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PRELIMINARY RESULTS FROM A SURVEY OF

WATER QUALITY IN SOME PUERTO RICAN LAKES

CENTER FOR ENERGY AND ENVIRONMENT RESEARCH

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Preliminary Results from

A Survey of Water Quality in Sone

Puerto Rican Lakes

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ABSTRACT

High nutrient levels in Puerto Rican Lakes resulted in

high productivity with average daily gross oxygen production

of 3.3 mg of oxygen per Liter in 1977. Moderate to high alg numbers caused an undesirable green color and Secohi readings

of Less than 2.3 meters. In spite of large variation in nutrient loads entering some of the lakes, the number of algae changed only slightly throughout the year. The ecosystem of Lake Carraizo resulted in effective oxidation of entering organic wastes, and removal of 1900 kilograms of nitrogen and 6.6 kilograms of phosphorus a day in a lake with a surface area

of 300 hectares. The lake was functioning as a tertiary sewage

treatment system for sewage from Caguas and other municipalitie:

Despite the efficiency of this system, Lake Carraizo, which unfortunately is also the San Juan water supply reservoir, was the most highly polluted lake of the 12 included in this survey. An appendix of ecological survey data is included at the end of this report covering the 4 years 1975-1978, but only the

1977 data 1s analyzed in the text.

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Preliminary Results from

A Survey of Water Quality in Sone

Puerto Rican Lakes,

INTRODUCTION

Twenty-eight lakes have beon created in Puerto Rico since 1913, for hydroelectric power, irrigation and water supply.

As the Island's population has expanded, additional water supply reservoirs have been constructed, including Lake La Plata which collects water for metropolitan San Juan and which was completed in 1976, These water supply reservoirs are also receiving considerable amounts of domestic wastes from upstream conmu-nlties and excessive growth of aquatic plants are developing (Figure 1), The lakes are contaminated by poorly constructed

drainage fields of houses without sewers and by municipal

sewage discharges located on streams in the watershed

Lake Carraizo receives the discharge of five municipal

Sewage treatment plants with a total output of 6.7 million gallons per day. This discharge makes up 6% of the total annual inflow to the lake and has an average oxygen demand (8005) of 114 mg 0, Liter and 64 mg/liter of suspended solids. In times of drought the excessive nutrients cause a severe water quality problem in the entrant streams of Lake Carratzo. Throughout the year travel on this lake is restricted by

heavy growths of water hyacinths which cover up to 30% of the

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through experience in temperate zones may not be relevant to

tropical environments. Previous stidies ion tropical lakes in

other a

's have demonstrated that these lakes are in general more productive than those in temperate zones. In order to examine these various themes this study was conducted on water quality of the major lakes in Puerto Rico (Figure 2). This

Feport includes analysis of data collected on certain of the

lakes in 1977. However the attached appendix also includ

additional data collected between 1975 and 1978,

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Figure 2. Sampling of lakes was facilitated with trailer-

drawn boats equipped with dredges and winches.

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Description of the Lakes

The lakes in this study range in volume from 700 to

49,000 acre fect (8.6 X 10° to 6.0 X 107 m®). Where data are available the mean depth ranges from 13 to 59 feet (4 to 18

meters), and the residence ti

Ss vary from one to thirteen months (Table 1), Lakes Carraizo, Dos Bocas, Caonillas and Carite are situated at elevations less than 1000 feet (300 m), whereas the others are located between 1000 and 2000 feet (300-600 m). Lake Carraizo, a major source of water for San Juan, is in the Loiza drainage basin (Figure 3); Lakes Dos Bocas, Caonillas and Garzas in the Arecibo drainage basin; Lake Carite in the Patillas drainage basin; and Lake Cidra in the Bayanén drainage basin. Although Lakes Prieto and Guayo are in the Afasco drainage basin, their discharge is to the Lajas Valley irrigation system by means of a tunnel. Lake Carratzo is in a heavily populated valley. The other lakes are in less populated areas, especially Lakes Garzas, Prieto and Toro which are quite isolated. The difficult nature of the terrain and roads have impeded eoologioal investigation in the past (Figure 4).

The lakes are located in the central mountainous region of Puerto Rico and were created by constructing dams at

strategic points in the rivers. Since the rivers of Puerto Rico flow through narrow valleys, the shorelines tend to drop

off rapidly with very little shallow water to provide a suitable

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habitat for submerged vegetation. Only two lakes, Carraizo and Garzas, are in broader valleys which provide less of a vee-shaped botton and are consequently more shallow (Table 1). Carraizo 1s the lake of most interest in this study since it is the lake receiving the heaviest nutrient loads and at the same time it serves as the principal source of San Juan's water supply. Carratzo is a very long narrow lake with a maximum width of about 250 meters and 5 kilometers in length. It fs fed by two major rivers, the Loiza and the Curabo, and

three small streams.

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Materials and Methods:

Sampling the Lakes

The stations for assessment of oxygen evolution, algae,

coliform bacteria and chemistry were selected to represent

the entrant streams as well as the body of the lake. The

number of stations varied between three and five depending fon the size of the lake. On several occasions only three

stations were used on Lake Carraizo because of blockage with

water hyacinths, Data analyzed in the text came from the

sampling during 1977 except for LakeCidra and Carite, which

were studied in December 1975. However the Data Appendix

covers the period from 1975 through 1978. Cach lake was

Visited every three to four months.

Samples for dissolved oxygen were fixed on the lakes and analyzed within two hours at the mobile Laboratory (Figure 5). Plates for total coliform determinations were also prepared and incubated at the mobile laboratory. Samples for chemical analysis were transported to the laboratory in San Juan and analyzed during the following week. Since all phosphate samples were transformed to orthophosphate by acid hydrolysis before analysis, it was not thought necessary to fix the

samples.

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Figure 4.

Photosynthesis surveys required three consecutive

days of oxygen measurements, thus a trailer for laboratory and sleeping quarterswas used in remote

mountain reservoirs.

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Chemical Analysis

The analysis of water samples was performed according to "Standard Methods" (23). Total phosphate determinations were

by the molybdate-stannous chloride method after acid hydrolysis. The nitrate plus nitrite concentrations were determined by the phenol disulfonic acid method after oxidation by permanganate. The azide modification of the Winkler method was used for Gissolved oxygen. For the determination of chlorophyl a the fixed algae were sedimented by gravity and centrifugation and extracted with 90% acetone. The absorbance at 665nm was corrected for the presence of pheophytin by reading the samples before and after acidification.

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Figure 5. Oxygen titrations, coliform bacteria filtrations

and reagent preparations were performed at the

lake site, in the small mobile laboratory.

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Biological Analysis

Twenty four hour oxygen production was measured using

surface water samples in two light and two dark bottles and

dissolved oxygen titrations. The samples were incubated in

situ at a depth of 0.5 meters (Figure 6). Since an initial oxygen sample was taken, the 24 hour respiration rate was the difference between the oxygen concentrations in the initial samples and in the black bottles on the following day. Net productivity was calculated by subtracting the initial oxygen concentration from the final concentration in the light bottle, whereas gross productivity was caleulated by subtracting the final concentration in the dark bottle from the final concentration in the light bottle.

Oxygen production and respiration were measured for 3 consecutive 24 hour periods. The 24 hour oxygen production was measured rather than & hour photosynthesis productivity because the former measurement is more directly related to water quality than the latter. Total coliform colonies for two consecutive days were counted after 24 hour incubation at 35°C, using Millipore media and filters. Algae were identified and counted by microscopy after fixation with

formaldehyde and filtration on Millipore filters.

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Figure 6.

Photosynthesis stations consisted of two clear

bottles and two opaque bottles in a basket suspended

from a float, 0.5 meters below the water surface.

These conditions simulate the natural algal

environment under daylight and in the absence of

light.

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For each lake the oxygen production and other parameters showed substantial variation from station to station and from Season to season. The variability frequently resulted trom high turbidity caused?by heavy sediment loads during flooding. The streams entering Lake Carraizo tended to be heavily conta- minated, with one stream, Bairoa Creek, consistently showing total coliform bacteria counts of 106/100 m1 or more. The high oxygen demand from the effluents of the sewage treatment Plants (see introduction) in the watersheds of Lake Carraizo caused anaerobic conditions with no photosynthetic activity at the head of the Lake during a drought in the Spring of 1977. By averaging the data over all stations and for the year, a more consistent pattern emerged. Oxygen productivity correlated with the amount of coliform bacteria, nitrate and phosphate with correlation coefficients of 0.70, 0.18, and 0.87 respectively (Table 2). The average Secchi depth was less than 1.0 meter in Carraizo, Caonillas, Dos Bocas and Prieto. Tt was inversely related to oxygen production with a corre- lation coefficient of 0.71.

The seasonal variation of productivity in the lakes was compared on a common basis by dividing the individual values by the annual average for a given lake. There was a correlation among the lakes in the variation of the productivity

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with tine (Figure 7). The changes in productivity were not simply related to the seasons, nor to the records of minutes of sunshine maintained by the local weather bureau (Figure 6).

In contrast to heavily enriched lakes in the Hainland North, at no time during 1977 in any of the lakes in Puerto Rico was there an Indication of algal blooms. The data in Figure 7 showing the modest and coordinated changes of oxygen Production in the lakes with time supported this observation. In the detailed algal counts for samples taken from the five larger lakes, the number of organisms per ml tended to be moderate with no counts approaching 500 per ml, the level commonly accepted as the threshold for algal blooms in the North (Ref. 1), One did not see a predominance of any particular alga. The number of algae per mi for Lake Carraizo was low particularly in view of the high nutrient levels and oxygen production. Chlorophyl - a values in Lake Caonillas ranged as high as 40 49/1 (Table 3). Although blue green algae such as Osetlatoria and Anabaena, commonly associated with pollution Induced algal blooms, were present in some of the more contaminated waters, their numbers were small (Table 4).

The nutrient levels in Lake Carraizo were high. The "Water Quality Record? (25) of the United States Department of the Intertor have been used to calculate average annual flows and chemical concentrations for the influent and effluent water

of Carraizo (Table 5). By calculating the average concentration

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of the incoming and outgoing water and the total flow of the water into the lake, we estimated that 1.9 metric tons of nLtrogen in the form of nitrate and 6.6 kilograms of phosphorus in the form of phosphate is removed from the water daily. Because the figures have not been corrected for evaporation and seepage as well as other errors, these numbers must be

considered rough estimates.

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TABLE 3

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CHLOROPHYLL 2 CONCENTRATIONS IN PUERTO RICAN LAKES

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Carraizo

Carratzo

Caonillas

Dos Bocas

Guayo

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August 8,

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June 16,

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May 20,

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July 8,

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Station

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24.0

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31.8

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Discussion

The biology of these lakes could be characterized by a simple food chain but only fragmentary information relevant to these factors are available for Puerto Rican lakes. In general the aquatic vegetation was minimal with the exception of Lago Carratzo where an appreciable portion of the lake was covered by water hyacinths. Many of the lakes have steep shore lines which minimize aquatic vegetation. Although this paper presented data on algal populations which form the base of food chains leading to fish and ultimately man, no information on zoo-plankton populations was available.

A report on fish populations in a number of these lakes has recently been published (9). The data for Lakes Carraizo and Cuajataca are relevant to this paper. The fish population observed in the former lake during 1975-1976 consisted almost entirely of Tilapia mossambica (83%) and channel catfish

(Letalurus ponctatus, 16%). This was in contrast to Lake

Guajateca where large mouth bass (Micropterus salmoides), Lilapia mossambica, threadfin shad (Dorosoma petenence) and sunfish (Lepomis microlophus) made up 32%, 40%, 18%, and 8% of the fish population respectively. Lake Carraizo supported a more varied populations of fish which included large mouth bass in earlier times when it was less polluted. The data 1s suggestive that Tilapia mossambica may be now displacing large

mouth bass in Lake Guajataca.

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Woodwell, et al (26) have studied the process of water Purification in several ecosystems and found a combination of a pond and marsh to be the most effective for treating domestic sewage. Their data were presented on the basis of surface areas. Extrapolating the data to a surface area equal to that of

Lake Carraizo, one calculates that their system removed 26 metric tons of nitrogen and 38 metric tons of phosphate per day whereas in Lake Carratzo the figures were 1.9 tons and 66 kilograms respectively. Lake Carraizo was less efficient especially in the removal of phosphate. The latter is probably removed by fixation to the soll in the marsh system (26) and consequently the lake {s substantially less efficient.

It is not clear how much of the water purification was the result of microbiological actions and how much of the nutrients were taken up by the water hyacinths. The productivity correlated with phosphate and total coliform concentration, with the best correlation being that with phosphate 0.87. Since these parameters are intercorrelated it 1s difficult to separate the effect of one from the other.

The 24 hour oxygen respiration is a reflection of activity by all the micro-organisms, principally bacteria and algae. It is also qualitatively related to the 5 day biochemical oxygen demand, and the two procedures should depend on the same parameters. Straskraba and Straskrabova (22) have shown

that there is on excellent correlation between BOD, and the

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Figure 9.

Lake Yahuecas in Lares, although in an almost

innacessible region, shows evidence of eutrophication, Probably due to agricultural fertilizers applied in the citrus, coffee and banana farms of the mountain

watershed.

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number of bacteria detected on beef-peptose plates. Using thetr data and that of this paper one can say that the level of oxygen production in these tropical lakes 1s correlated with the presence of decomposition bacteria.

That in the stable lake environments of the tropes an ecological system should evolve, where algae supply the oxygen for bacterial decomposers and the latter provide a favorable biochemical environment for the algae, is reasonable. It ts known that many algae depend on external sources of the vitamins, thiamine, biotin, and 8), (17), It 1s probable that the half 1ife of these vitamins in tropical waters is rather short, making the algae dependent on local suppliers. The fleld of biochemical interactions between aquatic organisms is largely unexplored. It ts known that the development of Sea-weeds is dependent on the associated microflora; but the blochemical nature of this interactions 1s unknown (12).

Qartsch and Allun (3) have emphasized the symbiotic relationship between bacteria and algae; with the bacteria supplying nutrients through decomposition and the algae supplying oxygen for the decomposition process. In general there is not a proportionality between respiration and photo-synthesis. Odum (16) has used the relationship to classify aquatic communities. Copeland et al (6) have emphasized the

Seasonal and temporal changes in the ratio of photosynthesis

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Figure 10.

The small reservoirs on Rio do 1a Plata near

Comerio show gross eutrophication due to senage

discharges. The 2 small reservoirs reduce some

of the wasteload on the new La Plata reservoir in

the San Juan water eupply system

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to respiration. This study is unique in comparing photosynthesis

and respiration in a series of tropical reservoirs where one

has a reasonably constant regime of light and témperature.

In the present case, a cursory examination of the data

showed that photosynthesis was not proportional to algal

numbers. This is reminiscent of another study which showed

that the ratio of chlorophyll-a to productivity varied by a

factor of 3 (25). This and the data above would suggest that

Photosynthesis activity depends on unknown physiological factors.

A symbiotic relation between decomposition bacteria and algae was shown to exist by McKinney (13) and its importance in stabilization ponds has been emphasized in an EPA report (2), The data from this report suggested that the Lakes studied here more closely resembled stabilization ponds than the lakes of the temperature zone studied by Odum (16) and Copeland (6). The ratio of respiration to photosynthesis appears to vary less in these tropical lakes than those in ?the temperate zone of North America.

One would expect more of a preponderance of blue green

algae in the lakes with high nutrient levels. These organisms

have a lower affinity for nutrients and consequently high Phosphate and nitrate levels are particularly stimulatory for the blue green algae (4) which do not have natural predators. The low transit times of 21 days in Lake Carraizo, 56 days in

Lake Dos Bocas, and 59 days in Lake Caonillas may have a

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dampening effect on the slow growing blue green algae. It is notable that in Lake Guayo which is a relatively clean lake but with a transit time of 390 days the blue green algae made up 52% of the total population (Table 4).

Physical factors are important in determining the amount of phytoplankton growth (17). Phosphate chemistry is dependent fon the degree of stratification and anaerobic conditions in the hypolimnion (8). Candelas and Candelas (5) have examined

the Puerto Rican lakes and found that there was little temp

rature difference between top and bottom; and consequently stratification was minimal. In addition, tropical lakes are more susceptible to the destabilization effects of winds and surface cooling by rain (12). Although all investigators are agreed upon the key role of phosphorus in algal growth, there 4s conflicting opinion concerning nitrogen. The general observation is that algal blooms occur with levels of nitrate greater than 0.2 or 0.3 mg/} (20, 22); but sone emphasize the ability of algae to fix nitrogen and the consequent unimportance of nitrate (21). The lack of blooms in the Puerto Rican Lakes may be related to the very high efficienty of denitrification in the lakes.

Nothing is known about the pressure of zoo-plankton grazing upon phytoplankton in Puerto Rico. There are a nunber of studies (17) which suggest that zoo-plankton grazing is an

important factor in controlling phytoplankton concentration.

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Jassy et al (9) in a microcosm system showed that the increase in 200-plankton numbers Lagged behind that of the phytoplankton increase. The peak in zoo-plankton concentratisn coincided with a sharp decrease in phytoplankton nunbers. The stability in phytoplankton numbers observed here may reflect a stable phytoplankton-zooplankton interaction. It is interesting to note that conditions for stability did not exist for several years after the formation of Lake Carralzo. Bloons of

Synedra occurred as frequently as four times a year during the first five years (7).

In conclusion, one may say that, although the artificial reservoirs in Puerto Rico were heavily contaminated, there were no algal blooms and photosynthetic activity showed only moderate changes throughout the year. There was suggestive evidence of a copperative interaction between algae and bacteria. This interaction may make the lakes tolerant to high nutrient loads. The principal problem was the water hyacinths which covered 20-30% of the water surface of Lake Carraizo and clogged the lower parts of the rivers on the north coast. Since the interaction of the environment with pollution 1s receiving increasing attention, it would appear desirable to study in detail the biechemical and microbiological interactions which make possible the efficient decomposition

of wastes In Puerto Rican Lakes.

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SUMMARY AND CONCLUSION

High nutrient levels and pollution in Puerto Rican Lakes lead to undesirable concentrations of algae, water of low clarity and poor sport fishing. Algae concentrations and photosynthetic productivity varied moderately throughout the year. In Lake Carraizo, large quantities of phosphate and nitrate were removed during the passage of water through the lake. A stable relationship between decomposition bacteria and photosynthesis by algae has developed in these tropical

lakes in a manner very similar to sewage treatment ponds.

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APPENDIX-REFERENCES

1. Anonymous. "Report on Lake Mendota Studies Concerning Conditions contributing to aquatic Nuisances, 1945-47." Wisconsin Coumittee on Water Pollution, Madigon, Wisconsin, 19 pp, 1949

2. Anonymous. "Performing Evaluation of an Existing Seven Gell Lagoon System", EPA-G00/2-77-086, 1977.

3. Bartsch, A. F. and Allum M. 0, "Biological Factors in Treatment of Raw Sewage in Artificial Ponds". tym. and Oceanog, 2:77-84, 1957.

4. Biermon Jr., V. J, "Mathematical Model of the Selective

Enhancement of Blue Green Algae by Nutrient Enrichment in

Modeling Biochemical Processes in Aquatic Ecosystems".

Canale, R. P, editor. Ann Arbor Science Publishers, Inc.

?Ann Arbor, Michigan, 1976.

5. Candelas, G. and Candelas, G, C. ?Plankton Studies on

Puerto Rico's Fresh-water Lakes. Physical & Chemical

4 (4), 451-458, 1964.

6. Copeland, B. J., Butter, J. L., and Shelton, W. L.

Photosynthetic Productivity in a Small Pond". Proc.

Okla Aci

Se!

Vol. 42: 22-26, 1962.

7. Guzmén, R. M. Control of Taste and Odors in the San Juan

Water Supply. Taste and Odor Control Journal, 29, 1-7, 1963.

8. Jansen, H. A. "Some Consequences of Adding Fertilizer to

Five Michigan Trout Lakes." Transactions American Fisheries

Society, Vol. 89, No. 2, pp 198-205, 1960,

---Page Break---

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12

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Jassy, A., Dudzek, M., Rees, J., Lapon, B., Levy, D., and

Harte J. "Production Cycles in Aquatic Microcosms"

LBL-5965 UC-11 T1D-6500-R65, Lawrence Berkely Laboratory,

University of California, 1977. -

Jobin, W. R Brom, R. A., Vélez, S. P., and-Ferguson, F. F.

Biological Control of Biomphalaria glabrata in Major

Reservoirs in Puerto Rico. Am. J? Trop. Med, and Hyg.

1018-1024, 1977

Ximel, B. L. and Lind. 0. T, "Factors Influencing

Orthophosphate Concentration Decline in the Water of

Laboratory Mud-Water System.

21, 439-445, 1970,

Texas Journal of Science,

Lewis, W. M. "The Thermal Regime of Lake Lango: (Philippines)

and its Theoretical Duplications for Tfopical Lakes

Limology _& Oceanography, 18, 200-217 1973

McKinney, R. E. Functional Characteristiés Unique to Ponds.

Paper presented before the conference ?Pondsas a Wastewater

Freatment Alternative", University of Téxas,Austin, July

23-25, Austin, Texas, 1975.

Morenthun, K. M, Introduction, ?itrogen and Phosphorus

in Water", United Sates Department of Health, Béugitton,

and Wélfare, Public Health Service, Division of Water

Supply and Pollution Control, 1965. ~

Mortimer, C,H, "Eutrophication: Causes, Consequencés

Correctives. . Physical Factors with Beating on Eutrophication

in Lakes in General and in Large Lakes in Particular.? National

Academy of Sciences, Washington, D. C., pp 340-368, 1969..

---Page Break---

16.

a7

18.

19

20.

38

Odum, H. J. and Hoskin, C..M. ?Comparative Studies

on Metabolism of Marine Waters". Publ. Inst. Mar Sci

Univ. of Texas. 5:16-46, 1958.

Porter, KG. "

?he Plant-animal Interface in Freshwater

Ecosystems". American Scientist

65: 159-170, 1977.

Provasoli, L. "Eutrophication: Causes, Consequences,

Correctives. Algal Nutrition and Eutrophication.

National Academy of Scigncces, Washington, D.C.

pp 574-593, 1969

Rivera, J. E, "Relationship Between the Population

Dynamics and Environmental Water Quality of Four

Fisheries in Puerto. Puerto Rico Sport Fisheries

Research and Surveys. pepartaent of Natural Resources,

Commonwealth of Puerto Rico, 1976

Sawyer, C. N. "Some New Aspects of Phosphates in Relation

to Lake Fertilization." Sewage and Industrial Wastes.

Vol. 24, No. 6, pp 768-776, 1952.

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Silverster, R. 0. "Nutrient Content of Drainage Water from

Forestal, Urban and Agricultural Areas. Algae and Metro-

politan Wastes." United states Public Health Service.

5.5. C. 7. RW. 61-3, pp 80-87, 1961.

Stroskraba M. and Straskrabova, V. ?Eutrophication: causes,

Consequences, Correctives, Eastern European Lakes." National

Academy of Sciences, Washington, D. C. pp 65-97, 1969.

taros, M. Arnold. E., Greenberg, Hook, and Rand, M. C.

Standard Methods for the Examination of Water and Wastewater

43th edition, American Public Health Association. American

Water Works Associates, Water Pollution Control Federation,

2015 18th St., N. W., Washington, D. c. 20036, 1975.

Taniguchi, A. and Kawamura, T. ?The Kuroshio 11". Proc. of

the 2nd CSK Symposium, Tokyo (ed. K. Sugawara), Saikon

Publishing Co., Ltd., Tokyo, 1972.

"Water Resources Data for Puerto Rico. Part 2. Water Quality Records". United States Department of the Interior. Geological Survey, Bld. 652, P. 0. Box 34168, Fort Buchanan, Puerto Rico, 00934, 1974.

Woodwell, G. M, Ballard, J. T., Clinton, J., and Peron, E. U. ?Nutrients, Toxin, and Water in Terrestrial and Aquatic Ecosystems Treated with Sewage Plant Effluents, BNL, 50513."

Brookhaven National Laboratory, United States ERDA, Upton, New York 11973, 1976,

---Page Break---

This appendix is a complete listing of chemica:, physical and biological data gathered from 12 lakes in Puerto Rico

between December 1975 and September 1978. Only the data collected during 1977 have been analyzed in the text of this report, the remainder will be analyzed in a subsequent paper.? Six reservoirs were studied intensively for seasonal variations and an additional

six were studied about once a year over the 3 year period.

---Page Break---

List of Tables in Appendix

See

---Page Break---

oo1¥ OLY3Nd NI S3NVI 40 NOLL¥907

---Page Break---

3

Table 6

Twelve Major Lakes Studied

1975-1978.

Lake Drainage | Elevation of

Area in ?Spillway

Square Crest

i Miles in Feet

Caonilias | 50.4 826

carite 19 1786

carratzo | 206.0 102

lb. cidra 8.6 azz

|5. Dos Bocas | 170.0 295

?6. Garzas 6.2 2ais

7. Guajataca | 24.6 646

ls. cuayo 9.6 1460

lb. Matrullas | 4.4 2aas

0. Patitlas | 25.2 217

1. Prieto 9.6 148s .

2. Toro, 40 1900

---Page Break---

SAMPLING SCHEDULE FOR TWELVE LAKE STUDY

LAKE

Caonities

corite

Corraizo

cidro

Dos Bocos

Garzos

Guajataca

Guayo

Motrutios

Patitios

Prieto

Toro

1975-1978

1977

1975, 1976

RE ie

1978

---Page Break---

Nese MOF ater

---Page Break---

---Page Break---

Figure 13.

Lake Surveys were conducted from boats transported to the

?mountain lakes by trailer and plek-up trucks. The larger

18" fiberglass boat was equipped with a snall winch and

dredge.

---Page Break---

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7

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48

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SOEHT TZ O80 BOZO EOTLD HOTHL LOFeL sete

STEER C2Z@ wOTLO GOTT OT TES GOEL SOTHE olen

BOGE ETI TOTS SOr90 BOTEL SOZEL EOTIL voErleD

+|

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Bopet UIZ@ EOFs wOTL 90789 9072? LOTO0L oaTie

POO Sts HT eT STITT etz9s CTz 9% eT; TL werTTWOED

4 1/6 1/60 1/68 1/Su 1/86 kop

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>8T0 001 saeg- saea- 83308 T3039 wos

woos seve era. ay seg BUTT yebkeo aye

?BL6T-SL6T ?OOTY o930ng UF, soxe7 aofeH 304 KreMUNS Peg UOBAKO

---Page Break---

Data Record By Lakes

The group of tables for cach lake are in the following order:

Nap of Lake with Sampling Stations

Chemical Water Quality

Varfation with Time and Station for each Chemical Parameter

Summary of Snail Surveys

Summary of Coliform Bacteria Data

Oxygen Data Summary

Phytoplankton Data

Water Level Record for Lake

---Page Break---

LAGo cAoNILLAS - UTUADS

---Page Break---

Figure 15.

Lake Caonillas has the largest volume of any of

the Lakes and discharges through hydroelectric

generating turbines Into Lake Dos Uocas.

---Page Break---

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mana 4 60 oud ae

ors ousane ???

THITTOOET vt wos AAMAS YIVE ALTTYND TWOTKSHO

---Page Break---

---Page Break---

---Page Break---

ASVARIATION WITH TIME

OO OOrrcvnnmnOES SSS

SAMPLE TOTAL NUMBER MEAN ?STANDARD

DATE oF DEVIATION

SAMPLES.

ic

Liyan7 28.5 4 7.33 0,80

23/4/77 22.2 3 ah 0.97

3 r6/6/77____37.3 5 7.46 3.43

sre SS

Ss0/9/77 30.7 5 6.14 0,99

Soray7e 17.6. 4 4a 0.75

TOTALS 136.3 23 5.93

BLVARIATION BY STATION

A 19.4 5 3,88 0,90

c 28.9 5 5.78 ?1,82

Ss ete

5 19.3 3 6.43 1,16

5H

---Page Break---

?TABLE 12

HYDROELECTRIC RESERVOIR STUDY

?SUMMARY OF DATA FROM

LAKE _ Caontilas

PARAMETER Hardness

wars g/1 Me 504

?

?AGVARIATION WITH TIME

ee EES

SAMPLE TOTAL NUMBER MEAN ?STANDARD

DATE oF DEVIATION

SAMPLES

Sa

2 373.2 4 93.3 1.84

Sa

2 322.4 5 106.8 a0

2 tog to

3 670.3 5 134.06 3.53

4 669.2 5 133,80 5.26

tt

3

85.68, 4.22

6

>

>.

>.

see

10

ee

TOTALS 2,577.8 23 112,08,

BLVARIATION BY STATION

??___SXasTAT10m By sanyo

20.78

A 52h.4 5 106.88

ett 20.78

ha 108.50 16.20

532.5 5

> SO

18.49

£ 573.4 3 114,68

St

2 569.3 5 113,86 20,27

te 20027

E 378.2 128,07 aad

|

[

2,577.8 23 122.08

55

---Page Break---

?A-VARIATION WITH TIME

SAMPLE TOTAL NOMBER EAN ?STANDARD

DATE oF DEVIATION

0.03 0.02

0.01 0.00

3 ou

0.05 0.01 0,00

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9,05 o.o1 0,00"

0.06

|

o.01

|

23 0,01

BLVARIATION BY STATION

0.05 0,01 0.00

9.05 0.01 0.00

°

ott 0,02 0.01

0.07 0,01 0,00

0.01 0,00

|

re

23 o.o1

56

---Page Break---

TABLE 14

HYDROELECTRIC RESERVOIR STUDY

?SUMMARY OF DATA FROM

PARAMETER Nitrate & Nitrite

uarrs pelt

?A-VARIATION WITH TIME

Sewis Tora owen MEAN ?STANDARD

DATE oF DEVIATION

SALES

4 0,29 5 0,06 0,01

5 0.63 4 0.15 0,01

£ 5. 0.10 9.05

° 5 0.07 0,07

2 on18 3 0.05 0.02

---Page Break---

?TABLE 15 56

HYDROELECTRIC RESERVOTR STUDY

SUMMARY OF DATA FROM

LAKE Caoni tas

PARAMETER __Iron

a

?AGVARIATION WITH TIME

SAMPLE TOTAL NOMBER MEAN ?STANDARD

DATE. OF DEVIATION

TOTALS 3.49 23 ons

BAVARIATION BY STATION

---Page Break---

?TABLE 16

HYDROELECTRIC RESERVOIR STUDY

SUMMARY OF DATA FROM

TAKE _Coo nitigg

PARAMETER _Turbidity

?unrrs Standard Unite

?ALVARIATION WITH TIME

SAMPLE TOTAL NUMBER MEAN ?STANDARD

DATE oF DEVIATION

SAMPLES

2 20.4 4 5.20 2.20

2g 4.80 3.92

3 23.2 5 4.64 2.18

4 2.2 5 0.46 0.18

> 2.2. 4 0.56 0.70

6 ?

3

PALS 72.0 23 3.13

39

---Page Break---

TABLE 17

HYDROELECTRIC RESERVOIR STUDY

SUMMARY OF DATA FROM.

Lake __ = Cagaitlas.

PARAMETER Color

errs _standard unit

AGVARIATION WITH TIME

SAMPLE TOTAL NUMBER MEAN ?STANDARD

DATE. oF DEVIATION

SAMPLES

1 52.0 13.00 2480

95.0 5 19.00 1.60

3 54.0 5 10.80 0.96

4 59.0 5 11,80 1.44

5 sao 4 9.50 0.75

6

7

@

9

20

TOTALS 298.0 23 12.96

BLVARTATION BY STATION

0 Cn

a

65.0 13,00 3.60

72.0 5 14,40 4,90

5 12.40 3.00

|

32.00 3.20

60

---Page Break---

TABLE 16

HYDROELECTRIC RESERVOIR STUDY

?SUMMARY OF DATA FROM

LAKE Caoni1ias

PARAMETER

A-VARIATION WITH TIME

SAMPLE TOTAL NUMBER MEAN ?STANDARD

DATE. OF DEVIATION

SAMPLES

SS

1 28.9 7.22 0.08

BLVARIATION BY STATION

OTALS 170.7 23 7.42

OT

ore

? a2 5 7.54 nat

a

37.0 5 7.40 0.46

tte

£ 26.1 5 7.22 0.39

tt

> azo 5 7.60 0.40

z 22.9 3 7.63 0.26

Saree

?TOTALS 170.7 23 7.42

nde

6

---Page Break---

TABLE 19 ?

HYDROELECTRIC RESERVOIR STUDY

?SUIQIARY OF DATA FROM

LAKE _Caoni Lisa

PARAMETER Dissolved Oxygen

UNITS g/t s

ee t

ACVARIATION WITH TIME

SAMPLE TOTAL NUMBER MEAN STANDARD

DATE OF DEVIATION

SAMPLES

TOTALS 1956 v7 7.27

BLVARIATION BY STATION

?TOTALS 123.6 v7 1.27

ee

---Page Break---

?ranur 20

HYDROELECTRIC RESERVOIR STUDY

?SUIMARY OF DATA FROM

LAKE _Caontllas

PARAMETER Chlorophyll A

weirs eft

?

?AAVARIATION WITH TIME

COS

SAMPLE TOTAL NUMBER MEAN ?STANDARD

DATE, OF DEVIATION

SAMPLES

Oo

a - °

a

2 = 2

a

3

128, 5 25.65, 33.10

? = °

ee

BLVARTATION BY STATION

63

---Page Break---

su

Table 21

ary of Snail Surveys in Lake Caonillas

6

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|) date

Inspector

Snails found

May. 6/76

P. Bermudez

Tarebla granifera

Marts:

sornuarietis

Nov. 23/76

|

1

W. Jobin

Lymnaea columella

Physa cui

Tarebia granifera

mar. 11/77

K. Timoney &

R. Hereado

Tarebia.granifera

jaan 20/78

A. Laracuente

Lymnaea columel1.

Tarebia granifera

Physa cubensis

Suceinea

A. Laracuente

Tarebia granitera

Marisa cornuarietis

---Page Break---

TABLE 22

65

SUNNARY OF COLIFORH DATA OF LAKE cgonttias _ IN_Utuado _, Pte

FROM Maren 197710 _ Janus 1978, :

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£ waft? VT cast0 Or rr 19,000

2 2077 T cx106 oa 1 12,000

z 7/3777 T cn-108 0.1 25 25,000

-{s 7777 Tca-130 on 13 13,000

+ eat a OL ? 4,000

4 8/3/77 Tans 1.0 19 1,900

c e377 [carta on z 2,000

+e CEH a L 2 2,700

Jin {e377 ch-128 0.2 6 6,000

a e377 | cant2e 1.0 T 3,300

z 8/3/77 au [21 To

" 8/3/77 Tena 1.0 29 2,900

18 8/3/77 F ex-140 on 2 2,000

2 S377 TF cantso 1.0 28 2,800

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le wrar7 a Lo va 00

£ TTT cues Lo 105 10,500

> 1/777 | caia or 35 35,000

> TST | enag Lo Dat

z 17ST TT en-20 Ot 1 15,000

z 376177 T en-20 1.0 80 8,000

2 WET | ~en=26 On 7 37,000

2 wert Tox Lo a 7,500

4 1/67 TV ca-28 out é 6,000

4 wisi | ca28 10 a 100

1/677 | canae On ° o

¢ 19/6/77 Tense 10 3 300

2 15/6/77 | ca-40 0.1 3 5,000)

D 18/6/77 | cx-40 10 36 3,600

2 15/6/77 | carae Ont ° °

EB. 15/6177 Teas 1.0 7 100

2 15/6777 [cast O41 3 9,000

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TABLE 22 (continued) 6

SUNNARY OF COLIFORM DATA OF LAKE. Caontiias IN utwsdo_, Pun,

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A 16/9/77 | cx-a2 on 3 3,000

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3 16/9/77 | en-s2 1.0 37 5,700

¢ 36/9/77 | can38 0.1 6 6,000

c 36/9177 38 10 6 3,600

2 16/9777 ha 3A 0.2 3 3,000

i wa [ess | 1-0 [30 3.800

= 16/977 CA~46 On nn 11,000,

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A 176 CA-10 10 88 880

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A w/e [cane Pa rr 7.400

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B 12/1/78 cA-40 L 60 6,000 7

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fi nye [eta 1 2 206

A 12/76 | eis [19 | 10 100

> 2/7 | caus [1 L 100

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z | ?|?/s0

ovenriow

CARITE RESERVOIR

TOTAL COLIFORM STUDY DECEMBER 1975

Figure 17

---Page Break---

---Page Break---

TABLE 26 80

HYDROELECTRIC RESERVOIR STUDY

bY OF DATA FROM

axe Cavite

:

PARAMETER Chloride

uNITs Mg/1

|

AGVARIATION WITH TIME

SAMPLE TOTAL NUMBER MEAN ?STANDARD

DATE OF DEVIATION

SAMPLES

i

Liosw/77_ 23.5 4 5.87 0.99

ae 5089

2 4/5/77 _ 38.2 ? 3.35 0.38

em 85g

3

a

4

a

ee

9

ee

10

??

TOTALS 61.7. 8 27

2, a,

BAVARIATION BY STATION

A 14.7 2 2.35 1.45

ss

2.8 1 7.80 0.00

Ss

9.8 1 9.80 0.00

9.8 1 9.80 0.00

13.7 2 6.85 2.95

5.9 5.90 0,00

|

?TOTALS 61.7 8 zn

aL,

---Page Break---

TABLE 27

HYDROELECTRIC RESERVOIR STUDY

?SUMMARY OF DATA FROM

LAKE _Carite

PARAMETER _jardaees

unrrs g/l of Mg S04

i

A-VARIATION WITH TIME

SAMPLE TOTAL, NUMBER MEAN ?STANDARD

DATE OF DEVIATION

SAMPLES

?

2 177.7, 4 44.62 2.80

2 58.0 7 16.50 7

a ci

3

?_?_?

BLVARIATION BY STATION

63.8 2 31.90 12,50

Sra

50.0 1 50,00 0.00

tt

32.9 1 12.90 70,00

?????S

1 a. 0,00

OTA 235.7, 8 29,46

TF

Oo rr

E

(

2 25.85 15,05

Bento 0.00

roms 235.7 8 29.46

oe

---Page Break---

TABLE 28

HYDROELECTRIC RESERVOIR STUDY

?SUMMARY OF DATA FROM

Lake ?Carive

PARAMETER _Phos phates

|

unrrs Mgit

AGVARIATION WITH TIME

em EESs

SAMPLE TOTAL, NUMBER MEAN ?STANDARD

OF DEVIATION

SAMPLES

SS

2 0.08 4 o,o1 0.00

ttt

2 0.06 4 0.02 0.01

2. ceo

Torats 0.10 8 o,01

BLVARIATION BY STATION

0.02 2 0.01 0.00

ae 2 or 00

0.01 1 0.01 0.00

tt

0,01 0.00

ole

E 0.06 2 0.02 0.01

a

---Page Break---

?TABLE 29

HYDROELECTRIC RESERVOIR STUDY

?SU@ARY OF DATA FROM

LAKE _Carite

PARAMETER Nitrate

wars yg,

a

ASVARIATION WITH TIME

=> > S_

SAMPLE TOTAL, NUMBER MEAN ?STANDARD

DATE oF DEVIATION

SAMPLES

-_?o

1 0.20 0,05 0.02

TOTALS 0.22 8 0.03

BLVARIATION BY STATION

?_?_? reams

a 0.08 2 0,08 0.06

mt

B 0,05 1 0.05 0.00

oO

83

---Page Break---

?TABLE 30

HYDROELECTRIC RESERVOIR STUDY

?SUMMARY OF DATA FROM

LAKE ___Carite

PARAMETER _Iron

unrrs g/L

TT

ASVARIATION WITH TIME

???Onr?enumONESES

SAMPLE TOTAL, NUMBER MEAN. ?STANDARD

DATE OF DEVIATION

?SAMPLES.

OO

1 1.00 4 0425 0.10

0.31 @ 0,08 0.06

tt

2 :

20006

TOTALS 1.31 8 0.16

ts

BLVARIATION BY STATION

B 0.10 1 0.10 0.00

Soe 0h 0.00

P 0.03 1 0.03 0.00

= 0.34 2 0.17 0.14

0,40 184000

1.3 8 0.16

cr

---Page Break---

TABLE 31

HYDROELECTRIC RESERVOIR STUDY

?SUMMARY OF DATA FROM

LAKE __Carite

PARAMETER Turbidity

unrrs Standard unit

ADVARIATION WITH TIME

SAMPLE, TOTAL NUMBER MEAN STANDARD

OF DEVIATION

SAMPLES

=

2 12.8 4 3.20 0.45

?w vss

Torats a 32

BLVARIATION BY STATION

2.7 1 2470 0.00

8 2.8 1 2.80 0.00

©

85

---Page Break---

TABLE 32

HYDROELECTRIC RESERVOIR STUDY

SUYDIARY OF DATA FROM

LAKE __Carite

PARAMETER _Color

wits Scanderd Unie

SSS

AGVARIATION WITH TIME

sO E_?_ rx

SAMPLE, TOTAL, NUMBER MEAN ?STANDARD

DATE OF DEVIATION

SAMPLES.

TTT

2 38.0 4 9.50 0.75

282 soos

2 40.0 4 10.00 0.00

2 0.00 0.00

3

SSS

4

5

es

6

SSS

7

?

8

Se

9

SS

10

eS

TOTALS

78.0 8 9.75

8 ts

BLVARIATION BY STATION

-???Serarars ree

a 18.0 2 9.00 1,00

a 10.0 1 10.00 0.00

© 10.0 1 10.00 0.00

> 10.0 1 10.00 0.00

5 20.0 2 10,00 0.00

F 10.0 1 10.00 0.00

6

---Page Break---

TABLE 33

HYDROELECTRIC RESERVOIR STUDY

?SUMMARY OF DATA FROM

Lake Cavite

PARAMETER _P. i.

units

AVARIATION WITH TIME

SALE TOTAL, NUMBER MEAN ?STANDARD

DATE. oF DEVIATION

SAMPLES

?_ ??????S

2 29.1 4 7.28 0.08

2 28.3 ? 7.08 0.08

tg 008

57.6 8 7.18

BLVARIATION BY STATION

a 1s. 2 7.25 ons

?_?as es

B 7a 1 7.10 0.00

c

D

= 1d 2 7.20 0.10

F

87

---Page Break---

TABLE 34

HYDROELECTRIC RESERVOIR STUDY

SUMMARY OF DATA PROM

LAKE _Carite

PARAMETER Dissolved Oxygen

UNITS g/t

OO

AGVARIATION WITH TIME

SAMPLE TOTAL NUMBER MEAN ?STANDARD

OF

DEVIATION

SAMPLES

i 26.4 4 5.60 0.40

to

2 22.3 3 7.43 0.18

2 sg tg

BLVARIATION BY STATION

5.8 1 6.80 0,00

81 __6.80 ood

TOTALS 48.7 7 6.96

Se

Serre

TOTALS 48.7 z 6.96

Ls

28

---Page Break---

89

Table 35

Summary of Snail Surveys in Lake Carite

-

| A. Laracuente | Marisa cornuarietis

Pomacea australis

| granifera

Nov. 18/77 |W. Jobin Marisa cornvari.

Jarebia granifera |

Dionphalaria glabeatd

Marisa cornuariett

May 3/78 W. Jobin

Jarebia granifera

Pomacea australis

Tarebia granifera

Marisa cornuarietis

ug. 8/78 | A. Laracuente

Physa cubensis

---Page Break---

SUMMARY OF COLIFORM DATA OF LAKE _carite

Table 36

20

IN_cuayana__, PR.

ROW _bacenber_1975 TO _tay 7.

5

STATION mare | BET vou. [couones | S20NTES7

te sau | en on i 3 3,000

B/L1/77. ee 1,0 64 6 400

z 8/11/77 cB 10 ?TTC

= /11/73 CE-17 On 2 2,000

a POE WC 200

= SLUL/77 CENT 10 tune

+4 BAL o. L 1,000

+ A 7 10 8 80,

A 7 » 65 650

2 8/33/77 Out 8 8,000

2 BLU. 1.0 5h 5,400

f Tawar 10 oe

7" tame | ace i a

= 1/5/78 cA-2 10 8 80.

A 1/3/78 Chg 1 0 0

A 45/78 cant 10 2 240

£ 1/5/78 ?ch-6 1 [2 200

c 1/5/78 ch6 10 |e 180

D s/78 cA-8 1 1 100

7 areas bo m

i 2/5/78 CALs L 2 200

= 8 Ch-1 10 8 80 C

4 2/5/78 CA-20 1 iu 1,100

A 2/5/78. h-20 10 4 40

rs si7s [cana [1 1 109

ysi7a | eanae 10] 20 209

2 78 CA-32 1 2 200

2 |_ 2/5/78 CA-32. 10. 3. 50

z 4/5/78 | ca-52 L o 0

" usin |~ase [10] 6

? sina [ease [a i Tos

pj 2 An 20 1 10

a srs [easy [1 A 500

i 415178. Ch-53 10 we 140

} }

---Page Break---

STATION pare | fTELD COLONIES ?ort |

?to 415/78 CAS L 0 0

2 415/78. CAST w | 3 ED

A Near tim 12/18/75 i60

fa 12/16/75. 480

?* 32/27/75 "20

("a Im lake near la Plate Riv 12/18/75 750"

= ?Ties =

2 32/16/75, 220

8 32/17/75, 250

{Sip cress im fa piame nivel 42/10/75 se

32 12/17/75 580

z 12/16/75 250

z 12/16/75, 660

enero =

La 12716775 =

4 12/17/75, 540

2. TepfeRen Above Sewaee To a75 320

Ta 12/18/75 20

J

{

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or ae

7 or

ET Trp 7

oer T or

Foor er 0

al oor 7

roe 7

wes oo

wo Tors oF

TO eo vr

or *

FE SF TF

q

qi

Ey

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RT

oo] wT TRS oF

Oa] aT TRS a

Tap BT ay SET

voy wr TRH

Ga ad aT

wat

wot

at Ro cal

?eg 8 yp TST ays Aes 180 OW

---Page Break---

taco cARRAIZO ee

Figure 18

---Page Break---

---Page Break---

fo

i

ki

---Page Break---

TABLE 40

HYDROELECTRIC RESERVOIR STUDY

?SUMMARY OF DATA FROM

LAKE __Cargaizo

PARAMETER __chloride

unrTs Mg/1

?

?ARVARIATION WITH TIME

=| ??Seae??errygssESESE

SAMPLE TOTAL, NUMBER MEAN ?STANDARD

DATE oF DEVIATION

SAMPLES.

OO

Ayay77 126.6 z 18.09 1,40

2 4 17.45 3.95

3 19/9/77 62.5 3 20.83, 0.89

4 yig77_ 32.8 3 10.92 3.16

21/4/78 56.8 4 14,20 4.53

6

?_).?

7

TE

8

9

TOTALS 348.5 2 16.59

BLVARIATION BY STATION

107.6, 6 17,93

SL a

99.8 6 16.63 3

ts 88

£ 80.4 5 16.08 2.54

> 60.7 15.18 2.02

z

99

---Page Break---

?TABLE 41

HYDROELECTRIC RESERVOIR STUDY

?SUMMARY OF DATA FROM

LAKE _Carraizo

PARAMETER Hardness

mits ng/L of Me S04

AGVARIATION WITH TIME

SAMPLE TOTAL, NUMBER MEAN ?STANDARD

DATE oF DEVIATION

SAMPLES.

1 870.1 7 124,30 7.83

2 163,68. 4,00

3 352.1 3 120,70 3.60

??{ _- rrr

4 3.6 3 114,80 4.93

5 425.7 4 105.43 22.63,

6

?_

7

ee SSSSSSSSSSSssSFs

a

?

9

b $$ ___________

Ce

TOTALS 2,657.0 2 126.52

BLVARIATION BY STATION

a 786.5 6 131,10 12.35,

tt

B

? 6 122.23 17.45,

©

5 323.6 20.68

2 520.1 4 130,03, 17.58

I

E

?

100

---Page Break---

?TABLE 42.

HYDROELECTRIC RESERVOIR STUDY

?SUMMARY OF DATA FROM

LaKe _Carraizo

PARAMETER _Phosphates

units g/l

AGVARIATION WITH TIME

????ornrnHmMbik&ke

SALE TOTAL NUMBER LAN StANDAKD

tate oF DEVIATION

SAMPLES

a

1

Sos 0.36 0.18

2 mi 0.52

3 0.27 0.09

Ao toe 000

5 0.6 4 0.14 0.06

6

TOTALS 5.9 2 0.28

a 2.6 6 0.43 0.33

B 1s 6 0.23 0.15

© 8 5 216 ont

2p La 4 0.28 0.13

F

F

>

?_?_

$$

?TOTALS 54 ? an

101

---Page Break---

?TABLE 43

HYDROELECTRIC RESERVOIR STUDY

SUMMARY OF DATA FROM

LAKE _Carraizo

PARAMETER Nitrate

me/t

unrTs

A=VARIATION WITH TIME

SAMPLE TOTAL NUMBER MEAN ?STANDARD

DATE oF DEVIATION

SAMPLES

?_

x 1.8 7 0,26 0.09

0.5 % 0.13 0.08

2 0.4 2 0.13 0.04

4

8.07 2 0.38

BLVARIATION BY STATION

6 0.36 0,35

Aa 2,05

lo

B

2.22 6 0.37 0.35

£ 1.8 5 0.36 0.30

>

PB 2.0 4 0.50 0.50

F

---Page Break---

?Taste 44

HYDROELECTRIC RESERVOIR STUDY

SUMMARY OF DATA FROM

LAKE Carraizo

PARAMETER Tron.

untTs ee/1

es

AGVARIATION WITH TIME

SAMPLE ?TOTAL, NUMBER MEAN ?STANDARD

DATE oF DEVIATION

SAMPLES

Se

* 5:3 z 0.76 0645

es ts

2 4 0.33 on19

0.20 0.07

4

4 3 3.47 0.22

on7

s 3.9 4 0.98

Se

21.5 2 1.02

a

BLVARIATION BY STATION

4 1s 6 1,23 0,88

B 5.9 6 0.98 0.86

£ 5.4 5 1,08 0.85

2 4 0.70 0.50

0 0

103

---Page Break---

?TABLE 45,

HYDROELECTRIC RESERVOIR STUDY

?SUWMARY OF DATA FROM

Lake _Carraizo

PARAMETER _Turbsaity

units Standard inst

es

AGVARIATION WITH TIME

2 o?r?r?ororr

SAMPLE ?TOTAL NUMBER MEAN ?STANDARD

DATE oF DEVIATION

SAMPLES

Ee

2 104,90 z 14.99 9.89

2 6 4 8.65 3.10

3 13.08, 11.95

4 133.0 3 44,33 Osh

2. an

5

ToraLs 311.73 vy 18.34

BLVARIATION BY STATION

-] i Cc [Fh

a

88.6 5 17.72 12,38)

B

83.33, 5 16.67, 14.67,

$$ 5 __16.67)_ 4.67

£ 101.5 4 25.38 12312

$1 588 tt

D

a 32.77 11.42

F

?

F

a

c

SS

a

?TOTALS es oe oe

10%

---Page Break---

TABLE 46

HYDROELECTRIC RESERVOTR STUDY

SUMMARY OF DATA FROM

LAKE _Carraizo

PARAMPTER _Coloe

units Standard unit

AGVARIATION WITH TIME

SAMPLE. TOTAL NUMBER MEAN ?STANDARD

DATE OF DEVIATION

SAMPLES.

a 142.0 z 20.29, a2

2 90.0 4 22.50 3.75

3 58.0 3 R33 0.89

4 112.0 3 37.33, 16.89

2 80.0 4 20.00 2.50.

yoTALs 482.0 a 22.95,

BLVARIATION BY STATION

a 162.0 6 27.00. 9.67

5 155.0 6 25.83, 8.50

© 9540 5 19.00 3,20

> 70,0 4 17.50 2,50

tts 25

ee

F

?

6

es

"

a

TOTALS cae

105,

---Page Break---

?TABLE 47

HYDROELECTRIC RESERVOIR STUDY

?SUYMARY OF DATA FROM

Lake | Carraizo

PARAMETER _P

unrrs

eS

AGVARIATION WITH TIME

E000 Oa? ?esS5

|

SAMPLE TOTAL, NUMBER MEAN STANDARD

DATE, OF DEVIATION

SAMPLES

SS

* 4 2 7.07 0.17

2 28.7 4 7.18 0.08

2s 0.08

3 22.7 3 2.57 0.26

Sa ee

? 2242 3 7.40 0.67

tt

52.1 a 7.2%

BLVARIATION BY STATION

43.1 6 7.8 0.15

ts

B 43.4 6 7.23

Se

£ 36.4 5 7.28 0.26

te

ha 2942 4 7.30 0.15

TOTALS deo on aa

Los

---Page Break---

?TABLE 48.

HYDROELECTRIC RESERVOIR STUDY

SUMMARY OF DATA FROM

axe Canraizo

PARAMETER Dissolved Oxygen

units eg/t

ACVARIATION WITH TIME

SAMPLE, TOTAL, NUMBER MEAN STANDARD

DATE OF DEVIATION

SAMPLES,

Sh

2 6.6 2 3.30 2

>was] ae

2 18, 4 4.65 8

Ag

2 14.8 3 4.93 1.22

?_?- dass SE Ee

107

---Page Break---

TABLE 49)

HYDROELECTRIC RESERVOTR STUDY

?SUMMARY OF DATA FROM

LAKE _Carraizo

PARAMETER chlorophyll &

umrrs sl

ASVARIATION WITH TIME

SAMPLE TOTAL NUMBER MEAN ?STANDARD

DATE oF DEVIATION

SAMPLES

or

1

$$$ $e

2 65.0 ? 16.25 3.75

25.0 16.25 9.75

3 23.3 3 8.43 2.08

a a a a 2 ey

4

?

5

?

6

ss

7

?

8

?

9

SS

10

es

TOTALS

9043 z 12.90

ae ee 2 es

BLVARIATION BY STATION

A 6.6 2 3.30 2.3

2 2042 2 10,10 19

ett

£ 3945 2 19.75 8.25

8

Pp 26.0 L 24.0 0.00

108

---Page Break---

109

Table 50

Summary of Snail Surveys in Lake Carrafzo

bate Inspector Snails Found

juts 14/76 |W. Jobin Biomphal, Labeat

Tarebla granifera

tralis

Pomacea a

fr. 20/78 | A. Laracuente | marisa cornuarietis

| Tarebia granifera

| Physa cubensis

bo

Lymnaea columella

Marisa cornuarietis

1

Pomacea australis

Laracuente | Tarebia granifera

australis

Physa cubensis

---Page Break---

Table 51 no

SUIMARY OF COLIFORM DATA OF LAKE Careatzo 1 Lean.

FROM Jemuary 197) 10 _apeit 1978,

?STATION pare] RE? [wpu. [couowres | SSL0N57

x an | i = 0

TE 77 7" 7 :

7 ayn | 7 i Too

n arin | 7 am .

an} Tea

Te avarrt[? peor

jr 277 = T pversrow

v 2/77 = 10 overgrown

iM. 2/77 = T T 09

[a alr = To 3 Ea

¢ BrP Tam

re shin | wtf 3 mo

4x 237% 10-6 10 > 30"

¢ ?shit 93 2 00

m BATT} ?}

Te whim [ea |} i hs

wan} Ta

: wart EHP

r a sae

? wear rae

" vw | fase io

¢ wrap Pe

wan | ee |

A 28/9/77 | -6 a ?164 "164,000

ri ein | ue | ae

1. 2a/sirr | ue | ae ae

~ 2819/77 Lis L TNCT

2/917) | tsk | Tas

z BOT ips ?135000

a anon ape 200,000

Ta ene 1 ass 253,400

rs nor Tea Sitter

| t -

---Page Break---

Table 51 (continued) uu

SUMMARY OF COLIFORM DATA OF LAKE Carratzo IN, + PAR

FROM January 1977 TO _Apeit 1978.

FIELD (COLONTES/|

STATION pare | ae vot. | conowres | COLONz

29/10/77 =

29/10/77 = 7 Tes

30/10/77 . 2.53 = 10

30/10/77 ? Tae i

30/0/77 : Tite

30/10/77 nes

30/10/77 1.65 x 105

39/10/77

Tae : Tax 0

21/4/78 T3550

27/4/78

27/4/78 5. 13 x 108

27/4178 r 33900

27/4/78 2,000

20/4/78. 00

---Page Break---

+ eae otee

---Page Break---

= 7

> =

" >

re :

Waareng | gatea | uthen .

pesdeta | Ting 30 oe ?res

hae :

epee eens

TOOT ZEST

---Page Break---

GRAFICA DE OXIGENO DISUELTO Y TEMPERATURA

(My

PROFUNDIDAD

LAGO CARRAIZO (ESTACION-A)

, DISTRIBUCION VERTICAL (3 DE AGosTo 1978)

3.0

38

as

5.0

as

60

és

10

1s

TEMP °c

LEYENDA

TEMP.

OxIGENO

OXIGENO (PPM)

1s

---Page Break---

PROFUNDIDAD (M.

UAGO CARRAIZO ?VESTA CION?8) Ls

GRAFICA iDE ?OXIGENO DISUELTO Y TEMPERATURA

DISTRIBUTION WERTICAL (3 OE ?AGOSTO 1978)

TEMP

2 90 8s ?40

10

EVE NDA:

TEMP

OXIGENO (PPM)

Figure 20

---Page Break---

vt Sri Tv

?4 CT OTTTPST xq SATE 1 os awwes viva HOW

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vp wT wT

wep wT] we

wT

a a eT vo

uas0 W 6°01 NBA STOWE TW

wz] oo

Topo

dope

we] oe

we

"wa CN STTTTT yt ? OPES ay1 wos saws vive OW

HRT RTT ETT

---Page Break---

TET Oe EE

we wee ToL we] TAYE ara

Ty sows

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1g

REPRESA

CaRRETERE

?% OUT OF ORDER JAN 16,17-1976 LAGO.

SPILLING IN LAKE DE

CIDRA

Figure 21

---Page Break---

---Page Break---

Figure 22.

This conerete dam across the Bayamén River forms

Lake Cidra part of the San Juan urban water supply.

Although this section of the lake near station A

fs clean, an upstream discharge of raw sewage was

stimulating water hyacinth growth in the southwest

branch near station £, during 1976.

---Page Break---

---Page Break---

---Page Break---

Table 55

Summary of Snail Surveys in Lake Cldra.

Date Inspector Snails Found

Jan. 23/76 W. obin, Pomacea australis

A. Laracuente Lymnaea cubensis

& 8. Velez Physa marmorata

Marisa cornuar!

---Page Break---

are

---Page Break---

Table 57 124

JOINT STUDY OF CAYEY UNIVERSITY COLLEGE AND PUERTO RICO NUCLEAR

PHYTOPIANKTON DENSITY

STATION AL

SUMMARY OF DATA FROM LAKE CIDRA,

?SURVEY OF: JANUARY 1976

SSS

Date Algae Total Count Density of

for ALL Phytoplankton

Squares per/ML

114-76 Fragtlaria spp. 4 4.30

Coelastrum spp. 1 1.10

Staurastrum spp. 2 2.15

Kirchneriella spp. 1 1.10

Flagellate (Diatom) ~ Unidentified 2 2.15

Gp. Green Algae ~ Unidentified 2 2.15

SS

Sum Total of Count for 2 -

All Squares

Total Phytoplankton Density - 12.90

per ML.

---Page Break---

Table 58 ies

ONT OF cay IVERSITY COLLEGE AND PUERTO RICO CENTER

PHYTOPLANKTON DENSITY.

STATION B

RY OP DATA FROM LAKE CID!

SURVEY OF: JANUARY 1976

Total Count Density of

Date Algae for AL Phytoplankton

Squares per/ML,

1-14-76 Staurastrum spp. 4 4.30

Gomphosphaeria spp. 1 1.10

Dictyosphaerium spp. 1 1.10

Frailaria spp. 1 1.10

Peridinium spp. 7 7.82

Flagellate (Diatom) - Unidentified 13, M0

Gp. Green Algae (Colonial) - 1 1.10

Unidentified

Sum Total of Count for 28 -

All Squares

Total Phytoplankton Density - 30.07

per ML

---Page Break---

Table 59

INT STUDY OF CAYEY UNIVERSITY COLLEGE AND PUERTO RICO NUCLEAR CENTER

PHYTOPLANKTON DENSITY

STATION C

SUMMARY OF DATA FROM LAKE CIDRA

?SURVEY OF:_JANUARY 1976

?Total Count Density of

Date Algae for All Phytoplankton

Squares per/ML

en

1-14-76 Fragilaria spp. 8 8.60

Frustulia spp. 1 110

Navicula spp. 1 Ato

Dictyosphaerium spp. 6 6.44

Mallomonas spp. 2 2.18

Coelastrum spp. 2 2.15

Synedra spp. 1 110

Scenedesmus spp. 1 1.10

Flagellate (Diatom) ~ Unidentified 3 3.22

Centric Diatom ~ Unidentified 1 110

?Sum Total of Count for 26 -

All Squares,

Total Phytoplankton Density - 28.0

per ML

---Page Break---

Table 60 127

IOINT STUDY OF CAYEY UNIVERSITY COLLEGE AND PUERTO RICO NUCLEAR CENTER

PHYTOPLANKTON DENSITY

STATION D

SUMMARY OF DATA FROM LAKE CIDRA

SURVEY OF: JANUARY 1976

?Total Count Density of

Date Algae for ALL Phytoplankton

Squares per/ML

1-14-76 Peridinium spp. 20 21.50

Staurastrum spp. 3 3.22

Gomphosphaeria spp. 2 2.15

Cosmarium spp. 1 1.10

Mallomonas spp. 1 110

Gp. Green Algae - Unidentified 1 1.10

Flagellate (Diatom) - Unidentified 19 20.40

Sum Total of Count for a7 -

All Squares.

?Total Phytoplankton Density - $0.50

per ML

---Page Break---

Table 61 128

ION? 1 INIVERSITY COLLEGE AND PUERTO RICO NUCLEAR CENTER

PHYTOPLANKTON DENSITY.

PATION,

SUMMARY OF DATA FROM LAKE CIDRA

SURVEY OF: JANUARY 1976

Total Count Densityof

Date Algae for All Phytoplankton

Squares per/ML

14-76 Erustulia spp. 1 1.10

Scenedesmus spp. 2 2.18

Mallomonas spp. 1 110

Fragilaria spp. 6 6.46

Dictyosphaertum spp. 1 1.10

Staurastrum spp. 2 2.18

Peridinium spp. 1 1.10

Gomphoneis spp. 1 110

Gp. Green Algae - Unidentified 1 110

?Sum Total of Count for 16 -

All Squares

?Total Phytoplankton Density - 17.20

er ML

---Page Break---

Table 62 : 129

JOINT STUDY OF CAYEY UNIVERSITY COLLEGE AND PUERTO RIGO NUCLEAR CENTER

PHYTOPLANKTON DENSITY

STATION X

Gelow Cattle igrid)

(Bubulous sbis) nest

SUMMARY OF DATA FROM LAKE GIDRA

SURVEY OF: JANUARY 1976

Total Count Density of |

Date Algae for AML Phytoplankton

Squares er/ML

114-76 Scenedesmus spp. 1 1.10

Peridinium spp. 5 5.40

Staurestrum spp. 1 1.10

Mallomonas spp. 1 1a

Euglena spp. 1 1.10

Cymbella spp. 1 1.10

Fragilaria spp. 3 3.22

Dictyosphaerium spp. 2 2.15

Navicula spp. 1 1.10

Gp. Green Algae ~ Unidentified 3 3.22

Gp. Green Algae (Colonial) - 1 110?

?Unidentified

Sum Total of Count for 20 -

All Squares

Total Phytoplankton Density - 17.20

per ML

---Page Break---

4

osisaey 20 aownne g/ o1w

osisauv-sv208 soo op¥7

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Figure 24,

A dense population of Tarebia granifera on a stick

taken from Lake Dos Bocas near station B.

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refpowod gt

|

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TABLE 64

HYDROELECTRIC RESERVOIR STUDY

SUMMARY OF DATA FROM

LAKE _ Dos Bocas,

PARAMETER Chlorides

units g/L

AGVARIATION WITH TIME

SAWPLE TOTAL, NUMBER MEAN STANDARD

DATE, OF DEVIATION

SAMPLES

1976

2 9.10-11/11 96.2 15 5.75, 410

24/277 50.8 10 3.08 0.96

3 20/5/77 37.3 5 7.46 1:87

4 29/8/77 36.1 5 7.22 1.26

8 sprai77_ 25.4 5 5,08 0.96

6 29/3/78 _ 26.5 5 5.30 0.72

262.3 45, 5,83

BLVARIATION BY STATION

a 13.3 2 6.65 175

s 48.9 8 6.31 Let

£ 46.1 8 5.76 0.80

> 37.5 8 4.69 Lag

g 3h.4 8 6.80 1.78

F 8.6 2 4.30 0.20

s 42.5 1 6.07 0.59

Md aw 2 5,50 0,00

---Page Break---

?TABLE 65

HYDROELECTRIC RESERVOIR STUDY

?SUMMARY OF DATA FROM

LAKE Dos Bocas

PARAMETER Hardness a5 Mg $04

unrts w/t

ACVARIATION WITH TIME

SAWPLE TOTAL, NUMBER MEAN STANDARD

DATE OF DEVIATION

2 1,294.5 as 86.30 15.21

967.0 20 96.70 10.38

389.7 5 117,96 2.93

* 610.2 5 122,04 6.05

94,18 8.94

£ 456.5 5 91.30 9.72

|

g

pals 4388.8 45, 97,53

BLVARTATION BY STATION

a 251.5 2 125,75 4.85

ba 21.2 8 102.65 13,91

97,0 8 99.62 20.86

73646 92.08, 13,05

752.8 2 94.10 17.30

2s 266.25

s 200.1 7 100.1 10,16

a on 2 ess ts

OAL. 4,388.8 45, 97.53

136

---Page Break---

?TABLE 66

HYDROELECTRIC RESERVOIR STUDY

?SUMMARY OF DATA FROM

take "Dos Bocas

PARAMETER _Total Phosphates_as P

units, g/l

ALVARIATION WITH TIME

SAMPLE TOTAL, NUMBER MEAN ?STANDARD

?DATE OF DEVIATION

SAMPLES

2 0.35 uw 0,02 0.01

30 0.01 0.00

OL 0.00

o,o1 0.00

0.05

0.05 o.01 0.00

0.05 0.01 0,00

0456 4 0.01

BLVARTATION BY STATION

a 0.07 2 0.06 0,02

® 0.32 8 0.02 0.01

0.01 0,00

0,01 0,00

ae tp

apap

aye

é

437

---Page Break---

TABLE 67

HYDROELECTRIC RESERVOIR STUDY

?SUMMARY OF DATA FROM

take _ Dos Bocas

PARAMETER __Nitrate & Niteite as N

units a/t

Se

ASVARIATION WITH TIME

SAMPLE TOTAL, NUMBER MEAN ?STANDARD

DATE oF DEVIATION

SAMPLES

a 48 u 0.36 0.18

2 tls 10 0.08 0.02

es ito ong 0.02

2 0.50 5 0.10 0,00

2 5 _o10 ooo

4 0,02 5 0,00 0,00

et

5 0.45 5 0.08 0.02

6 0.27 5 0.05

TF

BLVARTATION BY STATION

1b 2 0.70 0.10

B 1.6 8 0.18 0.16

0.58 8 0.07 0,04

> 0.66 8 0.08 0.05

5 0.61 8 0,08 0.04

0.60 2 0.30 0,00

---Page Break---

?TABLE 68

HYDROELECTRIC RESERVOIR STUDY

SUM?ARY OF DATA FROM

Lake Dos? Bocas

PARAMETER ____ Tron.

units ng/1

AGVARIATION WITH TIME

Sawur Tora Nowe pa STANOARD

ore oF BivEAS TON

sawwuns

2 11.5, 15 0.77 0.57

2 27 10 0.27 0.18

3 14 5 0.28 0.22

a

5 4.8 5 0.96 0.54

6 0.67 5 0.13 0.08

21.29 45 0.47 :

BLVARIATION BY STATION

a Pes 2 2.20 0.40

5S 3.66 8 0.46 0.06

¢ 2.03 8 0.25 o.n7

2 1.73 8 0.22 ont

5 2.36 8 0,29 0.23

2.9 2 1.45 0.05

s 3.63 z 0,52 0.28

H 0.6 2 0.30 0.10

TOTALS 21.29 45, 0,47

---Page Break---

TABLY 69

HYDROELECTRIC RESERVOIR STUDY

SUMWARY OF DATA FROM

LAKE "Dos Bocas

PARAMETER ?Turbidity

untts Standard Unite

?ALVAZIATION WITH TIMP

Swes? TOrAL Nome wan STANDARD

TATE oF INEVENTION

saMPLis

2 163. 13 12.58 9

2 48.9 3089

0.2 s 0,06 0.02

5 1041 s 14,02 2.82

7

@

2

10

sors 320.8 38 8.

a 25.0 1 _

B Toad z 10,60 8,03

© 3h. 1 4.89 3.57

2 52.9 1 7.56 3.34

' 60.8 2 8.69 4.60

Fr 26.0

°

?TOTALS 320.8 38 8.44

140

---Page Break---

?TABLI 70

HYDROELECTRIC RESERVOIR STUDY

SUMMARY OF DATA FROM

Lake Dos Bocas

PARAMETER __Color

units Standard nse

Sn

ALVARIATION WITH TIME

eo

SAMPLE TOTAL NUMBER MEAN ?STANDARD

DATE OF DEVIATION

SAMPLES

SSE

a 318.0 a5 21.20 16,03

SS

10

$e

TOTALS 695.0 4s 15.44

BLVARIATION BY STATION

et te

$$$ enr SATION

a 0 2 12.50 7.56

B 112.0 8 14,00 6,00

£ 96.0 8 12.00 3.00

50 __§ __iz.00 3.00

D

103.0 8 12.88, 410

ttt

E 117.0 8 14.62 5.28

et

72.5 50

|

12.43,

10.00 2 5.00 0.00

jms oe

TOTALS 69540 45 15.44

te

aan

---Page Break---

TABLE 71.

HYDROELECTRIC RESERVOIR STUDY

SUYMARY OF DATA FROM

LAKE Dos Bocas

PARAMETER PH.

|

units

?

AGVARIATION WITH TIME

?_?_? meee SSS

SAMPLE TOTAL NUMBER MEAN ?STANDARD

DATE OF DEVIATION

SAMPLES

?-??? SEE

2 108.6 35 7.26 0.20

St

2 8 10 7.28 0.13

22 ___o_ es tg

3 39.3 5 7.86 0.13

ts

4 36.5 5 7.30 0.20

ot

5 1 5 2.22 0.06

6 39.0 5 7.80 oz

tz

?

?

TOTALS 332.3, 4S 7,38

BLVARIATION BY STATION

A 14.7 2 7.35 0,05

B 58.5 8 7.31 0.31

© 59.5. 8 7th 0.18

e 59.7 8 7.46 0.19

E 59.1 8 7.39 0,29

F 13,9 2 6.95 0.05

s 51.9 7 7.41 0.30

15.0 2 7.50 0,10

ane

---Page Break---

?TABLI 72

HYDROELECTRIC RESERVOIR STUDY

?SUMMARY OF DATA FROM

PARAMETER Dissolved Oxygen.

ws aa/L

A-VARIATION WITH TIME

SAMPLE ?TOTAL, NUMBER MEAN ?STANDARD

DATE oF DEVIATION

SAMPLES

x 77.0 8 9,62 1,90

2 te

3 40.9 5 8.18 0446

4 34.0 5 6.80 0456.

5 4245 5 8.50 1,06

6

7

8

A

B 46.3 5 2.26 14a

£ 1.6 6 8.60 ?07

> a0 3 8.20 1,00

5 29.9, 5 7.98 Lm

F 47 1

s 36.0 5 1.20 1.36

® 28 A

163

---Page Break---

TABLE 73

HYDROELECTRIC RESERVOIR STUDY

?SUMMARY OF DATA FROM

LAKE _ "Dos Bocas?

PARAMETER Chlorophyll A

an

unirs

AGVARIATION WITH TIME

SAMPLE TOTAL NUMBER MEAN ?STANDARD

DATE ?oF DEVIATION

SAMPLES

???V???r

1

TOTALS 20.4 4 2.60

BAVARIATION BY STATION

aaa

---Page Break---

Table 74

Summary of Snails Surveys in Lake Dos Bocas

Date

Inspector

Snails Found

jul. 12/76

2. Ay Bermudez

Marisa cornuarietis

Tarebia granifera

W. Jobin

Lymnaea cubensis

Iarebia granifera

Marisa cornuarietis

Physa marmorata

Blomphalaria glabrat.

jar. 31/78

Re Brown &

Ay Laracuente

Physa marmorata

Lymnaea cubensis

Tarebia granifera

isa cornuarietis

Iropicorbis riiset

pug. 8/78

A. Laracuente

Helisoma caribacum

Tarebla granifera

Marisa cornuarietis

Physa marnorata

Lymnaea columella

14s

---Page Break---

Table 75

SUNMARY OF COLIFORM DATA OF LAKE moe Bocas IN| Arectbo

FROM Fede 19710 arch 1978.

\sTATION pare | RE] vow. [cononres | SOLONTES/

?Te aa | pase z 2 7

£ 3/2/77 DB-38_ 10. 0 o

D> aL Et: 1 1 100

D s/2/77 | ma-u5 1 n 70

£ 12 pB-52 1 3 300

Te. 3/2/77 | m-52 0 F 30

fe 3/2/77 DB-59 2 6 600

- = 3/2/77. DB-59 10 39 390

2 302l pee? r 2 1,200

3 3/2/77, DB-67 10. THT o

c 3/2/77 z rf ri 0

t 3 28/2/77. DB-95 10 3 30

2. 8/2/77. DB-85 1 2 200

2 8/2/77 DB-90. 10. 6 60

2 8/2/77 DB-90 1 o oO

te e277 | 08-92 18 c 2

js 8/2/77. DB-92 1 2 200

Lz 8/2/77 DB-93. 10 65. 650.

= 8/2/77 DB-93. 1 7 700

c evar) | 08-96 10 a 120

Te e/2/77 | a-96 ri ri 700

£ 9/2/77. 10 o o

A 9/2/77 z 3 o

> s/2i77 10 1 30

> 3/2177 ri o °

¢ 9/2177 20 n 0

S 9/2/77. 1 2 200

A 9/2177 10 2 20

= 9/2/77 > 1 1 100

3. 9/2/77. 10 192 1,920

2 9/2177, 1 34 3,400

Ce els Fe ° r

! ¢ x6/si77|_oe-201_| 1 0 2

t

Ud

4

---Page Break---

SUMMARY OF COLIFORM DATA OF LAKE _Dostocas

Table 75 (continued)

Fron February

STATION

DATE

16/5/77,

16/5/77,

16/5/77,

16/5/77

16/5/77,

16/5/77,

1/5/77

17/3/71

27/5/77

18/547

18/5/77

18/5/77

S/T

38/5/77

1/5/77,

18/5/77

19/5/77,

19/5/77,

19/5/77

u

710 March

FIELD

NUM,

8-203,

8-203,

8-204

DB-204

5-205

8-205

B=209|

215.

DB 215,

B=222

3-221

8-227

32

5-232

B=239)

DB 2:

DB=265,

1DB=247

3-247

8-248

268

147

IN Arecibo PR.

1978.

?COLONIES/

couonres | COLONK

100

o

---Page Break---

Table 75 (continued) Las

SUNMARY OF COLIFORM DATA OF LAKE Dos Bocas IN__Arecibo_, PR.

FROM February 1977 10 _Mareh 1978.

STATION pare] BRE | vpu. | orowres | Soo06557

= Ts w %

Zz r 300

> 19/5/77 10 %0 900 |

> 19/5/77, 2 18 1,800

A 9/77 10 3 0 z

in 9/7 2 2 200

is 39/77 70 Tv w

a" 1/9/77, 1 o o

c sir 10 ee 0

Te 19/77 ri 5 500

+2 w9/r7 10 26 260

D warm ?i 2 20

Le srr 10 102 1020

1E ber 1 2 800,

iA sna} mm 7 1000

wi 6/12/77 = 1,0 23 2.300

B Sei = OL 22 22,000,

2 shan | 1.0

c 6/12/77 ~ ot | 1000

? een | 1 5 1500

> saan | 2 ° 0

fe ena ? Fi 3 100

Ye s/2/77 - ah 15 15,000 | *

E ena | z 2 8,200)

a mar |= 1 0 °

rn zai | L a 4,100

2 mun | mn ° a

2 7am | 1 10 1,000

© Taam | a 6 6,000

£ 72/77 ~ 1 22 2,200

> mam | rm 7 7,000

?b maar) 1 10 1,000

= T1277 = al 26 26,000

z may |= 1 1s 24500

t

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Table 75 (continued) 14g

SUMMARY OF COLIFORM DATA OF LAKE Dos Bocas IN_Arecibo _, P.R.

FROM February 197710 mavens 1978.

FIELD ?COLONTES/}

STATION pars | fe vgt. | covozes | $9LONr

28/3/78 out 2,000)

28/3178 1.0 700

28/3/78 ct

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28/3/78 or

28/3/78 1.0

28/3/78 on

2873178 1.0

BITTE

2/3/78

28/3778

BITTE

28/3/78

Ba/3T78

2/3178

28/3/78

28/3/78

28/3/78

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HONORS STOEL

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LAgo 00s Bocas 155

GRAFICA DE OXIGENO DISUELTO Y TEMPERATURA

DISTRIBUCION VERTICAL ESTACION-c (8 DE AGOSTO DE 1978)

TEMPERATURA (*¢)

3 Levenoa

2 Tewrenaruna

2 Ta==s oxroeno

OxIGENO (PPM)

Figure 25

---Page Break---

DISTRIBUCION VERTICAL

(m)

PROFUNDIDAD

GRAFICA

50

er rt

180

150

156

LaGO DOS Bocas

DE OXIGENO DISUELTO Y TEMPERATURA

ESTACION-D (3 DE AGOSTO DE 1978)

TEMPERATURA

1s 20

m4

wey

LEYENDA

TEMPERATURA

~ OXIGENO

6

OXIGENO (PPM)

Figure 26

---Page Break---

ois

om

PROFUNDIDAD

Lasgo 0s Bocas

GRAFICA DE OXIGENO DISUELTO Y TEMPERATURA 157

TRIBUCION VERTICAL ESTACION-c (8 DE AGOSTO DE 1978)

TEMPERATURA (*c)

5 Is 20 25 30s

er ar

sof LEYENDA

TEMPERATURA

OXIGENO

sof

eof

no

ash

ooh

* 5 6 7 8

OXIGENO (PPM)

Figure 27

---Page Break---

my

PROFUNDIDAD

30

LAGO DOS Bocas

GRAFICA DE OXIGENO DISUELTO Y TEMPERATURA

DISTRIBUCION VERTICAL ESTACION-u (8 DE AGOSTO DE 1978)

TEMPERATURA (c)

5 10 18 20 as

Por A

LEYENDA

TEMPERATURA

OXIGENO

V2 sas ee

OXIGENO (PPM)

Figure 28

1s.

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Tay

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wp eo] oo

Hala:

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Teavesa05

outs |

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STO

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suaian

9161-9261 ' s¥D08 soo

anya

yos

awooay 13A37

ualvm

Nouyaaaa

aaa

Figure 29

---Page Break---

162

VERTEDERO TIPO

?TROMPETA

QUESRADA

AL OESTE

CARRETERA NO, 518

VALLE DEL RIO GARZAS

REPRESA

oe SAMPLING

STATIONS ?QuEeRADA//GRANDE AL SUR

REPRESA GARZAS DE ADJUNTAS, PR.

Figure 30

---Page Break---

163

Figure 31. Overflow spillway on Lake Garzas at high water

level in November 1976.

---Page Break---

---Page Break---

Figure 32.

Overflow spillway on Lake Garzas at low water level in July 1976.

164

---Page Break---

---Page Break---

poor

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? fe

sus [eee | ov | eatin on |an yar

stants | ?thier? | raieotoreouatonere| en sees

Tar

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?Her | rAedetor

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?TABLE 79

HYDROELECTRIC RESERVOIR STUDY

?SUMMARY OF DATA FROM.

Lake Soares

PARAMETER Chlorides

UNITS ay/L

AGVARIATION WITH TIME

SAMPLE TOTAL, NUMBER MEAN ?STANDARD

DATE oF DEVIATION

?SAMPLES

?.

2 30/11/78 19.5 3 3.90 0.00

2 23/6/77 8.1, 3 1.62 .6t

3 23/9/7778 5 1.56 0.53

4 27/1/78 49 4 1.22 0.72

5 17y/5/78_37.0 5 7.40 0.48

77.3 24 3.22

ee

BLVARIATION BY STATION?

A 17.6 3 3.52 1.86

B 35.7 5 3.6 2.47

£ 14.8 5 2.96 2.31

p 13.5 4 3.38 1,98

B 15.7 5 3.14 1.77

?TOTALS 7.3 2% 3.22

---Page Break---

?TABLE 60

MYDROSLECTRIC RESERVOIR STUDY

?SUMMARY OF DATA FROM

LAKE __Gerzas

PARAMETER Hardness a8 NeSo4

vunrrs ng/L

eS

AVARIATION WITH TIME

?).????X?¥?lrOmOm?S

SAMPLE TOTAL, NUMBER MEAN ?STANDARD

DATE OF DEVIATION

?SAMPLES

?

2 291.7, 5 58.36 182

a as

2 920.4 5 184.08 137.01

2 808 137,00

3 503.5 5 100,70 19.92

4 316.7 4 73.18 3.08

5 79.26 3.07

5 396.3,

Se

TOTALS 2,428.6 2 101.19

BLVARIATION BY STATION

?.??????? ?X?r?lrO?OS $_?

a 416.9 3 83.38, 13.04

So

399.4 5 79.88 10.86

461.3 5 88.26 20.35,

tet 20035

°

2 307.2 4 76.80 15.30

ttt g0

E 863.8, 5 172.76 11.5

Fe

F

?

6

---Page Break---

TABLE 81

HYDROELECTRIC RESERVOIR STUDY

?SAMPLE ?TOTAL ?NUMBER MEAN ?STANDARD

DATE oF DEVIATION

SAMPLES,

?.

2 0.0 5 0.00 0.00

tt

2 0.05 5 0.01 0.00

SSeS

3 0.05 5 0.01 0,00

$e to

4 0.04 4 0.01 0.00

5 1,56 5 31 0.44

qorats 7 4 0.07

ns

BLVARIATION BY STATION

a 0.06 5 o,o1 0.01

23 er tn

B 0.09 5 2.02 0.02

169

---Page Break---

TABLE 52

HYDROELECTRIC RESERVOIR STUDY

?SUMMARY OF DATA FROM

Lake _carzas

PARAMETER _yitrte & Nitrite 05 8

uns nest

AGVARTATION WITH TIME

SOLE TOTAL MOMBER MEAN ?STANDARD

ars oF Deviario?

?SAMPLES

2 ont 5 0.09 0.08

2 0.35) A 0.05 0.02

3 0.32 5 0.06 0.01

? 0.30 ? 9,08 0.02

5 0.0 5 0,02 0.01

a

3

é

2s

BLVARIATION BY STATION

v.25 5 0.05 0.02

g

on

E

1.39

---Page Break---

TABLE 83

HYDROELECTRIC RESERVOIR STUDY

?SUMGIARY OF DATA FROM

take" Gorzas

ae

PARAMETER __Iron

melt

wnrrs

ASVARTATION WITH TIME

NOWSER MEAN ?STANDARD

DATE, OF DEVIATION

SAMPLES

TOTALS yo a 0.08

BAVARIATION BY STATION

---Page Break---

TABLE 84

HYDROELECTRIC RESERVOIR STUDY

?SUMMARY OF DATA FROM

UKE. ?carsas

Paraneren Turbidity

urrs Standard Unit

?AGVARTATION WITH TIME

?SAWPLE ?TOTAL NUMBER MEAN ?STANDARD

DATE OF DEVIATION

SANPLES

2 11.40 5 2.28 0.85

2 2.40 3 0.48 O28

2 5.30 5 1,05, 0.83

4 0.23 4 0.06 0.03,

9

10

TORS 19.33, w 1.02

B-VARIATION BY STATION

a 5.43 4 1.36 1.52

B 2.07 4 0.52 0.09

£ 4.73 4 1s 1,02

> 2.40 2 0.80 0.73

z 4.70 4 1s 0.54

ae

---Page Break---

?TABLE 85

HYDROELECTRIC RESERVOIR STUDY

SUMMARY OF DATA FROM

LaKe __ areas

PARAMETER __Color

wars standard Unit

?AGVARIATION WITH TIME

?TOTAL NUMBER MEAN ?STANDARD

8

e

36.0 5 7.20 1.76

|

|

ALS 204.0

8.50

BAVARIATION BY STATION

A 45.0 5 9.00 1,60

82 seco

5 43.0 5 8,60 1.68

e 38.0 5 7.60 2.08

= 43,0 5 8.60 1,92

---Page Break---

TABLE 86

HYDROELECTRIC RESERVOIR STUDY

?SUMMARY OF DATA FROM

axe ?Careas

:

?AGVARIATION WITH TIME

SAMPLE TOTAL NUMBER MEAN ?STANDARD

DATE OF DEVIATION

SAMPLES,

x 37.0 5 7.40 0,08

2 37.0 3 7.40 0.20

2 40.2 5 8.06 0.05

4 30.1 4 7652 0.06

5 38.6 5 272 oat

3

>

20

Toms 12 2 Ta

VARIATION BY STATION

A 38.5 5 7.70 0.24

5 38.3 5 7.66. 0.27

= x09 : 758 0.26

= 22.8 5 1.56. 0.23

F

·– –

Rn

?TOTALS 182.9 ES 7.62

174

---Page Break---

TABLE 87

HYDROELECTRIC RESERVOIR STUDY

?SUMMARY OF DATA FROM

axe Gores

PARAMETER Dissolved Oxygen

UNITS aa/L

?ALVARIATION WITH TIME

Sweis?<TOrL?~=~*CER NAN Szaronn

Dare o DEVIATION

saeues

en

nt is et

2 25.1 2 e37 18

2 es ee

3 23.2 4 5.80 0.40

4 26.1 4 6.52 0,38

a 27.2 4 6.80 0.90

a 25.9 4 6.48 0.98

e 28.7 4 7.18 0.46

DB 3.6 1

ays

---Page Break---

Table 86

Summary of Snails Surveys In Lake Garzas

Date

Inspector

Snails Found * :

ban. 29/76

P. Bermudez

Biomphalaria uabratd

Physa marmorata

Marisa cornuarieti

Tarebia granifera |

bec. 7/76

He Negrén

Marisa cornuarietis

sis

Lymnaea cubensis

Physa marmorata |

Tarebia grantfere |

Biomphalaria glabrata,

Jun 28/77

W. dobin &

As Laracuente

"

isa gornuarietis

Tarebla granifera

Physa marmorata

Lymnaea cubensis

loco. 77,

W. Jobin

Physa marmorata

Bionphaleria glabrat

isa cornuarietis

Lynnaea cubensis

Feb. 2/78

W. Jobin

Marisa cornuarietis

Lymnaea gubensis

Physe marmorata

Tarebia grantfera

176

---Page Break---

Table 88 (continued)

Date Inspector Snails Found

May 17/78 R. Brown sa comuarietis

Tarebia granifera

Physa marmorata

Aug. 26/78 A. Laracuente ? Marisa cornuarietis

Iarebia granifera

a7

---Page Break---

Table 89 178

SUMMARY OF COLIFORM DATA OF LAKE _Ga rn 1 PAR

FROM 197_T0 1978.

FIELD ?GOLONTES/

STATION pare | Nowe vet. | couonzes | SoLONr

30/11/76_[oz-10 1 2 1200

30/11/76 10 105 To30

30/11/76 1 9,200

30/1176 10

30/31/76 1 32,700

?30/11/76 7

30/11/76 1 30,100

30/11/76 0

1 10,200

20/11/76 10

Ta

BE

ia76

wi2i76

77

3/1276

1/12/76

1/276

1/12/76

1/12/76

227

2/12/76

2/12/76

2/12/76

2/276

2276

2/76.

2/12/76

2/12/76

7

20/6/77

20/6/77,

---Page Break---

Table 89 (continued) 179

SUMMARY OF COLIFORM DATA OF LAKE Cares 1 + PAR

Fro 19710 1978.

STATION pare | fam? gt. | couonzes | COLONTES/

100 mt

20/6/77 T 7

2TH i

20/6/77 1

20/6/77 io

20/6/77 T

10

20/6/77 Fi

7 10

21/6/77 T

26/77 0

20/6/77 T

uss? 10

6177 1

21/6/77 10

2u/6/T7 1

21/6/77 io

1

t

22/6/77 10

22/6/77 10

22/6/77 i

22/6/77

22/6/77

22/6/77

22/6/77

22/6/77

ae

are

are

ae

5.5 = 103

7.9 x 103

hr = 108

2.0 x 10%

878 2.9 x 10%

sie 2.5 x 103

8/78 7.5 x10?

=. 553 x 10.

---Page Break---

---Page Break---

180

Figure 33, Outlet gate from Luke Garzas diverting flow to

turbines and irrigation system on south coast.

---Page Break---

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smn fe fe LE E BERGER PRERE EIS IE JE] avo | sans | sonverwon

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189)

Figure 35. Garzas River cascading into the Lake Garzas near

Station C. Quiet pool below cascade was site of

Bionphalaria glabrata populations: in 1975,

eventually replaced by large colony of Marisa

---Page Break---

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Laco

?omar

euAsaraca

190

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wus | some | ov | sstiao

stairs | ?teen? | rreqdetorn| penton

core onrang "THESES er

WATE mai vos mewans vue ALTIWAD ?WoOKEHO

---Page Break---

TABLE 93

HYDROELECTRIC RESERVOIR STUDY

SUMMARY OF DATA FROM

LAKE _Guajatace

PARAMETER Chlorides

warts g/t

?ASVARIATION WITH TIME

SAWLE ?TOTAL, ?NUMBER MEAN ?STANDARD

DATE, oF DEVIATION

SAMPLES

Jyys/77__ 0.0 3 0,00 0,00

192

---Page Break---

?TABLE 94

YDROELECTRIC RESERVOIR STUDY

?SUMMARY OF DATA FROM

LAKE _ Guajataca,

PARAMETER Hardness as Ms S04

wars g/t

AVARIATION WITH TIME

MEAN ?STANDARD

DEVIATION

i

i

216.40 4.80

643.2

i

3

5

643.2 3 214.40

BLVARIATION BY STATION?

|

|

210.8

210.8

221.6

|

i

643.2 3 214,40

193

---Page Break---

TABLE 95

HYDROELECTRIC RESERVOIR STUDY

?SUIGIARY OF DATA FROM .

LAKE _Gusjatace

wars s/t

?AGVARIATION WITH TIME

SAWPLE ? TOTAL, NUMBER MEAN, ?STANDARD

DATE oF DEVIATION

SAMPLES

2 0.03 3 0.01 0.00

Ee

3 0.01

BAVARIATION BY STATION

0.01

194

---Page Break---

?TABLE 96

HYDROELECTRIC RESERVOIR STUDY

, ?SUMMARY OF DATA PROM

LAKE _Cuajatace

PARAMETER Nitrate & Nitrite es N

ittate & tects as,

wars et

ACVARIATION WITH TIME

SAMPLE TOTAL NUMBER MAN ?STANDARD

DATE OF DEVIATION

SAMPLES

20

roms 0.23 3 0,08

BLVARIATION BY STATION?

195

---Page Break---

TABLE 97

HYDROELECTRIC RESERVOIR STUDY

?SUMHARY OF DATA PROM

axe ?Guajetace

PARAMETER __Izon

wars wt

?ASVARIATION WITH TIME

SAMPLE ?TOTAL, NUMBER MEAN ?STANDARD

DATE oF DEVIATION

?SAMPLES

2 0.28 3 0,09 0.07

TOTALS 0.78 3 0.09 0.07

196

---Page Break---

?TABLE 98,

YDROELECTRIC RESERVOIR STUDY

?SUMIARY OF DATA FROM

LAKE __Guajatace

PARAMETER Turbidity

wars Standard Uatt

?AGVARIATION WITH TIME

SALE TOTAL, NUMBER MEAN ?STANDARD

DATE. OF DEVIATION

SAMPLES

2 35.3 3 7 1.69

197

---Page Break---

TABLE 99

HYDROELECTRIC RESERVOIR STUDY

?SUMMARY OF DATA FROM

take ?Guajacace

PARAMETER __color

urs Standard Unit

OO

?ASVARIATION WITH TIME

SAMPLE ?TOTAL NUMBER MEAN ?STANDARD

DATE OF DEVIATION

SAMPLES

Se

x 30.0 3 10,00 0.00

30.0 3 10.00

ns

BLVARIATION BY STATION®

198

---Page Break---

TABLE 100

HYDROELECTRIC RESERVOIR STUDY

?SUMMARY OF DATA PROM

LAKE ?Guajatact,

PARAMETER PH

unirs

?ALVARIATION WITH TIME

SAMPLE TOTAL, NUMBER MEAN ?STANDARD

?OF DEVIATION

SAMPLES

TOTALS 23,5 3 7.83

BLVARIATION BY STATION

199

---Page Break---

axe _Guajetaes

PARAMETER Dissolved Oxygen

wars Mg/

?

AGVARIATION WITH TIME

_?_ ev , OC

SAWLE ?TOTAL, NUMBER MEAN ?STANDARD

DATE oF DEVIATION

SAMPLES

NS

2 22.9 3 7.63, 0.22

TOTALS 22.9 3 7.63

OT

BAVARIATION BY STATION

?? oo O?rv?srnresrvvOvarSr

200

---Page Break---

Sunmary of Sn.

Table 102

1 Surveys in Guajataca

-

Date

Inspector

Snails Found

jun 30/76

Quirindongo

Marisa cornuartetis

Tarebia granifera

Pomacea australis

fu. 10/78

W. Jobin

Marisa cornuarietis

Tarebla granifera

201,

---Page Break---

202

Se [Set | we one

pesdeta ting 30 | 85a =

aE LES |. pe

ToT ser

---Page Break---

(Mm

PROFUNDIDAD

Figure 37

LAGO GUAJATACA 709

GRAFICA DE OXIGENO DISUELTO Y TEMPERATURA

DISTRIBUCION VERTICAL ESTACION-A (10 DE AGOSTU DE 1978)

TEMPERATURA (°C)

5 1 15 2 2 30 35 40

horn

LEYENDA

??? TEMPERATURA

== OXIGENO

, 2 8 « Ss 6 7? 8 9 wl

OXIGENO (PPM)

---Page Break---

m.

PROFUNDIDAD

Fig

Lact

GRAFICA DE OXIGEN

DISTRIBUCION VERTICAL

TEMPERATURA

jure 38 208

0 GUAJATACA

0 DISUELTO Y TEMPERATURA

ESTACION-C (10 DE AGOSTO DE 1978)

wey

5s 10 1s 20 2 30 85

30

40

0

eo

a oo or

ry

oxic!

LEYENDA

TEMPERATURA

OxIGENO

ENO (PPM)

---Page Break---

Figure 39 205

LAGO GUAJATACA

GRAFICA DE OXIGENO DISUELTO Y TEMPERATURA

DISTRIBUCION VERTICAL ESTACION-E (10 DE AGOSTO DE 1978)

TEMPERATURA (°C)

5s 10 1s 20

ep or or ot

20 _

Z 30

g 40

8

20 LEYENDA

* TEMPERATURA

re - OxIGENO

?

?7

90¢

q

foobar a dg

OXIGENO (PPM)

---Page Break---

LAGO GUAYO-LARES- ADJUNTAS

a

---Page Break---

a

Figure

41, Concrete gravity dam at Lake Guayo in

Casi

fier. This lake is one of several

ich divert water to Lajas Valley

System. Tt is the clearest of the

lakes and has the longest residence

time of flow

---Page Break---

ey

i os hey ws

"OS? vt wos mameins ave azrnd <WoxaK

---Page Break---

i

TABLE 105

HYDROELECTRIC RESERVOIR STUDY

?SUMMARY OF DATA FROM

LAKE" Guayo

PARAMETER _ Chlorides

ues se/)

?ASVARIATION WITH TIME

NUMBER MEAN ?STANDARD

oF DEVIATION

i

i

Je77t__23.4

26/10/77 19.7,

7.80 1.33

4.92 166

4,65

315/2/78_18.6

|

425/5/78__ 52.7 13.8

4 1s 7.63

BLVARIATION BY STATION?

28.4 4 7.10 1.35

9.78 5.88

|

2.68

|

|

4,87 3.22

es 7.63

209

---Page Break---

TABLE 106

HYDROELECTRIC RESERVOIR STUDY

?SUMMARY OF DATA FROM

Lae _Cuayo

PARAMETER __lardnees (Mg S04 a8/1)

wars g/t

?AGVARIATION WITH TIME

SAMPLE TOTAL ?MUMBER MEAN ?STANDARD

DATE OF DEVIATION

59.80 41.07

130.10, a5

179.4

520.4

ans 117,98 2.58

|

495.6 121.40 3.20

i

1,657.3 110.49

BLVARIATION BY STATION?

505.0 128.25 9.13

406.3 101,58 27.04

°

380.8 95.20 42.35

°

355.2 121.73 2.7

210

---Page Break---

i

PARAMETER __Totel Phosphates as P

untrs g/L

?ALVARTATION WITH TIME

SAWLE TOTAL MOMGER MEAN ?STANDARD

DATE: oF DEVIATION

SAMPLES

0.01 0.01

0.01 0.00

0,04

2.04

o.01 0,00

o.21 0.05 0.03

3

é

0.02

BLVARIATION BY STATION"

0.33,

TEE LT

3.07, 0.02 0.01

0.06. 0,02 0.01

0,02 0,02

2

0.12 0,04

0.33, 0,02

au

---Page Break---

?TABLE 108

HYDROELECTRIC RESERVOIR STUDY

?SUMMARY OF DATA FROM

Lane ?coayo

PARAMETER Nitrate + Hittite as

errs g/t

ASVARTATION WITH TIME

SAWPLE TOTAL NOEER MEAN ?STANDARD

DATE: oF DEVIATION

SAMPLES

??_?. ????

2 2 3 0.80 0,88

tt

2 0.6 a 0.20 0.05)

Ang 005

2 Liz 4 0.30 0.20

ee wt

4

2.0 4 0,00 0,00

se

ee

De

ee

> OOS

oe

ee

roms 4.2 1s 0.28

BLVARIATION BY STATION

62

|

|

1 05

az

---Page Break---

TABLE 109

HYDROELECTRIC RESERVOIR STUDY

?SUMMARY OF DATA FROM

LAKE | Guay,

PARAMETER __Iron

wars g/t

AGVARIATION WITH TIME

SAMPLE ?TOTAL, MOMBER MEAN ?STANDARD

DATE OF DEVIATION

,

1 1.4 3 0.47 0.29

Boy 0000

4 0.07 4 0.02 0,02

3

SO

6

7

SO

@

2

30

?? $$

TOTALS 1.82 as 0.12

BLVARIATION BY STATION

a 0.29 4 0.07 0.06,

B 1.04 4 0.26 0.32

¢ 0.37 4 0,09 p10

> oz 3 0,06 0.03,

ais

---Page Break---

?TABLE 110

HYDROELECTRIC RESERVOIR STUDY

SUMMARY OF DATA FROM.

tae _Guayo

Parameren Turbidity

urs Standard Unit

?AGVARIATION WITH TIME

SAMPLE ?TOTAL MOMBER MEAN ?STANDARD

DATE. oF DEVIATION

SAMPLES

2 22.5 3 7.50 5.00

2 1s ? 0.38 0.08)

3 5.9 4 1.48, 0.28

4

TOTALS 29.9 n 2.72

?BAVARIATION BY STATION?

A 7.0 3 2.33 1.78

5 174 3 3.80 6.13

eS es La

. 1S 2 0.75 0.45.

ais

---Page Break---

SAWLE ?TOTAL ?NUMBER MEAN ?STANDARD

DATE oF DEVIATION

SAMPLES

oo

a 40.0 3 13.33 2.22

Sa

2 46.0 4 150 O75

2H 5S

3 40.0 4 10,00 0.00

$d ono

* 49.0 4 10,00 0,00

mt

20

?

TOTALS 166.0 15 11.07

SS

BAVARIATION BY STATION

|

a a 11,25 1.88)

8 47.0 4 11,75 175

¢ 42.0 ? 10.50 0.75

> 32.0 2 10.67 0.89

TOTALS 166.0 15 11.07

ais

---Page Break---

TABLE 112

HYDROELECTRIC RESERVOIR STUDY

?SUMMARY OF DATA FROM

LAKE _Cuayo

SAWPLE ?TOTAL NUMBER MEAN ?STANDARD

DATE OF DEVIATION

SAMPLES

2 22.4 2.47 0.51

2 30.0. ? 7.50 0.10

3 312 4 7.80 0.10

4 30.9 4 12 0.18)

7

8

∘

20

qoras 116.5 15 7.63

[BLVARIATION BY STATION

a 30.7 4 7.68 0.18

B 29.6 4 7.40 0.35

116.5 5 7.63

aie

---Page Break---

TABLE 117

MYDROGLECTRIC RESERVOIR STUDY

?SUMMARY OF DATA FROM

Lake ?"Goayo

PARAMETER Dissolved Oxygen

Saws Tora Nomen WAN STANDARD

Date oF DeviATroN

suns

2 29.6 % 7335 0.35

3 33.7 4 8.42 0,48

20

roms 63.3 a 7.37

A 22.3 3 2.43, fe

8

22.5 3 7.50 0.73,

? 22.8 3 7.60 0.27

2 15.7 2 7.85 0.25

---Page Break---

TABLE 114,

HYDROELECTRIC RESERVOIR STUDY

?SUMMARY OF DATA FROM

axe ?Cuayo

PARAMETER ChlorophyH A

vars sg/t

?AGVARIATION WITH TIME

SAMPLE ?TOTAL NUMBER MEAN ?STANDARD

214 3 7.33

BLVARIATION BY STATION:

|

218

---Page Break---

aig

Table 115

Summary of Snail Surveys in Lake Guayo

Date Inspector Snail Found

jun 30/77 |W. Jobin Marisa cornvarietis

Tarebia granifera

| Anpularia australis

hug. 26/78 | A, Laracuente | Marisa cornuarietis

Tarebia granifera

---Page Break---

Table 116 - 220

SUMMARY OF COLIFORM DATA OF LAKE _guayo. TN_tares __, PAR

FROM _July 197710 February _*

STATION are | RET ve

oun lees | ?10

ent

sri is

aL H

mm

mai

mit

anoy77

a/10/77

efo/T7

anol

0/77

4/10/77

torr

Aor

s/10/77

S/o/77

3/0/77

S/o

5/10/77

5/10/77

5/20/77

5/10/77

Da

BMT

13/2/79

13/2/77

---Page Break---

Table 116 (continued) 221

SUNMARY OF COLIFORM DATA OF LAKE gy Mazes, PR

FROM Joly, 197710 _February 1978

STATION pare | RR | ven. Yoouomnes | SobOuES7

13/2/77 i F000

33/277 1 2 72,000

Baim 1 36-008

TAT 2 soo

a) 3 Soo

15/2176

15/2/78

15/2/78

15/2/78

15/2/78

TST

2

33/277

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To PA aS TTT

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Ty rT a5]

To eT RITS

TS

Te] ey]

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TF

TTF

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(ALCAE DATA SuWURY FoR LME Cuno N_Lares__, am,

£3 bree. vfoo fos [s.22 [oo [00 foo [rs fee | 20107! ralestor

uy

Lake cuaye

Lake ouayo

Lake Guye

[Lake ai

Lake Ouye

---Page Break---

TST 31 wos sesses v0 ae

Tey Ta SaaS]

---Page Break---

227

No1nvaara

suaian

zy oanby4

e161 tse1

na efa wos vir fo my wa

8261-9461 OAVNO? axv1 wos auoDsH T3AT1? UdivA

(Cie uy anya go qaAaT aaava,

---Page Break---

arcuenre a

LAGO DE MATRULLAS- oROCOVIS:

---Page Break---

Figure 44,

Emergency Spillway of Lake Matrullas at high

water level.

---Page Break---

---Page Break---

|

Hit

LH

|

randodoro)

{PvE xOr ReMBMS vaVE ALITOND wWOUKGHO

---Page Break---

---Page Break---

---Page Break---

Table 121

Summary:of Snails Surveys in Lake Matrullas

Date Inspector Snails Found

eb. 27/75 | Quirindongo Physa marnorata

Tarebia granifera

frov. 14/75 | P, Bermudez Physa marmorata

ot. 20/78 | A, Laracuente | Tarebia granifera

@ R. Mercado Marisa cornvartetis

Physa marmorata

232

---Page Break---

Pee wT

2.22| 2.69 [0.0 [oo

:

2

5

a

Tasaaso

ALE BATA stWORY FOR LAME at

q

x. 3 fo.0 [sso]eas foo

Loon szari

---Page Break---

Sat RT a

sg FT 1 THT an os Aa vavD VOW

STRAT

ra] wal eo

i ?

---Page Break---

235

SURVEY OF LAKE PATILLAS

LAGO PATILLAS

OB

LevENoy

csucioúts sina

Figure 45

---Page Break---

---Page Break---

Figure 46.

Earthen dike on Lake Patillas near station 3.

Outlet to Patillas canal is hidden at left-hand end of dike, and is site for proposed low head

turbine installation.

---Page Break---

---Page Break---

or

eT} or

Pe ae | ae se

ous | some] oy | astao| Be) ar

stairs | ?trser [rrayetersofeaeterera] | aete0

ana x 6-0 fous aay sme

core onvana ?

Tae xr >

---Page Break---

Table 124

Summary of Snails Surveys in Lake Patillas

Date

Inspector

Snails Found

jul. 22/76

A. Laracuente

isa cornuarietis

Tarebia granifera

lay 9/78

W. Jobin

Marisa cornvarietis

Tarebia granifera

Ampularia australis

ju. 12/78

R. Mercado

Marisa cornuarietis

Tarebia granifera

Ampularia australis

---Page Break---

---Page Break---

(22 oursne ?aera ni ??aerrrteg it tos Neos vive Nx0KND

---Page Break---

PROFUNDIDAD

8

2a

LAGO PATILLAS (ESTACION-A)

GRAFICA DE, OXIGENO DISUELTO Y TEMPERATURA

DISTRIBUCION VERTICAL (20 DE JULIO DE 1978)

TEMPERATURA (°C)

Sm 1S 2 2 30 sto as

rr ee |

LEYENDA

TEMPERATURA

? = oxiGENo

OXIGENO DISUELTO (PPM)

FIGURE 47

---Page Break---

LAO PariLuas (estaciin-8)

GRAFICA DE CXIGENO DISUELTO Y TEMPERATURA

DISTRIBUCION VERTICAL {20 DE JULIO DE 1578)

TEMPERATURA

OxIGENO oisuELTO

FIGURE 48.

---Page Break---

LAGO PATILLAS (ESTACION-c)

GRAFICA DE OXIGENO DISUELTO Y TEMPERATURE

DISTRIBUCION VERTICAL (£0 DE JULIO DE 1978

TEMPERATURA ec)

so is tm ete we ae

Le

OxIGENO"DISUELTO (PPM)

FIGURE: 49

---Page Break---

LAGO PATILLAS (ESTACION-D)

GRAFICA DE OXIGENO DISUELTO Y TEMPERATURA

DISTRIBUCION VERTICAL (20 DE JULIO DE 1978)

re}

PROFUNDIDAD

as

TEMPERATURA (°C)

fo 15 20 25 30m as

Horonoe bord

i

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i

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é

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?

\

LEYENDA

??TEMPERATURA

OxIGENO

OXIGENO DISUELTO (PPM)

FIGURE 50

---Page Break---

~ FEERRERE ES EPEEREER ERE RRES EER EREEE] ce

mu PEERERER PERE EMER ERE EE CER EEE (EEE GEE Se [rm] smman

E BF FEET E Ey FLEE

: i

creat anew

ene sow

---Page Break---

LAGO PRIETO

B10 PRIETO

REPRESA

OVERFLOW

FROM

LAKE TORO

QUEBRADA

NJILONES

RIO PRIETO

ESCALA * 1: 10,000

5 Km

= _?

Figure 51

246.

---Page Break---

ool Tar} ero ve

= oral a

sus. | sono

---Page Break---

TABLE 128

HYDROELECTRIC RESERVOIR STUDY

?SUUARY OF DATA FROM

Lace Prieto

PARAMETER Chlorides

vunrrs ae/t

|

SALE TOTAL MOBER MEAN ?STANDARD

DATE oF DEVIATION

SAMPLES

?????X?X?X

2 2/7/78 20.5 4 5.12 2.36

2 21/10/78 6.8 3 2.27 0.84

eaiolg 6p gs ayo

2 sy3/78__3.9 2 1.95 1.95,

gs

4 1y6)78 16.6 2 8.30 3.50

208

---Page Break---

?taste 129 289

HYDROELECTRIC RESERVOIR STUDY

?SUOARY OF DATA FROM

take ?Petete,

PARAMETER _Hardnese as Mg S00

wars ea)

?ACVARIATION WITH TIME

?_?_ Sree

SAWLE TOTAL NUMBER MEAN ?STANDARD

DATE OF DEVIATION

SAMPLES:

?- ??

a 648.0 4 162,00 13.50

405.8, 3 135,27 2

254 2 137.70 5.10

2 196.8 29.00

ToraLs

et te

BLVARIATION BY STATION

??iauririzeurzs=s_aSS

a 558.6 4 164,65 30.58

Sit tees 0s

5 458.0 3 152,67 10,09,

0.09

e

417.2 3 139.07 8.09

2 189.0 i

|

1,722.8 u 156.62

er 662

---Page Break---

TABLE 130

MYDROELECTRIC RESERVOIR STUDY

?SUMMARY OF DATA. FROM

LAKE __prtetg

PARAMETER Total Phoophates as P

vunrrs xsi

?AGVARIATION WITH TIME

SAMPLE TOTAL NUMER MEAN ?STANDARD

DATE oF DEVIATION

SALES

2 0.08 4 0.01 0.00

out 3 0.0% 0.05

0.02 2 0.01 0.00

? 9.02 2 0.01 0.00

5 0.02 3 0,01 9,00

2 2,01 1

250

---Page Break---

TABLE 131

HYDROSLECTRIC RESERVOIR STUDY

?SUMOARY OF DATA FROM

tae ?Petete

PARAMETER Uitrate & Nitrite as 1

?AGVARIATION WITH TIME

SAMPLE ?TOTAL MBER MEAN ?STANDARD

DATE oF DEVIATION

SAMPLES

x 05 4 0.26 0.27

2 0.30) 2 0.10 0.00

2 1,00 2 0.50 0.10

? 80 2 0.40 0.10

qomis 3.15 1 0.29

BLVARIATION BY STATION:

S 2.45. 3 9.15 0.10

£ 0.60. 3 0.20 0,13

2 2480 1

=

---Page Break---

TABLE 132

MYDROELECTRIC RESERVOIR STUDY

?SUMMARY OF DATA FROM

take _Peteto

PARAMETER __Izon,

wars Mest

|

SAMPLE ?TOTAL NUMBER WEAN ?STANDARD

DATE OF DEVIATION

SAMPLES

?_??$? ?

2 0.13 4 0.03, 0.00

$a 4 os 00

2 8.30 3 2.77 0.56

205g

3 0.20 2 0.10 0.00

tte

? 20 2 0.15 0.05

8.93 u 0.81

ie

BLVARIATION BY STATION?

-? rv

a

asa 4 0.98 1a

8 2.43 3 0.81 0,99)

Se

gS 2.53 3 0.86 1,06

Se

---Page Break---

TABLE 133

HYDROELECTRIC RESERVOIR STUDY

SUGARY OF DATA FROM

ace SPE

PARAMETER turbidity

UNITS Standard vate

ee

AGVARIATION WITH TIME

SAMPLE TOTAL MBER MEAN ?STANDARD

DATE oF DEVIATION

SAMPLES

??_? eu

2 32.0 4 3.00 175

35,00 ae

es a ee a Lae

2 265.0 2

2 5.09

@

2

See

10

Se

TOTALS 177.0 7 25.29

BLVARTATION BY STATION

SRC

Oro

32,35

a 65.3 2 32.65

Se

26.10 23,90

tet 2.90

22.15

27.85

SS

ole

23

---Page Break---

TABLE 134

MYDROSLECTRIC RESERVOIR STUDY

?SUMMARY OF DATA FROW

pace Prieee

PARAMETER __Coloc

wars ?_ standard Unie

VARIATION WET TING

Soous_TorAL NOMGER NEAR ?STANDARD

Date oF DEVIATION

swruss

z 50.0 4 12,50 2,50

22.0) 3 14.00 1.33

2p tog 0200

4 20.0 2 10,00, 0,00

3

es ee es es es ee ee

Tomas 352.0 n 13.82

TBLVARIATION BY STATION

a ?70 ? nese

5 10.0 3 3

< 57.0 3 07

>

254

---Page Break---

TABLE 135

MYDROELECTRIC RESERVOIR STUDY

?SUMMARY OF DATA FROM

wane? Petete

Parwerer pi

ws

es

ALVARIATION WITH TIME

seer

?SALE ?TOTAL MOGER MEAN ?STANDARD

DATE OF DEVIATION

SAMPLES

OO

1 23.0 4 7.25 0.5

22.6 a 7a Dae

14.7 2 7.35 0.05

4 5.7 2 2.85 0.35

nme 81.8 nu 2h

?___Svnsratron ay svarton"

x 20.1 ? re

e 3 3 7.43. 0.18

>

2s)

---Page Break---

TABLE 136

HYDROELECTRIC RESERVOIR STUDY

?SUMMARY OF DATA FROM

Lake Prieto

PARAMETER Dissolved oxygen

wars ug)

?ASVARIATION WITH TIME

Shwe TOTAL, MOWER MEAN ?STANDARD

DATE oF DEVIATION

SALES

2 26.8 3 0.3

2 2 o.2h

2 4 2 4.20 0.20

TOTALS 50,9 2 6.36

?BLVARIATION BY STATION

a2. 3 5.90 1.93

2B 1.6 2 7.30 2,10

£ 18.6 3 6.20 1.60

D

256

---Page Break---

257

Table 137

Summary of Snail Surveys in Lake Prieto

Date Inspector Snails Found

eb. 2/76 | P. Bermudez Marisa cornuarietis

jul 15/77 | W. Jobin Pomacea australis

Helisoma cartbacum

Blomphalaria glabrata

far. 8/78 | R. Brown Marisa cornuartetis

Physa cubensis

Lymnaea columella

Siomphalaria glabrata

jun 1/78 | Ws Jobin & Marisa cornuarietis

As Laracuente | Lymnaea columella

\ug: 28/78 | A. Laracuente | Marisa corivartetis

Tarebia granifera

Biomphalaria glabrata

Lymnaea columella

ept.27/78 | A. Laracuente | Marisa cornuartetis

Biomphalaria glabrata

Physa cubensis

---Page Break---

Table 138 258

SUHMARY OF COLIFORM DATA OF LAKE _Prteto 1% + Pak

FROM Joly 19%, TO _october 1978,

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8/10/77

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19/10/77

39/10/77,

9/0/77

39/10/77

19/10/77

29/10/77

39/0/77

39/30/77

20/10/77

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Table 139 259

SUMMARY OF COLIFORM DATA OF LAKE _retets 6 + Pa

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zonioj77 | 1-36 76,000

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Figure 52

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270

Table 144

SUMMARY OF WIND PATTERMS FOR

PUERTO RICO 1975-1976

Direction Percent of Time

Tallabo

Se

" 2.95%, o.15%,

We, 2.81 3.10

NE 5.93 9.88

Exe 19.26 29.39,

E 71 1.93

ESE 12.73 13.88

SE 9.08 4.24

Sse 7.35 7.53

8 10.18 1.50

SoH 3.3 az

sw 1.65. 0.48

ww 1.98 0.13

Ww 134 0.18

way 0.36 0.17

mw 0.39 oi

ay 0,93 0.03

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lahh

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