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The Quality of Finnish Surface Waters and Future Trends

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Finland's water resources are abundant and can be considered adequate to meet needs except in some coastal areas. This abundance was previously considered so obvious that water resources were used carelessly, without a thought to the harmful changes in water quality caused by the reckless use of lakes e.g. for discharging waste waters. In the late 1950's people finally perceived the rapid deterioration of Finland's beautiful lakes. An administration for water pollution control was established and a new Water Act was passed at the beginning of the 1960's. Since then the fight for clean waters has continued with varying success. What is the state of Finnish surface waters now, and what are the prospects for the future?

Finnish Surface Waters - Physiography and Climate

The annual runoff in Finland is on average 300 mm. Runoff does not vary much from place to place or from year to year. Seasonal changes, on the other hand, are large, depending mainly on size and lake percentage in the river basin (Fig. 1). In small drainage basins with no lakes other physiographic factors, such as soil type, vegetative cover and land use, have the greatest effect on seasonal variations in runoff.

Lakes are by far the most dominating element in Finland's river basins. They level out the seasonal discharge and quality variations and improve water quality by acting as sedimentation basins. There are about 55 000 lakes in Finland. Their total area is 31 600 km^2 which is 9.4% of the whole area of the country. The average depth is about 7 m.

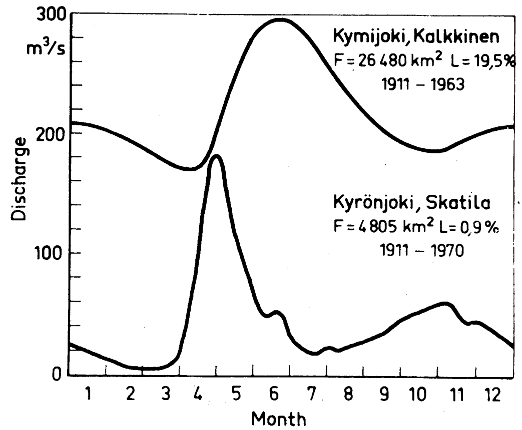

Fig. 1. Mean discharge in a big river with high lake percentage, and in a small river with low lake percentage.

Finland can be divided into three main regions according to the importance of lakes. In the coastal area bordering on the Gulf of Finland and Gulf of Bothnia the rivers are relatively small and there are very few lakes. The rest of the southern half of the country is dominated by large river basins with complicated chains of lakes covering 10 to 20% of the area. In northern Finland there are only a few large rivers with lakes comprising 3 to 5% of the area.

The special quality of the lake water is due to the low fertility of the soil and the large percentage of peat land. The bulk (90%) of the lakes have low primary productivity and some 60% of the lake water is brown, colored by humus from the peatland and thus subject to a heavy natural load. The mineral content of the water is usually low giving weak buffer properties. It is thus subject to many quality changes.

The 4-7 months' ice cover in winter also weakens the lakes' resistance to pollution.

The Present Quality of Surface Waters

The quality of Finland's surface waters has been studied systematically since 1962, when the Water Pollution Control Authority set up water quality monitoring networks . A network of 170 flowing water sampling stations has been monitored 4 times a year and a network of 160 lake deeps once a year (Fig. 2).

In addition to these large networks, a network consisting of 34 small (1-120 km^2) representative basins with no lakes has been monitored every month since 1962.

Monitoring includes about 20 water quality parameters. During these 15 years about half a million water quality data were collected from these three networks.

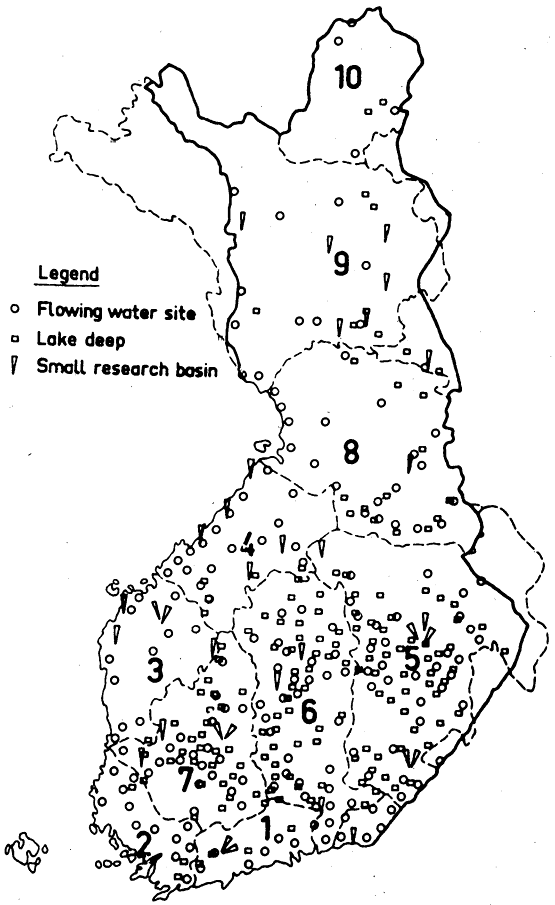

Fig. 2. Water quality monitoring networks. Numbers refer to Table 1.

These data make is possible to evaluate the state of Finnish surface waters and also to detect some trends in quality changes.

As the figure shows, the small coastal rivers with no lakes (groups 1 to 4) differ from these in the rest of the country, first for natural reasons such as the abundance of peat lands and clay soils (color 103 to 180 mg/l Pt and suspended solids 21 to 37 mg/l), but also because of pollution (total phosphorus 63 to 129 mg/m^3 P and total nitrogen 1000 to 1500 mg/m^3 N). It has to be kept in mind that low average quality also means large seasonal variations in quality. The inland group (5 to 7), consisting of large watercourses with plenty of lakes, is characterized by waters with a small amount of suspended solids (4 to 9 mg/l) and reasonable color (53 to 73 mg/l Pt) and, in spite of some pollution, a reasonable amount of phosphorus (29 to 58 mg/m^3 P) and nitrogen (600 to 800 mg/m^3 N). The quality of northern Finland's large rivers has heretofore

Table 1 - Averages of flowing water quality parameters in 1962-1968 on drainage basin groups (3)

Drainage basin No. Name	pH	Electrical conductivity μS	Suspended solids mg/l	Colour mg/l Pt	$KMnO_4$ mg/l O_2	Total phosphorus mg/m^3 P	Total nitrogen mg/m^3 N
Coastal area							
1. Southern coast	6.8	95	26	103	58	129	1 500
2. Southwest coast	6.6	161	37	109	62	112	1 400
3. Southern Ostrobothnia	6.2	123	21	176	93	88	1 200
4. Central Ostrobothnia	6.3	67	21	180	82	63	1 000
Lake area							
5. Vuoksi basin	6.6	33	4	61	44	29	600
6. Kymijoki basin	6.6	46	5	53	48	37	700
7. Kokemäenjoki basin	6.4	72	9	73	80	58	800
Northern area							
8. Oulujoki-Simojoki basins	6.6	25	5	73	44	25	500
9. Kemijoki-Tornionjoki basins	6.7	37	4	65	33	26	500
10. Paatsjoki-Tenojoki basins	6.9	35	1	18	14	8	200
1-10 Whole Country	6.6	69	13	91	56	58	800

been close to the natural state (suspended solids 1 to 5 mg/l, phosphorus 8 to 25 mg/m^3 P and nitrogen 200 to 500 mg/m^3 N). In inland lakes and rivers in northern Finland the seasonal varations are not large.

The usability of inland waters has been classified, taking into account various uses, e.g. water supply, fishing and recreation. This classification was devised by water resources planning technologists and is subject to a great deal of simplification. There are five classes as follows:

1st class; *excellent,* suitable for all purposes which require high water quality
2nd class; *good,* suitable for all purposes, but because of the high humus content chemical treatment is needed for community water supply purposes
3rd class; *satisfactory,* not always safe for swimming, effective treatment needed for water supply purposes
4th class; *fair,* suitable only for cooling water
5th class; *bad,* not suitable for any conventional use

About 3% of the total area of inland waters belongs to classes 4 and 5. These lakes and rivers are heavily polluted. Class 3 accounts for 19%. This figure comprises slightly polluted waters (10-15%), but also lakes where water quality is less suitable because of the natural characteristics of the drainage basin.

The rest of the inland water areas belong to classes 1 or 2, which are in many respects close to the natural state. The state and quality of Finnish waters is shown in Fig. 3.

About one quarter of Finland's population live near badly polluted waters and the other quarter close to slightly polluted waters. About 1.3 million people are supplied with water which originates from water sources which are of no more than satisfactory quality.

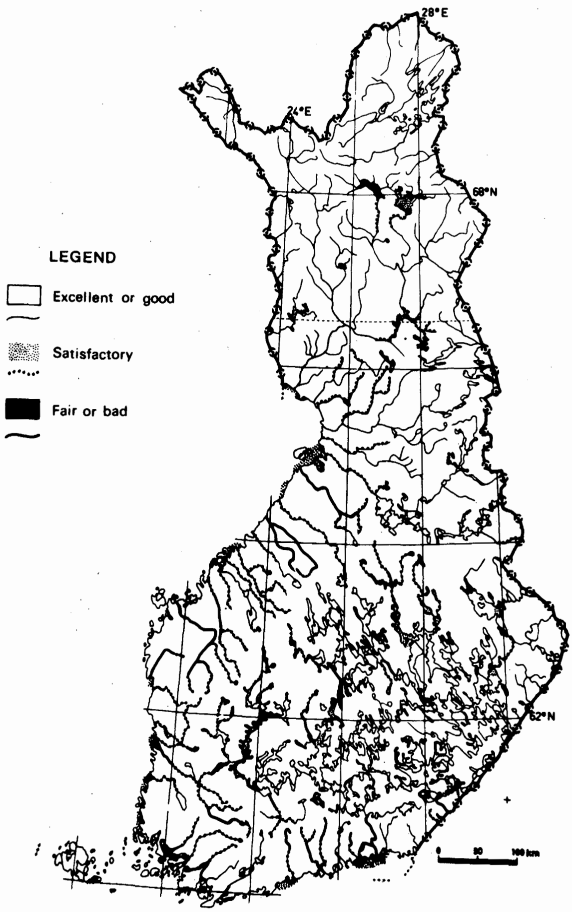

Fig. 3. The state and quality of Finnish waters.

Water Quality Changes During the Last 15 Years

The Water Pollution Control Authority has been in existence since 1961. There is no doubt that the waters were in a much worse state without pollution control measures; during this 15 year period the forest industry, for example, has more than doubled its production and the population using sewerage systems has also doubled. The question is, have our efforts in pollution control been enough to prevent the deterioration of waters. Since data have been collected systematically over a long period of time, some attempts are being made to discover any trends in the quality of Finland's surface water. (Kauppi, Laaksonen 1975).

Regression analysis of the data covering 1962 to 1973 was used (Laaksonen 1975) to find any significant trends in water quality parameters.

Some obvious tendencies were detected. The significant (95% reliability) increasing trend in electrical conductivity was found at 56% of the flowing water sampling sites. The decreasing trend was found at only 0.5% of the sites. The same type of tendency, although not as clear, was also found in chloride and total sulphur contents. The results from the network of lake deep sampling sites (Laaksonen 1975) and also from small basins (Kauppi) were in good agreement with the flowing water results. This means that the salt content of the waters has generally increased. The increasing trends are more numerous in lakes in Central Finland than in coastal or northern rivers. At the same time the total pollution load from point sources has not changed very much on average, although there are spatial changes and also changes in the type of pollutions. The diffuse load, caused by agricultural and forestry fertilization, water transport, airborne pollutants, etc. has increased. We do not know how significant this increase is.

However, no general tendency e.g. of increasing or decreasing phosphorus or nitrogen content was found in this data covering 12 years. Most parameters have a large stochastic variation and trends have to be very clear indeed in order to be significant in data from such a short period. Neither can the mere trends, based on historical data, be used for predicting water quality in future when pollution loading is expected to increase or decrease.

One reason for the relatively low nutrient content is that the lakes are still able to store most of the nutrient input on the bottom sediments. If the oxygen content of the water in the bottom of a lake becomes too low, it will start a fast phosphorus mobilization from the bottom sediments and lead to an accelerating eutrofication and pollution.

On some limited water areas close to big industrial plants or cities significant improvement has been noticed as a result of some efficient pollution control measures during recent years. On the other hand, many lakes previously in a natural state are now showing marks of slight change caused by various human activities.

Certainly more sensitive and flexible methods are needed in predictions. At the present time a lot of work is going on in the field of water quality models. A special research project was started in Finland in 1975 in order to find out e.g. the most suitable aquatic models for Finnish conditions. The objective is to predict at least the algae density in a lake using some measurable climatic, drainage basin and lake characteristics and pollution loading parameters as input data in the model. If applicable models can be developed they may offer the water authority valuable means to really control water pollution. The effect of any polluting measure, e.g. building a new factory, or a preventive measure, e.g. building a waste water treatment plant, can be calculated at least roughly.

At present the water authority bases its activity on the continuous reduction of any kind of pollution load. We only hope that the water quality will improve as a result of all the measures which can be taken under the present circumstances. Water legislation, economic and financial factors and the public interest in environmental problems are the realities which today determine the future of waters.

Water Pollution Control

The National Board of Waters has prepared a special program »The principles of water pollution control up 1985« (National Board of Waters 1974). The program includes an array of measures which tend to decrease pollution. Pollution loadings are planned to be reduced as shown in Table 2.

Table 2 - BOD and nutrient loads caused by population and industry. Situation in 1972 and goals for 1980 and 1985

Industrial field	BOD_7 tons/day			Phosphorus kg P/day			Nitrogen kg N/day		
or polluter	1972	1980	1985	1972	1980	1985	1972	1980[3]	1985
Residential centres[1]	126	60[2]	45	5700	3000	2500	30,5	38,0	38
Wood processing	1300	650	400	2000	2300[3]	1500	15,0	15,0	15
Fertilizer	1			560	200	100	3,5	2,0	1
Explosives	–			–			0,6	0,2	
Other chemical	20	<10	<10	60	<100	<100	1,0	1,0	<3
Leather	4			15			0,8	0,5	
Textile	4			200			0,6	0,3	
Food processing	60	10		900			3,7	1,0	
Total	1515	730	455	9435	5700	4200	55,7	56,0	57

1. The goals for residential centres include also the industrial effluents discharged to municipal sewers. Concerning the corresponding industrial fields, only the effluent load caused by separate discharges to recipient are presented.
2. 60 tons BOD_7/day corresponds to approx. 20.000 tons BOD_5/years
3. Trends

The program means a reduction of organic load to one third of the 1972 level and of phosphorus load to less than a half; nitrogen load will not be allowed to increase from the present level. The program is economically feasible and the legislation gives sufficient power to the water authorities. This program will be followed and the financing schedule has been accepted, although at present it is temporarily being slowed up because of the recession.

This water pollution control program will improve water quality, especially in lakes which are close to densely populated areas. About half of the area of lakes and rivers which now are heavily polluted will in future have satisfactory quality. Those waters which now are slightly polluted will mainly be applicable for high quality uses.

Water pollutants transported by air have received attention in recent years in Finland, too. Some preliminary studies (Haapala 1974) show that this source of water pollution can be significant. This is especially true of lakes which are otherwise in a natural state.

The general increase noted in salt content in Finnish waters may be explained partly by airborne pollutants. This aspect of water pollution may appear very difficult in future, because only part of the air pollutants are emitted in our own country.

Although we cannot say that the fight against water pollution has been won, we can say that we have been able to stop deterioration in general. Some local success gives us confidence; we know that the trend can be changed. The increase in diffuse pollution, on the other hand, is a serious problem that needs a solution. The next ten years will show how our plans have materialized.

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