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RESULTS FROM CHEMICAL-FYSICAL INVESTIGATIONS IN LAKE LÅNGSJÖN, April 1968 - January 1969

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I. Background to and treatment with aluminium sulphate

The course in principal in an "overfed lake"

A "natural" "young" lake functions as a trap for nutrient salts. This means that more nutriment is brought into the lake than is discharged. These nutriments - above all phosphorus - are stored in the bottom sediments (in the case of phosphorus it is an iron(3)phosphate-humus complex). As there permanently is a certain inter-change between sediment and water, the storage of nutriments in the sediments will at long sight increase the concentration of nutriments in the water too. The increased concentration of nutrient salts in the water brings along an increased primary production and an increased consumption of oxygen during the break-down of the formed organical substance.

As the lake is enough rich of nutriment - an uninfluenced lake might need ten thousands of years, while a lake polluted by humans might make it in a few decades - the production will be so high that all the available oxygen in the crop of water will be used during the stagnation period for breaking down the organical substance formed. Connected with this there is a principal change of the lake's status seen from the view of conversion of nutriments. Combined with lack of oxygen the ferric iron is reduced to ferro iron, and the iron(3) phosphatehumus complex which was earlier stable is brought into solution. By this nutriments are mobilized that were earlier bound to the sediments. The primary production during the following season will be higher thanks to the increased availability of nutrient salts. The lack of oxygen will be even

greater during the following period of stagnation and even more nutrient salts will be mobilized from the sediments and so on. Here you have an example of a negative feed-back - a speeding course of autofertilization.

Princip for treatment through chemical precipitation.
For precipitation of phosphates out of the water three compounds are fit for use: aluminium, iron(3) and calcium. These all form difficulty dissolvable phosphatecomplexes and are available as soluble salts to a reasonable price.

For these experiments aluminium sulphate was chosen.

The princip is to precipitate the free phosphate as difficulty soluble aluminium phosphate before the productive season. In this manner the algae are prevented from using the phosphates, which in most cases is the limiting factor of production. This causes a lower production, a lower oxygen consumption at decomposition, less or no lack of oxygen in the crop of water during the period of stagnation and a lessened leakage of nutrient salts from the bottom sediments. The following productive season would start with a lower concentration of nutrient salts in the water. The negative feed-back would be broken.

Object experimented on

Experiment to precipitate eutrophicated lakes have been carried out in lake Lötsjön in Sundbyberg and in lake Långsjön between Stockholm and Huddinge. Lake Lötsjön is a dredged birds' lake with the characteristics of a dam. The results of experiments carried out there will not be dealt with in this connection. Lake Långsjön is shallow with the characteristics of an eutrophicated lowland area lake, which for a long time has had a considerable load of municipal waste water, that by now mainly has ceased. You will find all symptoms for an eutrophicated lake: lack of oxygen and death of fishes during the winter, together with an extense blooming of blue-green

algae during the later part of the summer.

Investigations of status in the lake have been carried out by the Stockholm city municipal services department during the last twenty years. (The results are found in: "Sammanställning av resultat från undersökningar i Långsjön t.o.m. vintern 1967-68", which is an IVL-publication, No. B 33)

In order to diminish the blooming of blue-green algae there has certain years been carried out treatment with copper sulphate. During some winters the oxygen situation enforced an airation.

The area of the lake is about 350,000 m^2 (≅ 86 acres) and the volume about 650,000 m^3 (≅ 850,000 cubic yards).

Treatment

Aluminium sulphate was spread in the end of April 1968, two weeks after the break-up of the ice. Totaly 33.5 tons (≅ 5,276 stones) of aluminium sulphate was spread out, which means 90-100 g/m^2 (≅ 0.3 ounce/sq.yd).

II. Important factors for the result

1) As the precipitation was made as late as two weeks after the break-up of the ice (depending on difficulties of changing the time of the delivery of chemicals from normal time of ice's breaking-up) the concentration of phosphate - phosphorus in the water by the time of the precipitation was only 60-70 µg/l. During the latter part of winter there was a maximum of ≅ 180 µg/l.

This means that the phosphates were already used by the algaes to 60 %. The part of phosphorus withdrawn from production was only ≅ 40 %.

2) As the municipal waste water outlets have not entirely stopped, lake Långsjön has during the summer been the recipient of uncleaned municipal waste water with a high concentration of phosphorus.

With basis from the changes in the concentration of thermostabile Colibacterias the municipal outlet is calculated to be responsible for a considerable part of the increased concentrations of phosphate-phosphorus and the total amount of phosphorus in the water.

3) As the amount of sunny hours were extremely high and the summer 1968 was very warm the premises for a high production of blue-green algae were very good.

4) There was an outlet of about 200 litres of fuel oil into the lake during the latter part of autumn 1968 which lokally caused death of fishes. Further affects cannot be excluded.

III. The development during 1968

Condition of temperature

The shallow lake gives no temperature stratification during the warmer part of the year.

The water temperature rose 3-4 ^{o}C during the last week in April and was rather steady on +13 ^{o}C during May. The period with water temperatures exceeding 18 ^{o}C begun in June and ended in the beginning of September.

Water transparency, turbidity and colour

The water transparency has been measured with a white Secchi-disc (25 cm Ø). During the week proceeding the aluminium sulphate treatment the water transparency was reduced from about 1 meter to about 0.7 meter because of the increasing plankton production as the temperature rose. Immediately

after the treatment the transparency increased, and on several places the Secchidisc was seen on the bottom. During May and June the transparency decreased to about 0.5 meters, which was the lowest value during the summer, caused by the plankton production that had its maximum in the end of June. After this the transparency was about 1 meter until January when it was about 1.5 meters.

The values for turbidity show good correlation with the values of transparency.

The colour of the water, expressed in mg Pt/l has varied between 40 and 70 mg Pt/l.

The specific conductivity, pH

The specific conductivity is a way of expressing the total concentration of electrolytes in the water. The values from lake Långsjön show small variations during productional season. The period August - January shows higher values depending on the decomposition of organic substances.

The values of pH varies very little, because the lake is strongly buffered. The aluminium sulphate caused a rapid decrease in pH, but through the production of algae it quickly rose again. The highest pH-values in the end of April, June and October, are corresponding to a high amount of plankton.

O_2

The concentration of oxygen is constantly very high, depending on the strong plankton production. BOD_7 and the consumption of caliumpermanganate is a standard of the concentration of organical matter in the water. As Långsjön by almost every sampling during 1968 has had an supersautration of oxygen, the analysed BOD_7 might show too high a value, especially by lower temperatures.

The consumption of permanganate has been 30-50 mg/l during the summer, and the highest values correspond to high BOD_7-values.

Phosphorus, nitrogen

At the time of the precipitation a great part of the phosphorus and the nitrogen of the lake was already used for building organical substances. The phosphate-phosphorus value was then 50-60 µg P/l and the total amount of phosphorus about 150 µg P/l. At the precipitation these values decreased to <5 and 20-70 µg P/l respectively. The great variation in the amount of total phosphorus depends on the fact that the aluminium sulphate was not quite evenly spread over the lake. Between June and July the highest value after the treatment was reached.

The source of nitrogen for the algae is nitrite and ammoniumnitrogen, where nitrite is the intermediate at the oxidation of ammonium into nitrate. The concentration of nitrite and nitrate has not reached the limit of sensibility of the analysis during the summer. The value of ammonium shows little variation during the summer months, but increase a little during the autumn because of decomposition. In the end of October there is an intense blooming of green algae, which is shown in a lower value of ammonium but also in an increased concentration of Kjeldahl-nitrogen (organic nitrogen+ammonium).

IV. Comparison with earlier measurements

(Full report IVL-publication B 33)

Through out the summer lake Långsjön is well saturated with oxygen. The few values diverging from this are probably due to accidental outlets of municipal waste water.

The transparency has earlier had a value of about 0.5 meter during June-August, while in 1968 during the same period the value has been about 1 meter. This difference might be due to disparities in the composition of plankton. The samples from 1968 are dominated by green-algae while blue-green algae, which mostly assemble in the surface layers of the water, have been more common in earlier years.

The total phosphorus concentration has at earlier measurements in the summer had a value of 150-200 µg P/l while, during 1968 after the treatment, only one occasion has shown values higher than 100 µg P/l.

In earlier years the phosphate-phosphorus concentration has at several occasions reached high values of about 100 µg P/l even in the summer. During 1968 the corresponding values have varied between 10 and 40 µg P/l.