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Global Model for Nutrient Flux and Biomass Production in the Albufera of Valencia, Spain

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The Albufera of Valencia is an hypertrophic lagoon of 26 km² surface and mean depth 1.1 m. It constitutes the center of a Natural Park composed by this lagoon and the surrounding marsh land, dedicated almost completely to rice fields. Miracle et al (1986, 1988) emphasize the heavy eutrophication impact suffered by this lagoon in recent years. The present paper gives the global model of functioning of the Albufera in respect to the total nutrient input and the consequent biomass production which will be discharged in part to the sea, but in another and more important part to its own sediments. This study compiles results of seasonal measurements made in the 36 most important inflowing channels, the three outflowing channels and inside the Albufera during the year 1988. Parameters measured were the rate of inflow or outflow in the channels, and nutrient and chlorophyll contents in all sampling points (phytoplankton cells were also counted and identified). Primary production was also evaluated by ^{14}C experiments.

Results and discussion

The annual inputs of nutrients in Albufera of Valencia are extremely high (table 1). The inflow of sewage water registered in table 1 was calculated measuring the P concentration in the sewage discharge at their exit from the surrounding villages and estimating the proportion of sewage in the mouth of the channels from their P content. The concentration of nutrients in Albufera water is very low, as well as the inorganic nutrient output. Inorganic N and P outputs are respectively 10 and 50 times less than their corresponding inputs. The entrance of particulate P is mainly due to organic matter, while the outflow is mainly constituted by phytoplankton biomass.

Table 1. Albufera of Valencia. Global nutrient flux and pollution.

	N-ammonia	N-nitrate+nitrite	N-org	O - P	P - P	Sewage	
INFLOW CHANNELS							
T/y	1907.9	2076.9	4335.1	371.8	619.3	Hm^3 /y	78.6
$g/m^2.y$	74.3	80.8	168.7	14.5	24.1	$m^3/m^2.y$	3.1
						28 % total water inflow	
OUTFLOW CHANNELS							
T/y	178.8	191.8	1470.0	8.7	210.0		
$g/m^2.y$	7.0	7.5	57.2	0.3	8.2		

Figure 1 shows the functioning of Albufera of Valencia based on a phosphorous balance. Phosphorous enters in the Albufera in soluble inorganic form or as particles of organic matter with a low proportion of algal cells, and it goes out of the Albufera mainly in the form of phytoplankton biomass. Experiments in aquaria using Albufera water and mud, demonstrated that added dissolved phosphorus remains in the water and the rate of deposition in the sediments is extremely low. Nevertheless particulate phosphorus may be deposited in the sediment as not recycled organic matter.
On the other hand, 100 times more biomass goes out of the system than enters in it. This is because the lagoon acts as a continuous culture; primary production in the lagoon was evaluated to be 40,000 Tons of C/year. In the lake it is produced five times more biomass than it is outflowed. It is assumed that phosphorous used in primary production comes in equal parts from the external input and from the recycling of the decomposition of previous phytoplanktonic production. From this assumption and considering the relationship P/biomass = 1/500, it is estimated that the phytoplankton uses about half of the total P input (which was around 1,000 Tons/year). If soluble inorganic P is maintained in the water, then about 500 Tons of the allochtonous particulate P must have gone that year to the sediment altogether with 300 Tons of the particulate P of the 150,000 Tons of autochthonous not recycled primary production. Summarizing, half of the primary production is recycled and reincorporated again to enhance new production, while the other half is exported: 20 % to the sea and 30 % to the sediment. Primary production is low when compared with P input and the standing stock of algal biomass in the lake. The system is limited by light and production is around 2 g C/m³.h (corresponding to 4 mg C/mg chlorophyll) restricted to a thin surface layer, being negligible in the rest of the water profile. Thus, daily primary production is around 4 g C/m².

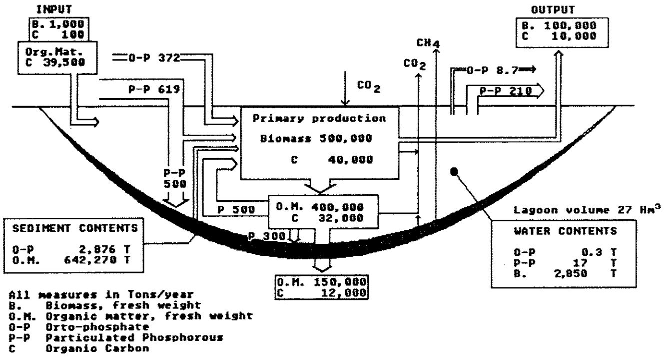

Figure 1. Functioning model of the Albufera.
Double lined arrows and numbers correspond to the estimated values of P circulation; single lines to C not quantified circulations.

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Nutrient Balance and Biomass/Productivity Interrelations in the Coastal Lagoon Lake Burullus, Egypt

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The Nile delta lakes are proximate reservoirs for the Nile water flowing to the Mediterranean. Taking Lake Burullus as a model, in this study we tried to estimate the amount of nutrient input to the water system and analyze their probable impact on lake productivity.

Lake Burullus is located between the Nile River branches, connected to the Mediterranean through Bz. El-Burullus. The lake area is 420 Km^2 of which 370 Km^2 are open water; the average depth is 1.25 m. The lake receives $3.6x10^6 m^3$ of fresh and brackish water/y of which $2.2x10^9 m^3/y$ is discharged to the Mediterranean. The islands divide the lake into four zones of different ecological conditions.

Water samples were collected during February 1987 - March 1988 from different zones and drains for determination of nitrogen, phosphorus and chlorophyll a (Strickland&Parsons, 1972) as well as primary productivity (Steeman-Nielsen, 1952).

Lake Burullus is considered a mesotrophic lake (average chlorophyll a 6.6 mg/m^3) specially when compared with Lake Manzalah (average 21 mg/m^3) (Hamza, 1985). The area receiving >80% of drain water reaching the lake recorded the maximum chlorophyll a average (10.8±14.1 mg/m^3). The same zone attained the maximum average productivity (0.23 g C/m^2. d) and contributes to about 1/3 the annual phytoplankton production of the lake i.e. 102,024 tons C/y.

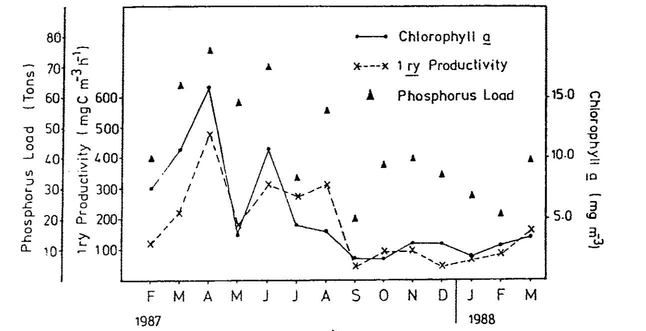

Figure 1 Biomass and productivity response to phosphorus load in Lake Burullus.

The question "what limits the lake productivity" is interesting to speculate. The fact that the lake don't receive any sewage disposal from heavily urban areas limits the phosphorus input to agricultural activities through the use of fertilizers. Mean-while, the dominant phytoplankton group inhabiting the lake are capable for nitrogen atmospheric fixation.

Table 1. Balance sheet for phosphorus and nitrogen in Lake Burullus.

ELEMENT	TOTAL* INFLOW (Tons/y)	OUTFLOW (Tons/y)	TOTAL GAIN (Tons/y)	DISSOLVED IN LAKE WATER (Tons/y)	SEDIMENTED OR UPTAKE (Tons/y)	PHYTO-** PLANKTON UPTAKE (Tons/y)	SEDIMEN-TED (Tons/y)
P	558	94	464	23.6	228	30	198
N	2318	291	2027	1416	611	238	373

* Rain water contributes 10 Kg P/y and 36 Kg N/y.
** Abdel-Moati (unpublished data).

Table 1 shows the dynamical balance of nitrogen and phosphorus in Lake Burullus. The wind driven circulation in the lake is set in a condition that the bulk nutrient derived to the lake flows northeast to the outlet. About 60% of inflowing water carrying 94 and 291 tons of N and P/y are conveyed to the Mediterranean i.e. 17% and 12% of N & P discharged, respectively. Only 42 and 61% of the total inflowing load of N and P are distributed throughout the water column. The annual phytoplankton consumption of N and P (in situ experiments) was 30 and 238 tons, hence sedimented P and N account for 35 and 16% of inflow. The increase of the lake water level over pumped drain water leads to sedimentation of nutrient bearing particles at discharge sites a process which controls the amount of phosphorus reaching the lake and prevent the lake from reaching its optimum production capacity. The short residence time of lake water (about 38 days) prevents the in-lake accumulation of organic derived material and continuously disturbs the lake equilibrium.

Direct relations not only occur between nutrient loading and lake-nutrient concentrations but also with the biomass and production levels. Figure 1 showed that biomass and production correspond to variations in phosphorus load in Lake Burullus.

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