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II

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Remark:

The WHO regional office for Europe, Copenhagen, presented for additional information the paper prepared by L. LANDNER (Stockholm, Sweden, 1976) "Eutrophication of lakes - its causes, effects and means of control with emphasis on lake rehabilitation". WHO - long-term program in Envir. Poll. Control EURO 3130.

GENERAL REPORT

by
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15 scientific papers were received from eight countries; and they are 1 from Egypt, 6 from GDR, 2 from India, 2 from Poland, 1 from Spain, 1 from Sweden, 1 from Hungary, and 1 from USSR.

The papers are alphabetically listed below:

Paper No. 1: "Eutrophication of the Swedish Great Lakes - sensitivity, state, and future"	by T. AHL from Sweden
Paper No. 2: "To the problem of complex management of impoundment reservoir catchment areas with the goal to prevent eutrophication"	by E. BEUSCHOLD from GDR
Paper No. 3: "Integrated measures for control and utilization of aquatic weeds"	by D. K. BISWAS from India
Paper No. 4: "Investigations on anthropogenous eutrophication of inland waters (fresh waters) of the USSR"	by Ju. A. CHUGUNOV and V. I. MALYUK from USSR
Paper No. 5: "Operating conditions for maximum phosphorus removal"	by F. A. EL-GOHARY from Egypt
Paper No. 6: "The importance of the subject to economic development"	by S. V. GANAPATI from India

Paper No. 7: "Problem relating to the long-term planned use of the natural water resources in GDR" by W. GRINGMUTH and H. ROOS from GDR

Paper No. 8: "Freshwater fishery and condition of waters" by H. HEROLD and D. BARTHELMES from GDR

Paper No. 9: "Effects of fertilizing forest areas on the eutrophication of waters" by T. KOCAN from Poland

Paper No. 10: "Fertilizer application and eutrophication" by H. KORIATH from GDR

Paper No. 11: "The integrated Water Resources Control System of the German Democratic Republic" by W. OTTO from GDR

Paper No. 12: "The influence of tourism and recreation on the eutrophication of freshwaters " by E. PIECZYŃSKA from Poland

Paper No. 13: "The relationship between lake Balaton and its catchment area" by I. SZABO from Hungary

Paper No. 14: "Eutrophication in Spanish man-made lakes" by J. RUIZ DE LA TORRE, J. L. O. CASAS and J. A. GARCIA from Spain

Paper No. 15: "Eutrophication of waters and problems of the special protection of nature" by H. WEINITSCHKE from GDR

Additionally the precious report by L. LANDNER from Sweden, prepared by order of the WHO have been used for information:"Eutrophication of lakes - its causes, effects and means of control with emphasis on lake rehabilitation"; WHO-Long Term Program in Envir. Poll. Control EURO 3130.

The 15 papers have been sub-divided into:

(a) Control of the external influx of nutrients from
    (1) pin-point sources (Paper No. 5);
    (2) surface run-off from fertilized arable land (Paper No. 10);
    (3) drainage from forest areas in the catchment area (Paper No. 9); and
    (4) from the entire drainage basin of the catchment areas (Paper No. 2).

(b) Limnological surveys of lakes to determine their trophic status and the causes of eutrophication in them (Papers No. 1, 4, 12, 13, and 14).

(c) A plea for nature conservancy (Paper No. 15).

(d) Planning the water wealth of a state for multipurposes (Papers 7, 8, and 11).

(e) On reuse of waste water (Paper No. 6).

(f) Control of water weeds (Paper No. 3).

Discussion

The salient features of the papers contributed under each of the six subheads are discussed below.

As the subject of Complex A is about eutrophication it will be proper to begin with a definition of the term eutrophication, types of eutrophication, symptoms of eutrophication, sources of nutrients of biological significance and the key nutrient phosphorus, and why rehabilitation measures are necessary, as briefly as possible to begin with.

1. Definition of eutrophication

Eutrophication may be defined in several ways. It is popularly defined as "enrichment of water, be it intentional or unintentional." It is a slow process of aging in nature and the natural process is accelerated by man's activities. It may also mean enrichment in nutrients leading progressively to the luxurient growth of plants. In a restricted sense it may mean the enrichment of a water body by inorganic plant nutrients especially compounds of nitrogen and phosphorus. Some others mean it as the increase in primary production, and LANDNER would like to adopt the definition: "all aspects of biological productivity." Eutrophication may mean also pollution if the results are undesirable according to MORTIMER.

2. Types of eutrophication

There are several types of eutrophication such as (a) incipient eutrophication; (b) advancing eutrophication; (c) seasonal or periodic eutrophication; and (d) pseudo-eutrophication.

(a) Incipient eutrophication

The incipient eutrophication may mean biologically a quantitative increase in biomass; qualitative and quantitative changes in the littoral, benthic, planktonic and in fish population. On the physico-chemical side the term may mean decreasing transparency and change in colour of water; overall decline in dissolved oxygen content in the hypolimnic layers of a lake during summer thermal stratification and the resultant build up of the chemically detectable average nutrient level of nitrogen and phosphorus.

(b) Advanced eutrophication

It may mean that the above symptoms have become more pronounced. A luxurient growth of phytoplankton particularly the blue-green algae: complete absence of dissolved oxygen; in summer in the bottom layers and accumulation of the resultant products of anaerobic decomposition; and the disappearance of the fauna may be noted.

(c) Seasonal and/or periodic eutrophication

This results from a gradual decrease in water level due to evaporation and draw-off for irrigation purposes in man-made lakes in the tropics with a concomitant increase in organic matter content so that one can easily calculate the values for organic matter content from the lake or reservoir level.

It is not known whether the type of eutrophication defined above is the same as or different from anthropogenous eutrophication of CHUGUNOV and MALYUK (Paper No. 4). They define it as "a disturbance due to the increase in level of primary production of organic substances on the basis of anthropogenous growth of nutrients which keeps developing according to ROSSOLIMO."

(d) Pseudo-eutrophication

It is another kind of enrichment in organic matter when the water from a man-made lake is used for slow sand filtration in summer months. Anaerobic conditions are created inside the three feet depth of fine sand layer of a slow sand filter when the sulphate reducing *Spirillum desulfuricans* begins to be active and reduces the sulphate in raw water to H_2S and the concomitant production of sulphur bacteria or sewage fungus in the filtered water.

3. Symptoms and indices of eutrophication

Microscopic algae or macroscopic water weeds when seen in abundance in any piece of water, indicate eutrophic conditions. Both of them seldom reach their dominance in the same water body, for there is always a keen competition between the two for attaining dominance. Several indices of eutrophication have been reported in literature. They are: (1) UHLMANN and HRBÁČEK's indices based on the trophic status or standing crop or changes in the rate of primary production, i.e. chlorophyll content; (2) changes in the diversity of phytoplankton; (3) increased values for chlorophyll-a and decreased SECCHI disc readings and (4) VOLLENWEIDER's guide-lines of ranges in plankton productivity.

4. Sources of nutrients of biological significance and the key nutrient phosphorus

They are: (1) regeneration from biota; (2) exchange with bottom sediments; and (3) from sources external to the water body. The nutrient substances of biological significance are organic and inorganic compounds of carbon, nitrogen-containing and phosphorus-containing inorganic substances. The key nutrient is considered to be phosphorus-containing inorganic substances because the other two substances are easily obtainable from atmosphere. Most of the attempts being made for controlling eutrophication are for the almost entire removal of P.

The nutrients may be obtained in two ways. They may be of (1) allochthonous origin, which includes pin-point and diffuse sources; and (2) autochthonous origin such as exchange with bottom deposits and regeneration from biota as already stated.

5. Economical and social effects of eutrophication

Excessive growth and development of aquatic weeds and/or microscopic algae are a source of nuisance, cause health hazards, economic water loss due to evapo-transpiration, toxic effects on fish, poultry and animals; fishing, boating, skiing, bathing are often made impossible. Such waters have to be treated at great costs for drinking purposes although they may be increasing the biomass or standing crop which may be used for producing fish, oyster, lobster, and algae for low-cost protein, industrial and medicinal products, so rehabilitation measures for their control are necessary.

LANDNER has reviewed exhaustively the literature pertaining to eutrophication and rehabilitation after 1968 to 1976. He has suggested 6 rehabilitation techniques for preventing further deterioration to water resources themselves and for "de-eutrophication" of the external influx of nutrients. Briefly stated they are: (1) taking measures affecting the oxygen reserves in hypolimnion; (2) reducing the period of stagnation; (3) by inactivation or removal of nutrients; (4) measures affecting the influx of nutrients from pin-point sources; (5) of organic matter; (6) preventing oxygen consumption by bottom deposits.

He has not mentioned any techniques for separating the microscopic algae from the highly eutrophied waters of Europe and America for their use as "low-cost protein" about which IBP has emphasized. The future of mankind is closely linked up with the urgent need for mass production of cheap protein and pure water which are in short supply on account of increasing population and industrial development. So new techniques and new sources of supply must be sought. This can be partly achieved by treating the vast volumes of sanitary waste waters produced by the world population and industrial development to such an extent that they can be used straight way for water treatment for drinking, irrigation or industrial purposes. At the same time the fertilizing elements i.e. N and P from the wastes can be profitably used in the large-scale manufacture of edible protein for animals and men. All these triple benefits can be had at one stroke by employing the aerobic lagoon process in which the principle of photosynthetic oxygenation is solely employed (GANAPATI, 1975) wherever possible. This process Professor OSWALD (1962) of the University of California hails as "The Coming Industry of Controlled Photosynthesis." This is one of the several nature's gifts to man.

GRINGMUTH and ROOS (Paper 7) have suggested that they propose to utilize nature's another gift i.e. the self-purifying capacity of running waters in artificially created installations. So, why not the other gift of nature i.e. the radiant energy from the sun be used in western countries for artificial illumination for the manufacture of low-cost protein for the teeming millions of the world. A suggestion for consideration!

(a) <u>Control of the external influx of nutrients from</u>

(1) <u>Pin-point sources</u> (Paper No. 5)

EL-GOHARY of Egypt has suggested a reliable method of control with operating conditions for the maximum removal of the key nutrient P from sanitary, industrial and agricultural wastes. A combination of a biological high rate, plastic-packed trickling filter unit followed by a chemical coagulation and flocculation unit is recommended.

The methods suggested for treatment are all right for those places where land is not cheaply available. But in the developing countries of the world whose land is cheaply available low-cost methods of treatment should be employed. Also, the treatment units should be simple to construct, have the least amount of mechanization and require little or no skilled operation and comparatively cheaper. All these requirements are met by the so-called "low cost waste treatment methods", which may be tried in the interests of economy in capital and running costs.

(2) Surface run-off from fertilized arable land (Paper No. 10)

In GDR intensified food production is done by the extended application of inorganic fertilizers and cattle organic manure on land in the catchment area of a lake or reservoir. At the same time a code of practice has been evolved as a result of which eutrophication of ground and surface waters has been greatly reduced. How this state has been reached is discussed by KORIATH in this interesting paper.

If intensive agricultural practices are to be employed on and for increased food production, leakage of N from soils cannot be althogether prevented. But it can be considerably reduced by adopting indicious policies formulated jointly with departments of agriculture, water management, and environment protection. Similar rules and regulations can be worked out for each country where intensive agricultural practices are adopted for increasing food production by examining the slope of land, underground water level and the location of surface waters.

(3) Drainage from forest areas in the catchment area (Paper No.9)

KOCAN of Poland discusses the toxic side effects of using fertilizers for increasing the growth of timber by intensive use of mineral fertilizers containing salts of N, P or K. The residue left over are carried to lakes and rivers after each rainfall, thus leading to eutrophication of surface waters. Toxic pollution of ground water may also result causing an extraordinary danger to the environment. So, appropriate measures should be taken in forest areas after carrying out certain scientific investigations for protecting surface waters. They are (1) not to use mineral fertilizers on mountain slopes and in forests with highly permeable soils; in forests weated in water sheds and in water holding forest areas. Grass, bushes, shrubs etc. should be grown on forest-free water banks.

In fertilized forest areas with high ground water levels, pyknometric instruments should be installed at appropriate intervals. Soil and water samples should be collected for analysis to determine the changes in the properties of water, soil and plants. The results of analysis should be used for correcting the relationship between fertilizer use and soil conditions, and for use of underwood and brush vegetation for controlling the humus content of soil and for reducing the input of nutrients. In this way pre-conditions for complete consumption of water by the soil and water can be effected. For fertilizing forest areas, it is therefore necessary to carry out complex research on hydrological, physiological, forestation and fertilizing aspects so as not to endanger water resources. These steps are worthy of adoption in forest areas in the catchment of lakes and rivers in other countries.

(4) <u>From the entire drainage basin in catchment areas</u> (Paper No.2)

BEUSCHOLD of GDR has discussed how far a raw water storage reservoir used as a source of raw-water supply can be allowed to be polluted with sanitary sewage, agricultural drainage water and forest drainage in the catchment area of a lake or reservoir. This has been viewed from the point of view of the key nutrient element P in the water. He has also discussed the relation between the cost of sanitary measures and the expenditure involved in water treatment for drinking purposes under the optimum conditions of production in the case of the Rappbode reservoir in GDR. This paper presents an excellent accounting of cost/benefit ratios of sanitary measures and water treatment.

(b) Limnological surveys of lakes to determine their trophic status and the causes of eutrophication in them (Papers No. 1, 4, 12, 13 and 14)

In Paper No. 14, RUIZ DE LA TORRE et al. have carried out limnological surveys of almost all the reservoirs of Spain during the last three years; and the results of 300 reservoirs are discussed with special reference to factors governing biological production and the causes of eutrophication in them. They have classified the lakes into 5 groups on VOLLENWEIDER's criteria taking into account the dividing line between mesotrophic and eutrophic waters. They consider 20 mg/m^3 of total P and 300 mg/l of N content as the limit between the two types of waters. They have concluded that the major reasons for increasing eutrophication in the man-made lakes of Spain are due to increasing population in the catchment areas, heavy cattle raising, long residence time, and summer stagnation conditions. They propose to reduce the degree of eutrophication by gradually increasing waste treatment practices.

In Paper No. 12, PIECZYŃSKA of Poland has discussed the effect of tourism and recreation on eutrophication of freshwaters in Poland. The author has suggested that research is necessary on the effect of the different forms of recreation activities with special reference to the negative effect of tourism on water bodies due to inflow of sewage and destruction of water plants. Other impacts have not yet been analysed. Littoral zones are affected considerably. The location of recreation centres, boat houses etc. cause definite changes in water quality. International water fowl Research Bureau, IBP, and MAB are studying these problems now.

The Polish National Committee of MAB is investigating the effect of tourism and recreation on water bodies at national and international levels. A questionnaire prepared by the Department of Hydrobiology at Warsaw University has been sent to all people in Poland and overseas and the results of analysis will be discussed at this Symposium. From a study of the Masurian lakes of Poland with reference to tourist pressure and recreation on their pollution, it has been found that the inflow of sanitary and industrial waste waters has considerably increased pollution.

Shores have been damaged by wave action and motor oil. Over 50 % of the lakes are visibly affected by tourism which is confined to summer season. After this short term pressure, it has been found that degeneration of water quality is quicker than restoration. So, there is a dire need to plan the tourist usage of lakes and reservoirs. Special precautions are necessary.

SZABO reported upon according conditions and requisitions from Hungary to protect the lake Balaton (Paper No. 13).

In Paper No. 1, the results of studies made on the Swedish great lakes - Vänern, Vättern, Mälaren and Hjälmaren - are discussed by AHL. The state of eutrophication in them is discussed. A figure of 1.3 kg N/ha.year is typical of N loss from forest areas, of which 75 % is organic and the rest nitrate; and a loss of 0.06 kg P/ha.year has also been noted. He has found the natural loading of P and N related to mean depth. The first two deep lakes were originally oligotrophic, and the other two meso- or eutrophic. The results show that the water quality in the great lakes as observed during the last one decade as excellent for SECCHI disc readings were 15 m for Vättern and 5 m in Mälaren.

In Paper No. 4, CHUGUNOV and MALYUK have discussed a new type of eutrophication in the lakes of USSR where they call as "anthropogenous eutrophication" of inland waters. A lot of work is reported to have been done in USSR and a second symposium for this type of eutrophication is considered necessary. Eutrophication is caused by production of allochthonous organic matter and also due to autochthonous organic matter. Considerable increase in biomass of phytoplankton is due to P, which is supplied mainly by sewage pollution while N is obtained from the catchment area. The author has made regional studies of this type of eutrophication in USSR and has suggested several control measures.

(c) A plea for "Nature Conservancy"

The author of Paper No. 15 of GDR pleads for the preservation and augmentation of rare, culturally valuable species of birds, and plants in certain lakes and reservoirs as "beauty spots" for people to visit. In GDR laws have been framed for the preservation of natural "beauty spots" reputed for rare plants, birds and animals in selected reserves as national trusts. Such places are called Nature Conservancy which are controlled by specialist organizations devoted to preservation of wild life for aesthetic, scientific and educational purposes.

There are 700 such landscapes in their typical development stages of which 13 % or 44 reserves are lakes of different types which are mainly eutrophic, multipurpose storage reservoirs used for boating, sporting, fish breeding and agricultural purposes. They serve two purposes: a allow a balanced exploitation of the water wealth so as to restore the old conditions of existence before damage was caused, and as "beauty spots". In such cases chemical or biological methods of treatment are not to be allowed.

(d) Planning the water wealth of a state for multipurposes
(Papers No. 7, 8 and 11)

GDR has an extremely tight water budget, being densely populated, heavily industrialized and is intensively exploiting the arable land. For meeting the present and future demands, it is necessary to know exactly the seasonal variations in quality and quantity of ground and surface waters. So, a centrally run, highly mechanized, integrated water resources control system was evolved and has been in use for several years. It provides the conditions required for full-ranging, quick information for short-term, medium-term and long-term planning.

The Paper No. 11 by OTTO of GDR explains the basic principles underlying the integrated system of control for measuring water quality, quantity, selection of criteria to his measure, measuring techniques with special references to lakes and reservoirs.

It is a highly complicated mechanized system of water resources control worthy of adoption in the technically advanced countries of the west.

GRINGMUTH and ROOS in Paper No. 7 have described the natural water resources, development demand by 1980, and water quality and pollution in GDR. There is water pollution and a growing demand for water quality and quantity. So, considerable efforts are being made for the construction of biological waste treatment plants followed by land treatment of the effluents in order to retain the inorganic nutrients of biological significance in the soil. The increase in treatment costs is due to chemical contamination. For these reasons the water economy in the state has to be planned in a uniform manner for meeting the ever growing requirements of the population. A long-term planning of the water economy involving a close relationship with the planning of environmental protection and the conservation of the natural conditions is found absolutely necessary.

HEROLD and BARTHELMES of GDR (Paper No. 8) had developed a concept as to how fish farming can help to solve the problem of eutrophication. This is proposed to be done by increased stocking of fish of different food spectra for a better utilization of the biotic potential of eutrophic waters, while at the same time improving the water quality. An attempt has been made to shoot two birds at one shot. In the Madras State (now Tamil Nadu) the Fisheries Dept. is trying to increase fish production by stocking ponds with surface feeders, column feeders and bottom feeders to obtain the maximum fish production. As a general rule, a pond is stocked with 50 % fingerlings of surface feeders, 25 % of column feeders and 25 % of bottom feeders. MACAN et al. (1942) have suggested a formula for calculating the total number of fingerlings with which a pond should be stocked. The same formula can be improved in GDR.

Do fish pollute water? Normally they are considered as the unfortunate casualities of water pollution! Under what circumstances can fish be a source of pollution of water? Scientists at the University of Georgia under SERL sponsorship are investigating this question now.

(e) <u>On reuse of waste water</u> (Paper No. 6)

Sooner or later the world population increasing at the rate of 1.7 % annually will have to face a very serious water famine on account of explosive population growth and increasing agricultural and industrial developments. Added to this menacing situation is the increasing eutrophication of surface and underground waters, which not only has reduced the available pure water supplies and also lowered their quality. Costly and complicated purification treatments are found necessary for treating the polluted waters.

The possible lines of action for saving mankind from the impending catastrophic situation within the next fifty years or so are: (a) to seek new sources of water supply, e.g. by tapping the snow-clad mountains, antarctic icebergs, purifying sea or brackish water, making artificial rains, changing the climate, or to exercise control over the use of existing sources of supply by careful planning or trying to reuse the same water as many times as possible either for the same purpose or for different purposes.

This line of action has been initiated in certain coastal areas of the north-east and middle-east regions and in western countries. Serious attempts are being made to convert sea water or brackish water into sweet water in countries which now lack adequate quantities of good water. The techniques being used for the purpose are distillation, freezing, hydration, reverse osmosis and electro-dialysis.

Reuse of waste water was anticipated by Karl IMHOFF as early as 1931, who showed the possibilities and limitations of water-sewage-water cycle. According to him a city is required to furnish its regular supply only to the extent of 10 % of the collected sewage volume as pure water, the remaining can be met from its own sewage.

An examination of the actual position existing today in the highly industrialized countries of the West shows that it is technically feasible and possible to reuse sewage after purification and natural or artificial regeneration. We have also the evidence of current research into the provision of water for cosmonauts by complete recirculation. So, increasingly reliable methods of sewage purification and regeneration with have to be systematically adopted in future; and sewage effluents or used water will become an important means of increasing supplies of drinking water, water for agriculture and for industrial purposes as in GDR today.

In the technically-advanced countries of the West, increasing volumes of sewage and/or industrial effluents were being discharged into streams, rivers, lakes and reservoirs whose insufficient dilution took place. The conventional waste treatment processes are unable to treat effectively the inorganic nutrients of biological significance with the result that when they are discharged into receiving waters cause eutrophication. So, attempts are being made to remove completely the chief nutrient P from sewage effluents.

An additional stage in waste treatment known as "polishing" or tertiary treatment for final treatment of sewage effluents has come into vogue. The important forms of such treatment are: lagoon treatment, intermittent rapid sand filtration, micro-straining, slow sand filtration, treatment in grass plots (not land irrigation) etc. Of these treatments lagoon treatment in the so-called "maturation ponds" is most economical. But it can be adopted only in such places where land is cheap, climatic conditions are suitable, organic loadings fluctuate widely and funds are limited. Most of these conditions are satisfied in tropical countries like Africa, Middle East, Near East and the Far East.

Maturation pond systems are useful in minimizing the hitherto un-controlled eutrophication of rivers, lakes, and reservoirs receiving purified sewage effluents to suit various useful purposes. The effluent to be put into maturation ponds should be already well stabilized in the conventional sewage treatment plants or from a series of stabilization ponds. In maturation ponds purification is effected primarily with reference to bacteriological quality. TAYLOR, the former Director of the Metropolitan Water Board in London, has summarized the results of his three year study of the method of lagoon treatment of an effluent from the conventional sewage treatment plants at Rye Meads, Hertfordshire in England. A part of the fully treated effluent was passed through three shallow lagoons of depth varying from 5.3 to 11.5 ft working in series and having a capacity of 30 million gallons at a flow rate of 1.5 mgd. This gave a retention time of 3 days in the first lagoon, 5 days in the second and 9 days in the third lagoon before final discharge into the river Thames after 17 days. The results were found to be highly satisfactory. A final effluent having a quality standard comparable to that of a good river water in every respect was produced. The lagoons acted as a "buffer" between the treatment plant and the river. Also this afforded protection to fish life in the river from any harmful matter in the sewage effluent. An outstanding feature of the lagoons treatment was the discharge of a fully oxygenated effluent into the river, avoiding any harmful effects on the fisheries. Another note worthy feature of the lagoon treatment was the reduction in the number of faecal bacteria by 99.5 %. Pathogens like the Salmonella group had virtually disappeared after passing through the lagoons. Enteroviruses were also isolated from the plant effluent on occasions but they were present in only two of the samples discharged from the third lagoon to the river during the three year period.

Public Health Engineers in USA are already thinking in terms of closing the gap between the end of sewage treatment and the beginning of water supply altogether so that in a sewered city it may be possible to produce from the city's sewage, water that is suitable for further treatment in the same city's waterworks for domestic water supply.

(f) On control of water weeds (Paper No. 3)

In Paper No. 3 BISWAS discusses the nature and magnitude of the problem of weed control in surface waters in India. He has recommended an integrated approach for their control and use for gainful purposes.

Weed control is a serious practical problem throughout the world. What weapons are now available to control weeds is the important problem for consideration! About 90 % of the free floaters can be cleared with 2,4-D, MCPA, Gramoxone, and Diquat. Acrolein acts effectively on marginal and submerged aquatics. If a chemical control is to be of use in the developing world it should come out of local research centres. At doses of 12-15 % ammonia kills 90 % of all submerged weeds. An aqueous solution of Kerosene, urea and soap was found to be highly specific for destroying Salvinia. Research has also shown that rooted weeds will not grow in soil until they have been continually submerged for at least six months.

Manual or mechanical removal of weeds will make more sense if something useful can be done with the dying vegetation. The most promising line of action seems to be biological control. Manatee, a large herbivorous animal is behaved to gobble up water hyacinth. An English farmyard duck is called the "Khaki Campbell" is reported to control Salvinia. Carps have shown considerable promise in clearing submerged weeds. Two weevils, two moth borers and a suite which attacks water hyacinth, a semi-aquatic grass-hopper, a borer seen to effect considerable control. But the control measures cannot be applied universally. So, research must go on for biological control.

Summing up:

There is a growing awareness on the part of those responsible for water management and environmental protection that both hydrophytes and microscopic algae which occupy the same environment are very important for the enhancement of water quality up to a point. Anything in excess is undesirable. Our knowledge about the nutritional requirements of aquatic weeds is very poor; and the cost of control measures appears to be very high. Information relating to weed and algal population control is still in a very primitive stage although a legion of methods has been suggested for their control. None of the methods suggested is outstandingly excellent for universal adoption. A multitude of mechanical devices such as flushing a lake with clean water, pumping surface water to the bottom, temporary lowering of water level, pumping out hypolimnic water; a variety of biological agents such as snail, cray-fish, carps, mammal, duck, beetles and chemical herbicides like 2,4-D, MCPA, Diquat etc. have been suggested. 99 % of the efforts at control of algal populations and blooms are aimed at the nutritional level of reducing the P content within a lake or outside it.

So, the present state of the art of weed and algal control is such that more research is needed to design a comprehensive, fully integrated, economic approach to the problem. Effective practical control will not be possible until extensive basic research has been carried out. A better understanding of the real cause of algal blooms is required and extensive environmental models need to be devised taking environmental variables into account before any control measures are actually undertaken in the field. Algal and weed control are not more scientific investigations. It is a serious practical problem demanding urgent solution everywhere.

Therefore, research will have to be carried out in Research Institutes specially established for the purpose in different regions of the world under the auspices of UNEP for water management, eutrophication control and education of the people at different strata of society.

THE EUTROPHICATION OF THE SWEDISH GREAT LAKES - SENSITIVITY, STATE AND FUTURE

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TO THE PROBLEM OF COMPLEX MANAGEMENT OF IMPOUNDMENT RESERVOIR CATCHMENT AREA WITH THE GOAL TO PREVENT THE EUTROPHICATION

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Summary

At the example of the East - Harz - storage reservoir system from the point of view of the drinking water supply will be discussed the question, whether and in which amount it is necessary to prevent or restrict the eutrophication of storage reservoirs.

On the base of a phosphorus balance for the Rappbode impoundment reservoir and for its catchment area the possibilities of influencing the nutrient import into the storage reservoir will be demonstrated and the corresponding degrees of benefit will be discussed.

With about 1,8 g $P/m^2 \cdot a$ the phosphorus loading of the Rappbode storage reservoir is very high. 66% of the total phosphorus amount coming into the storage reservoir are originated from the domestic sewages and 34% from the plain leaching - out. The share of the agricultural using at the phosphorus input makes up about 9%. By large - scale sanitation measures in the catchment area with an investment amount of about 92 000 000,- M the total phosphorus loading of the storage reservoir could be lowered from originally 0,19 to 0,12 g $P/m^2 \cdot a$.

An economic comparision of the expenditure of the operating expenses for the sanitation measures with the lowering of the water treatment expenses being attainable by the sanitation shows the disadvantageous relation expenditure : advantage of 26:1.

The asked question "maximum keeping back of eutrophicating substances or optimization of the relation between sanitation measures and technical expenditure of the water treatment" is discussed.

A drinking water storage reservoir can be considered as a technical installation, those loadibility with respect to the eutrophication corresponding to economic points of view can be used up to a certain degree.

Also in the field of eutrophication, especially in the context with the drinking water supply from storage reservoirs, an economic way of consideration will more and more assert. At this in an increasing measure it will be the point, that the sanitation measures in the catchment areas, aids in the storage reservoir itself and the possibilities of the water treatment techniques will be considered as a complex and in optimal way balanced one upon another.

1. Formulation of the problem

In the Harz in the years 1952 until 1961 the Rappbode impoundment reservoir with it's system of preimpoundment reservoirs was constructed. It's main goal is the gaining of raw water for the drinking water supply. The catchment area of the storage lake comprehends 270 km^2, of which 227 km^2 are wooded and about 42 km^2 are used by agriculture, i.e. as meadows and fields. Along the inflow rivers 10 villages with 20 700 inhabitants are situated. Additionally about 10 000 holiday - makers are recreating here, so that the population density makes out 116 inhabitants/km^2. The 9 villages being situated on the territory of the GDR are disposing of central water supply installations. Central sewerages and sewage purification plants had not been available. However the kitchen waste waters and the surface runnings of the streets and of farms were predominantly arriving the influxes. Besides this the tendency came out, that besides the recovery establichments also the inhabitants of the villages in an increasing degree are aspiring to an individual sewage sanitation of their estates by the construction of small sewage clearing sets in order to improve the sanitary conditions in these places. Such measures however are followed by a raising increase of the phosphorus import into the storage reservoir. Additionally the increasing use of fertilizing substances and the strong concentration of the cattle breeding occured in the scope of the socialist reorganization of the agriculture with the changings in direction towards an industrial organized production.

Due to this situation which has been described the question arose about the necessity and the amount of sanitation measures in the catchment area in order to prevent a too strong eutrophication of the Rappbode storage reservoir. With this from the first it had not been expected, that by means of the sanitation measures it would be possible to provide oligotrophical conditions in the storage reservoir. It was rather the goal to keep the trophy degree within such borders, that the storage reservoir water still could be treated by the planned treatment technology of the waterworks to an unobjectionable drinking water. In order to attain this goal the following complex sanitation program was established:

- It is the task of the sanitation measures to provide to the villages the possibility of modernization of the sanitary conditions, without any increasing of the phosphorus import into the Rappbode storage reservoir.

- Construction of central sewerages and of biological treatment plants with serial connected third purification step for the phosphorus elimination for the villages Hasselfelde, Stiege, Benneckenstein and Trautenstein in the partial catchment area of the Rappbode and Hassel.
- Renunciation of rationing of the water amount of the both preimpoundment installations at the Hassel and Rappbode, in order to attain a maximum phosphorus elimination in the two dam up basins by continuous full dam up.
- Introduction of measures in the cooperative and public sectors of the agriculture, which are restricting the phosphorus carry off from the arable plains while the agricultural productivity is completely granted.
- Farm sanitation in the estates with individual cattle keeping.
- Fixation of protection zones corresponding to the lawful basics.

A series of investigations has been carried out in order to establish the effectivity of the sewage sanitation measures, the influence of the preimpoundment installations on the phosphorus influx and the amount of the phosphorus leaching out of agriculturally used plains and the forestry plains. Moreover it was tried to consider in opposition the sanitation effect each with its corresponding sanitation expenses and thus to carry out an economic comparision between these sanitation expenses and the expenses due to the drinking water treatment.

2. The impoundment reservoir system

The Rappbode impoundment reservoir which is dammed up by a concrete wall with 106 m of height at normal dam up is 85 m deep and about 8 km long. It is an expressed groove basin. The installations which habe been set up at the Rappbode and Hassel have a depth of 14 m. They are serving to the preliminary purification of the influx water. In order to catch the particular steep flood runoffs from the Brocken area the high water protection basin has been constructed at the Cold Bode. Below the flowing together of Cold Bode and Warm Bode the transfer reservoir raises the Bode water level up to such degree, that through a tunnel to the Rappbode storage reservoir can be conveyed about 50% of its influx per year from the Bode.

Below the junction of the Rappbode still a further dam up wall was established. The lake of this Wendefurt storage reservoir is reaching up to the base of the dam up wall of the Rappbode storage reservoir. The Wendefurt storage reservoir does not belong to the drinking water storage reservoir system. It serves besides the tasks for the high water protection, low water raising and energy gaining also to the close by - recreation and to the fishery for feeding of trouts. In the table 1 are gathered those dates about the Rappbode storage reservoir and its preimpoundment installations which are most essential for eutrophication problems.

Table 1

Hydrological conditions in the storage reservoirs at normal dam up resp. at mean water delivery of the influxes

	height above normal zero	dam up volume	lake surface	dam up height	mean depth	stay time
	m	hm^3	ha	m	m	d
Rappbode impoundment reservoir	422,2	103,4	365	83	28,0	370
Hassel preimpoundment reservoir	433,0	1,5	26	14	5,6	29
Rappbode pre-impoundment reservoir	439,0	1,5	23	15	6,4	29
transfer reservoir	423,2	1,2	29	9	4,2	4
high water protection basin	454,0	0,5	12	9	4,3	7

3. The phosphorus import into the storage reservoir

3.1 Calculation basics

Since 1959 investigations about the phosphorus occurence in the catchmant area of the Rappbode storage reservoir and about the influencing of the phosphorus load in the storage reservoir system were carried out [1], [2], [3], [4], [5]. From the investigations results obtained for the paper in hand the following data gathered in tab. 2 have been derived:

Table 2

Phosphorus discharge per year from differently used plains and phosphorus discharge of villages without and with sanitation.

1. Discharge from plains	total phosphorus amount kg P/ha·a	ortho-phosphate kg P/ha·a
forest plains	0,126	0,037
extensively used meadow plains	0,180	0,074
intensively used meadow plains	0,552	0,274
of that natural share	0,124	0,037
of that share from agricultural using	0,429	0,237
2. Discharge from villages	**total phosphorus amount kg P/Pers.. a**	**ortho-phosphate kg P/Pers.. a**
unsanitated village (central water supply, but no sewerage)	0,11	0,04
sanitated village (central sewerage and biological waste water plant)		
- waste water plant influx	0,90	
- waste water plant delivery	0,56	0,40
sanitated village, additionally with post-purification ponds	0,28	0,22

In the table 2 the fields are not represented among the data about the phosphorus discharge from the agriculturally used plains, because in the catchment area the arable plains are situated only on the ridges and separated from the influxes in each case by extended meadow plains. At present in the catchment areas in the average 120 kg N/ha•a and 28 kg P/ha•a are used as fertilizer at the agricultural plains. The values for the plain leaching out given in the table were derived from mean values. They should not deceive over the fact, that in dependence of the hydrological conditions and especially of the intensity of the melting water delivery the amount of the nutrient leaching out during the snow melting is very different from year to year. In average 88% of the total phosphorus plain leaching out occurs in the time from October until May.

In the second part of the table is mentioned the phosphorus discharge from the post - purification ponds as a form of a third purification step for the nutrient elimination, it is still relative high, because temporarily in the ponds oxygenium fading occurs. Due to this phosphorus which already had been kept back is set free again. Here aeration devices will enable an increase of the phosphorus elimination. The two installations being available are consisting of each 4 resp. 5 serial connected ponds with 30 up to 40 days stay time for the biologically purified sewage.

The total phosphorus elimination in each of the preimpoundment installations is shown by the following putting up:

preimpoundment installation	total phosphorus elimination in %
Hassel preimpoundment reservoir	58
Rappbode - preimpoundment reservoir	58
high water protection basin	25 (October - May)
transfer reservoir	17 (October - May)

For the two reservoirs mentioned last the elimination is given for the time from October until May, because predominantly only in this time water from the Bode is guided over into the Rappbode storage reservoir.

3.2 Phosphorus balance

Applying the investigation results having been put up in the previous section for the system of the East Harz storage reservoirs and those catchment area now a total phosphorus balance has been calculated. The result is shown graphically in fig. a and b. The figures show in a balance diagramm the average load of total phosphorus amount per year and its alteration by the influence of sanitary measures, of the preimpoundment reservoirs and of the diversion of a part of the Bode water out of the catchment area by the river water delivery from the transfer reservoir.

At this the phosphorus load is still separated into it's shares of different origin, as village sewage, natural plain leaching out and phosphorus leaching out on the base of the agricultural using. The load is represented in megapond/a, at which also the absolute numbers are entered into the graphical scheme additionally. At the first view it is recognizable, how much the total phosphorus share from the village sewages is dominating.

Among the primary occurence (I) of 26,86 Mp P/a about 82% P originate from the sewage, 11% from the leaching out of forest plains, 5% are due to the influence of the agricultural using. The remaining 2% load share are the natural leaching out of the agricultural used plains, which occurs also without the agricultural intensivation. As primary occurence of the sewage phosphorus has been calculated the P - amount occuring in the rehabilitated villages in the sewerage influx plus the P - discharge per year of the unrehabilitated villages into the corresponding rivers.

Approximately 75% of the inhabitants and holiday - makers in the catchment area up to present have been connected with central sewerages with biological purification plants. By these purification installations the P - primary occurence from the sewerages is reduced by 36% and the total primary occurence still by 29% (II).

About 45% of the total sewage, occuring in villages with sewerage and biological purification after the passage through the purification installations is submitted additionally to a further P-elimination in the two post - purification plants in Hasselfelde and Benneckenstein. In spite of this relative small connecting degree with the ponds the phosphorus originated from the sewerage is reduced by approximately 10%.

The following sections (IV, V, VI) of the balance graph in fig.1 are demonstrating the influence of the different preimpoundment reservoirs. In those now besides the sewage - P the phosphorus being originated from the plain leaching out is comprehended too. Because of the very different long stay times which have been pointed in table 1 these reservoirs have a different P - elimination effect. Besides this through these storages different shares of the total influxes are running to the Rappbode storage reservoir. Those are at the high water protection basin 14%, at the transfer reservoir 53% and at the two preimpoundment reservoirs at the Hassel and Rappbode total 37%.

Among the reduction of the total phosphorus primary occurence the high water protection basin takes part with only 0,7%, the transfer reservoir with 5,4% and both the preimpoundment storages at the Hassel and Rappbode with 16%.

While now the influx water, coming from the preimpoundment reservoirs at the Rappbode and Hassel, altogether arrives into the Rappbode storage reservoir, of the transfer reservoir influx water only a share of about 54% is transferred through the tunnel into the Rappbode (VII). The remaining 46% are delivered to the river current of the Bode. With this water share also is diversed a part of the phosphorus load from the catchment area, by this additional 14% of the primarily occured phosphorus are kept away of the Rappbode impoundment reservoir.

By the totality of the measures described, which are serving partly exclusively, partly as additional functions to the phosphorus elimination, consequently the total phosphorus amount per year, occuring primarily in the catchment area, is reduced from approximately 26,9 to 6,42 Mp P before it arrives at the Rappbode impoundment reservoir. This corresponds to a lowering by approximately 76%.

The P - share originating from the sewage is reduced stronger than the P - share from the plain leaching out. While at the primary occurence the sewage - P made out 82%, among the input into the Rappbode impoundment reservoir are occuring only still 66% of the total P - input. The share from the agricultural using raises from originally 5% up to 9% in the storage reservoir input.

In the fig. 1 in the balance graph is given too the phosphorus amount which is delivered again from the Rappbode impoundment reservoir (VIII). This quantity was derived as a several years mean value from the measuring results of the continuously running phosphorus evaluations in the raw water taken from the storage reservoir. Putting in opposite this phosphorus delivery of 3,1 Mp P to the calculated mean input per year of 6,42 Mp P the total phosphorus elimination in the Rappbode storage reservoir would amount to approximately 52%.

4. The plankton development

In the Rappbode impoundment reservoir the investigation results of many years are proving the phosphorus as that substance that restricts the phytoplankton production.

If the plankton development has to attain only a small amount the phophorus import into the storage reservoirs shall not exceed a certain degree.

VOLLENWEIDER [6] has proved such a border range between an oligotrophical and an eutrophical lake in its dependence of the average lake depth for the loading with biological active total phosphorus amounts. He relates the P - import per year to the size of the lake surface and specifies this surface loading in g $P/m^2 \cdot a$. By this for the Rappbode storage reservoir the "tolerable loading" would be 0,2 g $P/m^2 \cdot a$ and the already "dangerous loading" 0,4 g $P/m^2 \cdot a$. If one takes as base the total phosphorus import of 6420 kp P/a into the Rappbode storage reservoir that has been determined in the phosphorus balance, then hence results for this storage reservoir a surface loading of 1,76 g $P/m^2 \cdot a$. Even if one stipulates together with GÄCHTER [7] , that eventually only about the half of the total phosphorus import is "biological active", then the phosphorus load remaines just still more than twice above the "dangerous loading" and thus far within the eutrophic range.

IMBODEN [8] introduces additionally into his phosphorus model still the hydraulic loading of the lake in order to pay into account besides the mean depth also the mean stay time of the water in the lake. In applying those relations as "maximum tolerable loading" a value of approximately 0,2 g $P/m^2 \cdot a$ results. Indeed the Rappbode impoundment reservoir on this high phosphorus import reacts with a strong plankton mass development. At this the diatomees plankton dominates. As up to present maximum in April 1968 40 000 000 cells of the diatomaceous Asterionella formosa were found in one litre epilimnion water. That corresponds to a displace volume of 30 mm^3/l or to a living weight of about 30 mg/l.

Hitherto the phosphorus loading of the Rappbode impoundment reservoir was different from year to year. On the one hand this is at least partly a following of the changing hydrobiological conditions, but on the other hand a dependence of the sanitation happening in the catchment area is noticeable too. The fig. 2 shows that at the example of the orthophosphate concentration in the impoundment storage at the end of the springtime full circulation in the course of the 13 years from 1963 to 1975. The increasing tendency is reflected by the year by year growing connection degree of the places with canalization in the villages in the partial catchment area Rappbode - Hassel. After conclusion of these village sanitations in the last years again a decreasing tendency of the phosphate concentration seems to appear. Without already having corresponding proofs nevertheless could be supposed already herein first results of further continued sanitation efforts in the catchment area. To this are belonging the beginning optimization of the fertilize spell and the removal of the hitherto bringing out of liquid manure out of the catchment area. At the post - purification ponds improvements have been introduced. In the transfer reservoir changings have been carried out in order to raise the P - elimination.

If one compares this demonstration of the phosphate concentration with the column diagram for the hypolimnical plankton amount in fig. 2, then between both yet a significant connection seems to exist. The diatomees biomass in principle shows in its changings the same tendency as the phosphate concentration. If one compares for instance the both spaces of time of each five years 1963/67 and 1969/73 an increasing of the phosphate concentration by 3,3 times results. The mean value of the hypolimnical diatomees volume increased by 8,4 times. Also the shortening of the phosphate concentration in the last years is answered by a diminuation of the mean hypolimnical diatomees volume.

5. Economic questions of the eutrophication and sanitation

The question has been put at the beginning about the permissible degree of eutrophication of the impoundment reservoir and about the necessity of further sanitation measures, this question now shall be discussed.

With this first of all are to be answered the following partial questions:

- Which disadvantages are resulting from the high exceedings of the tolerable and also of the dangerous phosphorus loading limits according to VOLLENWEIDER [6] for the water condition in the Rappbode impoundment reservoir and for the drinking water treatment ?
- Is a lowering of the present phosphorus loading of the impoundment reservoirs necessary ?
- Which measures for the decreasing of the phosphorus import into

the storage reservoir are realizable and which use effectivity they will obtain ?

To the first question:
Here first of all it is of significance, how much is the plankton content in the raw water which is taken from the storage reservoir for the drinking water treatment. The fig. 2 informs about this especially by the entered monthly mean values of the hypolimnical plankton displacing volume of the diatomees which have been measured in the raw water.These are the highest monthly mean values found in the space of time from April to October in the separate years.

At a specific weight of the plankton of approximately one a displacement volume of 1 mm^3 corresponds nearly one milligram plankton fresh weight or 0,1 mg organieal substance at diatomees and about 0,2 mg organical substance at other plankton algae. The highest monthly mean value having been hitherto established was according to fig. 2 7 mm^3 diatomees plankton/l raw water. It has been measured in May 1973. The highest value per one day of the hypolimnical plankton cohtent within the last 10 years lay at 11,3 mm^3 asterionella plankton/l. These amounts cause no difficulties at the drinking water treatment with the traditional treatment technology (aluminium sulphate contact filtration, open rapidfilters with 3,2 m/h filtration velocity, sand grained 1,5 - 2 mm and addition of 3 g active carbon powder / m^3 raw water). The filter operating time was at 11,3 mm^3 plankton / l still about 50 hours. In the epilimnion at this time were found at maximum 32 mm^3 diatomees plankton / l. Consequently under the given circumstances the plankton organisms themselves don't act disadvantageously upon the drinking water treatment. The same is valid too for the consequences of the plankton development which has been hitherto observed in the Rappbode impoundment storage, as the decreasing of the oxygen content and the increasing of the concentrations of carbonic acid and manganese in the hypolimnion and the occurence of substances being intensive as to smell and taste in the raw water. With exception of the first years after the primary dam up of the impoundment reservoir also at the deepest position of the lake the oxygen content did not sink below 2 mg O_2/l. In the range of 20 to 60 m depth at the end of the summer stagnation the O_2 concentration hitherto lay between 6,3 and 8,8 mg O_2/l. In the last years the mean hypolimnical O_2 - fading intensity lay between 0,020 and 0,025 g $O_2/m^3 \cdot d$.

The carbonic acid concentration attained values of about 10 to 13 mg CO_2/l. The manganese content regularly raises in the depth water not higher than 1 mg Mn/l. The iron content remains still lower. Consequently the hypolimnion in the Rappbode impoundment reservoir in spite of the relative high phosphorus import into the lake is not inadmissibly loaded.

The volume proportion of epilimnion to hypolimnion in the storage reservoir makes out in May 1:4,in July 1: 2,1 and in September 1: 1,2. In the course of the summer stagnation the the original hypolimnion water is about one time let out by river water delivery and raw water taking and replaced by water following after from the original metalimnion.

Now to the answering of the second question, if a diminuation of the present P - loading of the Rappbode impoundment reservoir is necessary. Corresponding to the explanations just made the answer should be "no". But here still additionally concluded is the question about the stability of the hitherto conditions for the impoundment reservoir which have been described, i.e. the question, if at an phosphorus input of 1,76 g $P/m^2 \cdot a$ must be reckoned with a sudden cropping up of the water conditions that cannot be mastered. However as to the plankton development for the Rappbode impoundment reservoir was shown already formerly [5] , that, also in accordance with observations at other eutrophicated lakes and impoundment storages, an essential increasing of the plankton biomass beyond the maximum values which have been measured hitherto in the storage reservoir is very improbable. With such a high phosphorus supply a raising of the phosphorus input within the alteration range that has been shown in fig. 2 is no longer answered by an essential increase of the maximum values of the plankton biomass. The reaction is rather an increasing of the bioproduction by a duration lengthening of the plankton maxima. By this an over - pretension of the oxygen supply in the hypolimnion is more or less possible first of all in single years. The causes would be an oxygenium leakage, an increasing of the concentrations of carbonic acid, of manganese and of organic substances and in extreme cases the occurence of free hydrogen sulphide. Regarded from the present state ofthe water treatment technology such consequences of a too strong eutrophication in the impoundment reservoir would not absolutely exclude the gaining of drinking water. With a water treatment technology that is adapted to this also from such storage reservoir water with normal expenditures can be gained drinking water, that satisfies the "TGL" - system of technical standards of the GDR. At the treatment of ground water the complete lacking of oxygen, carbonic acid concentrations of 50 to 100 mg CO_2/l, iron concentrations of 10 mg Fe/l and more, manganese concentrations of 1 to 2 mg Mn/l and the presence of free hydrogen sulphide are still regarded as normal and are technically mastered too.

In contrary indeed problematical as consequence of a too strong eutrophication is the occurence of hygienic doubtful organic substances being contented in the plankton or of metabolic-products, provided that the occur in concentrations which cannot be eliminated in a sufficient degree from the raw water using the available treatment technology. If in order to eliminate such contented substances additionally to the normal treatment technology will become necessary a raised addition of flokking substances, a long - term employment of active carbon and eventually an ozonization too, then a state is reached, where also at an impoundment reservoir water supply has to be put the question, if not a comprehensive sanitation in the storage reservoir catchment area for economic reasons is more advantageous than the extension of the treatment technology in the water - works.

Thus these problems guide over to the third question, which further sanitation measures are practicable in the catchment area of the Rappbode impoundment reservoir and which use effectivity they could have. The answer is given by the fig. 3, in which are summarized the hitherto carried out sanitation measures and those still being considerable, and that in their consequences upon the calculable phosphorus loading of the impoundment reservoir, the investment expenditures and the expenses for the drinking water gaining. According to this the total phosphorus loading of the Rappbode impoundment reservoir in the inital condition before the realization of the sanitation measures was 1,93 g $P/m^2 \cdot a$. In the inital condition (I) only Braunlage had a central sewerage and a biological purification plant. The preimpoundment reservoirs at Rappbode and Hassel were not yet existing. By the construction of the sewerages in Hasselfelde, Stiege, Trautenstein and Benneckenstein (II) then without cleaning of the sewages in the purification plants the phosphorus loading would increase to nearly 5 g $P/m^2 \cdot a$. By the 4 constructed purification plants (III) it is lowered to 3,7 g $P/m^2 \cdot a$. The post - purification installations in Benneckenstein and Hasselfelde (III) and the high P - elimination in the preimpoundment reservoirs (V) are lowering then the P loading below the original degree down to 1,76 g $P/m^2 \cdot a$. For this an investment expenditure of 47 million M was necessary. With a delivery of 60 000 000 m^3 per year the expenses for the drinking water supply would be debited by the now yearly occuring 767 000,- operating expenses of the sanitation with 1,278 Pf per m^3 drinking water. The next column (VI) in the fig 3 shows, by what a relative small value the P - loading of the storage reservoir will increase again, if in the villages which not yet have been sanitated the improvement of the sanitary conditions follows by self - actions, i.e. by constructing of small sewage purification sets based on individual initiatives. The columns VII, VIII and IX make clear, that with a central sewage sanitation plant in these villages, with the additional construction of chemical precipitation plants and of an additional preimpoundment reservoir in the Warm Bode yet only a rather small lowering of the phosphorus loading below the measurements at present (V) is possible. But for this relative small effect an additional investment expenditure of 45 000 000 ,- M would be necessary. By this at 60 000 000 m^3/a drinking water treatment the sanitation operating expenses would debit the water supply with 2,675 Pf/m^3 drinking water and would amount to about 1 600 000 ,- M per year.

The treatment expenses for chemicals and filter rinsing being additionally caused at present by the plankton content in the raw water are however in dependence of the plankton development amounting only to 25 000 ,- up to 65 000 ,- M per year. That corresponds about 0,042 up to 0,108 Pf/m^3. With realization of all sanitation measures mentioned in fig. 3 these additional treatment expenses could be lowered at the most only by 50%, because based on the still remaining phosphorus loading of the impoundment reservoir of about 1,1 g P/m^2·a a very strong reduction of the plankton development couldn't be expected.

The comparision of the operating expenses that additionally arise by this, i.e. of expenditures of 836 000 ,- M/a for the sanitation measures VII, VIII and IX according to fig. 3 with the lowering of the drinking water treatment expenses thus attainable from 65 000 ,- to 32 500 ,- yields a relation of expenditure : use of 26 : 1 . In order to lower the treatment expenses by 1,- M consequently 26,- M additional sanitation operating expenses would have to be spended.

From fig. 3 is visible, that the operating expenses for the sanitation measures hitherto realized amount to 767 000 ,- M/a. The futher sanitation measures which are still represented as realizable in the figure would lower the phosphorus loading of the impoundment reservoir from 1,76 only to 1,12 g $P/m^2 \cdot a$ and for this as equivalent provide additional sanitation operating expenses with an amount of 836 000 ,- M/a. For the same amount of expenses per year in the waterworks they cold dose continuously additional 3 g active carbon powder / m^3 and 1 g $KMnO_4/m^3$, double the quantity of flocking substances and cover the filter rinsing expenses which are increased by this.

The investigations about the use effectivity of the sanitation as to the phosphorus loading and the economic considerations are showing at the example of the Rappbode impoundment reservoir, that the sanitation questions can be rather problematical and that decisions about the necessity and the amount of sanitation measures in the impoundment reservoir catchment areas with regard to the possibilities of the water treatment technique are valuable with economic respect too.

The following common pointsof view can be derived:

- Using the treatment procedures being available at present in a suitable state for the practice also the water of an eutrophicated impoundment reservoir can be treated again to a drinking water that corresponds to the hygienic demands and to the existing standards, provided that the eutrophication does not exceed a degree, which is still compatible to the treatment technique.

- Very decisive is the question, where on the one hand lie the borders of the modern treatment technique and on the other hand up to which degree can be admitted the eutrophication of a surface water that serves to the drinking water gaining.
- A drinking water impoundment reservoir can be considered as a technical installation, those loadibility as to eutrophication due to economic points of view can be utilized up to a certain degree.
- Also in the field of eutrophication, especially in the context with the drinking water supply, an economic way of consideration will more and more dominate. At this in an increasing degree it will be the point, to consider as a complex and in optimal way to make agree the sanitation measures in the catchment area, aids in the water itself (deep water aeration, employment of algicides, ligating of the carbonic oxide by means of calcareous hydrate, destratification, turbulence generating) and treatment - technological measures.
- Besides the efforts for a continuously improving theoretical penetration and practical mastering of the eutrophication processes a purposeful further development of the water treatment technique is necessary in order to remove with economic acceptable expenditures the consequences of the eutrophication every-

where there, where an eutrophication is unavoidable and to produce an unobjectionable drinking water.

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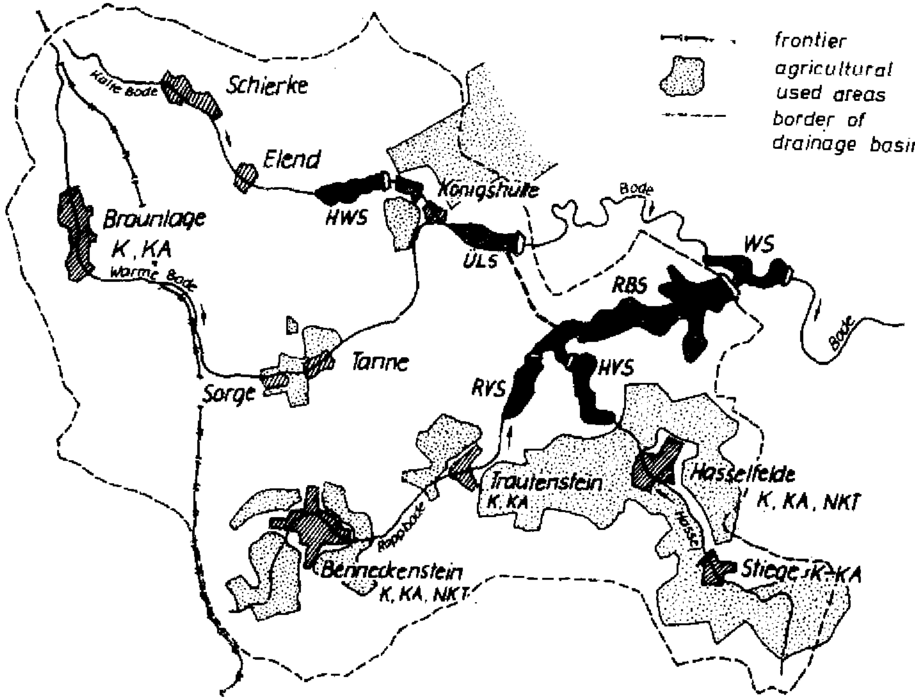

Fig. 1a The system of the Eastern Hartz storage reservoirs and its total phosphorus balance.
1b: The phosphorus transfer components are recorded in the balance diagram as average annual transfer in megapond (P/a).

RBS Storage reservoir Rappbode
HVS Preimpoundment reservoir Hassel
RVS Preimpoundment reservoir Rappbode
ÜLS leading over reservoir
WS storage reservoir Wendefurt

K central canalization
KA central sewage plant
NKT secondary sedimentation pond
HWS flood control storage reservoir

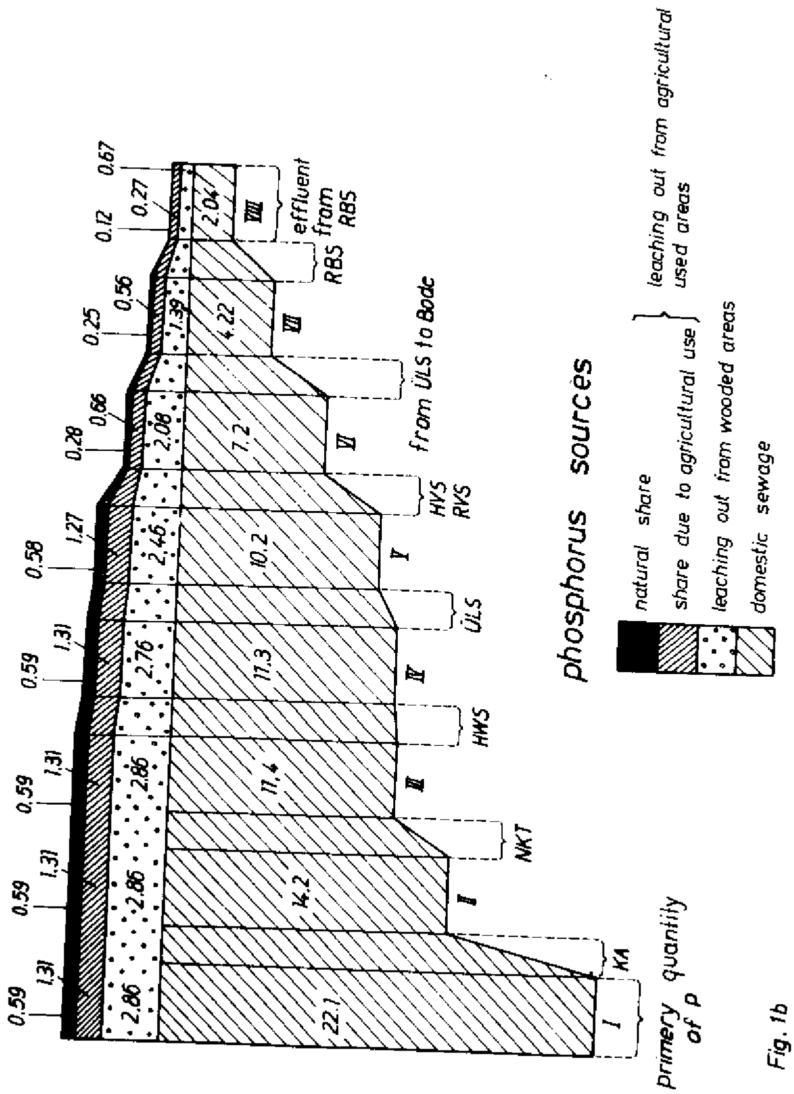
phosphorus sources
natural share
share due to agricultural use
leaching out from wooded areas
leaching out from agricultural used areas
domestic sewage
primery quantity of p
KA
NKT
HWS
ÜLS
HVS
RVS
from ÜLS to Bode
RBS
effluent from RBS
I
II
III
IV
V
VI
VII
VIII
0.59
1.31
2.86
22.1
14.2
11.4
2.76
11.3
0.58
1.27
2.46
10.2
0.28
0.66
2.08
7.2
0.25
0.56
1.39
4.22
0.12
0.27
0.67
2.04

Fig. 1b

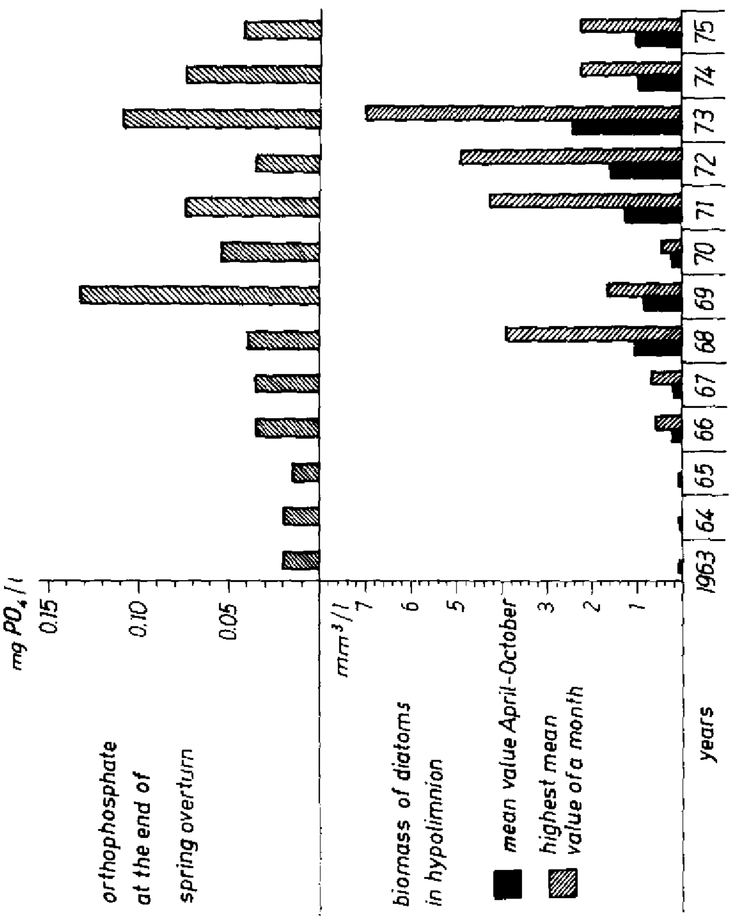

Fig. 2: Storage reservoir Rappbode 1963 to 1975
Orthophosphate concentration at the end of the spring overturn and average values of the diatom biomass in the hypolimnion for the period April to October.
The displacement volume of the diatoms in mm³/l is used as measure for the amount of the biomass.

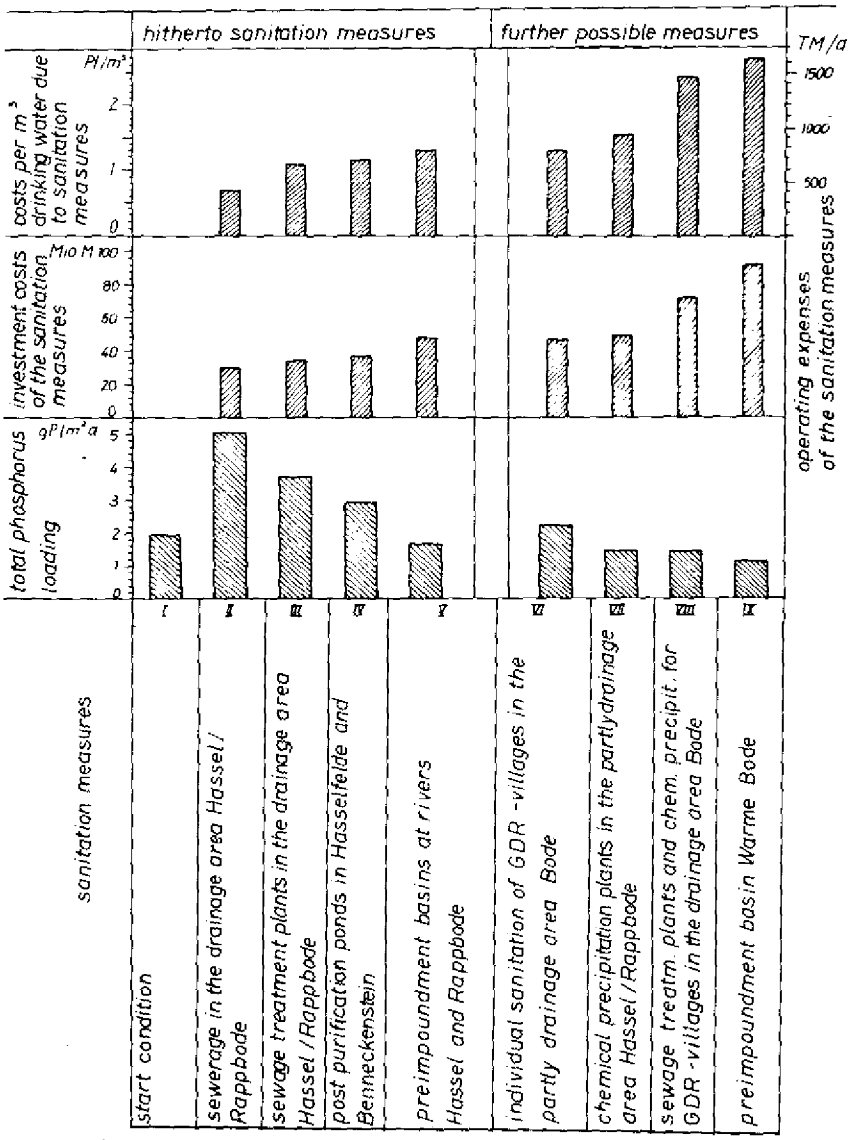

Fig. 3: Effect of the sanitation measures in the catchment area of the Rappbode-Talsperre (storage reservoir) on the total phosphorus surface loading of the storage reservoir, the investment costs and the annual operating expenses of the sanitation measures.
The operating expenses are also related to the costs of drinking water with a water supply of 60 000 m^3/a.

INTEGRATED MEASURES FOR CONTROL AND UTILIZATION OF AQUATIC WEEDS

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Summary

An aquatic weed is defined as any water plant which causes adverse affects on water bodies. While moderate growth in aquatic vegetation is useful for maintenance of ecological equilibrium, eutrophication leads to a series of environmental problems interfering with the efficient utilization of water resources, Nature and magnitude of the problem is discussed in the paper with particular reference to the Indian situation. The results of an Aquatic Weed Survey conducted by the National Committee on Environmental Planning and Coordination, Government of India are presented. Integrated approach for control and utilization of aquatic weeds is recommended in view of the limitations in different eradication measures and potential uses of aquatic weeds for gainful purposes like manure, animal feed protein extraction etc.

Introduction

Any aquatic plant which causes adverse physical, chemical or biological effects on water bodies may be termed as weed. It can also be simply defined as a plant that grows when and where it is not wanted. The threshold limit at which the aquatic plants may be classified as weeds depends on several factors among which the major uses of water and density of vegetation are the most important. An aquatic plant may be desirable in one area or by one interest and undesirable in another. For instance, a decorative plant like water lettuce may add to the scenic beauty but on the other hand provides an ideal habitat for breeding of mosquitoes. Moderate growth of water plants is inherently useful for the aquatic environment as food and shelter, while eutrophication is harmful for the fish population.

The aquatic plants like other green vegetation use energy from the sun for synthesis of carbohydrates. Part of the energy is stored for the growth of the plant itself while excess energy supports the living organisms in aquatic environment. Thus aquatic plants play an important role in the plant - animal food chains. The presence of aquatic vegetation also helps in protection of water quality. Submerged plants contribute to the water environment by taking in carbon dioxide and releasing oxygen during photosynthesis. While the presence of aquatic plants is conducive to the ecological structure, their excessive growth often becomes a menace to the population depending on it. In such situation, aquatic plant control becomes necessary for all aspects of water use including irrigation and drainage, human, animal and industrial consumption, recreation, navigation, abatement of pollution and public health hazards.

Cause and effect of the problem

The first step in any weed control programme is the identification of noxious species, cause and effect of their multiplication so as to ascertain the nature and magnitude of the problem.

Free-floating weeds such as water hyacinth, water fern and water lettuce; rooted submerged weeds such as Hydrilla verticillata, Vallisneria spiralis and pond weeds; rooted floating weeds such as lotus and water lily; emergent weeds such as cattails and alligator weed; and algae such as Chara and Nitella are some of the noxious weeds that are characterized by their fast rate of growth and multiplication thus interfering with the efficient utilization of water resources.

The aquatic plants reproduce from the seeds as well as vegetative fragmentation, the latter being more hazardous to control, particularly when mechanical methods of removal like cutting and raking are used. If an underwater moving machine is employed, fragments of the moved plant float with the current and may grow new roots, anchor and thrive in another area. As a result, the problem instead of being eliminated, is intensified. The activities like construction of dams, reservoirs and irrigation networks provide new habitats for the aquatic weeds. The weeds are carried to new aquatic locations by different agents including water currents, birds, wind etc. In many places, cattle, pigs and domestic buffaloes also act as the carriers of aquatic weeds.

The chemicals (mainly nitrogen and phosphorus) from the effluents of sewage plants, domestic waste disposal systems, industrial installations and run off from agricultural fields are some of the major stimulants for the prolific growth of aquatic weeds. Developmental programmes on water resources without proper ecolo gical considerations and management techniques have also been responsible for the explosive spread of aquatic weed infestation in many areas.

Environmental factors which inhibit the growth of aquatic weeds are deep water, steep shoreline slopes, unstable bottoms, cold water, coloured or turbid water and water of low fertility. On the other hand, lakes or ponds that are subject to dense aquatic plant growth usually have to or more of the following characteristics: shallow depth, gently sloping shoreline, stable bottoms, warm water, clear water and water of high fertility.

The magnitude of aquatic weed problem varies from one region to another depending on the consumption characteristics of water, socio-economic status, technological development as well as climatic conditions. According to a survey report by SOERJAHI and PANCHO (1974), the direct and indirect effects of aquatic weed infestation in the tropical climate of South-East Asian countries are as follows in order of their relative importance:

<u>Direct effects:</u>

1. Retardation in the growth of cultivated crops
2. Interference with irrigation and drainage systems

3. Interference with the hydroelectric power schemes
4. Covering of impounded water surface
5. Hindrance to fisheries
6. Interference with navigation
7. Loss of water through evapotranspiration
8. Decreased real estate value and unpleasent odour to drinking water
9. Public health problems in the riverine communities - encouraging the growth of insect vectors of epidemiological diseases.

Indirect effects:

1. Silting of rivers, canals, lakes and reservoirs by reducing the rate of water flow
2. Promotion of anaerobic conditions leading to production of hydrogen sulphide which seriously affects the generating equipment in case of hydroelectric installations
3. Promotion of eutrophication and water blooms
4. Creation of unaesthetic conditions.

Aquatic weeds in India

An aquatic weeds survey was recently conducted by the National Committee on Environmental Planning and Coordination, Department of Science and Technology, Government of India in order to assess the nature and magnitude of the problem in different parts of the country. According to the information collected in the survey, the following have been identified as the most widely-spread aquatic weeds in India.

Table 1

Noxious aquatic weeds in India

Botanical name	Common name	Type
1. Eichhornia crassipes	Water Hyacinth	free floating
2. Nymphaea stellata	Water Lily	rooted floating
3. Nelwmbo nucifera	Lotus	rooted floating
4. Hydrilla verticillata	Florida Elodea	rooted submerged
5. Typha sp.	Cattails	emergent
6. Lemnoids	Duckweeds	free floating
7. Vallisneria sp.	Tape grass	rooted submerged
8. Potamogeton sp.	Pondweed	rooted submerged
9. Pistia stratiotes	Water Lettuce	free floating
10. Salvinia sp.	African pyle (Water fern)	free floating

Among the abovementioned weeds, the water hyacinth is reported to be the most troublesome in India as well as in neighbouring countries of South-East Asia like Indonesia and Thailand. The trends of aquatic weed infestation in India during the past ten years (1965 - 1975) also reveal that the water hyacinth is rapidly enveloping the inland water surface.

Table 2

Status of aquatic weed infestation in India during 1965 - 1975

Sl. No.	Species	Number of districts showing		
		Increased infestation	decreased infestation	constant infestation
1.	Eichhornia crassipes	54	6	21
2.	Typha sp.	28	1	15
3.	Pistia stratiotes	20	2	11
4.	Hydrilla verticillata	14	5	18
5.	Lemnoids	12	1	8

Sl. No.	Species	Number of districts showing Increased infestation	Decreased infestation	Constant infestation
6.	Salvinia sp.	10	1	5
7.	Ipomoea sp.	10	0	1
8.	Vallisneria sp.	8	4	9
9.	Nymphaea stellata	8	3	16
10.	Potamogeton sp.	7	2	23
11.	Nelumbo nucifera	6	14	18

The major problems caused by the aquatic weeds in India as identified from the districtwise reports are as follows:

1) covering of impounded waters
2) hindrance to fisheries
3) choking of flowing waters
4) interference with growth of cultivated plants
5) pollution of water
6) increased loss of water
7) disease problem
8) impediment to navigation
9) hindrance to aquatic sports.

The nature and magnitude of aquatic vegetation in India are quite alarming. It is estimated that nearly 40 % of the total cultivable waters (80,000 hectares) is infested by weeds in West Bengal, Bihar, Orissa and Assam and 20 - 25 per cent in the rest of the country. The water hyacinth itself covers a vast stretch of water surface - 1,50,000 hectares in Bengal alone and 5,00,000 hectares throughout the country.

The beautiful lakes in Kashmir are now heavily infested and polluted, with 20 - 40 per cent lake area being covered by the aquatic weeds. The aquatic weeds in Kashmir include all life forms. The two submerged species (Myriophyllum spicatum and Ceratophyllum demersum) together cover an area of more than 60 % in various waterbodies, causing great difficulty in fishing, swimming, boating, skiing and other types of aquatic sport. The most dangerous weed is Salvinia natans, which is spreading fast and causing immense problems in potential sites for fish culture due to its high capacity of regeneration and vegetative reproduction. The mat formation of this species sharply changes the physico-chemical characteristics of water, resulting in oxygen depletion and fish mortality. Noxious macrophytic growth has also adversely affected the aesthetic value of this scenic tourist spot. So far, only occasional dredging and manual eradication has been attempted in localized areas which has evidently proved futile.

In the Kakki Reservoir, Kerala, the introduction of salvinia took place in 1966 and within the next 4 years nearly 60 % of the total water surface was infested by this weed. Many rivers, irrigation channels, lakes both natural and manmade are choked by the explosive growth of aquatic weeds. Some of the river valley projects like Chambal Irrigation, Bhakra Nangal Canal, Punjab are seriously affected by aquatic weed infestation. Within three years of operation in Chambal Irrigation System, the canals could not pose the designed discharge, even though they were run 15 cm. above the full supply level. Heavy growth of aquatic weeds in the canal system is a significant cause of reduction in flow besides other factors like irregularity of bed slopes, erosion of banks, nature of soil, seepage etc. According to an estimate in the Chambal Irrigation System, the evapotranspiration losses caused by aquatic weeds would otherwise be enough to irrigate about 1,16,800 hectares of wheat or 46,720 hectares of paddy fields.

Measures for control

Various measures used or attempted for removal of weeds include

1) physical removal by manual labour or mechanical means
2) use of chemicals and weedicides
3) biological control.

The physical removal of aquatic weeds by manual labour or mechanical devices is suitable for small and shallow water areas. But this method cannot be used for larger water areas since the results are far from satisfactory in view of the recurrent efforts and expenditure involved.

The chemical method is quite suitable for larger water areas but for the following drawbacks:

(a) The chemicals being toxic may be injurious to fish population

(b) Introduction of chemicals may lead to water pollution

(c) Certain chemicals after losing their initial toxicity may act as manure resulting in luxuriant growth of weeds

(d) The method requires expert supervision in handling the chemicals

(e) Removal of dead weeds as a result of chemical treatment also becomes difficult at times.

The increasing cost of labour and material and the risk of polluting inland aquatic ecosystem by continued use of chemicals make it imperative that suitable biological methods are evolved for control of weeds. Biological control, if successful, will provide long term benefits at lesser cost.

Experiments conducted for eradication of aquatic weeds in the Chambal Irrigation Project have shown that judicious stocking with the weed eating grasscarp fish can be very effective for control of weed growth. It has also been observed that the grasscarp does not cause any damage to the fish population.

The Commonwealth Institute of Biological Control, Bengalore, has investigated the possibility of biological control of Eichhornia crassipes and Salvinia auriculata. Surveys carried out in northern South America and in the West Indies have yielded some host-specific natural enemies which are considered to be suitable for field trials in other areas. These include two species of weevils, Neochetina bruchi and N. eichhorniae, two lepidopterous borers, Acigona infusella and Epipagis albiguttalis, and a mite Orthogalumna terebrantis (all attacking water hyacinth) a semi-aquatic grasshopper - Paulinia acuminata, a lepidopterous borer - Samea multiplicalis, and a weevil - Cyrtobagous singularis (all attacking water fern). Studies on their biology and screening tests carried out with a number of economic plants at the C.I.B.C. Stations in Bangalore and Trinidad have shown that these natural enemies are specific to the two weeds and worth field trials in other areas. If they become established in one or more parts of India where these weeds occur, and are themselves free from attack by indigenous parasites, predators or pathogens they may gradually build up their populations and suppress, if not eradicate the weeds.

Mechanical and biological methods may prove valuable in dealing with submerged aquatics. In the case of emerged and surface aquatic like cattails and water hyacinth, mechanical and chemical methods may be useful. Chemical methods appear promising against weeds on ditch banks. In irrigation channels, chemicals, particularly the soil sterilants, would be useful. When water is not flowing through the channels, these can be applied to control weed growth for varied lengths of time. Whatever be the method adopted for control of weeds, timely, concerted operations including follow-up management measures and proper utilization of cleared areas for fish culture or other utilities are the most essential requirements to avoid the recurrence of noxious vegetation.

Integrated approach for control and utilization

No single method of pest control can be claimed as full proof and effective enough for eradication of aquatic weeds. A combination of different methods may be required depending on the nature and magnitude of infestation. As such, an integrated approach needs to be evolved and employed so as to not cause any ecological disturbance nor create pollutional problem. This would definitely require an appreciation of the function of the ecosystem as a whole which will involve a study of the process, interaction and transfer rates of different organisms as well as organisms and their environment. Surveillance will also be necessary to obtain precise and timely information in the initial stages of infestation so that the malady is nipped in the bud before any widespread and intensive damage is done.

One of the major handicaps in eradication of aquatic weeds is the cost function. Therefore, any rational programme should take appropriate actions so as to recover the expenditure involved in eradication of weeds. The control measures cannot, therefore, be considered in an isolated manner without exploring the possibilities of utilizing the aquatic weeds, as such, or in processed form for some gainful purposes. A plant is only a weed if it is worth nothing. Hence it will be appropriate to define a weed as being a plant whose usefulness has yet to be discerned in the situation in which it is flourishing. The aquatic weeds are green plants containing valuable nutrients like protein, carotene, carbohydrate etc. The large amount of water in the aquatic weeds dilute their nutritive content and adds to the labour and cost of transportation. But if the weeds cost more to harvest, they cost nothing to grow either.

One of the practical and profitable ways for utilization of aquatic weeds would be the preparation of manure by composting. The chemical analysis of water hyacinth compost shows that bulk for bulk, it is nearly twice as rich as town compost and 4 times as that of farmyard manure in the contents of plant nutrients (nitrogen and phosphorus).

Table 3

Chemical composition of compost manures (dried)

	Water-hyacinth compost	Town compost	Farmyard manure
	per cent	per cent	per cent
1. Nitrogen	2.05	1.0	0.50
2. Phosphoric acid (P_2O_5)	1.10	1.0	0.25
3. Potash (K_2O)	2.50	0.80	0.30
4. Lime (CaO)	3.91	3.0 - 5.0	0.2
5. C/N ratio	13	10	12 - 13

The proposal for eradication of pernicious aquatic weeds like water hyacinth through production of compost manure is not only self remunerative but also techno-economically viable like the town compost and other allied schemes. Moreover, the water hyacinth and for that matter most of the aquatic weeds are easily susceptible to anaerobic bio-degradation. The rate of their bio-conversion is also quite satisfactory which can be exploited for production of bio-gas and bio-fertilizer particularly in the developing countries suffering from the shortage of fuel and plant nutrients. Some of the research findings regarding utilization of aquatic weeds for extraction of leaf protein, growth hormone and carotene etc. are quite promising and worth further exploration. The plant residues if used as mulches, can help in soil moisture conservation and at the same time prevent the growth of undesirable weeds in the soil.

Another potential use for the plant material is to supplement it as animal feed which will however require detailed studies to assess the various aspects of nutrition, palatability and storage of plant materials. Production of fast growing aquatic plants may be considered as one of the effective techniques for exploitation of solar energy by biological means to produce the animal as well as human food. The laboratory experiments have shown that it is possible to grow as much as 0.75 t per hectare per day of algae while the yield for food crops is limited to nearly 7.5 t per ha per year only.

Considering the vast amount of raw materials available from the aquatic plants, it is surprising that concerted effort has not yet been made for their utilization, altough the unit operations involved in harvesting, drying, crushing and processing are relatively simple.

Based on the above discussions, it may be concluded that in the process of eradication, certain returns can be obtained from the aquatic weeds. However, the possibility of utilizing these weeds should not lead to a <u>laissez-faire</u> policy with regard to their spread, which was rightly pointed out as early as 1917 by the then Agricultural Adviser to the Government of India while commenting on a paper entitled "Water hyacinth, its value as a fertilizer".

INVESTIGATIONS ON ANTHROPOGENOUS EUTROPHICATION OF INLAND WATERS (FRESHWATERS) OF THE USSR

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Under the conditions of growing technical progress and increase of population in the course of time, the concern for the purity of waters moves more and more into the centre of attention on a global scale. Theoreticians and practicians mutually agree that the danger of the qualitative exploitation of resources together with their pollution and eutrophication represent a much more serious problem than the danger of their physical inaccessabilities (25). Water quality worsens as result of anthropogenous effects on waters in the following three main directions: pollution by toxic waste products of industry and pouring toxic chemicals into the water inflow areas, eutrophication and heating, as well as "thermal pollution".

The main drawback on water quality in future will be anthropogenous eutrophication. This results from the process of substance transformation and equilibrium in the ecological system of the waters and the growth tendency of anthropogenous influence on the biosphere.

Toxic agents (with few exceptions) are subject to irreversible detoxication processes, heavy metals are deposited in the soil, the use of toxic chemicals will be restricted and substituted by easily decayable ones. Eutrophication will however continue with growing speed. This will be caused by the increased drainage of nitrogen and phosphorus from water inflow areas and from sewage as well as their continuous renewal resulting from internal water processes of the substance equilibrium. The denitrification process of compounds into molecular nitrogen and its separation from the cycle no longer compensates for the addition of solid nitrogen compounds resulting from natural and artificial nitrogen fixation. The worldwide production of nitrogen fertilizers, for instance, from 1950 to 1968 increased by five times to level off at about 30 million tons per year. Forecasts expect an annual production of 1 billion tons of nitrogen fertilizers in the year 2000 (14). The deposition of phosphorus in the soil also lags behind the rate of its being added to the waters.

In the last years a number of papers have been published on the questions of anthropogenous eutrophication of waters as consequence of the broad front of research works in our country. In September, 1974 the Institute of Inland Water Biology of the Academy of Sciences of the USSR conducted the first All-Union Symposium on anthropogenous eutrophication, which was organised by the Academy of Sciences Commission on the protection of natural waters (3). A summarising report on anthropogenous eutrophication of dams was published in "Vodnye resursy" (42). The paper of A.N. MUSATOV (30) includes data on anthropogenous eutrophication from 138 sources of literature (including 127 foreign). Many papers were published in the hydrobiological magazine, including the work of L.L. ROSSOLIMO with a theoretical character. Extensive data on the characteristics of the sanitary state, pollution and anthropogenous eutrophication are included in the collected works of the consultations on results of research work on the Volga and Volga dams "Volga 1" and "Volga 2" as well as in the materials of the All-Union Conference in Perm on the problem of complex exploitation and protection of water resources of the Volga basin (11,12,27).

Soviet authors participated in the work of a symposium in the GDR on eutrophication and water protection in October, 1973 (50). A sizeable number of articles on the problem of "pure water", eutrophication and the sanitary condition of waters are included in the collected volume of materials of the III Republic Conference of the Ukrainian Branch of the VGBO (39), in the collected volumes of the III VGBO Congress (44), in the collected volume of materials of the Second All-Union Symposium on sanitary hydrobiology (4) and collected volume of the scientific-technological All-Union Consultation on Working and Organising out Complex Water Protection Measures (36).

Let us take a closer look at the general questions of anthropogenous eutrophication.

<u>On causes and parameters of eutrophication of waters</u>

L.L. ROSSOLIMO defines anthropogenous eutrophication as follows: it is "a disturbance in the limnetic ecology system due to the increase in the level of primary production of organic substances on the basis of anthropogenous growth of nutrients which keeps developing" (37). In the ecological system of lakes this is noticed in the tremendous development of phytoplankton (water "blooming" mostly with blue-green algae) or in intensified growth of shallow water or higher water plants, by thread algae and in the expansion of phyto-microbenthos. In most cases the causes are mineral phosphorus compounds as well as nitrogen compounds together with the presence of certain components of mineral composition and environmental conditions (temperature, insolation of deeper water layers, presence of a substrate, and many more) which limit nutrients. It is important to stress that the disturbance in the limnic ecological system happens as result of hyperproduction of organic matter, with a biological pollution effect at a definite level. In eutrophication the processes of production overweigh the destruction of organic matter, the relationship of primary gross production A to complete destruction P being characterised by the positive factor $A:P > 1$. An equilibrium of this process $A:P = 1$ is the optimum condition for the proper operation of the ecology system. A collection of biomass producers causes a retrograde process leading to superiority of destruction as compared to production. The positive correlation between biomass of phytoplankton and rate of photosynthesis in the collection of blue-green algae above 100 grams/square metre is destructive. For some kinds of algae a reverse dependency exists between these process on different biomass size. With a collection of thread algae, oxygen production exceeds destruction at biomass amounts of 5 to 6 kg/square metre, and higher amounts cause biological pollution leading to a lack of oxygen due to the intensified destruction. In the Kremenchug Reservoir high growth and intense collection of biomass causes higher water plants which lead to swampiness of this reservoir (18).

The following situations should be taken into consideration:

1. In characterising the ratio of gross production to reduction for the ecosystem we should not speak of a superiority of production over destruction but of an optimum ratio of these processes in which the quantities characterising these processes are close to one (0.8 to 1.2).

2. The phenomena of anthropogenous eutrophication apply not only to lakes but also to water courses with relatively retarded flow (rivers in flatlands, brooks, canals). In the latter the excessive accumulation of biomass and the biological disturbances are mainly due to the respective producers (macrophytes and phyto-microbenthos). Investigations by the Institute of Hydrobiology showed that this is to be observed to a lesser degree in canals with a natural (sandy) bed surface and to a greater extent in canals embanked with gravel or concrete (33). Also typical for water courses is the increase in nutrient content in time. Many years of studies on small rivers in the Ukraine have shown that the mineral nitrogen amounts in small rivers in the steppe zone of the Ukraine increased from 0.1 to 5.0 milligrams/litre according to data taken from 1971 to 1973 and in some cases even increased to 12.5 mg/l (35).

Eutrophication is caused not only by the production of autochthonous organic matter but also by the flowing off of allochthonous organic matter (detritus, dissolved organic substances, bacteria and other organisms). This is indicated by a disturbed equilibrium of primary production towards a decrease of the A:P > 1 ratio.

On the bioelement content and inflow sources

Extensive literature is available which has largely been summarised in articles by A.N. MUSATOV (30), A.V. TOPAČEVSKIJ et al. (43) dealing with biogenous elements which limit primary production in waters with their contents and the sources of their supply into the water. Considerable increase of the biomass of the phytoplankton is usually due to the supply of phosphorus whose content in waters is often found to be a minimum. The limiting value of phosphorus in primary production was discussed at length at the XIX Limnological Conference (8). Phosphorus is supplied to the waters mainly by sewage whereas nitrogen is supplied by the territories of the water catchment area. We do not want to repeat the quantitative parameters of these processes which are stated in literature. The question of correcting and complementing existing standards for permissible limit concentrations of biogenes in waters of different types is considered significant.

Specifying the permissible limit concentrations biogenous elements is important on two grounds. Firstly, for important waters instruments should be introduced which automatically record the concentration of the most important biogenous elements meaning reliable signalisation of any undesired consequences to eutrophication. Secondly, in the not too distant future limitations will be worked out on the addition of sewage to waters. In this case it would be easier to fix the limits of sewage additives according to the readings of instruments.

Currently under discussion is the question of fixing reliable limits on the disposal of waste products into waters which shall be proposed to each factory giving off sewage (34).

Bioelements are supplied to the waters mainly by the water catchment areas and by sewage from populated areas and industrial centres; atmospheric precipitation, erosion and damages to banks are involved to a certain extent in this process. The specific percentage of these sources in the enrichment of waters with biogenes varies according to landscaping, physical and geographic conditions of the water catchment areas, the degree of soil cultivation, population of the area (especially of the areas close to the banks of water courses) and the industrial development of the area (number, capacity and arrangement of industrial establishments).

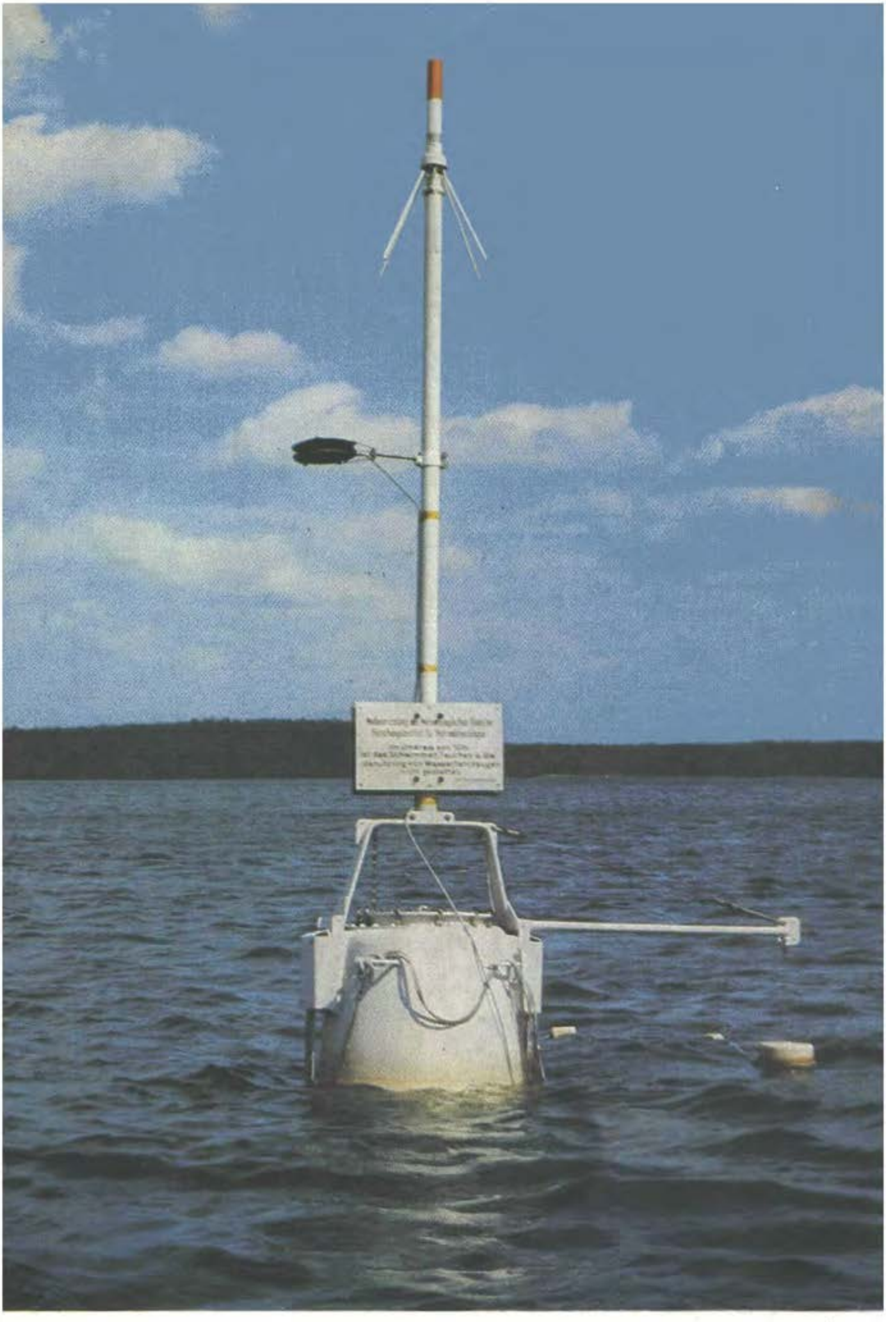
Inland water processes of the bioelement cycle

Surface and ground waters first of all flow into small waterways, and from there following the erosion slope, go into lakes, reservoirs and oceans, where the aerosols, biogenic and organic substances carried with it and accumulate. The transit of bioelements in rivers is no condition for the cycling and for an intensive increase of the bioactivity of phytoplankton. In restricted flow sections however (below 0.5 metres/second) the permanent character of supplying bioelements in increased quantities entails a considerable boost of biomass and a rise in their bioactivity.

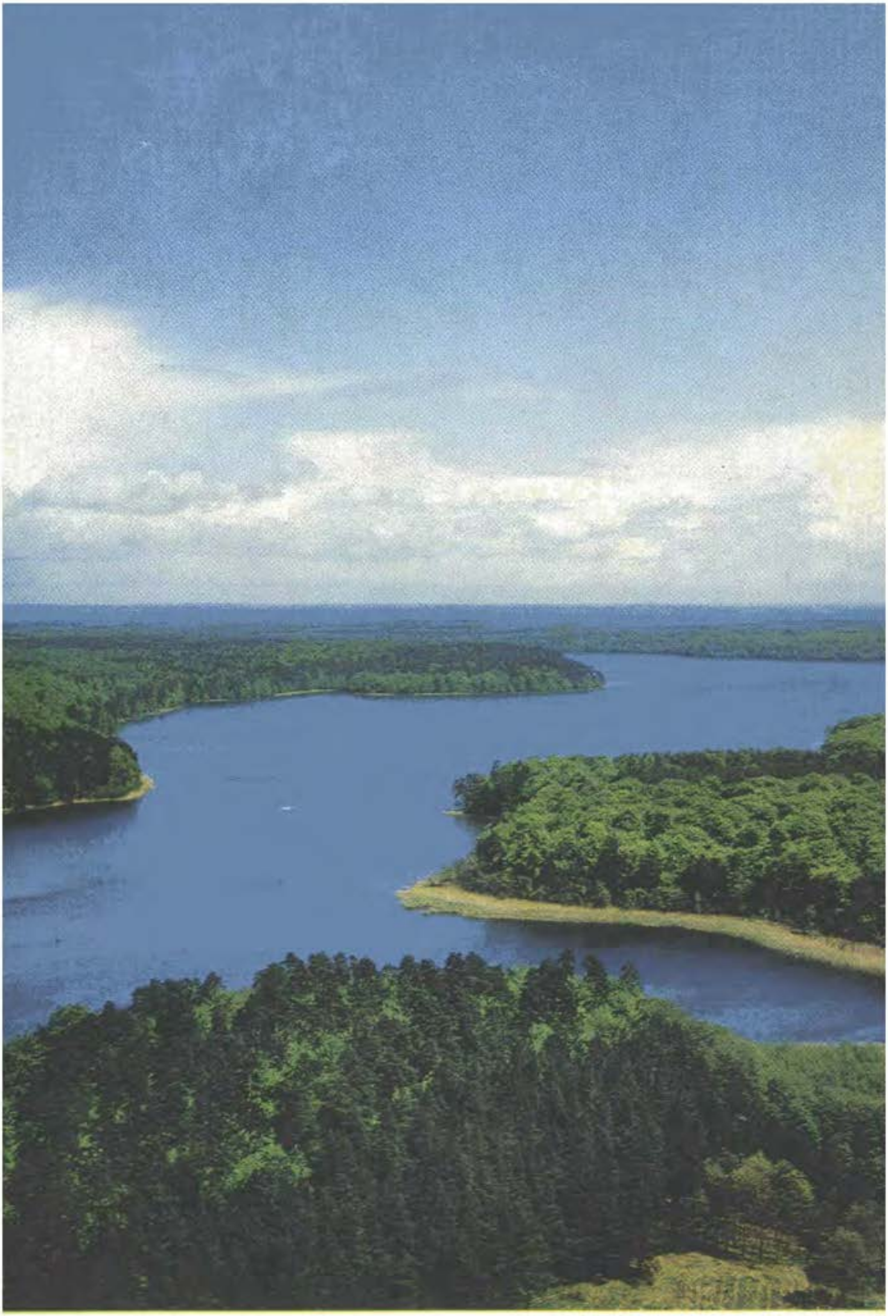
The bioelements consumed by the autotrophic organisms during photosynthesis are returned to the water in the exchange processes of the organisms of the ecosystems and in the bacterial destruction of the dissolved organic matter. This is the essence of metabolism. In this context the speed of decomposition of nitrogen organic substances in waters has been studied (38). An equation for the rate of decomposition of protein was worked out. The rate constant of decomposition depends on the temperature and oxygen saturation of the water; in aerobic conditions decomposition is faster by between 1 and 2 orders of magnitude than in anaerobic conditions.

Regional studies on anthropogenous eutrophication and limitation measures thereof

The large lakes of the north-western European territory of the USSR (Ladoga, Onega and Karelic Lakes) have so far undergone little changes and retain the peculiarities of their limnological specific nature (31). The waters of the pre-Baltic, the Daugava, the smaller rivers and lakes on the other hand have been affected strongly by pllution and eutrophication (22). Eutrophication of



III, 1



III, 2

III, 3

III, 4

Lake Sevan resulted from deverting its original water reserves (up to 24 km^3), by lowering its water level by 18 metres, reducing the depth, uncovering the litoral, and the supply of biogenes from the depths in the destratification of water mass (24). The disturbed structure of the ecosystem of the litoral of Lake Baikal results from raising the water level of the lake due to the damming effect of the reservoir on the Angara and the effects of supplying industrial sewage (19). The concern for the protection of this unique lake, its water resources and its endemic fauna is underlined by relevant resolutions passed by government bodies. The water reservoirs on the Volga and Dnieper were subjected to particularly heavy pollution and eutrophication. Especially in the Dnieper reservoirs intensive "water blooms" caused by blue-green algae and extended biological pollution was observed (43). The Institute of Biology of Inland Waters of the USSR Academy of Sciences, the Institute for Water Affairs of the USSR Academy of Sciences and a number of other institutions have been studying the Volga for a number of years. Scientists from 27 organisations and scientists from 35 organisations took part in the first complex expedition on the Volga in 1971 and the second in 1972, respectively (35).

The main task of all these studies was to work out the scientific basis for ensuring water protection of the river basins, work out measures on restoring the natural quality of water and on improving the complex use of the biological and water resources of these rivers. Combatting eutrophication was a focal point of the XIX Limnological Conference, especially the oligotrophication (rehabilitation) of waters by diverting sewage, chemical precleaning of sewage by precipitating phosphorus with aluminium sulphate and iron sulphate and other reagents.

The Institute of Hydrobiology of the USSR Acadèmy of Sciences together with the Institute of Hydromechanics have developed a technique for removing the seston biomass from reservoirs in collecting points of blue-green algae with subsequent use of the same as raw material to obtain complex amine of fertilizers.

Concluding we note that the extent of research work being carried out in the USSR on anthropogenous eutrophication of waters is such an amount that a second symposium could be summoned to deal with the results thereof.

We would be pleased if our paper has given a general idea on the state of research in this field in the USSR.

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OPERATING CONDITIONS FOR MAXIMUM PHOSPHORUS REMOVAL

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Summary

The extensive discharge of wastes from rapidly expanding municipal, industrial and agricultural complexes initiates and aggravates the process of eutrophication. This nutrient enrichment in water resources results in both economic and aesthetic problems. Phosphorus is considered by many investigators to be the key nutrient in breaking the eutrophication cycle. Attention has been focussed on the use of biological processes for phosphorus removal. As a result of this, considerable controversy has been developed with regard to the phosphorus removal capacity of the activated sludge process and the mechanisms involved.

On the basis of a series of batch laboratory studies, it has been concluded that a proportional relationship between phosphate uptake and sludge load exists. On the other hand, a decrease in the amount of nitrogen uptake was observed by raising the sludge load.

Removal by biological means, however, is limited to cell metabolic need and what ever excess phosphorus can be encouraged to be taken and stored by the cells. Key design criteria and operational parameters have not been sufficiently isolated and identified to effectively implement controlled phosphorus removal by solely metabolic mechanism. Therefore, if phosphorus should be removed from wastewater on a reliable basis, we must choose the chemical methods.

Coagulation with subsequent flocculation has been shown to be suitable for phosphorus removal. Because coagulation is principally a process of high operating costs, it would be interesting if such costs could be partly offset by a saving in the costs of

biological treatment.

Continuous laboratory studies using high-rate plastic packed trickling filter followed by chemical coagulation achieved phosphate removal up to 97.5 %. In addition bacterial cells were destabilized and removed concurrently with other colloidal matter.

I. Introduction

Historically, the reduction of the carbon and suspended solids was the principal objective of wastewater treatment. Recent research however, has demonstrated that when there is increased demand by population and industry on limited resources, the highest degree of treatment may not be sufficient to prevent the deterioration of receiving waters through eutrophication.

The tragedy of eutrophication, by contrast with ordinary pollution, is that once it has become established it is virtually impossible to reverse the process, even if the source of nutrients is eliminated (1). This nutrient enrichment in water resources results in both economic and aesthetic problems of major proportions.

A great deal of thought and study has gone into how these valuable fertilizing elements might be recovered and returned to agricultural lands where they belong, and through their removal prevent fertilization of receiving waters. Early studies (2) showed that both nitrogen and phosphorus could be removed almost completely by activated sludge treatment, if the sewage was fortified with adequate amount of carbohydrate matter. Such practice was considered impractical for most situations and attention was then turned to removing either nitrogen or phosphorus.

It was soon found that it is extremely difficult to remove all forms of nitrogen (ammonia, organic, nitrite, and nitrate), by any single means of treatment. Furthermore, it became apparent that the growth of all forms of algae could not be controlled by limiting nitrogen, because certain blue-green algae, with great nuisance potential, were capable of utilizing nitrogen from the atmosphere (3).

Thus, removal of phosphorus is considered by many investigators to be the key nutrient in breaking the eutrophication cycle (4, 5). Researchers, however, disagree on what the lowest allowable limit should be, but a frequently mentioned figure is 0.03 mg/l as PO_4 after the effluent is mixed with the stram (1).

The major sources of phosphours contributing to eutrophication are domestic sewage, industrial wastes and agricultural runoffs. Domestic sewage is the primary source in critical areas. Phosphate gain entrance to sewage from human body wastes and through the use of condensed inorganic phosphate compounds as builders in detergent formulations. Each of these sources accounts for about half of the phosphorus in domestic sewage (2).

II. Phosphorus removal

The matter of phosphorus removal has been attacked by many investigators. In general, two approaches have been considered namely, biological and chemical techniques.

II.1. Biological removal

It has been reported by several experts that, because of the unfavourable ratio of carbon, nitrogen and phosphorus in sewage, it is not possible to remove more than 25 to 50 per cent of soluble phosphorus from domestic sewage by biological processes (6,7,8).

However, despite this unfavourable ratio, several investigators have demonstrated, using both full scale and laboratory units, that when operated under certain conditions, the activated sludge process can remove significant amounts of phosphorus from sewage (9,10,11).

It has been reported that activated sludge microorganisms are capable of biologically removing and storing phosphorus considerably in excess of what they require for growth through the mechanism of "luxury uptake" (12,13).

As more data have been collected, an alternative chemical explanation has been advanced. MENAR and JENKINS (14) have postulated that high removals occur because of chemical precipitation of phosphates and subsequent entrapment of the precipitate in the matrix of the biological floc. This amount of precipitated calcium phosphate, especially in hard water areas, and the precipitation of additional phosphorus by traces of iron, aluminium, and magnesium normally present in wastewater would produce an efficient overall removal. If this contention is correct, efficient phosphate removal by activated sludge requires a change in the chemical environment, particularly pH.

Optimum removal of phosphorus requires not only that uptake be maximized, but also that subsequent release of soluble phosphorus back to the effluent supernatant be minimized. It has frequently been observed that, following uptake during substrate stabilization, the overall efficiency of the process was significantly lowered by desorption of phosphorus during continued aeration and or final clarification (10,11). As with uptake, the mechanism of release involved and the parameters associated with such a release, remain in dispute.

The literature indicates that several factors exert an influence on biological phosphorus removal. The rate of aeration and the aeration time have been indicated by most investigators as the most important criteria. There is some disagreement in the literature with respect to the optimum concentration of mixed liquor suspended solids (MLSS). Apparently, increased uptake has been attained at both low and high MLSS from 500 mg/l up to 4300 mg/l. At the San Antonio, Texas treatment plant, the optimum appeared to be 1000 mg/l or slightly higher (12). It was also found that the maximum overall phosphate removal occured at organic loadings of 45 to 55 pounds of BOD/day/100 pounds of MLSS under aeration. Other researchers have reported that biological phosphate uptake is always proportional to the new sludge growth (15,16,17).

II.1.1. Report on laboratory investigations
effect of aeration period and sludge-load on phosphorus and nitrogen uptake

In an attempt to define the nature and elucidate the mechanism of phosphate and nitrogen uptake and release by activated sludge, several research investigations have been conducted by the author and NAWAR (18). The research emphasis has been primarilly directed towards the effect of aeration period and sludge load. Results obtained from batch laboratory experiments using desize and desize-kier waste mixture are illustrated graphically in figs. (1-7).

From Fig. 1, it may be seem that the amounts of nitrogen required increased gradually during the first hours of aeration after which a gradual decrease was observed till the twenty fourth hour of aeration.

The amount of phosphorus utilized was found to range from 0.65 to 1.1Kg P/100 Kg BOD removed when the detention period was one hour. This value reached its maximum at the fourth hour of aeration after which a gradual reduction was observed till the twenty fourth hour of aeration (Fig. 2). The same trend recorded for desize waste was observed in the experiments carried out using kier-desize waste mixture (Fig. 3, 4).

From Fig. 7 it may be concluded that a proportional relationship between phosphats requirements and sludge load exists. On the other hand, a decrease in the amount of nitrogen required was observed by raising the sludge load (Figs. 5, 6).

This may be due to the fact that in a complex waste mixture at high BOD concentration, the rate of synthesis is independent of feed concentration. As a result, there is a constant and maximum rate of cellular growth. At this stage the phosphorus requirements increased steadily with the increase in growth rate.

When the rate of removal begins to decrease, the sludge still contains unassimilated organic carbon. While removal is progressively decreasing in time beyond this point, synthesis will continue at a maximum rate until the excess carbon concentration in the cell is depleted by conversion into cellular mass. This causes a rapid decrease in cellular carbon and phosphorus requirements accompanied by a corresponding increase in cellular nitrogen. This phenomenon has been demonstrated by several investigators (19,20,21). GAUDY (22) in the treatment of pulp mill wastes, showed a peak in cellular carbohydrate after 3 hours aeration with a corresponding cellular protein peak after 6 hours aeration.

Mc WHORTER and HEUKELEKIAN (19) showed that in the presence of available external substrate the nitrogen content of the cells was 8 to 9 per cent by weight and increased to 12 per cent when the stored carbon was used for synthesis. The rapid decrease in a cellular mass after substantial exhaustion can be attributed to conversion of stored carbohydrate to cellular protoplasm (21). This may explain the reduction of nitrogen requirements with increasing the organic load.

II.2. Chemical removal

Phosphorus removal by chemical precipitation is out of the research stage. Field experience on full-scale and large demonstration pilot plants shows that iron salts, aluminium salts and lime can be equally effective as phosphorus precipitants in wastewater.

The chemically bound precipitated phosphorus is removed with the sludge and is not resolubilized during sludge disposal unless the pH is substantially lowered.

Chemical doses of iron and aluminium salts are related to the phosphate content and the requirement to provide sufficient hydrolysis products of the metal. A laboratory study in Cincinnati obtained 80 and 90 % phosphate removal with an Al^{3+}:P molar ratio of 1.5 : 1 and 1.4 : 1, respectively (23). THOMAS (24) has indicated a dosage of 2.05 mg/l of Fe^{3+} as being required for the removal of 1 mg/l of P. BARTH and ETTINGER indicated a need of 1.8 mg/l of Al^{3+} for the removal of 1 mg/l of P (25).

Strict chemical methods precipitate phosphorus either in the primary settler or in a tertiary clarifier. The chemical-biological method employs direct chemical dosing to the aeration tank of an activated sludge plant. For trickling filter plants, the chemical precipitation should be accomplished in the primary tank. Direct dosing of chemicals to the trickling filter has not proven to be highly effective. Subsequent passage through trickling filter to satisfy metabolic needs serves as a polishing step.

With an activated sludge plant, it makes very little difference where the point of addition of the metal ion is. Efficient removals have been obtained when dosing wastewater after primary settling, in aeration tank, or near the mixed liquor exit point. However, the overall plant efficiency is dependent upon the ability of the biological floc to collect these dispersed precipitates and remove them from the final plant effluent.

II.2.1. Laboratory investigation

Because coagulation is principally a process of high operating costs, it will be interesting if such costs could be partly offset by a saving in the cost of biological treatment.

Continuous laboratory investigations to study the optimization of the treatment of sewage by a combination of high rate plastic packed filter with chemical and physical treatment were carried out. Fig. (8) shows schematically the basic plant flow. Average results obtained are given in table (1). Chemical coagulation was carried out using non-setteled biological effluent.

Analysis of the data obtained shows that effective removals of the organic compounds present in trickling filter effluent were achieved when aluminium and iron salts were used at their optimal dosages and pH-values. COD removals ranging from 93 to 95 % were attained. Corresponding BOD removals varied from 95 to 97 %. Bacterial cells were destabilized and removed from solution concurrently with coagulation of other colloidal material. Approximately 91 per cent of the viable bacteria initially present were removed at the optimum coagulant dose. In addition, the coagulation process achieved significant removals of the nutrients responsible for eutrophication. Total phosphate removal up to 97.5 % was recorded.

The addition of an activated carbon filter showed an increase in the treatment efficiency. COD removal ranging from 46 to 78 %, from chemically treaed effluent was attained. Residual total organic carbon varrying from 0.5 to 5 mg C/l was recognized. Further 90 % reduction of the viable bacterial cells were achieved. Effluent phosphorus concentration less than 0.05 mg P/l was recorded.

III. Discussion and conclusions

From the results of these investigations and the literature reviewed, it may be concluded that the removal of phosphorus by biological synthesis and "luxury uptake" is not a controllable process. Key design criteria and operational parameters have not been sufficiently isolated and identified to effectively predict and implement controlled phosphorus removal by solely metabolic mechanism. If we are to reliably remove phosphorus from wastewaters on a sustained basis, we must choose the chemical or the chemical-biological methods.

Coagulation, however, is principally a process of high operating costs. Therefore, it would be interesting if such costs could be partly offset by a saving in the cost of biological treatment. EDEN (26) found that the BOD production of an effluent of 20 mg/l, in one stage by biological filtration followed by humus tank will require a filter loaded at about 0.15 lb BOD/Yd^3/d. An effluent of BOD, say, 50 mg/l could, however, be produced from an average sewage by treatment in a high-rate biological filter at a loading of 1.5 lb BOD/Yd^3/d with a very considerable saving in filter capacity. The plan area of the filter would be further reduced if plastics media are used, since the filter could be made much taller. In general, in addition to the advantages of high-rate plastic packed biofiltration systems mentioned before, (27-29), the combination with coagulation flocculation unit has been shown to offer a number of advantages.

Analysis of data and review of the operating experience presented permit the following conclusions:

1. Effective removals of the organic compounds present in trickling filter effluent were achieved when aluminium and iron salts were used at their optimal dosages and pH-values. COD removals from 93 to 95 % were attained. Corresponding BOD removals varied from 95 to 97 %. Bacterial cells were destabilized and removed from solution concurrently with coagulation of other colloidal material. In addition, the coagulation process achieved significant removals of the nutrients responsible for eutrophication. Total phosphats removal up to 97.5 % was recorded.

2. The addition of an activated carbon filter would increase the treatment efficiency. This is particularly suitable for application to certain wastewater treatment facilities that require high levels of treatment. Residual percentage COD removal of 46 to 78 % from chemically treated effluent was obtained. Residual total organic carbon ranging from 0.5 to 5 mg C/l was recognized. Further 90 % reduction of the viable bacterial cells was achieved.

__Table 1:__ Summary of experiments using biological, chemical and physical treatment processes

Grain size (mm)	Detention period (min)	COD (mg O_2/1)			TOC (mg C/1)			Total phosphate (mg P/1)		
		T.F. effl.	Ch.Tr. effl.	A.C. effl.	T.F. effl.	Ch.Tr. effl.	A.C. effl.	T.F. effl.	Ch.Tr. effl.	A.C. effl.
0.5-0.75	20	27.0	13.0	7.0	20.0	8.0	4.5	2.6	0.5	0.05
	30	29.0	18.0	4.0	19.0	11.0	5.0	3.0	0.4	0.00
	60	22.0	13.7	3.0	12.5	3.0	0.5	2.9	0.3	0.02
0.3-0.5	20	24.5	14.9	4.6	13.0	8.0	3.0	7.0	0.5	0.02
	30	28.0	17.5	4.0	20.0	14.0	4.5	3.6	0.7	0.05
	60	28.5	17.0	3.6	19.8	7.0	1.5	3.0	0.5	0.05

T.F. effl. = Trickling filter effluent
Ch.Tr. effl. = Effluent from the coagulation flocculation unit using 30 mg Al^{3+}/1.
A.C. effl. = Effluent after activated carbon treatment.

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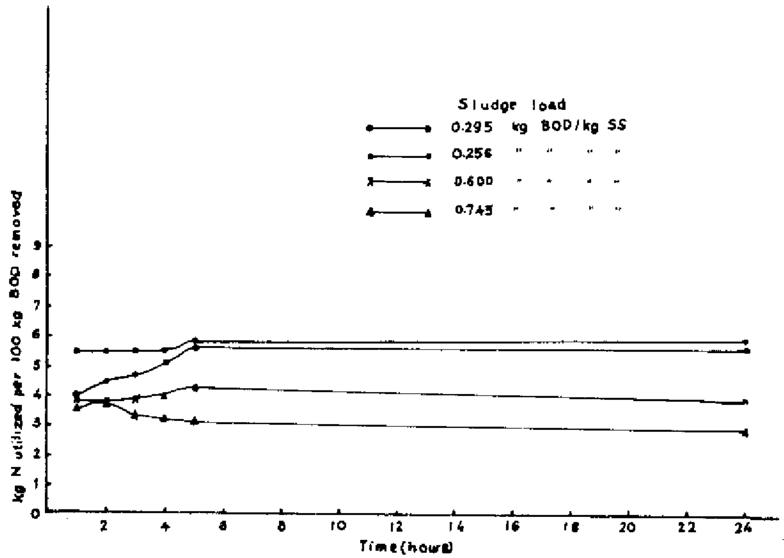


Fig.1: Effect of aeration time on the nitrogen requirements of desize waste at different sludge loads.

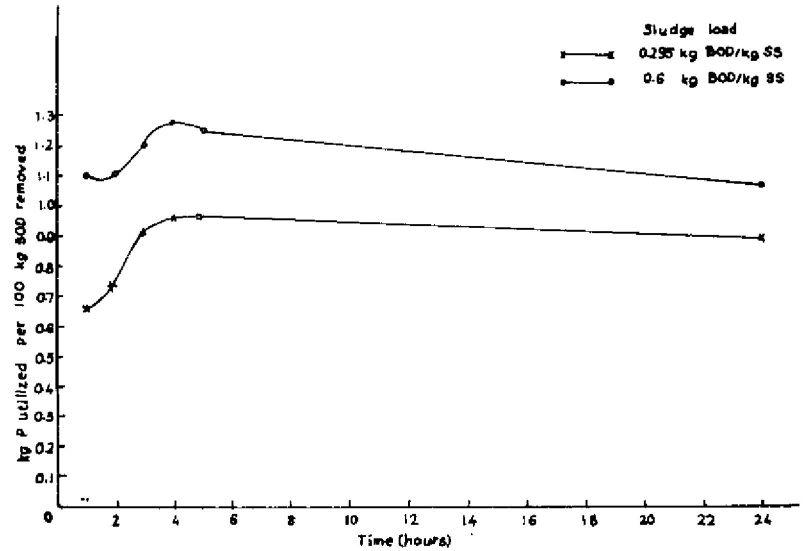
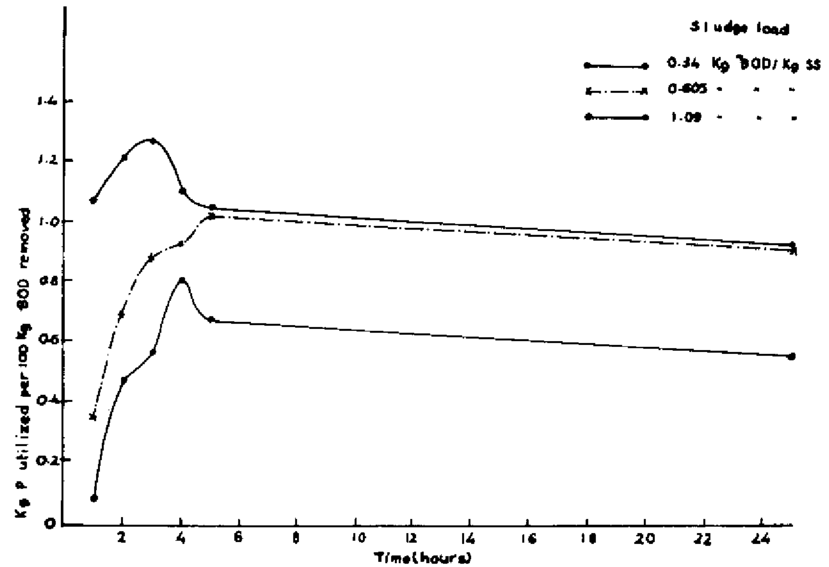


Fig.2: Effect of aeration time on the phosphorus requirements of desize waste at different sludge loads.



<u>Fig.3:</u> Effect of aeration time on the phosphorus requirements of kier-desize waste at different sludge loads.

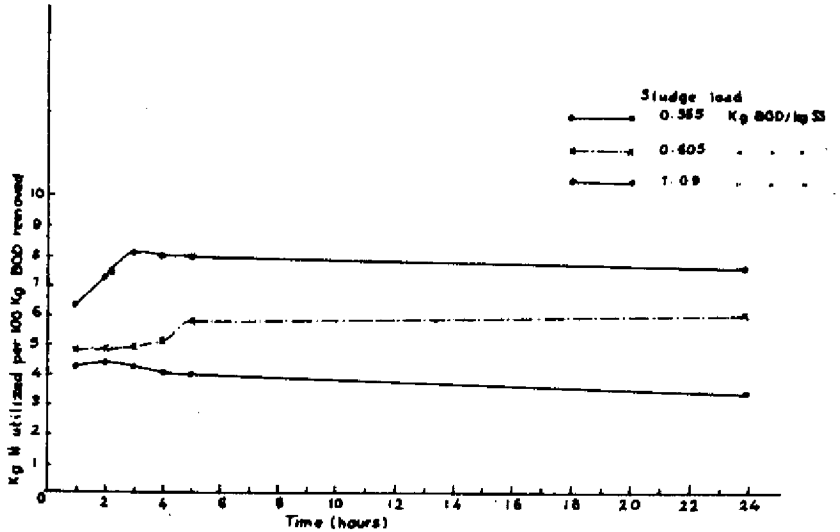


Fig.4: Effect of aeration time on the nitrogen requirements of kier-desize waste at different sludge loads

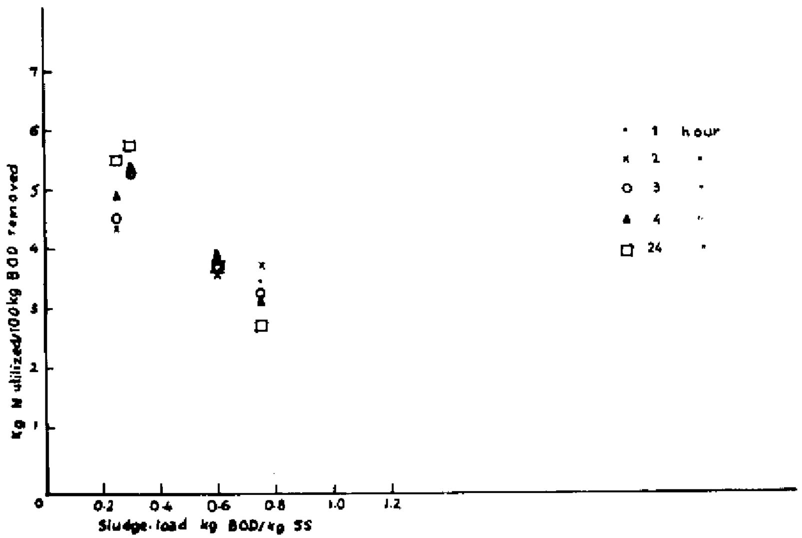


Fig.5: Relationship between sludge load and the nitrogen requirements for desize waste treatment at different aeration periods.

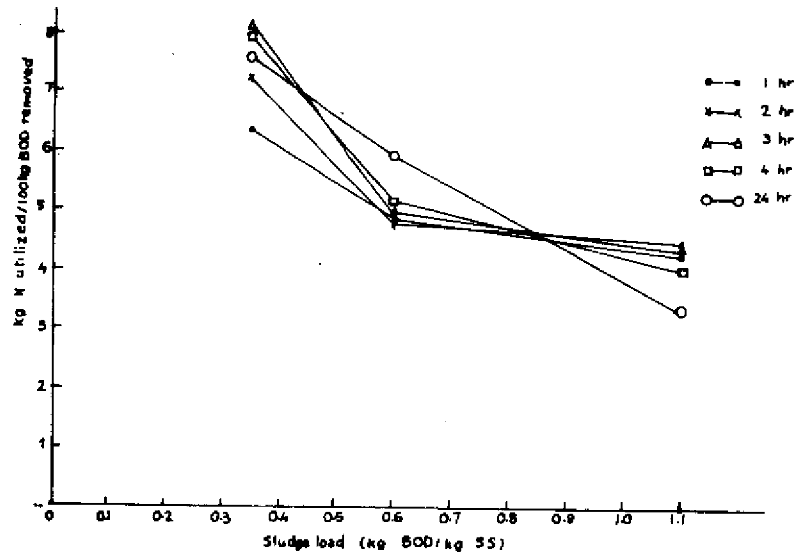


Fig. 6: Relationship between sludge-load and the nitrogen requirements for kier-desize waste treatment at different aeration periods.

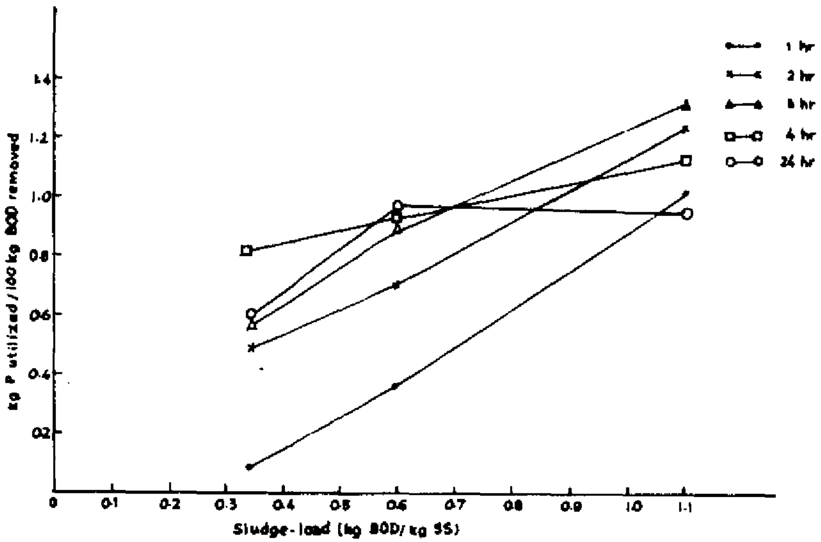


Fig.7: Relationship between sludge load and the phosphorus requirements for kier-desize waste treatment at different aeration periods.

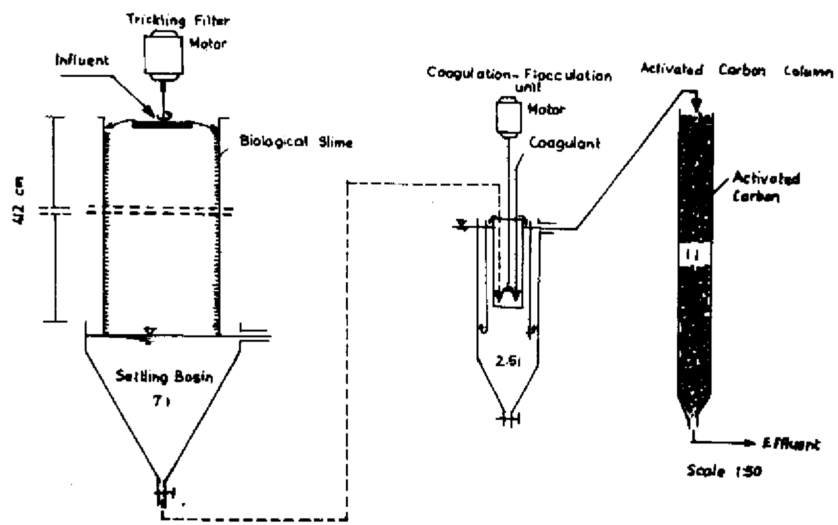


Fig. 8: Schematic diagramm of the plant used.

ECONOMIC AND SOCIAL ASPECTS OF EUTROPHICATION; THE IMPORTANCE OF THE SUBJECT TO THE ECONOMIC DEVELOPMENT

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Compared to the total area of oceans and seas which occupy three-fourths of the earth's space, the sources of fresh water, both lenitic and lotic seem to be insignificant. Also, the amount of water beneath the surface of land is very great, although the actual quantity is not known.

In spite of this, sooner or later the world with the existing population of about 3,000 million and increasing at the rate of 1,7 % annually, may be faced with a very serious water famine due to the explosive population growth and increasing agricultural and industrial developments. Added to this menacing situation is the increasing eutrophication of surface and underground waters, which not only reduces the available purewater supplies and lowers their quality, but also involves costly and complicated purification treatments. Without an adequate supply of pure and safe water, nations cannot exist and also cannot produce the food required for their survival.

The possible lines of action for saving mankind from the impending catastrophic situation within the next half a century or so are:

(i) to seek new sources of water supply, e.g. by tapping the antarctic icebergs, purifying sea water, making artificial rains changing the climate etc. (3); or

(ii) to exercise control over the use of the existing sources of supply by preventing their unnecessary pollution, by trying to reuse the water as many times as possible, either for the same purpose or for different purposes until it finally becomes so polluted as to necessitate regeneration before further recirculation (4).

New sources of water supply

This line of action has already been initiated in certain coastal areas of the north-east and middle-east regions and in western countries. Serious attempts are being made to convert sea or brackish water into sweet water in countries which now lack adequate quantities of good water. The techniques being used for the purpose in the technologically advanced countries of the west are: distillation, freezing, hydration, reverse osmosis and electrodialysis. The first three methods are thermal in nature and are based on temperature changes which remove the dissolved solids by either vaporising or solidifying the water. The last two methods are based on separation of the salts from the water by the use of membranes.

Conversion of sea or brackish water into sweet water

Important studies towards reduction of the cost of desalination of brackish waters through the development of nuclear-powered electric plants are underway in USA. The basis of this approach is to use the excess steam produced in the nuclear plants for desalting sea water, thus making the process economical.

At present water is being pumped to Benghazi in Libya from bore-holes some 30 km away from the town. It is brackish and has 650 to 2,000 ppm of total dissolved solids compared to 350 ppm in London's water supply. Brackish water which has lower salinity than sea water is more economically desalted by electro-dialysis than by any other method. A giant plant for supplying 5 million gallons per day has been constructed by Britain. Considering the fact that the residents of Benghazi have been drinking water with up to 2000 ppm salinity, the new plant will be a boon.

A scheme is reported to be in hand in Israel to reclaim all sewage in Tel Aviv region, purify it in the sand dunes to the south of the city and redistribute if for use in factories, kitchens and farms. The sewage reclamation and purification scheme has not been conceived as an isolated measure. It is connected with another scheme which envisages the setting up of a sea water desalination plant on the Mediterranean cost. Each scheme will augment Israel water resources by 100 million gallons per day. It is proposed to combine the two schemes so as to make them economically feasible. The treated sewage water by itself would be inexpensive and pure but too salty for wide spread use. On the other hand desalted Mediterranean water would be too costly. A blend of the two in equal proportions, however, would make farming as well as any other use to which the water is put simultaneously safe and inexpensive.

<u>Re-use of waste water</u>

This line of action was anticipated by the German sanitary Engineer Karl IMHOFF, who had stated as early as 1931 the possibilities and limitations of water-sewage-water cycle as follows: "Viewed from the stand point of water purification and as a result of observations from nature and experiments, there can be little doubt that a city's sewage can be purified and reused in rotation as many as ten times. This implies that in order to halt the increasing salinity, a city is required to furnish its regular supply only to the extent of 10 % of the collected sewage volume. Merely this 10 % plus evaporation loss is required as pure water brought from without. The city's remaining requirements can be met from its own sewage" (5).

This line of action is feasible for cities and towns which are located in arid and semi-arid regions and/or far away from coastal areas. In fact, reuse of sewage effluents seems to offer the only way of meeting the increasing water shortage due to eutrophication in these places at the present time.

An examination of the actual position existing today in the highly industrialized countries of the west shows that it is technically feasible and possible to reuse domestic sewage after purification and natural or artificial regeneration. At Chanute in the United States, the city's waste water is being purified in sedimentation tanks, while at Bielefeld in Germany the sewage effluents are being treated biologically and returned to the underground table from which the city draws its water supply.

We have also the evidence of current research into the provision of water for cosmonauts by complete recirculation.

It will be evident from the foregoing that increasingly reliable methods of sewage purification and regeneration will have to be systematically adopted in future, and sewage effluents or "used water" will become an important means of increasing supplies of drinking water, or water for agriculture and/or industrial purposes (6).

Existing situation

In the technically advanced countries of the west, increasing volumes of sewage and/or industrial effluents (or factory liquid wastes) are being discharged into streams, rivers and lakes and reservoirs, where insufficient dilution takes place with very good quality of water. The conventional waste treatment processes are unable to treat effectively an expanding list of "refractory", compounds from factories manufacturing detergents, pesticides, herbicides etc., and these may have disastrous effects even in minute concentrations, as dilution water is becoming less and less available, and stream self-purification, generally, does not work for inorganic stream pollution and for organic compounds have which already resisted waste treatment (7).

In Great Britain, it was found that in the beginning of this century, the rivers generally had a 5 day BOD value of 2.0 ppm. During the next 50 years or so, the condition in the rivers had radically changed for the worse. There is an increasing rate of abstraction of river water and its replacement by an equal volume of sewage and/or industrial effluents of one kind or the other. Therefore, reliance can no longer be placed on dilution to reduce the effects of pollution caused by purified effluents, containing inorganic salts and highly complex organic substances.

Besides, industries keep on introducing newer organic compounds as detergents, pesticides and herbicides. Some of these organic pollutants are not only extremely refractory but also remain potent even after extensive dilution. So, must of the water supplies which draw water from polluted streams and rivers in the west at present are endangered by "creeping pollution" (8).

An additional stage in waste treatment known as "polishing" or "tertiary treatment" or final treatment of sewage works effluents has came into vague. The important forms of such treatment are: lagoon treatment, intermittent rapid sand filtration, micro-straining, slow sand filtration, treatment in grass-plots (not land irrigation), chlorination, adsorption by activated carbon, ion-exchange resins and membranes. Of these treatments, lagoon treatment in the so-called "maturation ponds" is most economical. But it can be adopted only in such places where land is inexpensive, the climate conditions are suitable, organic loadings fluctuate widely and funds are limited. Most of these conditions are satisfied in trophical countries like Africa, Middle East, Near East and Far East.

The National Institute for Water Research of the South African Council for Scientific and Industrial Research has been carrying out research on the use of oxidation pond systems for purification of sewage and sewage effluents, and the results of these investigations have formed progressive applications in South and South-West Africa (9). Their important findings are that the system of treatment by the oxidation pond method (or stabilization pond method) has the advantages of economy, simplicity of construction, ease of operation and maintenance. The resulting effluent is fit for reuse, and the system provides better barriers against pollution in the event of mismanagement than other conventional treatment systems.

Maturation pond systems are useful in minimizing the hitherto uncontrolled eutrophication of rivers, lakes and reservoirs receiving purified sewage effluents to suit various useful purposes. The effluent to be put into maturation ponds should be already well stabilized in conventional sewage treatment works or from a series of stabilization ponds. In maturation ponds purification is effected primarily with respect to bacteriological quality and advanced biochemical purification as illustrated by further reduction of synthetic detergents. This improvement in chemical quality is often masked by profilic algal activity.

The biological processes which improve a sewage effluent chemically and bacteriologically also bring about virological purification. From the virological point of view a pond system should be as shallow as possible and so extensive that the retention period exceeds the normal survival time of an infectious virus. This stresses the importance of preventing shortcircuting and points to the necessity of having a number of ponds working in series for tertiary treatment of sewage or sewage effluents.

Lagoon Treatment: TAYLOR (10) has summarized the results of his three-year study of the method of lagoon treatment of an effluent from the conventional sewage disposal plants at Rye Meads, Hertfordshire in England. A part of the fully treated effluent was passed through three shallow lagoons of depths varying from 5.3 to 11.5 ft working in series and having a capacity of 30 million gallons at a flow rate of 1.5 million gallons per day. This gave a retention period of 3 days in the first lagoon, 5 days in the second and 9 days in the third lagoon before final discharge into the river Thames after 17 days. The results were highly satisfactory. A final effluent having a quality standard comparable to that of good river water in every respect was produced. The lagoons acted as a "buffer" between the treatment plant and the river in that any excess of suspended sludge or humus was held back in the lagoons or a sudden "wedge" of the toxic or undesirable substance in the plant effluent was diluted by the large volumes of the recurring waters in the lagoons. Also, this afforded a protection to fish life in the river from any harmful matter in the sewage effluent.

There was also considerable improvement in the organic quality of the effluent after passing through the lagoons. An outstanding feature of the lagoons treatment was the discharge of a fully oxygenated effluent into the river, avoiding any harmful effect on the fisheries. Algal growth did not adversely affect the suspended solids and BOD values, and it was the usual experience to obtain values below 5 mg/l for these two parameters. An effluent of this consistently high quality could be safely discharged into the receiving water course even if the flows in the latter were only of the order of twice the volume of the effluent, or even less if the quality of water in the stream were exceedingly good. Another noteworthy feature of the lagoon treatment was the reduction in the number of sewage indicating bacteria by 99,5 %. Pathogenic organisms such as those of the Salmonella group had virtually disappeared after passing through the lagoons. Enteroviruses were also isolated from the plant effluent on occasions, but they were present in only two of the samples discharged from the third lagoon to the river during the three year period.

It follows that lagoon treatment in a series of ponds is highly effective in removing pathogens, parasites and viruses.

Stabilization lagoons at Ahmedabad, India

The Ahmedabad Municipal Corporation was perhaps the first in India to construct a series of 8 lagoons as an experimental measure through which about half a million gallons of raw, settled domestic sewage was passed every day before the final effluent was discharged into the Sabarmati river. The ponds have been in existence since 1962. They were examined during different seasons of 1966 and 1967 for physicochemical, biochemical, bacteriological and biological aspects in order to assess their performance as to their ability to produce at all times a final effluent complying with the standards of purity fixed by WHO and the Indian Standards Institution (I.S.I.) for raw water used as a source of water supply before further treatment so that it can be used in an emergency for potable purposes after treatment in the water works.

The ponds were self-regulating requiring very little attention in the nature of operational control. From the examination of their effluents for nearly 2 years, PAREKH (11) concluded that the physicochemical variables in the final effluent showed considerable improvement. Bacteriologically the final effluent conformed to the WHO and I.S.I. Standards fixed for raw water used as a source of water supply and was also free from pathogens. Retention in a lagoons for 42 days was expected to make the final effluent free from entero-viruses.

Development of the concept of waste water rehabilitation

The need for reuse of waste water is increasing as fresh water resources become exhausted. It is little realized that reuse is inherent in the dual water supply and waste water disposal practized all along the American water courses. So, if a city or an industry were to reclaim 80 % of the water it uses, its existing fresh water supply could be enlarged effectively five times (7). Considerable effort is being expended in the west in educating the public on the concept of using recovered water and on the desirability of eliminating the unrealistic division between water and waste water. As the demand for water increases and sewage effluents and river waters are used more extensively, the quality will be determined by the use to which a water is put rather than the need to prevent nuisance or support fish. The gap between the end of sewage treatment and the beginning of water supply will soon be narrowed down. Public Health Engineers in USA are already thinking in terms of closing this gap altogether so that in a sewered city it may be possible to produce from the city's sewage water that is suitable for further treatment in the same city's water works for domestic water supply. Alternatively it may be possible to produce an effluent which can be used either indirectly in power production, industry or agriculture, as compensation water or for recharging aquifers or indirectly for replenishing the depleted flow in a river which may itself subsequently be used as a source of raw water (12). So, water cannot be used once and discarded. "Water must be used, and then reused, and reused

PROBLEMS RELATING TO THE LONG-TERM PLANNED USE OF THE NATURAL WATER RESOURCES IN THE GERMAN DEMOCRATIC REPUBLIC

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Summary

The water resource situation, the water balance and the development of demand are shown. The water economy of the GDR has to use the multiple utilization of water because of the high demands of the developed socialist society. A long-term, planned use of the resource water can only be attained through the further development of the forms of intensification of water use in particular the multiple utilization of water. The quality of water of the running waters and lakes reflects on the one hand the considerable water utilization and the adopted production technologies as well as efforts undertaken the cleanse the waste water. Treatment is given to measures taken in the GDR for a planned utilization of water

The German Democratic Republic (GDR) is amongst the highly industrialized states with an intensive agricultural and forestry sector.

Consequently high demands aro made in the GDR on all natural resources in particular in regard to water. The water balance shows that with an average annual precipitation of 628 mm and an input of Elbe River and Oder River corresponding to an annual precipitation of 88 mm the GDR evidences the lowest water resources of all industrial countries. Whereas in all European states the available water resources per inhabitant are above 2,000 m^3, in the GDR it is only some 900 m^3. However only about half of this water quantity is available for utilization. This yields a stable water resource of 8.7 thousand million m^3/year whereby in low water periods an addition of one thousand million m^3 is available from reservoirs and controlled lakes. As regards ground water the reserves on hand during the five-year plan period 1971 to 1975 were sufficient at 120 million m^3/a; on the other hand the goal in respect of hydro-geological investigation for the period 1976 to 1980 is in some 140 to 16o million m^3/a.

The degree of utilization of water in the GDR is about 40 per cent and this heads the table of industrial states of the world. (Comparison: the degree of utilization of the remaining European states is less than 17 percent). The multiple utilization of water can at present during dry months increase to the factor 1.5 whereby in the agglomeration areas a value of 3 to 4 is attained.

This relatively constant water supply was counterposed by the following water demand:

Table 1

Water requirements in the GDR (millions of m^3/a)

	1970	1975	increase (%)
Population	930	1,130	21
Industry	5,520	5,860	11
Agriculture	790	1,110	40
Total	7,240	8,100	12

The envisaged development of demand in the GDR to the year 1990 expects the greatest increase in agriculture, a doubling of the requirements of the population and a slight increase in industry. The development of water demand indicates that in 1990 the water demand in the GDR will, on the average, reach the stable water resources. In the following years a multi utilization of water has to be substantially increased, this in turn necessitating further water economy measures for the intensitve extension of the natural resource water in particular for the improvement of the water quality.

As regards the anticipated considerable expansion of irrigated agricultural land, measures are necessary by the authorities responsible for the water quantity management. Irrigation which indicates a level of 50,000 ha of agricultural area in 1970 is to expanded till 1980 by about 480,000 to 520,000 ha. As the required water cannot be wholly derived in the vegetation period from running water, in future strong increase in reservoir capacity is necessary. Such an increase of reservoir capacity for agricultural purposes alone will then require a considerable share of the planned reservoir capacity increase envisaged by 1990. By 1980 an extension of the volume of water storage to 1.4 thousand million m^3 is planned.

The economic and social-political objective laws operative in the developed socialist society require a high growth rate of the national economy. This exerts an influence on the water economy too. Thus a high part of 4.8 per cent of total investments were invested in the water resources policy (1974). The branch water economy has a very considerable stock of capital assets(only in communal field 14.700 thousand million marks). This means that there exists a share of water economy capital assests of 6.8 per cent of the capital accets of industry; here the water economy capital assets belonging to industrial enterprises have not been included. These figures show that in the GDR very considerable sums are allocated in order to guarantee meeting the growing demands on the water supply.

The tendency of increasing water requirements is continuing although simultaneously in the GDR considerable efforts are being undertaken to reduce the specific water use and, in particular, water use with losses in the national economy through technologies requiring less and even no water at all. The Directive of the 9th Party congress of the SUP for the development of the National Economy of the GDR envisages a reduction of the specific water utilization by industry of 20 per cent by 1980 and to increase multiple utilization. The water demand of our society shows an absolute upward trend alongside the economic development as a whole (growth of production) and above all as a consequence of the improved meeting of the living requirements of the population (construction of flats and social buildings as well as the qualitative improvement of older dwellings) as well as on account of the unity of economic and social policies. The water use of the population is a significant factor in increasing water utilization as a whole. In Berlin, for example, use during the winter months is today as great as five years ago in summer. The difference in water use in various types of flats is shown in the following table:

Table 2

Water use in the inner districts of the Capital, Berlin

l/day/person (average)

40 - 70	in old dwellings
110 - 115	in modernised dwellings
125 - 135	in new flats

Increasing important is also accrueing in respect of water also for retaining the ecological functions and for the stabilization of the biogeozenoses in the intensively used territory of the GDR.

At the present time there are no practicable possibilities for an absolute increase in primary water volumes, that is to say an extensive expansion of the natural resource water. The objectively growing demands on the natural resource water can only be met in GDR through an intensification of water utilization. The intensification thus becomes the main problem in the rational use of the natural resource. It is realised here in two ways:

- in the multiple utilization of water which is at the same time usually a multi-purpose utilization
- in the reduction of water use and water usage in the national economy in particular related to each unit of production.

This method of economizing is generally not applicable as regards the requirements of the population. In the materials published in connexion with the 9th Party Congress of the SUP water supply and waste water treatment for the housing construction programme is characterized as the decisive task of water economy in this five-year plan period.

In 1975 water requirements in the GDR were met 3/4 from surface water and 1/4 from groundwater. The increase of water earmarking to satisfy the growing water requirements will ensue both through increasing groundwater hauling and above all also through greater withdrawals of surface water. Key here is the improvement of the quality of water in running waters, the reduction in the degree of eutrophication in the lakes and reservoirs as well as increasing the share of steerable surface water through reservoir installations. This proportion is present theoretically some 1/5 of the surface water withdrawal and thus already indicates a relatively high degree of steering.

Because of the high demands of the developed socialist society and of a population with a high per head usage of water and a high population density the water economy of the GDR has virtually necessary the multiple utilization of water. A long-term, planned utilization of the natural resource water in countries such as the GDR evidencing a high utilization intensity can only ensue given the further development of specific forms of intensification of water utilization. That is to say all pre-conditions for such an intensification through the multiple and multipurpose utilization must be created. Such pre-conditions include the following:

- the reduction of the nutritive matter content of the surface water with the consequent pronounced production of biomass,
- the development of commensurate technologies to prevent yield of such nutritive matter as a means to this end and

- in the economic field the hindrance of the costs progression in the multiple utilization of the water per unit of water with growing degree of eutrophication.

The struggle against the eutrophication of the waters as an important problem as regards the quality of water shows that in countries with intensive utilization of territory society has already for a long period found it necessary to intervene in the stabilization of the biosphere. Now, because of the high costs alongside improved utilization of available effective principles (technologies, procedure) for such a stabilization, also new ones (for instance nutrient elimination from the water) have to be employed. In this stabilization a new level in technology and economy has to be attained.

The quality of water of the running waters in the GDR reflects on the one hand the considerable water utilization and the production technology which stems from capitalist conditions as well as, on the other hand the efforts for cleansing sewage. Despite the high production increase in the GDR 2/5 of the running waters are either clean or somewhat contaminated. Great successes have been recorded regarding the connexion to the central water network and canalisation (with effects on the quality of water) as indicated by the following table:

Table 3

Capacity and Performance of Water Supply and Waste Water Treatment Units

Year	Available maximum capacity of drinking and usage water (mill. m^3/d)	Supplied water amount per head of persons connected to the central water (1/d)	Inhabitants connected to the central water net work (% of total population)	Inhabitants connected to canalisation Total	of whom % connected to sewage treatment plant
1965	3.8	93	79	59	39
1970	5.1	100	81	60	43
1974	5.8	112	84	63	46
1980 (plan)	6.8				

By means of economic provisions (water usage levies, sewage introduction and sewage levies on the basis of limit values) the cleansing of the waters are stimulated as a result of which in some river sections the quality of the water could be improved by one or two utilization categories. In accordance with the Water Resources Law of the GDR programmes for a step by step restoration were drawn up for all river basins.

However the territorial structure of the national economy of the GDR must be particularly taken in consideration for it is characterized by strong spatial concentration. Half of the industrial production takes place on only 15 per cent of the area of the state in question on which 2/3 of the population is concentrated. Consequently water contamination in the industrial agglomeration remains high. Seen from the hydrographical angle one reason is that of the four agglomeration areas in the GDR

(Berlin, Leipzig/Halle, Karl-Marx-Stadt/Zwickau, Dresden) in which half the industrial production is concentrated, only Dresden has a position on an efficient river. The Vereinigte Mulde, a river with a medium discharge of some 60 m^3/sec absorbs the sewage of two industrial agglomeration areas.

The lakes and reservoirs of the GDR show generally a high degree of eutrophication. Thus within the framework of the bio-activity of the waters they show a high intensity of primary production. Oligotrophic lakes are rare. Eutrophic on the other hand are both the biggest GDR lake, the Müritz as well as the 7.7 sq.km big Müggelsee (lake also) with an average depth of five metres which lies within the Berlin city boundary and is important for Berlin's water supply. Many lakes do not possess aerobic hypolimnion and thus no certain phosphate connexion in the sediment.

The high nutrient content of the natural lakes in the GDR which are mainly in the northern and central parts of the country is based on the intensive utilization of the natural resource water and the soil. It bases on the multiple utilization of the water and the utilization for various purposes, for example for the intensive livestock raising of fishes and water-fowl, the recreational utilization and the absorption of communal and industrial sewage of various degrees of cleanliness. Finally erosion products of the intensively used cultivated areas go into the lakes.

The intensity of the agricultural land utilization in the GDR which influences the eutrophication is shown in the following. Particularly since 1960 there is a sharp increase in the amount of mineral fertilizers in evidence. Compared to 1960, in 1973, in respect of the decisive nutrients for the eutrophication, almost three times as much nitrogen and almost twice the amount of phosphorous acid was used. An annual average for the period 1968 to 1972 shows that 236 kg of fertilizers (nitrogen, phosphorous acid, potash) were used per ha of agricultural land. For 1980 some 340 kg are envisaged for the same area. The relationship between N : P : K was 1 : 0.4 : 1 (1970, Above all the usage of mineral fertilizers is important in a water economic connexion and overrates visavis the employment of organic fetilizers. As regards the total nutrient supply for our territory the organic fertilizers account for only 27 per cent in respect of nitrogen and 20 per cent in respect of phosphorous acid. As regards the territory of the GDR one assumes that some 3/4 of the nitrogen entries and 14 per cent of the phosphorous entries in the waters stem from our agricultural used areas. Under our economic and natural conditions 1 ha of agricultural used land regarding water load pertains to 8.1 inhabitants in respect of nitrogen and 0.4 inhabitants in respect of phosphorous acid.

Despite the development of new effect principles for the reduction of the relatively high fertilizer losses (switch to highly concentrated mineral fertilizers, more favourable selection of the timing of fertilizer treatment, urease- nitrification restraint) the steering of the agriculturally conditioned water contamination is not yet sufficient to perceptibly reduce the eutrophication of the waters.

The increased water transformation in the natural budget, to be precise the increasing irrigation of agricultural surfaces as well as the drainage with its greater drain efflux, given the same fertilizer effect principles, causes an increase in the mineral flushing from the ground.

Another factor results from the high level of industrial-like production methods in livestock breeding which causes increased quantities of liquid fertilizers (liquid manure) which takes first place in respect of its nutrient richness amongst the organic waste products. These animal waste products give rise to particularly high demands regarding their harmless elimination visavis the protection of the ground and surface water. They are used in the GDR by means of the soil, in the plant production.

This is the most efficient method at favourable costs from the point of view of using the nutrients and the organic substances. It does, however, promote the eutrophication of the waters. Research regarding other usage and employment of the liquid manure are undertaken in an intensive manner in the GDR because the necessary agricultural area for the usage of liquid manure is not on hand at every site of animal production. Moreover it is basically advantageous to have available various and variable procedures for an environmental-prone handling and employment of waste products because, in this manner the special environmental and local conditions as well as certain aims (desodoration, nutrient diminution, river suitability) can be more readily taken into consideration.

The quality of the surface waters is furthermore dependent on the extent of sewage and their degree of cleanliness as well as an the self-cleansing potential of the waters. In this connexion in the GDR industrial sewage assume considerable importance for the quality of the water. More than half the industrial sewage stem from enterprises of the coal and energy sectors as well as the chemical industry.

The self-cleansing potential of the surface waters must be retained. This is a free service by nature of great significance and very pronounced efficiency. The national economy of the GDR is particularly required to use this potential. It is not possible to yield accumulation funds so that these cleansing processes may be solely and wholly undertaken in artificially created installations.

A further pre-condition for retaining the self-cleansing potential in the GDR is that the considerable warming of the surface waters through industry and powerstations (with commensurate influence on the eutrophication) is mitigated. The GDR has a very intensive electro - power national economy in particular also as a consequence of the high share of the chemical industry.

The GDR, recording an electric power production of 80 thousand million kWh and a per head and year usage of 4.750 kWh and is thus amongst the leading power production countries. The artificial warming which takes place on account of power stations and other industrial processes must be seen as a water contamination cause and as a factor of neutrophication.

Another complicating factor is the great range of toxic ingredients in our waters which stem, above all from our industry.

Thus in the GDR there is water pollution alongside a simultaneous high demand on water resources regarding amount and quality. These requirements are even still growing, amongst other reasons because the water is increasingly involved in the interterritorial division of labour and interlocking (regional redistribution) which also raises certain demands in respect of the degree of eutrophication of the water.

In the GDR considerable efforts are undertaken by means of the construction of waste water treatment plants with biological cleansing and partly with subsequent soil treatment to keep back more nutrients from the surface waters.

Alongside the intensification of water utilization, with the multiple utilization of the water and the closer and closer interlocking of the natural water circulation with the social reproduction process the running water contamination initially increases as well as the eutrophication, at least as a tendency. The six to eight-fold utilization of the water which may be regarded as a maximum in respect of multiple utilization has, on average, by no means been attained in the GDR but in the industrial agglomeration areas there is sometimes already an approximation to this level. Such an increase in the intensity of water utilization leads even where the customary waste water treatment is assumed to a high residual contamination and requires in the future a further elimination of nutrients.

This requires considerable costs of cleansing the running waters and lakes. For this purpose mathematical models for the optimization of the costs for the construction of waste water treatment and water preparation installations has been developed and tested in agglomerations areas. According to LEHMANN 1971, the following cost values pertain for the direct preparation of river water according to the quality of water: Illustration (now at the end).

Thus there emerges a clear series of dependencies of the water treatment costs in line with raw water conditions and quality. The increase of the costs alongside greater contamination of the raw water given direct for conditioning arises principally through the absorption of chemicals costs. From a certain limit the preparation costs rise sharply alongside increasing raw water contamination. In a model calculation for the Vereinigte Mulde River the costs of waste water treatment and the thus avoided costs for the enterprises using this river water were determined showing the following results:

Table 4

Assumed Decomposition in the River	Avoided Costs of Water Treatment in per cent as related to Costs of Waste Water Treatment
1 (light)	68 - 49
2 (heavy)	114 - 84
3 (none)	160 - 118

In view of the fact that the assumed decomposition 2 and 3 predominate in this running water the (quantitative) avoided costs of water treatment are greater than the costs for waste water treatment. Thus there arises an economic effect. We have here not an economic load caused by environmental measures (waste water treatment) but economic advantages.

Forms and measures in detail in respect of a long-term, planned utilization of the natural resource water and their intensive use in the GDR for the prevention of water contamination and water eutrophication are:

- the implementation of state water management research programmes with a unified plan (above all Ministry of Environment Protection and Water Management, Ministry of Science and Technology)
- the preparation of long-term strategy models for river basins and reservoirs by means of which the usable water output could be increased by 10 per cent
- the control and operating of groundwater by means of the employment of geohydraulic models
- orientation on the utilization of groundwater above all for drinking water and the surface water increasingly as usage water
- reduction of the surface water withdrawal, of the biological oxygen requirements (in German BSB_5) as well as the entry of nutritive matter into the waters by means of economic stimuli (up to changing production processes; water circulations)
- the construction of joint waste water treatment plants (municipal and industrial waste water together) stimulated through the socialist ownership of the means of production
- the incorporation of the agricultural (also forestry) utilization into the waste water treatment process (third purification stage); transformation of out-moded sewage irrigation fields in the vicinity of the cities
- researches about national economic expenditure for the construction of separate canalisation systems in the new housing areas in order to reduce the volume of waste water.

Under the conditions pertaining in the developed socialist society in the GDR the water economy reproduction process is planned in a uniform manner in the territory. Goal is by means of the necessary water-economic measures, to meet the correspondingly growing requirements of both national economy and population and to yield the greatest possible national economic structural effects in the spirit of an intensive extended reproduction. Alongside the growing degree involvement of the natural resources, including water, in the economic reproduction process the intensive expansion of the natural environmental conditions is assuming enhanced importance and requires a long-term planning of the water economy which includes a close relationship with the planning of environmental protection and the conservation of natural conditions.

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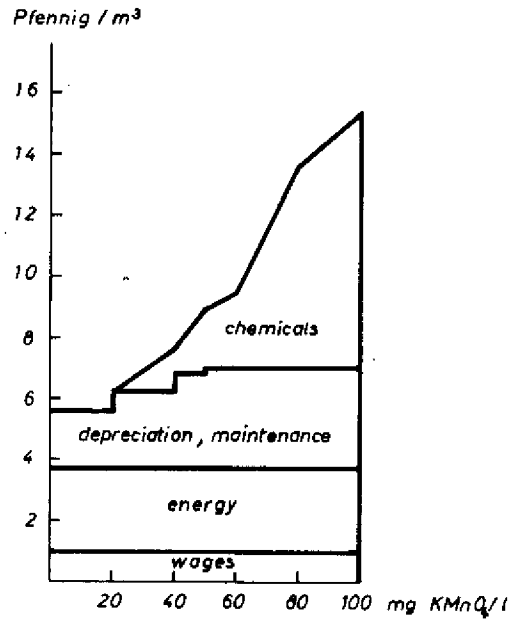

Specific cost of direct water treatment and proportionate cost of the treatment of raw water group I amounting to 40 000 m³/d (according to H. Lehmann)

FRESHWATER FISHERY AND CONDITION OF WATERS

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Summary

The planned increase in freshwater fishery production in the GDR is a trend in keeping with the world-wide need for opening up all reserves for food production. At the same time, it takes into account the specific situation in the GDR with regard to water resources. The limited utilizability of inland waters in the GDR for fish production due to sewage inflow and excessive eutrophication are some of the factors which make it necessary to intensify fish production in the remaining areas. Intensification of production has and is focussed on fishery ponds. In spite of the heavy nutrient inputs in ponds, there is no risk of an additional eutrophication of the recipients, whereas this has to be anticipated to a certain degree for the planned extension of industrial-type fish farming in lakes. However, the organizational conditions have been provided which will enable these effects to be kept within narrow limits so that they will not become apparent in the majority of cases. At the same time, a concept was worked out as to how fish farming methods could help solve the problem of lake eutrophication. Increased stocking with fish of different food spectra is to afford a better utilization of the biological production potential of eutrophic waters by the fisheries while helping to improve the quality of the water. By our present state of knowledge such an approach is feasible and promising. In the long run, the highly diversified effects brought about by various fish stocks let expect that we will be able to make ever better, well-aimed use of these effects in the interest of optimising the exploitation of waters for the national economy as a whole.

The task set to the GDR freshwater fishing industry is to raise the production of freshwater fish by over 40 % within the next five years. This target is in keeping with the trend to be observed the world over arising from the need to enhance human food production as quickly as possible. In setting this target full allowance has been made for the specific conditions of the exploitation of rivers and lakes prevailing in this country, eg an extremely tight water balance, heavy pollution by industrial waste waters and growing eutrophication. Under these specific conditions the freshwater fishing industry, like all other users of water, has to find an economically optimum method of water exploitation. The possibilities for freshwater fishing in the GDR depend to a great extent on the interactions between fishery and the condition of the waters.

Ever since the last century, the pollution load on waters has limited the potentialities of freshwater fishing. The first to decline was the once profitable river fishing industry. According to ROCHLITZER (1965), over 80 % of the GDR's major running waters had to be classed as Grade III waters in 1963, that is waters with a high incidence of fish mortality. These nuisances, most of which date to the capitalist period of development, take a long time to eliminate. In the past, damage was caused mainly by industrial and municipal wastewaters, whereas in recent years there has been an increasing pollution by agricultural effluents. Fish mortality due to oxygen deficiency is a more and more frequent occurrence (MÜLLER 1969, ANWAND 1975). The reasons are primarily oxygen-depleting substances in the water, but also the influx of nutrients associated with it which lead to an extreme trophic state. The majority of our stratified lakes exhibit an anaerobic hypolimnion in midsummer so that large areas of the lakes cannot be used for fish farming.

This limitation imposed on the utilizability of fresh waters for fish production is one of the reasons why production in the remaining areas is intensified more or less heavily. This applies first of all to pond fishery which has to provide the bulk of the production increase in freshwater fishing by 1980. What matters here is the broadscale introduction of intensive methods using full-value pellet fodder. In spite of the large amounts of nutrients supplied with the fertilizer and fodder, no additional loading of the recipients with nutrients is to be expected (BARTHELMES, 1975). The ponds are generally operated without a stream of water being passed through them. Only the amount of water lost by evaporation and infiltration is replaced. Totel-P concentration on draining the ponds in autumn does not exceed that in the water used for flooding, taking into account the 'thickening' of the pond water during the season. Concerning nitrogen compounds, the ponds act now as before as de-aerators. At the end of a season the water in the ponds contains only about half as much nitrogen as the water used for flooding (refilling) the pond. Even if intensification is further stepped up, the nutrient budget will remain well-balanced as the supply of nutrients for fish farming purposes must not be increased further in the interest of favourable oxygen levels and a low ammonium content. The export of nutrients will be enhanced eg by regular dredging which is necessary for technical reasons of fishing-out. Also planned are polycultures with herbivorous fishes which would likewise mean an accelerated removal of nutrients (see BARTHELMES' article "On the effect of Hypophthalmichthys molitrix in the lake and pond ecosystems"). On balance, it is to be expected that neither will pond fishery as the central point of intensification in freshwater fishing be disturbed by deficiencies in water quality caused by its own fault nor will it add to the deterioration, of profound economic implications, of the quality of the recipients due to eutrophication.

Lake fishing is also going to be intensified but on a much smaller scale, the intention being to fully exploit the biological production potential which is steadily increasing as a result of eutrophication. On a lesser scale, lakes and running waters ware to be utilized for extending fish production on pellet fodder in reserves wired off with netting. In order to avoid a further acceleration of the eutrophication of water-

ive studies into this issue have been reported by HRBÁČEK and co-workers (HRBÁČEK 1958, HRBÁČEK, DVOŘAKOVA, KOŘINEK, PROCHAZKOVA 1961). In carp ponds and small waters in the Elbe lowland extremely large fish stocks with a biomass of up to courses in the GDR because of this, an action plan was signed in 1973 between the managerial bodies of the Freshwater Fishing Industry and the Ministry for the Protection of the Environment and Water Resources. Its purpose is to make the by now well-known amounts of nutrients supplied with the pellet fodder for carp and trout in wired off reserves (KNÖSCHE 1971, ALBRECHT 1972, ROHDE 1973, BARTHELMES 1975) largely unavailable for further eutrophication by suitable place . At the moment there are two alternatives: a) to dimension the wired-off reserves in a given body of water such that their share in the total nutrient supply and B.O.D. will amount to not more than a few per cent, which may be neglected in the nutrient balance or their concentrated use in waters where light rather than nutrients has become the factor limiting primary production so that artificial aeration is sometimes inevitable. The action plan also provides for amplifying research efforts into nutrient recovery and artificial oligotrophication by the fishing industry and water resources. This has been done and in this context a number of fish farming methods have been worked out which will help to solve the problem of eutrophication and will be outlined in separate contributions (JÄHNICHEN, BARTHELMES).

The task of freshwater fishery to fully exploit the steadily growing production potential of the lakes resulting from eutrophication cannot be attained by conventional means and methods. With conventional management of the lakes using the natural fish population, the yield follows a curve with an optimum. The most favourable yield ratios are obtained in the range of the low-mesotropic eutrophic state (see Fig. 1). With a very low nutrient state the yield rises initially with the trophic status. In more eutrophic waters the yield is again tending to decline. This point had been reached in many lakes in this country during the first decades of this century. Fishermen complained of a growing 'deterioration of the lakes' with the water becoming turbid, water plants scant and hydrogen sulphide developing in the deeper parts of the lakes (WUNDSCH 1940, SCHÄPERCLAUS 1941). At the same time there occurred changes in the structure of the fish stock causing the yields to decline in spite of growing primary and secondary production. On the one hand some species of table fish were forced back into the lakes owing to biological changes. This is true particularly for the small whitefish, but equally for pike and tench. On the other hand the trend to over-population and hence, to small and slow growth became more and more apparent in the widespread Cyprinids, the bream, for example. This was due partly to the thinned-out stocks of pike, partly to a growing imbalance between the conditions for the brood becoming more favourable in the littoral and feeding conditions aggravating for the older fish living on the bottom because of oxygen depletion and the formation of hydrogen sulphide in the deeper parts. Nowadays it is possible to push up the trophic limit at which quantitative damages to fish farming will occur by increasing the fish stocks. This holds especially for stocking with Cyprinids from the Far East which graze on plankton but also for the increased stocking with indigenous species like the eel. Considering the present conditions in freshwater fishing it can be said that fish yields may increase with growing trophic state up to a limit when regular fish mortality results owing to oxygen deficiency or high pH and ammonium values. However, a lasting damage caused by eutrophication is the relatively early disappearance of the above-mentioned fine fish species. This qualitative damage cannot be adequately compensated for by stocking since the living conditions generally fail to meet the requirements of these species. The aim of freshwater fishing to make reasonable use of the increased natural productivity of the lakes can be obtained on principle by modifying the composition of the fish, with intensified stocking as quoted above being an important preliminary. It generally raises the question as to the effect produced by the fishes on the trophic status of the water.

Considering the interrelations on their own merits one could easily arrive at a negative assessment of the role of fish in the sense that they increase the trophic state. The most exhaustive studies into this issue have been reported by HRBÁČEK and co-workers (HRBÁČEK 1958, HRBÁČEK, DVOŘAKOVA, KOŘINEK, PROCHAZKOVA 1961). In carp ponds and small waters in the Elbe lowland extremely large fish stocks with a biomass of up to courses in the GDR because of this, an action plan was signed in 1973 between the managerial bodies of the Freshwater Fishing Industry and the Ministry for the Protection of the Environment and Water Resources. Its purpose is to make the by now well-known amounts of nutrients supplied with the pellet fodder for carp and trout in wired off reserves (KNÖSCHE 1971, ALBRECHT 1972, ROHDE 1973, BARTHELMES 1975) largely unavailable for further eutrophication by suitable place . At the moment there are

1 ton/ha and a low weight per piece were found to cause an intensification in the production and respiration of the waters. The excessive grazing pressure of the fishes causes a shift in the species compositon of the planktonic filterers towards less accessible species. Smaller species are selected which by their faster metabolic rate tend to increase the trophic status. Conversely, in low density fish populations or in waters containing poisoned fish, large filtering animals are predominating in the zooplankton which, on the one hand, graze effectively on the phytoplankton thinning out the stock of algae to clear-water level and reducing bioactivity as a whole on the other. At the same time it became evident for the first time by nutrient balance studies carried out by HEDLICH (1965) and HRBÁČEK (1965) in the reservoirs of Saidenbach and Slapy that the direct removal of biomass and nutrients with the crop is in general completely irrelevant. Although both reservoirs are only fished, it follows from the ration of magnitude of the elements in the balance that even conventional fish farming with yields up to 100 kg/ha . a would change nothing. Consequently, the effects produced by heavy fish stocks, that is an increase of the trophic state due to a shift in the biocoenotical structure, are not counterbalanced by any appreciable output of nutrients with the fish crop. Under these aspects it is only logical when RUDOLF (1965), for example, underlines the threat which the numerous malformed perches present to the Daphnia population, which are considered to play an important role in water-supply, in the Saidenbach reservoir, and HRBÁČEK (1965) arrives at the opinion that fish had better not be kept in impounding reservoirs. But this view fails to take into account every aspects of the problem. It can therefore hardly be maintained. First it is to be stated that all natural waters contain by nature fish stocks which often, especially when not exploited for fish farming, develop into extremely large populations of a slow growth rate, showing in an even more pronounced manner the effects observed by HRBÁČEK. Further, all heterotrophic organisms, not only fish, have on principle a regulating effect on the trophic status of rivers and lakes which grows as their number increases, for they release bound nutrients and thus provide conditions which are

essential to an acceleration of the nutrient cycle. Of decisive importance, however, is the concentration of consumers. When these put an excessive strain on a given population of nutrient organisms, a shift in the dominance structure and in the function of the system will result. By this definition, too large stocks of fish grazing on zooplankton act up to that point basically in the same way as too large populations of Daphnia measured by the same standard. Daphnia reduce the species of algae and algal stages of suitable size and favour, while releasing nutrients, the formation of clear-water stages, but also the formation of water blooms consisting of large phytoplankton associations which, when grown-up, cannot be filtered off any more. When there is no excessive strain on the populations of nutrient organisms by the consumers and when these are utilized such that they just about balance the loss by grazing - which is well-known to be possible within wide limits - then there will be hardly any changes in the dominance spectrum. The processes quoted by HRBÁČEK for large fish stocks would then be of secondary importance to regulatory trophic variations of a different kind in eutrophic waters and be virtually irrelevant. It is evident that the intended intensive stocking in freshwater fishery will provide a better possibility for adjusting the required level of fish stocks then if the fish stocks and the populations of organisms depending on them would be left to themselves. The concept developed here is tantamount to a reasonable exploitation of all trophic levels and a comparatively strong energy degradation. In our opinion it makes equal allowance for water resources and fishery considerations. To translate the concept of the reasonable exploitation of all trophic levels into practical terms would require that we supplement our lakes with primary consumers, in particular. According to the data available by now and with due consideration of the principles outlined, fish yields can be improved in the order of several 100 kg per hectare by stocking with silver carp, a species which grazes on phytoplankton. Good results may also be expected from stocking with other species of fish, depending on the prevailing conditions. Finally, presupposing a sound knowledge of the cause-effect relationships, it is possible to

.xtend stocking beyond the level described by using species of different nutritional spectra with the aim to bring about the desired changes in the ecosystems of rivers and lakes (for examples see the contributions by JÄHNICHEN and BARTHELMES). The more is learnt of the interactions the more widely can this knowledge be applied in practise wherever the organizational conditions have been advanced accordingly. The freshwater fishing industry of the GDR follows this road to help find an economically optimal solution to the problem of eutrophication and to scale down the disproportion between the biological production potential of the lakes and their yields of fish meat.

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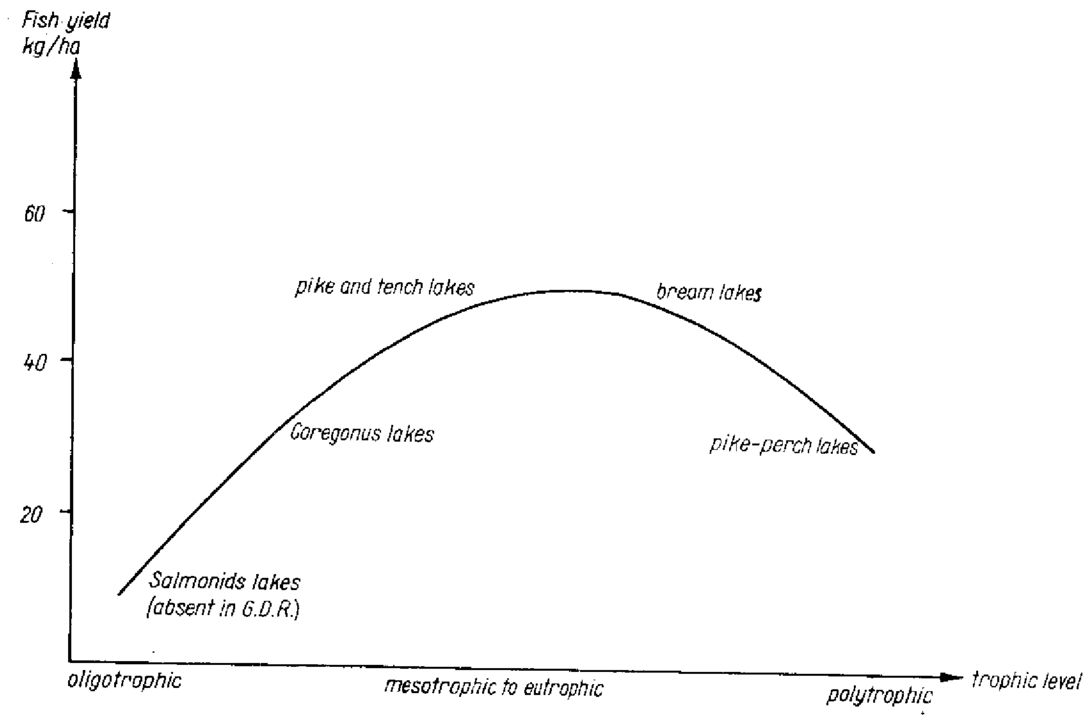

Fig. 1 : Relations between fish yield, types of fishing-biological lakes and trophic level in traditional fishing of the GDR, based on the yield data indicated by BAUCH (1954) for the respective subtype I of lakes as well as on the data given by the authors' team COLBY, SPANGLER, HURLEY and Mc COMBIE (1972)

EFFECTS OF FERTILIZING FORESTED AREAS ON THE EUTROPHICATION OF WATERS. GENERAL THESES

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1. Increasing the growth of timber by using fertilizers offers the desired results, the side-effects however represent a danger to the purity of waters. This problem is intense in economically developed countries today, and the same danger is also expected for the other European countries.

2. An intensive use of mineral fertilizers in forests in pure form at a dosis of about $CaCO_3$ - 2,000 kg/hectare, N - 200 kg/hectare, P_2O_5 - 125 kg/hectare and K_2O - 80 kg/hectare can cause a surface erosion of fertilizer residue not used by the plants from rainfall which can lead to the eutrophication of rivers and lakes.

3. An intensive use of mineral fertilizers in forests of the following kinds: moist coniferous forests, young coniferous forests, young mixed forests, alder woods, etc., with a high ground water level and dosis exceeding the absorption capabilities of the soil and trees can cause a toxic pollution of the ground water, a reduction of its economic and general applicability, and affects the soil-water environment of the forest.

4. The intensive use of mineral fertilizers in forests on permeable light or mountainous soils infiltrates toxic ground water into the deep waters of the first and second horizon, poisoning them continuously.

5. Considering the water-controlling part of forests as source of pure water and as bio-regulator for toxic damages, it can be noted that the phenomenon dealt with here represent an extraordinary danger for the environment. As team-mate for

the protection of nature and the waters, forestry becomes a dangerous enemy of water protection.

6. Without overlooking the necessity of intensifying commercial timber production, the appropriate measures in forests must be taken (after previous scientific investigations) the objective of which is water protection.

7. Scientific investigations should be based on the following: refrain from using mineral fertilizers in mountainous forests, forests on highly permeable soils, in watershed forests and so-called water-holding forests.

8. Strips with appropriate vegetation - grass, bushes or copse vegetation - with adaquately high regulating effect on the humus substrate should be made on forest-free water banks (towards the lake or river), such strips should also be used on the territory of common forests to counteract the flow off of surface waters oversaturated with mineral solutions, with a simultaneous complete utilization for the production of biomass.

9. In fertilized forested areas with high ground water levels, pyrometric instruments should be installed at appropriate intervals. Samples should be taken, and chemical water and soil analyses as well as chemical and morphological-physiological analyses of the assimilation aparatus and wood roots performed to assess possible results of changes in the properties of water, soil and plants.
   Analyses results must serve as basis of correcting the relationship and intensity of using mineral fertilizers in forests, and for deciding on the possible use of underwood and brush vegetation for increasing the controlling effects of the humus layer of the soil as well as withdrawal of excessive nutrients from the ground water and soil as added by the mineral fertilizers and not consumed by the trees.

10. An appropriate dosis of mineral fertilizers creates the preconditions for complete consumption thereof by the soil and trees. The use of mineral fertilizers in forests together with pure water irrigation limits the negative side-effects of amelioration to a natural level. Of course this operation must be repeated several times during the vegetation period and in the appropriate periods of the production cycle. Such a kind of research work naturally jumps ahead of the current situation as today noted in forests, it is however still required in consideration of the growing demand on wood and principle adherence to the previous production areas.

    In relation with the use of fertilizers in forests it is necessary to conduct complex research on the problems connected to hydrological, physiological, forestation and fertilizing aspects.

    It is regretful that forest scientists who protect the wood as a whole only follow steps in their own interest without considering the dangerous side-effects for the waters. Proof of this is offered by the international symposium from 12 to 14 August in Klagenfurt (Austria) on "Increasing Wood Production by Using Fertilizers in Mountainous Forests", which dealt with the effeciency of using fertilizers, however which also neglected the after-effects of thus poisoning the waters. Apparently we must challange such actions of the forest scientists. They should first of all conduct scientific investigations so as not to endanger such a vital elements as water in their aims of success.

FERTILIZER APPLICATION AND EUTROPHICATION

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Summary

By the extended application of mineral and organic fertilizer, the problems of the eutrophication of water in research, as well as in the practice, is given great attention in the GDR. In the paper, results of field and lysimeter tests on nitrogen dislocation and removal through manuring with fertilizers and liquid manure will be presented. By far the greatest part of the washed-out nitrogen comes from the reserve in organic connected agricultural soil. In comparison to fertilizer, the liquid manure given up to 320 kg N/ha led to no higher rate of removal. On the other hand, connections exist between rainfall, the quantity of leakage water, the soil texture, vegetable stock, the amount and the time liquid manure is given. The manuring recommendations used in the GDR and which are got by means of the electronic data processing take into account such parameters, which limit the eutrophication effects of the fertilizers applied.

For the intensification of the food-stuff production, the optimum nutriment supply of vegetable stocks build a significant foundation. The increased yields in vegetable production which has been reached in the German Democratic Republic, has its basis to 50 % in fertilizing. By the extended application of mineral and organic fertilizer, the problems of the eutrophication of water in research as well as in the practice, is given great attention, particularly considering that the high production yields and the shaping of an efficient culture landscape have equally significant tasks in the socialist agriculture of the GDR. The measures taken to keep out harmful influences on the social reproduction process form an integral part of the production process, and should be conceeded as such. This meeting of equally oriented interests in agriculture, water-management and environmental protection is expressed particularly in the demand of a high soil-fertility and the best possible cultivation. Connected with this are the biological, biophysical and biochemical conditions and processes in the soil, which are responsible for nutriment storage, nutriment transformation and layer build-up. They influence the heat and air resources, the water capacity, the equilibrium between the organisms of the soil population and finally the phyto-sanitary antibody of the soil as well as, on the whole, his capacity to reduce harmful ingredients. These peculiarities, qualities and effects of the soil determine his precedented importance as place, means of production and object of vegetable production, and consequently as the main means of production in agriculture. They are at the same time decisive for the high purification efficiency of the system soil-vegetation, a function, which adds an ever-growing importance to the shaping and keeping the biosphere healthy in connection with increased intensification of the production and the industrialisation.

By tests on the possible eutrophication of ground and surface waters by means of fertilizers, the vegetation nutriments nitrogen and phosphorus take an important place. The mobility of the nitrogen forms, which appear in the period of the turning over of fertilizers containing amid and ammonium, increase in the order of ammonium-N < urea N < nitrate-N, through which loss by washing-out occur almost entirely in nitrate form. The ammonium ions are to a great extent adsorbed by the soil-colloid. Apart from nitrogen manuring, which is justified according to demand and measured in an optimum for the individual fruit-types, the form of N-fertilizers and the time of application are therefore important criteria for the prevention and limitation of losses through washing. During the period from 1968 to 1972, the washing-out and removal of nitrogen by means of plants with isotope-marked and unmarked urea in monolithical field lysimeter on five places with different soil textures were tested /1/. The average of five years of tests on all sites show values of wash-out between 8.8 and 16.7 kg N/ha per year. An exception to this is the site with loess black earth, where the value of wash-out reaches only 0.9 kg N/ha yearly. From the total washed-out nitrogen, only 10.5 to 15 % were accredited to the fertilizer-nitrogen, so that the main part of the washed-out quantity were due to soil-nitrogen. The washing-out of the fertilizer-nitrogen in tests performed, amounted to between 1.8 and 2.5 kg N/ha or 1.5 and 2.1 % of the nitrogen given over.

Even by intensive vegetable production with sprinkling, only insignificant or no nitrogen shifting could have been discovered after six years of application of nitrogen (table 1).

Table 1

N_t-contents (%) in the soil by a high quantity of nitrogen and sprinkling (from JAUERT and ANSORGE /2/)

Manuring	Sprinkling	Average contents		
		before testing-plant	after 6 test-years	
kg N/ha		0.20 cm	0–20 cm	20–40 cm
Black earth				
0	without	0.145	0.159	0.137
235	without	0.145	0.158	0.133
347	without	0.145	0.162	0.138
0	with	0.145	0.152	0.137
235	with	0.145	0.154	0.138
347	with	0.145	0.155	0.136
Clayey sand				
0	without	0.075	0.076	0.041
235	without	0.075	0.076	0.049
347	without	0.075	0.082	0.048
0	with	0.075	0.080	0.046
235	with	0.075	0.078	0.042
347	with	0.075	0.078	0.042

The results of long-year tests from PFAFF /3/ show that no increase in the washing-out of nitrogen has occurred due to soil-sprinkling, although nitrogen were given up to an amount of 320 kg N/ha, and the quantity of leakage water even reduced.

The crop increase led to a higher utility of water and nitrogen. Under the climatic conditions of the German Democratic Republic, nitrogen is seldom lost through washing-out from soil grown with cultivated plants and which have no ground-water during the period of vegetation. An influence of nitrogen fertilizers on eutrophication occur more through the increase of production of roots and crop-arrears, which have its effect on the raising of the contents of organic-connected nitrogen in the soil, a part of this undergoes the washing-out process during the vegetation-break of plant-growth. This is mobilized as nitrate. This relation between the sign of higher soil-fertility, like the contents of organic substance and nitrogen in the soil as well as its soil-biological movement, and the factors which thrive the washing-out of nitrogen, lead to the already mentioned occurrences, that the far greater part of the washed-out nitrogen comes from the soil reserve. The works of the Soviet scientists ANDREEV and MICHEEV /4/, BOBRICKAJA /5/, SMIRNOV /6/ a.o. have significantly contributed to the clarification of this set of related problems.

Out of the to date known scientific knowledge on the causes of the wash-out of nitrogen, conclusions in manuring practice in the GDR were drawn and which were considered in the manuring recommendations deriving yearly from calculations from data processing. In these calculations, high quantities of nitrogen given will be handed over, subdivided according to the development stages. The exacting of the nitrogen fertilizer in the spring, especially in recording the nitrogen excess from the past year, is carried through by means of on-the-spot soil-tests. In order to determine the optimum quantity of the 2nd nitrogen dose on grains, the process of plant-analysis is used. The autumn manuring of fallow crop with urea may only be done on clay and earth-en soil, then only at the beginning of November. By temperatures under 10 ^{o}C, the change of urea into the ammonium form takes place slowly, and by temperatures under 5 °C one can only expect a very small nitrification. The ammonium formed in November undergoes no change in the nitrate form, which is worthy of mentioning. No nitrogen manuring is done in autumn on the winter crops. An exception is only made by straw-manuring in autumn. When planting winter rapeseeds, nitrogen to the ratio of about 40 kg N/ha is only given in autumn when the grains were provided for as preliminary fruit. After fallow crops or leguminous plants, winter rape-seeds also receive no nitrogen manuring in autumn. The nitrogen manuring in the early spring should not be given on hard-frozen soil or on the snow-blanket, since this in the first place on hanging ground through the wash off can lead to loss and to eutrophication of the waters.

Of great importance for the prevention and limitation of the nitrogen wash-out is the intercropping. It shortens the vegetation-break and increases the plant cultivation utility of the mobilized nitrogen. This effect of intercropping will be made clear through the fact that the highest washing-out of nitrogen is found on uncultivated lands, whereby the by-far smallest amount of nitrogen wash-out exists on greens.

On the question of phosphorus manuring the present test-results are confirmed, that phosphorus succeeds only in extraordinarily small quantities out of the cultivated soil into the waters. In the forefront stands the locally limited wear through erosion or surface outflow of rainfall during the period of the vegetatien-break. Against this, the ameliorative and cultivation measures do work, like e.g. the giving of the phosphorus manuring before plough furrow.

In the field of organic manuring, a strong change has been perfected in the last years in the GDR. With the transition to industry-like process of animal production, the amount of liquid manuring has enormously increased, at the same time the stall-dung has shown a decrease. The determining factors for the use of liquid manure goes from the fact that the significant quantity of this liquid organic manure can be used for the reproduction of the soil-fertility. By storage, transport and the bringing-out of liquid manure, the demands of the environmental protection on the stall-dung management have been very strongly increased. For an absolute erradication of local eutrophication of ground and surface waters there exist lawful regulations.

These derive from the constitution of the GDR, according to which all economic branches, enterprises and citizens are obliged to keep waters clean and to protect the surroundings. The storage of liquid manure is only allowed in impermeable containers; the transportation to the utilization areas must be carried out with vehicles or by pipe-lines, which exclude an uncontrolled leakage of the liquid manure. For the manuring of the agricultural areas with liquid manure, the state-institutions for agriculture and the water-management officies have laid down compulsory directives, which provide optimum amounts and limits after taking the types of liquid manure, the soil and the planted fruit-types into account. On sites identified as drinking-water protection areas, flood areas and health-resorts, special instructions are valid for the organic and mineral fertilization.

An important problematic is the one that liquid manure must be brought out even during the vegetation-breaks in autumn and winter, since, from an economical point of view, the storage capacity could not be measured as being so great as one wishes. In order to get parameters for the measurement of the quantity of liquid manure given during the yearly periods, depression lysimeters were installed in different soils five years ago. These soils receive liquid manure with 160 to 320 kg N/ha alone, as well as in a combination with straw-manure or intercrop green manure by the rotation of the crop-types potatoes - winter rye - silo maize - oats. The quantity of leakage-water are measured in 1 m depth. A first interim analysis of the results shows that the liquid manure given in an amount reaching from 160 to 320 kg N/ha in bi-annual turns, led to no higher or significantly more washing-out of nitrogen than the fertilizer. On grounds of periodical testing of leakage water, it was concluded that the first and fourth quarters of the year are significant for the washing-out and dislocation of nitrogen in the under-soil. During the time of vegetation, i.e. in the second and third quarters, quantities of leakage water with nitrogen contents appear in small amounts, and especially when little plant-growths and high rainfall are recorded. A part of the test-results with high amounts of liquid manure on sandy soils are shown in table 2.

Table 2

Nitrogen dislocation in kg/ha and year by higher liquid manuring in autumn on sandy soil, according to tests in depression lysimeters (1 m depth)

Year	Type of crop	without manure	320 kg N/ha as liquid manure	320 kg N/ha as liquid manure with straw-manure	320 kg N/ha as liquid manure with intercropping manure
1972	Potatoes	44	48	28	12
1973	Rye	20	23	18	30
1974	Silo-maize	30	22	33	4
1975	Oats	20	62	48	27
		114	155	127	73
	$\bar{x}$	28.5	38.8	30.1	18.2

In comparison to the variants not manured, liquid manuring effect with 320 kg N/ha in the average rotation an increase on the wash-out nitrogen to an amount of about 11 kg N/ha a year. By the combination of liquid manure and straw-manure a clear reduction of nitrogen washing-out occur through immobilizing the nitrogen of liquid manure. The intercrop green manuring with winter rape-seeds reduces the nitrogen wash-out during the autumn and winter months very rapidly. This effect is caused by a smaller rate of leakage and an increased nitrogen removal. The test-results presently at our disposal show that in the case of liquid manuring, the nitrogen wash-out is dependent on the period and the amount of liquid manure, vegetable stock, amount of rainfall and the quantity of leakage-water, as well as on the texture of the soil. From the present available lysimeter-tests, one can further conclude that the organic and mineral harmful matter in water could itself be effectively eliminated from the soil. This also applies for the appearance of coliform bacteria in leakage water /7/. The reduction capacity and the natural-biological cleaning effects caused by the soil during the agricultural use of liquid manure and waste-water amounted to over 90 % and even reached values of nearly 100 %. This performance of the soil, and here especially the biological active and fertile soil, is difficult to reach with the same economical effect through artificial-technical process.

The calculated optimum criteria for liquid and other organic manuring are taken into account in the caluclation of manuring recommendations got from the electronic data processing.

For certain sites there are principle restrictions, independent of the type of vegetable production. No application of liquid manure given to sites with a ground-water level of under 0.4 m. For lowland sites with a ground-water level between 0.4 m and 1.0 m the organic-mineral manuring 250 kg N/ha per year should not be exceeded. On flatland soil over cleft and carst stones in the mountains, the amount of manure is limited to a total of 300 kg N/ha. per year. On application areas with hanging tendency and which borders on surface waters, minium intervals of 10 m to 100 m depending on the slope of the ground and the soil-fertility, must be kept during the process of liquid manuring.

By the increase of the soil-fertility and the intensification of the vegetable production, the washing-out of nitrogen from the soil cannot be disregarded altogether. Through certain measures of manuring and cultivation, however, it could be strongly reduced. These measures, aimed at satisfying the concrete site situation, is a task, which agriculture, water-management and environmental protection are together incumbent.

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THE INTEGRATED WATER RESOURCES CONTROL SYSTEM OF THE GERMAN DEMOCRATIC REPUBLIC

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Summary

The contribution defines the principles underlying the integrated system for measuring water quality and water quantity. It deals with the economic aspects, the selection of criteria to be measured, the measuring techniques and their representation in course of time. The classification of control systems in general and with reference to measurements in lakes and impounding reservoirs is outlined. Finally, it details the scope and the manner of primary data determination, data acquisition, transfer and reduction.

Introduction

The territory of the GDR has an extremely tight water budget, being at the same time densely populated and heavily industrialised, with large agglomeration areas and intensive exploitation of the arable land. This calls for a central management of water resources.

In order to meet the present and future demands on drinking and industrial water supplies as well as water for irrigation purposes, the sector of Water Resources and national economy as a whole need to have full-ranging information on the quality and quantity of surface and ground-water resources including their tendencies to variation.

To fulfil these tasks it is planned to set up a standardised system for measuring the quality and quantity of water resources and to radically improve measurements in water management processes in the GDR.

Principles underlying the set-up of the control system

The function of a control system is to gather, record, transfer, condense and evaluate different data in a suitable and organized manner. These data occur at different times and places and are sufficiently suitable for describing the natural or technical process in a body of water in such a way as will enable to intervene in the process by such general means of regulation as are available, in a qualitatively and quantitatively correct and welltimed manner.

By control system we understand the implementation in concrete technical terms: buildings, instruments and equipment for data logging, transfer and evaluation, with some of these functions being semi- or fully automatic or to be carried out manually. The control system includes, in addition, stationary and mobile automatic measuring devices as well as stationary and mobile laboratories.

To define the scope of the water resources control system in terms of equipment and personnel we proceeded from the following questions:

Why do we measure (economic aspect)

Every measurement must be utilisable for information and control purposes, otherwise national capital spending is not justified.

Generally speaking, we understand by control, as used in this context, the purposive control of natural and technical water management processes, which may be short-, medium- or long-term processes, and which range from the purely technical intervention, eg in a sewage treatment plant or the warning issued to a recipient in the event of an extreme water supply situation, to complex-scale process control, for instance in a partial area (combined reservoir water supply) and to the working out of the scientific basis for long-range planning of water management measures aimed at a thorough improvement of rivers and lakes, eg by water clearing plants, impounding reservoirs, enabling economy to make optimum multiple use of the waters, general measures to protect water, particularly groundwater, as a natural resource.

What do we measure (selection of criteria)

The criteria to be measured have to provide the information needed with regard to time and place. Which criteria are selected depends mainly on

- the scientivic-technical facilities for their determination
- the access time required
- the need to control the measured state.

The selection of criteria is governed by statutory provisions in the form of standards

- classification of the quality of running waters
- water quality management in lakes
- drinking water quality requirements
- water quality control

How do we measure (techniques)

The methods to be employed for measurement are standardised, comparable, manual, semi-automatic and fully automatic. The aim is to use a standardised stock of equipment. The personnel engaged in the measurement, transfer, condensation and evaluation of the data has to have the necessary qualifications. The methods and techniques are subject to continuous modifications aimed at streamlining, automation, and the elimination of error sources; new methods have to be developed for substances not studied so far.

Where do we measure (density of control stations)

The density of control stations depends on the nature and the intensity of the demands made by the economy on the natural resource of water. Co-operation with other departments and institutions and the resultant interlocking of control systems will only in some cases enable us to reduce the number of our own control stations. The density of control stations will continue to depend on

- the water turnover rate of the river basins,
- the agglomeration areas of the population, industry and agriculture,
- the size of and technology used, in water management plants,
- the role of water as a future source of water supply and recreation within a particular territory.

How often do we measure (representation in course of time)

The frequency of measurements is determined by the tendency of conditions to persist. At present, mostly seasonal samples of an inadequate number are examined, from which conclusions are drawn by statistical generalisations as to the general trend which fail however to be scientifically substantiated.

This shortcoming is to be remedied by the use of

- automatic laboratory equipment for handling larger series of samples
- automatic control stations to measure the quality of surface waters,
- automatic water level gauges and
- automatic measuring instruments in water supply installations.

Owing to their adequate representation in course of time continuous samplers used in surface waters and water supply installations as laboratory aids replace in many instances continuously measuring, recording and transmitting facilities.

In order to estimate the optimum density of the control system and the optimum representation in course of time area-specific studies are necessary, such as river basin simulation, process control models.

Classification of the control systems

In the GDR the water resources control system for quality and quantity measurements breaks down in the parent system, the monitoring and control system and the special system.

Parent system

The water resources parent system covers the whole of the GDR. It has been in use continuously for many years. Its function ist to provide a body of data which covers sufficiently closely the area and period concerned, containing as many as possible of the criteria (of a general nature or relating to the specific area) essential to the information needed now and in the future. The measurements are carried out in the water environment or in the laboratory. By carefully co-ordinating the water quality system with the corresponding water quantity system it is to be ensured that quantity related information will be obtained on the quality of the water.

Monitoring and control systems

These are continuously operated measuring stations for the provision of data required in monitoring, forecasting, and controlling bodies of water unless this information is provided by measuring stations which are part of the parent system. Measurements in water supply installations.

Functions:

- to monitor the quantity of water drawn off and the amount and condition of incoming sewage (off-limit checking)
- to provide input data for forecasts and operative routing of messages to water users and residents to warn them as early as possible of critical situations and to start protective measures.
- field measurements for process control and off-limit checking in water supply and sewage treatment plants.

Special systems

- Measurements of limited duration in extreme situations and the event of damages to monitor the running processes and their effects.
- Expeditionary measurements to record in detail certain conditions and processes in rivers and lakes and installations.
- Detailed process studies in experimental and representative areas and at selected sites.
- Special systems for preparing and carrying out special water management measures, investment projects, etc. to study and compute eg groundwater streams in natural and controlled regimes.
- Special measurements at specific hydraulic engineering objects and water supply facilities, such as monitoring of the functional reliability of inponding reservoirs, dykes, etc.

Measurements in lakes and artificial reservoirs

In future, quality measurements in lakes and artificial reservoirs will be carried out and graded as follows:

Parent system:

Grade I:

Survey cycle over one or several successive years with more than five surveys a year during the winter stagnation, the circulation periods and, at least, at the beginning and at the end of the summer stagnation. Repeat examinations at least every three to four years. Deep sampling with about 20 informative criteria. The criteria are selected according to the standard "Water Quality Management in Lakes" and with regard to certain service requirements.

In drinking water impounding reservoirs at least once a month a series of samples from the deeper parts is to be taken during the ice-free period.

Grade II:

Survey cycle of one year with between four and five surveys a year during the periods of stagnation (at least at the end of the summer stagnation) and during full circulation. Repeat surveys at least every five to six years. Deep sampling with about 20 informative criteria.

Grade III:

Survey cycle of one year with between two and four surveys a year, but at least at the beginning and at the end of the Summer stagnation. Repeat surveys at least every eight years. Deep sampling with about 20 informative criteria.

Monitoring and control system

Water quality analyses are carried out to control the inflow and runoff rates and for off-limit checking. The number of samples depends on the given purpose. Mostly the number of criteria examined is smaller.

Special systems

These are systems operated temporarily in extreme situations and the event of damages and which are varied according to requirements with regard to the place where samples are to be taken, the frequency of sampling and the number of criteria.

The control system for running waters, ground water and water management installations is composed analogously to a parent, monitoring and control system, including special systems.

Primary data collection

In the areas administered by the five Water Management Boards which cover the whole of the GDR there exist at present about 9,000 control stations for surface water quality control which carry out about 800,000 separate operations a year.

The number of separate operations is to increase to about 1.3 million by 1980 and to over 2 million by 1985. Apart from this increase in number many investigations are becoming more complex and time-consuming, such as studies of the saprobic level, bacteriological conversion, toxicological findings, analysis of plant protectives, etc.

As the supply of manpower for sampling, sample analysis and evaluation is expected to increase by a limited extent only, it is necessary to considerably raise the labour productivity of the individual investigating units.

This is effected by

- centralizing laboratories in efficient units even at the expense of longer sample transport routes
- using increasingly mobile laboratories (laboratory trucks and boats)
- using high-productivity automatic laboratory equipment for determining frequently recurring criteria in routine analyses
- using test stations for the continuous measurement and recording of automatically determinable water quality parameters at certain critical points of surface waters and the transmission of the test results to the headquarters of the Water Management Boards.

Data acquisition

The preparation of EDP-based methods of data acquisition must proceed from the fact that by 1980 the annual volume of characters to be handled will amount to 150 million, reaching a total of 225 million by 1985.

All measured data are recorded on standardised data sheets suitable for EDP. Because of the specific criteria applying to lakes and seas as well as impounding reservoirs, special types of registration documents are used. A unified number system is applied.

Data transfer

The measured values recorded on the primary data sheets in a manner suitable for EDP are transmitted via cable, telephone or telex, either available or to be installed to the headquarters.

Data evaluation

The data are evaluated by electronic data processing machines at the Water Management Boards enabling the competent Divisions of Water Supply

- to control water management processes in the catchment areas of the rivers which fall within their province
- to pass management decisions quickly and correctly
- to evaluate measured data for trend calculations
- to file condensed primary data provided with verbal comments in such a way that they will be readily accessible at any time.

For the GDR there exists a central office equipped with computing machines for this purpose. Its function is

- to collect the condensed and commented data from the heardquarters by means of EDP
- to provide information for central decisions to be passed by the Water Resources authorities of the GDR.

A centrally-run water resources controlling and monitoring system of the kind described above provides the conditions for full-ranging and fast information as well as for short-term, medium-term and long-term planning.

Thus the branch of economy 'water management' is paying an important contribution to fulfill the task set by the Party and Government to the national economy of the GDR, i. e. ensuring the implementation of the housing programme (construction or reconstruction of 850 000 flats within 5 years) and steady supply of population, industry and agriculture with water. At the same time it helps to reduce national spending on the building and operation of water supply installations (eg comprehensive sanitation of entire river basins, restoration of lakes, building of impounding reservoirs, distant water supply, sewage treatment).

Making use of the advantages of a socialist economic system this water controlling and monitoring system has created certain conditions which are beneficial the community life and avoided other which are unfavourable to it.

THE INFLUENCE OF TOURISM AND RECREATION ON THE EUTROPHICATION OF FRESHWATERS. GENERAL THESES

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In many countries lakes, reservoirs, rivers and other waters are under heavy touristic and recreational pressure. Among various human impacts the tourism is responsible for the most differentiated, although perhaps not the most important disturbances of waters. Tourist centres built close to water bodies, roads, parkings, harbours, angling, swimming, water skiing, shooting, motor-boats etc. vary in their influence on the ecosystems.

Changes in chemical composition of water due to sewage inflow, the mechanical destruction of vegetation and shores, changes in the amount and quality of inflowing allochthonous matter caused by the disturbance of drainage basin, direct effect on particular animal populations due to angling and hunting, produce complex reactions of aquatic biocenosis, disturb the biocenotic balance.

In many cases the water bodies used by tourists are also altered by other activities of man. Thus the research is necessary to estimate the joint effect of recreation and other land and water usage containing difficult to estimate synergic interactions.

The effect of different forms of recreational activities on aquatic ecosystems has been little investigated from the ecological point of view.

In such studies usually one chosen kind of tourist activities is taken into account. Few more general analyses are known. They are based, for example, on comparisons of long-term changes of the number of tourists, sailing intensity etc. with the changes of limnological indices of pollution and eutrophication of waters.

Among practical and theoretical problems of recreational usage of freshwaters the following seem to be of primary significance:

- Quantitative determination of the effect of different tourist and recreational activities on the water bodies,
- Restoration of degraded ecosystems,
- Estimation of potential ability of different ecosystems to absorb varying types of recreational usage,
- Elaboration of models for proper tourist and recreational usage of waters.

Tourist usage causes the disturbances of water bodies primarily if the number of tourists is too high for the ecological capacity of ecosystem and when the locality of recreational facilities is not well chosen and also wrongly utilised. Usually all these unfavourable factors occur together. The negative effect of tourism on water bodies due to the inflowing sewage and mechanical destruction of shore and vegetation have been mainly investigated. Other impacts are little analysed yet. Thus it is of primary importance to elaborate indices which can be used for complex estimation of effects of varying forms of recreational usage, to separate the mechanism of particular effects and estimate the synergism of pollutants. In spite of scarce data a preliminary synthesis is necessary to estimate the present ecosystem damages.

Tourist usage of water bodies which frequently caused unfavourable ecosystem changes provides simultaneously an inspiration for restoration works. Some regulations and tourists requirements determine for example the quality of waters used for swimming. Various kinds of restoration of aquatic ecosystems are applied / diversion of sewage, aeration, removal of vegetation and other organisms, artificial turbidity etc./. These methods can be also used for the restoration of waters destroyed due to tourism and recreation. Nevertheless, the specific reaction of particular ecosystems requires a thorough ecological analysis of individual water bodies.

The proper tourist usage of ecosystems should aim in the direction of the smallest changes of natural conditions. Therefore it is absolutely necessary to determine the ability of ecosystems to absorb recreational usage, to estimate the potential capacity for various forms of use. Now, in some cases the indices are applied when areas are planned for such purposes /e.g. permissible number of people per 1 ha of beach/. But these estimations are very formal, and they do not include the specificity of individual ecosystems. Depending on the state of biocenotic balance, succession stage and synergic reaction with other factors particular ecosystems may react quite differently to the same intensity of tourism pressure.

Ecological grounds for best recreational management of freshwaters require multidisciplinary works on aquatic ecosystems and their drainage basins. Only part of the tourist pressure acts directly upon the water environments. A considerable influences are due to changes in surroundings of water bodies. Some general desiderata /protection zones with specially planted vegetation in areas close to water bodies etc./ are widely discussed by different specialists interested in this problem. Less common are the detailed ecological expertises made for individual areas. But it should be pointed out here that ecology has a number of methods which can be used for recreational planning of areas. As an example the phytosociological methods can be mentioned, where on the basis of analyses of habitat, actually existing vegetation and potential natural vegetation there is a possibility of indicating the areas in the surrounding of water bedies fit for extensive touristic use, the areas where only limited penetration is possible and also areas on which touristic activities should be prohibited.

A considerable part of "directly aquatic" tourist and recreation impacts concern mainly the littoral zone - the most differentiated part of water bodies. The studies on the lake littoral show that some parts of the littoral may utilize a considerable amount of anthropogenous effects, being simultaneously a protective barrier for the lake, whereas other parts are quickly damaged even under a smaller pressure. This depends on the configuration of near shore shallows, exposure to wave action and to a great extent on the character of vegetation /species composition, life cycle, condition etc./. Therefore the locality of recreation centres, boat-houses etc. can basically decide about the changes in water biocenosis.

The increasing effect of tourism and recreation on aquatic ecosystems is analysed by several international organizations scientific programmes e.g. formely International Biological Programme /IBP/, and now UNESCO/MAB - Programme on Man and the Biosphere.

Tourism and recreation in Poland is dynamically developing in the last years. Thus it is very important to elaborate ecological grounds for rational guidance of this kind of ecosystem usage. At present, several institutes concerned with the ecology of water bodies take into consideration tourism and recreation among the factors of anthropopressure and these problems have the priority.

Polish National Committee for MAB Programme analyses the effect of tourism and recreation on surface waters on a national and international scale. In the first stage the results of a questionnaire /prepared in the Department of Hydrobiology at the University of Warsaw/ sent to several hundred institutes in Poland and abroad are being analysed thus providing information about the kind and degree of tourist pressure on aquatic ecosystems and about the state of ecological investigations in this field. This analyses will be presented during the Symposium.

Department of Hydrobiology at the University of Warsaw within the research of Masurian Lakeland /northern Poland/ also analyses the tourist-recreation impact on lake ecosystems. Masurian lakes are under heavy recreational pressure and the recently observed increase of eutrophication and pollution of these lakes is largely due to the tourist usage of the area. The inflow of sewage and wastes increases, the shores and the littoral are mechanically damaged, the high number of motor boats is responsible for wave-creation and oil-pollution. Over 50 % of lakes in this area are visibly changed as a result of tourism.

The most distinct changes which can be quantitatively estimated are:
- local transformations near big recreation centres
- intense changes in lakes at the height of tourist season /July, August/.

In some lakes the local degradation of environment is so great that it can no longer be used by tourists.

A detail analysis of littoral zone in the direct neighbourhood of the tourist centres shows visible transformations. Plant and animal communities are degraded. Distinct changes in chemical composition of water and transformation of sediments are observed. Two littoral zones are usually observed in the polluted area. The zone directly affected by sewage /saprotrophic zone/ is characterized by prevalence of decomposition processes and a strongly reduced biocenosis. The second zone, in the immediate vicinity of the former, is fertilized by diluted sewage. This is a polytrophic zone in which biological production is high and the plant and animal organisms are abundant.

The strong effect of tourist activities on water bodies is limited to the summer period under our climatic conditions. Therefore the possibility of natural restoration of ecosystem after heavy but short-term pressure is the main aspect here. Several field experiments were conducted in our Department in order to determine the intensity and rate of changes of biocenosis under the influence of various environmental conditions. The principle of experiments was moving of several communities /periphyton, plankton, macrophytes/ from polluted littoral environments to the unpolluted ones and vice versa. The results have shown that degradation of biocenosis is a much quicker than process of biocenosis regeneration. Some changes are irreversible. Therefore when planning the future tourist usage of waters special precautions should be taken.

EUTROPHICATION IN SPANISH MAN-MADE LAKES

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Summary

About 27 % of 296 Spanish reservoirs surveyed were found be eutrophic and 11 % meso-eutrophic. Central and northeastern watersheds account for the highest percentages of eutrophic reservoirs in each major drainage basin, amounting up to 50 % in Eastern Pyrennees and about 60 % in Tajo Valley.

Major causes of eutrophication in Spain appear to be the occurrence of upstream urban concentrations, heavy cattle raising in drainage basins, decomposition of natural submerged vegetation in new reservoirs, and feeding from upstream eutrophic lakes, together with high residence time and hard summer weather. All these nutrient sources but cattle manure and vegetation decomposition are expected to exert increasing impact in future.

Introduction

Impounding naturally flowing waters is the logical response to the challenge posed by the background conditions Spain has ever been faced to. In fact, rainfall shows very high differences in distribution both in time and space what results in a large portion of the country commonly refered to as the "dry Spain". On the other hand, landform turns out to be quite rough all over most of the country, the average elevation amounting up to 700 m above sea level. Keeping in mind these two factors it will be easy to understand why there are about 700 reservoirs all over the country thus placing it among those with the highest number in dams. In this way an array of purposes concerning water resources management are achieved: hydroelectric power development, flood control, agricultural irrigation, domestic and urban water supply, recreation activities, and industrial water supply.

The increasing worldwide concern about water quality preservation along with the great national importance of the water resources impounded in our man-made lakes led the General Directorate of Water Works, of the Ministry of Public Works, to sponsor a number of monitoring projects involving the study of eutrophication in freshwater bodies.

Two nationwide limnological surveys have been carried out during the last three years. One is already completed by the University of Barcelona, Department of Ecology, while the other will be completed in 1977 by the Center of Hydrographic Studies. The former involves about one hundred reservoirs while the latter covers nearly three hundreds. In this paper we shall deal just with the latter.

Other projects also carried out by the Center of Hydrographic Studies are concerned with the study of eutrophication trend in three selected reservoirs, and the assessment of the relationship between of trophic degree and nutrient sources in the drainage basins.

A limnological survey of reservoirs

The first stage of this project was intended to supply an acknowledgement of the current water quality conditions in reservoirs regarding the factors governing biological productivity and studying the causes of deterioration in eutrophic water bodies.

The second stage allowed us to assess the trend of water quality in the previously surveyed reservoirs and to approach the influence of the different causes of degradation. In some cases it will be possible to suggest some measure for either preservation or restoration.

The program consisted of the measurement of a small number of parameters in all the reservoirs. The selection of the parameters and methods for their determination was made according the guidelines given by the Sector Group of Water Management of the General Directorate of the Environment, OECD.

The following parameters have been measured in all the reservoirs included in the program:

Physical: Secchidisk transparency, colour, temperature, conductivity.

Chemical: Dissolved oxygen, chemical oxygen demand, pH, total phosphorus, total organic nitrogen, ammonia, nitrite, nitrate.

Biological: Plankton species determination and cell counting, Background information about nekton population.

On the basis of these parameters a classification has been outlined according the trophic condition in the water body. Five groups have been considered chiefly based on phosphorus concenration, nitrogen concentration, dissolved oxygen profile, chemical oxygen demand, biomass, and overall composition by biotic communities. Although no single classification has been followed, the ranges suggested by THOMAS and quoted by VOLLENWEIDER (1968), have been basically kept in mind. In broad terms, 20 mg/m^3 for total phosphorus and 300 mg/m^3 for inorganic nitrogen have been regarded as the limit betwen mesoeutrophic and eutrophic. Sometimes, howeyer, exceptions have been made whenever other parameters suggested to do so.

Table No. 1 shows the numerical distribution of all the reservoirs included in the survey into the five categories refered to as above and accounting for the different major hydrographic areas. As it can be noticed in this table, most of the reservoir located in watersheds draining to the Cantabric Sea turn out to be oligotrophic in spite of high human population density and heavy cattle raising. Several reasons account for this, namely wet-temperature climate, high forestation coverage area, scattered dairy farm operations and spread human population.

The scarce cases of eutrophic reservoirs in this area are due to either domestic wastes from some major city (i.e. Oviedo, as the main nutrient source in Prianés Reservoir), or agricultural fertilization (i.e. Limia agricultural area, which causes eutrophication in Las Salas Reservoir).

In the Central Plateau about half of the reservoirs appear to be in eutrophic condition. Major nutrient sources are domestic

Table 1

Reservoir classification according the assessed trophic degree

Hydrographic region	Total number of reservoirs	Number of reservoirs surveyed (n)	Oligotrophic No.	Oligotrophic % (rel. to n)	Oligomesotrophic No.	Oligomesotrophic % (rel. to n)	Mesotrophic No.	Mesotrophic % (rel. to n)	Mesoeutrophic No.	Mesoeutrophic % (rel. to n)	Eutrophic No.	Eutrophic % (rel. to n)
Norte	89	49	33	67.4	8	16.3	5	10.2	1	2.0	2	4.1
Duero	44	31	12	38.7	5	16.1	3	9.7	1	3.2	10	32.3
Tajo	108	48	3	6.3	4	8.3	12	25.0	0	0.0	29	60.4
Guadiana	48	17	3	17.7	1	5.8	4	23.5	3	17.7	6	35.3
Guadalq-Sur	69	42	2	4.8	7	16.7	11	26.2	8	19.0	14	33.3
Segura	15	11	5	45.4	2	18.2	2	18.2	0	0.0	2	18.2
Júcar	38	23	5	21.7	4	17.4	3	13.1	7	30.4	4	17.4
Ebro	125	67	17	25.4	15	22.4	16	23.9	11	16.4	8	11.9
P.Oriental	8	8	0	0.0	2	25.0	1	12.5	1	12.5	4	50.0
Total	444	296	80	27.0	48	16.2	57	19.3	32	10.8	79	26.7

sewage and cattle raising. Oligotrophic lakes are all located in the upper reaches of the basins, where vegetation is usually quite dense and climate is cold. Special importance is played by the city of Madrid discharging a great amount of partially treated municipal waste water into Tajo river, where 60 % of the reservoirs studied turn out to be eutrophic.

In Southern Spain about one third of the reservoirs were found to be eutrophic, major nutrient sources being domestic sewage and cattle feedlots. There are a number of new reservoirs where decomposition of submerged vegetation accounts for present deterioration in water quality (i.e. Guadarranque, Guadateba, La Concepción, Guadalhorce, etc.).

In the eastern basins (Segura, Júcar) eutrophication is mainly caused by agricultural fertilization. About one third of the reservoirs are to be regarded as eutrophic. It should be pointed out here that most of the man-made lakes in this area are located in the uppermost elevations, surrounded by forest vegetation and subjected to rather cold weather conditions.

Finally, in the Ebro Valley and the Northeastern area of the country about 25 % of the reservoirs are either eutrophic or meso-eutrophic. Aside from municipal wastewater, the most important source of nutrients are often industrial wastes, such as the ones from paper mills and food industries.

As a result of the survey we can conclude that among 296 reservoirs studied, 79 are in eutrophic condition and 32 are meso-eutrophic. The hydrographic regions supporting the highest numbers of eutrophic reservoirs are Tajo, with 60 %, and Pirineo Oriental with 50 %. Watersheds showing the best conditions as far as eutrophication is concerned are Northern Spain and Ebro, supporting 4 % and 12 % of eutrophic reservoirs, respectively. These low values are due to the fact that a great proportion of man-made lakes occurring in these two large areas are rather small impoundments located in high elevations surrounded by forests.

Major reasons for increasing eutrophication in Spanish reservoirs turn out to be the occurrence of urban populations upstream from the concerned lakes, heavy cattle raising and feedlots in drainage basins, and recent beginning of impoundment. These factors are often enhanced by long impounded residence time and long hard summer weather conditions. Nutrient sources from municipal wastes are expected to grow up, while cattle raising will keep steady or slightly decreasing. However, the consequence from domestic and industrial discharges must be gradually diminished, as a result of extended waste treatment practices.

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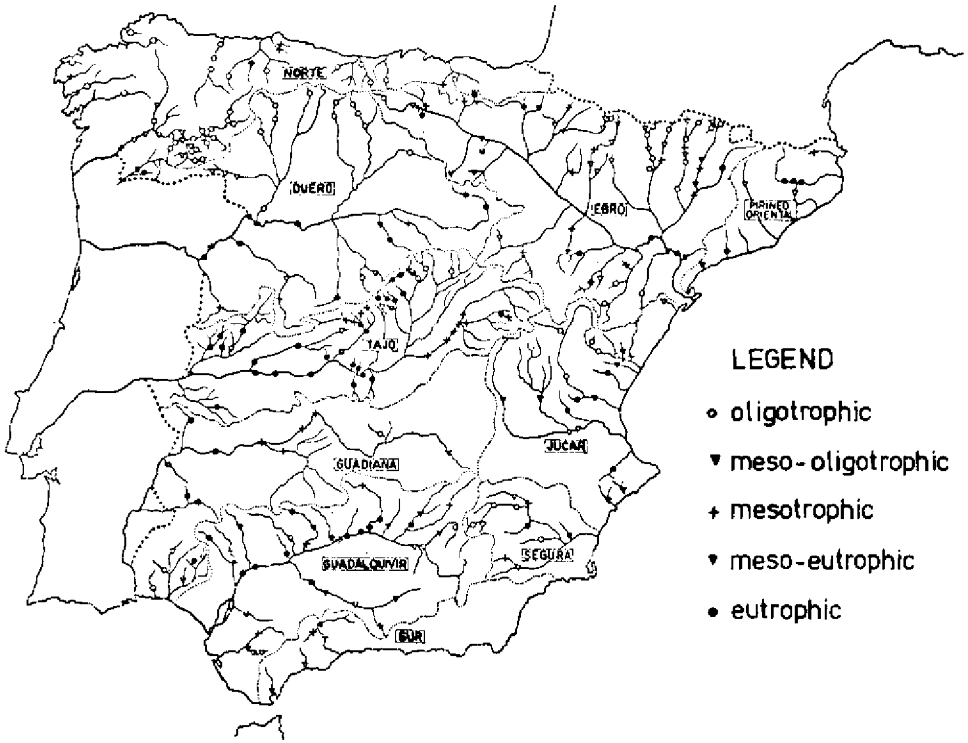

Fig.1 - Geographical distribution of the reservoirs included in the survey.

THE RELATIONSHIP BETWEEN THE BALATON AND ITS CATCHMENT AREA

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Introduction

The Balaton is the largest lake in Hungary. It needs very long time for water renoval and its water is used primarily for recreation and water sports. From the point of view of quality of water the greatest dangers for the lake are its great size, the in part slow circulation of water, the greatly increased tourism in the summer and the demands made of a catchment area that ought to serve other comparable areas of land. The lake can satisfy these demands and conditions, today and in the future, only if steps are taken to protect the quality of the water. Considered from the point of view of using the lake as a place of recreation, the main task is slowing down the process of eutrophication. As in the process by which mud is created there are other sources of danger or dangerous influences that need to be considered. In order to attain this objective, most if not all branches of science have to be drawn upon. Just as pollen analysis was of considerable value in consolidating measures to hinder the development of marshes, it is likely that other branches of chemistry and biology, for example in employing isotopes or applying the systems theory and modern data processing, could contribute to making comparable the various influences of pollution and the results, which today are not yet homogeneous. On the basis of the conclusions thus drawn the main tendencies and methods, to which future efforts should be directed, can be considered and planned. However all the local and central organs of state, the plants and factories, and all the scientists (each within his own field), must already do everything possible today in order to protect the Balaton, the health resorts round it and its catchment area, so that both we and future generations may continue to rejoice in its exceptional beauty. These problems can be solved by suitable public campaigns as well as by individual and coordinated activity at a high level.

1. Formulation of aims

Working out plans for future development is always a very complicated task, solving which of course demands knowledge about the past situation, that of the present and an estimate of changes that are to be anticipated. The role of the environment in planning, or even the planning of the environment, are concepts met with ever more frequently. One could also put the question whether plans need to be worked out from the ecological point of view, having regard, that is, to the environmental aspect, or whether, starting out from the changes of relations in nature, one should attempt to create a new environment. Thus the question is whether we should be concerned with protecting the environment or with developing it (1). However there is no substantial difference between these two concepts.

The Balaton, Hungary's largest lake, merits careful attention on account of its particular importance in the field of recreation. The so-called regional plan for the development of the recreational area of the Balaton was first worked out at the beginning of the sixties (2), and this laid down the measures for development, meeting the needs of recreation and starting out from the characteristics of the settlements along the shore. The central programme, completed in 1969, for developing the Balaton, in which the area taken into account was somewhat reduced, set out the most important directions of development for the 40 towns and villages along the Balaton (figure 1) for the 4th five-year planning period (3). Already at this time it became clear that the development of this area would require a detailed examination of the lake and of its nearer and more distant environment (catchment area and bordering territories). The central Balaton water supply programme (4) serving these aims was passed and implemented. Numerous measurements, examinations, tests and interim plans preceded the working out of the total plan for the development of the catchment area, serving regional aims. Nevertheless this plan needs to be supplemented in some respects and developed in further detail.

The Balaton is treated as a unified system, but its links with the environment in the broader sense show nevertheless that the lake is part of a further more extensive system. From this it follows that it does not suffice, for a complete and detailed examination of the lake, that one should just analyse the processes going on in the lake and interacting with one another within it. It is necessary that the whole character and development of the interaction between lake and catchment area should be explored. It is a matter of uncovering the factors that influence it, and, starting out from the demands that will be made on the future use of the lake, of working out a comprehensive plan for the development of the catchment area, which must then be set out in more exact detail (5). The ultimate aim is to work out a plan making it possible to undertake some changes, in which nevertheless everything is done in order to ensure a "survival" of the environment (6).

The government of the Hungarian People's Republic has decided: "The principal objective in developing the environment of the Balaton is to satisfy social needs with regard to recreation". The aim of this contribution is to set out the tasks on the basis of an analysis of the interaction between the lake and its catchment area and the changes coming about there. Despite the growing dangers, solving these tasks can ensure that bathing in the Balaton and recreation along its shores will long remain possible.

2. The importance of the lake and principal data

Long ago, lakes, just like rivers, constantly offered favourable preconditions for the development of towns and villages, for traffic, and as a source of water etc. In recent years their importance has grown further in view of the increasing significance of recreation and water sports. 0.3 % of the total fresh water reserves in the world are to be found in the natural still waters of lakes with a capacity of altogether 125,000 km^3 (the volume of man-made lakes amounts to about 5,000 km^3). The mass of water in lake Baikal amounts to 23,600 km^3, which means that it is as much as in the American great lakes taken together. The capacity of the Balaton amounts to 1,800 km^3. The most important piece of data respecting lakes however is not the quantity of water but the reserves of useful water, the quality of the water, these being data that frequently depend on the natural characteristics of the catchment area. Data of several lakes follow as information.

Table 1: Characteristic features of several lakes

Name	Average depth (m)	Surface area (km^2)	Length of shore (km)	Capacity (mill. m^3)	Catchment area	Relationship of area of catchment area to that of lake
Lake Geneva	150	582	167	89000	8000	13.7
Balaton	3	596	197	1800	5180	8.7
Lake Fertö	0.8	280	100	250	1019	3.6
Lake Velence	1.30	25	26	31	615	23.7

The Balaton, with its area of 600 km^2, is the largest open area of lake in Hungary and Central Europe. It has an organic relationship to its catchment area with an area of 5,200 km^2. Its favourable geographical area, its large capacity, its open waters and the rapidity with which they warm up are at the same time a source of danger. In this lake all the phenomena may be perceived which, directly or indirectly, exercise influence on it. Further factors to be considered are the initial composition of the water in the Balaton and the process of water renoval.

3. The changing of water in the Balaton and the influences to which it is subjected

The examination of the composition of the water in the Balaton respecting its source and the changing of the water was carried out by SZESZTAY (7, 8) and BARANY (9). On the basis of the measurements carried out by BARANY the following facts are known to us:

- The figures for the composition of the water reserves according to their source, going back over a number of years, vary along the length of the lake, while the reserves of water originating from other sources reach their highest proportion at about 90 % in the area of Kezthely, and the lowest proportion, at about 50 %, in the area of Siófok. The relations between reserves of water from rainfall are reversed.

- The average renoval of the water is 15 months in the area of Kezthely, 4 years in the area of Szigliget-Fonyód, 6 years in the area of Balatonakali-Szemes and in the area of Siófok 9 years.

- The average amount of time needed for the water to be changed in the area of Siófok is at the same time the total span of time required for changing the water in the Balaton as a whole.

- A first step on the way towards developing the use of the water resources of the lake is to take account of the factors that influence the lake, its water reserves and the quality of the water. By regulating the water level of the Balaton, limiting its catchment area and by being stricter in the issue of permits, it has been possible to ensure that the water reserves of the Balaton in all probability will not need any replenishing for several more decades (10). The sources at our disposal for replenishment are unfavourable from a qualitative point of view and thus unsuitable either for replenishing the water or for improving its quality. The most recent results of tests carried out at the Research Institute for Water Supply indicate a further increase in the level of eutrophication in the year 1975. The increase in the amount of algae and the rapid rise in the quantity of bacteria have already extended to the most northerly bay of the lake. The phosphate content in suspended substances in organic compounds has increased within the whole area of the lake (11). The danger is increasing continually, and recording, evaluating and analysing the harmful influences as well as establishing a reduction of these influences have become an urgent problem. A solution of this problem is perfectly possible. As an example we should like to refer to research into the formation of layers of mud (12), the results of which led to the measures that were applied at the end of the sixties. The influences determining the quality of the water are considered in three groups as follows: immediate influences on the lake, influences of the shore area and influences of the catchment area.

4.1. The development of direct influences

A source of direct influences of this kind is the air (atmosphere); these influences come about in the water and on the surface of the water, and in this way they influence the quality of the water.

- Components encouraging pollution enter the water from the air by means of dust and rain. The atmosphere in the area round the Balaton is already a danger (13). The phosphorus content in rainfall varies within the range of 0.3 mg/l to 130 mg/l (14). Its influence makes itself felt to differing degrees in the course of the whole year.

- Illustration 2 shows the development of the number of bathers in the Balaton, although these numbers are to be regarded as average values, there being a particularly large number of bathing enthusiasts at weekends, not all of them of course being in the water at the same time. The adverse effects resulting from this lead in the course of the three months of the holiday season to a direct pollution of water with detergents, oil, etc. One can only guess at the total impact (in 1975 the numbers recorded staying overnight in public rented establishments amounted to 5 million; this season that number is expected to almost double).

- The number of motor-boats on the Balaton (Hungarian and foreign) is at the present time approaching the thousand mark (15). The pollution caused by operating these boats and putting in fuel has, even if only to a small extent, a harmful effect on the quality of the water in the holiday season. If the use of motor-boats is banned within a short time, this source of danger will be eliminated.

- The places on passenger ships amount at the present time close to 2.5 million. Three shipping firms transport 1.5 million passengers on the Balaton and plans envisage a growing number of passengers. There being no collecting tanks, all the waste matter from wash-basins and toilets is discharged straight into the water. This source of danger can be removed by the installation of collecting tanks and central drainage for waste substances.

- Freighters and shipping cranes sail on the Balaton throughout the whole year, except when the lake is covered with ice. Here the kinds and methods of pollution and ways of preventing it are of the same order as in the examples indicated above. On account of the growing amount of traffic on the water, the building of collecting tanks is to be recommended in this instance too.

The area covered with reeds is continually expanding. At the present time 3 % of the total surface of the Balaton, that is 18 hectares, is covered with reeds, which are harvested only in part or not at all. Several tons of organic material fall into the water in the form of dried reeds. The area thickly covered with a tangled growth of water plants is also growing, and procedures for harvesting and removing this are only at the experimental stage. Harvesting the reeds and removing the water plants will lessen this source of danger.

- Today there already exist possibilities of pollution as a result of chance and these possibilities will increase in the future (resulting from fuel from ships, goods being transported, etc.). Lessening these risks can be made possible by means of stricter regulations and checking measures.

Thus the totality of influences that pollute directly is tending to rise in quantity, a fact that must be taken into account when considering the uses to which the Balaton can be put (see Tables 1 and 2).

4.2. The development of direct influences of the shore area

Unfavourable influences of the shore area are: the growth of the population, purified and unpurified waste water, pollution caused by industry, continuing or chance pollution from settlement areas.

- The influence of the growth of the population. By shore area of the Balaton we understand the health resort area to which the 40 towns and villages shown in figure 1 belong, their population numbering in 1975 in all 120,000. In the summer season the total number at weekends is on average four times higher than the number given above, and at peak times the rush of visitors exceeds it by even 500 %, if one counts both holiday-makers and people on day visits. Figure 2 shows the growth of the population in the belt of health resorts up to the present day and its future development (the future development will also be taken into

Table 2: Factors influencing the quality of the water in the Balaton

Designation	Period of influence	Tendency	Method for reduction
1	2	3	4
A. Direct influences			
Atmosphere	throughout the year	rising	unknown
Bathers	in the season	rising strongly	known in part
Motor-boats	in the season	greatly reducing	is being solved
Passenger steamers	in the season	rising strongly	known (collecting tanks and central drainage)
Fishing boats and barges	throughout the year	rising	" " "
Rushes, reed, mud	winter, summer	increasing	known
Chance influences and particular incidents	throughout the year	increasing	stricter checking measures
B. Immediate influences from the shore area			
Growth of population	in the season	rising strongly	limitation on building, regulation of the particularly large number of weekend visitors by means of pricing policy
Drainage and purification of waste water	mainly in the season	increasing	building purification plants
Unpurified waste water	" "	" "	" "
Pollution from industry	throughout the year	reducing	more active purification

1	2	3	4
Emitted from towns and villages	in individual cases	increasing	environmental protection, greater cleanliness
Influences of a chance character and chance origin	throughout the year in individual cases	increasing	in two directions: being prepared for such cases and protection
<u>C. Immediate influences from the catchment area</u>			
Resettlement and size of population	throughout the year	increasing slightly	purification of waste water and environmental protection
Industry	" "	rising	" "
Traffic	" "	" "	mainly environmental protection
Increased use of chemicals in farming	throughout the year and in individual cases	increasing strongly	protective measures, protection of the ground using modern procedures, care in bringing in and storing crops
Large plants for animal protection	throughout the year	increasing	waste water purification and environmental protection
Machine centres, processing plants	throughout the year	increasing	waste water purification and environment. protection
Influences of a chance character and chance origin	throughout the year	increasing	environmental protection

account in the detailed planning). Including the allotment gardeners the average total population at weekends in the year 2000 may well reach a million persons in the summer season (five times the permanent population). This is of course considerably more than the optimal density previously established (600,000 persons). In the interest of a reduction of the dangers, a limitation of population numbers appears to be desirable.

- The influence of removal and purification of waste. At the present time the belt of health resorts has at its disposal a total capacity of 23,500 m^3 per day, 30 % of the waste water being in part or entirely purified, the rest flowing directly or indirectly into the Balaton. The third stage of water purification was begun recently in order to protect the Balaton. Difficult problems and great dangers are encountered in the holiday season. By the year 2000 total purification (90 %) of waste water is envisaged (16), and even the purified waste water is to be drained away from the Balaton, so that the tendency respecting the quality of the water is a favourable one.

Unpurified waste water is at the present time a threat in part to the groundwater, in part to the environment on account of there being insufficient places for collecting the water and directly to the lake itself. The same applies to sewage carried by sewage vehicles. The installation of purification plants however makes it possible, even with a growing population, to keep the amount of pollution over a certain period of time at the same level, or later even to reduce it.

- Pollution of industrial origin arises in factories in towns situated in the belt of health resorts. At the present time the greater part of this waste is purified. In the future this proportion will grow. In consequence of the uneven level of activity in the course of the whole year, this problem merits particular attention. A ban on the development of industry will only be able to reduce the level of pollution in the belt of health resorts at some time in the future.

- An important future source of pollution is the washing away through rainfall of rubbish from towns and villages in the health resort belt, for example from built-up areas, and the growing motor traffic and increase in the number of filling stations. It has been established that substantial rainfall washes away more solid rubbish from settlements than drainage does. In the USA the phosphorus content for example amounts to 0.1 mg/l - 4 mg/l, and a considerable amount of pollution from oil and other sources has been established (17). The problem arises in individual cases, and, spread over the whole year, increases steadily.

- Influences of a chance character include collisions on the railways or on roads and the pollution caused by components in oil, which, as may be observed, seeps out when tanks in factories are damaged. The possibility of this happening is increasing steadily, and it may moreover do so at any time. The needs of protection demand careful organization and planning and implementation of the necessary measures immediately the centre causing the pollution has come into being.

Summarising this discussion, we should like to draw attention to the urgent need to take account of the harmful influences from the belt of health resorts that can affect the quality of the Balaton. These influences are listed in Table 2.

4.3. Indirect influences of the catchment area and factors indicating that they should be recorded more thoroughly

The changes already taking place in the catchment area of the Balaton, and changes that will take place in the future, influence the quality of the water to a steadily growing extent. It is almost impossible to summarise these influences, but the tendencies are already apparent. Figure 3 shows the distribution of the catchment area of the Balaton. The indirect influence which this catchment area has on the quality of the Balaton comprises the following factors: number of settlements and size of population, industrial development, traffic, the use of chemicals in farming, large plants for animal production, machine centres, etc.

In accordance with the statistics issued by the Central Office for Statistics, Table 3 lists all the places outside the health resort belt along the Balaton and the size of population, with the corresponding subdivisions. In the catchment area of 5,200 km^2 we find altogether 317 towns and villages outside the belt of health resorts, and of these 275, that is to say 64 %, lie in the catchment area of the river Zala. The large number of small towns and villages, which is hardly likely to get any smaller in the future, must be taken fully into account.

The size and distribution of the population is of even greater importance. Outside the belt of health resorts the Balaton is polluted and threatened by the activities of 300,000 inhabitants. Drainage and purification of waste water are only slowly being developed in the small places. In the long term 400,000 people outside the season, and in the season 1,300,000 people, will stay in the catchment area, a fact which simply cannot be ignored.

Table 3: Villages in the catchment area of the Balaton and size of population, based on statistics issued by the Central Office for Statistics for the year 1970

Name of region	Number of villages			Size of population in thousands		
	outside the health resort belt	in the health resort belt	catchment area as a whole	outside the health resort belt	in the health resort belt	catchment area as a whole
Catchment area of the river Zala	176	1	177	176	4	180
Northern catchment area of the Balaton	50	24	74	44	62	106
Southern catchment area of the Balaton	49	17	66	65	54	119
total	275	42	317	285	120	405

– There has been hitherto no important industry in the catchment area. Unimportant enterprises in oil, light industry and foodstuffs may be mentioned here. In the interests of the full employment of all working people in this area too, some development is expected. As a result the danger of pollution will also rise. Effective waste water purification and a more effective protection of the quality of the water can be a means of limiting the pollution.

- In the field of transport the pollution caused by passenger and goods traffic on the roads is a particularly dangerous factor, but railway traffic should also not be ignored. The development in this field too shows a rising tendency, so that both constant and change pollution may be anticipated. The task of environmental protection will grow.

- An intensive use of chemicals in the area in question began 20 years ago. For example the application of artificial fertilizers in the three areas along the Balaton has risen by 700 %. As is also the case abroad, a further rise in the use of artificial fertilizers is expected. If we assume that as little as 2 - 4 % of the active materials in the fertilizer introduced into the soil get on to the surface of the water, this means that even so several hundred tons of nitrogen and phosphate, notwithstanding every care in using the fertilizers, will arrive in the Balaton every year. In the event of careless use, this amount will be still higher. The application of plant protective agents is equally an immediate and continually growing source of pollution. Both these problems make themselves felt throughout the year, while after rainfall, when the water level rises, a rapid increase in the amounts recorded is to be observed. The run-off can partly be kept under control by means of preimpoundment basins. At the present time however the level of efficiency of preimpoundment and the retention time necessary for removing the nutritive materials are still unknown to us.

- On the Balaton there are some 70 large plants for animal production. In 19 of these considerable quantities of manure are produced. Reducing and regulating the influence that this has is vitally important. In future the need to build more plants of this kind will grow in the interest particularly of supplying the population. Even while these plants are being constructed, using forms of construction that exclude pollution of the environment, account has to be taken of chance, unplanned negative influences caused by them.

- The machine centres and the plants for processing farming products represent, with their purified or unpurified waste waters, significant sources of pollution and danger factors for the quality of the water in the Balaton (waste water containing oil, pollution from wine producing combines, waste water from bottling plants that contains detergents, etc.). In the future the number of machine centres and the machine storage unit will grow. Temporarily damaging influences can (however) be kept within limits by more effective environmental protection (for example buying up waste oil etc.).

- The possibility of polluting of chance character and origin will increase in the future (defects in oil pipe lines or tanks, or damage to storage units for fertilizers or chemicals can occur at any time, and if the necessary measures are not taken very quickly, mean even extreme danger for the Balaton).

The indirect harmful influences arising from the catchment area show a rising tendency. Taken as a whole, one may regard them as a major source of danger. In the Table they are also listed in general terms.

5. The development of factors influencing the quality of the water considered from the point of view of time

The most dangerous factor affecting the Balaton directly or indirectly is the influence of the catchment area, which, along with factors having their effect along the shore, has a growing direct impact on the Balaton. The registration or assessment of the problems just in our view be undertaken starting out from two factors. The first of these factors relates to problems experienced at particular times of the year or throughout the year; the second type of problem has to be considered from the long-term point of view (Tables 1 and 2). The measures necessary to protect the quality of the water and their efficiency can only be implemented and assured on the basis of these factors.

More and more writers are attempting to prove that draining waste water and purifying it can solve the problem of protecting the quality of the water in the Balaton. The facts referred to above do not give unqualified support to these claims.

The same applies to procedures tried out in other countries. Among the acknowledged methods used in improving water quality

(17), that of changing the water of the Balaton, a water of high quality, cannot be recommended. One also cannot recommend direct treatment of the water, nor even the replenishment of the lake (16). Our ultimate aim consists in maintaining life in the lake by reducing the components that get into the lake and cause its pollution, by slowing up the process of eutrophication. As we know all the limits, we must endeavour to make all the influences reconcilable with one another. Above all it is a matter of neutralizing the sources of pollution, even though they may appear at first sight to be insignificant. Removing them can lead to an improvement of the quality of the water, not only in the Balaton but also of other lakes. We must overlook neither the character of the lakes, which is that they are dependent on rainfall and influenced by the catchment area, nor the danger of harmful substances in these lakes and the growing danger of eutrophication.

It is not a matter of chance that the USA and Canada have concluded a treaty on reducing the pollution of the Great Lakes (19) and that has been worked out corresponding recommendations for lake Como (20). The rise in the standard of living and of the length of holidays leads throughout the world to waters, particularly those of lakes suitable for recreational purposes, being more intensively used. The growing degree of use requires a higher level of water supply, drainage and waste water purification. The increase in transport and the harmful influence of the environment demand that greater attention should be paid to protecting the quality of the water and of the environment. These tasks can be solved if substantial investment and expenditure are devoted to them, these being accounted for in large-scale extensive research and established in complex perspective plans.

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not presented by the author

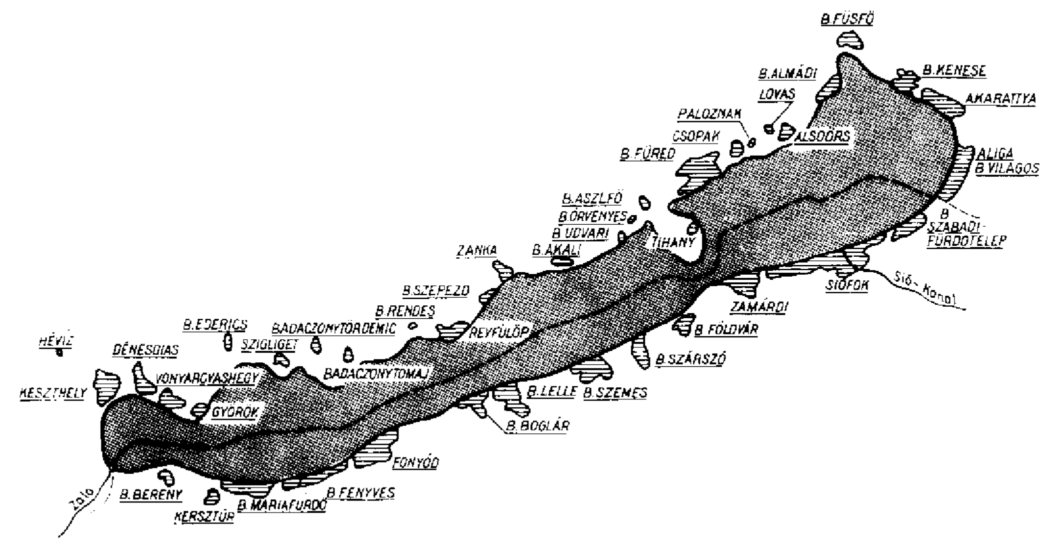

Figure 1: Settlements in the health resort belt round the Balaton

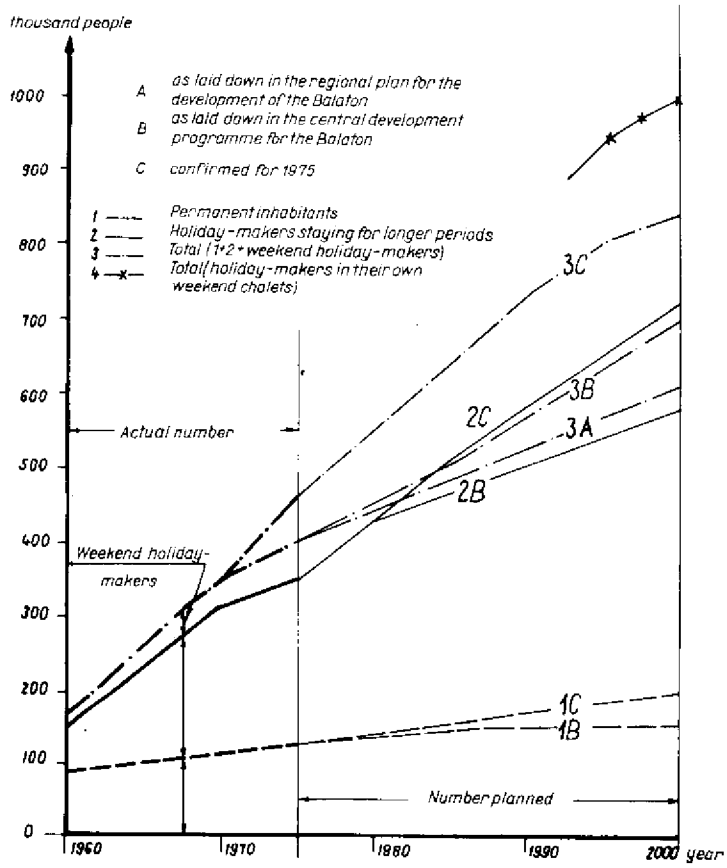

Figure 2: Population development in the holiday area round the Balaton.

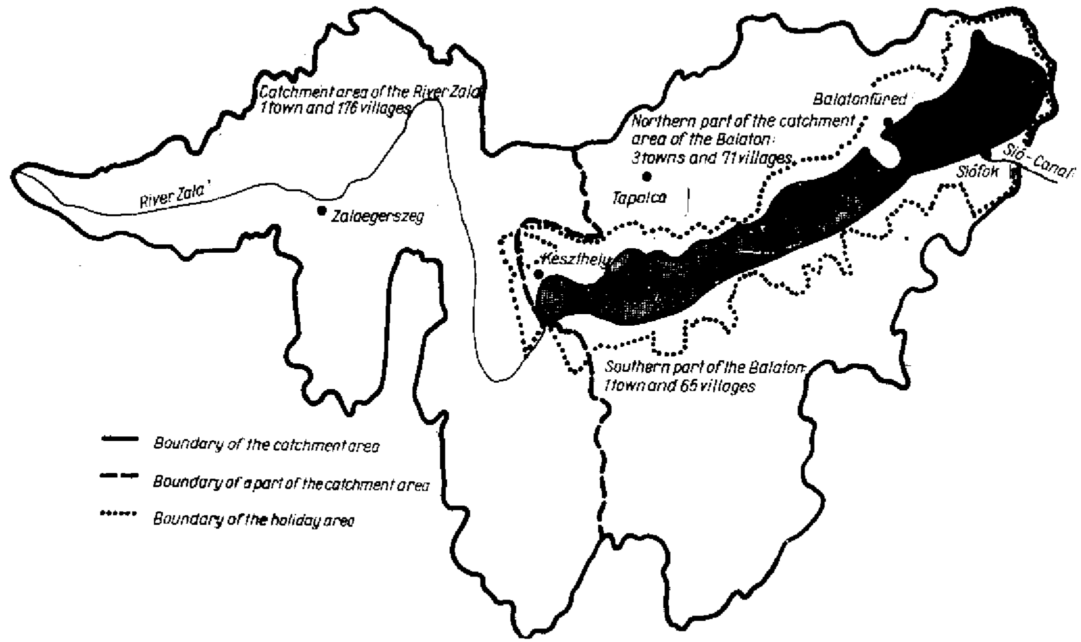

Figure 3: Catchment area of the Balaton taking account of the influence of the surrounding areas

EUTROPHICATION OF WATERS AND PROBLEMS OF THE SPECIAL PROTECTION OF NATURE

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The preservation and augmentation of rare, scientifically or culturally valuable or peculiar and especially striking species of plants and animals, the conservation of protected natural objects as well as the choice and cultivation of reservations are diverse tasks of the special protection of nature. In this connection not so much the form of the protection of such objects is decisive for the general characterization of the work on the protection of nature of a country than rather the aim related thereto, i.e. the social problems which are solved with the aid of the protection of nature.

In the German Democratic Republic these problems are settled by laws in which at the same time the importance of the special protection of nature within the social development is fixed. Like all social ranges the protection of nature in the GDR also contributes to the further increase in the substantial and cultural standard of living of the population and to the satisfaction of social needs.

The selected reservations protected by legal status and systematically cultivated serve in our Republic for the documentation of characteristic biogeocenoses, as areas of ecological research as stabilizers of the landscape and its household as well as for purposes of education and training.

The waters of our country as well have been utilized by mankind for centuries and have been influenced by it in a different manner. Although the original character of waters was changed by men, a number of running or stagnant waters or at least parts of them have been incorporated into the system of national trust properties in the GDR. This type of national trus properties comprises a wide spectre of various forms of waters differing from one another in their genesis, in their former utilization, and in the natural usage and conditions. Hydrographical, hydrological-limnological, botanical, or zoological pecularities are the reasons of choice and placing under cover by characterizing at the same time the spectre of feasible or necessary scientifical investigations in these reservations.

On the basis of legal provisions was built up in the German Democratic Republic, with the aid of the scientifical institutions assisted by the national executive organs, a system of national trust properties, which comprises within the reservations altogether 700 the characteristic forms of landscape of our country in their typical development. Such forms do not only result from the natural usage but also from the economic sphere of influence of men.

A scientific target of the work on the preservation of nature with a clear tendency, the promotion of the protection of nature by the public executive organs, and first of all the manufacturing conditions, i.e. the social property of the abundant beautiful scenery, are the prerequisite to this. All these factors exist in the German Democratic Republic.

The territories protected and belonging to the system of reservations are divided into various categories according to their environmental forming, their function and the reason of their placing under cover.

The category of reservations with lakes comprises approx. 13 % (94 reservations) in the GDR. In this category we distinguish various types which are characterised by the dimensions, the manner of origin, and first of all by the trophic level of lakes. Especially oligotrophic lakes and other stagnant waters are rare because the utilization of nature by men in the past and in the present time in most cases contributed to a secondary eutrophication of waters.

The water reservations are preeminently considered as natural resources of high economic value. Stagnant waters are also made use of today and in future for various purposes. They represent water reservoirs for the drinking-water and process water supplies, may be storage basins for the irrigation of agricultural cultivations, serve for the breeding of fishes, and gain more and more importance to aquatics and bathing sport, particularly in the favourite holiday centres. As already explained above, they have a high scientific or cultural and consequently social value also, at the same time as objects of the special preservation of natural beauty as the characteristic form of landscape. From the constantly progressing development in the GDR results the socially involved repeated utilization of the landscape, which is fixed in the law governing the planned forming of the socialist land improvement in the GDR. This law governs all questions alluding to the natural environment including the special preservation of natural beauty.

The principle of repeated utilization also fully applies to waters as components of the landscape and as natural resources of the society. In most cases the aim is a complex multi-variate social utilization, and in each case it must be decided which forms and which proportions can be used on behalf of a utilization which is as lasting as possible.

Not all the forms of utilization are likewise applicable to all waters. Various functions of waters are mutually exclusive. This specially in case that definite types of waters in reservations shall retain their characteristic condition. The planned exploitation of natural resources in the GDR on behalf of the whole society on the basis of the social property on the lakes is the prerequisite to the well-timed bringing in line of the various social interests; on the other hand, it provides the possibility to restore damage, if any by systematic treatment.

Such a case is to be represented following the example of the national nature reserve "Galenbecker See" where in consequence of utilization damage was caused which could be repaired by means of time-coordinated measures of the protection of nature.

Situated in the north of the Republic, lake Galenbeck with a surface of the water of approx. 700 ha and a mean depth of 1 m is an example of extremely flat lakes. It belongs to the largest lakes in the north-east part of our country. A lake being eutrophic by nature is involved, which is not subjected to any secondary pollution by bringing-in organic foreign substances. The water is extremely clear because the plant nutrients originating from the drainage area are for the most part not embodied in the plankton but in a luxuriously developed submersed vegetation. The low depth of water joined with poor development of planktons is the prerequesite to the excellent luminous effects in the lake. This encourages the development of the submersedly living plant supplies, in which characeae take part in a high degree. Investigations carried out from 1959 to 1962 revealed that especially the species Chara tomentosa, Ch. rudis, Ch. fragilis as well as Nitellopsis obtusa are widespread. Such plant supplies are extremely rare and are protected for this reason. The available organic substance from the rich vegetation is steadily deposited, in an extensively oxidized form, as thick sludge layers at the bottom of the lake.

The abundant subaqueous vegetation completed by a wide bank of reeds at the water's edge shapes lake Galenbeck into an important breeding and resting place of waterfowls with plenty of species. A number of 106 species could be determined as hatching birds, and another 50 species as temporary visitors to the district which is therefore one of the most important waterfowl habitations. The frequent occurrence of the swan (Cygnus olor) must be emphasized, which belonged to the species threatened with dying out in the GDR up to the new legal regulation of the year 1970. The numerous swans gave the lake Galenbeck the denomination of "Swan's lake". A similar concentration of these swans can be encountered only just in the district of Olsztyn in the north-east of the People's Republic of Poland where a "Swan's lake" is also protected as an ornithological reservation.

As the lake conted by nature among the eutrophic lakes the possibilities given for intensive carp- breeding should be utilized much more. The stock already existing of carps (Cyprinus carpio), which, however, is very moderate, was increased in 1965 by artificially brought in young animals of this species in order to obtain additional fish to provide a better supply of the population. The food offered for animals was increased by artificial feeding with wheat. An approximate quantity of 240 tons of corn per year was used for feeding.

But already after one year a clearly negative development was shown. The formerly clear water of lake Galenbeck was troubled by the carps which were seeking their food in the muddy deposits of the lake. By this an important factor for the growth of the abundant subaqueous vegetation, viz. the light, reached the. downward scale. The submersed vegetation slowed down very much. The constant turning up of the soil reduced the possibilities of its colonization with subaqueous plants. The nutrients which existed in the water were now no longer consumed by the submersed vegetation but promoted the development of the plankton, which involved further troubling of water and even stronger suppression of the submersed vegetation. The incomplete reception of the feeding corn by carps caused the remaining stock to decompose, which was gradually fermented. The chemical composition of water underwent a total change particularly within the range of feeding places. Investigations carried out by a diving group revealed that approx. 20 % of the feeding corn were not consumed but deposited in the lake.

The oxygen content of water was further decreased by the destruction of the submersed vegetation. This encouraged an intensification of anaerobic processes resulting in a further production of plant nutrients.

Enormous were the effects on the feathered world of the lake. The species existing there in great numbers slowed down to one tenth of their stock or even more. Particularly hard afflicted was the population of the swan (Cygnus olor). In 1966, one year after the beginning of the intensive keeping of carps, numerous perished young swans were found. Veterinary-hygienical investigations stated a mycosis as a cause of death, which, however, was primarily attributed to a total debilitation of young swans due to the shortage of fodder. This swan chiefly feeds on feeding off submersed plant supplies. This is absolutely possible up to a depth of water of 80 - 100 cm. The low depth of lake Galenbeck thus offered ideal conditions of feeding the swans. The dying down and exterminating, respectively, of the submersed vegetation destroyed the food-basis of the swan (Cygnus olor) and was therefore undoubtedly the primary reason of its retrogression, particularly owing to the high mortality of the young swans.

The changes occurred in the biogeocenosis proved to be adverse to the challenge and the value of lake Galenbeck as a nature reserve. On behalf of a further support of the reservation it was necessary to alter the condition immediately.

After a discussion and voting between the interested parties it was laid down that the intensive keeping of carps on lake Galenbeck should not be continued. The young carps already put into the lake were fished out as fast as possible. This required a longer time because not all the carps could be caught at once on account of the thick sludge deposits on the bottom of the lake, in which fish were living.

The feeding of corn still necessary for the preservation of the remaining stock was temporarily reduced to one third and was discontinued completely after a short time. The limited feeding only took place in one section of the lake.

By adopting these measures it was brought about that as early as 1968 the number of carps were already reduced in such a manner that the stock correspond to the situation before the beginning intensive keeping.

In the following years began a gradual redevelopment of the biogeocenosis into the condition existing before the intensive keeping. The troubling of the water slowed down, the subaqueous vegetation prospered again and little by little also the formerly observed waterfowl species began to frequent the lake. The following chart gives a survey of the development of the supplies of a few selected species of bird significant as indicators in the years 1962 (before the intensive keeping), 1966 (after a one-year intensive keeping), and in 1974 and 1975 after sexannial regeneration.

Table 1 - Changes in the stock of selected species of bird in the nature reserve lake Galenbeck (countings were each performed in October)

	1962	1966	1974	1975
Swan (Cygnus olor)	240	40	269	330
Broad-bill (Spatula clypeata)	240	10	80	235
Dunbird (Aythya ferina)	200	19	240	250

It is to be expected that in addition to the species of bird staying here at the time of passage also the hatching bird populations will develop in the same manner. A continuous check is ensured and observations made of late plead for the "normalization" of conditions.

The example of lake Galenbeck proves that even in the waters which are eutrophic by nature another eutrophication can take place by economic measures. Such interferences as disregard from the first all possible kinds of secondary effects to the full involve basic changes in the biogeocenosis, as the consequence of eutrophication in the example.

On the other hand, lake Galenbeck also shows that it is absolutely possible not only to hold up but also to cancel again any negative developments which have come to pass in order to preserve the scientifical and cultural value of a nature reserve for the future.

It is true that the necessary prerequisite is a universal concordance of interests, it being essential not only to start from economical interests. To preserve the reservation it was indispensable to renounce the additional production of carps. This was only possible because neither private interests nor economical advantages of individuals were decisive for the further cultivation of lake Galenbecker See but the interests of the whole society.

The principles of the protection and the utilization of nature and its resources by men are embedded in the legal fundamentals for the preservation of natural beauty in the GDR and are fully used in the further opening up of natural resources. Planning executive organs and specially trained economists will see to it that in addition to economical interests also the problems of the protection of nature and the conservation of a feathered world abundant in species are fully regarded and treated on a basis of equality.

In this way only the economical utilization of natural resources and its simultaneous protection can be ensured in the long run in the socialist society.

WATER-TIED RECREATION AND EUTROPHICATION

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The contribution "Problems of a long-term, planned utilization of the natural resource of water in the GDR" (GRINGMUTH/ROOS), which is published in the Proceedings, has attached chief importance to the economical aspect of the utilization of waters and the water, respectively, speaking in a narrower sense.

In this contribution to discussion another aspect of the utilization of waters is to be embarked upon, i.e. the utilization of recreation and its relation to eutrophication.

It is the aim of the socialist society and its national economy to constantly increase the substantial and cultural standard of living and to satisfy more and more the growing and varying needs of the society. This was again confirmed during the IXth Party Conference of the Socialist Unity Party of Germany (SED).

An acknowledged and growing need is the active recreation on the waters. All activities with and without the bodily contact with the water will increasingly become indispensable to the human organism as well as the preservation and the restoration of the working-power. The waters and their functions on behalf of the reproduction of the human working-power will constantly increase their importance. This means at the same time that any reduction of the efficiency of waters may be in consequence of eutrophication is a loss to the society respecting the utilization of recreation.

This is particularly decisive for the GDR, which is a country with a small area and a dense population (157 inhabitants/km^2). The natural recreative potential of the GDR is divided into 24 recreative landscapes, which chiefly serve for a long-time recreation. These landscapes comprise an area of approx. 20,000 km, which corresponds to a share of 18.5 % in the territory of the GDR.

Besides, there are still many smaller portions of landscapes which are particularly suited to the short-time recreation. To the above figure may be added approx. 6,000 km^2, which corresponds to a 5.5 percentage of the state territory.

This means that recreative landscapes are only available to a restricted extent in the GDR. This will require an extensive utilization of all available means of recreation and in this connection, too, on the waters in particular.

Considering the landscape type the water-tied recreation appears especially

- by the shore-side of the Baltic, which has approx. 40 % of the capacities of holiday-makers'places, in which case camping has been developed very much;
- in the lake landscapes particularly in the northern and middle section (Mecklenburger Seenplatte, Havel- und Spree-Seengebiet) comprising approx. 30 % of the holiday-makers' capacity and a little more than half the camping capacity of the Republic;
- on the artificial reservoirs and the running streams in the uplands.

The travelling and recreation frequency must also be considered. Already in 1966 nearly 50 % of GDR citizens started on a holiday trip every year. This quota has constantly increased from year to year. Based on these figures the GDR is among the top-ranking nations on an international level. Not to forget the great importance of the short-time close range recreation for the population living in large towns and agglomeration districts, and this feature will gain more and more importance in compliance with the provided general introduction of the 40-hour week and the increasing motorization.

KLAPPER has developed an evaluation scale for judging the utilization effect of waters for recreative purposes. In this connection a subdivision into the three main groups will be made:

A Factors of environmental forming,

B Factors characterizing the degree of preparation for the utilization of waters for recreative purposes,

C Factors diminishing the utilization of recreation of waters.

With reference to A the following comment is given: The relief-formation, the recreative value of surroundings, the formation of shores, the development of the surface water and subaqueous flora, the trophic degree, and the bioclimatic conditions.

Factor B asks for: The recreation required on a close range level, the traffic connections, the supply facilities, etc.

Factor C reveals utilization which are adverse to recreation such as waste water inflows and duck feeding on open surface water; furthermore, hygienic conditions, noise annoyance, air pollution, insects, and overburdening by too many visitors.

The individual factors (seven in each case) of the main factor groups A, B, C are steadily evaluated with figures 0 to 2, in which case normal conditions are estimated at 1, conditions adverse to recreation at < 1, and especially favourable conditions at figures ranging between 1 and 2.

By means of the formula

$$\frac{\dfrac{\sum_{i=1}^{7} A_i}{7} + \dfrac{\sum_{i=1}^{7} B_i}{7}}{2} \cdot \frac{\sum_{i=1}^{7} C_i}{7} = F_w$$

a complex factor is then obtained as a numerical value (F_w) from all these values. This factor enables already a certain comparison to be made of individual waters. On this basis it would be recommendable to make further-reaching economical investigations for the determination of the expenditure (costs) on behalf of the recreative efficiency of waters.

The restaurative anti-eutrophication measures tending towards lowering the nutritive content of the waters to be evaluated, towards removal of weed and mud, keeping out the waste water, and restriction of utilization adverse to recreation find expression in the increased means of recreation; and various restoration processes will become comparable in a reasonable manner.

THE MANAGEMENT OF ECOSYSTEMS, BASED ON SCIENTIFIC CONSIDERATIONS, AND ITS ROLE IN THE STRUGGLE AGAINST EUTROPHICATION

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The solution of the problem of the eutrophication of waters requires the joint activity of natural scientists, technologists, economists and sociologists for the purposes of a new discipline: the management of ecosystems for the systematic management of the water quality of stagnant waters.

In connection with natural sciences, a deepening of the knowledge about ecological factors in the system configuration, the hydrographic, physical, chemical and biotic factors and their interaction is necessary. With respect to eutrophication, the causal relations between the nutrient offer and bio-production, the effect of an increasing nutrient load and bio-production (eutrophication) or the extraction of nutrients by restoring interventions (oligotrophication) in the system configuration, respectively, are of special interest. A heavy nutrient load is in correspondence with a high bio-production leading, on the one hand, to a decrease in nutrient content (biological self-purification) but, on the other hand, strongly effecting high utilizations such as drinking-water supply or recreation, or making them impossible (colouration by vegetation, lake blooms, oxygen depletion, weediness, sludge accumulation, aggradation).

Although stagnant waters should be regarded as open systems, they have, due to their low rate of regeneration (often less than 10 % /a), a considerable inertia (UHLMANN and KLAPPER, 1973). In addition to the detention period, buffering mechanisms within the lakes have stabilizing effects. Only if critical load values are exceeded, qualitative changes are to be found, e.g. concerning the mass transfer on the sediment. Numerous individually processes were observed in nature and confirmed by laboratory tests, series of measurements were processed by variation statistics, so that the time has come to pass from the descriptive stage on to the conscious and systematic environmental management. Mathematical modelling (at least of partial processes), knowledge about the critical load values as well as the limiting factors of bio-production, the mapping of waters and other information now available may serve as a basis of an objective decision-making in the management of ecosystems.

The socialist states are aiming at the long-term planning of the social, economic and technical potentials for utilizing, and drawing on, the natural environment in such a way that, within the responsibility to coming generations, a stable supply, e.g. of drinking water, is guaranteed also in the future.

The role of technology is shown most impressively where large (partly huge), new ecosystems of waters are created by dams, impounding reservoirs of rivers, depleted open pits, quarries etc. These "man-made lakes" are excellent objects of study for ecological research, e.g. concerning first settlement, development of biocenoses and of the biological equilibrium.

The technician and technologist should be informed also on the effect of water-engineering activities on the water quality. The siting of a dam decides on the fact whether the future dam will have steep banks (with small coastal strips) or will be shallow. At present, the scope of design and the height of the retaining construction, and thus the water volume, are always determined by the economic aspects of the cost of construction. But the depth of water, the extension of the hypolimnion and thus the oxygen content of depth water are also decisive for the emerging bio-production and therefore influence the cost of subsequent water treatment or the yields of fish to be expected.

In the GDR, there are design guidelines and a standard for the systematic use of preliminary dams for eliminating phosphate (TGL 27 885/02). But the construction of big dams has also unwanted and unintentional side-effects, not only of an economic nature but also strongly influencing sociological factors. Such African reservoirs built, above all, for energy generation as Lake Volta, Lake Kariba, Lake Nasser brought up problems of resettling the population and an economic boom of fishing and agriculture (irrigation) but also unexpected problems of weediness even involving the decrease of fishing and the impassability of great lakes for water transport. The weediness created new biotopes for the Bulinus and Biophalaria snail genera as intermediate hosts for parasites of the Schistosoma genus causing the notorious bilharzia, and some more helminthoses were also favoured (GOLTERMAN, 1975). Here the solution of weediness problems has become an urgent economic and sociological task within the framework of the ecosystem management.

Man-made ecosystem modifications should be taken into consideration even in the phase of planning to observe the critical values from the beginning and to avoid any exceeding of them which would result in collapse. Not only the safety of constructional engineering but also of ecology should be observed to eliminate irreversible consequences.

In the GDR and the countries of the community of socialist states, ecological problems are solved by interdisciplinary and international cooperation in accordance with the objective social potentialities. National economic tasks of general management are solved by institutes of the disciplines concerned on the basis of a partnership with equal rights.

In order to enable technical experts for the far-sightedness required for ecological problems, environmental questions are considered even in college and university training based on differentiated curricula. Ecological problems during the preparation of construction work may also be solved by systematic cooperation. Thus in the GDR, e.g. for each shrinkage stoping, a limnological opinion is to be obtained during the phase of planning, in which the development of the future ecosystem is assessed and the project planner is advised on the suitable constructional design from the aspect of the management of water quality.

The ecological science becomes directly a productive force by providing the fundamentals of planning for an objectively justified extent of design, e.g. of drinking-water dams, for the recovery of the drainage area, the construction of third purification plants of sewage treatment, the construction of preliminary dams, and others.

The rapid development of recovery processes creates new technological tasks, e.g. concerning the methods for de-sludging lakes and utilizing sludge, impounding lakes, precipitating nutrients in water, diverting depth water, the mechanical, chemical and biological combatting of plants, supporting the oxygen balance by artificial aeration (surface aeration), destratification or depth-water aeration.

The economic connections between plankton development and drinking-water treatment are well-known. The oligotrophication of a dam by recovery measures may be compared with the alternative increase of the expenditure for water treatment (to achieve an equivalent improvement of quality) also by cost-benefit analyses (BEUSCHOLD, 1976). Due to the importance of changing the condition, e.g. by eutrophication, which influences the entire national economy and even social policy, the economists endeavour to evaluate also the natural environment functions of waters (KLAPPER, 1972; SALTANKIN and SHARAPOV, 1974). The above mentioned restoring measures should be expressed in an increase of the value for recreation. The expenditure for increasing the use-value by different recovery methods should be objectively comparable. Where considerable state funds are invested for the management of ecosystems, the systematic use based on scientific considerations is an order given by society, which cannot nearly be carried out by the limnologist or technician alone.

Together with other disciplines, ways and methods for a suitable economic integration of restoring measures should be prepared, an integration which should be as suitable as possible. The FDP-fertilizing recommendations binding on the socialist agricultural enterprises of the GDR, for instance, are directed to minimum wash-out losses and take into consideration also the interest of water management in a minimum discharge of nutrients into the waters. Lake sludge used for improving soil and increasing soil fertility raises the sorption capacity of the soil, thus decreases the wash-out of nutrients and improves the ecosystem of a lake and its environs. This contribution aims at pleading for a close cooperation of all scientific disciplines concerned within the framework of the conscious environmental management for the welfare of society.

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On behalf of the delegation of the GDR I should like to express my appreciation of the extensive work done by the rapporteur. As has been outlined by Dr. GANAPATI, the consequences of eutrophication immediately injure the living conditions of hundreds millions of people in the developing countries by affecting health and lessening the food supply for the population. Eutrophication furthermore implies not only increased costs, but also lower stability in drinking water supply, simultaneously causing losses of nutrients which are needed for food production. The delegation of the GDR wishes to emphasize the conclusion drawn by the rapporteur that more attention should be given to those sewage treatment practices which simultanieously can contribute to intensification of food production. Indeed most of the present biological and chemical sewage treatment systems primarily result in a destruction, a biochemical combustion of substances which also could be converted to digester gas, to food for stock farming and for irrigation, fertilization and structural improvement of soils. Recently in the GDR good results were obtained in recycling of wastes for agricultural purposes. Oligotrophication of lakes by diverting nutrient-rich water from the hypolimnion may be combined with the irrigation of fields. Removing the mud from eutrophicated lakes contributes to improvement of poor soils, especially for fruit cultures. In the GDR measures which try to find a good combination of ecological and economical points of view in areawide water quality planning substantially are favoured by the social-economic conditions.

Small man-made lakes also are able to serve as nutrient traps, thus protecting succeeding drinking water reservoirs from eutrophication. These installations are able to treat or to store nutrient-rich effluents from non-point pollution sources which cannot be catched by conventional practices. The self-regulatory properties of such artificial ecosystems mean, that the demand for workmen in general and for trained personnel in particular is small. These advantages in many cases compensate for the substantial areal demand. As the design procedures for ponds and preimpoundment reservoirs tested in our country not seem to be only of regional applicability, we hope that they also can contribute to help some developing countries in solving related water quality problems. Our delegation should like to emphasize the statement met by the rapporteur that the conversion of sewage into algal biomass serving as a protein source deserves increased attention. In developing countries the extremely high production potential of algae - up to 0.75 t dry matter per ha and day as favoured by the climatic conditions - may help to increase food production. We suggest that UNEP should give this question a high priority and promote the activities concerning the development of the scientific base and of appropriate technologies which are able to combine remedial or prophylactic measures against eutrophication with the reuse of water and nutrients for agricultural production.

MANAGEMENT MEASURES FOR THE UTILIZATION IN DRINKING WATER GAINING IN CATCHMENT AREAS OF ARTIFICIAL LAKES

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In closely colonized countries with small water resources besides the forestry areas also the agricultural used regions have to be taken up for the drinking water gaining. This leads to remarkable function superpositions in the utilization of the plains. For the security in the drinking water gaining an exact voting is needed between the economic branches being situated within the territory, including compromises with respect to the utilization intensity. On this symposium especially by BEUSCHOLD, KALBE, KRAMER and others is pointed to the relevance of the complex management of drinking water catchment areas. Function superpositions are existent preponderantly between waste water-producing industrial branches, the agriculture, forestry and municipal economy on the one hand and the drinking water gaining on the other hand. By its utilization methods used at present the forestry is contributing to the preservation and improvement of the water quality. Questions of a restrictive water amount planning by forestry management measures are still remaining unconsidered. At the same time with a total nutrient balance forestry plains are buffering unadvantageous influences on the water quality. The voting of the agricultural production to the concerns of drinking water gaining prepares increased difficulties, because the nutrient sources are diffusely distributed, and can be influenced only hardly by water management measures, besides this considerable nutrient concentrations are appearing in certain points.

In mountain sites the maximization of the agricultural production leads by force to an injury of the water body quality. An optimization of the production branches is, therefore, unavoidable. The injury of the water quality is frequently caused not by intensive management procedures themselves but by management mistakes.

In the GDR in the districts Magdeburg, Gera and Karl-Marx-

Stadt there are examples which have lead to a successful accomplishment of the rehabilitation of drinking water reservoirs by measures of utilization coordination. This presumed that the economic management organs, the municipal organs, the enterprises (agriculture, forestry and industry), regional planning organs, scientific institutions and institutes of hygiene under the direction of the water management organizations elaborated and accomplished a concept for the rehabilitation of the territory. According to investigations of BEUSCHOLD (1975 as result of a coordination in an example - region of the district Magdeburg the nitrogen load has been remaining constant for more than 10 years with simultaneously planned intensivation of the agriculture, whereas the nitrogen load in other agricultural managed catchment areas is showing an increasing trend.

Further examples from drinking water catchment areas in the districts Gera and Karl-Marx-Stadt, where partially more then 90 % of the N loadings are caused by agriculture, are showing, that optimizations of the production which have to be summarized to an utilization coordination are the base of reasonable rehabilitation measures.

The joined efforts of all organs mentioned will lead, especially in the district Gera, to a trend inversion of the nitrogen load in the preimpoundment flooding installations, which was strongly increasing until the year 1976. In his contribution to this symposium WEGENER mentiones single measures for the agricultural management of catchment areas of artificial lakes. The most important measures are:

- According to the electronic data processing fertilization model the fertilization should be carried out in the optimum times, paying attention to the restrictions included here.
- The cultivation structure should be changed favouring the forage cultures and meadows.
- Slope sites, spring areas and meliorated areas are requiring an especial management being voted to the drinking water gaining.

Comprehensive landscape - cultural measures against the surface erosion should be introduced.

In the GDR measures of the agriculture within the utilization coordination with the water management are facilated by:

- the large-scale plain management which can be controlled in centralized manner by the municipal organs in the territory,
- the concentrated cattle - keeping in large installations with sewage purification and recycling plants, underlying control of a water management assignee,
- a comprehensive educational work on the significance and the protection of the water resources in the territory, especially the postgraduational education and training in the agriculture and forestry with the aid of the Agricultural Science Society, the Chamber of Techniques and the Society for the Propagation of Popular-Scientific Knowledge.

In this coordination work the reginal planning organs are bearing in great responsibility, whereas by long-term landscape developings plans the concerns of the main users could be realized still better and by creating of appropriate landscape - planning organs a still more effective rehabilitation of drinking water catchment areas will be possible.

PROTECTION OF NATURE AND SOCIAL PROBLEMS

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Waters including ground water form an indispensable base of social process of reproduction particular to drinking water supply, to requirements of industrial water, to irrigation water used in the socialistic agricultural and forestry production and moreover to inland navigation and fishery.

Resulting from these facts the water resources are to preserve and to use rationally. The prevention of water pollution will be secured to a continual development of political economy, to the aid of health, to people's recreation and to physical training and sport.

These facts were formalized in the law for systematic management of socialistic environmental conservation on GDR and it regulates the principles of water use and water protection in our republic.

The treatment of water is contained full in the efforts of our society, to manage the natural environment in such a way, that it is possible to satisfy man's demands to-day and in future.

The great number of possibilities for utilization but also being in great need of actions in protection and maintaining require a systematic cooperation by all industrial and agricultural plants and also by people and their cooperative organizations which were guided for this reason by executive authorities in each case in the territory.

This cooperation also in water use and water protection is the base principle in all operations of environmental conservation and environmental management and contributes even in this sphere to the increasing of material and cultural life of citizens.

These global problems are specified in the water act with its pertinently regulations. Especially economical fixations to the prevention of water pollution and to rational use of ground and surface water determine the how of stimulation actions of a more efficient use of surface water with the support of water use recompense. Besides by way of sewage payment restraints are given, to observe the determined marginal values of water stress by sewages.

The stressed water balance in GDR demands a careful and economical treatment and use of the water resources. The executives are competent for the establishing of water reserves in order to secure use of water resources which primarily serve for people's water supply.

It is possible to make known in these areas use limits and injunctions which are particularly of practical use in the protection of water for pollution.

In these areas the eutrophication and its restraint respectively prevention plays a dominant role. Those water reserves with functions as catchment areas of drinking water reservoirs or as drinking water winning areas form an important part of agricultural and forestry production. Here are to develop ways and means for quantitative and qualitative operations to meet the danger of eutrophication.

After consulting agricultural and forestry plants executives formulate the different regulations referring to drinking water reservoirs and reserves. They contain problems such as soil utilization, selection of crop species and crop rotation, treatment of stands as well as fertilizing and the application of pesticides. In those territories available water in best quality takes precedence for other economical demands. These regulations presuppose the socialistic property in nature and natural resources and the planful and proportional development in all branches of political economy.

Both premises are given in GDR and therefore the possibility for the rational and careful use of water resources too.

The methods and problems of using water reserves related more specifically to agriculture and forestry are objects of some papers and discussions in this symposium.

Another aspect which demands economical regulations in water use includes the maintaining of nature reserves characterized by standing or running water or parts of them.

In Central Europe original nature regions are nearly non-existing. Also the reserves with water bodies are impacted and changed by man. The further intensive utilization of water in nature reserves will be only possible if scientific problems and objectives which will be settled in reserves suffer no impairments.

The tenor of adjustments in these cases tends to an effective utilization of nature resources under keeping and aimful development of the natural contains of the reserves which must correspond to cooperative aims.

The reasons for establishing reservates often are not only the water body but the connecting flora and fauna.

Water body is the most remarkable element of the biotop and it will be managed in such a form which helps to fill the tasks of the nature reserve.

That are only some aspects in so many demands of the society to waters and which need great efforts for their realization. Besides material-technical suppositions it is necessary to awake and to deepen the understanding of complicated interrelationships between waters and the other parts of landscape.

Treatments in schools, high schools and universities help us in this field but also a wide enlightenment in publicity.

All those principles are fixed in the laws of environmental and nature conservation in GDR. The great attention of party and government in this field helps us better and better in further forming the developed socialistic society filling the problems which are connected with utilization and protection of water bodies.

THE EFFECTS OF USE OF AGRICULTURAL CHEMICALS ON EUTROPHICATION OF WATER

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The use of chemicals in agriculture and its effects on eutrophication of surface water is very wide problem and I should like to limit it to the influence of inorganic fertilization on this process.

The high growth of population and decrease of cultivated area force to insensification of food production first of all.

It concerns many countries and among them Poland, where we only have less than 0.50 ha available arable soil per person. We intensify our agriculture and applied more than 170 kg/ha NPK.

Poland is very poor in water, we have 1.700 m^3 per person per year. The characteristic feature of our waters is large enrichment in nitrogen compounds. The ratio between mineral carbon and nitrogen in mineral forms is lower than 10 and it is very similar to ratio in algae. This enrichment causes the big development of algae not only in stagnant water but also in rivers.

For instance, in our main river Vistula the highest number of algae exceeds 290 mil. cells per liter (RORUM 1976). The dam reservoirs built on Karpathien rivers receive high load of nitrogen and phosphorus (17 g N/m^2. year; 3,9 g P/m^2. year, after PLUŽANSKI (1976).

The agriculture influences these changes of chemical and biological features of surface waters. Intensification of agriculture increases the eutrophication of soil which is closely connected with eutrophication of water.