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AN ENVIRONMENTAL EVALUATION

OF UA PLATA TAKE, TOA ALTA

THIRD QUARTERLY REPORT

(APRIL-JUNE, 1982)

CENTER FOR ENERGY AND ENVIRONMENT RESEARCH

MARINE ECOLOGY DIVISION

COLLEGE STATION

MAYAGUE?, PUERTO RICO

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?T RESEARCH

---Page Break---

TABLE OF CONTENTS

---Page Break---

INTRODUCTION

La Plata Lake is one of the most important water reservoirs of the island of Puerto Rico, It supplies the domestic and Industeist water requirements of the municipalities of Bayancn, toa Alta, Toa Baja, Naranjito, Comerio, Dorado, Cataiio and sone sections of the metropolitan area of San Juan, the lake is also

4 very attractive resource for recreational activities such a

camping, boating, fishing, swimming and other:

The Lake, which was formed largely as an impoundment of La Plata River, developed acute water quality problems shortly after the end of its construction in 1976, In a study conducted in 1977, Carvajal (1979) indicated that oxygen depletion below 4-5 m, eutrophication, bacteriological concentrations above acceptable standards, choking of the lake surface by water

hyacinths and the pr:

nce of infective stages of schi:

snsoni were the major water quality problems affecting La Plata

Lake. Martinez (1979) also concluded that the trophic state condition of La Plata Lake was eutrophic.

?The management of artificial lakes for water production and other recreational activities requires understanding of the basic unit and the hydrographic characteristics of the basin and ite relationship with the local climatological pattern. The steategies for management and water quality regulations have been generally extrapolated from studies related to temperate region systems. However, there are significant differences in the natural pattern of water quality between the tropical Puerto Rican lakes and the lakes from temperate regions. The dynamics

of temporal variability constitutes one of the central

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@itferences among temperate and tropical regimes. Temperate systems are generally monomictic or dimictic (having one or two periods of free circulation), where the Large, seasonally-celated temperature variations result in convective mixing of the watec column. On the other hand, tropical Lakes are often considered oligomictic, cacely (or very slowly) mixed or polymictic, frequently mixed, Mixing or the actual turnover of the lake may depend on the magnitude of tributary river discharge and the occurrence of storms, This concept was clearly documented by Quinones-Macquez (1980) at Loiza Lake.

?The present investigation is conceived under EPA Clean Lakes

Program (PRL 1388-4) as a diagnostic-restoration/feasibility study of La Plata Lake. The principal objectives of the study aces

(1) To provide a basic characterization of the water

quality of La Plata Lake as an input-output syste:

(2) 70 identity among measured inputs those potentially important in water quality degradation.

(3) To study the natural patterns of spatial and temporal variability of important lake quality features.

(4) To develop recommendations needed for the

restoration of the water quality of La Plata Lake.

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?APPROACH,

In order to achieve the above mentioned objectives the following sampling scheme has been designed:

(1) Establish a routine sampling of selected water quality measurements at the three main tributaries to La Plata Lake (La Plata River:W-1; Guadiana River:W-2; and Cafas River:W-3) and at one station in the lake proper (L-1).

(2) Design special investigations needed to understand the effect that unusual climatological events have upon the condition of the lake water quality.

(3) Perform oversampling of selected water quality parameters in order to understand the level of uncertainty

inherent to sampling and analytical variability.

METHODS:

No detailed presentation of methods is made in this report.

?The reader is referred to the proposal and quality assurance documents for that information.

The location of sampling stations at the lake and major

tributaries is pri

ated in Figure 1,

RESULTS

?The results from water samples and field measurements taken

during the third quarter of the study (April-June, 1982) are

included in Tables I thru XLVII along with a preliminary analysis

of the existing data up-to-date.

---Page Break---

Figure I. tocation of crnpling stations at ta Plata Lake and mayor

tributaries.

Seate 1:41,000

Magnetic worth

---Page Break---

A brief discussion on fish mortalities observed at La Plata during sampling activities has been incorporated as part of this

report.

GEOMORPHIC CHARACTERISTICS OF LA PLATA BASIN

La Plata Lake is located between the municipalities of Toa Alta and Naranjito in the intecior mountainous region of the northeastern section of Puerto Rico, The centroid of the lake is at 18°20'N, 66°13 W and is located in the Naranjito quadrangle of the U.S.C.8. 7.5 topographic maps of Puerto Rico, The surface elevation of the Lake is at 47 m above MSL, maximum elevation of the surcounding watershed is at approximately 980 (Picé, 1975).

The lake has maximum extensions of 0.5 km width and 9.6 km

Length, covering a surface area of 3.07 km?, The La Plata River

watershed (see Pigure II) represents approximately 908 of the

total drainage area. The drainage basins of Guadiana and Canas

River account for approximately 6.2 and 3.5 percent of the total

drainage a1

1 cespectively.

?The topographic relief of the basin is characterized by

moderately to very steep slopes, with well-drained soils on side

slopes and rounded hilltops of strongly dissected uplands

(Boccheciamp, 1978). The soils are formed in residuum from basic

voleanic rocks.

The climate of the region is described as humid in

Thornthwaite's climatic index applied to Puerto Rico (Giusti and

Lopez, 1967). Mean annual rainfall is approximately 190 cms

(Climate of Puerto Rico and U.S. Virgin Islands: Isopleths of

---Page Break---

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mean annual precipitation), Historically, the distribution of rainfall over the year in Puerto Rico does not show an absolute wet season-ary season relationship, but only a relatively wet and relatively dry season (Calvesbert, 1961). The distinction between the two seasons is less marked in the northern section af the island but, in general, the dry season normally begins in February and ends in April (Calvesbert, 1961), Ambient temperatures (based on data for the period between 1931 and 1952) fluctuate between a maximun mean of 31.1°C in July to a minimum mean of 167°C in January (Climate of Puerto Rico and U.S. Virgin

Islands: Isopleths of mean maximum and minimum temperatures).

MORPHOMETRY AND HYDROLOGY

La Plata Lake hi

a volume of 3.085 X 107m} and a mean depen of 10m, A bathymetric map of the lake is shown in Figure 122, The lake is relatively long and narrow (L:®=19.1) and hae « relatively low surface to volume relationship (relative depth is

04), The depth distcibution of volume is roughly conical. as

shown in Figure IV, approxi

tely 64% of the total volume is

found in the 0-8 m depth interval. Table I reviews som

morphometric and geographical characteristics of La Plata Lake

Mean monthly precipitation in the basin ranged between 32.70

ema in December, 1981 and 3.25 ems in March, 1982, averaging

12.54 cms/month (see Table II). The runofE coefficient (9/P)

determined as the average of three gauging stations in La Plate

basin is 0.50 (data taken from Giusti and Gomez, 1967).

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eMg0TX ?TOA ?TOA x " ?

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TABLE 1. Review of Geographical and Morphometric

Characteristics of La Plata Lake.

Latitude: 10°20'N

Longitude: 6e138

?otal Length: 9.6 km

Max. width: 0.5 km

Surface Elevation

above MSL: an

Max. Elevation

of watershed: 980

ieee, meee 4.50 x 10 a?

volune: 3.088 x 107

Surface Area: 3.07 x 108 9?

Mean Depth: tom

Relative Depth: 0.08

Maximum Depth: 330m

yor Tributaries Dealnage Ares

La Plata River 4.050 x 108 a?

Guadiana River 2.835 x 107 a?

cafas River 3.575 x 107 n?

0

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The net discharge by tributary rivers (considering

consumption of water by PRASA) for the period between October,

1981 and April, 1982 was 1.677 x 108m} which equals 2.4 x

107m3/month, The theoretical ceplacement time was 23 days.

Table IT{ describes the monthly fluctuations of discharge by

tcibutary rivers of La Plata Lake during the study period to

dat

During 1981 La Plata Lake averaged a daily supply of

drinking water of 42 million gallons (Ing. Joglor-PRASA, personal

communication).

LIMNOLOGICAL CHARACTERIZATION OF LA PLATA LAKE AND

MAJOR TRIBUTARIES - THIRD QUARTER 1962

Water Temperature

Watec temperature profiles at La Plata Lake (Table Iv)

er

nted a gradual decline with depth during the months of April and May, 1982, The month of June, 1982 evidenced the establishment of a thermocline between the depths of 3-4 m with a Maximum 07 of 2.0°C/m. The presence of a thermocline constitutes evidence of stronger thermal stratification in the water column, Monthly temperature profiles (Pigure v) are Suggestive of a seasonally related trend toward increased thermal stratification in the summer. The average rate of temperature decline with depth during the third quarter of the study (April-June, 1982) was of 0.19°C/m.

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Table 411, Not Monthly Discharge of Tributary Rivers to ta Plata Lake during the period between October 1961 and April 19620

ba Plata SGuaa ana Caras,

River River ver otal

ont ° 0 ? ?

october 3.561 x 107 2.414 x 108 1.658 x 10° 3,019 x 107

Novenber 1.974 x 107 1.230 x 108 8.744 x 104 2.006 x 107

Decenbor 6.633 x 107 4.571 x 10% 3.091 x 10° 7,121 x 107

January 9.041 x 10 6.221 x 10% 4.251 x 04 9.706 x 10%

February 9.276 x 108 5.887 x 105 4.256 x 104 9.879 x 108

march 6.567 x 10% 2.061 x 108 3.074 x 104 6,993 x 108

april 4.089 x 107 6.809 x 10% 6.250 x 10% 1,163 x 107

otal 1.564 x 10%? 1,046 x 107m? 7.406 x 10% 1,677 x 1080?

Monthly

Mean 2.235 x 107m 1.494 x 10%? 4.058 x 10° 2.395 x 107m?

Note: Net Discharge was Calculated as:

Not Discharge Drainage , Monthly Runoff _____PRASA monthly water

area ?precipitaticn Coefficient consumption at Naranjito

ana

13

---Page Break---

J Water Temperature vs. Doj:th at Lake Station tel

Depth

Surface

1

2 26.1 26.4 28.1

3 26.1 28.0

5 26.0 24.9

6 25.8 243

7 25.3 24.0

e 28.6 23.8

° aay 23.7

10 22.8 23.65

n 23.7 23.6

2 as 23.6

» a4 23.6

? aa 23.55

8 23.3 23.55

16 23.2 23.55

? 22.2 23.55

8 23.2 23.55

1° aa.2 23.55

20 23.2 23.55

?TABLE v.__Water Temperature at Tributary Stations.

SANLING DATES,

Stations (6-02 56-62 6-3-82

wt 25.2 24.9 a4

we 26.7 24.5 30.2

23.5 28.7

4

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Figur ¥, Representative Yeo Les of Water teaperat un at.

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Depth 7

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Teilatacy rivers (Table v) averaged 25.7°C at ua Plata Miver, 2°.1°C at Guadiana River and 25.6°C at Canas River during the thir quarter of the study.

Chinograde oxygen profiles were maintained at the Lake Station 1-1 during the peciod between April and June, 1982. A Strong chemocline fluctuated between 2-5 m (see Table vi). Oxygen depletion with zero vaiues in the hypolianion has been Shown to be a recurcent Lake feature in the La Plata Lake, see Figure VI. The steucture of 0, distribution in La Plata Lake is @ictated by complex physical, hydrodynamic and biochemical factors, The major features ace probably: lake morphometry, nuteient loading and biological response, chemical and biological oxygen demand, tributary flow and the tropical setting.

The lake has a relatively low surface to volume relationship (relative depth is .04) and its location protected by high mills tends to prevent wind mixing and reaeration. Loading of the Lake by Nand P via rain-runofE is high and sustains relatively high internal primacy productivity. phytoplankton respond with densities so high in the eustace that Light penetcation is Festricted (compensation depth is only 3-4 m even in open water areas), Water hyacinth crops ace high and cover approximately 40-508 of the total surface areas of the Lake. where present, they virtually screen out all the Light. Organic materials

@ischarged to the lake in rain events and sedimenting

Phytoplankton and dead particles of hyacinths support the growth

Of microbes which consume available oxygen in the layers of the

16

---Page Break---

TABLE VI. _pissolved oxygen vs. Oupth at _Lake Station jer -

SAMPLING DATES

Depth	46-82	56-02	oe
He	mg		
Surface	42	2.75	64
1	28	24	64
2	2.8	1	6.25
3	0.6	ae	5.8
?	©	na	oa
5	°	1	0.2
6	°	°	ont
7	°	°	0.08

8 ° ° °

° o ° °

0 ° ° °

? ° ° °

12 ° ° °

3 ° ° °

4 ° ° °

1s ° ° °

6 ° ° °

? ° ° °

18 ° ° °

9 ° ° °

TABLE VIE. Dissolved Onygen at tributary stations.

SAMPLING ATES

Stations 46-02 s-6-82 e382

i et yt

et 7.04 79 6.46

wa 11.0 8.03

m3 9.25 8.05,

Wv

---Page Break---

Pigure VI. pissotves oxygen Profiles at Station I-1 in La Plata

Lake (October 1981 through June 1982)

oof

:

of!

ae 5

pip 0 2 ap

Bp o 2 4

© x-7-81,

oxt-10-81

oxrt-15-82

o 1-12-62 111-3-82

© vr-3-82

1

---Page Break---

lake below 4-6 m and render it anaerobic and reducing. such

reducing conditions, in general, are unfavorable for the growth

of phytopiankton and other aerobic sife. Thus photosynthetic

oxygen renewal does not occur either.

The Large seasonal reduction in temperature, which in more temperate areas result in convective mixing of the water column, do not occur here and the higher and less variable temperature regime keeps metabolism high while preventing physical Feaeration. The most important input of dissolved oxygen into the Lake probably occurs via tributary discharge, where 02 concentrations are consistently high in relation to concentrations at LI. The distribution of dissolved oxygen in the Lake reflects higher concentrations in a gradient toward La Plata River and at the surface of the water column (see Figure VII).

The average dissolved oxygen concentrations at tributary rivers during the third quarter (April-June, 1982) were 7.1 mg/1 at La Plata, 9.1 mg/1 at Guadiana and 8.3 mg/l at Cafas River (see Table vir).

BH

Profiles of pH measured at station L-I during the third quarter of the study are presented in Table VIII. pil values were generaliy higher in the upper strata and gradually declined with depth (range 6.9-6.4). The photosynthetic removal of CO, in the photic layers of the water column are postulated to be involved in the maximum values observed, However, tributary rivers also Presented higher pil values than the lake (means of 7.8 at La

Plata, @.3 at Guadiana and 6.4 at Caflas River) allowing the

---Page Break---

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alternate explanation that those input waters simply dominate the upper layers of the lake. For this Latter explanation to hold, however, requices that the colder input water turbulentiy displaces or mixes with the wacmer surface layers, Table 1x presents pH values at tributary rivers during the period between April and June, 1982.

Conductivity

?The average conductivities of the water column at t-f during the third quarter (April-June, 1982) were of 290 umhos/em in April, 302 umhos/cm in May and 263 umhos/em in June, 1982. Conductivity profiles maintained a consistent decline with depth with maximum fates of change fluctuating between 8-11 meters in

April and May and 4-5 meters in June, 1982 (see Table x).

Tributary rivers presented higher conductivities than the lake during this period (% = 357 umhos/em at La Plata, 311

umhos/em at Guadiana and 309 umhos/em at Cafias River) see Table

xt.

Water Transparency

Secchi disk transparency averaged 1.8 m at L-I during the

third quarter of the study (see Table XII). Monthly fluctuations

in Secchi disk readings at t-1 evidenced a minimum value in

December, 1980 which corresponded to the month of higher precipi-

tation and tributary loading of sediments (see Figure vitr).

After December, 1980, monthly readings showed a gradual increase

until May, 1980, Profiles of Light attenuation indicated that on

the average the 18 Light penetration or "compensation depth" at

InI is found in the 3-4 depth interval (see Table xrrr).

---Page Break---

TABLE vt. pil vs pepth at Lake Station Ler.

Sampling Dates

depen 46-82 56-82 6-302

* units nies unite _

surface 68 6.6 69

1 6.7 oe 68

2 6.6 68

a 6.6 6.6 6.7

4 6.5 66 64

5 6.6 66 6.55

6 6.6 6.6 6.6

7 65 66 6.6

8 65 6.6 6.55

° 6.5 6.6 65

10 6.5 6.6 65

" 6.5 66 65

2 6.5 6.6 6.48

3 65 6.6 6.45

14 6.5 6.5 6.45,

15 6.48 6.5 6.48

6 6.4 6.5 6.48

7 6.4 65 6.48

18 6.4 os 6.45

? 6.4 65 6.45

2 6.4 65 6.45

?TABLE 1X. PH at Tributary Stations

SAMPLING DATES

Stations 4-6-2 56-42 63-82

Unies unite units.

wt 19 a 7.46.

wa 8.0 1

WS 8.2 82

22

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Table MATT. profite of Light Fenctration at La Plate Lake, in Foot/candtes

Depew sonore) 2en5-oy tag ag gee x

° 30 4,200 160 2,000 200 1966

1 60 210 2 1,300 290 376

2 ? 16 as 360 10 01

3 33 oe 7 170 26 a

? 6 2 *% 6 18

5 1 05, 37 56 °

? 02 9 1 ?

7 78 a8 16

2 oy 08 oa

° as 0.3

18 of Total Light Penetzation =19.66 Foot candies

Compensation depth =n

Pigure ViL1. Monthly variation of Secchi Blak Readings at La Plata take.

Mean Secchi Dish Reading = 1.48

---Page Break---

iuctivity vs. Devth at Lake Station 4-1

?SAMPLING DATES

46-62 s-6-82 Gees

umhos /om wihos/em tumor Ze

110-300 346 ae

337 347 ae

340.5 ar a2

335 307 aay

332 387 308

338 307 am

334 oz 201

227 335 248

319 36 238

204 293 232

288 280 229

268 270 226

255 253 22s

204 224

239 281 22

234 236 220

229 232 220

22s 220 220

219 227 220

215 225 29

215 221 ae

TABLE X1. Conductivity at Tributary stations

station

=m

m2

wa

a 8

SANPLING OATES

46-02 s-e-a2 6-362

sunhos/en anos /em unhos es

3a we Ee

325 250 357

354 a7 387

---Page Break---

Total Suspended solids

The mean water coluan concentration of 785 at L-I during the third quacter of the study (April-June, 1982) was 24.9 mg/l. tn general, the vertical profile maintained its consistent increase with depth during this quarter (see rable x1v). ts concentrations at tributary rivers for the third quarter are presented in Table XV. An average profile of 165 vs depth at the

lake station L-r hai

shown significant differences in its vertical distribution (see Figure 1x). Considerable variation has been observed on a monthly basis in water column averages of 88, these variations are associated with high sediment loading to the lake during periods of high rainfall and tributary discharge, Table XVI presents the monthly suspended sediment loading by tributary rivers to La Plata Lake, The monthly loading rate has been calculated as 2.001 x 106 kg/lake/month.

La Plata River contributed 98.58 of the total sediment load to

the lake.

Total Dissolved solids

TDS averaged 319 mg/l in the water column at L-I during the

third quarter of the study (April-June, 1982), Monthiy means

ranged between a minimum of 175 mg/l in June and a maximum of 587

g/l in May, 1982 (see Table XVII}. AS previously noted there

Was no significant relationship between the concentration of 7S

and the specific conductance of the water at La Plata Lake. the

relationship between specific conductance to TDS will vary

depending on the distribution of the major chemical species

Present (Water Quality Criteria, 1973).

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WARLE XBE.__Sevch) Dig Readings at Jx1 and Trivutury Stations

SAWPLING ATES

stations 6-82 5-6-8 eis

om ? =

?et 2.0 2.0 as

wt 0.75 8 0.8

wa 1908 (3m) sow (am) ie)

3 ros ($m) sou (Sm i)

sasuE x

Total

suspended Solids vs. Depth at Lake Station t-1.

?SRIWLING DATES

Depth 41-82 6-382

» o/h east

° 7.0 47

4 5. a0

8 9.2 17.0

2 15. 3.0

6 13.5 54.0

2 52.0 51.0

TABLE XV. Total Suspended Solids at Tributary Stations. _

SAUPLING OATES

stations sen e382

tt

wr Me na 16.2

we 2.4 n2.0 aa

ws a4 si2.0 na

---Page Break---

Pigure 1x, . Moan and Standard error of Total Suspended Solids at

Station te1 (October 1981 ~ dune 1382)

se 08 0 BEL ppm ps0

7

8

l ?

Table xvi. Suspended Sedinent Loading from tributary Rivers to

?~ ag Plata take (Octaber 1981-= Apri} 1983).

ont ta Plata Guadiana cahas ?otal

e/a fms ey

october 2.949 x 108 242 x 10% 5.001 x 108 4st x 108

Novenber e114 x 109.337 x 107 ates x 10% 8.338 x 10?

Decemer 4.875 x 107 2.925 x 107 2,349 x 10% 4.906 x 10

anaasy 4.611 x 107 7.465 x 108 2,342 x 10% 4.920 x 107

February 2.786 x10 4.129 x WS 6.810 x To 2.778 x 108

March 5.976 x 107 Gre x oS 4,535 x 10% 6.053 x 107

ports 1.509 x 108 G00 x 106 5.250 x 11.658 x 108

Totat t.30rx 1092 tar7 x 10% 4.169 x 107 sao x 10

Monthy Mean = 2.091 x 10? gx/a?/me

2.001 10° kg/mm.

---Page Break---

?Tributary rivers averaged 162 mg/l at La Plata, 148 mg/1 at

Guadiana and 167 mg/1 at Cafas during this quarter of the study

(see Table xvIII).

Total Alkalinity

Monthly means of total alkalinity measurements ranged

between 96.2 mg/l as Caco, in June and 151 mg/l as Caco in

May, 1982. The profile of total alkalinity at the Lake station

L-I presented higher alkalinities in the upper strata where

aerobic conditions prevail and pH values are higher (see Table

XIX), Lower alkalinities result below the oxygen chemocline.

Teibutary rivers averaged 140 mg/1 as Cacos at La Plata, 112

g/l as $CaCO_3$ at Guadiana and 104 mg/l as Caos at Calas during

the third quarter of the study (April-June, 1982) see Table xx.

NUTRIENTS OF BIOLOGICAL INTEREST

Ammonia Nitrogen (Ny-N)

Water column average concentrations of NHj-N ranged between

0.12 mg/i in Apeil and 0.27 mg/l in May, 1962. The profile of

NHy-N maintained a pattern of increase with depth during the

third quarter of the study (April-June, 1982) see Table xr.

Ammonia nitrogen is generated by heterotrophic bacteria as the

primary end product of decomposition of organic matter, either

directly from proteins or from other nitrogenous compounds

(Wetzel, 1975). High concentrations of Wi3-N in the hypolimnion y be the result of accumulation under anoxic conditions in the

bottom strata of the lake (see Pigure x), Under aerobic

conditions in the trophogenic zone NHj-N is assimilated and

metabolized by photosynthetic algae and floating macrophytes.

---Page Break---

TABLE WIZ. Total Dissolved Solids ve. Depth at Lake Station LZ. _

SAMPLING Dames

Depth fe1-82 sove2 6-302

? nat g/t __na/?.

° 216 os 342

4 zor on 155

8 169 598 360

2 187 563 198

16 202 ost 5

20 va 543 208

a

TABLE XVITE, Total pisolved Solide at Tributary Stations.

SAMPLING DATES

Stations 56-62 3-82

mast g/t

wer 243 so ase

we 226 9 198

ws 240 28 223

TABLE 2X. poral Alkalinity ve. Depth at Lake Station Int.

SAMPLING DATES

Depth ae 56-82 eos-82

? g/t as CacO3 g/t as CaCOy ng/ has Cay

7 Tae TT

? 128 aoa 7

s 128 ro 96

2 107 ros. e4

16 86 93 a

20 80 ea cs

29

---Page Break---

TABLE yy. Total Alkalinity at Tributary stations.

ERE A dey ot Tes babary Stationgs

SAMPLING DATES

Stations 2 5-6-2 6-3-82

mg/f as caco; g/t as Caco; g/t as Caco,

188 147.5 ne

120 92.5 123

2 68.5 27.5,

ZABLE 44._Anmonig-Nitrogen vs. Depth at Lake Station Lt.

SAMPLING DATES

bepen 41-02 56-82 6-3-82

au ng/k mg/h g/t

° 201 ° sot

4 202 ° on

8 208 ° 08

2 209 235 39

16 ? 156 48

20 48 n 45

ee SSSSSSFSFSSSSSSSSe

TABLE OAT, _Anmonia-Nitrogen_at tributary stations

SAMPLING DATES

Station 4-1-02 5-6-a2 63-82

ng/h _na/i nase ?

we -04 2 203

we 025 ons, oz

wea -025 08 02

30

---Page Break---

?Tributary rivers averaged 0.06 mg/i at La Plat, 0,02 mg/1.

at Guadiana and 0.08 mg/1 at Cahas during the third quarter of the study (see Table xxII).

Nitrite - Nitrate (NO,-NO, as N)

Nitrite-nitrate concentrations ranged between 0.01 mg/l in May and 0.05 mg/l in June, 1982 during the third quarter at L-I (see Table XXIII). The average profile of nitrite-nitrate concentrations reflects a weak dichotomic distribution with a Maximum average concentration at 12 meters (see Figure XI). In very productive lakes where clinograde 0, profiles prevail a Gichotomic distribution of NOs-NO, concentrations may result when nitrate is removed by assimilation in the trophogenic layer and reduced under anoxic conditions near the bottom of the water column (Hutchinson, 1957).

Tributary rivers evidenced substantially higher concentrations of NOj-NO, during the third quarter of the study with means of 0.79 mg/l at La Plata, 1.55 mg/l at Guadiana and 1.02 mg/l at Cahas River (see Table XxIV).

Total Kjeldahl Nitrogen

?The water column average of TKN for the quarter (April-June, 1982) was 0.65 mg/l (range .52-.73 mg/l) at L-I (see Table xxv).

TKN concentrations were higher in the deeper portions of the water column (see Figure XII), These higher concentrations near the bottom are possibly associated with the sedimentation and accumulation of organic compounds there. Tributary rivers,

specifically La Plata River, presented lower concentrations of

---Page Break---

TABLE UII, _Nitrite-Mitrate vs. Depth at Lake Station u-t.

SAMPLING OATES

Depth a-1-02 56-02 6-3-8

* ng/ ib g/t g/t _

° 208 ° 0

4 201 ° 02

° < .001 ° 23

2 < .001 or 01

16 < .001 201 °

20 101 202 00

TABLE uv, Nitrite-Nitrate at Tributary Stations

SAMPLING DATES

Station 41-92 5-6- 6-32-02

g/t na/t g/t

wer -66 +70 aon

#2 v.72 1.30 1.68

wea 8 venz aaz

TABLE AAV. Total Kjeldahl witrogen ve. Depth at Lake Station Lor.

SAMPLING DATES

Depth s-6- e-3-02

a - s/t gt

° a 8

4 a 40 56

° 158 40 8

2 as on 2

16 87 1.08 93

20 12 4.23 286

32

---Page Break---

Figure X.

Mean and Standard Exe of Amnonia-Nitrogen Concentrations

?vs. Depth (October 181 = June 1982).

Amonia =H (ag/2)

Poof 6 8 0 2 te ye ye

?

Depth

8

va

20

Figure x2, Mean and Standard Error of Nitrite-titrate Concentrations

ve. Depth at La Plata Lake (October 1981 June. 1982)

Nitrite ~ witeate (99/2)

Poe je 1,0 12 ne

°

bepth

?e)

®

20

33

---Page Break---

TKN than those measured at the lake (see Table XXxVI), implying

that the lake is internally cecycling nitrogen or fixing

atmospheric sources.

?The average monthly Loading of nitrogen into La Plata Lake

has been calculated as 1.56 X 104 kg N/lake/month (see Table

XXVII). La Plata River contributed 95% of the total N loading to

the lake. A seasonality related maximum of N loading was

observed since 858 of the total loading occurred during the first

three months of the study (October-December, 1981) which

corresponded to the period of higher precipitation in the

watershed basin.

Soluble Reactive Phosphorus

?The water column average of SRP concentrations at L-I during the third quarter was 0.07 mg/l (range .04~.095 mg/1), see Table XXVIII, SRP is the most available source of phosphorus for phytoplankton and aquatic vegetation in their metabolic Processes. Lower concentrations of SRP above the chemocline (4m) suggests rapid epilimnetic removal by photosynthetic organisms (see Figure x11). All tributary stations evidenced higher concentrations of SRP during the third quarter indicating their importance in delivering nutrients to the lake (see Table XxIX).

Total Phosphorus

?Total phosphorus concentrations presented a water column average of 0.14 mg/l at L-I during the third quarter of the study (see Table Xxx). This concentration characterizes the lake as hypereutrophic according to BPA 440/5-80~11 document. as

previously established, the main vehicle of phosphorus Loading to

---Page Break---

35

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TABLE SX, Total Kjeldahl witrogen at Tributary stations.

Stations aot-02 5-6-82 6-3-2

nt ms tnt

wet 16 32 a

wee ar 133 32

3 2 1.69 20

TABLE XxVIIZ Soluble Keactive Phosphorus vs. Depth at Lake Station

Lt :

SAMPLING DATES

Depen 41-02 56-02 6-382

ma Bg/t nasi. g/t

° 04 02 03

4 03 .02 03

a 08 205 3

2 10 06 33

16 mn 04 a3

20 209 03 a2

TABLE xx1y___ Soluble Reactive Fhosphorus at Tributary stations.

SAMPLING DATES

Stations 4-102 5-6-22 6-3-82

g/t ng/ ft na/t

wet 8 2.14 22

we? 1 ?7 226

wa 08 4 a

36

---Page Break---

uobOI01N THEPTOAH TROL se pereTHOTES gen obOTsTH TeIeL v9

rx eee OL KEY Jor oe pore sort sreser

° ? ? a are

pr EOE con por x erre see

nt got EL euerpenn

xe joe wets er

20 non 300 saernara

?SaPaWe/a = BS Wy SANT VIET OT OF SIOnTE MHSMGTAL Ta DANNOT WBS TSE TAN TTR

TT

37

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the lake is La Plata River. The average concentration of total

Phosphorus at La Plata River during the third quarter of the

study was 0,28 mg/l (see Table XXxxI), The estimated monthly

average loading of total P to the lake via La Plata River is 6.88

X 10 g P/lake/month, which represents 94% of the total monthly

average loading of phosphorus to the lake (see Table XXXII). The

estimated areal loading of phosphorus based on these figur

28.5 gt P/m2/yr,

The vertical distribution of total phosphorus in the water column at L-I (Pigure XIx) showed no significant differences from top to bottom, On a monthly basis total phosphorus concentrations were higher during the period of high rain (October-December, 1961) in the watershed. During periods of low discharge most of the phosphorus was found ae soluble reactive phosphorus (see Figure xx).

BIOLOGICAL CHARACTERISTICS

Phytoplankton Abundance and Distribution

?The monthly variations of phytoplankton abundance at the lake station L-I are presentd in Figure xXxI. The large Feductions in abundance which resulted after October, 1981 were

related to a marked incre:

in teibutary discharge and rapia turnover cates evidenced during the period from October-December, 1981. After December, the lake experienced less flushing allowing more time Cor phytoplankton growth and reproduction. The vertical distribution of phytoplankton cells in the water column (Pigure XXII) at L-I evidenced substantially higher abundances at the surface and 4 m during the period between

---Page Break---

TABLE xn, _Total Phosphorus ve. Depth at Lake Station wat.

pares

Depen 41-62 5-6-82 63-82

Moe bn soft

° a6 06 a2

4 a9 -07 22

a 223 09 2

2 19 -09 a1

16 22 -07 an

20 235 06 a0

FABLE XXt. Total Phosphorus at Tributary stations.

SAMPLING pares

Stations 4-102 56-02 63-82

7 mest mast o/h

1 38 20 226

2 23 10 a7

- 2 +09 v

39

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pot eS

SRO GG REL GOL KSOTE ONSET OX Oo jor IN joecass

OLX OS" OL X EBS OL K 99"L OL X SOL

Xess cor x 80

x EOE gor PLL Sor x LBs eves

OLE GOL KeW'Z col x tes col KEY co x gore eUeTPERD

Ot EPP GOL KILL OL OBL OL K STL OL x ZS"E OLR GOL OL ROL wRETE eT

a8 ae as ee pea on 30 Arwynasxa

v6 1661

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Figure ?0% Profile of Total Phosphors Plgure yyziz Profile of Solsbio

?Concentrations at ia Plata Lake feactive Phosphorss

(october 1981 = ane 1982) Concentrations: at La en Pita lake (October 1981 =

an ser mast Sone 1982)

a Sy f 185 eg

4 7 3

2 epen

& ?m)

Higu mh. - Gieoarian of the nonehiy Fluctuations of Total Phorporae

fand Soluble Reactive Phosphorus tn ba P

?© Total Phosphorus (1.

© Solubie Reactive

Phosphorus (20,)

a

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oe

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igure %90i. Vertical distribution of plytoplankton abundance at La Plata Lake

Station iT. " .

fH calte/ai «10 # const 0?

2%» 50 w 2%» 4 50

© ccteber 10, 198 © December 15, 1981

© Novonbur 10, 1981 6 fo Sanuary 12, 1982

+ cenis/mt 207

30 0 4 50

© February 1982

march 1982

12

43

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October, 1981 and February, 1982; however, the maximum peak of abundance shifted to the 8 m depth in the month of March, 1982.

?The shift towards a deeper maximum in phytoplankton abundances

was also reflected in chlorephyll-

concentrations measured

during the summer at the lake station L-I (see Table xxXIII).

The variation from previously higher abundances in the surface to deeper maximums of abundance observed during the summer (Figure XXIII) may be related to higher surface temperatures and diminished inorganic turbidity during the summer months.

Tributary rivers evidenced relatively lower concentrations of chlorophyll-a (see Table XXXIV) confirming the indogenous nature of the lake values. The vertical distribution of chi-a is Presented in Figure XXIV. The average surface concentrations of

chi~

measured at La Plata Lake classify this system as eutrophic according to EPA~440/5-79-015 (1973).

chiorophy11-

concentrations are considered as a biological manifestation of nutrients in aquatic systems and applied as a direct index of phytoplankton biomass (Hern, et al., 1981). Monthly fluctuations of Chi-a are present in Figure xxv. water column average concentrations of Chi-a showed a significant Positive correlation (r=0.82) with water column average abundances of phytoplankton cells/ml at La Plata Lake (see Figure XAVI). Biovolume conversions of phytoplankton cell counts will

be used to asses

the validity of using Chi-a concentrations as a

quantitative index of phytoplankton biomass in Puerto Rican lakes.

46

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SAMPLING DATES

Depth a-t-02 5-6-02 6-3-62

a n/n g/m g/_n? _

° tea 10.9 23.2

4 24.7 16.8 34.2

6 6.3 ne 5.7

2 9.4 3.0 5.2

16 as 24 19

20 2.9 8 a3

TAMLE WOMIV. Chlorophyli-a at Tributary stations. __

SAMPLING DATES

Stations 4-1-2 56-82 6-3-8)

mg/m} ng/n? n/m

45

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© Octaber 10, 1981

rs

Decenber 15, 1981

2»

Vertical distribution of eh lorophyLi-

?Station l=

4 march 3, 1982

nam?

a

46

nay 6,

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© Apes 6, 1982

1992

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Figure ON Moan and Standard Error of Chilorophyll-a Concentrations YE. venth.

(October 1981 = sane. 1932),

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Figure "1V. ?onthly Pluctuations in Chlorophy}i-a Concentrations at

ta Plate takes

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Primary Productivity

During 6 April 1982 4 single experiment to estimate primary

productivity was performed near station L-I using the dark-Light

bottle method, The results of this experiment are presented in

Table Xxxv. The net primacy productivity at 1.0 m depth from

bottles incubated in situ for 4 hours was relatively low (315 mg

02 23 dal, Gross productivity, however, was high (

3

3387 mg 02

73 da?lybecause of high respiration rates(

1072 mg 0, mm3da-h),

?The results from this single observation in time at La Plata Lake are consistent with the idea that this system has a low capacity for biological regeneration of dissolved oxygen by photosynthetic organisms in relation to the existing respiration rates.

nd

Biological Oxygen D

?The water column average BOD at station L-I was 1.57 mg/L (range 1.05 - 2.27 mg/l), see Table XxxvI. Tributary rivers (Table XxxvI1) evidenced relatively lower values (1.18 mg/l at La Plata, 1.49 mg/l at Guadiana, and 1.41 mg/l at Cahas River)

sugai

ting that the lake BoD's are autochthonous.

Assuming, on the basis of the above estimates, an average 07

Production in the euphotic zone of the Lake (0-4 m) of 1,260 ag

02 m?3 dav} and zero production below 4m depth the estimated monthly production of 0.0. in the water column would be of approximately 37,800 mg 0) a"? monl, the respiration potential,

calculated as a monthly B00 for the water column was 94,200 mg 07 mo?! (using 10 m as the mean depth). Clearly the respiration

potential exceeds oxygen renewal and is consistent with the

observed 0.0. deficit at the lake station (P/R Rati

40).

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?TABLE XEXY, Single observation in Time of Primary Productivity at La Plata

Lake (pri 6, 1982).

1,0 Meter Depth cnly Station L-r

initial

Light 2

Ligne 2

(Grand Mean Light

(©) ark

Net ».

Respiration

sete 6ott = 6.38 0 08 ag CE a nee

le tela > Sens ?eo mg cd dees

Fores. sensi cha ne

Net. = 22.5 mg 0, a3 bet

Gross = 150. mg OF wD HED

Respiration? 126 mg 02 3? he

Dally Rates (Assumes 14 he Lights 10 he dark)

a

net = 5 m0 acd aal) 8 118 mp Cw

eptration 2 3072 my of wae? TO

Grane Lie eeB. 3887 wp 0, a? aa"? #1270 ap ©? a

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wo

coe oso on

98°0 zoe eet oe en

eee set rot zoe aso z6°0 A

Ea 78 178 Wem 7 at

ea/e/9 e8/9/s ze/i/e zarese eesiise ee/ei/t Noruwes

soveg Surrdues

TSIOTWETE KASGRgTAL VE PRINT USbIND TWOVESTORe TAMIR TE,

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7 178 7 Te 5

zae/9 23/9/s eevee ra/iise zerei/e nuaaa

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Maccophyte Coverage

The dominant macrophyte species present in Lake La Plata is the watee hyacinth, Bichhornia crassipes. Visual estimates suggest that 40-508 of the total lake surface area is impacted by water hyacinths. the criteria in evaluating the area impacted within 2 x Secchi disk depth was not considered in view of the fact thet E crassipes is a floating macrophyte species which invades Lake surface waters and is not limited by light penetration.

Watec hyacinths may induce or enhance dissolved oxygen deficiencies in the water column by limiting light penetration

and inhibiting photosynthesis. they also repre:

nt a recreational

Problem by obstructing navigation and fishing. An illustration of hyacinth cover in La Plata Lake is presented in Figure xxvII.

The fast growth rates and nutrient assimilation by water hyacinths represents a potential tool of nutrient removal in aquatic systems for Puerto Rico, Extensive experimentation in the use of water hyacinth for nutrient removal in sewage treatment ponds was reported by Wolverton and McDonald (1978). The productivity of water hyacinths in Carraizo Lake was calculated by Nevarez and Villami (1981) to be approximately 9.7 gm? dal (dry weight) with an average elemental phosphorus composition of .22% of the dry weight per plant. Assuming such kates apply the observed standing crop of hyacinths at La Plata Lake product 1.19 x 107 g m2 dam1 (dry weight), at .228 P the crop of plants in La Plata would be removing about 2.6 x 104 g of P per day. ?That rate of phosphorus removal corresponds to about

---Page Break---

Figure MWILWater hyacinth coverage at La Plata Lake.

Magnetic North

4

pots represent hyacinth

Scale 1: 28,000

53

---Page Break---

118 of the average Loading to the lake. A comprehensive study of water hyacinths productivity and nutrient assimilation at La Plata Lake is highly recommended in order to examine the potential of water hyacinths as a tool in eutrophication control.

BACTERIOLOGY

Total Coliforms

Table XXXVIIt presents the profiles of total coliform concentrations at L-I which resulted during the third quarter of the study (April-June, 1961). The avecage water column concentration was 490 MPN colonies/100 mls (range 220-957 MeN colonies/100 mls). Standard regulations of water quality (z08, 1973) recommend an upper Limit of 10.000 MPN colonies/100 mis for superficial waters of Puerto Rico.

Tributary civers evidenced relatively higher concentrations of total coliforms than the lake station (see Table XXxIx).

Guadiana River presented concentrations above the standards during the months of May and June, 1982. Caias River presented concentrations above the standards during the month of May, 1962.

Fecal Coliforms

Fecal coliforms averaged 272 MPN colonies/100 mis (range 58-625 MPN colonies/100 mis) at Lr during the third quarter (see Table XL). ?The standard regulation of water quality recommends an upper Limit of 2,000 MPN colonies/100 mis (£03, 1973).

Guadiana River presented concentrations above the standard during the months of May and June, 1982. Cafias River presented concentrations above the standard during the month of May, 1982

(see Table xLI).

---Page Break---

TABLE 1UViTT gota) Coliforms ys. Depth at Lake Station et

SAMPLING oaTES

Depth, % .	41-82 MPN colonies/ml	5-6-02 MPN colonies/ml	6-382 MBM colonies/ml
°	330	700	220
4	130	490	190
8	230	330	490
2	330	*	2200
16	190	?	1300
20	170	1»	400

TABLE KOI, _Total Coliforms at Tributary Stations

Station

wt 260 7,300 1,300

we 4,300 > 24,000, 33,000

wa 2,600 > 24,000, 4,980

35.

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TABLE _XL.___Fucal coliforms vs. Doyth at take Station t-t

?SAMPLING OATES

Depth 41-02 56-02 6-382

s MPN colonies/mi___MPN colontes/ml __MPN colenies/mi_

° 20 110 19

4 » ? «

8 10 490

2 10 2 430

16 120 2 1300

20 170 e 1400

TABLE tz. fecal Coliforms at Tributary Stations _

SAMPLING DATES

Stations ae1e2 s-6-82 6 s82

NPN colonies /at NPN colonios/al____MPN colonies/=

wt 280 1,850 1,500

wee 790 > 24,000, 10,480

wa 625 > 24,000, 1,080

56

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The higher concentrations of total and fecal coliforms

observed at tributary rivers is consistent with our previous

determination that tributary rivers are the most important input

of bacteriological contamination to La Plata Lake.

Fecal streptococcus

Table XLII presents the concentrations of fecal

streptococcus at L-I during the third quarter (April-June, 1982).

Water column averages ranged between 8-23 MPN colonies/100 mis.

Evidence of fecal streptococcus contamination was found on all

sampling dates. Concentrations were higher at tributary stations

(see Table XLIII) with means of 194 MPN colonies/100 mls at La

Plata, 8,113 MPN colonies/100 mls at Guadiana and @,1i4 MPN colonies/100 mls at Cafas River.

HEAVY METALS

The concentrations of Cu, Cd, Pb, an and Hg (in ug 174) at the lake station L-I and tributary rivers are presented in Tables XLIV and XLV, The average concentrations of heavy metals determined during the study peciod to date (Table XLVI) reflect values above the standard for surface waters of Puerto Rico for Hig and zinc,

The origin of ig concentrations found in the water column at L-I is presently considered as a non-point source given the fact that the high concentrations result from all tributary stations sampled, Immediate attention to the occurrence of Hg in La Plata Lake will be performed during the last quarter of the study. Special investigations will include analysis of the lake's sediment and bioaccumulation in the tissues of nektonic organisms

including fishes and crustaceans.

---Page Break---

TABLE uit. Fecal Streptococcus vs. Depth at Lake Station Io

?????????????????EEeeeeee

SAMPLING DATES

Depth a1-e2 56-02 6-302

? MeN colonies/al MPN colonies/=1 YEN colonies/at

° 5 8 °

4 3 3 2

e 5 e 8

ir 2 2 ?o

6 ° 5 3

20 5 2 ?6

TABLE _xu1i1, Fecal streptococous at Tributary stations

SRE eis Strepiovoeevs at Peabutany stations

SAMPLING DATES,

Stations arez 56-02 6-302

MEN colonies/ml MPN colonies/nl MEN colonies el

wm 66 515 1

2 333 > 24,000 5

ws. 330 > 24,000 a

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SYNTHETIC ORGANICS

Pesticide residue analysis of 12 water samples from La Plata Lake (station L-I) and major tributaries (La Plata, Guadiana and Cafias River) failed to present any detectable concentrations (see Table XLVIT). Samples were collected on 1 April 1982 and analyzed on 4 June 1982 by the Agrological Laboratory of puerto Rico, The methodology for these determinations followed EPA procedures and regulations, CEER will conduct analysis of pesticide residues in sediment samples during the last quarter of

the study.

REPORT OP PISH MORTALITIES IN LA PLATA LAKE

May 6, 1982

During 6 May 1962 dead individuals of the *Phreadfin shad?

Dorosona petenense (Gunther) were observed trapped within a dense

hyacinth mat approxi

tely 4.5 km downstream from the bridge

(Road 164) at La Plata Lake, Mortality was estimated to be

approximately one thousand individuals. Most specimens were

fceshly dead, but some were swimming w

kly at the surface and

could be

sly captured by hand. No signs of apparent disease

was observed, i.e., scales and fins were intact and braquiostegal filaments did not show evidence of severe parasitological

infection, Individuals which were still alive were seen trying

to breathe at the surface with an apparent oxygen deficiency.

GilL membranes were clearly distended.

Field measurements of dissolved oxygen, pil, conductivity and

water temperature were performed at the site of the mortality

immediately after the observation, A copy of the original data

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6.

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Table Alvi . Water Colum Means and Range of Heavy Metal.

Concentrations in ta Plata take (October 1381 -

June_1982), in ug/t _

Surface Waters Linkt

mata Mean Range Recommended

va/ vat vat

Hg 3.19 2 - 6.23 10

co 7.64 4.70 13.50 40.0

ca 1.99 1.58 - 2.50 5.0

ce © 10.00 Not detected 50.0

cy 12.57 5.98 -20.2 50.0

za 63.30 17,65 ~166.92 50.0

a < 5.00 Not detected

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Table xLvir . Concentration of Pesticides in Water Samples from

La Plata Lake.

Pesticide

Copper Compound

Granaxone

organochlorinated Pesticides

Organophosphates

carvamates

Concentration

Wot detected

Hot detected

Not detected

Not detected

Not detected

Source: Laboratorio Agrol6gico de Puerto Rico.

Departanento de Agricultura

---Page Break---

form is presented as Table XLVIII. Low dissolved oxygen concentrations at the surface and almost zero oxygen below the root zone of the water hyacinths may have acted as a trap and caused the mortality by asphyxia.

July 8, 1982

During 8 July 1962 about 100 dead individuals of Tilapia spp. were seen floating at the surface and washed to the shores of La Plata Lake, The higher abundances were observed within one kilometer from the bridge (Road 164) of La Plata River. The specimens observed were all big Tilapia (range 20-30 cms), sone (approximately 108) had their head decapitated, one individual which was observed still alive at the time of the mortality showed signs of asphyxia: abnormal distension of the beanquiostegal membranes and pronounced pulsation of the opercular flap. Dissolved oxygen at the site of higher accumulation of dead or stressed fish was between 6.0 mg/l and

7.0 mg/l (measurements were made at midwat

total depth was 3

meters). Most of the individuals, however, were in an advanced stage of decomposition indicating that the mortality may have started several days before.

?The available data do not permit any strong inference to be

made regarding cause of death. Any explanation of this event

must take into account the following point:

1) The kill apparently affected only large individuals of

one species, Tilapia.

2) The dying fish showed evidence of respiratory stress.

3) No visual evidence of active contamination (e.g, 011),

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TAWA MILL, Field Heeuremat a Of Tesperature, Disiwlved Oxygen, pi

ond Cuvtuctivity at the Site of Observed Mortality Of

Fisher of the swetes, Dor vie during May 6, 1982.

Serie

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foey po

65

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4) ?The Limnological features of this and/or nearby station

were within the range regarded as nor

1 for this site.

5) The deaths had been occurring over a period of several days.

6) A curious and possibly related phenomenon is the observation that roughly 108 of the dead fish had been decapitated sonehow.

PRELIMINARY SUMMARY

Reflection on the cumulated set of data has lead to a number of related conclusions or observations with respect to the general nature of the La Plata system. A tentative and

relatively unordered list of such observations follow:

?the
reader is cautioned that this list is tentative, incomplete and

probably in error with respect to si

je of the specifics. It has

been included as an indication of direction for comment but net

for citation.

1, There is increasing evidence that La Plata is driven by

hydrological events rather than seasons, Thermal stratification

y have a Seasonal component with obvious thermoclines in sus

and more gradual gradients in other seasons, Even when thermal

stratification is weak it is frequently sufficient to prevent

physical exchange between hypolimnion and epilimnion except when heavy rainfall and possibly violent storms (i.e., winds) occur.

2. Dissolved oxygen stratification with anaerobic conditions persistent below 4 meters is a dominant feature of the lake key to its functioning as a system. The cause seens to be

the physical separation of epilimnion and hypolimnion, coupled

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with substantial organic input both from tributary BoD and net productivity of water hyacinths maintained at high levels as a

result of nutrient input.

?The plankton subsystem of the lake is substantial but restricted in depth distribution and potential effect because of the combination of light restriction under the hyacinth mat and unfavorable conditions (anaerobiosis) in depths greater than 2-5

meters.

?The dissolved oxygen profile is clinograde with a strong chemocline between 2-5 m.

5. Low values of net primary productivity of phytoplankton are consistent with the idea that the Lake has a low capacity for biological regeneration of dissolved oxygen by photosynthetic

organisms in relation to the existing respiration rat

Chlorophyll-a, phytoplankton abundance, water hyacinths and biological oxygen demand increase downstream from La Plata River indicating their indogenous character.

7. Uoading of nutrients, suspended sediments, dissolved oxygen and bacteriological contamination are Largely contributed by tributary rivers.

8. Le Plata River has contributed a 958 of the total nitrogen and 94% of the total phosphorus loading to the lake @uring the study period to date.

9. Approximately 85% of the total N and 808 of the total P

loading occurred during the "wet" period (oct.-Dec., 1981). Bacteriological contamination above recommended limits are also

associated to periods of high precipitation in the watershed.

---Page Break---

10. The measured concentrations of total phosphorus and chlorophyll-a continue to be high and consistent with the classification of La Plata as an eutcophied system.

LL, Available micronutrients such as SRP and NHy-N evidence higher concentrations in the hypolimnion suggesting rapid epilimnetic removal by photosynthetic organisms and accumulation under the anoxic strata of the lake. The vertical distribution of NOz-NO3 concentrations follows a weak dichotomic pattern.

12, Among the trace metal concentrations studied (tig, cu, Pb, Ni, Cr, Cd, and Zn) Zn and Hg exceed surface water standards for Puerto Rico.

13. synthetic organics studied (copper compound, Gramaxone, organochiorinated pesticides, organophosphates and carbanates) failed to present detectable concentrations in water samples from

the lake and major tributaries.

14, Special close-time interval sampling has indicated that the standard lake station L-I is essentially the same (within a small acceptable sampling error) as a station adjacent to the dan and may, therefore, fairly represent the main body of the Lake.

15, Being considered as possible lake restoration practices to be applied at La Plata Lake ace the following:

(a) Reduction or diversion of nutcient-rich point sources in the basin.

(b) Implementation of aMP for the control of fertilizer and pesticides application.

() Employment of barrier strip of vegetation along

the shorelines of the lake.

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(2) Macrophyte harvest as a tool of nutrient removal from the system, also in relation to some economic use in the basin.

(e) Implementation of BMP for the control of non-point

sources of nutrient contamination in the basin (e.g., livestock,

poultry, ete.).

(£) Implementation of reforestation practices in

critical areas of erosion.

(3) Use of mechanical aeration in order to reduce

stratification and enhance the fisheries potential of the system.

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