Alfred M. Beeton[1]

EFFECT OF POLLUTION ON THE TROPHIC STATE OF LAKES

UTICAJ ZAGAĐENJA NA TROFIJU JEZERA

Abstract

The present trophic conditions of Lake Erie, USA and Lake Skadar, the largest lake of the Balkans, are compared. The data for Lake Skadar have resulted from the cooperative study between the Biological Institute, Titograd and the University of Wisconsin-Milwaukee, financed by the Yugoslavian FIASEC and the Smithsonian Institution, Washington, D.C., USA. Information is presented on the effects of pollution on Lake Erie since 1900. The possible long-term effects of pollution and other man-made changes on Lake Skadar are evaluated in terms of the chemical and biological conditions, the effects on the aquatic macrophytes and fish populations and the adverse effect on the beneficial uses of the lake.

Izvod

U ovom radu uporeduje se trofija jezera Iri (SAD) i Skadarskog jezera, najvećeg jezera na Balkanu. Podaci o Skadarskom jezeru proistekli su iz zajedničkih proučavanja Biološkog zavoda — Titograd i Univerziteta u Viskonsinu — Milvoki, koja su finansirali jugoslovenski ZAMTES i Smitsonijeva institucija, Vašington, D. C. SAD. Daje se informacija o posljedicama zagađenja jezera Iri od 1900. godine. Mogući dugotrajni efekti zagađenja i ostalih promjena izazvanih čovjekovim djelovanjem na Skadarsko jezero procjenjivani su sa biološkog i hemijskog aspekta, kao i sa aspekta populacija vodenih makrofita i riba i budućeg uticaja na racionalno iskorišćavanje jezera.

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[1] Contribution No. 208 of the Great Lakes Research Division, Great Lakes and Marine Waters Center, University of Michigan, Ann Arbor, Michigan, USA 48109.

INTRODUCTION

The effects of water pollution may be obvious and readily identified when fish are killed or visible oil and chemical discoloration of the waters occur. These effects may be catastrophic, but frequently they are short term. A more difficult problem to deal with is the subtle effects of continual inputs of nutrients or low concentrations of toxic materials. Such inputs, while not easily detected, may have significant long-term effects on the productivity and trophic state of a lake. Eutrophication, i.e., the nutrient enrichment, of the Zurichsee (Thomas 1969) and the St. Lawrence Great Lakes (Beeton 1969), as well as many other lakes, is well documented.

Skadar Lake is the largest lake of the Balkans (approx. 370 km^2) and one of the truly ancient lakes. It is a valuable freshwater resource of Yugoslavia and Albania. It is a very productive lake; the Yugoslavian commercial fishery produces about 1,000 metric tons annually (Stein et al. 1975). The abundant aquatic and bird life, plus the beautiful surroundings, have great value for recreation and as a tourist attraction. The lake and river waters have the potential for increased use as a water supply for irrigation and domestic and industrial consumption. Scientists from Yugoslavia and the United States of America recognized the importance of this resource and developed a limnological study to provide the scientific information essential for planning for wise use and protection of the lake. This study, which is funded through the foreign currency program of the Smithsonian Institution and by the Yugoslavian Government, was initiated in 1972. It is now a cooperative study between the Biological Institute of Titograd and the University of Wisconsin-Milwaukee and the University of Michigan.

In addition to evaluating the results of the work that has been underway on Lake Skadar, it is necessary to try and predict the consequences of the possible effects of pollution on the lake. In order to assist in making such predictions, the effects of pollution on other lakes should be studied. It is for this reason that a résumé is presented of the changes resulting in Lake Erie due to pollution.

TROPHIC CLASSIFICATION OF LAKES

Various attempts have been made to develop classification schemes which would include all types of lakes. None of the proposed classifications are truly all inclusive, and usually the more detailed and specific a classification scheme the greater the number of exceptions. Consequently, most limnologists have accepted the simple classification of oligotrophic, mesotrophic, and eutrophic, which refers to a gradation from nutrient-poor to nutrient-rich. An additional category, dystrophic, is included for the brown water, high organic content, bog lakes.

The following are useful criteria for classifying a lake into one of the main categories:

Oligotrophic

Total dissolved solids less than 100 mg/l.
Mean depth usually more than 15 m.
Secchi disc depth greater than 6 m.
Chlorophyll less than 4 μg/l.
Total phosphorus less than 16 μgP/l.
Dissolved oxygen distribution orthograde or if clinograde, greater than 60% saturation at depth.
Annual primary productivity less than 100 gC/m^2/yr.

Mesotrophic

Total dissolved solids 100 to 150 mg/l.
Mean depth usually less than 30 m.
Secchi disc depth 2.5 to 6 m.
Chlorophyll 4 to 8 μg/l.
Total phosphorus 16 to 24 μgP/l.
Dissolved-oxygen clinograde to anaerobic at depth.
Annual primary productivity 150 to 250 gC/m^2/yr.

Eutrophic

Total dissolved solids greater than 150 mg/l.
Mean depth usually less than 10 m.
Secchi disc depth (transparency) less than 2.5 m.
Chlorophyll greater than 8 μg/l.
Total phosphorus greater than 24 μgP/l.
Dissolved-oxygen depletion usually occurs in bottom waters.
Annual primary productivity 300 gC/m^2/yr or greater.

Figure 1 illustrates how nutrient-poor lakes can evolve into eutrophic lakes. Lakes originating in infertile watersheds receive small nutrient input and remain oligotrophic. Changes in fertility of a lake parallel those of its drainage basin. Slight increases in nutrient loading may not affect the oligotrophic nature of the lake. Continued and increasing nutrient loading will eventually lead to a period of rapid transition, i.e., eutrophication, and the lake becomes mesotrophic or eventually eutrophic. Studies of many lakes have shown that natural eutrophication can occur in a relatively short time. The eutrophication process can be greatly accelerated due to alteration of the watershed by man, e.g., through increased use of fertilizers or direct inputs of organic material from pollution. The broken line in Figure 1 indicates that eutrophication can be initiated and/or accelerated at any time in the history of a lake.

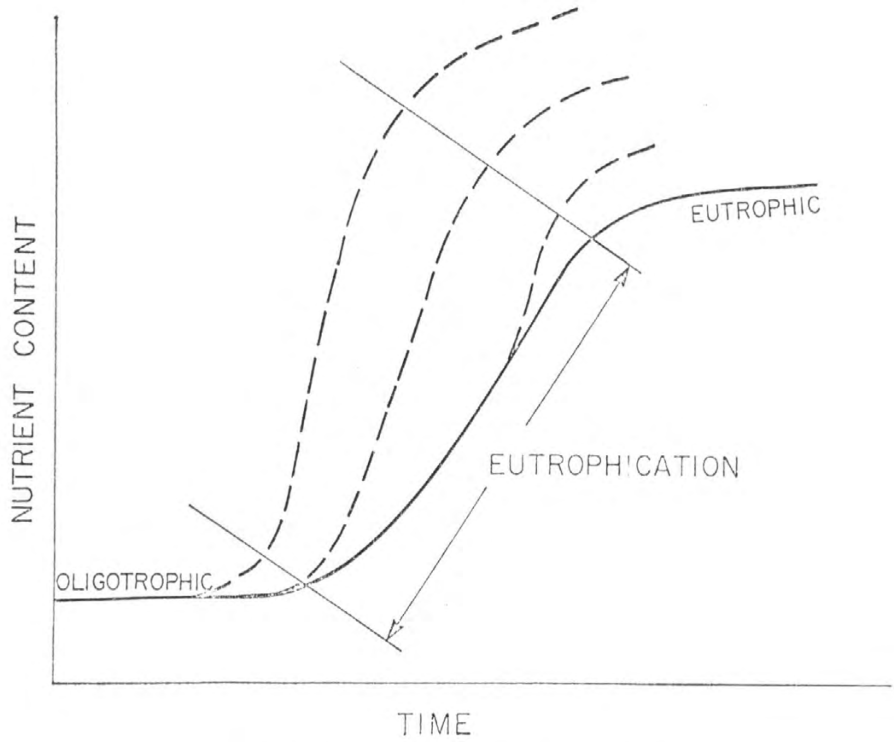

Fig. 1. Natural and accelerated eutrophication
Sl. 1. Prirodna i ubrzana eutrofikacija

Significant changes in physical and chemical conditions and in kinds and abundance of aquatic organisms have been observed in lakes undergoing eutrophication. The following all have been observed:

1. Increases in nitrogen and phosphorus.
2. Increases in total dissolved solids and associated major ions.
3. Development of low dissolved-oxygen concentrations in the bottom waters.
4. Changes in abundance and distribution of aquatic macrophytes.
5. Changes in species composition and abundance of algae.
6. Decrease in transparency.
7. Changes in species composition and abundance of benthos.
8. Changes in species composition and abundance of zooplankton.
9. Decrease in abundance of salmonid fishes and changes in growth rates of all species.
10. Nature of and level of productivity.
11. Changes in sediments.

EFFECT OF POLLUTION ON LAKE ERIE

Lake Erie is the eleventh largest lake of the world, with a surface area of 25,766 km². It is the shallowest of the five Great Lakes, with a mean depth

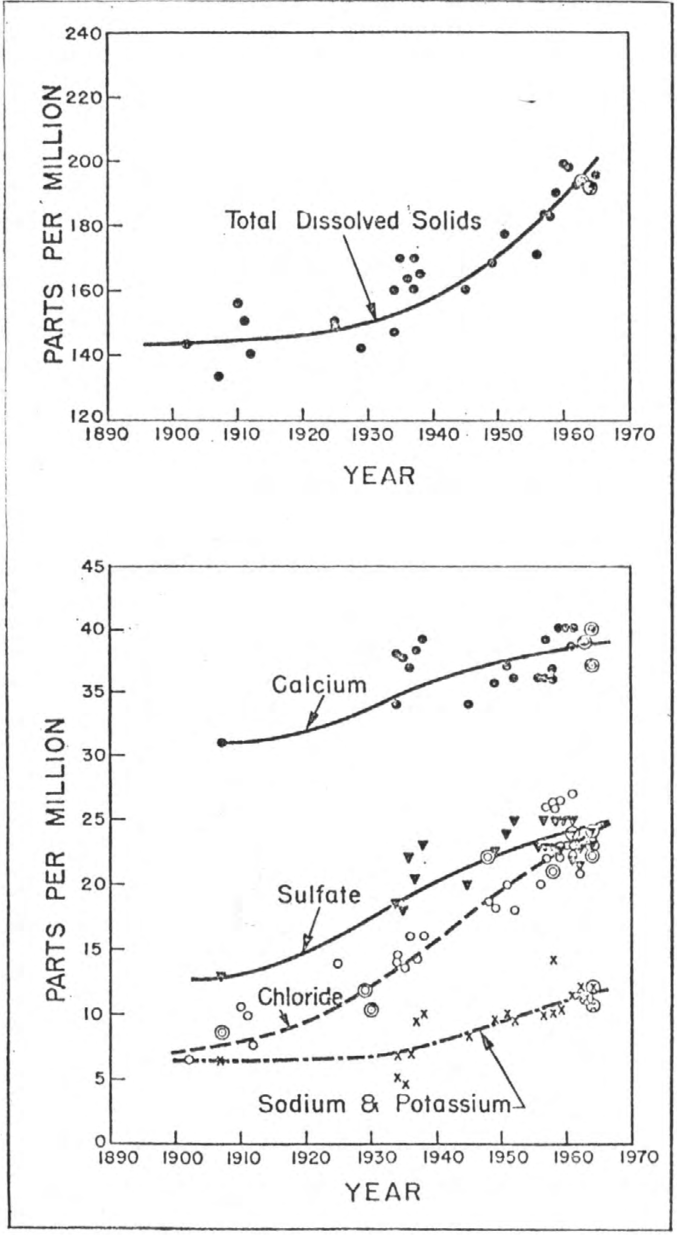

Fig. 2. Changes in the chemical content of Lake Erie (from Beeton 1969)

Sl. 2. Promjene u hemijskom sastavu jezera Iri (Beeton 1969) of 18.6 m. Like Lake Skadar, aquatic macrophytes are important in the shallow waters, although they are not nearly as abundant as they were 50 years ago. Over the past 50 years Lake Erie has been described as oligotrophic, mesotrophic, and eutrophic. Extensive data are now available which substantiate that Lake Erie has undergone accelerated eutrophication due to pollution.

Concentrations of calcium, chloride, sodium, and sulfate all have increased (Fig. 2). The increase in total dissolved solids shows the combined

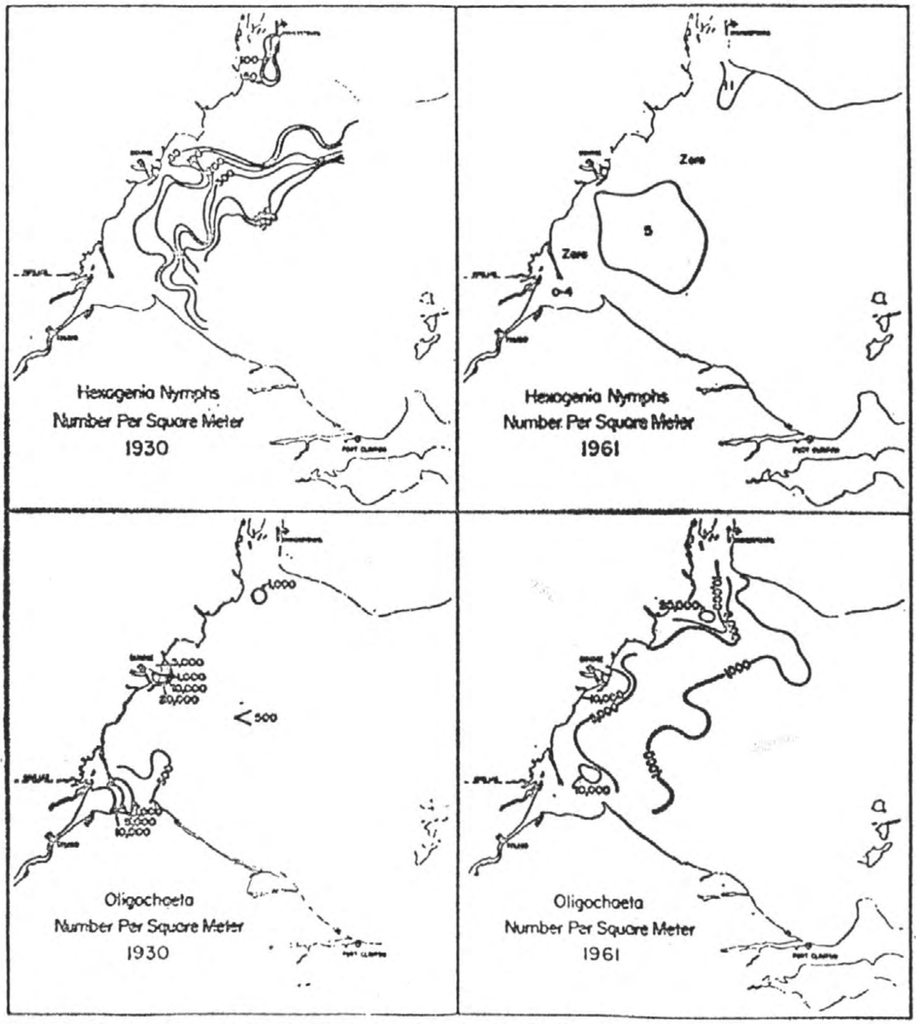

Fig. 3. Changes in the distribution and abundance of Oligocheta and Ephemeroptera *(Hexagenia)* in western Lake Erie (from Beeton 1969)

Sl. 3. Promjene u distribuciji i obilju Oligocheta i Ephemeroptera *(Hexagenia)* u zapadnome dijelu jezera Iri (Beeton 1969)

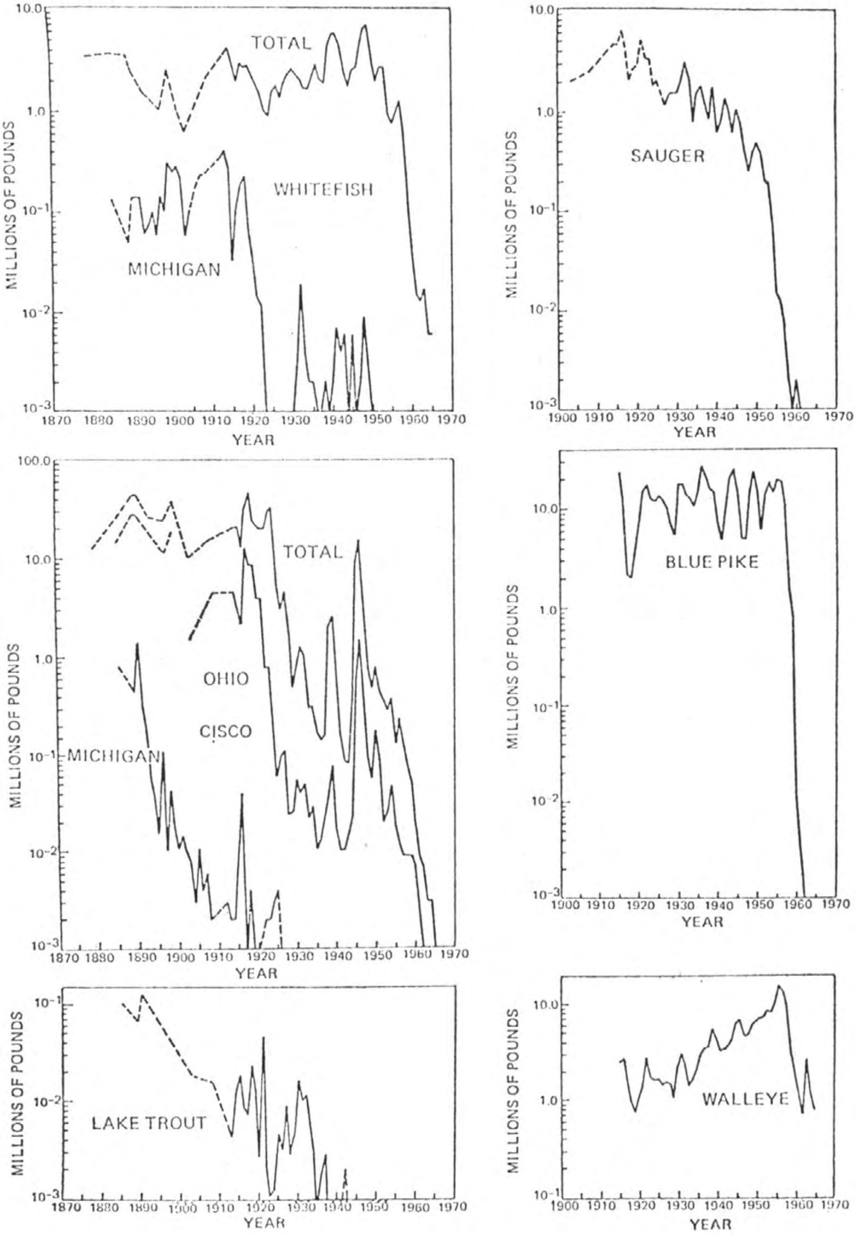

Fig. 4. Changes in the commercial fisheries of Lake Erie (from Beeton 1969)

Sl. 4. Promjene u komercijalnom ribarstvu jezera Iri (Beeton 1969) effect of these ions. The major increases apparently started around 1910, during a period when large sewerage systems were being built which discharged to the lake. The human population in the basin increased from about 3 million to about 12 million between 1900 and 1970. Nitrogen concentrations increased five-fold and phosphorus about three-fold during this period.

Dissolved oxygen concentrations were near saturation at all depths, except in a very few places in 1929 (Wright, 1955). Low dissolved-oxygen concentrations in the bottom waters during summer started to become an annual occurrence by 1959. A lake-wide survey in 1959 showed that an area of 4,160 km^2 had dissolved-oxygen concentrations less then 1 mg/l (Beeton 1963).

Algal blooms have increased in intensity as well as duration since 1920. Several species of diatoms had become major species by the early 1960's, although they were not abundant in earlier years or had not been reported previously. Both spring and fall phytoplankton pulses were dominated by diatoms until the late 1940's, when green and blue-green algae assumed major importance in the fall pulse.

Major changes in the species composition and abundance of benthic organisms have taken place in Lake Erie as shown by comparison of the results of surveys conducted in 1930 and 1961 in western Lake Erie (Fig. 3). Nymphs of the burrowing mayfly, *Hexagenia*, a „clean water" organism which once dominated the benthos, had almost disappeared to be replaced by pollutiontolerant oligochaetes, such as *Limnodrilus hoffmeisterii*, by 1961 (Beeton 1969).

Changes in the commercial catch of fish show the disastrous effect of environmental changes on the fish populations of Lake Erie (Fig. 4). The species composition of the fishery has changed markedly over the years and some species have almost disappeared. The cisco *(Coregonus artedii)* fishery was producing up to 18 million kg annually, but the fishery collapsed after 1925, with only a brief recovery in 1945. The sauger *(Stizostedion canadense)* started to decline in 1920 and the fishery collapsed in the 1950's. Today the blue pike *(Stizostedian vitreum glaucum)* is considered extinct and cisco, lake trout *(Salvelinus namaycush)*, and whitefish *(Coregonus clupeaformis)* have almost disappeared. The fate of the walleye *(Stizostedion vitreum)* is uncertain, although a closely controlled fishery has assisted in recovery of this fishery.

LAKE SKADAR

Lake Skadar is subtropical and lies in a karst region. Water enters the lake from several tributaries, although the Moraca River is the only important one, and a number of sublacustrine springs (okos). Outflow from the lake is via the Bojana River. Annual flooding of extensive pastures greatly increases the surface area.

Based on data which have been collected during this project, the lake should be classified as mesotrophic, using the usual criteria. Transparency as measured with a Secchi disc has ranged from 1.5 to 5 m. Total phosphorus concentrations ranged from 6 to 74 μg/l P (T i t u s et al. 1975). The low values, which were from the open lake, are representative of oligotrophic conditions. Phosphorus concentrations usually were greater near shore and in the Moraca River. Dissolved oxygen concentrations have been near saturation and mildly clinograde. These high dissolved-oxygen concentrations are probably a result of wind induced mixing, since the shallowness of the lake (open water 6—8 m) promotes mixing. Total dissolved solids ranged from 110 to 215 mg/l (B o j b a s a & V u k c e v i ć, 1975).

Obviously the lake is more productive than implied by a classification of mesotrophic. A commercial fish production of 1,000 metric tons indicates a basic productivity greater than that associated with mesotrophic lakes. The problem is that the criteria for trophic classification are suitable for lakes where phytoplankton are the dominant primary producers. Such a classification scheme may not be suitable for lakes, such as Skadar, that have extensive production of aquatic macrophytes.

The studies which have been made on Lake Skadar during the project indicate that water quality of the lake is closely similar to that of the Moraca River, October into early June. Water also enters the lake through the okos, but water quality of okos is closely similar to the Moraca River and the flows are minor compared to the river. Once the aquatic macrophytes become well established in late spring, the chemical characteristics of the open-lake waters differ from the river in that specific conductance, alkalinity, and phosphorus are lower in the lake than in the river.

It appears that the Moraca River determines the quality of the lake water during that part of the year when aquatic macrophytes are not present. Once the macrophytes are growing in dense beds they have a major influence on the quality of lake water. This is true even at the mouth of the Moraca River, since it must flow through dense stands of macrophytes as it enters the lake. Flooding of the terrestrial environment must also be important, especially since extensive growths of periphyton can be observed around every tree branch, bush, or dead plant. The importance of this flooding has not been determined, however.

The influence of aquatic macrophytes on chemical characteristics is shown by the results of several experiments where aquatic macrophytes were enclosed in plastic bags with lake water. Table 1 presents the results of one experiment. Significant decreases occurred in specific conductance (μmhos/cm at 25°C) and total alkalinity (Fig. 5). The pH and dissolved oxygen increased. Similar changes occurred when *Myriophylum* or *Potamogeten* were used. The bag which was kept dark with aluminum foil showed minor decreases in pH and dissolved oxygen and a small increase in specific conductance.

The changes in the clear plastic bags are the results of photosynthesis; those in the dark bag show the opposite effect of respiration. These results can be found under natural conditions. On several occasions specific conductance as low as 100 μmhos and total alkalinity of 40 mg/l were observed in growths of macrophytes.

Studies made on the lake on May 14 and 15, 1976 further show the effect of macrophytes on water chemistry (Tables 2 & 3). On May 14, 1976 samples were taken in the river and on a transect extending into reeds and

Tab. 1. Changes in chemical conditions when *Ceratophytum demersum* was enclosed in plastic bags in Lake Skadar water, May 14, 1976. Bags were submerged in lake water in aquaria in full sunlight.

Tab. 1. Promjene u hemijskim uslovima kada je *Ceratophylum demersum* bio u plastičnim kesama u vodi Skadarskog jezera, 14. maja 1976. Kese su bile potopljene u akvarijumu sa jezerskom vodom i izložene punoj sunčevoj svjetlosti.

	Bag 1 Clear plastic Kesa 1 Providna plastika	Bag 2 Clear plastic Kesa 2 Providna plastika	Bag 3 Clear plastic Kesa 3 Providna plastika	Bag 4 Covered with aluminum foil Kesa 4 Pokrivena aluminijskom folijom
Time 09:00 (start of experiment) *Vrijeme 09:00* (početak eksperimenta)				
Temp °C Temperatura °C	17.5	17.5	17.5	17.5
pH	7.7	7.7	7.7	7.7
Conductance (μmhos) Konduktivitet (μmhos)	205	205	205	205
Dissolved oxygen mg/l Rastvoreni kiseonik mg/l	12	12	12	12
Alkalinity (as mg/l $CaCO_3$) Alkalinitet (kao mg/l $CaCO_3$)	131	131	131	131
Time 12:00 *Vrijeme 12:00*				
Temp °C Temperatura °C	22	22	22	—
pH	7.9	8.1	8.5	—
Conductance Konduktivitet	195	170	170	—
Dissolved oxygen Rastvoreni kiseonik	14	17.5	17	—
Alkalinity Alkalinitet	116	101	100	—
Time 13:30 *Vrijeme 13:30*				
Temp °C Temperatura °C	22	22	22	21.2
pH	8.3	8.0	8.0	7.6
Conductance Konduktivitet	180	142	150	220
Dissolved oxygen Rastvoreni kiseonik	15	15	17	5.5
Alkalinity Alkalinitet	106	78	83	131
Dry weight of plants (gm) Težina suve materije biljaka (gm)	2.802	2.888	2.405	2.798

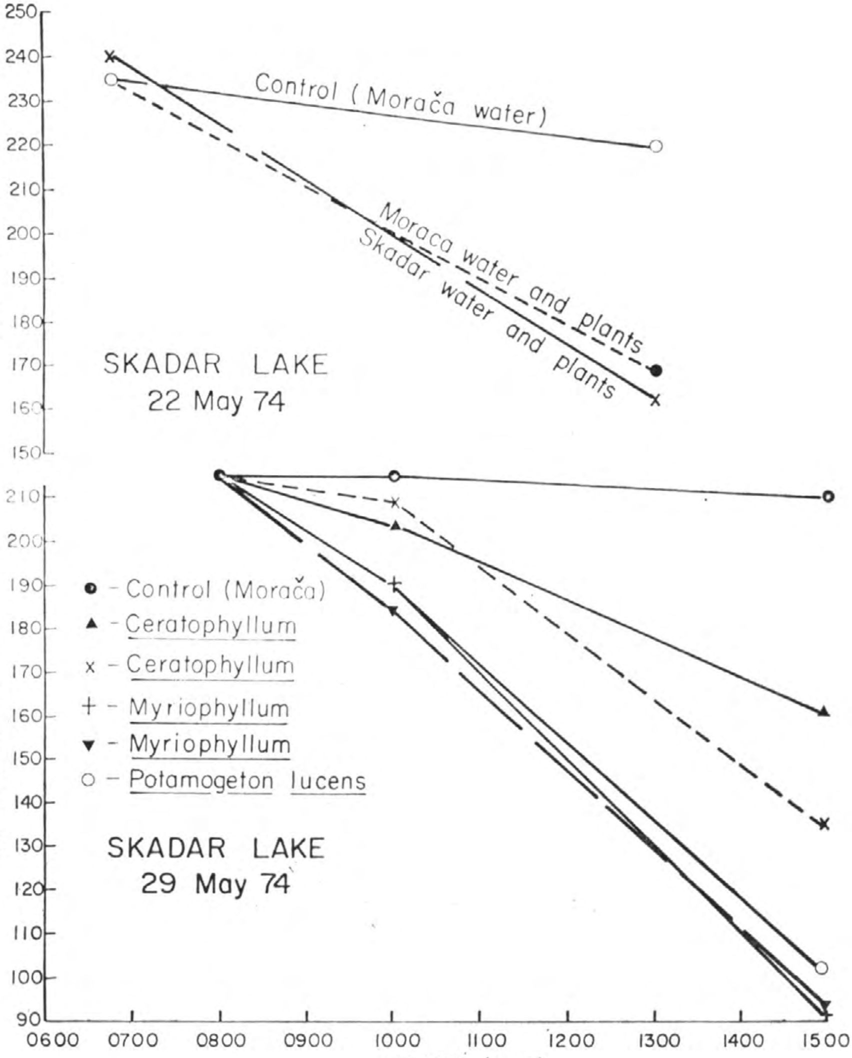

Fig. 5. Changes in conductivity of Moraca River and Skadar Lake water when macrophytes were enclosed in clear plastic bags, May 22 and 29, 1974.

Sl. 5. Promjene u konduktivitetu voda Morače i Skadarskog jezera kada su makrofite bile u providnim plastičnim kesama, 22. i 29. maja 1974.

a few *Nuphar*. Conductance, silicon, nitrate, and alkalinity decreased among the macrophytes (Fig. 6); pH showed only a small increase.

On May 15, 1976, samples were taken on a transect extending from the open lake into a very dense growth of *Phragmites communis* and *Nuphar*

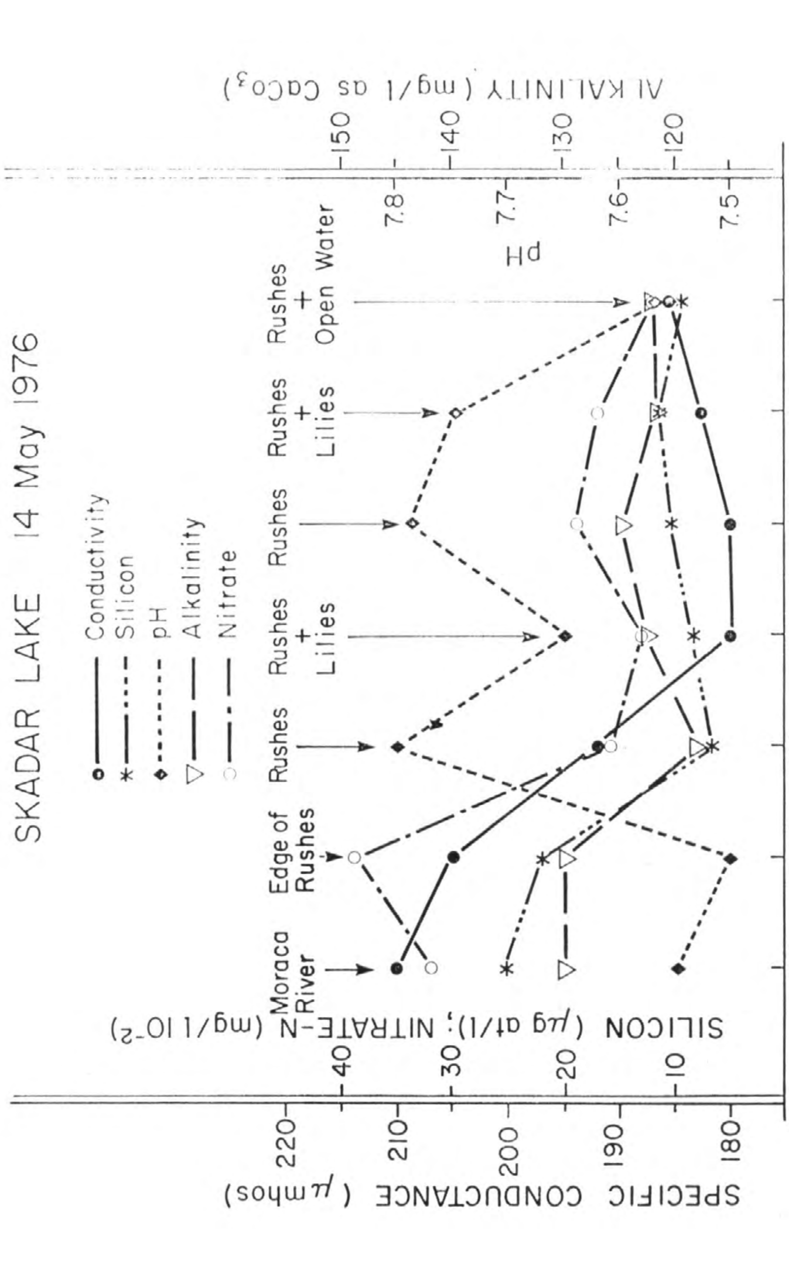

Fig. 6. Differences in alkalinity, pH, silicon, nitrate and conductivity between Morača River and in water among macrophytes, May 14, 1976.

Sl. 6. Razlike u alkalinitetu, pH, silicijumu, nitratu i konduktivitetu vode Morače i vode u zoni makrofita, 14. maja 1976.

Tab. 2. Chemical conditions on a transect from the Moraca River into a growth of aquatic macrophytes, May 14, 1976.

Tab. 2. Hemijski uslovi na presjeku Morače do zone obrasle vodenim makrofitama, 14. maja 1976.

Sampling location / Mjesto gde je uzet uzorak	1 River Rijeka	2 Edge of river Obala rijeke	3 Macrophytes Macrofite	4 Macrophytes Makrofite	5 Macrophytes Makrofite	6 Macrophytes Makrofite	7 Macrophytes Makrofite
Temp °C Temper. °C	11.5	12.5	14.7	15.0	15.2	14.5	15.0
pH	7.55	7.50	7.80	7.65	7.79	7.75	7.55
Conductance Konduktivitet	210	205	192	180	180	183	185
Alkalinity Alkalinitet	130	130	118	123	125	122	122
Silicon (μg-at/lSi) Silicijum (μg/l Si)	25	22	7	8	10	11	10
Nitrate (mg/lN) Nitrat (mg/l N)	0.32	0.39	0.16	0.13	0.19	0.17	0.12

luteum. In places where reeds were not abundant, the *Nuphar* growth was so dense as to cut off light penetration below the lilies. The open-lake sample was taken 300 m from the macrophytes, a sample was taken among some *Scirpus*, then at a distance of 75 m into the *Nuphar*; the next sample was taken at 15 m into the reeds, and then at 10 m distance. Thousands of fish fry were present in any open water.

Nitrate and pH decreased among the macrophytes (Fig. 7). Specific conductance, alkalinity, and silicon increased (Table 3) among the macrophytes. This was opposite to the results of the sampling on May 14, although these results are closely similar to those for the Gnadensee of Lake Constance (B a n o u b 1975). Based upon the results of the bag experiments it can be concluded that the conditions observed on May 14 were due to active photosynthesis. Few lilies were present to limit light penetration. Decreases in silicon and nitrate probably were due to uptake by the large masses of periphytic diatoms growing on the macrophytes. Reducing conditions probably were dominant in the water below the lilies on May 15, since little light could penetrate for photosynthetic activity. Consequently, pH decreased. Silicon would be released from decaying diatom frustules. Nitrate decreased on both dates, but the decrease on May 15 probably was the result of denitri-

Tab. 3. Chemical conditions on a transect from Lake Skadar into a dense growth of *Nuphar* and *Phragmites*, May 15, 1976.

Tab. 3. Hemijski uslovi na presjeku od pelagijala Skadarskog jezera do zone obrasle *Nupharom* i *Phragmitesom*, 15. maja 1976.

Sampling location / Mjesto gde je uzet uzorak	1 Lake Jezero	2 *Scirpus* *Scirpus*	3 *Nuphar* *Nuphar*	4 *Nuphar* & *Phragmites*	5 *Nuphar* & *Phragmites*	6 *Phragmites*
Temp °C Temper. °C	19.7	19.8	19.8	20.0	20.5	20.5
pH	7.4	7.3	7.2	7.2	7.15	7.25
Conductance Konduktivitet	230	265	295	292	293	290
Alkalinity Alkalinitet	123	165	182	182	186	182
Silicon Silicijum	11	48	67	52	46	42
Nitrate Nitrat	0.28	0.17	0.19	0.15	0.18	0.18

fication, whereas on May 14 it was probably due to uptake of nitrate by the plants.

The results of these observations as well as other experiments and surveys show that the macrophytes can and do affect the water chemistry of Lake Skadar.

POSSIBLE EFFECTS OF POLLUTION ON LAKE SKADAR

Increased nutrient loading would lead to eutrophication, although it is likely that the initial effects would not be detected by the criteria cited previously since the aquatic macrophytes would probably be able to take up more nutrients than at present. This increased production of macrophytes would enhance the macrophyte influence on the water chemistry. Also, it is uncertain as to how much of any increased nutrient loading may end up in the terrestrial environment as a consequence of flooding.

A continued increase in nutrient loading would eventually supply large amounts of nutrients to the open lake and promote the growth of algae. The increased growth of algae would result in decreased transparency and thereby directly limit light available to submerged macrophytes. The increased oxygen demand resulting from decaying algae and macrophytes would stress the system and lead to lowered dissolved-oxygen content at the sediment-water interface and bottom waters and thereby affect the fish populations and benthos. Changes could take place which would be closely similar to those which occurred in Lake Erie.

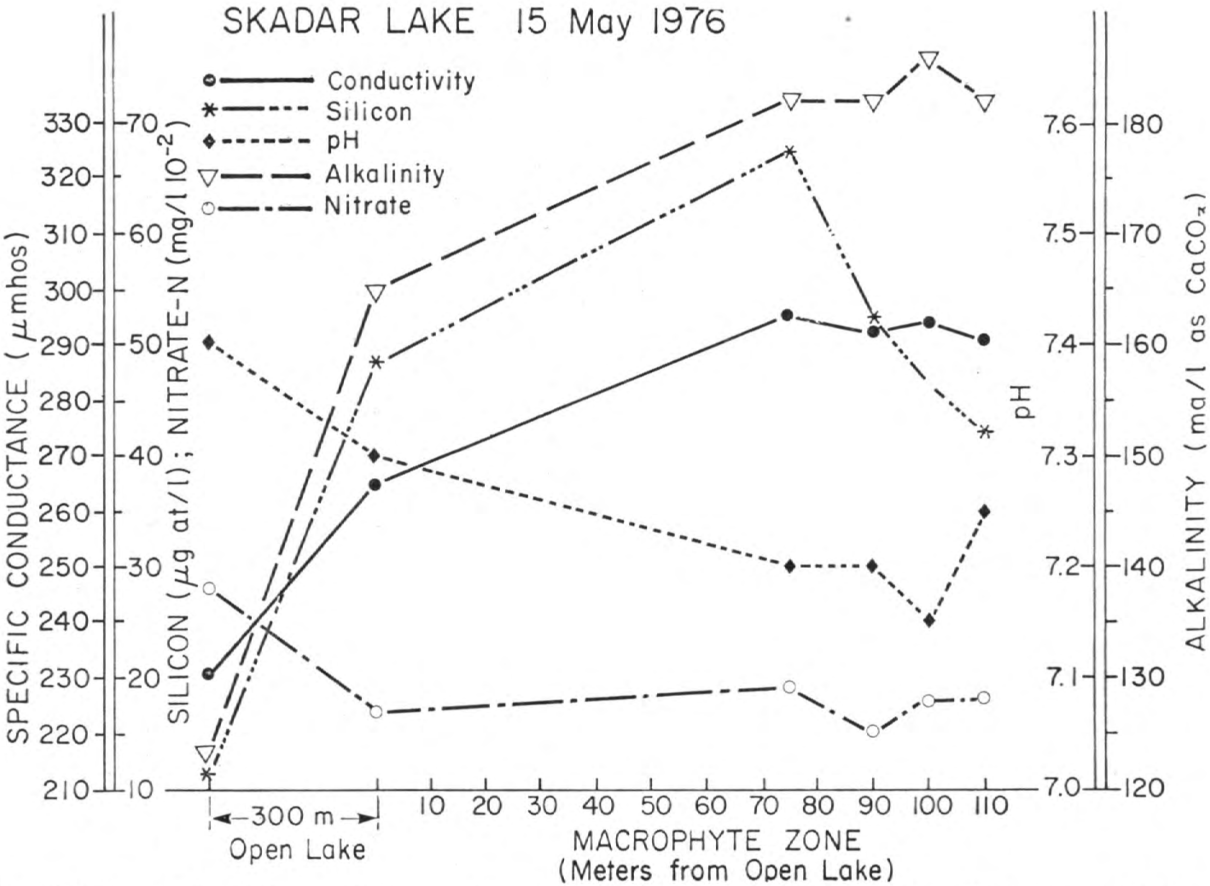

Fig. 7. Differences in alkalinity, pH, silicon, nitrates and conductivity between Skadar Lake and water among Nuphar and Phragmites, May 15, 1976.

Sl. 7. Razlike u alkalinitetu, pH, silicijumu, nitratu i konduktivitetu vode Skadarskog jezera i vode u zoni Nuphara i Phragmitesa, 15. maja 1976.

Toxic substances could have a direct effect on the fish and other aquatic organisms. A major threat would be the long-term subtle effects of toxic material which could restrict the growth of the macrophytes.

Other changes, which would not be pollution but which could have a disastrous effect in the ecosystem, are those which would affect the yearly fluctuations in water level. It appears that the very productive fishery must be in large part due to the annual flooding of the terrestrial environment and the extensive growth of aquatic macrophytes. Water diversion which would greatly reduce flooding and the extent of macrophyte growth could have very adverse effects on the fishery as well as other aquatic life and aquatic birds.

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Alfred M. BEETON

UTICAJ ZAGAĐENJA NA TROFIJU JEZERA

Rezime

Stalno priticanje hranljivih i toksičnih materija u malim količinama može imati delikatan i dugoročan efekat na produktivnost i trofičnost jednog jezera. Istraživanja Skadarskog jezera, koja su u toku, treba da omoguće procjenu posljedica zagađivanja (polucije) jezera. Da bi se predočile posljedice zagađivanja, prikazano je jezero Iri, kao jedno od već zagađenih.

Učinjeno je više pokušaja klasifikacije jezera prema zagađenosti, no ni jedna nije potpuna. Prosta klasifikacija označava jezera kao: oligotrofna, mezotrofna i eutrofna, gradirajući ih od siromašnih do bogatih hranljivim materijama. Oligotrofna jezera mogu da evoluiraju i postanu eutrofna (slika 1), prema promjenama u fertilitetu jezerskog sliva. Takođe, eutrofikacija može da se ubrza i ljudskom djelatnošću. Povećanje hranljivih materija je u vezi sa opadanjem rastvorenog kiseonika, smanjenjem prozirnosti vode, kao i promjenama u brojnosti alga, makrofita, bentosa, zoplanktona i riba.

Jezero Iri, po veličini jedanaesto u svijetu, za posljednjih pedeset godina podleglo je ubrzanoj eutrofikaciji. Zasićenost važnijim jonima se povećala (slika 2). Ova je pojava posljedica povećanja broja stanovnika od 3 miliona na 12 miliona od 1900. do 1970. godine. Ranije je rastvoreni kiseonik bio do stepena zasićenosti; od 1959, u ljetnjem periodu, niske koncentracije kiseonika u vodi pri dnu redovna su pojava. Od 1920. vidljiviji su, i po intenzitetu i po trajanju, indikatori porasta alga. Povećano je učešće zelenih i plavozelenih alga, uporedo sa eutrofičnim formama dijatoma. Važne promjene su se desile u sastavu organizama i brojnosti vrsta bentosa (slika 3). Kretanje ulova ribe pokazuje porazan uticaj promjena sredine na populacije riba (slika 4).

Skadarsko jezero je najveće jezero na Balkanskom poluostrvu. Leži u karstnoj oblasti i u njega se uliva nekoliko rijeka, od kojih je najvažnija Morača. Hrani ga vodom i više podjezerskih izvora (oka). Primjenjujući uobičajeni kriterijum, jezero bi trebalo da bude klasificirano kao mezotrofno. Providnost je mala, totalna koncentracija fosfora varira između 6 i 74 μg/l, a niske vrijednosti su u pelagijalnom dijelu jezera. Koncentracija rastvorenog kiseonika je obično blizu zasićenosti.

Komercijalni ulov riba od 1 000 metarskih tona pokazuje da je osnovna produktivnost jezera veća nego što je svojstveno mezotrofnim jezerima. Problem je u tome što su kriterijumi za klasifikaciju trofičnosti pogodni za jezera u kojima su fitoplanktoni primarna produkcija. Takva klasifikaciona shema možda nije pogodna za jezera, kakvo je Skadarsko, u kojima je produkcija vodenih makrofita ekstenzivna.

Izgleda da Morača determiniše kvalitet jezerske vode u toku onog dijela godine kada nema vodenih makrofita, što pokazuje velika sličnost hemijskog sadržaja vode rijeke i jezera. U periodu rašćenja makrofita znatan je njihov uticaj na kvalitet jezerske vode.

Uticaj makrofita na kvalitet vode iskazao se u rezultatima nekoliko eksperimenata sa makrofitama u plastičnim kesama sa jezerskom vodom, koje su bile izložene sunčevoj svjetlosti. Specifični konduktivitet i alkalinitet su opali, dok su se pH i rastvoreni kiseonik povećali (tabela 1, slika 5). U kesama koje su bile zamračene desile su se manje promjene u ovim hemijskim karakteristikama. Ove promjene, posmatrane u prirodnim uslovima jezera, u vezi su sa fotosintezom.

Uzorci uzeti 14. maja 1976. godine pokazuju da su se konduktivitet, silicijum, nitrat i alkalinitet progresivno smanjivali od sredine rijeke prema gustim kolonijama trske. U malom porastu bio je pH (slika 6). Uzorci uzeti 15. maja 1976. pokazuju da su se konduktivitet, silicijum i alkalinitet povećavali, a nitrat i pH progresivno opadali od pelagijala prema vrlo gustom rastinju *Phragmites* i *Nuphar* (slika 7). Rezultati dobijeni 14. maja su uslovljeni aktivnom fotosintezom, jer su lokvanji ograničavali prodiranje svjetlosti. Opadanje silicijuma i nitrata je vjerovatno posljedica uzimanja njihovih većih količina od strane perifitnih dijatoma na makrofitama. Uslovi smanjivanja vjerovatno su bili naročito izraženi ispod lokvanja 15. maja, jer je za fotosintetičku aktivnost prodiralo malo svjetlosti.

Zagađivanje Skadarskog jezera organskim materijama moglo bi da dovede do njegove eutrofikacije. Početni znaci ne mogu se otkriti na osnovu uobičajenih kriterijuma, jer vodene makrofite mogu uzeti više hranljivih materija, što može imati uticaja na kvalitet vode. Stalno priticanje hranljivih materija dovelo bi do porasta alga, a time i do smanjenja prozirnosti vode. Umanjena prozirnost vode ograničila bi svjetlost potrebnu podvodnim makrofitama. Povećana potrošnja kiseonika, kao posljedica raspadanja algi i makrofita, imala bi uticaja na populaciju riba i bentosa.