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Nutrient Content in Irish Rainfall Water

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Abstract: Emissions of gases from industrial activities and even from agriculture activities and from soil as releasing of nitrogen from soils to atmosphere have been increasing steadily therefore, acid rain is the concern throughout the world. The hill field at the UCD research farm was chosen as the representative of good versatile, on which moderate to intensive farming is practised in the drier rainfall areas of Ireland. Nutrient contents in rainfall water samples were measurable, although the site of rainfall sample collection is located in the east of the country far away from the Atlantic Ocean. TDP (total dissolve phosphorus) concentrations in rainwater samples were very low. While DRP (dissolve reactive phosphorus) is the main component in some samples, the DUP (dissolve unreactive phosphorus) is dominant in others. DRP values accounted for less than 50% of dissolved phosphorus in rainfall. Sodium (Na) and Chloride (Cl) ions had the highest concentration value, because most of Irish rain originates from the Atlantic Ocean. Nitrate (NO_3) had the highest value 15.2 $\mu g \cdot mL^{-1}$ but it associated only with mineral fertiliser spreading time.

Key words: Irish rain, acid rain, nutrient content.

1. Introduction

Emissions of gases from industrial activities and even from agriculture activities and from soil as release of nitrogen from soils to atmosphere have been increasing steadily [1]. As example, emission of nitrogen (NO_x) is increasing in industrial and developing regions throughout the world [2]. Therefore, acid deposition is a serious problem throughout the whole of the world. Few countries have taken significant steps to avert the atmospheric emission [3], although at the national scale, legislation may provide effective mechanisms for controlling emission of atmospheric pollutants. However, many of the major pollutants can travel long distances [4]. Therefore, monitoring the concentration of elements and compounds in rain water is sensory.

1.1 Rainfall in Ireland

Atlantic Ocean gives Ireland an equable climate with fairly uniform temperatures over the whole country. The general impression is that it rains quite a lot of the time in Ireland but in fact two out of three hourly observations will not report any measurable rainfall. The average number of wet days (days with more than 1 mm of rain) ranges from about 150 days a year along the east and south-east margins, to about 225 days a year in parts of the west. Average hourly rainfall amounts are quite low, ranging from 1mm to 2 mm, short-term rates can be much higher; for example, an hourly total of 10 mm is not uncommon and total of 15 mm to 20 mm in an hour may be expected to occur once in 5 years, the hourly total exceeding of 25 mm is rare in this country and when they do occur they are usually associated with heavy thunder storms [5]. The number of wet and very wet days is becoming of more interest to many people, knowledge of the likelihood of days with 5, 10, 15 or more millimeters of rain in a day is needed by those who manage and monitor runoff from land and pollution of water. A value of 10 mm of rainfall or more has been used to define as the standard of very wet day. Long-term records collected by the meteorological service show that Delphi Lodge in west Mayo is amongst the highest in this scale with 88 days and Casement Aerodrome (near Dublin) is the lowest

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with a mere 17 very wet days per year on average.

1.2 Climate of Lyons Estate

Relative warm waters and prevailing south-westerly winds coming from Atlantic Ocean give Ireland an equable climate with fairly uniform temperatures over the whole country. The Lyons Estate situated within 20 miles of the Irish Sea has a typical maritime climate, with relatively mild, moist winters and cool, cloudy summers. It has a lower average rainfall and longer periods of bright sunshine than most other parts of Ireland. Data obtained from the synoptic weather station at Casement Aerodrome, about 6 km from Lyons Estate, shows that the farm is situated in one of the lowest rainfall areas in the country, with total mean annual rainfall being just over 700 mm. While the figures show no marked periodicity, on average, the driest months are April and July, with December and January being the wettest. Since water is a powerful solvent there is no pure water in nature. A wide range of substances which are present in the atmosphere become dissolved in the rain. Most of Irish rain coming from the Atlantic, is especially rich in anions and cations associated with marine conditions. Chief among these are the cations of sodium, magnesium, calcium, potassium and anions of chlorine and sulphur; the amount received varies from element to element but increases with altitude, proximity to the Atlantic, and with the structure and surface area of the vegetation. In addition to the marine ions and those from other natural sources, there are significant quantities of ions and compounds in the atmosphere and in precipitation arising from municipal, industrial and agricultural sources. The most studied of these in recent years have been the ions sulphate, nitrate and ammonium, as well as the gases sulphur dioxide, ozone, nitrogen oxides, hydrocarbons and chlorofluorocarbons [6].

2. Materials and Methods

2.1 Description and Management of the Field Site

The Hill Field at the UCD Research Farm was chosen as being representative of good versatile land, with undulating topography, on which moderate to intensive farming is practiced in the drier rainfall areas of Ireland. Historically the field was included in the tillage rotation of the farm, but it has been in permanent grass for the last 25 years. The field is roughly square in shape, and occupies an area of approximately 4.5 ha with elevation ranging from 72 m to 76 m The Hill Field is normally grazed by sheep and young cattle from August to December, and from February to April each year. One cut of silage is taken between the middle and the end of May. Chemical fertilizer in the form of urea is applied at a rate of 60 kg $N{\cdot}ha^{-1}$ before grazing commences in the spring and again at a rate of 180 kg $N{\cdot}ha^{-1}$ when it is closed up for silage. After silage cutting, animal slurry (a mixture from cattle and pigs) is applied at a rate of 27 $m^3{\cdot}ha^{-1}$ along with calcium ammonium nitrate (CAN) at a rate of 100 kg $N{\cdot}ha^{-1}$. No P or K chemical fertilizer, in addition to that applied in slurry, has been used for the last 5 years, but the field has received occasional, but unquantified, additional applications of slurry when conditions demanded outside the grazing periods. All slurry applications were applied by tractor drawn vacuum tanker.

2.2 Rainfall Water Collector Samples

During September and October 2003 two monitoring stations were set up in the Hill Field at top and bottom of the field. Two rainfall collectors, each consisting of a 10 cm diameter circular polypropylene funnel inserted into 1000 mL glass bottles, as shown in Fig. 1, were placed at ground level in two stations in the top and bottom of the field. A very fine nylon filter mesh placed in the neck of the funnel protected the sample from contamination. Samples were discarded if there was clear evidence of contamination by bird droppings, or if insects/slugs or other debris had passed through the filter mesh. Samples were collected on a weekly basis, except for a few samples that were collected over shorter periods during more intense rainfall.

Fig. 1 Rainfall water collector samples.

2.3 Chemical Analysis of the Rainfall Sample

All rainfall water samples were filtered through 0.45 µm Millipore filter paper immediately after collection. Dissolved reactive phosphorus (DRP) was measured colorimetrically by the ascorbic acid ammonium molybdate method [7] and read on a visible-ultra-violet spectrometer at 880 nm. The remainders of the filtered samples were stored in a dark cold room at 4 °C until further analysis was completed. Total dissolved phosphorus (TDP) was measured by the method of Ref. [7] after digestion using potassium persulphate [8]. The difference between DRP and TDP gave dissolved unreactive phosphate (DUP). Sodium (Na), potassium (K), magnesium (Mg), and calcium (Ca) concentration were determined by inductively coupled plasma optical emission spectrophotometer (ICP-OES). When the K concentration was less than 1 mg/L, it was measured by flame atomic emission spectrophotometer (FAES). The chloride (Cl), nitrate (NO_3), biphosphate (HPO_4) and sulphate (SO_4) concentration were measured by ion chromatography (IC), using an anion exchange column and conductivity detection, and pH was measured on most samples, by low-conductivity combination electrode.

3. Results and Discussion

3.1 Nutrient Content in Rainfall Water Samples

A total of 144 rainfall water samples were collected during the monitoring period. The samples had low EC and pH values, and although their nutrient contents were very low, they were measurable due to site position in the east of the country far away from Atlantic Ocean. The data in Table 1 are in agreement with the conclusion of Ref. [6] that Irish rain is relatively rich in anions and cations because most of it originates from the Atlantic marine conditions. Chief among these are the cations of sodium, calcium and potassium.

3.2 Dissolved P (DP) Content in the Rainfall Samples

TDP was measured in 58 rainwater samples. Concentrations were low while DRP the main component in some samples. But with DUP dominant in others DRP values accounted for less than 50% of dissolved phosphorus in rainfall. Overall DUP accounted for 62% of TDP in some samples analysed. While DRP concentrations were generally very low, with a range from 0.00 to 0.0347 µg P/mL, it was unusually high in samples collected in the last two weeks of September and first two weeks of October 2004. Concentrations over the whole period of monitoring are shown in Fig. 2.

Table 1 Mean and other statistic parameter of the chemical characteristics of rainfall water samples.

	EC	pH	DP	Na	K	Mg	Ca	Cl	NO_3	HPO_4	SO_4
	(µS/cm)		(µg·mL^{-1})								
Min	11	6.4	0.000	0.2	0.07	0.1	0.6	1.0	0.1	0	0.0
Max	105	7.2	0.347	6.9	3.25	1.0	3.9	8.4	15.2	0.29	3.9
Mean	40	6.8	0.014	2.5	0.78	0.4	1.8	3.9	1.4	0.02	1.2
Median	38	6.7	0.000	2.6	0.54	0.3	1.8	3.7	0.8	0	1.0

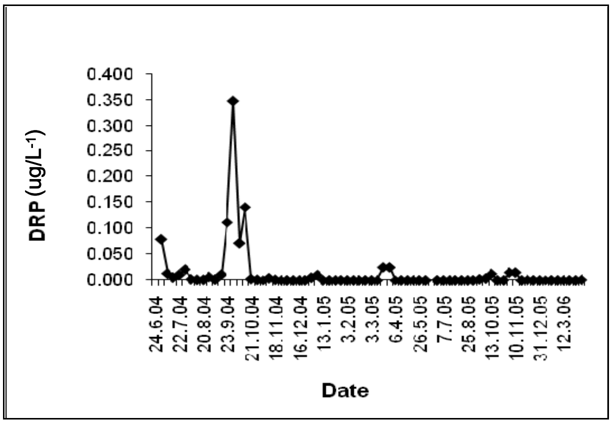

Fig. 2 Mean DRP concentrations in rainwater samples during the monitoring period.

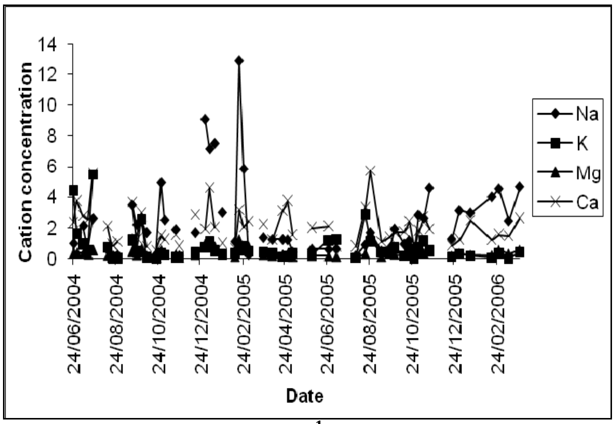

Fig. 3 Mean cation (μg·mL^{-1}) in rainfall water samples during the monitoring period.

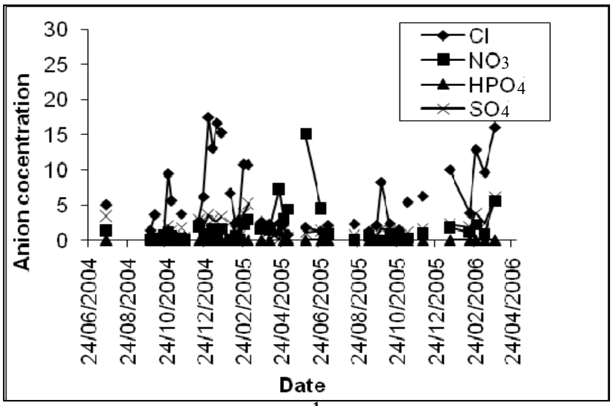

Fig. 4 Mean anion (μg·mL^{-1}) in rainfall water samples during the monitoring period.

3.3 Cation Concentration in Rain Water

Cation concentration in rain water samples is low because the site situated in the east of the country far away from the Atlantic Ocean in the west of the country from where the most of rain coming. The Na concentration is the highest coming after that Ca then K and at last Mg as seen in Fig. 3. This conform what mention by Ref. [6] as the most of rain coming from the Atlantic, is from the Atlantic, which is especially rich in cations associated with marine conditions. Chief among these are the cations of sodium, calcium and potassium.

3.4 Anion Concentration in Rain Water

Anion concentration in rain water is a bet low due to site position in the east but the chloride still has the highest concentration of anion. The NO_3 concentration in the rain was generally low. However, the range (0.1-15.2) included some higher values associated with rain events that occurred within the period from 1/4/05 to 5/5/05. They were associated with mineral fertiliser spreading in the days shortly before the rain events. It appears that fertiliser particles adhering to the grass foliage, or lying on the ground, may have been transported by raindrop splash directly into the rainfall collectors or even by falling directly into the rain collectors during spreading. The fluctuation in the rainwater anion concentration during the monitoring period can be seen in Fig. 4.

4. Conclusion

Since the water is a powerful solvent there is no pure water in nature. A wide range of substances which are present in the atmosphere become dissolved in the rain. Most of Irish rain coming from the Atlantic, is especially rich in anions and cations associated with marine conditions. Chief among these are the cations of sodium, magnesium, calcium, potassium and anions of chlorine and sulphur; the amount received varies from element to element but increases with altitude, proximity to the Atlantic, and with the structure and surface area of the vegetation. In addition to the marine ions and those from other natural sources, there are significant quantities of ions and compounds in the atmosphere and in precipitation arising from municipal, industrial and agricultural sources. The most studied of these in recent years have been the ions sulphate, nitrate and ammonium, as well as the gases sulphur dioxide, ozone, nitrogen oxides, hydrocarbons and chlorofluorocarbons. A total of 144 rainfall water samples were collected during the monitoring period. The samples had low EC and pH values, and although their nutrient contents were very low, they were measurable due to site position in the east of the country far away from Atlantic Ocean.

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