOT AVAILABLE					0.95	1.10	1.01	0.96	1.12	1.03
	D_y						880	1288	1130	1230	1128	1131
	d_y						611	820	876	545	814	733
	%						69.4	63.7	77.5	44.3	72.2	64.8
CLONES	C	1.12	0.88	0.92	1.16	0.97	1.15	0.93	0.83	0.81	1.29	1.00
	D_y	1302	876	867	984	984	775	825	683	765	850	891
	d_y	960	605	684	756	701	588	594	468	477	625	646
	%	73.7	69.1	78.9	76.8	71.2	75.9	72.0	68.5	62.4	73.5	72.5
BIRR	C	0.64	0.70	0.74	0.76	0.68	0.87	0.73	0.60	0.52	0.76	0.69
	D_y	609	577	662	468	545	534	543	450	447	516	535
	d_y	291	299	434	311	285	356	321	306	197	368	317
	%	47.8	51.8	65.6	66.5	52.3	66.7	59.1	68.0	44.1	71.3	59.3

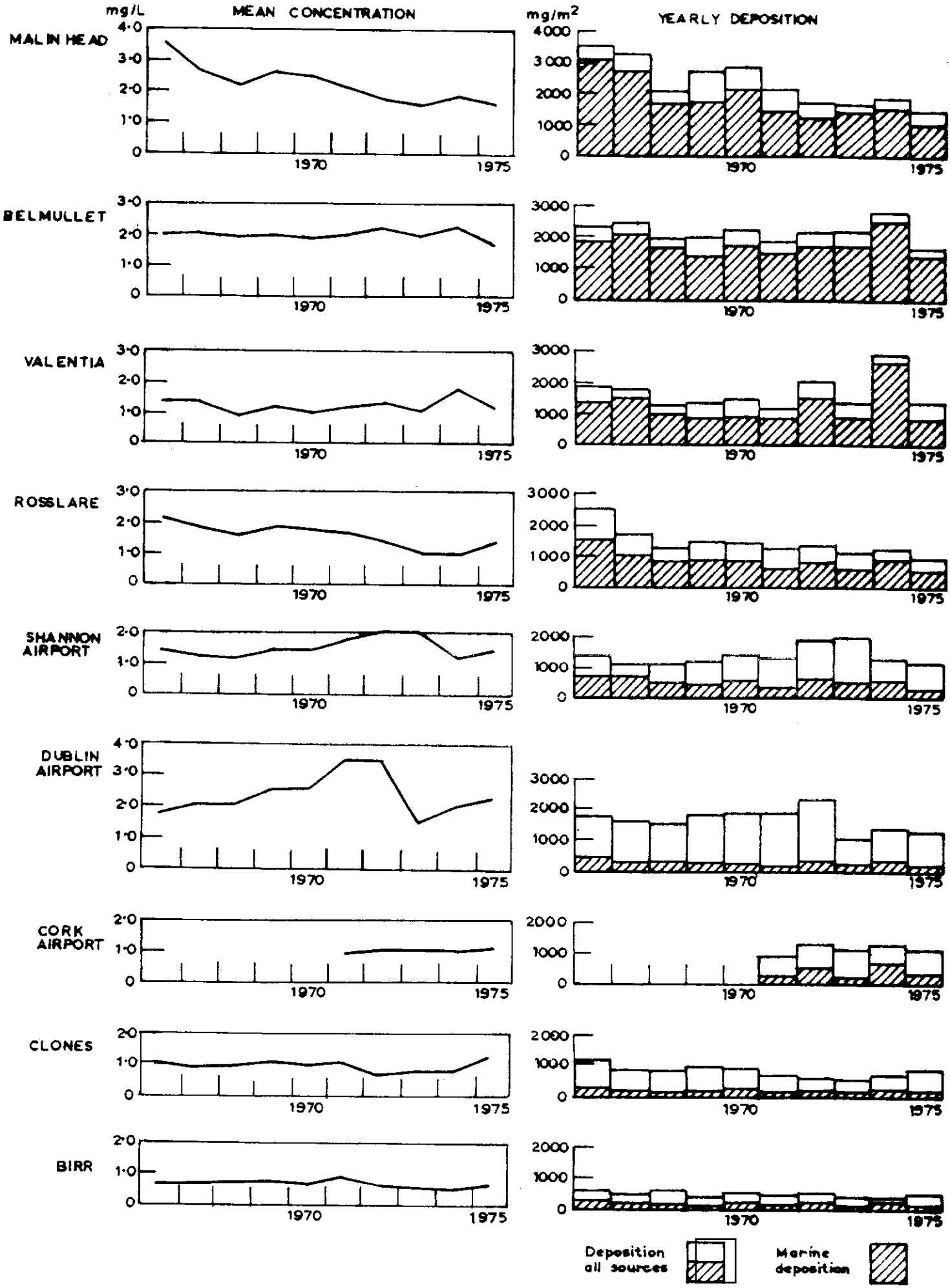

Fig. 3(a). Sulphur yearly values.

TABLE 4 : NITROGEN (NO_3) - MEAN MONTHLY VALUES, 1966-75

C = Mean (weighted) concentration, mg/L.
D = Mean deposition, mg/m^2.

STATION		JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
MALIN HEAD	C	0.21	0.31	0.30	0.38	0.50	0.28	0.21	0.21	0.14	0.18	0.12	0.14
	D	22.5	25.0	22.4	22.0	30.8	17.7	13.5	16.9	13.7	18.6	15.1	14.5
BELMULLET	C	0.12	0.18	0.25	0.23	0.36	0.19	0.17	0.15	0.10	0.12	0.08	0.09
	D	15.3	16.5	17.0	13.0	21.8	12.3	10.5	12.8	10.8	13.0	10.8	9.4
VALENTIA	C	0.10	0.18	0.24	0.21	0.24	0.19	0.16	0.15	0.09	0.12	0.08	0.12
	D	19.8	23.7	16.3	17.8	22.1	12.9	11.0	14.9	11.3	15.2	12.7	14.6
ROSSLARE	C	0.25	0.51	0.74	0.54	0.49	0.67	0.29	0.38	0.30	0.38	0.27	0.27
	D	30.0	36.9	32.6	33.1	32.3	25.4	19.3	26.8	23.3	30.3	26.7	19.4
SHANNON AIRPORT	C	0.21	0.24	0.37	0.42	0.61	0.46	0.81	0.32	0.18	0.18	0.20	0.17
	D	20.3	18.4	19.8	23.1	37.5	24.8	45.9	23.7	16.6	15.0	21.5	14.4
DUBLIN AIRPORT	C	0.42	0.60	0.88	0.78	0.65	0.70	0.49	0.69	0.44	0.56	0.38	0.41
	D	32.7	32.5	35.4	49.6	41.4	32.9	27.5	40.8	32.5	32.4	26.2	26.0
CORK AIRPORT	C	0.15	0.30	0.66	0.73	0.36	0.60	0.31	0.26	0.17	0.44	0.21	0.22
	D	28.7	30.1	34.2	34.3	40.4	22.7	25.4	20.4	18.8	48.8	18.9	19.5
CLONES	C	0.19	0.26	0.32	0.41	0.42	0.25	0.25	0.26	0.18	0.21	0.18	0.16
	D	18.6	19.5	18.2	23.9	30.8	17.2	15.7	20.0	14.6	16.7	16.5	11.8
BIRR	C	0.15	0.29	0.39	0.40	0.33	0.24	0.23	0.21	0.16	0.20	0.13	0.16
	D	13.1	15.3	17.0	21.5	21.1	11.1	13.5	13.4	12.0	16.0	11.3	10.5

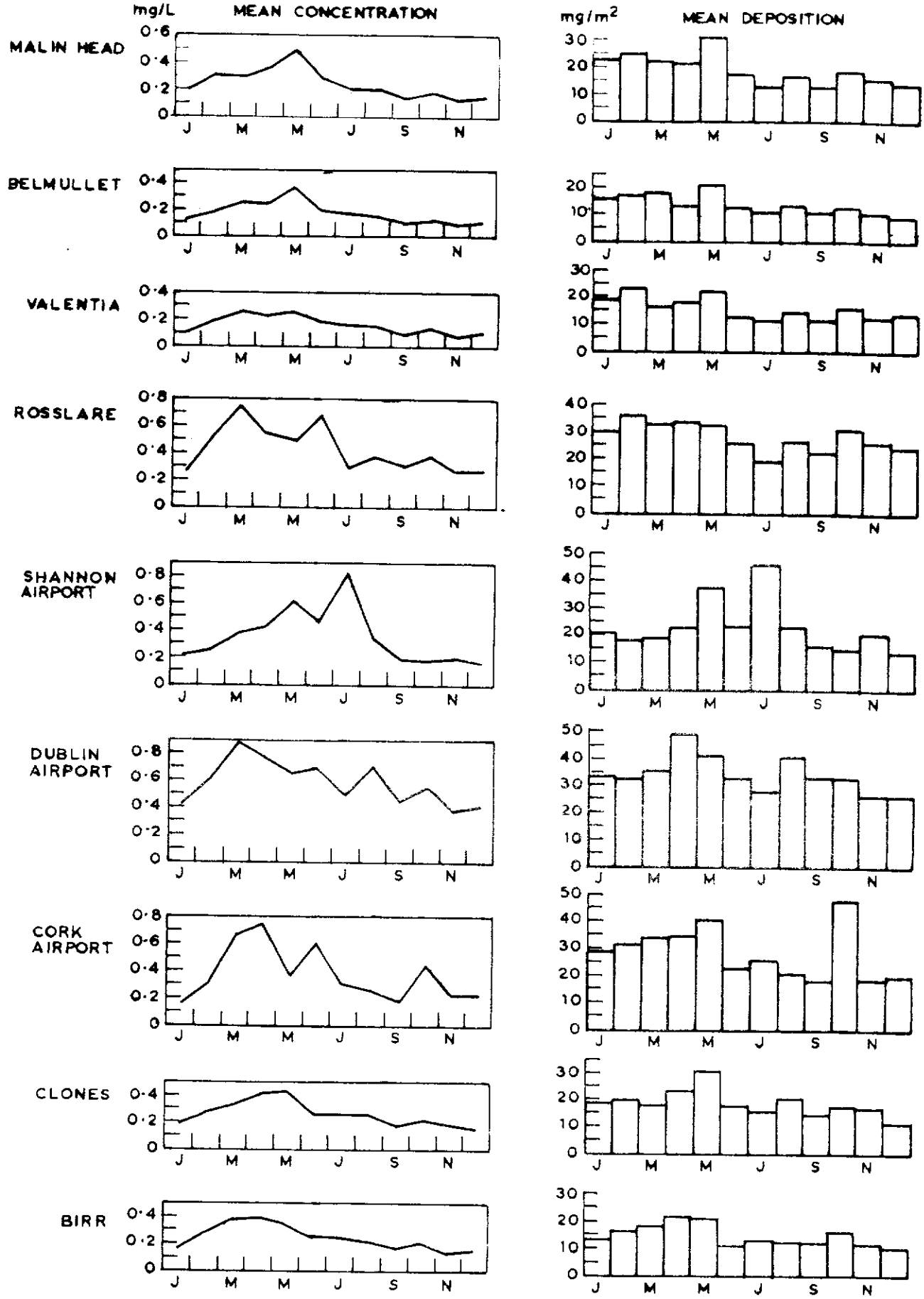

Fig. 4. Nitrogen (NO_3) mean monthly values.

TABLE 4(a) : NITROGEN (NO_3) - YEARLY VALUES, 1966-75

C = Mean (weighted) concentration, mg/L, over the year.
D = Total deposition, mg/m^2, over the year.

STATION		1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	OVER-ALL
MALIN HEAD	C	0.27	0.19	0.23	0.27	0.22	0.31	0.27	0.11	0.23	0.18	0.23
	D	276	236	227	282	246	304	256	114	228	159	233
BELMULLET	C	0.16	0.18	0.12	0.17	0.09	0.16	0.12	0.15	0.28	0.10	0.15
	D	190	202	130	146	106	144	111	164	345	91	163
VALENTIA	C	0.18	0.17	0.13	0.15	0.17	0.19	0.13	0.06	0.15	0.12	0.14
	D	259	227	194	166	237	188	190	68	243	148	192
ROSSLARE	C	0.36	0.29	0.38	0.42	0.45	0.51	0.36	0.36	0.34	0.47	0.39
	D	413	264	325	321	374	378	341	319	320	307	336
SHANNON AIRPORT	C	0.17	0.14	0.21	0.23	0.24	0.36	0.39	0.62	0.22	0.59	0.31
	D	167	125	194	189	228	254	347	588	231	485	2.81
DUBLIN AIRPORT	C	0.38	0.35	0.33	0.48	0.49	0.60	0.50	0.53	0.95	1.31	0.56
	D	383	272	263	342	347	355	335	365	670	766	410
CORK AIRPORT	C	NOT AVAILABLE					0.38	0.29	0.34	0.26	0.31	0.31
	D						351	342	380	329	308	342
CLONES	C	0.24	0.21	0.18	0.24	0.30	0.33	0.23	0.18	0.29	0.32	0.25
	D	277	214	173	202	307	222	200	149	277	213	223
BIRR	C	0.22	0.18	0.19	0.21	0.24	0.34	0.21	0.13	0.29	0.29	0.23
	D	207	147	170	129	191	212	157	101	250	193	176

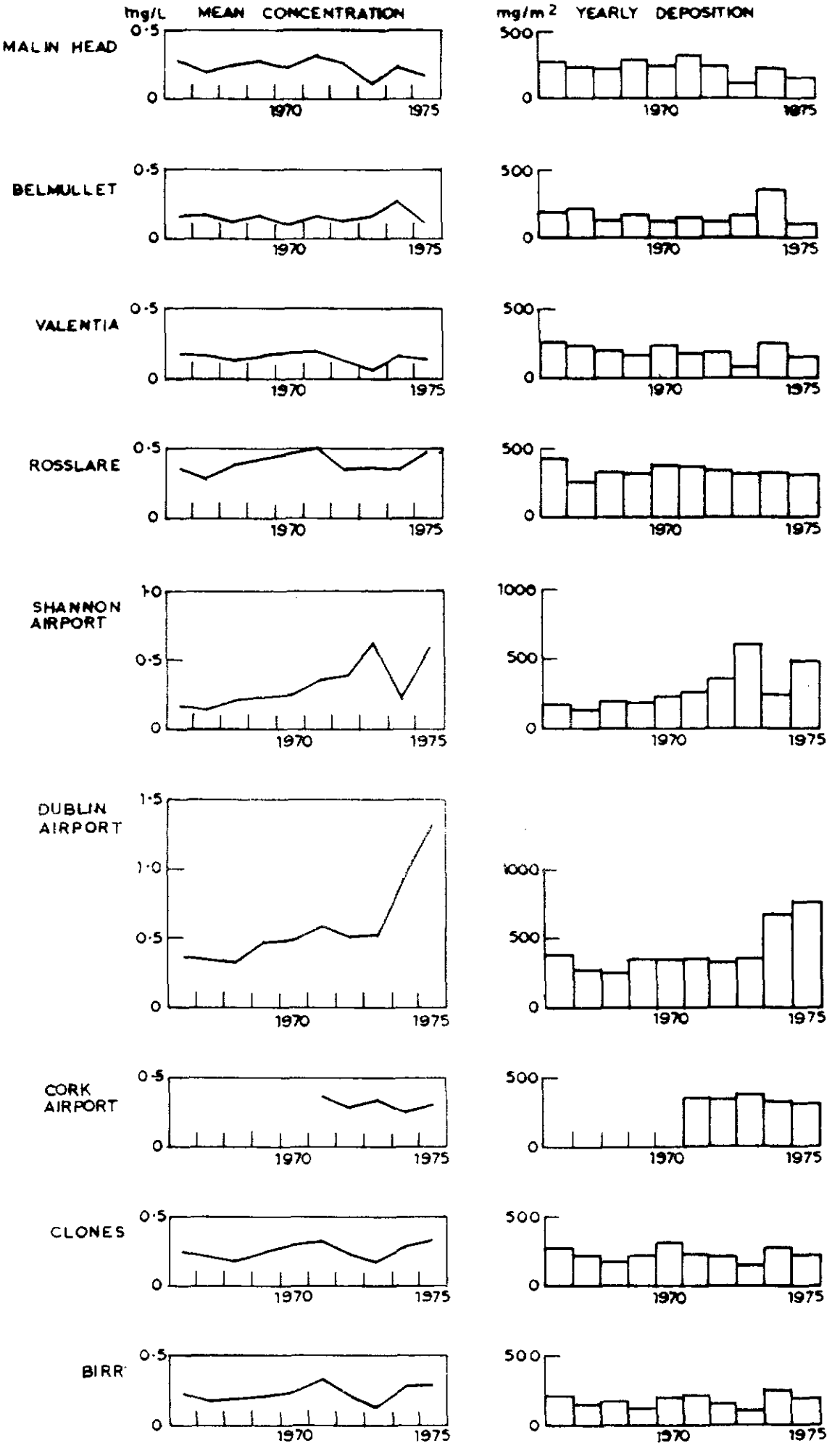

Fig. 4(a). Nitrogen (NO_3) yearly values.

TABLE 4(b) : NITROGEN (NH_4) - MEAN MONTHLY VALUES, 1966-75

C = Mean (weighted) concentration, mg/L.
D = Mean deposition, mg/m^2.

STATION		JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
MALIN HEAD	C	0.17	0.22	0.21	0.20	0.35	0.47	0.24	0.13	0.11	0.12	0.06	0.11
	D	18.4	18.4	15.6	11.5	21.5	29.6	16.0	10.5	10.4	13.2	8.2	10.6
BELMULLET	C	0.10	0.19	0.15	0.14	0.21	0.27	0.14	0.08	0.05	0.08	0.04	0.06
	D	12.2	17.5	10.6	7.8	12.6	17.5	8.7	6.6	5.2	9.2	5.2	6.3
VALENTIA	C	0.10	0.14	0.23	0.24	0.14	0.10	0.12	0.12	0.10	0.13	0.12	0.12
	D	18.6	18.7	15.7	19.8	12.6	6.7	8.2	11.5	12.3	16.3	18.2	14.3
ROSSLARE	C	0.18	0.26	0.36	0.35	0.33	0.53	0.30	0.20	0.27	0.22	0.19	0.31
	D	22.3	19.0	16.0	21.2	21.8	20.1	20.1	14.2	21.3	17.5	18.9	21.8
SHANNON AIRPORT	C	0.19	0.18	0.23	0.70	0.60	0.61	1.57	0.99	0.43	0.34	0.70	0.51
	D	19.1	14.3	12.7	38.0	36.6	32.9	88.8	73.8	40.2	27.5	77.0	41.8
DUBLIN AIRPORT	C	0.32	0.28	0.46	0.59	0.43	0.57	0.50	0.52	0.51	0.20	0.43	0.37
	D	24.8	15.0	18.5	37.7	27.4	26.6	27.7	30.1	38.0	11.8	29.9	23.0
CORK AIRPORT	C	0.18	0.40	1.05	1.32	0.55	0.86	0.40	0.28	0.15	0.41	0.24	0.35
	D	35.0	40.1	54.2	62.2	60.8	32.5	32.3	22.0	16.0	46.1	21.2	30.5
CLONES	C	0.49	0.52	0.60	0.59	0.50	0.26	0.54	0.35	0.25	0.32	0.39	0.48
	D	47.6	39.2	34.0	34.4	36.9	17.8	33.6	27.1	19.8	25.7	35.1	35.9
BIRR	C	0.22	0.25	0.27	0.27	0.22	0.17	0.11	0.13	0.09	0.14	0.18	0.27
	D	18.9	13.2	11.7	14.8	14.0	7.8	6.2	8.2	6.9	10.7	15.3	17.7

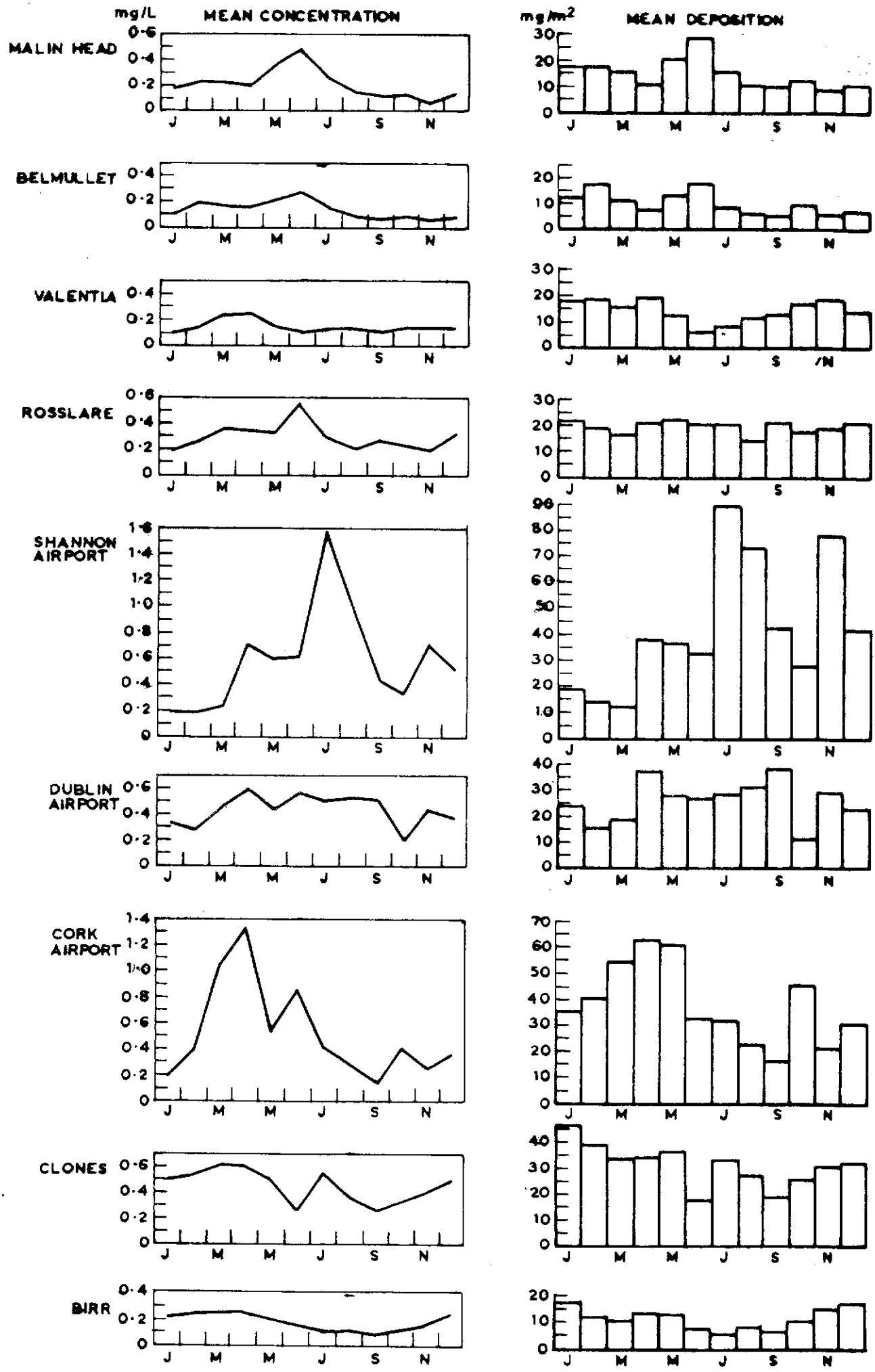

Fig. 4(b). Nitrogen (NH_4) mean monthly values.

TABLE 4(c) : NITROGEN (NH_4) - YEARLY VALUES, 1966-75

C = Mean (weighted) concentration mg/L, over the year.
D = Total deposition mg/m^2, over the year.

STATION		1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	OVERALL
MALIN HEAD	C	0.35	0.18	0.17	0.34	0.18	0.18	0.19	0.04	0.09	0.06	0.18
	D	356	218	169	356	206	176	180	41	86	49	184
BELMULLET	C	0.12	0.18	0.07	0.08	0.08	0.07	0.06	0.30	0.10	0.04	0.11
	D	145	210	69	69	98	66	54	323	118	42	119
VALENTIA	C	0.16	0.13	0.11	0.10	0.18	0.18	0.14	0.03	0.14	0.12	0.13
	D	225	169	162	108	244	180	219	40	229	149	173
ROSSLARE	C	0.32	0.29	0.18	0.40	0.29	0.32	0.23	0.25	0.16	0.26	0.27
	D	370	268	158	304	243	237	218	223	152	167	234
SHANNON AIRPORT	C	0.10	0.15	0.08	0.15	0.33	0.79	1.25	0.88	0.40	1.65	0.56
	D	102	133	77	127	311	562	1116	828	419	1352	503
DUBLIN AIRPORT	C	0.31	0.28	0.19	0.26	0.24	0.35	0.12	0.68	1.04	1.00	0.43
	D	312	221	153	182	172	208	80	467	730	585	311
CORK AIRPORT	C	NOT AVAILABLE					0.37	0.33	0.38	0.47	0.51	0.41
	D						341	384	421	600	519	453
CLONES	C	0.43	0.35	0.32	0.31	0.36	0.52	0.44	0.55	0.57	0.52	0.43
	D	499	353	305	260	367	353	392	455	537	345	387
BIRR	C	0.25	0.18	0.16	0.16	0.16	0.31	0.19	0.15	0.18	0.13	0.19
	D	237	151	144	101	131	190	144	116	152	86	145

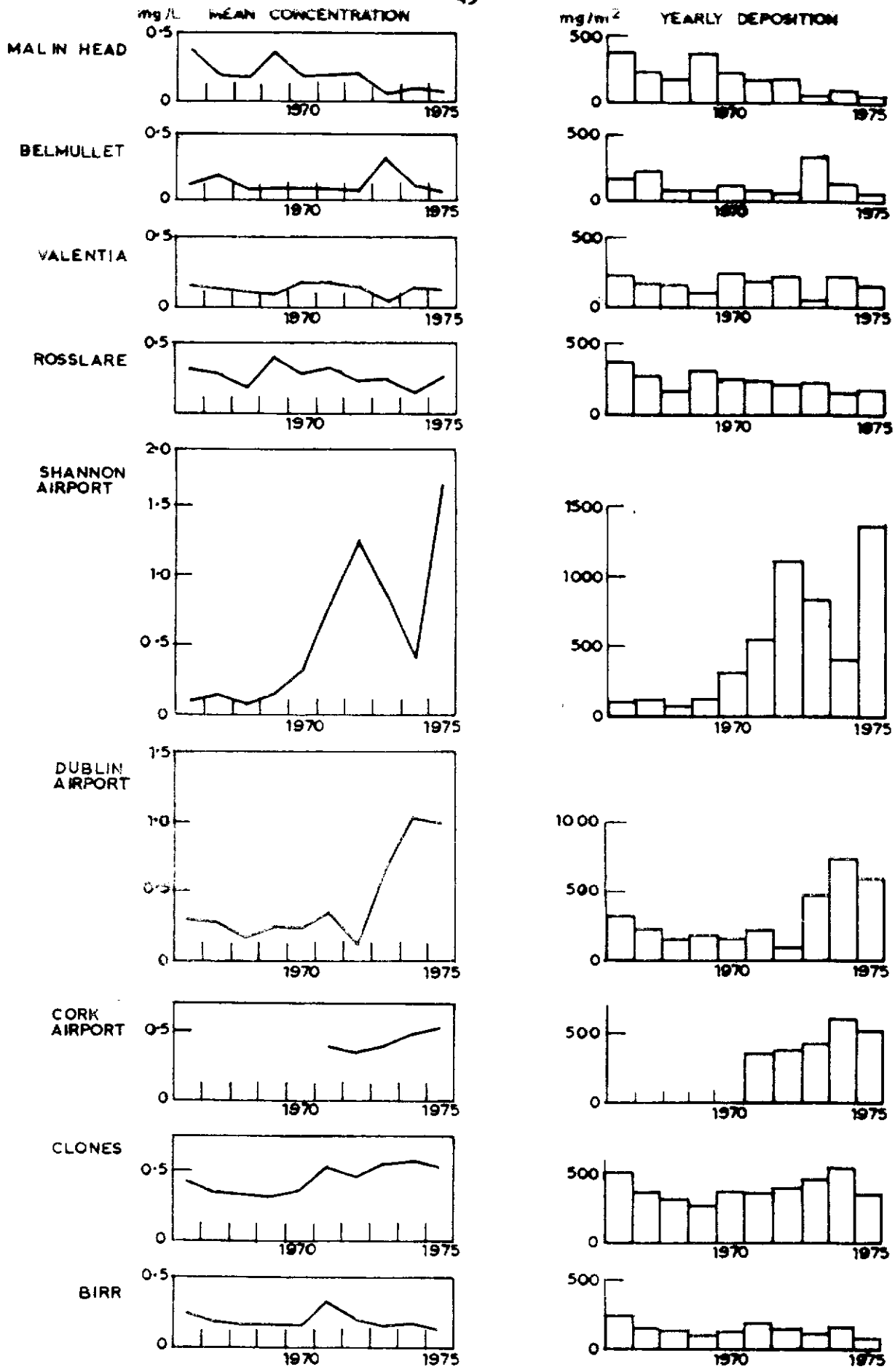

Fig. 4(c). Nitrogen (NH_4) yearly values.

TABLE 5 : - pH - MEAN MONTHLY VALUES WITH MAXIMUM AND MINIMUM VALUES 1966-1975 INCL.

W.M. = Weighted Mean

STATION		J	F	M	A	M	J	J	A	S	O	N	D
MALIN HEAD	W.M.	4.99	4.92	5.21	4.78	4.71	5.16	5.28	5.00	5.46	5.42	5.43	5.62
	MAX.	6.3	6.7	6.0	7.0	6.2	6.7	6.5	6.2	6.7	6.4	6.3	6.6
	MIN.	4.6	4.5	4.5	4.4	4.2	4.6	4.5	4.6	5.1	4.9	5.0	5.0
BELMULLET	W.M.	5.56	5.62	5.53	5.61	5.75	5.59	5.46	5.73	5.86	5.71	5.57	5.73
	MAX.	6.1	6.5	6.6	6.5	6.8	6.5	6.5	6.6	6.5	6.7	6.6	6.8
	MIN.	5.1	5.1	5.1	5.2	5.1	4.8	4.8	5.4	5.4	5.2	5.2	5.1
VALENTIA	W.M.	5.51	5.70	5.80	5.18	5.05	5.28	4.93	5.26	5.39	5.31	5.60	5.62
	MAX.	6.2	6.5	6.5	6.6	6.4	6.7	6.6	6.4	6.1	6.5	6.4	6.4
	MIN.	5.0	5.2	5.2	4.2	4.5	4.8	4.5	4.6	4.7	4.8	5.3	5.2
ROSSLARE	W.M.	5.00	4.78	4.65	4.74	4.61	4.66	4.85	4.91	5.18	4.89	4.95	4.97
	MAX.	5.6	5.5	6.6	6.0	6.0	6.5	6.3	6.2	6.7	5.5	5.9	5.8
	MIN.	4.7	4.3	4.2	4.1	4.2	4.1	4.5	4.4	4.6	4.2	4.5	4.5
SHANNON AIRPORT	W.M.	5.82	5.80	5.95	6.04	5.89	6.18	6.18	5.99	5.80	5.35	6.10	5.99
	MAX.	6.6	6.3	6.5	6.6	6.6	7.1	7.2	7.0	7.1	6.6	6.4	6.7
	MIN.	5.3	5.4	5.5	5.1	5.0	5.8	5.7	5.7	5.4	4.3	5.6	5.4
DUBLIN AIRPORT	W.M.	4.95	4.88	4.68	4.80	5.24	4.96	5.43	5.19	5.52	5.03	5.27	5.39
	MAX.	6.3	6.6	6.6	6.7	6.7	6.5	6.6	6.8	7.0	6.7	6.6	6.8
	MIN.	4.4	4.4	4.2	4.1	4.8	4.4	4.3	4.1	5.1	4.2	4.7	4.9
CORK AIRPORT	W.M.	5.17	5.02	5.09	5.31	4.83	4.83	4.97	5.04	4.97	4.58	4.99	5.39
	MAX.	5.7	5.9	6.3	6.1	6.7	6.6	6.2	5.5	5.4	5.0	5.8	6.4
	MIN.	4.8	4.8	4.7	4.8	4.6	4.5	4.5	4.6	4.0	4.2	4.6	4.4
CLONES	W.M.	5.15	4.90	4.96	4.70	4.67	4.73	4.89	4.92	5.23	5.07	5.04	5.15
	MAX.	6.4	5.7	7.0	6.5	6.3	5.7	6.2	6.7	7.4	6.1	6.4	7.0
	MIN.	4.4	4.4	4.4	4.1	4.3	4.2	4.2	4.2	4.9	4.7	4.6	4.7
BIRR	W.M.	6.05	6.03	6.36	6.25	6.07	6.30	6.07	6.26	6.16	5.77	5.86	5.86
	MAX.	6.8	6.7	6.8	6.6	6.8	6.8	6.7	6.7	6.8	6.4	6.4	6.6
	MIN.	5.8	5.6	5.9	5.9	5.8	6.0	5.8	6.0	5.8	5.2	5.6	5.4

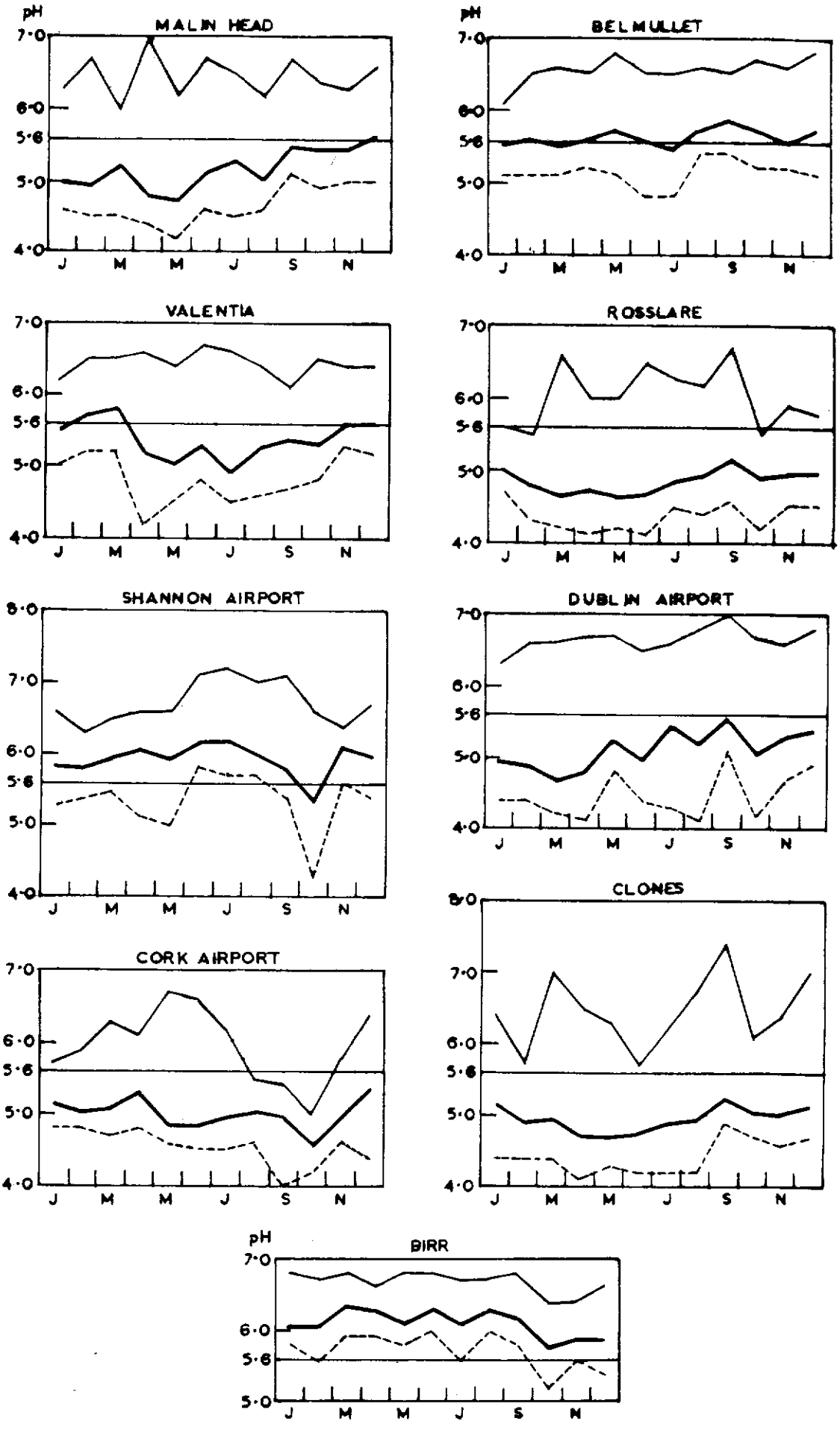

Fig. 5. pH monthly values

TABLE 5(a) : pH - YEARLY MEAN VALUES, 1966-75 INCL., WITH MAXIMUM AND MINIMUM VALUES FOR EACH YEAR

W.M. = Weighted Mean

STATION		1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	Over-all
MALIN HEAD	W.M.	5.04	5.26	5.26	5.02	4.99	4.92	5.12	5.00	5.61	5.51	5.12
	MAX.	6.5	6.3	6.1	6.7	6.4	6.7	6.3	6.6	7.0	6.4	7.0
	MIN.	4.5	4.6	4.6	4.5	4.3	4.4	4.5	4.2	5.1	4.8	4.2
BELMULLET	W.M.	5.50	5.79	5.76	5.96	5.58	5.77	5.58	5.58	5.62	5.45	5.64
	MAX.	6.2	6.3	6.3	6.5	6.6	6.7	6.5	6.5	6.7	6.8	6.8
	MIN.	5.1	5.4	5.2	5.5	5.2	5.1	5.1	5.1	4.8	4.8	4.8
VALENTIA	W.M.	5.51	5.89	5.59	5.81	5.57	5.17	5.16	5.06	5.18	5.41	5.36
	MAX.	6.6	6.6	6.3	6.5	6.5	6.3	5.7	5.8	6.1	6.7	6.7
	MIN.	4.8	5.5	5.2	5.1	4.9	4.6	4.5	4.5	4.2	4.7	4.2
ROSSLARE	W.M.	5.23	5.26	4.88	4.80	4.91	4.65	4.89	4.64	4.84	4.66	4.85
	MAX.	6.6	6.5	6.2	6.7	5.5	6.2	5.9	6.0	5.9	5.4	6.7
	MIN.	4.7	4.9	4.3	4.2	4.1	4.1	4.5	4.2	4.1	4.4	4.1
SHANNON AIRPORT	W.M.	5.88	6.02	5.83	6.05	6.25	6.20	5.89	5.38	5.74	6.05	5.84
	MAX.	6.5	6.6	6.4	7.2	6.7	6.7	7.1	7.1	6.6	7.0	7.2
	MIN.	5.4	5.7	5.6	5.4	5.8	5.9	5.3	4.3	5.1	5.0	4.3
DUBLIN AIRPORT	W.M.	4.80	5.06	5.45	5.00	5.78	5.93	5.97	5.08	4.77	4.83	5.07
	MAX.	6.6	6.4	6.6	6.7	6.6	6.4	7.0	6.7	6.8	6.4	7.0
	MIN.	4.4	4.6	4.5	4.2	5.2	5.2	5.5	4.2	4.1	4.1	4.1
CORK AIRPORT	W.M.						5.01	4.86	4.71	5.32	5.13	4.96
	MAX.	NOT AVAILABLE					6.0	5.6	6.2	6.4	6.7	6.7
	MIN.						4.5	4.0	4.2	4.8	4.4	4.0
CLONES	W.M.	4.83	4.85	4.92	4.83	4.80	4.78	5.09	5.12	5.26	5.21	4.93
	MAX.	6.4	5.4	6.5	6.6	6.3	7.0	7.4	6.4	6.7	7.0	7.4
	MIN.	4.4	4.2	4.5	4.2	4.2	4.1	4.4	4.4	4.8	4.8	4.1
BIRR	W.M.	6.03	5.91	5.86	6.23	6.12	6.21	6.10	5.73	6.22	6.29	6.02
	MAX.	6.8	6.7	6.7	6.7	6.8	6.5	6.8	6.6	6.7	6.8	6.8
	MIN.	5.6	5.6	5.4	5.8	5.6	5.8	5.8	5.2	5.9	6.0	5.2

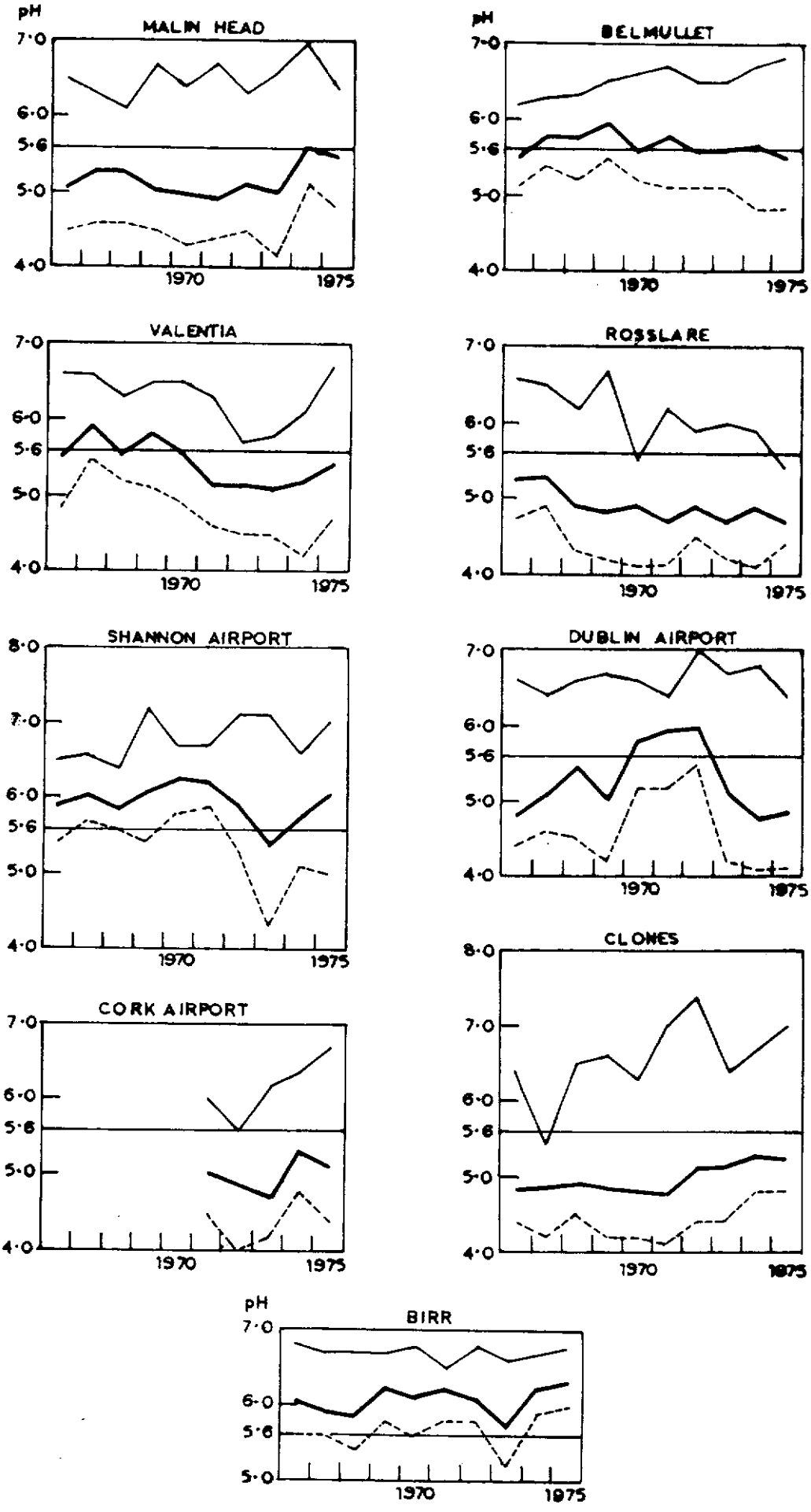

Fig. 5(a). pH yearly values.

TABLE 5(b) : pH - FREQUENCIES OF OCCURRENCE OF pH VALUES

STATION	pH Values (each range includes the end-points)											TOTAL
	4.0 -4.2	4.3 -4.5	4.6 -4.8	4.9 -5.1	5.2 -5.4	5.5 -5.7	5.8 -6.0	6.1 -6.3	6.4 -6.6	6.7 -6.9	⩾7.0	
MALIN HEAD	1	7	13	21	20	21	15	10	8	3	1	120
BELMULLET	0	0	2	5	19	24	19	26	20	4	0	119
VALENTIA	1	2	8	14	16	18	28	16	16	1	0	120
ROSSLARE	6	17	21	27	17	16	8	4	3	1	0	120
SHANNON AIRPORT	0	1	0	3	5	12	22	32	35	3	7	120
DUBLIN AIRPORT	5	8	6	8	13	15	13	19	25	7	1	120
CORK AIRPORT	2	4	13	7	9	8	7	6	3	1	0	60
CLONES	4	8	22	29	18	10	10	5	8	1	3	118
BIRR	0	0	0	0	2	8	22	35	39	14	0	120
TOTALS	19	47	85	114	119	132	144	153	157	35	12	1017

TABLE 6 : POTASSIUM - MEAN MONTHLY VALUES, 1966-1975

C = Mean (weighted) concentration of Potassium, mg/L
D = Mean Deposition of Potassium, mg/m^2, from all sources
d = Mean calculated deposition of Potassium from other than marine sources, mg/m^2
% = d expressed as percentage of D

STATION		JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
MALIN HEAD	C	0.87	1.23	1.60	1.01	0.74	0.66	0.51	0.36	0.51	0.82	1.31	1.30
	D	94	101	121	58	46	42	34	29	49	87	168	131
	d	14	17	14	11	14	22	13	9	14	15	23	19
	%	14.9	16.8	11.6	19.0	30.4	52.4	38.2	31.0	28.6	17.2	13.7	14.5
BELMULLET	C	1.23	1.41	1.39	0.71	0.69	0.58	0.48	0.43	0.63	0.83	0.95	1.22
	D	153	132	96	40	42	38	30	37	69	91	122	131
	d	30	40	19	8	11	16	11	16	23	22	24	23
	%	19.6	30.3	19.8	20.0	26.2	42.1	36.7	43.2	33.3	24.2	19.7	17.6
VALENTIA	C	0.75	0.70	0.81	0.39	0.31	0.25	0.19	0.14	0.52	0.34	0.56	0.65
	D	143	91	56	33	28	17	13	13	64	43	84	80
	d	21	18	11	9	7	5	5	3	13	11	14	16
	%	14.7	19.8	19.6	27.3	25.0	29.4	38.5	23.1	20.3	25.6	16.7	20.0
ROSSLARE	C	0.72	0.81	0.90	0.63	0.46	0.61	0.30	0.27	0.53	0.52	0.56	0.62
	D	87	58	40	38	30	23	20	19	41	41	55	44
	d	17	10	7	8	6	12	13	9	15	7	12	9
	%	19.5	17.2	17.5	21.1	20.0	52.2	65.0	47.4	36.6	17.1	21.8	20.5
SHANNON AIRPORT	C	0.54	0.54	0.70	0.77	0.76	0.74	0.90	0.44	0.66	0.34	0.62	0.81
	D	54	42	38	42	46	40	51	33	61	28	67	67
	d	27	17	13	24	29	32	43	26	42	12	35	34
	%	50.0	40.5	34.2	57.1	63.0	80.0	84.3	78.8	68.9	42.9	52.2	50.7
DUBLIN AIRPORT	C	0.52	0.62	0.62	0.48	0.47	0.32	0.37	0.54	0.36	0.43	0.37	0.39
	D	41	33	25	30	30	15	21	32	27	25	26	24
	d	17	18	10	19	20	11	16	26	21	14	13	10
	%	41.5	54.5	40.0	63.3	66.7	73.3	76.2	81.3	77.8	56.0	50.0	41.7
CORK AIRPORT	C	0.43	0.33	0.47	0.31	0.23	0.42	0.46	0.19	0.21	0.24	0.25	0.37
	D	84	32	24	15	26	16	37	15	23	27	22	33
	d	28	13	15	9	15	12	34	11	11	13	11	12
	%	33.3	40.6	62.5	60.0	57.7	75.0	91.9	73.3	47.8	48.1	50.0	36.4
CLONES	C	0.21	0.26	0.38	0.24	0.13	0.16	0.19	0.10	0.12	0.14	0.23	0.21
	D	20	19	21	14	10	11	12	8	11	12	21	16
	d	7	8	7	6	4	8	9	5	5	3	5	3
	%	35.0	42.1	33.3	42.9	40.0	72.7	75.0	62.5	45.5	25.0	23.8	18.8
BIRR	C	0.20	0.28	0.37	0.23	0.15	0.18	0.15	0.13	0.16	0.16	0.16	0.27
	D	17	15	16	12	9	8	9	9	12	13	13	18
	d	5	4	4	6	4	4	5	5	6	6	4	5
	%	29.4	26.7	25.0	50.0	44.4	50.0	55.6	55.6	50.0	46.2	30.8	27.8

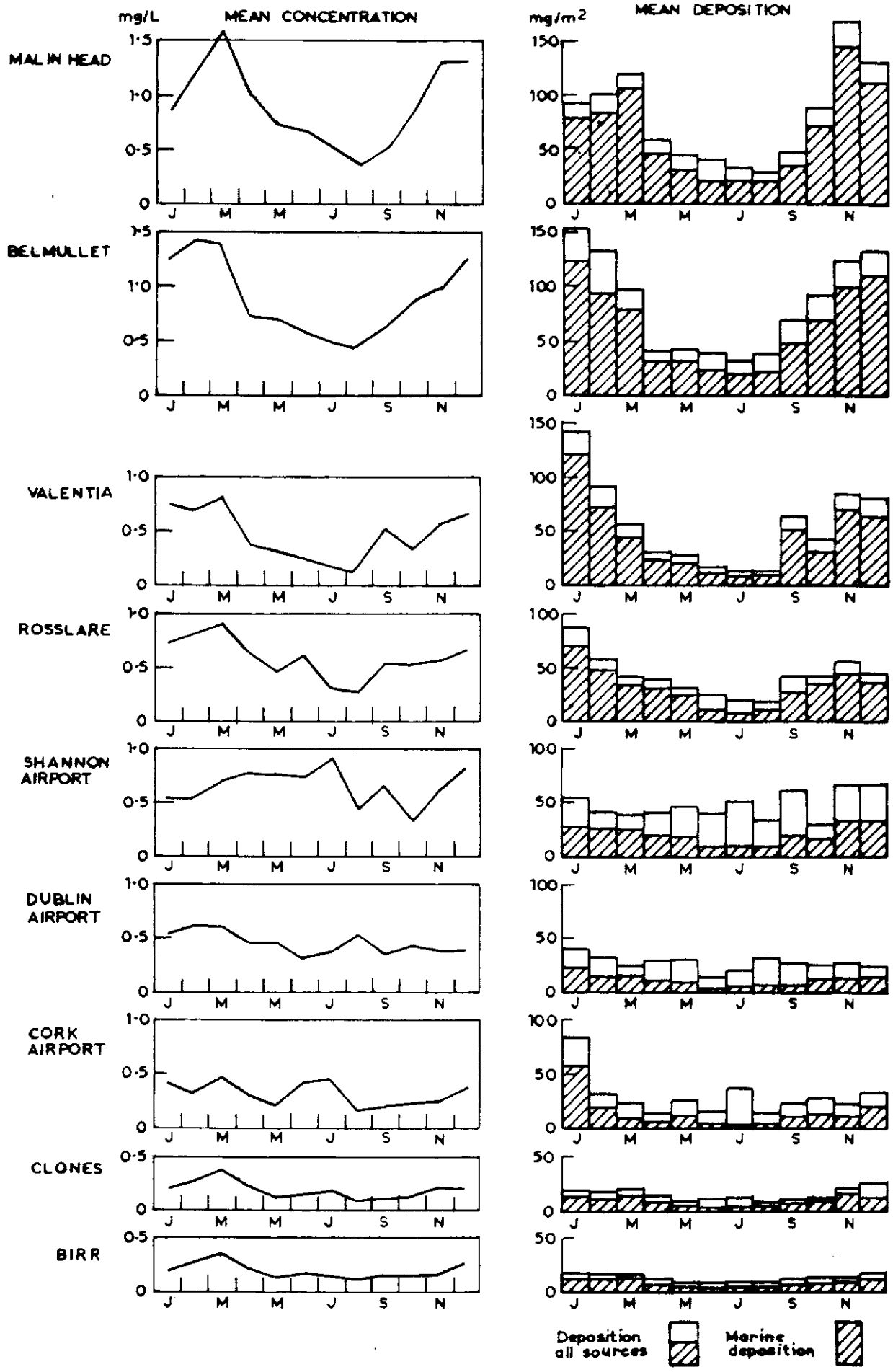

Fig. 6. Potassium mean monthly values.

TABLE 6(a) : POTASSIUM - YEARLY VALUES, 1966-75

C = Mean (weighted) concentration of potassium, mg/L, over the year
D_y = Deposition of potassium from all sources, mg/m^2, over the year
d_y = Calculated deposition of potassium from other than marine sources, mg/m^2, over the year
% = d_y expressed as percentage of D_y

STATION		1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	OVER-ALL
MALIN HEAD	C	1.55	1.16	0.88	0.99	0.99	0.80	0.68	0.67	0.82	0.69	0.93
	D_y	1596	1438	857	1041	1119	792	659	699	807	597	960
	d_y	267	244	162	286	190	172	134	100	142	144	184
	%	16.7	17.0	18.9	27.5	17.0	21.7	20.3	14.3	17.6	24.1	19.1
BELMULLET	C	0.80	0.95	0.81	0.77	0.81	0.90	0.90	1.17	1.15	0.84	0.91
	D_y	971	1088	851	761	958	832	871	1270	1407	797	981
	d_y	182	207	150	168	253	185	177	577	327	206	243
	%	18.7	19.0	17.6	22.1	26.4	22.2	20.3	45.4	23.2	25.8	24.8
VALENTIA	C	0.53	0.60	0.35	0.38	0.37	0.44	0.53	0.39	0.86	0.45	0.50
	D_y	739	808	518	431	522	432	809	481	1369	546	666
	d_y	147	138	87	67	132	81	159	103	207	197	132
	%	19.9	17.1	16.8	15.5	25.3	18.8	19.7	21.4	15.1	36.1	19.8
ROSSLARE	C	0.77	0.68	0.53	0.65	0.56	0.52	0.48	0.44	0.57	0.48	0.57
	D_y	884	619	456	491	463	386	455	384	536	311	499
	d_y	207	139	102	124	98	118	108	130	139	81	125
	%	23.4	22.5	22.4	25.3	21.2	30.6	23.7	33.9	25.9	26.0	25.0
SHANNON AIRPORT	C	0.65	0.52	0.39	0.38	0.41	0.59	0.91	1.00	0.58	0.93	0.63
	D_y	630	459	363	314	386	421	812	940	606	757	569
	d_y	300	128	137	124	153	260	524	735	357	633	335
	%	47.6	27.9	37.7	39.5	39.6	61.8	64.5	78.2	58.9	83.6	58.9
DUBLIN AIRPORT	C	0.39	0.44	0.62	0.34	0.35	0.38	0.43	0.41	0.53	0.68	0.45
	D_y	398	342	493	240	248	226	289	281	371	397	329
	d_y	216	206	353	112	130	129	128	172	210	303	196
	%	54.3	60.2	71.6	46.7	52.4	57.1	44.3	61.2	56.6	76.3	59.6
CORK AIRPORT	C	NOT AVAILABLE					0.25	0.31	0.25	0.39	0.40	0.32
	D_y						232	364	280	494	402	354
	d_y						117	164	171	201	267	184
	%						50.4	45.1	61.1	40.7	66.4	51.9
CLONES	C	0.24	0.17	0.14	0.18	0.17	0.21	0.18	0.17	0.23	0.25	0.19
	D_y	283	172	134	154	174	143	158	143	217	167	174
	d_y	137	56	56	57	53	63	59	51	93	72	70
	%	48.4	32.6	41.8	37.0	30.5	44.1	37.3	35.7	42.9	43.1	39.9
BIRR	C	0.20	0.20	0.19	0.17	0.21	0.18	0.21	0.14	0.24	0.21	0.19
	D_y	189	162	167	105	169	109	153	103	211	142	151
	d_y	53	43	69	38	57	33	58	42	104	78	57
	%	28.0	26.5	41.3	36.2	33.7	30.3	37.9	40.8	49.3	54.9	38.1

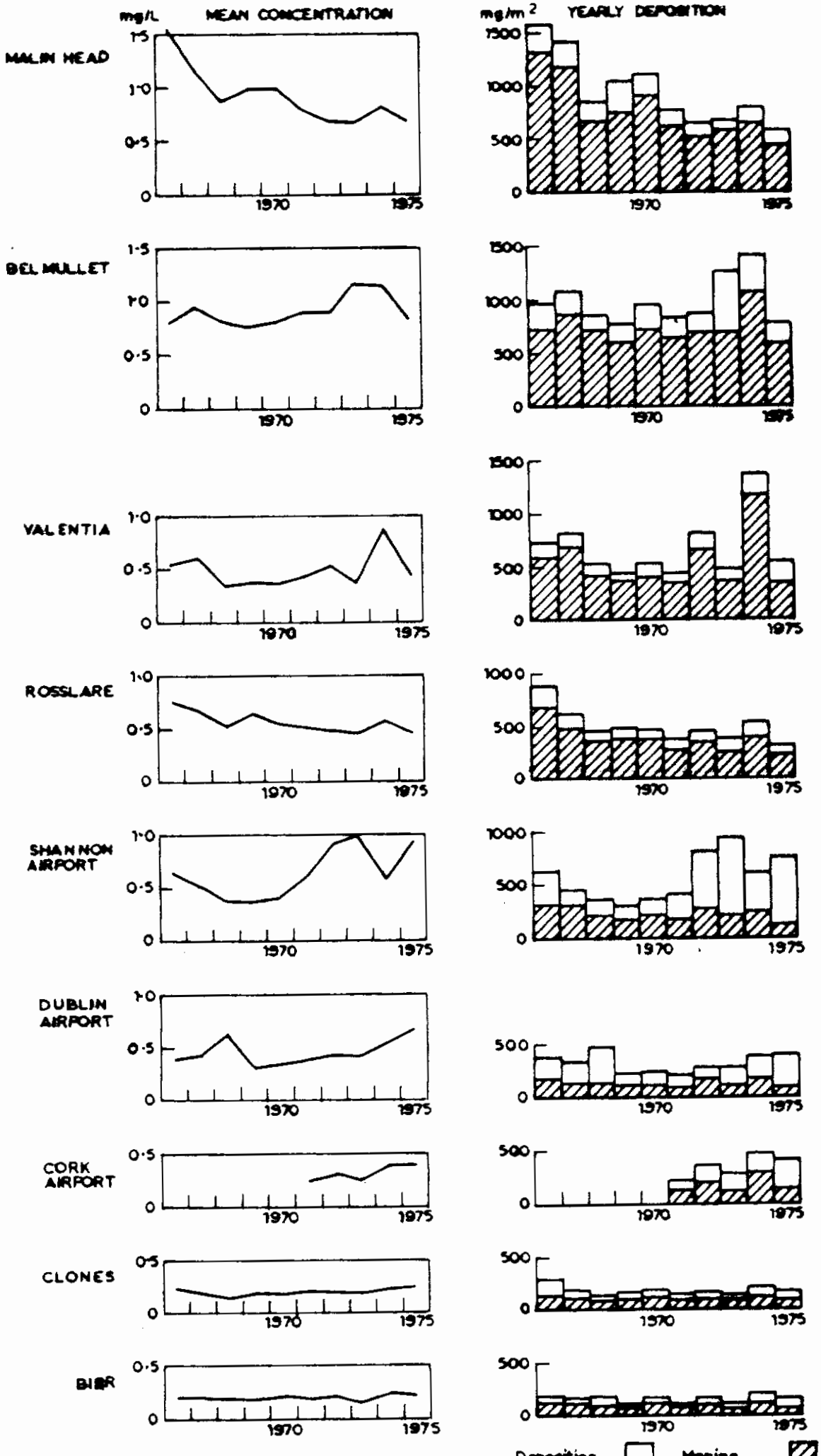

Fig. 6(a). Potassium yearly values.

TABLE 7 : CALCIUM (Ca) - MEAN MONTHLY VALUES, 1966-75

C = Mean (weighted) concentration of Ca, mg/L

D = Mean Deposition of Ca from all sources, mg/m^2

d = Calculated mean deposition of Ca, mg/m^2, from non-marine sources

% = d expressed as percentage of D

STATION		JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
MALIN HEAD	C	1.44	1.87	2.24	1.97	1.62	1.20	1.15	0.99	1.08	1.35	1.69	1.94
	D	156	153	170	114	101	75	76	81	104	143	217	195
	d	71	64	57	64	67	55	54	60	67	67	63	77
	%	45.5	41.8	33.5	56.1	66.3	73.3	71.0	74.1	64.4	46.9	29.0	39.5
BELMULLET	C	1.41	1.60	1.99	1.55	1.44	1.22	1.12	0.82	1.05	1.18	1.45	1.56
	D	173	150	137	86	87	80	70	70	116	130	186	168
	d	43	52	56	53	55	57	50	48	67	57	83	53
	%	24.9	34.7	40.9	61.6	63.2	71.3	71.4	68.6	57.8	43.8	44.6	31.5
VALENTIA	C	0.94	0.85	1.10	0.73	0.70	0.62	0.50	0.46	0.70	0.50	0.79	0.85
	D	180	111	76	61	65	42	35	44	88	64	118	104
	d	50	33	29	36	41	29	26	33	34	30	44	37
	%	27.8	29.7	38.2	59.0	63.1	69.0	74.3	75.0	38.6	46.9	37.3	35.6
ROSSLARE	C	1.01	1.35	1.90	1.43	1.26	1.53	0.85	0.85	1.11	1.03	1.01	1.17
	D	122	97	84	88	83	58	57	60	88	82	99	84
	d	48	46	49	56	58	46	49	50	60	46	53	46
	%	39.3	47.4	58.3	63.6	69.9	79.3	86.0	83.3	68.2	56.1	53.5	54.8
SHANNON AIRPORT	C	1.48	1.61	2.24	2.11	1.93	2.11	1.77	1.35	1.42	1.24	1.78	1.69
	D	146	125	121	115	117	114	100	101	134	101	195	140
	d	118	98	94	97	100	105	92	94	114	85	160	105
	%	80.8	78.4	77.7	84.3	85.5	92.1	92.0	93.1	85.1	84.2	82.1	75.0
DUBLIN AIRPORT	C	2.86	3.42	4.31	2.75	3.04	3.06	2.21	2.30	1.85	2.80	2.25	2.86
	D	223	184	173	175	194	143	123	136	138	163	157	180
	d	198	168	157	163	183	140	119	130	132	151	143	164
	%	88.8	91.3	90.8	93.1	94.3	97.9	96.7	95.6	95.7	92.6	91.1	91.1
CORK AIRPORT	C	0.66	0.81	1.41	1.41	0.71	1.18	0.69	0.60	0.59	0.68	0.75	1.14
	D	128	80	73	67	79	45	56	48	65	76	67	101
	d	69	60	63	61	68	41	52	43	53	61	55	79
	%	53.9	75.0	86.3	91.0	86.1	91.1	92.9	89.6	81.5	80.3	82.1	78.2
CLONES	C	0.60	0.63	0.82	0.93	0.71	0.65	0.55	0.77	0.51	0.49	0.68	0.65
	D	58	47	47	55	52	45	34	59	41	40	62	49
	d	44	35	31	46	46	41	32	56	35	31	45	35
	%	75.9	74.5	66.0	83.6	88.5	91.1	94.1	94.9	85.4	77.5	72.6	71.4
BIRR	C	0.88	1.51	2.05	1.75	1.44	1.52	1.58	1.17	0.90	0.94	0.83	0.92
	D	75	79	89	94	93	70	93	75	68	74	69	61
	d	62	68	76	88	87	66	90	71	61	67	60	48
	%	82.7	86.1	85.4	93.6	93.5	94.3	96.8	94.7	89.7	90.5	87.0	78.7

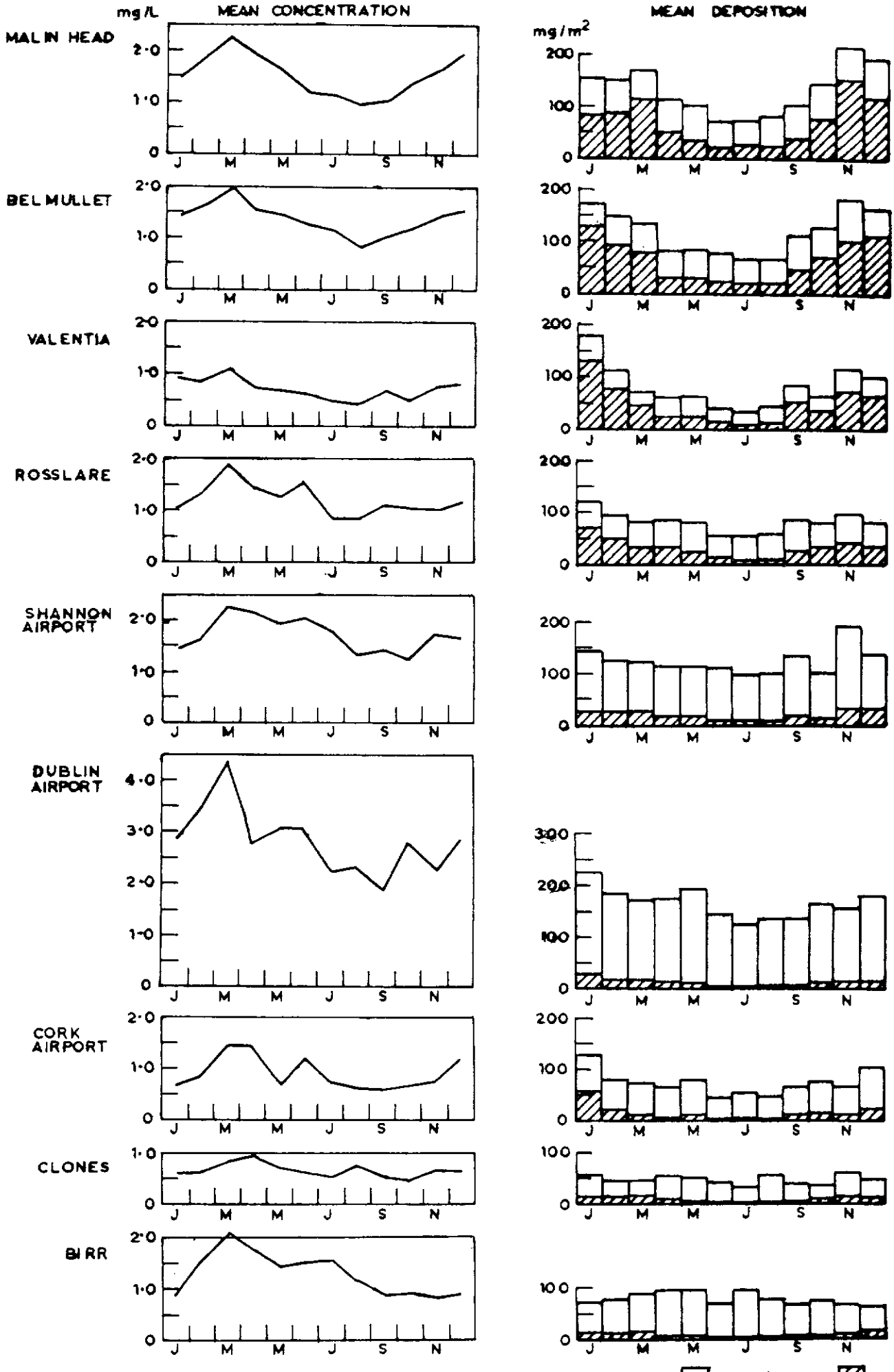

Fig. 7. Calcium mean monthly values.

TABLE 7(a) : CALCIUM (Ca) - YEARLY VALUES, 1966-75

C = Mean (weighted) concentration of Ca, mg/L, over the year

D_y = Total calcium deposition, mg/m^2, over the year

d_y = Calculated deposition of Ca, mg/m^2, from non-marine sources, over the year

% = d_y as percentage of D_y.

STATION		1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	OVERALL YEARLY MEAN
MALIN HEAD	C	1.79	1.64	2.03	1.66	1.68	1.46	1.46	1.15	1.41	1.05	1.54
	D_y	1842	2040	1979	1753	1895	1442	1408	1191	1390	906	1585
	d_y	440	780	1245	955	915	788	854	559	688	428	765
	%	23.9	38.2	62.9	54.5	48.3	54.6	60.7	46.9	49.5	47.2	48.3
BELMULLET	C	1.16	1.53	1.42	1.44	1.20	1.38	1.34	1.31	1.67	1.05	1.35
	D_y	1402	1748	1492	1427	1423	1270	1292	1432	2038	1002	1453
	d_y	569	818	752	802	678	588	559	701	899	378	674
	%	40.6	46.8	50.4	56.2	47.6	46.3	43.3	49.0	44.1	37.7	46.4
VALENTIA	C	0.69	0.92	0.69	0.79	0.64	0.79	0.73	0.55	1.01	0.60	0.74
	D_y	969	1235	1002	894	891	778	1100	674	1610	718	987
	d_y	343	528	547	509	480	407	415	275	383	349	424
	%	35.4	42.8	54.6	56.9	53.9	52.3	37.7	40.8	23.8	48.6	42.9
ROSSLARE	C	1.25	1.17	1.27	1.32	1.23	1.16	0.99	1.03	1.01	1.10	1.15
	D_y	1448	1072	1086	1001	1015	858	947	908	954	716	1001
	d_y	733	565	713	613	630	576	580	640	535	474	606
	%	50.6	52.7	65.7	61.2	62.1	67.1	61.2	70.5	56.1	66.2	60.6
SHANNON AIRPORT	C	1.41	1.55	1.55	2.56	1.93	2.39	1.57	1.76	1.32	0.98	1.68
	D_y	1372	1371	1455	2118	1820	1694	1403	1659	1395	800	1509
	d_y	1024	1021	1218	1918	1574	1525	1099	1441	1134	670	1262
	%	74.6	74.5	83.7	90.6	86.4	90.0	78.3	86.9	81.3	83.8	83.7
DUBLIN AIRPORT	C	1.71	2.17	2.54	3.09	3.58	4.73	4.98	1.19	2.23	1.94	2.74
	D_y	1741	1706	2006	2199	2553	2797	3343	819	1567	1136	1987
	d_y	1549	1562	1858	2063	2430	2706	3174	704	1398	1037	1848
	%	89.0	91.6	92.6	93.8	95.2	96.7	94.9	86.0	89.2	91.3	93.0
CORK AIRPORT	C	NOT AVAILABLE					0.92	0.79	0.75	0.75	0.82	0.80
	D_y						860	932	836	957	829	883
	d_y						739	720	721	647	688	703
	%						85.9	77.3	86.2	67.6	83.0	79.7
CLONES	C	0.50	0.46	0.49	0.67	0.58	0.85	0.94	0.63	0.83	0.77	0.66
	D_y	581	459	464	567	587	578	831	519	787	505	588
	d_y	418	336	382	463	458	492	724	421	658	404	476
	%	71.9	73.2	82.3	81.7	78.0	85.1	87.1	81.1	83.6	80.0	80.9
BIRR	C	0.99	1.00	1.22	1.19	0.62	1.47	1.17	1.21	1.61	1.82	1.22
	D_y	941	821	1099	741	501	907	871	913	1394	1229	942
	d_y	797	695	996	670	384	827	770	848	1282	1162	843
	%	84.7	84.7	90.6	90.4	76.6	91.2	88.4	92.9	92.0	94.5	89.5

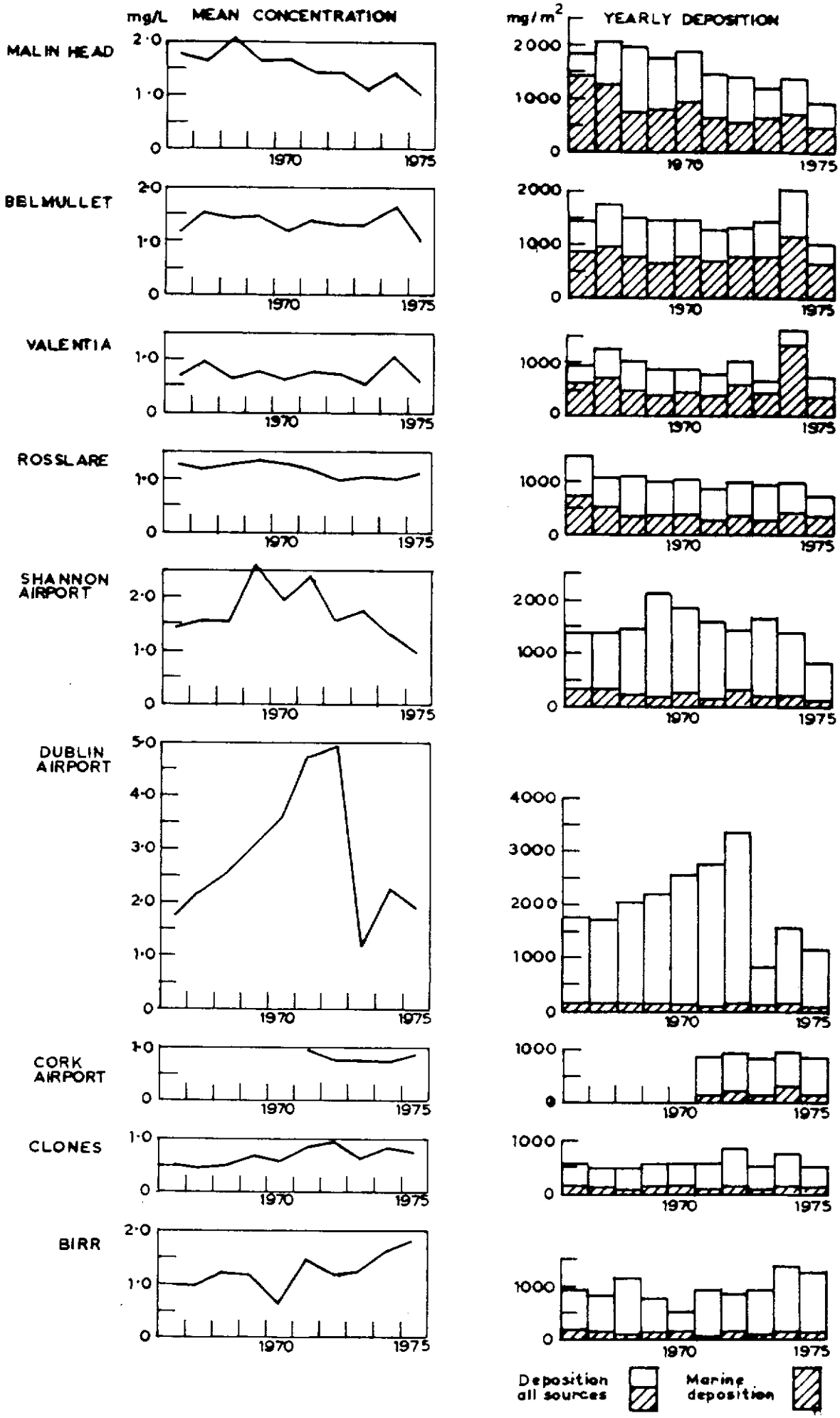

Fig. 7(a). Calcium yearly values.

TABLE 8 : MAGNESIUM - MEAN MONTHLY VALUES

C = Mean (weighted) concentration, mg/L.
D = Mean deposition mg/m^2.

STATION		JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
MALIN HEAD	C	2.49	3.43	4.66	2.71	1.75	1.03	0.95	0.79	1.21	2.25	3.75	3.69
	D	270	281	353	156	109	65	62	65	117	240	480	371
BELMULLET	C	3.33	3.34	3.78	1.86	1.67	1.08	1.05	0.79	1.33	2.05	2.52	3.27
	D	413	313	261	104	102	71	65	68	147	225	323	354
VALENTIA	C	2.09	1.82	2.19	0.89	0.74	0.49	0.39	0.30	1.20	0.80	1.51	1.69
	D	401	237	150	75	69	33	28	29	150	102	226	207
ROSSLARE	C	1.99	2.32	2.56	1.79	1.32	1.15	0.45	0.50	1.23	1.50	1.53	1.67
	D	241	166	113	109	87	44	30	36	97	119	149	120
SHANNON AIRPORT	C	I/R*	1.13	1.60	Insufficient Results*						0.61	I/R*	
	D		88	86							50		
DUBLIN AIRPORT	C	Insufficient Results*											
	D												
CORK AIRPORT	C	0.96	0.54	0.62	0.50	0.24	0.36	0.14	0.17	0.26	0.39	0.38	0.81
	D	186	54	32	24	27	14	11	13	28	43	34	71
CLONES	C	0.46	0.50				0.19	0.16	0.15	I/R*		0.56	0.51
	D	44	37				13	10	11			51	38
BIRR	C	0.45	Insufficient Results*						0.20	I/R*	0.28	0.37	I/R*
	D	39							13		22	31	

*The entry "I/R" or "Insufficient Results" indicates that the volume of the monthly sample was too small, on too many occasions, to permit reliable mean values to be calculated.

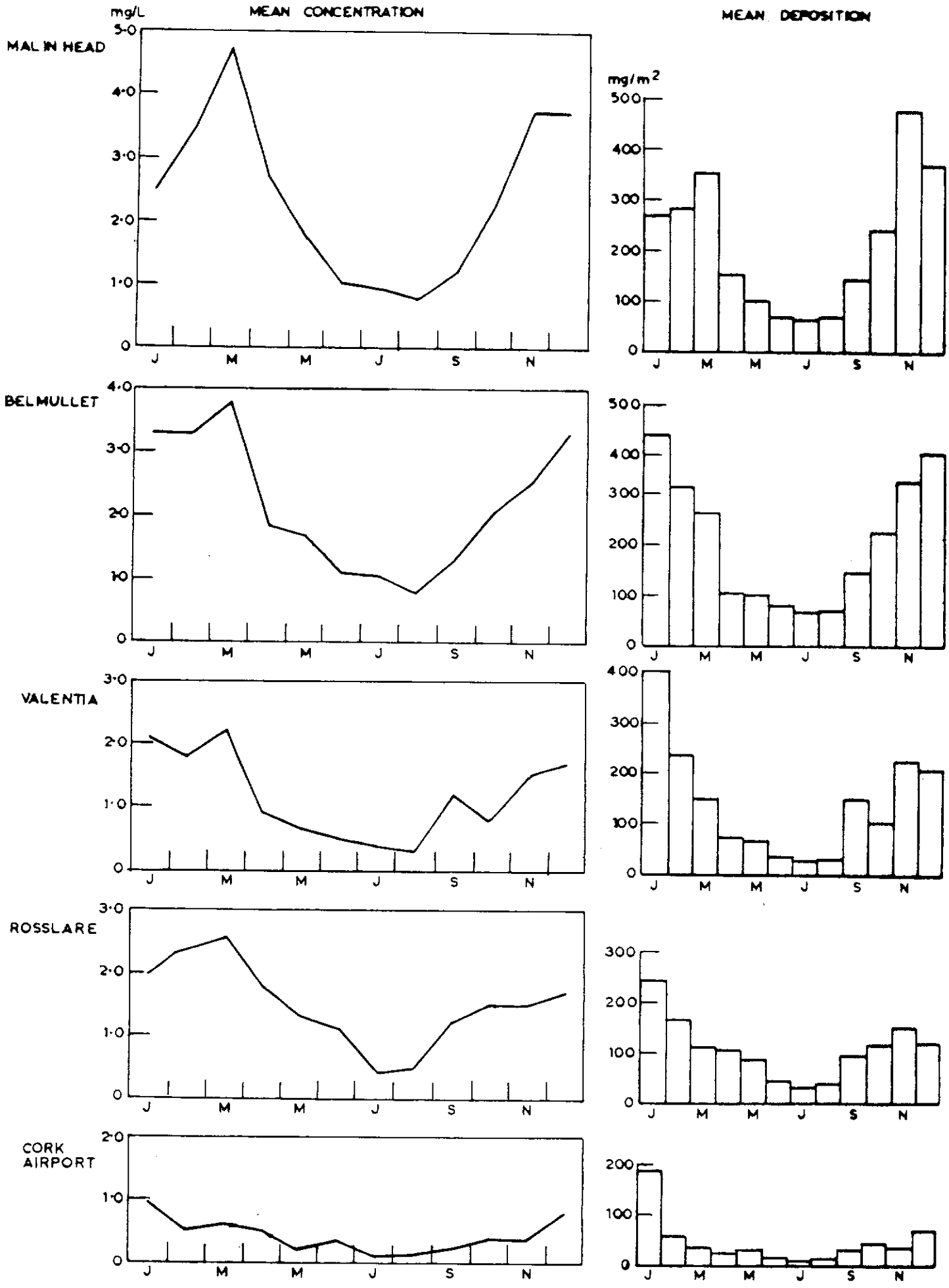

Fig. 8. Magnesium mean monthly values.

TABLE 8(a) : MAGNESIUM - YEARLY VALUES

C = Mean (weighted) concentration, mg/L, over the year
D = Deposition, mg/m^2, over the year.

STATION		1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	OVERALL YEARLY MEAN
MALIN HEAD	C	4.36	3.17	2.40	2.34	2.69	2.08	1.79	1.92	2.22	1.67	2.50
	D	4488	3938	2339	2465	3035	2058	1726	1996	2194	1439	2568
BELMULLET	C	2.20	2.61	2.19	1.98	1.99	2.36	2.36	2.14	2.90	1.96	2.28
	D	2660	2991	2292	1967	2358	2177	2274	2329	3534	1870	2445
VALENTIA	C	1.39	1.48	0.92	0.99	0.92	1.21	1.33	0.98	2.41	0.91	1.29
	D	1960	1991	1337	1126	1285	1192	2016	1211	3830	1100	1705
ROSSLARE	C	2.25	1.89	1.35	1.63	1.51	1.25	1.24	0.98	1.38	1.15	1.51
	D	2701	1729	1159	1233	1260	924	1181	861	1300	753	1309
SHANNON AIRPORT	C	1.32	1.25	0.82	0.92	Insufficient Results*						
	D	1286	1104	774	655							
DUBLIN AIRPORT	C	0.74	Insufficient Results*									
	D	753										
CORK AIRPORT	C	NOT AVAILABLE					0.42	0.54	0.36	0.69	0.38	0.49
	D						392	628	406	878	381	537
CLONES	C	0.43	0.37	0.27	0.37	0.40	0.40	I/R*	0.39	I/R*		
	D	504	373	253	314	406	271		321			
BIRR	C	0.52	0.48	I/R*			0.43	I/R*				
	D	4.92	393				265					

*The entry "I/R" or "Insufficient Results" indicates that the volume of the monthly sample was too small, on too many occasions, to permit reliable mean yearly values or total depositions to be calculated.

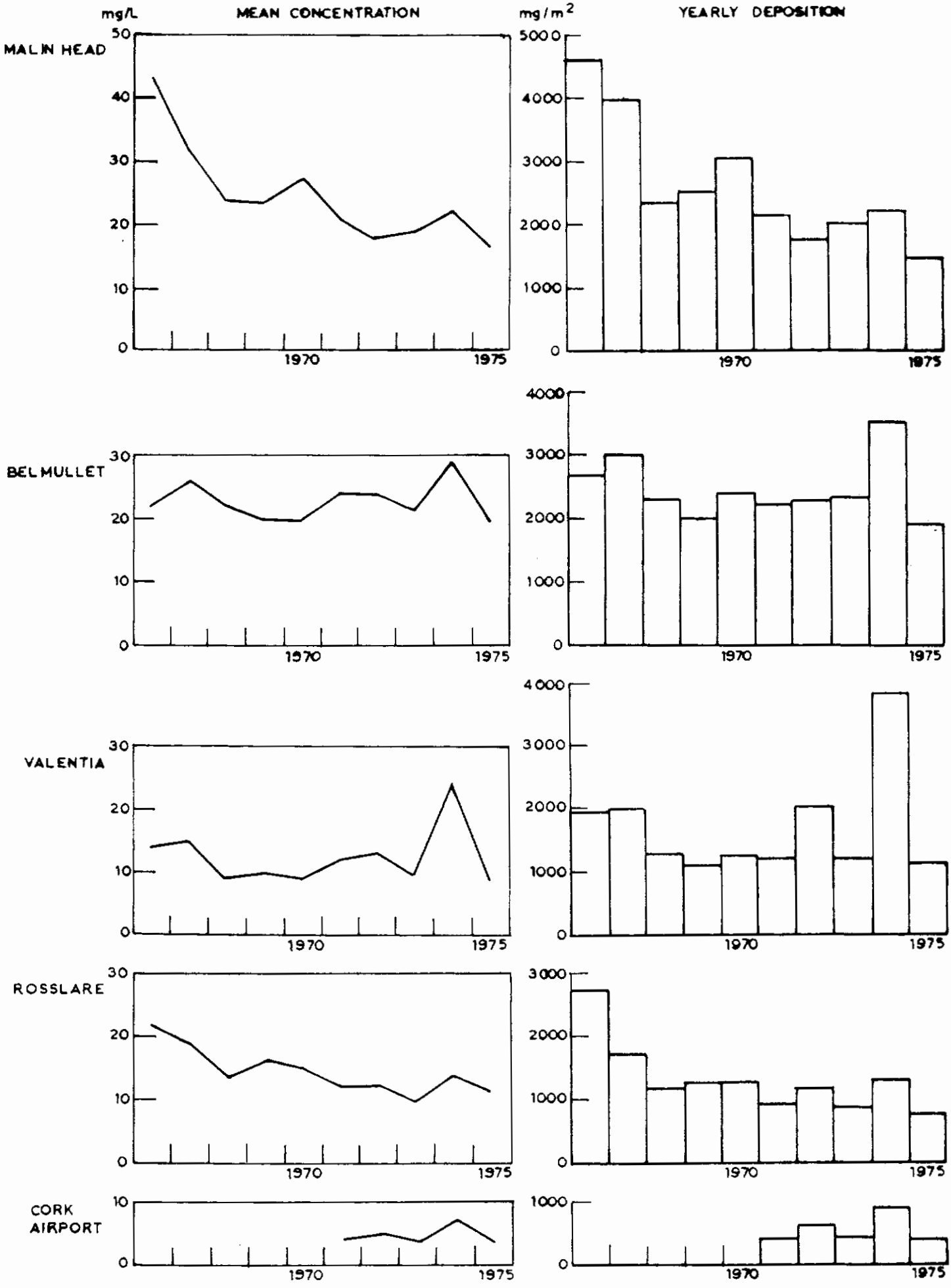

Fig. 8(a). Magnesium yearly values.

TABLE 9 - YEARLY MEAN ACIDITY/ALKALINITY VALUES
(Micro-equivalents per litre) 1972-1975 incl.

STATION		1972	1973	1974	1975
MALIN HEAD	ALK.		16.2	52.4	14.2
	ACID.	2.7			
BELMULLET	ALK.	19.2	25.0	43.5	33.5
	ACID.				
VALENTIA	ALK.				5.9
	ACID.	6.2	8.3	1.0	
ROSSLARE	ALK.				
	ACID.	14.2	27.0	16.5	30.7
SHANNON AIRPORT	ALK.	118.0	75.1	40.7	60.7
	ACID.				
DUBLIN AIRPORT	ALK.	72.7	49.9	50.0	
	ACID.				1.8
CORK AIRPORT	ALK.			1.7	
	ACID.	17.3	20.9		1.0
CLONES	ALK.	18.2	3.6	9.1	17.5
	ACID.				
BIRR	ALK.	35.0	18.7	52.3	59.7
	ACID.				

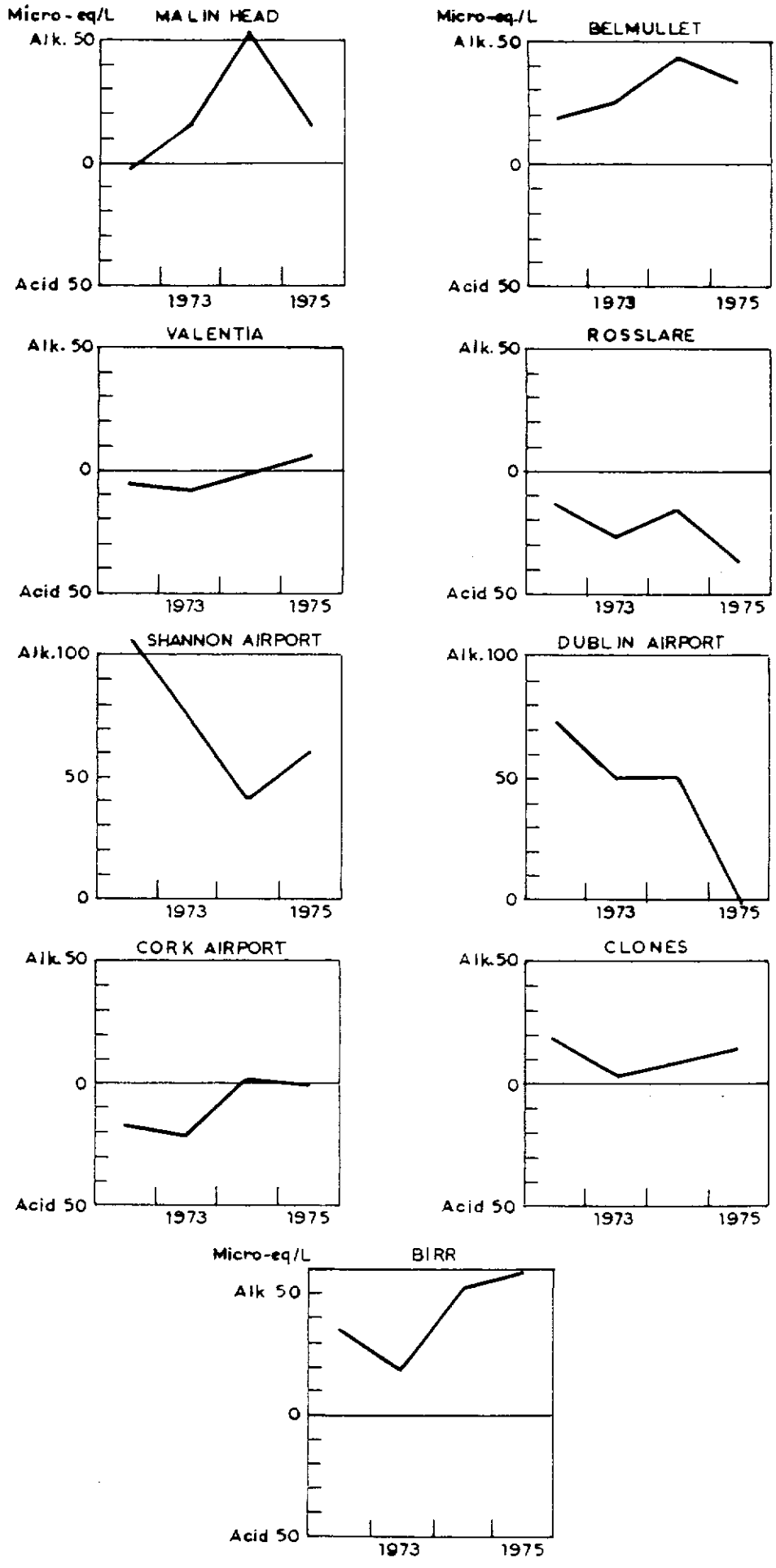

Fig. 9. Acidity / Alkalinity yearly mean values.

APPENDIX I : MEAN MONTHLY RAINFALL (mms), 1966-1975 incl.

STATION	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
MALIN HEAD	108.4	82.0	75.9	57.7	62.2	62.9	65.6	81.9	96.2	106.3	128.0	100.5
BELMULLET	124.0	93.6	68.9	55.7	60.8	65.8	62.2	85.2	110.3	109.6	128.4	108.2
VALENTIA	192.0	130.3	68.5	83.9	92.2	67.4	70.3	96.9	124.6	127.9	149.3	122.6
ROSSLARE	120.9	71.7	44.1	61.2	66.1	38.1	67.2	71.1	78.8	79.5	97.4	71.5
SHANNON AIRPORT	98.8	77.8	54.0	54.6	61.0	54.1	56.6	74.5	93.8	81.4	109.4	82.4
DUBLIN AIRPORT	77.8	53.8	40.1	63.4	63.6	46.8	55.8	59.1	74.3	58.1	69.3	62.8
CORK AIRPORT*	194.4	99.0	51.8	47.0	111.4	38.0	81.2	79.0	110.4	112.0	88.4	88.2
CLONES	96.5	74.6	56.9	58.7	72.8	68.9	62.4	77.0	80.3	81.0	90.9	75.1
BIRR	86.1	52.5	43.3	53.8	64.3	46.4	59.2	64.6	75.4	79.0	83.6	66.6

*In operation only from January 1971.

APPENDIX II : YEARLY RAINFALL (mms), 1966-1975 incl.

STATION	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	MEAN ANNUAL
MALIN HEAD	1030	1244	973	1053	1129	991	966	1039	987	864	1028
BELMULLET	1211	1144	1047	993	1185	923	964	1089	1219	952	1073
VALENTIA	1406	1349	1459	1133	1392	987	1513	1230	1586	1204	1326
ROSSLARE	1155	914	857	758	827	738	952	880	943	652	868
SHANNON AIRPORT	976	883	939	826	941	709	896	943	1053	818	898
DUBLIN AIRPORT	1016	785	789	711	714	591	671	687	704	586	725
CORK AIRPORT	NOT AVAILABLE					930	1173	1114	1279	1008	1101
CLONES	1165	996	941	845	1012	675	884	825	950	658	895
BIRR	954	821	897	620	804	616	743	753	864	676	775

APPENDIX III : PRINCIPAL ELEMENTS PRESENT IN SOLUTION IN SEA-WATER*

Element	mg/kg.	Ratio (Sodium = 1)
Chlorine	13,980	1.80
Sodium	10,561	1.00
Magnesium	1,272	0.12
Sulphur	884	0.084
Calcium	400	0.038
Potassium	380	0.036
Nitrogen - Nitrate	0.001-0.7	0 to 0.00007
Nitrogen - Ammonia	0.005 - 0.05	0 to 0.000005

*From Handbook of Chemistry and Physics,
Chemical Rubber Publishing Co.,
Cleveland, Ohio.