

CHEMICAL COMPOSITION OF THE PRECIPITATION OVER THE NETHERLANDS

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ABSTRACT

The chemical composition of precipitation may have a great influence on the quality of ground water. In the Netherlands precipitation is collected on several sampling sites which are homogeneously distributed over the country. As an example maps with isolines of the ammonium, chloride, sulphate and nitrate content of precipitation collected in the summer season 1979 and the winter season 1979/1980 are given.

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INTRODUCTION

Precipitation takes part in the hydrological cycle and may influence the composition of underground water. Nearly all precipitation deposits in the form of rainwater in the Netherlands. Quality as well as quantity of rainwater are of importance. The quality of rainwater is determined by the amount of dissolved and non-dissolved substances. In relation with ground water quality, only the effective precipitation resulting after evaporation is of interest. However, this evaporation does not influence the deposition. On percolating, rainwater and dissolved substances may interact with soil and may liberate deleterious substances. As rainwater and dissolved substances are suspect of negative influences on soil and groundwater, rainwater analysis is highly needed.

NETWORKS

In 1971 the first report on the acidity of water in small mountain lakes was published in Sweden. This report generally has aroused interest in the chemical composition of precipitation. In the Netherlands, which is located in a highly industrial area in Europe, rainwater has been analysed since about 1950. In 1972 the possible impact of rainwater quality on groundwater quality became a field of interest.

Since 1978 two national networks are in operation. The KNMI-RIV network 1) samples are taken monthly on 12 sites. The main purpose of this network is to identify a trend as well as the mutual relation between the components. The other national network, the RID-network 2), covers 26 locations. The main purpose of the RID-network is to determine the deposition. Both networks are complementary and despite small differences in sampling methods, the results of both networks can be used in combination for several purposes.

#### SAMPLING AND ANALYTICAL PROBLEMS

Sampling may be contaminated by bird droppings. Also insects may affect samples during sampling periods. Alga and bacterial growth may also occur. Since the concentrations in the rainwater are relatively low, the risk of contamination in the field as well as in the laboratory is high. Finally, different methods of analysis used in the laboratories may decrease the comparability of the results.

#### DEPOSITION

When studying the influence of precipitation on groundwater one is especially interested in total deposition. However, deposition exists of a dry and a wet portion. The behaviour of these fractions with respect to capture by surfaces is quite different. It is generally assumed that the amount of wet deposition will gradually change from one place to the other. The dry deposition however, strongly depends on the characteristics of the soil surface and may abruptly change over short distances. If the dry deposition is only a small part of the total deposition, the difference between wet and total deposition will be small. Then, calculation of the total deposition for larger areas from quality data of rainwater samples collected on one site may be permitted. However, when dry deposition is large with respect to total deposition such an approach is not allowed. In the Netherlands, this problem is studied at present.

#### TRANSPORT THROUGH THE SOIL

On the soil surface precipitation will evaporate partly. In the Netherlands in winter period this evaporation is negligible and in summer period the evaporation is about 50 to 100%. Only effective precipitation is important in relation to groundwater quality. The composition of the effective precipitation will be different from the original composition and the concentration of non-volatiles will be increased. Dissolved substances in rainwater may be adsorbed as well as

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converted during passage through the soil. On the other hand rainwater may dissolve substances from the soil. In case of lime containing soil calcium may be dissolved; in other cases the iron content will be increased; ammonium, an important component in rainwater (up to about 2 mg/l, see maps), will not contribute to the ammonium amount of groundwater because of its conversion by oxidation in the unsaturated zone. Suspended solids from rainwater are filtered by the soil. The increasing acidity of rainwater is possibly caused by air pollution and related to an increasing use of mineral fuels. Much attention is paid to the ability of acid precipitation to liberate weakly adsorbed metal ions. At present only restricted knowledge on the processes causing change of the quality of percolating precipitation is available. This is also true for information on the quality of the precipitation. Studies on transport models in soil and underground are of great interest.

#### CONCENTRATION OF AMMONIUM, CHLORIDE, SULPHATE AND NITRATE IN PRECIPITATION IN THE NETHERLANDS

Using the results of the networks presently available from analysis of rainwater collected with open samplers, some maps with isolines have been constructed for the seasons summer 1979 and winter 1979/1980. These maps show the concentrations at the sites of the KNMI-RIV-network. It has been possible to refine the pattern of the isolines using the results of some of the regional networks. For each season the range of the amount of precipitation is presented also. Figures 1.1 and 2.1 show an increase in ammonium concentration from coastal areas to the inland. The highest values have been found in the south-eastern part of the country. The isolines for chloride in figures 1.2 and 2.2 demonstrate the influence of the sea. The ratio between the concentration along the coast and the inland amounts to a factor 10. As to sulphate - figures 1.3 and 2.3 - it may be concluded that the higher concentrations are measured in the southern part of the country. The pattern of the nitrate concentration shown in figures 1.4 and 2.4 is less clear. In the southern part in the summer higher values are measured than in the winter.

No maps of the distribution of total deposition over the Netherlands can be presented due to the problem of dry and total deposition mentioned above.

#### TRACE ELEMENTS

The RID measures trace elements in rainwater at 26 sampling sites. For each station weighted means and median values are calculated for the elements arsenic, cadmium, chromium, copper, mercury, selenium, nickel, lead, vanadium and zinc during the period from July 1978 until January 1980. In table 1 the ranges of these weighted means and median values are presented.

TABLE I

Trace element content of rainwater in  $\mu\text{g/l}$ . Ranges of weighted means and median values in the period 1/7/78 - 1/1/80 (RID rainwater quality network).

Component	weighted mean	median
Arsenic	0.4 - 2.0	0.5 - 2.0
Cadmium	0.3 - 4.3	0.2 - 2.3
Chromium	0.0 - 0.5	0.0 - 0.5
Copper	6.0 -42.0	4 -32
Mercury	<0.1* - 1.3	<0.1* - 0.1
Selenium	<2 * -<2	<2* -<2
Nickel	1 - 4	1 - 3
Lead	9.4 -38	8.8 -26
Vanadium	<5* -12	5* -15
Zinc	31 -559	25 -405

\*: limit of detection

The data indicate that the deposit of some trace elements is of the same order as trace element concentrations in surface waters. In heavily industrialized areas the vanadium content is sometimes very high. In densely populated areas the lead content can rise to high levels. At some locations relatively high copper concentrations have been observed. In general it may be stated that the deposition via precipitation can be substantial part of the total trace element burden of the environment.

#### ORGANIC MICROPOLLUTANTS

The measurement of organic micropollutants in rainwater is still in an initial phase. Some measurements on polycyclic aromatic hydrocarbons and pesticides are available. It has observed that in the main part of the samples of the Dutch groundwater sampling network volatile organic halogens occur. This indicates that rainwater may be an important source of these substances. Measurements of volatile halogenated organics will be an important object of future investigations.

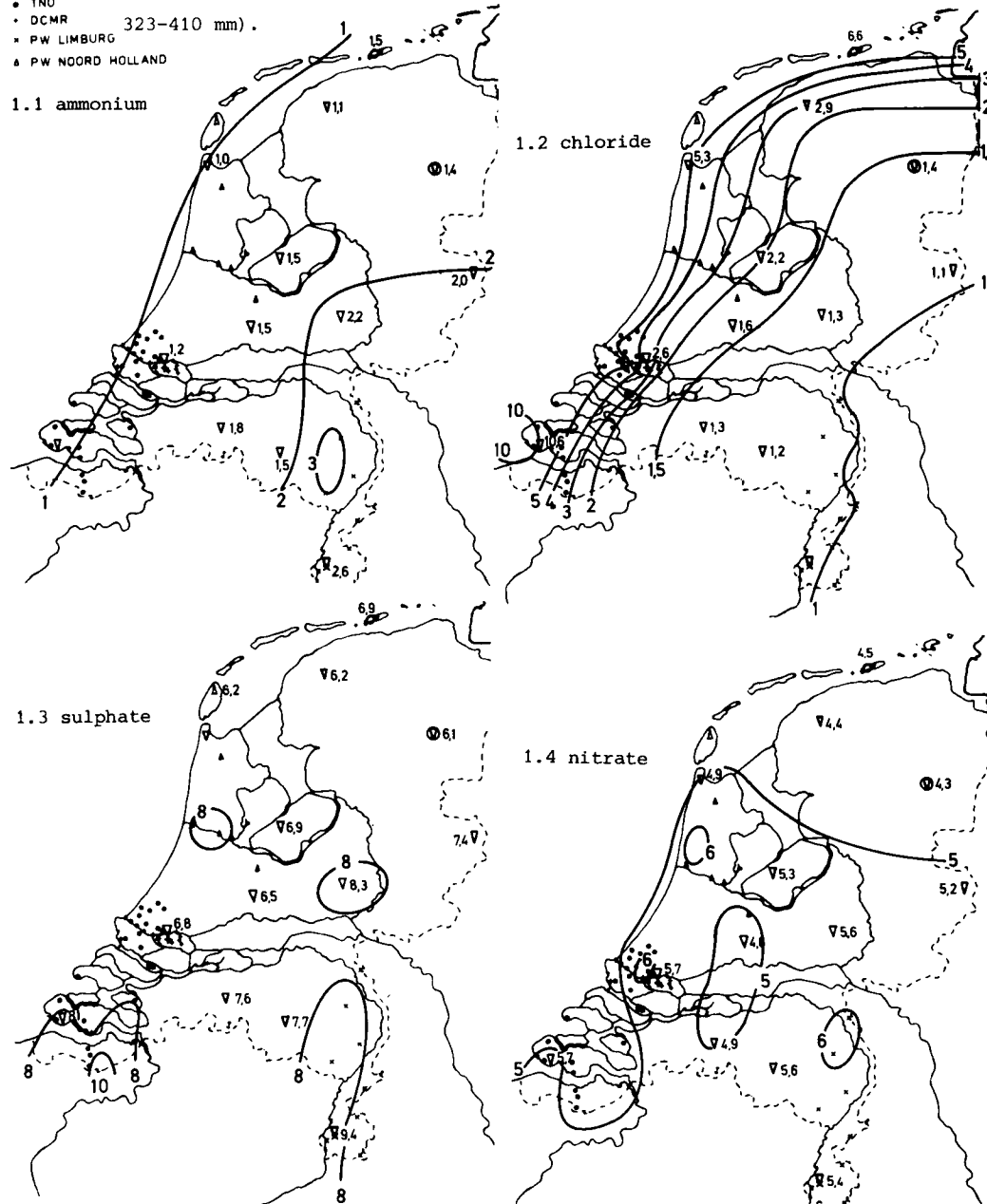
#### CONCLUSIONS

Obviously, rainwater is a potential source of various contaminants. In relation to groundwater quality only scarce knowledge on some components exists. Rainwater may have an impact on groundwater by its own composition as well as

by liberation of components from soil.

For better understanding of the effects of contaminated rainwater on groundwater quality beside accurate measurements in groundwater, groundwater transport models should be developed urgently.

▽ KNMI/RIV Fig. 1. Concentration in mg/l in precipitation of ammonium (1.1), chloride  
 ○ WMO/KNMI (1.2), sulphate (1.3) and nitrate (1.4) in summer 1979 (precipitation  
 • TNO  
 • DCMR 323-410 mm).  
 • PW LIMBURG  
 ▲ PW NOORD HOLLAND



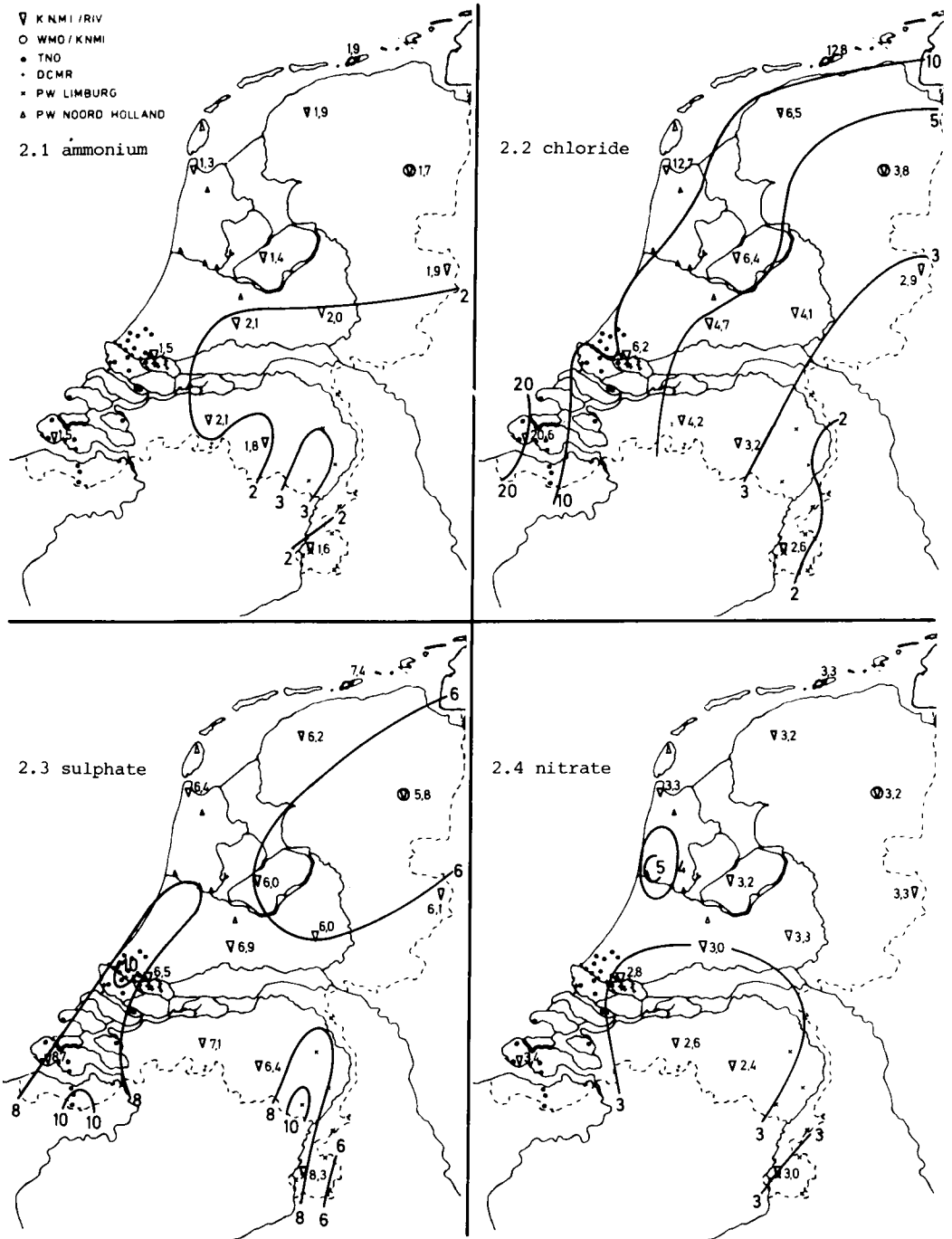


Fig. 2. Concentration in mg/l in precipitation of ammonium (2.1), chloride (2.2), sulphate (2.3) and nitrate (2.4) in winter 1979/80 (precipitation 315-497 mm).