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Further developments in Lake Brokopondo, Surinam.

by

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At the congress of the SIL in Poland, 1965, I presented a paper on the observations which were carried out during the first filling of the newly constructed Brokopondo man-made lake in Surinam (LEENTVAAR, 1966). The observations were continued during the three succeeding years by J. van der HEIDE. In 1967 the continuous research by a team of biologists ceased and in the following years the lake was only investigated occasionally. The author revisited the lake in April 1968 and it is the observations made then which are considered here.

In August 1967 the level of the water near the dam was 43 metres and on April 30th, 1968, it was 41.80 metres. This shows the fluctuations of the water level, which may be caused partly by the operation of the turbines and partly by the varying amounts of precipitation. The significance of evaporation and evapotranspiration in this connection is clear, but insufficient data were available at that time. Tests with water hyacinth indicated that the water loss caused by evapotranspiration was much greater than the evaporation from a free water surface. According to the observations of the Department of Hydraulics in Surinam, the evaporation of the free water surface at the dam amounted to an average of 4.5 mm per day. The precipitation of Afobaka averaged 5.5 mm and at Pokigron 5.7 mm This means, that a small surplus of precipitation resulted. However, the rate of evapotranspiration has not been taken into account. It must be mentioned also that two observation stations for precipitation measurements are insufficient and therefore the Department of Hydraulics has established several other stations in the lake area, which will give more reliable results in the future. The problem of evapotranspiration also needed more research, which has been obtained by some experiments (WEERT, v.d. & KAMERLING, 1967). The development of the water hyacinth in the lake in relation to water loss was of great interest for the managers of the turbines. From 1964 the problem of chemical control was considered by the Surinam Aluminum Company, which started control by spraying 2 - 4 D by plane and boat. In 1968 some results were recorded: in 1966 the area covered by water hyacinth was 41 200 hectares (53 %) (J. van DONSELAAR, 1968), in 1968 it was estimated that about 40 % of the surface area was occupied by the plants.

The effect of the control of water hyacinth, together with the disappearance of tree tops under water, was clear from the increasing area of open water. As a result, wind action increased and this caused better mixing of the water layers. Consequently, the rotting of the organic matter proceeded more rapidly than anticipated, as will be shown by the observations on oxygen content. Water hyacinth fields still occurred between the trees and in the southern part of the lake. The floating water fern *Ceratopteris pteridoides* was no longer present so far as I could see, but bladderwort (*Utricularia sp.*) and *Jussieua natans* must be mentioned. Amongst the roots of water hyacinth many organisms were found, for example larvae of dragonflies, water bugs, water beetles, crustaceans, like *Cyclestheria hislopi* and shrimps, and also young fish. Of the aquatic snails only a few *Drepanotrema anatina* were found locally. The fish in the lake were dominated by pireng (*Serrasalmo rhombeus*) and the toekoenari (*Cichla ocellaris*), both of which gave a good sport.

At the fixed sampling stations in the lake, measurements on conductivity, temperature, oxygen content and plankton were carried out. Thanks to the activity of the Department of Hydraulics in Surinam, regular monthly observations were made at the stations, which guaranteed a continuous picture of the developments in the lake. During my stay in April 1968 I took samples at the stations in the lake and one in the affluent Surinam River near Pokigron. The temperature of the water ranged from 26° near the bottom to 32° at the surface; the conductivity ranged from 20 μS at the surface to $>$ 100 at the bottom near the dam where the depth of the water is greatest. pH ranged from 5.3–6.7. It appeared that near the dam (Afobaka) free oxygen was present close to the bottom. On April 11th, at Afobaka 3 mg/l.O_2 were present at 35 metres; in the centre of the lake at Kabel, 7.3 mg/l. at 25 metres (bottom) and at station Sara, which is situated in a drowned forest area, the concentration was 5.2 mg/l. at 30 metres (bottom). The vertical distribution of the oxygen alternated with anaerobic layers. Therefore, at the stations of Afobaka and Sara the vertical series of measurements were made every two hours on one day. The results showed that by day the surface layers, from 0–2.5 metres, were always almost saturated with oxygen. Below this depth the oxygen content was very unstable. Total absence of oxygen alternated with oxygen supersaturation within a few hours - even at the bottom. In these samples, living planktonic crustaceans were observed when oxygen was present and dead specimens if no oxygen was found. The cause of the instability must be related to the increased wind action on the open water, especially after heavy showers and wind, causing abrupt and intensive mixing of the water from different areas.

The improvement in the oxygen content of the deeper water layers indicated that the mineralization of the organic matter proceeded rapidly. Laboratory tests with oxygen bottles made it clear that in samples of the superficial layer from about 5 metres the oxygen content after three days in the dark remained fairly constant, whereas those from the deeper layers were often depleted of oxygen within three days. This difference in degree of mineralization shows that the epilimnic water layers contain cleaner water. Samples from deep water often contained H_2S. This was always the case at wind protected locations, in shallow water with many submerged trees and under fields of water hyacinth. At these locations a sharp drop of temperature could be found in the first 5 metres (32°–28°) and oxygen also dropped sharply from 7–8 mg/l. to zero over the same depth interval.

It has been shown on a former occasion that the lake might be divided into a riverine zone, a transitional zone and a lake area as an expression of the effect of the Suriname River in the lake and the related processes of self-purification. Apart from the physical and chemical differences in the zones, the composition of the plankton is instructive. The flowing water of the Suriname River contained few specimens. Brown detritus was fairly abundant, together with spiculae of sponges, iron bacteria, and colonies of the flagellate *Rhipidodendron huxleyi.* The plankton had a brown colour. Further to the north in the lake, where the water became stagnant, the plankton was less brown and most of the species of the potamoplankton were absent but there was a slight increase of zooplankton. On the next stretch into the lake, the colour of the plankton turned to pale green, as algae such as *Volvox, Eudorina* and *Cosmarium* became abundant. In this zone the water was supersaturated with oxygen (transitional zone). Near to the middle of the lake large quantities of *Cyclops* and *Ceriodaphnia cornuta* were present together with large numbers of *Cosmarium spp.* and *Eudorina elegans.* Here the water was not supersaturated with oxygen. Further to the north, in the direction of the dam site, all these species decreased in numbers and the plankton was composed mainly of large quantities of desmids, such as *Staurastrum leptacanthum* and other *Staurastrum spp., Closterium spp., Cosmarium sp., Cosmocladium sp., Desmidium sp.,* and *Micrasterias spp.* Crustacea, Rotifers, *Volvox* and *Eudorina* were less abundant. Typical components of the plankton were the Ostracods, which generally live in shallow water near the bottom. In conclusion, the plankton of the lake environment at this time was composed mainly of desmids, Crustaceans, Rotifers, *Volvox* and *Eudorina.* Diatoms and blue-green algae were virtually absent. The actual bloom of desmids and the decrease of flagellates indicate that the water is less saprobic than in former years, which is in accordance with the data on oxygen content and oxygen consumption. As far as I know, blooms of desmids are a rare phenomenon in great lakes and they indicate that a biological equilibrium has not yet been established here, in spite of the fact that there is a succession in plankton communities. As soon as the lake becomes equilibrated, it may be anticipated that no bloom of desmids will appear. However the lake will remain as an oligotrophic environment in which desmids will dominate.

For further details on the development of plankton in Lake Brokopondo, reference may be made to the paper of J.v.d. HEIDE at the S.I.L. - Congress in Leningrad, 1971. and to my paper presented in May this year at the International Symposium on Man-made Lakes, Knoxville, U.S.A..

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Summary

After the closing of the dam in the Suriname River in 1964, the changes in the environment and plant and animal life were followed continuously during three years. Several publications about the vegetation, fish fauna and hydrobiology from different investigators appeared.

In 1968 the author revisited the lake for some weeks and the hydrobiological observations in that period are given here, in addition to the data given at the IVL-Congress in 1965 (see: IVL-Handl. 16, 1966).

In May 1968 the water gauge was 237 ft. In August 1967 the mark of 241 ft. was reached and the work was ready for use. An estimated 40 % of the lake was covered by water-hyacinth (*Eichhornia crassipes*). The plants were controlled by spraying 2 - 4 D, from aeroplane and boats. Information from 1970 reports that the water-hyacinth is practically absent now.

As a result of the drowning of trees and the disappearance of water-hyacinth the effect of wind on the water has increased. This caused currents and mixing of the lake water.

Oxygen was found even at the bottom at a depth of 35 m. The vertical distribution of oxygen was irregular and changed rapidly at all depths during the day. In sheltered stations oxygen remained low and was absent below 5 meter. The observations in 1968 point to an improvement of the oxygen content in the lake; the information from 1970 however indicates that no further progress is made, probably as a result of the large amounts of decaying water-hyacinths, which must be present near the bottom by the radical control.

Fish developed well in the lake but there are few species, represented by *Cichla ocellaris* and *Serrasalmo rhombeus.*

The pH at different stations ranged from 5.5 to 6.4 with the highest value at the surface. Conductivity ranged from 20 to 40 μS at the surface and increased to the bottom. In this environment Desmids develop in great numbers; diatoms and blue-algae were scarce; plankton crustaceans and rotifers were present in great numbers. Compared to former years, the rich development of *Volvox* and *Eudorina* was decreasing.