Acta Botanica Neerlandica **12** (1963) 498–520

DUNE WATERS IN THE NETHERLANDS

I QUACKJESWATER, BREEDE WATER AND VOGELMEER

P. LEENTVAAR

(RIVON, Bilthoven)

(RIVON-communication nr 156)

(received August 5th, 1963)

Abstract

Monthly chemical and plankton samples were taken from three shallow freshwater dune waters on the westcoast of the Netherlands. In the Quackjeswater (origin ± 1500) no decalcification could be found. In the Breede Water (origin ± 1920) and the Vogelmeer (origin 1952) decalcification was heavy. The difference is related to a difference in submerged vegetation. In the Quackjeswater there is plenty of organic matter and a vegetation of aquatic mosses (*Fontinalis antipyretica*); in the Breede Water and the Vogelmeer a vegetation of *Chara sp.*, *Myriophyllum* and *Elodea* is found. There are certain differences in the composition of the plankton in the three dune waters, caused by a difference in density of submerged vegetation, difference in exposition to wind, light conditions, situation near the seashore, salinity and age.

In the Netherlands the shallow natural waters, found in the dunes along the North Sea coast are interesting from a hydrobiological point of view. In the first place they are near the sea and the influence of the prevailing seawind and the rainfall characterise these waters ecologically. Moreover the dune waters are of different age and as a result differences can be found in the development of fauna and flora. Thirdly, these dune waters are isolated, there is no industrial and domestic pollution and little disturbance by recreational activities.

In this publication the results are given of monthly samples taken in the dune waters Quackjeswater and Breede Water on the island Voorne southwest of Rotterdam, both belonging to the Netherlands Association for the Protection of Nature at Amsterdam, and the Vogelmeer situated in the National Park "Kennemerduinen" near IJmuiden. The research was carried out from March 1962 until January 1963. The data of previous observations in the years 1957, 1959, 1960 and 1961 are not given in this paper. Similar research will follow on other dune waters situated on the islands in the Waddenzee in 1963.

The monthly samples were all taken in one day. For chemical analyses 2 liters of water were taken straight to the laboratory and water samples for oxygen titration were fixed before transport. At the sampling station the water temperature was taken. Plankton was collected by pouring four buckets (30 liters) of water through a plankton net. Finally the water level was noted.

In the Quackjeswater samples were taken from the northern part bordered by trees and also from the southern part surrounded by an open landscape.

The results of the chemical analyses are given in graphs; the analyses of plankton in lists. In the plankton lists an estimation is given of the relative abundances of the species.

RESULTS

Chlorid

The monthly observations show that the amount of chlorid in the Breede Water is always 20 mg/l higher than that from Quackjeswater and Vogelmeer. The difference between Quackjeswater and Vogelmeer is only a few milligrams. Except under icecover (January 1963), when the concentration of salts increases as a rule, the amount of chlorid did not exceed 100 mg/l, so the dune waters should be considered as fresh waters, in spite of the fluctuations in the course of the year.

In summer the amount of chlorid is higher than in spring and winter. This is caused by evaporation in summer and also by a difference in rainfall during those periods. The water level drops in the course of the year. (see graph of water level at Vogelmeer). As chlorid is biologically nearly unutilized, an influence of organisms on the chlorid-ion may be ruled out.

Comparison with other shallow waters, situated on sandy soils more in the center of the country which were investigated at the same time, shows that chlorid was more constant there. Chlorid fluctuated here between 10 and 15 mg/l. This is not only due to differences in precipitation and evaporation, but also to a difference in composition of the rainwater. Near the coast rainwater contains 16 mg/l Cl; at approximately 60 kilometers from the coast (Hilversum) 4 mg/l (Leeflang, 1938). The distance from the sea is an important factor in relation to the composition of the rainwater. Seasonal differences may be caused by differences in the direction of the wind and wind velocity (Maschhaupt, 1941), in relation to transport of salt particles. In one stormy night more salt might be precipitated than normally in one year. This fact could explain the high amount of Cl on 19 September in the Vogelmeer (see graphs).

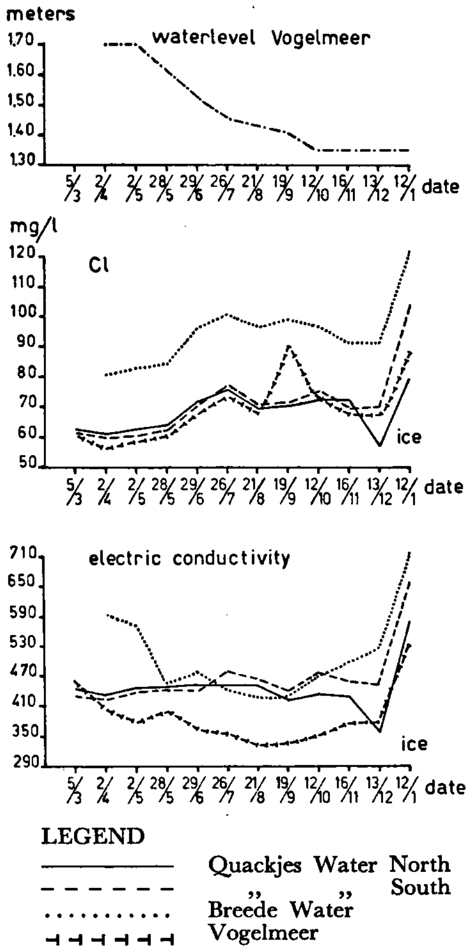
The constant higher chlorid of the Breede Water may be explained by the geographic position just near the sea coast and the nature of the subsoil. Hydrologic research has been done by J. ter Hoeve from the State Forestry Service in 1960. The bottom of the Breede Water was more porous than that of the Quackjeswater.

The concentrations of chlorid in the two places in the Quackjeswater do not differ normally except on 13 December when the northern sampling station showed a decrease caused by the thawing of the ice. A similar decrease was found in the concentration of Ca and conductivity. At that date, in the south of the Quackjeswater there was no icecover.

The concentration of chlorid in the Breede Water fluctuates between 80–100 mg/l, that of the Quackjeswater between 60–75 mg/l and the Vogelmeer between 55–75 mg/l. Other observations sustain these data: Breede Water May 1957 100 mg/l; Quackjeswater May 1957

80 mg/l; September 1961 74 mg/l; Vogelmeer March 1960 60 mg/l.

HOFKER and VAN RIJSINGE (1932) found in August 1930 in the Breede Water 84 mg/l chlorid and in the Quackjeswater 118 mg/l. The biological analysis of these two dune waters showed a community of predominantly fresh-water organisms in the Quackjeswater, and of



brackish water organisms in the Breede Water, which was rather surprising. The chemical and biological observations of 1962 are in concordance with each other. Dr. van Rijsinge told me that the data from 1930 concern an incidental observation, and moreover the observations on the Quackjeswater and the Breede Water were not done on the same day. So conclusions may have been erroneous.

Some data of other natural ponds and pools in the dune area of the island of Voorne are given here: Tenellaplas, near the biological station Weevers' Duin: May 1957 76 mg/l; September 1961 70 mg/l; Goudvispoel near Weevers' Duin: May 1957 42 mg/l; September 1961 54 mg/l. Both ponds are situated in the dunes at a considerable distance from the sea. The Tenellaplas is polluted by waterfowl. Four pools on the "Oude Groene strand" had in May 1957 resp. 144, 180, 340 and 256 mg chlorid per liter. These pools are situated near the sea behind the first row of dunes. Salt water from the subsoil may well have influenced these data.

Electric conductivity

The conductivity gives an insight in the total amount of ions in the water. The chlorid-ion in most surface waters runs parallel to the conductivity. The graphs show that the conductivity at both sampling stations in the Quackjeswater is rather constant.

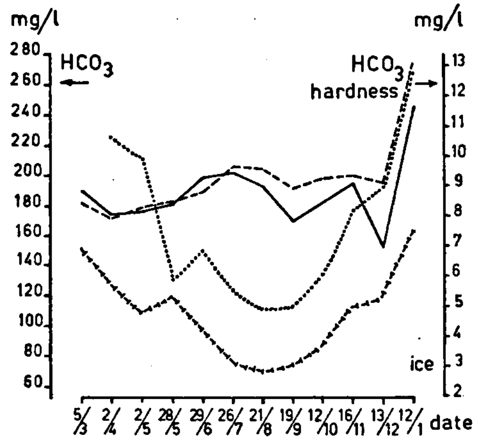
In the Breede Water the conductivity decreases rather sharply until the end of May, then runs parallel to that of Quackjeswater, but in September increases again. In this case electrolytes disappear from the water in summer, as these are utilized by organisms.

The Vogelmeer shows the same picture. The effect however is less marked and the values are lower. As chlorid-ions are increasing in summer, other ions must be implicated as well.

In comparison with other inland waters in our country, as for example the broads, conductivity is rather low. Similar values are only found in the Vechtplassen, which are moderate hard waters.

Calcium-hydrocarbonate equilibrium

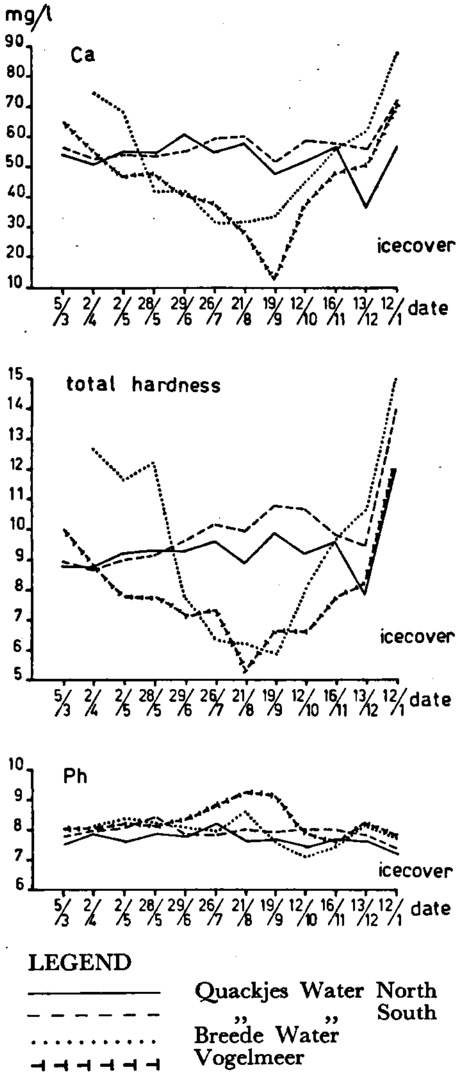
In the Breede Water and the Vogelmeer the graphs of Ca, HCO_3 and total hardness are similar. Under the influence of the assimilation



LEGEND

——————— Quackjes Water North
– – – – – – ,, ,, South
. . . . Breede Water
⊣ ⊣ ⊣ ⊣ ⊣ ⊣ Vogelmeer

of the green organisms calcium carbonate is precipitated, HCO_3 decreases and the pH mounts. This is very marked in the Vogelmeer in July, August and September. In the Quackjeswater practically no changes are to found in Ca, HCO_3 and pH throughout the year. Chemically these waters are of a different type. WESTHOFF (1953) states that the vegetation of the Breede Water is totally different from that of the Quackjeswater. The character of the vegetation of the Quackjeswater is similar to that of many inland fresh waters, with *Menyanthes trifoliata*, *Comarum palustre*, *Utricularia neglecta*, *inter alia* and a considerable amount of deposits is formed.



My own observations in 1962 roughly agree with this picture but I also observed a predominant growth of *Fontinalis antipyretica*. In the Breede Water growth of *Fontinalis* was very poor and here *Chara sp.*, *Littorella uniflora*, *Elodea canadensis inter alia* were predominant. In both waters a dense growth of filamental algae (*Mougeotia sp.*) develops. As a result of this dense vegetation, plankton is very scarce and so the water is transparant. These facts suggest that by lack of green plankton organisms, only bottom vegetation can affect the calcium-hydrocarbonate equilibrium. Finally, we see that the vegetation of *Fontinalis* does not affect the concentration of Ca and HCO_3 of the water, but that the vegetation of *Chara* is very active. These observations in the field are confirmed by observations in the laboratory, see RUTTNER, BARTH (1957) and others. They found that mosses like *Fontinalis* can only use dissolved CO_2 for assimilation, and Phanerogames like *Elodea*, *Potamogeton*, *Myriophyllum* and algae only HCO_3. As a result submerged mosses only occur in waters with a high amount of dissolved CO_2, such as bog lakes, the littoral of lakes subjected to wave action, the profundal of lakes and in little streams.

In the Quackjeswater a high concentration of dissolved CO_2 is caused by a high content of organic matter.

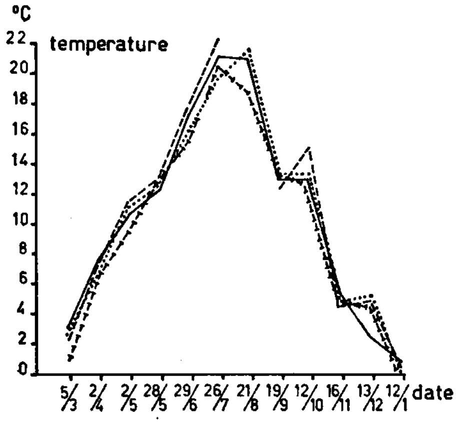
In the Breede Water there is a heavy decalcification caused by *Chara*. The difference in submerged vegetation of the Quackjeswater and the Breede Water results in a difference in conductivity, calcium and bicarbonate content and pH of the water.

The Vogelmeer also has a submerged vegetation of *Chara*, *Elodea* and *Myriophyllum* and resembles the Breede Water as an environment. However decalcification in the Vogelmeer is lower. At September 19 a very low concentration of calcium was found and at the same time Cl was very high. At August 21 the total hardness was very low, but now this seems to correlate with low values in dissolved and non-dissolved organic matter, as is visible in the graphs.

In the Quackjeswater the concentration of calcium has a rather constant value, as has been said already. In summer and autumn it increases a little. In the graphs this is very marked for the total hardness, though on September 19 we find some decalcification which may be caused by the action of waterplants and filamental algae which use HCO_3. At the northern sampling station the total hardness, the calcium and the HCO_3 are lower than at the southern station. Probably this is caused by a diminished assimilation activity on this overshadowed spot and the presence of more dissolved CO_2.

TEMPERATURE

The distance between the Quackjeswater and the Breede Water is only a few kilometers. The Vogelmeer is situated about 100 kilometers to the north. The graphs show that in spring the Vogelmeer warms up later and in summer the maximum temperature is about one degree lower. In autumn there is little difference in the temperature curves. In September and November temperature has increased during a period of warm weather. After December 13 all dune waters were ice covered.

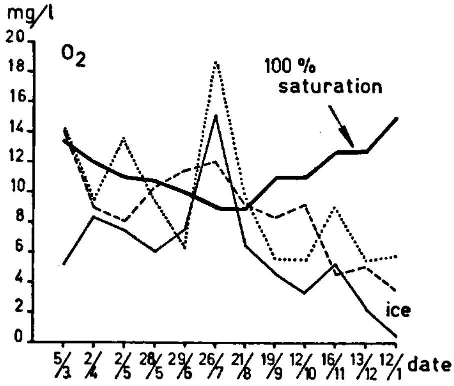


LEGEND

———— Quackjes Water North
- - - - - - „ „ South
. . . . Breede Water
⊣ ⊣ ⊣ ⊣ ⊣ ⊣ Vogelmeer

Dissolved oxygen and biochemical oxygen demand

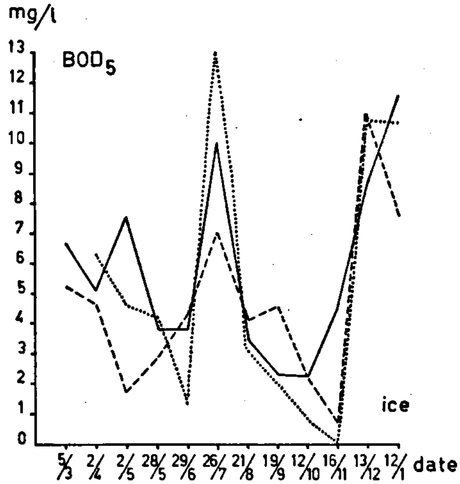
In the graphs the line of theoretical oxygen saturation is given. The oxygen values in the northern part of the Quackjeswater show that only on the 26th of July sufficient oxygen is present for the respiration of various organisms with some oversaturation caused by the assimilation of green organisms. In the southern part the oxygen



LEGEND

———— Quackjes Water North
- - - - - - „ „ South
. . . . Breede Water
⊣ ⊣ ⊣ ⊣ ⊣ ⊣ Vogelmeer

saturation is complete. Between March 5 and August 21 sufficient oxygen or oversaturation may be found. So the northern part and the southern part of the Quackjeswater show big differences in the oxygen balance. These may be caused either by a difference in light intensity or by a difference in oxygen consumption.



LEGEND

————	Quackjes Water North
– – – – – –	„ „ South
....	Breede Water
⊣ ⊣ ⊣ ⊣ ⊣ ⊣	Vogelmeer

In the Breede Water oxygen saturation runs fairly parallel to that of the northern part of the Quackjeswater (see graph). The Breede Water, however, is not overshadowed. The supersaturation on July 26 is coupled with a high oxygen consumption (see BOD_5). In winter, the BOD_5 is very high again, but the oxygen saturation is low as a result of diminished assimilation. The data are not sufficient to make some conclusions possible about the different roles played by bottom vegetation and plankton in the production and consumption of oxygen.

Organic matter

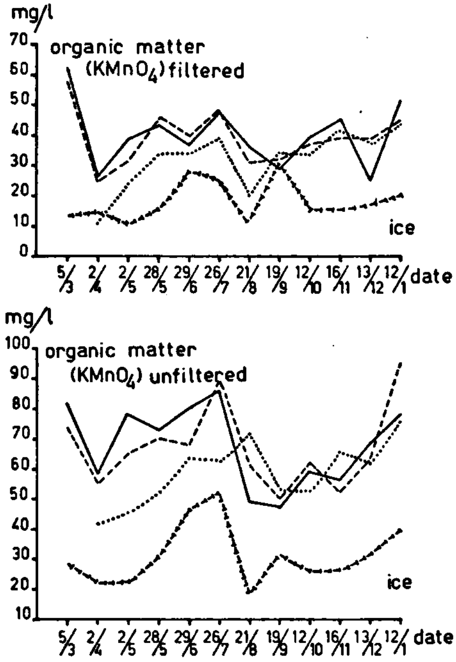
The amount of organic matter in filtered and unfiltered water was estimated by the $KMnO_4$-test. The total amount of organic matter is higher in unfiltered water, as the dune waters are very shallow with a dense growth of submerged vegetation. In the Breede Water and the Vogelmeer more open water is present.

The graphs show, that the Vogelmeer contains the smallest amount of organic matter, the Quackjeswater the largest. The Quackjeswater is the oldest one (origin ± 1500) and much organic matter may have accumulated. The Breede Water originated in ± 1920, when the dune valley was closed from the sea. The Vogelmeer finally was excavated in 1952.

In the Quackjeswater more organic matter is dissolved in the water during spring and summer. Under ice cover there is also much organic matter as bacterial mineralisation is lowered. This is as found in unfiltered water and so there may be a relation to the development of microorganisms (*Dinobryon*, *Peridinium*, *Cylops*). In autumn there is less organic matter, probably by a diminished development of microorganisms (especially decrease of *Dinobryon*) and an increased bacteriological activity.

In the Breede Water dissolved organic matter increases in the course of the season. At August 21 organic matter decreases, corresponding with an increase of PO_4 and NH_4. The relation to activities of microorganisms can only be guessed from a large quantity of zooplankton; growth of phytoplankton is very limited during that time of the year.

The curve of organic matter in the Vogelmeer runs parallel to that of the Breede Water. We also see an increase of zooplankton (*Polyarthra*, *Keratella cochlaris*) and of undetermined unicellular green flagellates.

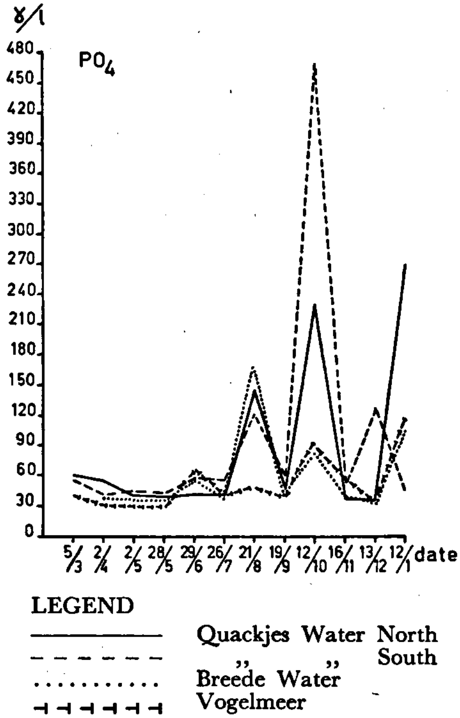


LEGEND

————————	Quackjes Water North
– – – – – –	,, ,, South
. . . .	Breede Water
⊣ ⊣ ⊣ ⊣ ⊣ ⊣	Vogelmeer

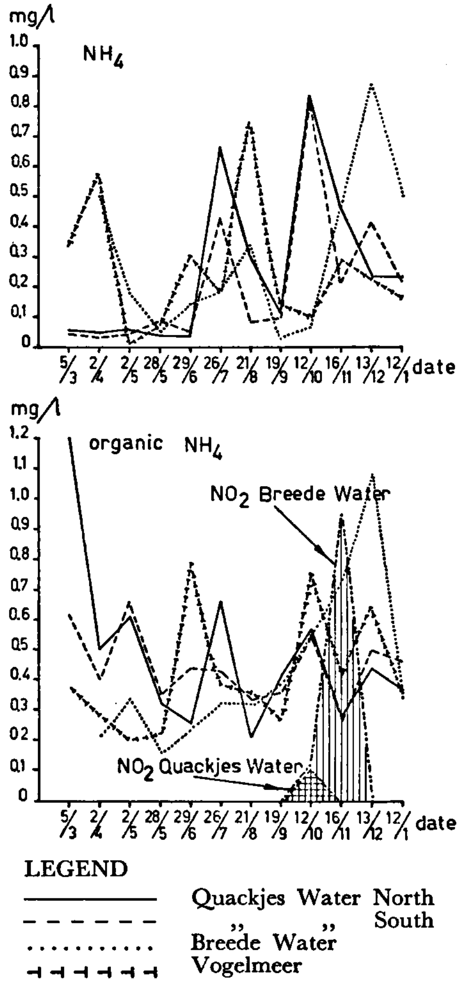
PO_4 AND N-COMPOUNDS

PO_4, NH_4, organic NH_4, NO_3 and NO_2 are present in rather varying quantities, so no conclusions in relation to biological activities can be given. The graphs show that PO_4 is high in summer and autumn; NH_4 and organic-NH_4 increase in the Breede Water in the course of the year; in early spring in the Quackjeswater (northern part) much organic ammonium is present. NO_3 was always absent in the three dune waters. NO_2 was only detected in autumn in the Breede Water and the Quackjeswater.



Comparison of the maxima of PO_4, NH_4 and organic-NH_4 shows the following points of interest. In spring PO_4 is low in the three dune waters, as it is used up by the intense growth of the organisms. At August 21 dissolved inorganic PO_4 is increasing in all waters except in the Breede Water, probably due to an initial starvation of the organisms. We also see that in some cases the PO_4-maximum is preceded by a maximum in organic and inorganic NH_4, as is the case on July 26, but on October 12, the maxima coincide. At this time NO_2 is also detected and it is clear that mineralisation products remain in solution by lack of organisms capable of using them. In November a slight increase in temperature shows an increase of oxygen and a month later a slight increase of PO_4, NH_4 and organic-NH_4

follows. (see Quackjeswater). The relations are complicated by the fact that the metabolism products of some organisms add to organic and inorganic PO_4 content of the water. Conclusions therefore are rather speculative.



BACTERIOLOGICAL DATA

For bacteriological examination samples were taken in the three dune waters by Miss F. C. Roest, of the State Sanitary Institute. This was done in connection with other research concerning the effect of waterfowl on the chemical and biological quality of the water (guanotrophy). The dune waters are only polluted by the excrements of birds and so all the *Escherichia coli* found will be bird coli. In the Vogelmeer and the Breede Water there is a colony of blackheaded gulls (*Larus ridibundus*), in the Quackjeswater only a few birds (ducks) are present. The number of Coliform bacteria in the Vogelmeer was 540, in the Breede Water 540, in the northern part of the Quackjeswater 9 and in the southern part 32. The birds also bring organic matter into the water, especially PO_4. In the analyses the effect of this addition of PO_4 is not noticeable. The influence must have been small, probably because the birds nest on the land. In an other water, situated more inland, (Wasmeer Hilversum), birds nest on Molinia surrounded by water and here the number of Coliform bacteria was estimated during the same period at 1500 and an increase of PO_4 was found as well. The bacterial counts after cultivation at 22° C were as follows. Quackjeswater—north part 1150, south part 1400. Breede Water 1400, Vogelmeer undetermined. The number of bacteria cultivated at 37° C respectively: 375, 510, 460, 320. The numbers of the first group are somewhat higher than that of the Wasmeer, those of the last group are of the same order of magnitude. In comparison with other waters in our country (broads) the numbers in the first group are slightly, those of the last group very much lower.

MICROORGANISMS

The dune waters are very shallow (depth 1–2 meters) and there is a dense growth of submerged vegetation.

The Quackjeswater is richest in number of species. The list shows, that some species occur regularly. These are *Cyclops sp.*, *Diaptomus gracilis*, *Polyarthra sp.*, *Mytilina mucronata*, *Peridinium sp.*, *Dinobryon sertularia*, *Botryococcus braunii*, *Mougeotia sp.* Some species develop well in spring as *Synchaeta sp.*, *Keratella quadrata*, *Synura uvella*, *Dyctiosphaerium sp.*, *Dinobryon sp.* and others. The Cladocera reach maxima in autumn, Rotifera develop in summer. Flagellates, green algae, desmids, diatoms and blue algae occur predominantly in summer and autumn. The species found are common in eutrophic fresh and shallow water and this is in accordance with the chemical analyses of the water. Flagellates are dominant, diatoms are few and also green algae are not present in great numbers. There are many species of Cladocera and Rotifera.

There is no vegetation colour caused by development of plankton organisms. Only a few species develop in great numbers and of these separate graphs are added.

There is some difference in the composition of the plankton in the northern part and the southern part of the Quackjeswater. The northern part is overshadowed by trees and sheltered from wind. The submerged vegetation is evenly distributed and probably no factor of importance to the microorganisms in this relation. In the southern part were found mainly: Rotifera *Platyias patulus*, *Lecane luna*, *Filinia longiseta*, Cladocera *Pleuroxus aduncus*, the green algae *Pediastrum integrum* and the gelatinous globules of *Nostoc sp.* In the northern part, were found: Cladocera *Daphnia longispina*, *Simocephalus expinosus*, *Scapholeberis mucronata*, *Eurycercus lamellatus*, *Ostracoda*, Rotifera *Rotaria sp.*, *Squatinella rostrum*, *Brachionus bakeri* and the blue green filaments

TABLE 1

	Quackjeswater											
1962											ice	ice
Month	3	4	5	5	6	7	8	9	10	11	12	1/63
Day	5	2	2	28	28	26	21	18	12	15	12	11
Quackjeswater	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Crustacea:												
Cyclops sp.	11	32	53	31	11	1	1	21	1	21	22	22
Diaptomus gracilis		1	1	2	1	11	21	2	22	22	1	
Harpacticiden		1	1		1	1			11		1	1
Daphnia longispina		1								1	1	
Bosmina sp.				1	1			1				
Acroperus harpae			1					1	11	1	1	11
Simocephalus vetulus . . .					11	1		11	11	1	1	
Simocephalus expinosus . .									1	1		
Simocephalus serrulatus . .									1			
Scapholeberis mucronata . .									1			
Alona quadrangularis . . .			1	1		1		1	11			
Alona sp.					1			1			1	
Chydorus sphaericus	1	1	11	1	11	1		1	1			
Graptoleberis testudinaria .						1			11	1		
Rhynchotalona rostrata . .											1	
Peracantha truncata							1					
Eurycercus lamellatus . . .								1	1	1	1	
Ostracoda	1								1	1	1	
Pleuroxus aduncus								1	1	1		
Alonella nana				1				1	1		1	1
Ceriodaphnia pulchella . .												
Diaphanosoma brachyurum .												
Camptocercus rectirostris . .												
Rotatoria:												
Keratella cochlearis					11		1	11		11	1	11
Keratella quadrata		11	52	1								
Polyarthra sp.	11	44	12	11	21	1	13	11	1	11		1
Platyias patulus								2	2	1		
Platyias quadricornis . . .	1											
Testudinella patina			1		1	11		1	11	11	1	1
Trichotria tetractis						1	1			1		
Trichotria pocillum	1	1			11	1	1	11	11	1		1
Notholca foliacea	11	11										
Rotaria sp.									1	1	1	
Synchaeta sp.	1	11	3	21	1		1	1				
Monommata longiseta . . .		1		1	1	11	1					
Euchlanis sp.					11	1	11	11	1			1
Lepadella rhomboidula . .							1					
Lepadella patella					1	1				1		
Lecane sp.				1		11	1	11	11	11		1
Lecane luna	1	1			1		1	1				
Lecane lunaris		1										
Mytilina mucronata	1	1	1	1	1	1	1	1	1	1	1	11
Mt. ventralis var. macr. . .						1	1	1	11		1	1
Colurella sp.					11	1		1		1		
Anureopsis fissa					11	2	1					
Squatinella rostrum						1	1					
Trichocerca longiseta . . .				1		1	1	1		11		1
Brachionus bakeri							1	1				

TABLE 1 (continued)

	Quackjeswater											
1962											ice	ice
Month	3	4	5	5	6	7	8	9	10	11	12	1/63
Day	5	2	2	28	28	26	21	18	12	15	12	11
Quackjeswater	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Br. calyciflorus	1											
Cathypna luna												1
Lophocharis salpina		1										
Scaridium longicauda					1							
Eudactylota eudactylota						1						
Filinia longiseta	1	1	1									
Asplanchna sp.									1			
Protozoa:												
Arcella vulgaris	1	1			11	1	11	21	1	11		11
Centropyxis aculeata					11	2	1	11	1	1		1
Difflugia sp.												1
Flagellatae:												
Synura uvella	23	11	3								1	1
Peridinium sp.	23	32	43	32	22	11	33	31	2	1	12	13
Dinobryon sertularia	24	33	52	33	31	12	12	11				1
Eudorina elegans	11	11			11	12	22	1	11	11	1	11
Pandorina morum	2	11	11			1	1		11	11		
Euglena acus		11	11	1		1	1			1		11
Trachelomonas sp.		1			1	1	1		1			
Euglena sp.					1				1	2		
Volvox aureus				11	11		1					
Gonium pectorale					11	12	11	1				
Phacus tortus										1		
Phacus pleuronectes							1					
Phacus longicauda		1				1	1			11		
Phacus sp.									1	1		
Uroglena volvox								1	2	1		
Chlamydomonas sp.								21	21	2		
Gymnodinium sp.						1		1	1	1		1
Undetermined						12	22		1		1	11
Chlorophyceae:												
Pediastrum biradiatum							1	1	11	11		1
Pediastrum boryanum		1		11	1	11	1	1	11	11		1
Pediastrum duplex						1			1	1		
Pediastrum integrum/gland.		11		1		1		1	1	1	1	
Scenedesmus quadricauda		1		1	1	1	1	11				
Scenedesmus acuminatus						1						
Scenedesmus sp.	1											
Coelastrum microporum						1						
Dyctiosphaerium sp.	11	1	31	3	21	11	1			1		
Botryococcus braunii	1	1	1	11	11	1	11	11	11	2	1	11
Ankistrodesmus falcatus		1			1	1	1					
Oocystis submarina					1		1	1	1			
Selenastrum gracile						1	11	11		1		
Tetraedron minimum	1											
Tetraedron sp.	1											
Crucigenia rectangularis									1			
Mougeotia sp.	11	11		12	13	33	11	14	14	22	1	1

TABLE 1 (continued)

	Quackjeswater											
1962											ice	ice
Month	3	4	5	5	6	7	8	9	10	11	12	1/63
Day	5	2	2	28	28	26	21	18	12	15	12	11
Quackjeswater	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Cladophora sp.						1						1
Spirogyra sp.		1			2		1	1	1	2	1	1
Zygnema sp.												
Desmidiaceae:												
Pleurentaenium sp.	1					2		1	11	1	1	1
Closterium sp.	11	1			1	2	1	11	1	1	1	1
Staurastrum sp.	1	1	1			1	1	11	11	1		
Micrasterias truncata												1
Cosmarium sp.						2	11	12	12	1	1	1
Gonatozygon kinahana						11						
Euastrum sp.						1	1	1	11	1		
Diatomeae:												
Diatoma elongatum	11	1										
Fragilaria capucina	11	11		1			11	1	1	11	11	1
Fragilaria crotonensis						1	1	1				
Synedra ulna	1	1			1			11	2	11	12	11
Nitzschia sigmoidea									1	1		
N. acicularis	2						11	1	1			
Kleine pennatae	21						1	11	21	21	1	2
Cyanophyceae:												
Cylindrospermum sp.						1	2	3	1	2	1	
Gomphospaera aponina											1	1
Chroococcus sp.										1	1	
Nostoc sp.						1	1	1		1	1	
Tolypothrix sp.										1	1	

1 = present, 2 = few specimens, 3 = many specimens, 4 = abundant, 5 = very abundant.
* = present in 1959, 60 or 61.

TABLE 2

	Vogelmeer											
1962												ice
Month	3	4	5	5	6	7	8	9	10	11	12	1/63
Day	5	2	2	28	28	26	21	18	12	15	12	11
Crustacea:												
Cyclops sp.	1		2	2	1	1	2	2	2	1	1	
Daphnia longispina			1	1		1	1					
Daphnia pulex	*		*									
Bosmina sp.								1	1	1	2	1
Acroperus harpae	1											
Simocephalus vetulus	1											
Alona quadrangularis						1			1			
Alona sp.	1	1										
Chydorus sphaericus	1											
Eurycercus lamellatus												
Ostracoda						1	1	1	3			
Pleuroxus aduncus												
Alonella nana								1				
Ceriodaphnia pulchella												
Harpacticiden												
Pleuroxus uncinatus									3			
Daphnia magna							*	*				
Simocephalus serrulatus												
Rotatoria:												
Keratella cochlearis			1	1	2	1	3	3	2	3	3	3
Keratella quadrata		1	1			1	1	1		1	1	1
Polyarthra sp.	1	4	1	1	1	2	1	3	2	3	2	2
Testudinella patina							*					
Trichotria pocillum						1	1					1
Notholca foliacea	2	1										1
Notholca acuminata	1	1		1								1
Notholca striata												1
Synchaeta sp.	1	1	1		1						2	1
Euchlanis sp.	1							1				
Asplanchna sp.			1	1	1	1	1	1	1	3	1	
Trichocerca sp.				1								
Colurella sp.				1								
Cathypna luna				1								
Lecane sp.					1			1				
Lepadella patella						1						
Filinia longiseta							1	2				
Anureopsis fissa							3					
Pompholyx sulcata								1				
Rotifer sp.										1		
Mytiina mucronata							*					
Lecane lunaris												
Brachionus rubens												
Metopidia oxysternum												
M. triptera												
Brachionus bidens												
Collotheca mutabilis												
Conochilus unicornis												
Protozoa:												
Ophrydium versatile				1		1						

TABLE 2 (continued)

	Vogelmeer											
1962												ice
Month	3	4	5	5	6	7	8	9	10	11	12	1/63
Day	5	2	2	28	28	26	21	18	12	15	12	11
Centropyxis aculeata . . .						1	1					
Arcella vulgaris						1	1		1	1		
Flagellatae:												
Eudorina elegans	1			1	1	1	1					
Pandorina morum	1			1					1			
Dinobryon sertularia . . .				1					1			
Peridinium sp.	1		1	2								1
Gonium sociale				1								
Gymnodinium sp.												
Trachelomonas volvocina .						1						
Undetermined	1	2					1	3	3	2	2	2
Uroglena volvox												
Volvox aureus												
Chlorophyceae:												
Botryococcus braunii . . .				1		1	2	3	2	1		
Pediastrum boryanum . . .	2			1			1		1	2	1	1
Pediastrum integr/gl	1	1	1	1	2	2	1		2	2	1	
Scenedesmus quadricauda .						1				1		
Scenedesmus sp.						1			1		1	1
Coelastrum microporum . .	1				1				1			
Crucigenia rectangularis . .					3		1					
Oocystis submarina					4	2			1	1		
Dyctiosphaerium pulchellum								1				
Mougeotia sp.	1	1		1		1	1					
Spirogyra sp.	1	1		1						1		1
Oedogonium sp.												
Pediastrum biradiatum . .							*					
Cladophora sp.							*					
Zygnema sp.												
Kirchneriella obesa												
Desmidiaceae:												
Cosmarium sp.	1			1	1	1	1		1	1		
Staurastrum sp.	1					1	3		2	1		
Closterium sp.					1	1	1			1	1	
Euastrum verrucosum . . .						1	1					
Gonatozygon sp.												
Penium sp.?				1								
Pleurentaenium sp.												
Diatomeae:												
Diatoma elongatum	5	1				1	1			1	2	1
Diatoma vulgare	1	4								1		
Fragilaria capucina	3	3			1	1	1	1	2	2	1	1
Fragilaria crotonensis . . .	3											
Synedra sp.	1					1					1	1
Surirella sp.					1							
Pinnularia viridis					1				1	1		
Nitzschia sigmoidea						1	1			1	1	
Nitzschia acicularis							3	2				

TABLE 2 (continued)

Vogelmeer												
1962												ice
Month	3	4	5	5	6	7	8	9	10	11	12	1/63
Day	5	2	2	28	28	26	21	18	12	15	12	11
kleine pennatae	3	1			1			1	2			
Cymatopleura elliptica										1		
Cyanophyceae:												
Oscillatoria aghardii cf	1	3	3	3						1		
Anabaena sp.									1			
Gomphosphaera aponina					1	1	1	1	1	1	1	
Merismopedia sp.	1											
Gloeiotrichia pisum						3						
Lyngbya limnetica								1				

Breede Water												
1962												ice
Month	3	4	5	5	6	7	8	9	10	11	12	1/63
Day	5	2	2	28	28	26	21	18	12	15	12	11
Crustacea:												
Cyclops sp.		2	1	1		3	2	1	3	1	3	3
Daphnia longispina					1	1	1	1	1			2
Daphnia pulex			2						2	1		
Bosmina sp.												
Acroperus harpae		1	1	1								1
Simocephalus vetulus			1	1	1					1		
Alona quadrangularis			1									
Alona sp.				1								
Chydorus sphaericus				1								
Eurycercus lamellatus								1			1	
Ostracoda				1				1	1			
Pleuroxus aduncus			1	1								
Alonella nana			1	1							1	
Ceriodaphnia pulchella					1		1	1				
Harpacticiden			1	1	1							1
Pleuroxus uncinatus												
Daphnia magna								*				
Simocephalus serrulatus			*									
Rotatoria:												
Keratella cochlearis		1	2		2	1	1	1	2	1	1	
Keratella quadrata					1						1	
Polyarthra sp.		2	1	1	1	2	2	2	2	2	1	1
Testudinella patina		1		1						1		
Trichotria pocillum		1		1								1
Notholca foliacea		1	1									
Notholca acuminata												
Notholca striata												
Synchaeta sp.			1		1			1	2	1	2	1
Euchlanis sp.			1									
Asplanchna sp.			1			1	1	1	1		1	1
Trichocerca sp.								*				

TABLE 2 (continued)

	Breede Water											
1962												ice
Month	3	4	5	5	6	7	8	9	10	11	12	1/63
Day	5	2	2	28	28	26	21	18	12	15	12	11
Colurella sp.												
Cathypna luna												
Lecane sp.				1	1		1	1	1			
Lepadella patella												1
Filinia longiseta				*								
Anureopsis fissa						1	1		1			
Pompholyx sulcata						1						
Rotifer sp.												
Mytiina mucronata				1								1
Lecane lunaris							1					
Brachionus rubens					1							
Metopidia oxysternum				*								
M. triptera				*								
Brachionus bidens				*								
Collotheca mutabilis								*				
Conochilus unicornis								*				
Protozoa:												
Ophrydium versatile												
Centropyxis aculeata				1								
Arcella vulgaris				1			1	1				
Flagellatae:												
Eudorina elegans					1	1	1					1
Pandorina morum												
Dinobryon sertularia		1			4	1						1
Peridinium sp.		1			2	2	1	1	1	1		2
Gonium sociale												
Gymnodinium sp.										1	1	1
Trachelomonas volvocina												
Undetermined									2	2	2	2
Uroglena volvox			*									
Volvox aureus			*									
Chlorophyceae:												
Botryococcus braunii				1	1	1	1	1	2	2		1
Pediastrum boryanum		1			1			1	1	1		
Pediastrum integr/gl			1		1				1	1	1	
Scenedesmus quadricauda					1					1		
Scenedesmus sp.								1				
Coelastrum microporum												
Crucigenia rectangularis												
Oocystis submarina												
Dyctiosphaerium pulchellum						1	1					
Mougeotia sp.		1	2		1	1	1	1				1
Spirogyra sp.		1	1									
Oedogonium sp.					1							
Pediastrum biradiatum												
Cladophora sp.												
Zygnema sp.			*									
Kirchneriella obesa								*				

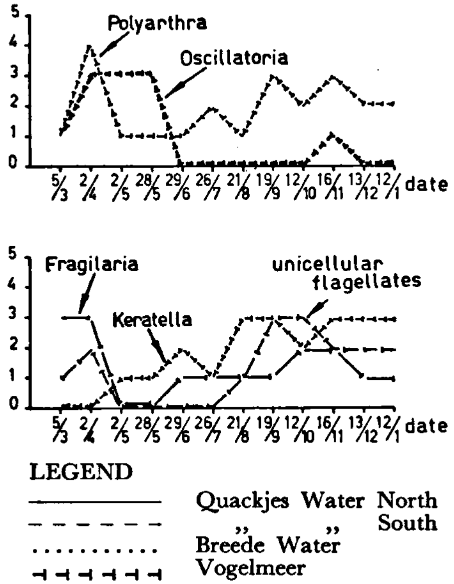
TABLE 2 (continued)

	Breede Water											
1962												ice
Month	3	4	5	5	6	7	8	9	10	11	12	1/63
Day	5	2	2	28	28	26	21	18	12	15	12	11
Desmidiaceae:												
Cosmarium sp.			1		1							
Staurastrum sp.					1		1		1			
Closterium sp.					1		1					
Euastrum verrucosum . . .												
Gonatozygon sp.					1							
Penium sp.?												
Pleurentaenium sp.			*									
Diatomeae:												
Diatoma elongatum					1						1	1
Diatoma vulgare												
Fragilaria capucina		1							1			1
Fragilaria crotonensis . . .												
Synedra sp.												1
Surirella sp.										1		
Pinnularia viridis												
Nitzschia sigmoidea			1		1							
Nitzschia acicularis												
kleine pennatae		1			1							
Cymatopleura elliptica . . .											1	
Cyanophyceae:												
Oscillatoria aghardii												
Anabaena sp.					1			1				
Gomphosphaera aponina . .									1	1	1	1
Merismopedia sp.								*				
Gloeiotrichia pisum												
Lyngbya limnetica							2					

of *Cylindrospermum sp.* The influence of the greater light intensity in the southern part shows clearly in the abundant growth of *Mougeotia* filaments. The occurrence of the cladocere *Scapholeberis* clinging to the watersurface in the northern part, may be explained by the sheltered situation. The presency of more decaying leaves in the water is certainly also an important factor.

The plankton observations in previous years are in agreement with those in 1962. No essential differences were found in the composition of the plankton. The dune waters are undisturbed and have a fairly constant chemical composition and the composition of the plankton community seems to be more or less constant too.

The Breede Water and the Vogelmeer are different from the Quackjeswater in composition of plankton. There is more open water and so fewer bottomliving organisms are caught. In both waters are present: *Cyclops sp.*, *Keratella cochlearis*, *Polyarthra sp.*, *Asplanchna sp.* In the Vogelmeer are regularly present: *Keratella quadrata*, *Pediastrum* *integrum*, *Cosmarium sp.*, *Fragilaria capucina*, *Gomphospaera aponina*. In the Breede Water: *Botryococcus braunii*, *Daphnia pulex*, *Peridinium sp.*

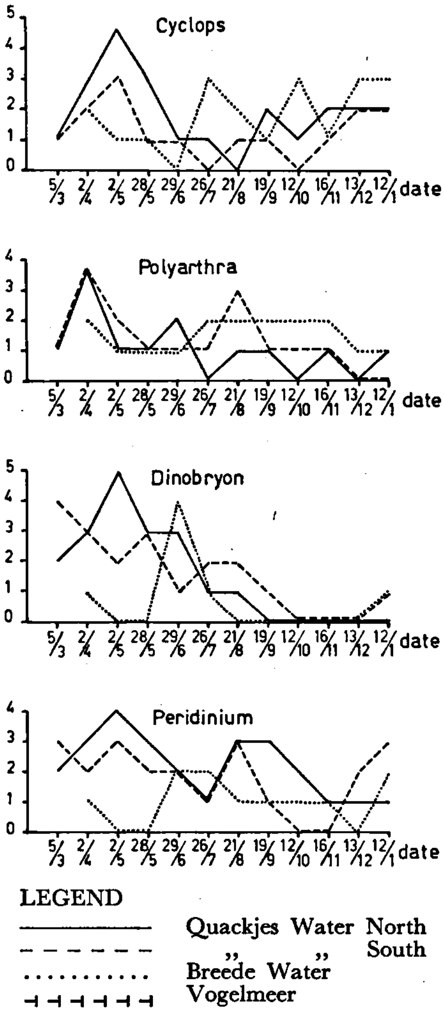


The amount of species is about the same and less than in the Quackjeswater. A striking difference between the two waters is the scarcety and irregular occurrence of diatoms in the plankton of the Breede Water. In the Vogelmeer some species are rather numerous as *Polyarthra* (spring, autumn), *Keratella cochlearis* (summer and autumn), *Fragilaria capucina* (spring), *Diatoma elongatum* (spring), *Oscillatoria cf. aghardii* (spring); in the Breede Water these are: *Cyclops sp.* (summer, autumn), *Dinobryon* (spring), *Peridinium* (summer). Except under the ice at March 3, 1962 the Vogelmeer never shows very great numbers of individuals. Some similarity between the plankton of the Quackjeswater and the Breede Water exists in the combination of the species *Dinobryon*, *Peridinium*, *Cyclops* and *Polyarthra*. The Vogelmeer stands separately with a combination of *Oscillatoria*, *Fragilaria capucina*, *Notholca spp.* and *Gloeiotrichia pisum*. *Oscillatoria cf aghardii* also was found in previous years and only occurs in spring. It is of interest that in the Breede Water no *Bosmina spp.* were found.

The Copepod *Diaptomus gracilis* is a typical freshwater organism. This species was found only in the Quackjeswater. Hofker and van Rijsinge (1932) made the same observation. This again strengthens general opinion, that a plankton community in a body of water is constant as a rule, some species being present every year and others lacking every year.

An important factor in the development of the biocommunities of the dune waters may be that in dry summers no water remains.

This however occurs only with intervals of many years in the three dune waters under discussion. In pools that dry up every year in summer, a typical community may be found of specially adapted organisms. These biotopes have not been under observation this time.



It has been mentioned already that in 1963 other dune waters will be investigated in the same way. The results will be compared with those of the three dune waters discussed in this paper. Probably the data will provide a better insight in the complicated interrelations of microorganisms, bottom vegetation and chemical conditions in these shallow waters.

REFERENCES

BAARS, J. K. und I. J. LE COSQUINO DE BUSSY. 1960. Revue Suisse d'Hydrologie **22**, fasc. 1.

BARTH, H. 1957. Aufnahme und Abgabe von CO_2 und O_2 bei submerse Wasserpflanzen. Gewässer und Abwässer, H 17/18.

HOEVE, TER J. 1960. Enige aspecten van de Waterhuishouding in Voorne's Duingebied. Rapport van het Dienstvak Natuurbescherming van het Staatsbosbeheer.

HOFKER, J. en C. VAN RIJSINGE. 1932. De Levende Natuur **36**.

——— en ———. 1934. Over het duingebied van Voorne. Voorne-nummer van Natura juni.

———. 1928–29. Tijdschr. Ned. Dierk. Ver **3**: I.

———. 1940. De Levende Natuur **45**.

LE COSQUINO DE BUSSY, I. J. 1959. Verslag van een limnologisch onderzoek in een poeltje in de duinen van Meyendel. Rapp. Inst. Gez. Techn. TNO.

LEEFLANG, K. W. H. 1938. Chem. Wkbl. **35**.

LEENTVAAR, P. en L. W. G. HIGLER. 1963. De Levende Natuur **65**.

———. 1957. De Levende Natuur **60**.

———. 1960. Hydrobiologische waarnemingen op het eiland Voorne. RIVON-rapport.

MASCHHAUPT, J. G. 1938/41. Lysimeteronderzoekingen aan het Rijkslandbouwproefstation te Groningen en elders. Versl. en Landb.k. onderz. I, 1938; II, 1941.

WESTHOFF, V. 1953. Natuur en Techniek **21**: 6.