PRNC195

PUERTO RICO NUCLEAR CENTER

CHANGES IN SELECTED WATER QUALITY PARAMETERS

AS INFLUENCED BY

LAND USE| PATTERNS IN THE ESPIRITU SANTO DRAINAGE BASIN

DECEMBER , 1975

EWvira Cuevas and Richard G. Clements

?Terrestrial Ecology Division

OPERATED BY UNIVERSITY OF PUERTO RICO UNDER CONTRACT

NO. & (40.1)1899 FOR US ENERGY RESRARCH AND DEVELOPMENT ADMINISTRATION

---Page Break---

(QUALITY PARAMETERS AS INFUJMICED BY

?cuANGES TN SELECTED WATER

TRI GANTO DRATHAGE BASTIE

AND USE PATTERNS 1 THE FSP!

[ELVIRA CUEVAS AND RICHARD G. CIFAHNTS

DIVISION OF TERRESTRIAT. PCOLOGY

DECREER, 1975

PUERTO RICO NUCLEAR CENTER

OPERATED BY THE UNIVERSTIY OF PUERTO R100

FOR THE

[ENERGY RESEARCH AND DEVELOPWIOI? ADMINISTRATION

---Page Break---

ABSTRACT

Bi-weekly measurements and samples were taken on the surface

waters of the Espiritu Santo river and its tributaries Quebrada Grande, Quebrada Jinénez, and Quebrada Sonsdora. The parameters studied were temperature, Aisvolved oxyren (DO), Bll, free carbon dioxide (00,), salinity, and the concentrations of sodium (Wa), potassium (K), cal chum (Ca), mgnestun (Mz), and chloride (C1). The results indicated fa general increase in the values of all the parameters measured, from higher to lower elevations vith the exception of DO vhich decreased

slighty and war found to be near saturation at all time

Cop ranged

within the nome] values for natural surface waters as were the pi values which renced trom 6.5 to 8.2 with @ modal value of 7.0. The concentration of Na, K, Ca, Mg, and C1 were found to be below or near the accepted for drinking water standards. Significant differences ?were found between each river or tributary for the concentration of the elements mentioned above. No marked seasonal variabilities were observed during the period studied except for the tenperature of the water which reflested the lovering of ai tenperatures during, the

winter month

rte

---Page Break---

ACKIONLEDGDENTS

?The authore wich to express their appreciation to the many people who have contributed each In their ow way to this study.

To David Padgett, Alejo Estrada Pinto and Juan Martinez for assist- ?ance in the collection of water samples; to José A. Colén for his aesietance in the collection and the analysis of the samples by atomic absorption spectrophotometry; and to Arthur MeR. Block, Fred Ya Caro and Félix Santos for their constructive coments on the formation of this docunent. Our deep appreciation is extended to Ang Josefina Correa and Bri Colén for their patience and understand~ ing from the preparation of the first rough drafts through the final version. Our thanks to David Sruck and Michael Byers of the Depart nent of Biology, Rio Piedras for reviewing and providing constructive coments on the manuscript. Last but not least, we are indebted to Severino Ramos, director of the Computer Center at Rio Piedras, and

nis

yeaft for their support in the data reduction and statistical

programs.

sa

---Page Break---

LIST OF TABLES AND FIGURES

?Table =

10.

ne

wm

Characteristics of the Espiritu Santo Basin ~

Popstation ensue from the tom of Rio Grande for the

Years 1940 to 1970

Site Description, Elevation, and Location of Selected

Sampling Gtatsons on the Eapiritu Santo Drainage Basin

Combination: of Data for Statistical Analysis -

Average Values for the Variables Measured at Selected

Stations of the Espiritu Santo Drainage Basin -

t-test and levels of Significance for Forested Versus

Grassland Stations in the Espiritu Santo Drainwe Basin t-test and Levels of Significance for Forested Versus

Graceland Station, Forest Versus Boundary Station, ans

Boundary Versus Grassland Station in the Espiritu Santo

River =

totest and levels of Significance for Forested Versus

Gragsland Stations in the Quebrada Grande Tributary ~

?tetest and levels of Significance for Forested Versus

Graseland Stations in the Quebrada Jiménez Tritutary

totest and Levels of Significance for East Branch Versus

West Branch Stations in the Guebrada Sonadora Tributary

Summary of Hesults of P-test from Analysis of Variance,

Sinvle Way Classification, for all Possible Combinations fof the Data for the Variables Studied st Selected

Stations of the Fspiritu Santo Drainage Basin

Sumary of the Results for Sodiua, Potassium, Calcium,

Magnesium, ind Chloride in Streom Water according to

Vegetation Type

---Page Break---

Figures

Espiritu Santo Draiige Basin: Stations

Elevation, and Tden\{tication Numbers ~

» Looation

Composite of Vegetation Types for Temperature,

Dissolved Oxygen (D0) and Free Carbon Dioxide (C0)

An the Espiritu Santo Drainage Basin ~

Sumary of Mean Valies for Temperature, Dissolved

Onygen (00), and Free Caton Dioxide (0p) across

Tine n=

Summary of Mean Values for the Concentrations of

Sodium (Nia), Potassium (K), Calesum (Ca), Magnec jum

(W:), and Chloride (C1) across Tine

Moon Salinity Values: per Station the Fspiritu Santo

Drainage Susin ~

List of Appendix Tables

Concumptive Use of Water taken from Freshwater

Sources within the Municipality of Rio Grande for

the Fiseal Year 1972-1973

Bi-vookly Temperature Trends in ?C at Selected

Stations in the Espiritu Santo Matershed

s-woekly Discolved Oxygen Trends in me/2 at

Selected Stations in the Eapirits Santo Watershed

Bi-weekly Free Carbon Dioxide Measurements in PPI

at Selectes Stations in the Espiritu Santo Watershed ~

Bicweekly pil measurenents at Selected Stations in the

Espiritu Santo Watershed ~

vt

9

ne

we

hs

6

a

hg

---Page Break---

Introduction

Water -esources are a determinant in the managonent and ef

fective use of an area, The quantity and the quality of the vater

availble in an area will influence and will be influenced by land utilization and conservational practices and controls. Rivers and takes throughout the world are being used contimuously for aifferent yporposes such as recreation, fishing, electricity, public supply, irrigation, sewage disposal, ete. Wise managenent and utilization

of a water resource will prevent to a large extent many destructive effects on both a short termed and @ long termed basis. ?The maintenan? of a good quality of water throughout @ systen will help in the pre- vention of long term effects viich could impair future utilization of

?the water not only by man but by other orgenisms in the ecosyste

Water quality indices such as temperature, pi, dissolved oxy fen, 0p, and nutrients will detemtne the eapueity of @ systen to maintain a healthy community and its capability for reestablishnent in case of danage to the ecooystem structure.

?temperature is a prime regulator of natural processes within the aquatic environment. It largely affects the rate of metabolien fand activity on all organisms. Acting directly or indirectly in com ination with other quality constituents, {t affects chenieal reacticn rates, enzyme structures and molecular movement and exchange within

nenbrance in the external and internal cellular environment.

---Page Break---

?The solubility of gases including oxygen varies inversely with the temperature in the water, In fresh water the solubility of atmospheric oxygen is decreased by about 59% as the temperature rises from 0c (32°F) to Mote (10N"P) under one atmosphere of pressure (7160 nen Hg) (MacKenthum, 1969).

Dissolved oxygen is very important in the aquatic enviroment. In appropriate concentrations it is essential to sustain Life and to ?sustain species reproduction, vigor, and the development of populations. [At reduced discolved oxygen levels many organicns undergo stress that rake them less able to sustain their populations. Oxygen enters the water by absorption directly fron the atmosphere or ty plant photo-aynthesie, and is renoved by respiration of organisms and by decon-position. Oxygen derived from the atmosphere may be fron direct aif-fusion or by surface water agitation which my also release dissolved onygen under conditions of supersaturation.

pH, © measure of hydrogen ion concentration, varies over & wide range in natural vaters, Natural waters having « low pH contain ?very little bicarbonate or elee contain high concentrations of free carbon dioxide or organic acids. Values of pil in most of the streans of the United States ranges from 6.5 to 8.5 (MacKenthun, 1969) Bogart (1964) reported pi values ranging fron 6,8 to 8.1 for periodic stations fon streams in Puerto Rico.

?The productivity of an aquatic ecosystem ie determined ty the

availability of mtrients. These mutrients can be divided into two

---Page Break---

categories: macronutrients and micronutrients. Macronutrients include carton (C), hydrogen (If), oxygen (0), nitrogen (It), phosphorus (P), sulfur (8), potassium (K), magnesiue (Mg), calcium (Ca), (except

for algae where St 4s @ micronutrient), and sodium (Na), Micronutrients include iron (Fe), manganese (Yn), copper (Cu), zine (Zn), molybdenum (Wo), vanadiun (V7), boron (B), chloride (C1), cobait (Co), and silicon (Si). The role of the major and minor elenents in the biological systen has been discussed by Saith (1966), Odum (1971), and MacKenthun (1969),

among others,

Past Research

Puerto Rico's river system have been partially investigated by

the United States Geological Survey (U.S.

.8.), Water Resources Division.

Strean flow has been cophasized in the past fow yeurs with some chemica studies performed on an infrequent basis during 1958 to 1972 (Water Resources Data for P.R., U.8.6.8. 1950-1972). One of the first attempts to present an overview of the ater resources of the island including sone aspects of the quality of the water vas that of Rovart (1964). At ?that Uime measurenents of some water quality variables vere strictly related to feasibility of water use for bhunan consumption, agriculture, and tydroelectric power supply. Since then there has been an increase 4n.the denand of water for industrial purposes.

?The Mater Resources Ress

sch Institute in Mayarrucz has compiled a bibliography of the information published to date pertinent to the

water resources situation in Puerto Rico (Véequex et. a gro). They

---Page Break---

reviewed and reported around 300 titles and included abstracts on each. The vork was further separated by eubject matter into the following categories: 1) Nature of water; 2) Water cycle; 3) Water supply augmentation and conservation; 4) Water quantity management and control 5) Water quality management and protection; 6) Weter resources and planning: 7) Resources data; 8) Engineering works: and 9) Man power, grants

and facilities. The earliest work reported under vater quality managerent and protection vas in 19/1. The major thrust on water quality studies began in the mid 1960's with most of the work reported deal ing with sanitary conditions of major streans, lakes, and constal waters.

Few of the works reported have dealt directly with base studies of rivers, ?lakes and lagcons. ?They have dealt prinarily with human related problems uch as sanitary conditions or water availability for public consumption.

(azquer et. al., 1970). Some of the basic studies published to date from retervotre and lagoons are those of Candelas (196!) and Rute de Reyes (ayn).

Candelas determined some vhysical and chemical paraneters of eight lakes, seven of them reservoirs, ?The reoulte shoved that the rmaximin temperature recorded was 31°C and the minimum 22°C. No extensive thermal stratification was noted. pil ranged from 7.0 to 8.0 and dissolved owyren concentrations ranged from 0.2 to 11.25 mg/l. Dissolved oxygen ?was found to be present from the surface to the bottom. Mo free CO, vas found on the surface of any of the Iakes.

Rufz de Reyes conducted an ecological study of the Tortuguero

?ungoon located on the north const. The results shoved that salinity

---Page Break---

fluctuated between 1,530 and 2,620 mg/1 vith dissolved oxygen values ranging between 4,28 and 5.67 mg/l. Temperature varied between 24°C and 31°C during the perfod studied. Mo noticesble thermal stratification or any anoxic areas were found in the Lagoon.

There have been no ecological studies published to date of

?the rivers and streams of Puerto Rico. Due to severe demands for land

?usage and water consumption it has become pertiment to study rivers

as part of a dynamic ecosysten in vaich interdependency i vital for continuity of the biota. Studying a definable unit of lang, such as a watershed, provides a unifying concept in the evaluation of a systen because its output reflects the integration of all ite related factors and its subordinated ecosystens. Tt mist also take into consideration ?the impacts brought about by political and socio-economic decisions.

?A watershed has been defined

2 system tn dynamic equilibrium and a definable unit of land on which all water flows to @ common outlet. and is derived fron, consists of, and is characterized by a hoct of pover-ful interacting factors which vary over tine, over their natural range, and with respect to each other (Black and Leonard 1968). Odum (1971) as described it as a minimum unit to be considered when man's activi-?ties in his surroundings will determine or greatly affect the quality of Sts environnent.

While many suitable watersheds could be found for thie type of study, the Espiritu Santo drainage basin was selected because a broad

Gata base already exists for the upper reaches of the area. Since 1963

---Page Break---

?the Terrestrial Beology Progran of the Puerto Rico uclear Center

thas conducted extensive studies on the ecolory of the Inguille

Emerinental Forest. Many of the results for the period 1962 to

1968 are sumarized in Odus (1970). Stream flow measurements have

been monitored by the USGS in the Fepiritu Santo river from 1960 to

the present.

General Description of the Drainage Basin

?The Mepiritu Santo bacin located in the northeastera part of

Puerto Rico draine the norttn

fem slopes of the Inquille Mountaine

fand flove northward into the Atlantic Ocean. With a drainage area of

20.6 Kn? it presents a diversity of ecosystems ranging from forested

areas to manrrove conmmnities. ts main rivor, the Espiritu Santo, originates at approximately 1,000 meters elevation and falls to sea

level over a distance of 20 kilometers. The main tributaries are the

Quebrada Sonsdora, Quebrada Jiménez and Quebrada Grande, all originating

fat the base of El Yunque rock. Some of the characteristics of the system

fare presented below in table 2.

Table 1. Characteristics of the Espiritu Sento Basin

eT

Main Strean 2 ?ae

Espiritu Santo 19.5 5a 20.6

Two W to 50M eter. 6.9 10.6 *

SOM to Sea level 10.6 O.h7 2

Tributaries

Giebracn Sonadora 38 ao as

Guebrada Grande au ie x3

?Giebrade Jinenes 13 1216 3.9

---Page Break---

Above 200 meters four distinct types of forest are recognized:

Dwarf or Mossy Forest, the Sierra Palm Forest, the Colorado Forest and

?the Tabomuco Forest (Cook and Gleason, 1972, Wadsworth, 1961; Evel and

Wattmore, 1973). Between 100 meters to 200 meters elevation the middle

watershed includes cultivated land, pasture land and transitional forest.

?The lover watershed or coastal plain area includes pasture land, sugar

cane fields, abandoned fields, minor crops, coconut plantations, and

?the estuary bounded by mangrove communities of Rhizophora mangle L.,

Iagincularia racemosa I. Guertn., and Avicenia nitida, Jacq.

fman use of the middle watershed zone consists mostly of

residence, agriculture and recreation. Agricultural land ie mainly

devoted to minor crops like plantains and bananas. A large area of

?the land is now abandoned or being zoned for small lots from 1/2 acre to S acres. There are many intermittent streans that drain the lend on ?the middle watershed. In this area the african snail Blombalaria glabrata, the vector for Schistosomiasis, 1s present.

?The lover waterched comprises the flat lovlands of the coastal plain which extend landward for approxinately five Kiloseters. Rio Grande, the major town, is located on the coastal plain about 0.5 kilo- eters west of the Espiritu Santo River. The terrestrial systen was dominated at one tine by sugar cane but today tt ie almost equally occupied by suger cans, pastures, minor crops and coconuts

?The flood

plains to the west of Rio Grande are nov being developed

?urban areas

utilizing now a large land area formerly devoted to agriculture.

---Page Break---

For approximately two kilometers inland from the coast Line

?the red mangrove Rhizophora mangle flanks both sides of the river. Behind the red mangrove, well established stands of Laguncularia racemose are found, To the east of the river, extensive areas of angroves have Deen renoved and the land drained and filled for tourisa develoment construction purposes. Due to the lov elevation of the coastal plain, drainage is necessary for crop profuction. The inter+ face systen is comprised of both natural and nan nade drainage ways about which very Little is mown.

?The Soil Conservation Service (1968) has described five major

soil aseoctations for the area: (1) Swamp-Marshes, (2) Coloso-Toa-Bajura,

(3) Caguabo-Hiicara-Narenjite, (l)) Lor Guineoe-Humatas-Tirtos, and (5)

?The Rain Forest Association, Of these five associations, the last three occupy the most extensive area within the watershed studied.

?The geology of thie arca was deseribed by Seiders (1961) and presented in the USGS geologic maps of the El Yunque Quadrangle and the Rto Grande Quadrangle. The predominant rocks are the instrusive and atratified socks. The first are quartz dlorite and the second are chief-

ly of marine origin such

?the Hato Puerto formation. Tn the lower reaches of the watershed, alluvial deposits and terrace deposits are fa1so found. The weathering process of these rocks will define to a certain extent the chemical eceporition of the strean waters.

Land use patterns also influence the quantity and quality of ater.

?In 1972 an inventory of the island resources was compiled by the Department

---Page Break---

of Natural Resources of the Comonwealth of Puerto Rico. Through this agency {t wae possible to obtain the land use inventory for the year 1972 for the municipality of Rio Grande, in which the Espiritu Santo Watershed is located. Based on this inventory, 98.10% of the total acreage ie in use as residential areas, water resources and wetlands, forest and agriculture. Of this 98.4of, 51.70% was forested acreage, 35.4Gh vas devoted to agriculture, 6.1% of the area vore water resources and wetlands, and 5.12% wae residential. (See Appendix Table 1).

Although such s small percentage of the total area is used for housing purposes 52.25$ of the consumption from Rio Grande?s mnte-Spal water supply in Pebruary, 1974 vas used for residential water and sewage. Although 0.19 of the total mntetpality area is used for

Antustry, the water consuned by the latter for the same month was 37.82% of the total consumption. (See Appendix Table 2).

?These mmbers concern only the ton of Rio Grande which obtains its water from Lake Carra{zo. The "barrios", geographical areas within ?the municipality, obtain their water from quebrada Jiménez and Quebrada, Grande, Espiritu Santo ineide the forest and Zarcal (vest branch of Quebrada Jiménez). Monthly estimates given by the Water and Sewage Authority Indicate thet out of 21,293,000 gallons of water punped fron these streans, 11.24 1s taken from a comon outlet of Quebrada Jinénez and Quebrada Grande, ?and 87.636 ie taken from the Bspiritu Santo River, This water is mainly utilized for residential purposes within the rural zone. (Appendix Table 3).

---Page Break---

|A population census taken in April 1, 1970 in the Rio Grande minicipality indicated a relative increase of 27.8% from 1960 to 1970

(Teble 2). ?This relative increase was almost ninefold from the relative Increases for the years 1940-1950 and 1950-1960 vhich were 3.3% and 3.5% respectively. The recent large increase reflects the urban sprawl that

that occurred around the town of Rio Grande.

?Table 2, Population Census from the Tom of Rio Grande, Puerto Rico for

the Years 1940 te 2970

a

ation Census, April 1st. Absolute, Relative (

Ugo _1950__1960_3970 9-50 50-60 60-70 0-50 50-60 60-70

16126 16651 17244 22032 535582 W199 3335 27.8

An investigation was carried out on several selected water quality

parameters in the river system at the upper and middle portions of the

watershed. The lover portion of the watershed was not included in the

study, since the attendant problens associated with the study of estuarine

conditions were beyond the scope of this investigation,

The objectives of the study vere: 1) to evaluate the changes in

selected water quality variables as influenced by the existing land use

patterns of the area, and (2) to evaluate the gradation of these variables from high elevations to near sea level.

20

---Page Break---

To evaluate the influence of land use pattems on selected

water quality yareneters, ten sampling stations vere established

along the Espiritu Sento river and its tributaries Quebrada Sonadora,

Quebrada Grande, and Quebrada Jiménez. These streans originate in

?the upper reaches of the Iuquillo Experimental forest and flow through

forested arene and grassland areas with the exception of Quebrada Sona-

dora that enters the

spirity Santo inoide the forest. The upper

reaches of the Espiritu Santo river and the Quebrada Sonadore drain

northwestern slopes vhile Quebrada Grande and Quebrada Jiméne: drain

?the northern slopes of the Tuguillo mountains.

?Two stations were located on each tributary, one in the forested

area and on dn the grassland area. Because the Quebrada Sonadora meets

?the main strean inside the forest, the stations vere respectively located fon the east and west branches of the strean to determine the ingut of each branch to the system. Four sampling stations vere located on the Bepirity Santo river: inside the forest, at the boundary between forest and gracs~ and, onthe grassland-ares, and at the uppermost part of the estuary.

?The latter station reflected the salt vater input into the river system.

?Tho location of each station was selected to evaluste the influence of vegetation types upon selected physical and chenicals parsneters over fa period of six months. Sampling and measurenents were done on @ bi-weekly basis. Measurements vere taken in situ and surface water samples collected from each station in plyethylene bottles were taken to the

Inboratory for chemical anslysis

---Page Break---

?The parameters to be studted were: Aiesolved oxygen, pil, fr carbon dioxide, chloride (C1), salinity as NaCl, and elesental concen=

?trations of calcium (Ca), magnesium (Mg), sodium (WWa), and potassium

(Xk), Following are the methods and/or instruments used for the deter-

mination of the paranetere mentioned shove.

Temperature and Dissolved oxygen: In situ determinations made

with YBI Dissolved Oxygen eter, Model SIA using a YSI $718 Oxygen-

?Temperature probe.

pil; Orion Specific fon Meter, model 40h with a combination pi

glass and calome) reference electrode. In situ.

Pree 00,: Titrimetrie Methods for Free Carbon Dioxide as stated

in Standard Methods for the Bumination of Water and Wastewater 13th.

Hatton, 1971. Tn situ.

Chloride: Orion Specific Ton Meter, mode YOK, using model 94-17

Solid State Chloride Electrode in combination with the Tonanalyzer Double

Gunetion Reference Electrode, model 90-02.

Salinity (ae NaCl): ppm CL x 2.65 = ppm NaCl, as stated in

Standard Methods for the Examinstion of Water and Wastewater, 13th edition 1971.

Chemical analyses for Ca, Mg, la and K: Atomic Absorption Spectro-Photometry. Thformation on rainfall for the period of study was obtained from the daily rainfall records of the area taken and maintained at the El Verde Field Station located on Highway 186, Km, 19.3. It is the only station that maintains daily rainfall records on the northern slopes of ?the Inguille Experimental Forest, There are no available records for ?the lowland area.

---Page Break---

?The results obtained from field measurements and laboratory

analyses were transferred to TIM cards for date processing and sti

tistical analyses,

Results and Discussion

The Espiritu Santo basin and the tributaries along with the station location and identification mubers are show in Figure 2.

?The description and site characteristics of each station are sumarized in Table 3.

For study purposes the watershed was divided in two areas: forest and grassland. The forest $s defined as a considerable area of land covered with a heavy growth of trees; in our case a tropical rain forest with @ precipitation ranging from 75 snehes to 150 inches per year (Odus, 1910).

Grassland is defined as the area vhich has been cleared for agricultural or housing purposes and in which the veretation is composed of grasses and the trees are Limited to stream valleys or are widely scattered.

?The system is then defined as the river basin whien flows through forest and grassland until it reaches the uppersost part of ?the estuary and flows into the ocean. The aysten in itself shows the influence of the existing vegetation types in a composite manner.

The data were analyzed statistically utilizing anglysie of variance, single way classification, Duncan's New Multiple Rance Test

to separate means, and T-tests were applicabl

Stations values are

grouped in various combinations for data analysis ac shown in Table i,

B

---Page Break---

---Page Break---

a6 rwnges 9 39 cums manstia 6

iar

oom

Bott eed spmmip wmicors g

ose yong soupens wegen

sot pevteseig sour wpescen °

as verrernio omg mparieg ?

06 pevrerasg spreso wpeiner 1

ea sepmog owes marsrig ?

026 ?ensog vg nanses z

= 006 ong ?scopes wyesger> at

sors eomee sopwuos wrez@n> HT

WTSI ST RTT a Sar Saar

or 3098804 worms

soyeng ofwareia oyuwe nerzrdey aun uo suor eis SurTdaw yexssTeg Jo woTaNsoT paw ?uoT ARTE ?uoTadTsONeG BRE ?E OTM

---Page Break---

?Table ll, Combinations of Data for Statistical Analyste

Wd, Ee

Combination Nia woo 3 7 5 6 7 8 9

ALL Statione woox X eK x x Kx xX x

ALL Stations

except upper

estuary 9 kX KX Xe XK x x

Forest 6 x xxx x x

Forest w/o

Doundary 5 ox oe x x x

Grasstend 3 XK x

Grasstand

ine. boundary 4 xe x x

Each variable will be discussed separately, firct in terms of

?the overall system, then in terms of the system exeluding the upper

estuary, and finally ac forested versus grassland arcas as a fmction

of time.

?enperature

?The bi-weeldy water temperatures for the selected sampling

stations of the Espiritu Santo watershed are presented in Appendix Table

4, Mean station values ranged from 19.1°C + 0.8 inside the forested

zone (Sta. 2) to 2h.0°C + 0.5 in the uppemost part of the estuary

(Sta. 9) (Table 5). During the period of study, averare miniman and

?maximum water temperature occurred in mid-January and late October,

respectively, The data sugrest that averave minimum vater temperature

---Page Break---

eB FATT Ma ayo OF

oat oeaes WAN PARETISS BOT

aon emo

- vorardes,

sewinot oxen

ens

seers one

wine

receews eemie

wees

ware

owereso mee

wees

seems some

wees

wma ym wpmoe

Saker steed

weet omen peoreoe

Say eae

on scriSamy wast

fog om 20 suovasng Gousetes 28 pemewn,sorqeTsma wwe sas roma afmisey ?TERE

---Page Break---

in the forested areas occurred about two weeks after the minima

temperature in the grassland areas (mid-January versus the end of

January). Temperature ranges during the study period varied depend-

?ng upon station location, elevatton and type of vegetative cover.

The minimin range of 3.3°C was found at Station la (510 m elevation, forest cover) while the maximm of 6.5°C occurred at Station 9 (5 m elevation, grassland area). Generally, the mean texperature of the water floving from the forested areas was 3°C lover than the grassland (open) areas (See Figure 2). Temperature differences were found to be significant at the 0.05 and the 0,01 level ven the data were combined fas grassland versus forest for the entire systen and t-teste were performed, (See Table 6). Testa performed on the date for each river system shoved no significant differences between forest and grassland

stations for the Quebrada Grande. However, the dat

for the Espiritu
Sento river and the Quebrada Jiménez vere significantly different vhen tested. (See Tables 7,8,9 and 10). The differences may be due to vegetative cover, elevation and reduced insolation at the higher ele-vation due to cloud cover or a combination of these factors.

?The effect of elevation on air temperature gradients in the Tuguillo National Forest was measured by Jagels (1963). Working from ?the El Verde area to the El Yunque peak, he measured air temperatures fat five locations and reported values of 25°C at 360M, 24.7°C at 428M, 23.1°C at 567 M and 21.NC at 636M. This is a difference of 3.4°C

over an altitudinal change of approxinately 275M. Odum (1970)

reported that temperatures at the forest floor were 0.5 to 1.1°C lower

---Page Break---

o We ti

2 Gane

o Fost

sel

gal

= ul

S10

1

st

Fadl

2 104

8

so

gx

£ aw

Fw

Hb al ee el mw sl al

ccronee tone? tee air ? cman? Baacn aha

Figure 2 Types for Temperature, Dissolved Oxygen (00), and Free Carbon

rity Sante Drainage Basi

---Page Break---

Table 6, t-test and Levels of Significance for Forested Versus Grassland Stations in the Espiritu Santo Drainage Basin.

TTT rT

ar. 0. of Significance

Temperature aye T 73.3960 2.365

2s 7 i300.

Dissolved a) 7 Teor 18

oaygen 2) 70.9850 18

Free Carbon Ro7 ame | *

Dioxide 2 7 wis" Ne

Salinity a) 7 -2.87h0

2) 7 -Ligrre xs

Sodium 1) T Behn? ?

2) 7 -leore "

Potassium a) 7 2.6857" ~

2) 7 paket 8

calcium) 7 3enB ot ?

2) 7 ee" ?

Magnesiua 1) 7 3.6807 ?

2) 7 7215889 *

chloride yo 7 2.6862

2) 7 1.8918

2} forest vermus grassland nen

2) forest minus boundary station versus grassland plus boundary station

+ Highly ofgniticant

WS Hot significant

---Page Break---

Table 7. t-tests and Levels of Significance for Forested versus Grassland

Station, Forest versus Boundary Station, and Boundary versus Grassland Station in the Fepiritu Santo River.

TTT LTT OE

Variable Combination aft 0.05 Significance

?Temperature Pye ee 7.176 ?

Pye B 22 -s.lin33 ?

BveG 2 115078 6

Dissolved Fyec 22 0,108 xs

Oxygen Fes ze 1.6729 18

ByeG 2 1.7301 8

Free Carbon Pye 19 0.3261 1s

Dioxide Pye B 19 0.6658, 18

Bye 3B 0.8106 18

Salinity Frys 20. 1.8500 cS

Pye B 20 -1:3609 ms

ByeG 20 0.7736 1s

Sodium Pye 22 8.5055 "

Pye B 22 1.5589 ?

Bye 22 -212el3 *

Potassium Pye 22 6.7901 ?

FveD 22 10.3950 =

Bye 2 3.609 ?

calcium Frys 22 8.386 ?

FvsB 2 6.8778 ?

Bye 2 ?2:7210 +

Magnesium Pye 22 -12.6800 2.074 ?

PveB 22 ?011208 © 2.074 ?

ByeG 2 310962 BLO ?

chioride Pye 20 1.8498 2.086 us

PveB 20 113615 2.086 us

BveG 20 0.728 2,086 18

F = Forest, 1B = Boundary G = Grasstand

NS = Not Significant, * Significant M Highly Significant

a

---Page Break---

?Table 8, t-test and Levels of Significance for Forested versus Grassland

Stations in the Quebrada Grande Tributary.

Tre OE

Variable ae £ ?os Significance

?temperature a -1.9396 2.080 1

Dissolved

onsen a ?1.069 2.080 s

Pree Carbon

Dioxide Fry ?4.5887 2.101 ?

Salinity ct 2.2490 2.098 .

Soatum a 6.2321 2.080 ?

Potassin aa ~1.1610 2.080 ?

caleiun a 8.87 2.080

Magnessn 2 1.2183 2.080 a

Chloride » 0.7370 2.093 1s

---Page Break---

?Table 9. t-test and Levels of Significance for Forested versus Grassland

Stations in the Quebrada Jiménez Tributary.

. Tavel oF

variable at t 2.05 Significance

?Temperature 22 5.8710 2.0m ?

Dissolved

Oxygen 22 2.0848 2.078 18

Free Carbon

Dioxide 8 2.3017 2.101 *

Salinity 20 2085, 2.086 ?

Sodium 20 12.2016 2.086 ?

Potassium por =10.5250 2.086 ?

calesim 20 © -18,.0040 2,086 ?

Magnesium 20 -21.1ho5 2.086 ?

cmoride 20. 4,208 2.086 ?

WS © Wot Signiticant * Signi rteant * Mighly Significant

---Page Break---

Table 10, t- Test and Levels of Significance for East Branch versus

West Branch Station in the Quebrada Sonadore Tributary.

aed OF

5

Variables ag. t 0.05 Significance

?Tesperature 2 0.6861 2.07s 15

Dissolved

Oxygen 22 -1.1760 2.07h 15

Free Carbon

Dioxide 20 -0.1547 2.086 15

Salinity 20 0.3960 2.086 Xs

Soaiun 22 4,z159 2.o7h ?

Potassium 22 3.812 2.074 ?

catctun 22 1.9698 207k ns

Magnesium 22 8.5386 2.078 ?

chloride 20 0.3959 2.086 %

WS = Not Significant

* = Significant

+ © Highly Significant

---Page Break---

?than at the canopy level in the Tabomuco Forest (elevation, approx!- nately 500M). ?The vegetation cover of the forest would in tum reduce ?the heating of the soll resulting in @ lower soil tenperature. The subsequent infiltration of rainfall and percolation through the cooler ?temperature regime of the soil profile could result in the lovering of soil water temperatures before its release as flow.

?The data in Appendix Table li were subjected to an analysis of variance, single vay classification, to test for differences anong

stations end also across sampling dat

?The results showed significant

aifferences anong stat

wn means et the 0.05 level. ?Those stations that

Aieter significantly from other are presented in Table 11, Temperature variations became statistically significant vhen analyzed acro:

sampling

dates. Pigure 3 shows s lovering in texperature throughout time which

coincided with the cooler months of Novenber, Decenber and January, Mean

?temperatures ranged from 20.2°C ¢ 0.5 to 22.

°C + 0.5. Although the aif-

ference between the average is only 2.\"'C, the differences over tine are

statistically significant. (See Table 11).

Dissolved Oxyuen

?The dissolved oxygen values obtained throughout the study period

were found to be near saturation at all tines (See Appendix Table 5 and °?

Mean D0 concentration values per station ranged fron 8.2 me/1 + 0.1 at the upper estuary to 8.7 + 0.2 mg/1. (See Table 5). The differences anone stations were found to be nonsignificant at the 0.05 level. Within this narrow range a gradient fron forested to grassland was observed with the

---Page Break---

sm . st oa ox su oes ot

Bnew sara aia . ~ . . - seanaatins,

mw 2 . , oom . 7

a a es a s a as oa 2

~ - #4 oe a s ot a ?

ewe ox st oo st 4

? ? st oa x mo en

. ? a si . . a Foo sae

. . st = « 7 asyures

Tera par TR oR aT ET TTT

Somreenio. ose arog swan

or ore,

---Page Break---

highest DO concentrations inside the forest and the lowest concentrations im the graselant areas.

Within the grassland area Quebrada Jinénex (Sta, 6) varied significantly trom the other tvo stations, This station ie located at a ower elevation than the other two grassland stations and its moan temperature for the period studied was the highest of the three. When station 3 vas included tn the grassland values, no significant differences were found between stations. This Le due to the fact that the DO values ?for station3 fall intermediate between the values for the other samplin stations this eliminatin; any sharp differences betwcen them.

Dissolved oxygen concentrations fluctuated throughout the sampling period, These fluctuations vere found to differ algnificantly at the 0.05 level except within the grassland system (See Tsble 11). ?The inereace and @ecrease in concentrations coineided with the periods of decrease and increase in temperature during the period studied (See Figure 3). Low water temperatures in the forested arene along with the steep stream gradients give rise to constant and maximum acration vhich ie probably responsible for the high DO values found in the stroane. A t-test performed fon the data for each river system showed no simnificant differences between

forest and gracsland stations for the sane river (Tables 7,8,9,10).

Carbon Dioxiae

The bi-weekly values for free carbon dioxide are precented in

Appendix Table 6. The values encountered fall within the nomal range for

surface waters vhich normally contain less than 10 wr/1 60,

27

---Page Break---

SE

:

:

\

:

Sangha

concen we

F

Tearcure *

ONEALL ncHES

on woe an eros msc are

Hove

---Page Break---

Methots for the Bxasination of Water and Wastewater, 1971). Mean values ranged from 2.04 mg/1 in Quebrada Sonadora (forest) to 3.52 ug/1 in Quebraia Grande (grassland). The overall mean concentration for the entire systen, excluding Sta, 9, wis 2.11 £ 0.25 me/2. The highest observed values were recorded at Station 4 (3.52 + 0.21 me/1) and Station 9 (3.44 + 0.22 mg/1)(See Table 5).

Mots values axong stations were found to atfer significantly ft the 0.05 Level (Table 11). Station means were separated using Duncan's

Multiple Range Test, ?The mean for station 4 was found to be different from al other stations Ia, 1b, and 7. Although the atererence én these values might have @ statistical elgaiticance, ve eantot drew any con-

clusions at this menent. The inputs from respiration and chemice?

reactions to the aquatic system could be considered minimal. The main source of GO, to the water could be the gurface aeration caused by the steep gradients end in turn the constant turbulence and turnover of the systen.

When stations were separated according to vegetation cover, te. Forest ve. grassland, the means from the grassland stations vere found to Gifter significantly from the forest stations utilizing the t-test (See ?Table 6).

However, C0, determination in the field is highty subjective epending upon 2ight conditions and color interpretation. The lovest values in Appendix Table 6 belong to areas heavily shaded, whereas the highest values belong to open areas. Errors in reading due to this di?-ference in light intensity could be the reason for the variation encountered in the aysten.

29

---Page Break---

aH

Out of @ total of 119 observations in Appendix Table 7, 87% of the values fell between pi 6.6 and 7.4 with @ modal value of 7.0. Sixty four percent of the values vere of pH 7 or lover. Based of this ata there seems to be no apparent trend for the period studied. Further studies will provide more information on the acidity of the river system.

Data reported by sis (Report 1973) from 1968 to 1972 for the Fepirity Santo River ranged from 6.2 to 8.6 with 8lf{ of the observations falling between pHi 6.7 and 7.5. 87% of the values vere of pH 7.5 or jower. This information gives similar results for pH values as the ones obtained in this study. In general, pif valuee seems to be more acta in ?he forested areas and more alkaline at the lover reaches of the rivers

o statistical analyses were carried out to test this hypothesis.

Elemental Concentrat ions

fenental concentration in the overall systen is influenced by

soil types, rock weathering, rainfall, dryfall, salt spray, and vegetation

types. Salt vater intrusion at the uppermost part of the

sbuary also

Provides enother source of input to the river systen. Cintrén (personal

communication) mapped the salt water intrusion for the Espiritu Santo

tusry and estinated that the salt vater wedse extends about five Kilo-

?meters from the estuary into the fresh water syste. So{l and rock

weathering provide the major eupply of tons to natural vaters (Gorhax,

1961) with the concentration of the dissolved salts related to the parent

---Page Break---

material varying with rocks types (Miller, 1961; Bogart, 1964).

Seiders (1971) deserived the rock formations for the Gurabo and EL

?Yonque quadrangles and presented sone data on oxides found in the

aifrerent rock formations.

USGS data are available for the period of 1968 to 1972 for

?two locations on the Fspiritu Santo river (USiS Report, 1973, Fart

2k). USGS Station 00638 ts equivalent to station 2 of the study vhile

?the second station was located approximately 50 meters upstream from

?the confluence of the Quebrada Jinéner with the Espiritu Santo, These

measurements were taken on a eporadic basis of approxtaately two to

eight times per year. When averaged over a five year period the data

gave approximate average values for the concentration in mg/2 of Wa,

% Ca, Mg, and Cl of 5.5, 0.4, 4,0, 1.7 and 7.9 respectively for

station one and 6.6, 0.37, 6.1, 3.8 and 9.33 respectively for station

two.

In general the average values are similar to those found in the

carrent study with the exception of Ca and Cl. ?These differences might

?be due to analytical methoda in which the gensitivity of the measurements

could vary according to the techniques utilized. The USGS values for Ca

fare almost to to three tines higher than the values found in the current

study. The values reported by Clenents and Colén (1972) on the Ca content of the Quebrada Sonadora and Quebrada Grande for the period of 1971 to

1973 are in agreesent with those found in the current study.

The results of the chemical analyses for Ca, Ma, Na, K, and CL

?re presented in Appendix Tables ,9,10,11 and 12. Average elenental

---Page Break---

concentrations chowd 8 marked increased in station ») (uppermost

art of the estuary) with values of 88.14 § 23.0 mg/1 1a, 3.291 0.8

Be/1 Ky 2038 4 0.2 me/ Coy 14.86 + 3.3 mg/L Ms, and 3K.27 + 97.89 me/

1?1 as compared to the average concentration Cor the other stations

taken together which were 6.46 ¢ 0.1, 0.33 + 0.0, 1.30 10.2, 2.19 ¢

©.2, and 17.58 + 1.22 respectively,

A steniticant atttcrence was found anong station's means for

the concentration of Nay K, Ms, ani Cl. Table 5 presents the verege

values per station and also hich stations after trem others according to the New Duncan's Muttiple Range Test. Table 12 presents a sumary

of the results presented according to vegetation types which suggeste

* eradient fron the lovert concentrations in the forested area, inter-
Rediate concentrations in the grassland areas, and the highest concen-
trations at the uppemost part of the estuary. ?The wide fluctuation
encountered in the uppemost part of the estuary reflects the salt wmter

intrusion in the area.

Table 12. Summary of the Results for Sodiun, Totassiun, Calesun,

Marnestun, ant Chloride in Strean Water According to Yege-

tation Types. (Concentration Is given in sefl)

Vegetation

?vze___soaiun | Potsssiua | catetun Chloride

Forest, 0.06 fo.40 + 0,00] 1.04 + 0.02] 5.75 + 0.96

1 0.22f0.39 + 0.00/1.88 + 0.07 let.ov + 1.36

[3-29 + 0.8412.3% + 0.03 32/3.27 £97.83

2

---Page Break---

Small differences appear to exist from east to west with the eastermost stations having higher elesental concentrations than the westernmost clutions. Differences in geologic substrate and soit types can produce this type of variation in adjacent arear. The effect of orographic rain can also influence rlemental variation tn fan area, In forested coosystems, reinfell is a source of nutrient elenents (Odum, 1970, Clonents and Colén, 197%). Tn the Luquillo

mountaine, the ot

tern part of the sierra gets the highest anount of rainfall per year (Wadsworth, 1951). Form this we can speculate thet the easternmost cide of the sierra will receive a larger input of mitrients in the rainfall which coupled with soil and geological input will increase the absolute ctrean elemental content of Cl and Wa which in this area are primarily of atmospheric origin. Future research wil ?be required to assess the elenental variability of the streams in the

Inquillo mountains and to correlate it, 4f possible, with the soure

mentioned before. t-tests on the date for each stream chowed aignificant dieterences between the forest stations and the grassland stations (Table Je10). No siymificant @ifterences were found at the 0.05 level for the concentration of Na, X, Ca, and Mg when the data were tested ac a function

of tine (See Pigure 4). Clemente and Colén (2973) monitored the Quebrada

Sonaaora and Quebrada Grande (Sta. \) for the period of 1971 to 1973. No

significant variations across tine were found although there were aif-

ferences in concentration between the two sampling sites. Chloride con-

centrations in the streans fluctuated significantly across tine (See

Pigure 4). Odum (1970) related the chloride content in the system to

---Page Break---

a

§

nn

By

RE

---Page Break---

proceases of exchange at the sea surface with wind controlling the ancunt of spray released into the rising air thet passes the Luquillo mountains, Corban (1961), has also related the fluctuations of chloride concentration in time with the concentrating and diluting effects of ary and vet weather. Wo seasonal variations vere observed

during the period studied.

Salinity

Salinity values were computed by measuring the chloride con- ?centration in the stream water and expressing 1t as sodium chloride according to the forma me/1 NaCl = 1.65 X me/1 C1? given in Standard Methods for the Examination of Water and Wastewmter, 13th Edition (ag7). The date for the period studied gives evidence of @ salinity gradient with the lowest concentrations in the forest area, intermediate concentrations in the grassland areas, and the highest concentrations in the uppermost: part of the estuary. The relationships between station jocation, elevation and salinity values are presented in Figure 5. The data aloo suggest @ salinity gradient fron east to west: with the eastern~ most stations having © higher salinity concentration. Salinity values for station 9 fluctuated widely from 4 low of 38.28 ma/1 NaCl to a bieh of 1019 mg/2 reflecting the tidal influence at this station and also the influence from river discharge fron the mounteins. In periods of heary and/or contimous rains vhen the river discharge is increased, surface water samples will reflect the elenental concentration of the rivers in ?the mountains. During base flow conditions it will tend to reflect not only the fresh water concentration but also the mixing of the salt water

Snflow during bigh tide (Appendix Table 13).

---Page Break---

ita 5 eae Saliniy Votes pr Sa 1 Espisite Saale Drainage

---Page Break---

Yo eliminate the effect of tidal fluctuations, the data from station 9 vere excluded from the statistical antlysic. Significant aifferences were found anong stations which depended upon the station

location within the drainage area (8.

?Table 11 and Figure 5). Table

5 gives the mean saDintty values for each station. These values ranged ?from 22.57 ng/1 in the wst branch of the Quebrada Sonadora (Sta. 1.d)

to 0.05 mg/l at Quebradi Jiménez, grassland (Sta. 6). Using Duncan's Multiple Range Test to separate means, station 4 and 6 were found to be similar but significantly different from all the other stations. Salinity values for stations la, 1, 2, and 3 vere not slgntficantiy different: but varied significantly from station 7 (forest). Mean values for station

5 (grassland), 7 and 8 (?orest) were similar ranging intemediately with station 1a, 1b, 2 and 3 (forest). ?These differences indicate a possible salinity gradient across the systen which could be determined by elevation,

and use, elemental concentration in rainfall, wind, geclogy, and soils.

?Summary

?There was @ general increase in the values of ell the paraneters ensured from higher to lover elevations with the exception of dissolved oxygen (DO) that decreased slightly. DO values vere found to be near saturation at all tines. Free carbon dioxide (C0,) concentrations ranged within the nomial valuer for natural surface waters as were the pH values that ranged fron 6.5 to U.2 with @ modal value of 7.0. The values for the concentration of sodium (lit), potassiua (K), caleiun (Ca), magnecsun (Me), land chloride (C1) were fiund to be below or near the accepted for drinking water standards (See Appendix Table 7).

?

---Page Break---

Pach river or tributary differed significantly fron the others in the concentration of the elenents mentioned above, ?These differences ere maintained throughout the tine period during which the measurements were made. No marked seasonal variabilities were cbserved except for water temperature which reflected the lovering of air temperatures during ?the winter months.

Based on the results obtained for the concentration of elenents, the Fepirity Santo drainage basin appears to be in steady state conditions in which no time dependent variations occur within the aquatic system,

?This scons to agree with the results of Johnson (1969-1971) who showed fa constancy of the chemical concentration of selected ions for the Hub-ard Brook streams during the period studied. Stream flow measurenents will determine the tote? elenental Alscharge which will vary depending upon

?vase flow or bigh flow condition

Rapid tumover of the water keeps the systen under constant renewal, ?This characteristic makes 4t difficult for possible health

pavards to take hold and thrive, Any modification of land use patterns ?that could modify the flow rates of the streans making then flow slower

could result in the creation of optim habitats for the liver parasite, Schistosoma panconi, a health hazard for man.

---Page Break---

LITERATURE CITED

?American Public Health Acsocistion, 1971. Standard Methods for the Examination of Water and Wastewater, 13th Baition. American Public Health Association, N.Y., 87h pp.

Departamento de Salud, Censos de Poblacién de Puerto Rico, 1940, 1950, 1960, y 1910.? Gobiemo de Puerto Rico.

Soft Conservation Service, 1968. Soil Survey of the Humacao District. ?Unpublichea.

United States Department, of Interior Geological Survey, 1974. Water Recources Data for Puerto iico, Part 2a, Water Quality Records 1968-1972. United States Departaent of Interior Geological Survey, Washington, D.C. 10 pp.

Black, P.Z. and R.E, Jeonard, 1968. The Principle of Watershed quillbriun. Water Resources Bulletin li; 49-50, Bogart, D.B., T. Arnox, and J.W. Crooks, 1964. Water Resources of Puerto Rico, a Progress Report. Water Resources Bulletin No. 4. United States Geological Survey, Washington, D.C. 402 pp.

Candetas, G., and G.C. Candelas, 196. Plankton Studies on Puerto Rico's Freshwater lakes: Physical and Chemical Nature. Caribbean Journal of Seience li: 451-58.

Clenents, R.G.,and J.A. Colén, 1972. Yerrestrial Ecology Program Annual, Report. Puerto Rico Nuclear Center Annual Report No. 165. 111-2 pp

Clements, R.G., and J.A. Colén, 1973. Terrestrial Ecology Program Annual Report. Puerto Rico Nuclear Center Annual Report No. 176. pp. 132.

Evel, J.J., and J.L. Weitenore, 1973. The Eoologieal Life Zones of Pierto Rico and the U.S. Vingin Islands. Forest Service Research Paper ITF-18. Institute of Tropical Forestry, Rio Piedras, P.R. PP. 72.

Gleason, H.A., and Mi. 7. Cook, 1927. Plant Heology of Puerto Rico. HY. ?Acad.? Sci. Scientific Survey of Porto Rico and Virgin Islands.

Vol. 7: 1-273.

Gorham, E., 1961. Factors Influencing Supply of Major Ione to Inlend Waters, with Special Reference to the Atmosphere, Geological Society Of America Bulletin 72: 795-810.

---Page Break---

Jagels, ¥.P., 1963. The Variation of Rainfall, Temperature, Soi) Molsture, Soil Characteristics, and Vegetation with Elevation ?as These Affect Lhe Computation of a Water Balance in a Localized Drainave Area of the Luguiilo Mountains. Unpublish-ed Course Report, Institute of Tropical Forestry, Rio Piedras, Puerto Rico.

Jolnson, N.M., G.B. IAkens, ¥.H. Bormann, D.W. Fisher, and B.S. Pierce, 1969.? A Working Model for the Variation in Stream Water Cheaistry at the Hubbard Brook Experimental Forest, New Hampshire. Water Rosourees Research 5: 1353-1363.

Johnson, W.M., 1972. Migeral Equilibria in Ecosystem Geochemistry. Booloty 52: 529-531.

MacKenthum, K.M., 1969. The Practice of Water Pollution Biology. USDI, FaPCA. 261 pp.

Miller, J.P., 1961. Solutes in Snail Stress Draining Single Rock Types, Sangre de Cristo Range, New Mexico. United States Geolo-gical? Survey, Water Supply Paper 1535". 23 pp.

Odum, E.P., 1971. Fundsnentals of Zoology, 3rd. edition. W.B, Saunders Co., Philadelphia. 574 yp.

+s and K.P, Pigeon, 19/0. A Tropical Rain Forest, A Study of Irradiation ?and Ecology at #1 Verde, Puerto Rico. USABC Division of Technical Information Fxtension, Oak Ridge, Tennessee.

Rul de Reyes, N., 1970. Estudio Beolégico de 1a Laguna Tortuguero, Puerto Rito, Informe Pinal. Water Resources Research Institute, Mayaguez, Puerto Rico. 119 pp.

Seiders, VM. 1971. Geologte Map of the E1 Vunque Quadrangle, Puerto Rico.? Map 1-658. United States Geological Survey, Washington, D.C.

Seiders, VM. 1971, Cretaceous and Lover Tertiary Stratigraphy of the

Gurabo and #1 Yunque @uadrangies, Puerto Rico. ?eological Survey

Bulletin 1201.F. United States Geological Survey, Washington,

D.c., 58 pp.

Smith, R.F., 1966. Ecology and Field Biology. Harper and Rox, New York.

686 pp.

Vésquez, A.8., R.B. Rangolam, H. Quijano-Vives, and A, Ranos-Vi1lame va,

1970.? ?The Water Resources Situation ih Puerto Rico: An Evaluation

of Miblished Inforaxtion. Technical Completion Report A-O12-PR.

Water Resources Institute, Mayaguez, Puerto Kico.

Wadeworth, P.li., 1992) Forest Management in the Iuquitlo Mountains; I,

Setting. The Caribbean Forester 12: 93-10h,

---Page Break---

Appendix

---Page Break---

Appendix Table 1. Tard tse Inventory tor the Municipality of Rio Grande,

Puerto Rico according to the date furnished by the Nepertment of

Natural Resources, 1/0.

aE OE

Hand Use Category ___Horeage __ Acreage ?Potad

Communications

Power Substation 1.26

Radio Towers 8:79 10.05 0.08

?Transportation 9,00 0.00 9.00

Non-produetive

Sant-Coastal 106.22 106.22 O27

Outdoor recreation-all types 202.35, 28.95 0.56

Public factlities-al) typ m.2h ua 0,28

Comercial 6.1 0.22

Urban-dovntoun

Comereial-strip

Motels

Industrial 74.78 0.39

Light-non-pollutent, 28.91

Heavy-poltutent 16.33

Industrial Park 29.51

Residential Urban 1001.26 2.26

Light density 1.88

Mediun density 3518

Keavy density 275.31

sium 6.28

Unconstructed within urbas

Area, 10.05

Under construction 556.96

Resident ial-Rural 1229.52 2.86

?Light density

Medium density

Blue

Strip

---Page Break---

Cont. Table 1

seen de aT Pca OF

Use Catego Acreage __Acreaze Acreage,

Water Resources and Wetlands 219.73 6.14

Rivers, Streans (width 50'+) 8.05

Enbayed, protected 215.59

Natural? fresh water pond Wito

less than 1 acre

Mangrove swanps 1585.84

Shrub, bushy wetland 20.7%

Saltwater marsh 139.54

Freshwater march 359.53

Forest Use 20392.90 51.70

Fine, woody growth 6281.80

Solid crown cover 1325.62

Light, scattered crow 88.63,

Public Forest, 1269685

Agriculture 13985.97 35.46

Sugar Cane 632.70

Cocomt groves 2064625

Grazing 1899/21

Floriculture 6.28

Coffee én

Intensive comercial crops 64.73

?Small holder (planted) 67-88

Citrus plantation 6.28

Banana plantation 9128

Inactive gia

Active 25.14

?TOTAL 39540.12

SC

a3

---Page Break---

Appendix Table 2. consumptive Water Use for the Mantetpality of Rio Grande

for the Month of February, 1974. Source of Water-lake Carraizo. Data

from Records of P.R, Aqueducts and Severe Authority.

Fea, 97 Facer 6 ?

Use Category cubic Meters? ?Gallons ?Total

Residentiad Water 158,159 4,753,976 35.617

?jin semeces T1919 20,586,456 17.58

Water cetinated 24626 653,264 0.59

Ablic fountains 1,008 266,12 0.23

comercial Water 21,23 §,608,350 Lp

comercial Vater 9363 akraaxe ean

pis eevege

Betinated Vater 778 469,390 oko

Mater plus semge ere 71,868 0.06

Fire tydrants 3,268 60,752 1.65

industry 1312 3,930.368 1.65

ithe sewse 160,378 42,339,792

soraL 43,386 127,053,908

SSS

My

---Page Break---

Appendix Table 3. Consumptive Use of Water taken fron Freshwater Sources

within the Municipality of Rio Grande for the Piseal Year 1972-1973.

a teat Fei

Source of Freshwater Estinatet Betimate Betinate

Quebrada Jiménez and

Quebrada Grande 79,000 gal. 2,400,000 ga. 28,800,000 gat.

Espiritu Santo (622,000 gar. 18,660,000 ga. 227,000,000 gal.

Zareal - Tributary of

Quebrada Jinénez 220,000 gat. 330,000 gal. 40,000,000 ga.

?TOTAL 811,000 gal. 21,293, 000 gal. 295,800,000 ga.

eS

* Data from records of P.R. Aqueducts and Severe Authority.

us

---Page Break---

spayesoymn ox soz aaores enon uy poperauy ou ?Arongse oy Jo yw a80m 9s

raoyaypucs seapsuew piv tocnn UB Zo some sows You TENS

a a

oma a i PL z

Ce

i a a a

bo Ge ose oe sts ore Ge gto StI

wo wwe ow oz om ome ote ots See werent tal selt a a

a i

a

fo Lee oe ote om oes Sows Settee Leet

a ad

wo ete 6 ve of oso te ET we ree nia tt

bo 9 oR = + om oe Ooms ote oreo T

bo re om one ote vue omer wte bet

Rg ea

xs ?y woltws wring sori worms woHms uoriNg sorimig sortms uoTINGg worms oTES

fy af suopyeig ponoeras 38 9, UF spun sarGUsedsoT foyeanens N STRE

sapcedty

spogessaen oats 4

---Page Break---

payszesen 9qy 405 sencea swe oT popstour 30H ?éramas9 ays go awd om stddiow

acoraypis snopenzey paw seven "Bq 30 somasey Unces YOU aTEENSe

TOS ¥

a | | ¥

oo ce ee ove vee eek

oo ce ve 98 Se 6s 9G 8 ete

oo se ye ve ove 98 98) See

ro $e ae o6 oe ee 8 ze Le oe oe ve nbisele vo ge ee ove ee ove 68 06) Seve

woes vs $8 16 ve wots

vo es ee se 6 ve 08 68 ve ve 8

voee 98 vee fe 98 Ber

oo ve oe ote ous we tee eee

oo se oe ove ote Se Ree

vo re oe =» 94 ve 08 fe 64 cB 68

eh oo ore ee eve ze ee exejor

=F ge a

worig worms wolime worinye wimg uohime worms wore stem

fonoms mavardea ous ur auopaeas pauseren 9 1/SE Bt spurs wodldeo paatowsTg ArIaeeTE ?§ eEREL

Seusily

?

---Page Break---

sasomameeee os,

?cufet/te Tram ayBeq 200 PTD saueEe TENE

speuezeyan os 105 senrun vee ut pepetoct you teiwnste sus 30. Sie 00 seddhee

suoqaypuce rropseate pe Z9yRn WPT Jo S4TwDIG UoxeS OU F9LCENSe

BO HOA

a a Sr a

woos - ce ot = : : +i we we wre

vo me ove aie v's cbs ose tz werz vets

zo me oe oye Gt EE ewe eT TT

zo ee wT Tare ore ore ore atts oe wt

ome re owe ome ee aE meee ww

zo sre ove Gre ez we ove wy eee

vo we re owt wT i ove mE we waves

zo ue Be GT OT week wT

zo we ove ewe cree Ete Te

rout wy 62 we owe Ge ey ee ore wT Oe

Fo wT Oy eT wT we Ewe wwe

r a we

ng worms wring sas WTI

a T 3

aSties urine corms worms corms uo)

?poussoyun oes Nq]s1G0y 043 UT UOT NIG FOIDETES 48 HAs TY SHUPMRINETEM SpIAOT

UOQND ves ATOMMNHE ?9 aTeHE

?Spundly

---Page Break---

?ouoyyypuoo seopsereg ue a9y0R TY JO oeNI?G TENN 30u TENGE

Cr a a a whale

ag 3938s wD wupel

Th 89 rh 9 Ltt u/s

ol 690 ok Lok ww wusele

eo ek kk LLL wuferfe

69 rh rk rh re ob thst wufeere

vk ek kL LD wih

eo ek ek eupeeler

S999 69 HDL kx fotet

7 a SS a) eapape

on ts 89 oe kL twat

fL fh ok tL eee La or

z 3 7 t z og 7 ar

worms worms uoTvesg uoTIeae uorzeg uoHTeg woTHeS LormE woryms worms stan syerezeyey ops wardeg ow Hy suorveae panserog yw eto i KEHOE ?got

?Srponily

---Page Break---

spoyeurmeaice atéamseee

speyssegun 9 405 soncun mas up yooneouE Gut Meiweaas ouyigo ped 3ect dadlhes

raotaspios mopsereg Dw Zoybh 1TH Zo samaaeg twa 1Ou oT EDy

WE so WO go TS | BOT ow TT

oe oe a a nS er x

So 069 corer 69S TF EFS eS Ula

vo seg ct 9S STR TS eS nya

60 69 We GS HE FHT

So og eGUt LS e GDB wE'S wy tale

So aug tom aL SHG TG SED Saye

yo, worg BOT EG ca eee BS wh 19'S ws ork 0s safest

fo WS BL 69 ORs ore aos 89 ws eas en es alot

Lo 6g"9 6grMet Loh LS ey 6 we mes ay en Eisele

so Erg E99 DHS ae 9 ave ons wos one in ?exfor/er

re

vo ety auc +S SEG kaa

wo 9b'9 wear 69 STE OST Ea

eg a

Te Wooten weilne wring words serine vorlme worms wring wre wes ete

poysioyey ovms morsdeg 24) £00]

fis pay2eT9S 9¥ nd BT TOOT mMLEDS ADHERE ?g STaEE

Sipuasty

---Page Break---

?youezoven ey a5 semua uvee U5 popntouy sou ?Arwngse ou 20 320i 4805 sedéeee

?peseumaes ordawgee

eoorsypaoo sroprerwy pow soqm (By Jo orewoe eon? 398 STEN,

fro sero STT seo 680 two RO wo to oo leo kero ule

wo ao ago mero 620. sero iso, nro eo | to RO RO ulele

wo eo Loe so eo. wre to aro uso aro geo oto ee

wo 0 EBtO ozo azo eno ?eo 0 eo 60 (gato 10 sulsele

bows ws wy ue owe to fo eee own oes

bows oe wom wm wo ao tes gre we wes

ome ws wo we ee to go ee wy we wl

foro ?E0g8"9 o2"0 geo ono, 10, ono. zo ay gO a2"0 nb /sefer

mows we wo uo ws ee tee we wee hun

BO MEO BED 8 BBO mo 0 tro, eo HO Seo ez"0 xfer

bo we ory owe veo are wets wre es uh

BOW wis ke orks orks ons wats one ole elu ams spogasazey oping mapstdex a oF

Frey vessoTOg 39 Hid UF ETaAeT eMpEENNOE AproMN He ?6 OTeRE

xrpondly

---Page Break---

poqiseimn om Sop semtea aves = popatouy ou ?ArengH

spogmuremios ordi ees

og go. 3nd 3400 Jedd

seooyaypioo stopmezey pin dove Su jo setwoog Ugey 300 8TENS oe To ro a a =

FOOT ESET EET ETT 2 ¥

zo ar wr oct we wet wal

zo wet fer wt me ort TT Owe

zo set met ort weasel

zo eT wet owt owe ete two OD lsala

zo get er oat ae et eT wool

zoe WT tae rae THT www

ro wt Gr wt ot Ot gto wT

zo yt vet cet Set aster two wt eis let

eo Wet wet ert ote ET we BT OOH eLVonet

vo wt fer et ate ose ott DSO Hae

eoovr we =e wet eet we eT OO wet

oc

er z Z z + =r =r

ws "F wiamg worms sores crime uorins worms sores wHMs corNs corms ? aTéme

pouszoyey oxtes syrsvdea 9g) UT suoT IMS

98 90 aE UF etHNNT MTOTND ADVOOR- TE

?ot argos,

srpunddy

---Page Break---

-porupenguoe otdmasees

?youssoven our S05 eanqua unos uy papnrouy you ?cronyss qi Jo Wor 4800 19s

suoraTguso snopswiwy Pav saat GBT Jo cerwoog uy 2o0 stds.

ES SE ae a m

a GEES HTT ¥

vo 92 Guy EE Owes ETT

vo use Se 62 ews wee att ulzle

wo we our 62 ure aye ware Tart Tuttle

wo we es ee bre oye Ew ele

So Ge wrt we OE SHOE swe UE

wo we ton ee cee se 6S wwe TT alt

wo sre ez we we ET ET Tet

go SUE gx": Gee SEES EHS eT Tw age /et

wo oe erie ea] eT ETT eT Eater

So gre Geek WE we SEES we wT SET wet alt

go ee wee eS Ea ae wwe Lett

So mre eee use EES HE GUS pets afoot

+e z Z 5 7 z z ar ar

uoTng worms worse uoTaNs votes scTImE uoTINIg uoTIME voTINe worms ? oTaMS

?vovesonen cava mapapdag 009 uF euoTeN;s Fa:

230 as UF STSAOT myZOUMK ATISONNTE ?TE STN

speedy

3

---Page Break---

spoqesoyen 9x2 105 sonqws uae UT POPHTSUT sex ?EswRg0 ow JO 48H Dine

Tcopseunptme Amst

?swuoyaypuco snopswzuy pow 490% WPT Jo spTMDeG HES 3OU HTH a a a TFT ¥

SUE EE RHR RR a THT ¥

- - - - - - - - - ny

HT Oe ge SUT, «OTC: eet OTHT null

Gere cet opt OSES SEE HB vases

wet COT 09 OTOH: ulsele

aut wet of (OTST oe SE SNOT ST SO wuerla

wo ayer oy «ores: wteT ee ST eT SBE nue

ger Gyut ate OE: ET gosta walsh

net WR om wer SEE SET OG SOE ett ex/se/er

gue erst oe ROEM aE SST one eSET euorjer

eg Sat of) OreE ST oe ST Ee wet TOE eufiaee

vt 6rot 0 | eat OL SUK ee ome Ewe eujerree

ee exfocjor

Ee 7 T 5 7 r z a Ag ot

ye ?fueling worms worms corms orshs worMs were woHmE WIRE HorINS odes syeeseeny comes MrysTdsa 2 wF uoTsWag PETOETAG 9¥ Ie UT SyEOEITENEH ePHIOTID AtHoeN TE

ax ores,

ernaaey

---Page Break---

uopiourgtae SuomEseUT eee

?pounroyen 0) 03 sonTwA tees oT popnToEE yor ?erwnse ott Jo Yet ¥soH soddiey

-snoraypue mnopswzw paw sagan "BT" Jo semwaee Gores 308 STEMS

TH EE ss =

RET WS Te FE TH RE ae

soe : - : - : - : : = wwe blah

Use BEE ox eae SETTE | STS ThE Gath woe: k'GeS gels? lla

a a ca a Td

noe GE OG SETTE vet OLE OEE Ong ge GN? onge?lse/a

WOT WOE os'mG ETE gaTee OEE SOE ayo aus ce wee Ute

NET GEE 00°99 Ge"Ty OEE wOTTE ETE OEE pao geTge aCe ML/b

wee glee game we SETTE SHE wre ENE Ores: mE GHTee ote Ula /t

nee tle covet mete mele teeta Tweet ok0e = orte«EL/oa/et

SOT UM O6'EEE GGG ONEZ HIE weg] SNE Us Gyrte So oktoe «gaze eL/ot/ar

2 G92 Osroet oL"62 owes eT wee Sime teeta eae

%

WT We OF WE wre were © YE onrge | wees ute gree eL/et/t

HE WOE oornseT oe"g OTE? alot ETNS © EE ge «STEEL wO'EEL/OR/ov

ts z T 3 7 2a bg ar

ye F wOHmS vorrms uoIaTs woHHHS worBIs WoTaeag uoFSING UOTIaG MOTHS woTTMS

?eTdaNy

?Pewss040n ovis wstsidey ody UF FUOIIWYS PeADNTOG IR TON Hed UE SyuaEANENON

KSTUTTES ACHOMNNTE ?ET SABE

Saresaty

---Page Break---

Appendix

Table 1h, Analysis of Variance, Single Way Classification. Results from

the Variables Tested in Tine et all Stations.

,

Variable Source er Moan Square PF __ "005

?Temperature Date a 12.7698

Error 108 Wl0390 3.262 1.89

Dissolved Dates a ong

Oxygen Error 108 1092279 1.89

Carbon Dates 9 0.5794

Dioxide Brror 90 okrr3 eth 2,00

Salinity Dates o ?25299.8906

Error 99 SET6B1U3N0 04535 1.95,

Sodium Dates a 663.4934

Error 108 1291618252 1.89

Potassium Dates a o.gtan,

Error 108 16579 0,508 1.89

catetum Daves a 0.2549

Brror 108 orton 0,636. 1.89

Magnesium Dates a 28.9949

Error 108 27.8356 0.6Be 1.89

Chloriae Dates 10 10616.95

Error 99 Bailé.iio 0.52 1.95

---Page Break---

Appendix

Table 15. Analysts of Vartance, Single Way Classification. Results

fron the Variables Tested in Time at Stations 1a-6,

Variable Source at. Mean Square __p__?0.05

?Temperature ates pay 10.7930

Brror % 3.5818 3.013 1.90

Dissolved Dates a 0.4525

Oxygen Error % 0.1003 .5a1 2.90

carbon Dates 9 0.6608

Dioxide Error 80 0.3508 «1.882 2.08

Salinity Dates 19 210.8241

Error 8 62.772 3.81

Sodium Dates: a 0.7309

Error % 2.6795 0.273 1.90

Potassium Dates a 0,006

Error % 010060 0.38 1.90

calcium Dates a 0,086

Error % 0:2855 0.302 1.90

Magnesinn Datee a 0.7463,

% 1.8819 0.405 1.90

chtoriae 20 87.09

88, 23.68 3.64 1.96

---Page Break---

Appendix

Table 16. Analysis of Variance, Single Way Classification, Results fron

?the Variables Tested in Tine at Forested Stations.

Variable Source af Mean Square Fo.05

Temperature Dates, n 5.0688

= Error 6 2289 3.013, 1.73

Dissolved Dates u 0.3798

Oxyeen Esror ro ori009 3.76373

carton Dates 9 0.3285

Dioxide Eeror 50 Ones 2.576 2.08

Salinity Dates 10 161.2696

Error 55 29.8998 5.398 2.01

Sodium Dates n 0.129

Error 60 of ose.

Postassiun Dates n o.0o12

Error 6 0.0038 0.388 Las

caletun Dates a 0.0138

Error © o.089 0.33773

Magness Dates nu 0.0906

Error 6 one? 0.21873

cmoriae Dates ao 59.0

Error 55 10.98 5.39 2.01

8

---Page Break---

Appendix

?Table 17.

Analysis of Variance, Single Way Classification.

fron the Variables Tested in Tine at Forested Stations not

including Station 3.

Reeults

Variable ae quare Fo.05

?Temperature a

us 2.789 2.00

Dissolved a

Onyren? is 2.759 2.00

carbon Dates 9

Dioxide Error 4 2.53 212

Salinity Dates 20

Brror My 4.03 2.06

Sodium Dates a

Brror 48 one 2.00

Potassium Dater na

Error ie 0.266 2.00

cateiun Date a

Brror us 0.209 2.00

Magnesiua Dates a

Error 4B 0.100 2.00

chloride Dates 2.0

Beror My was 2.06

59

---Page Break---

Appendix

Table 18, Analysis of Variance, Single Wey Classification. Results troa

?the Variables Tested im Tine at Grassland Stations.

ss

Variable Source af Mean Square F 05,

?Temperature Dates. =

Brror ak. ab.321 Bat

Dissolvea Dates =

oxen Error 2h 2.091 2.2L

carbon Dates 9

Dicxide Error 20, 0.920 2.39

Salinity Dates 10

Error 22 2.018 2.30

Soatum Dates = lL

Error 2 0.703 eer

Potassiun Dates =

Error 2h 0.516 ear

catetum Dates =.

Error 0.516 eer

Magnesiun Detes =n

Error 2b 0.800 een

chtoride Dates 10,

Error 22 2.0 2.30

---Page Break---

?Appendix

Table 19. Analysis of Variance, Single Way Classification. Results

from the Variables Tested in Tine at Grassland Stations

including Station 3.

Variable Source ar Square Fr 0.05

?Temperature Dates na

Brror 6 23.005 2.07

Dissolved Dates, a

Ongaen Brror %6 1.738 2.07

Carbon Dates 9

Dioxide Error 30 1.063 2a

Salinity Dates ao

Error 33 2.937 2.3

Soaiua Dates a

Error %6 0.588 2.07

Potassium Dates, a

Brror % 0.525, 2.07

Cadetum Dates a

Error % ove 2.07

Magnesium Dates a

Error % 0.652 2.07

Chloride Dates 10

Error 33 2.107 2.33

Sanne

a

---Page Break---

Appendix

?Table 20. Analysis of Variance, One Way Classification. Results from

the Variables Tested at all Stations.

Variables Source af Mean Square F (0.05,

Temperature Location 9) he.1667

Error no 1.7925 23.52 1.99

Dissolved Location 9) 0.2619

Oxyzen Error no 011266 2.068 1.99

Carbon Location 9 2.9634

Dicxide Error 9 2389 22.40 2.01

Salinity Location 9 +326238.8750

Error 109286982390 21.02 2.00

Sodium Location 9 ?8026.8438

Error no 636.50 22.61 2.99

Potassium Location 9) 10.5935,

Error 0 0-452 12.53, 1.99

Cateiun Location 9 4.0986

Error 00 082 48.63, 1.99

Magnesium Location 9 192.6624

Error no 31324650 2k. 2.99

chloride Location 91629. bls

Error 100 2054-81 ace 2,00

SaaEEEEEEEEEEEEeEeesee eee

---Page Break---

Appendix.

Table 21. Analysis of Variance, One Way Classification, Results fro

?the Variables Tested at Stations 1a-6,

Variables Source af Mean Square e 0.05

?Temperature Location 8 37.6433,

Error 9 116306 23.085 205

Dissolved Location 8 0.2783

Onyeen Error 9 011331 1.3h0 2.05

carbon Location 8 2.233

Dioxide Brror a 0:20 = 10,201 2.08

Salinity Location 70,8450

Error 90 \gialg7 to. 2.07

Sodium Location 8B 30.2180

Error 9 0.2377 e713 2,05

Potassium Location 8 0.0585

Brror 9 crook = 2575205

Catetun Location 8 3.25)

Error ~ Oroei2 134.208 2.05

Magnesia 8 20.9508

9 0.1760 119.036 2.05

Chioriae 8 138.56

9 15.698 8.83 2.07

---Page Break---

Appendix

Table 22. Analysis of Variance, Single Wey Classification. Results

from the Variables Tested at Forested Stations.

Variables Source at Mean Square EB Fo.05

Jemperature locaton 5 21.8129

Error 6 2.3337 16.3591 2.36

Dissolved YWooation 5 0.2316

Oxygen Error 6 ont Ol 2.36

Carbon Location 5 0.3055

Dioxide Error oh 0.4363 232.39

Salinity Location 5 164.679)

Error 60 40.5807 4.053 2.37

Sodium Location 5 9.0847

Error é 0.07 = 115.58 2.6

Potassium Location 5 0,004

Error 6 0.0006 67.32 2.36

caleiun Location 5 0.406

Error % 0.008, 23 2.36

Magnesium Tocation 5 4.7583

Error é ool. 15.77 2.36

Chloride Tocation 5 60.428

Error 6 i. goin 4.058 2.37

eer

---Page Break---

Appendix

Table 23 Analysis of Variance, Single Way Classification. Results

from the Variables Tested at Forested Stations not including

Station 3.

Variables Source __af Mean Square? 0.05

Temperature Location bb 26.9131

Brror 6 2180. 24.33, 2.55

Discolved Location ong

Oxygen Error 35 013375 0.8 2.55

carbon Location 0.3487

Dioxide Error 45 013273 2.739 2.59

Salinity Vocation 204.8720

Error 50 ¥.5529 4.59 2.97

Sodium Location 20.3196

Error 5 1077 5.96 2.95

Potassium Location 0.0490

Error 8 on e.67 2.95

Cetetum Location 0.4573

Error 35 ones 56.46 2.55

Magnesium Location 5.5105

Error 55 oreo gn. 2.55

chloride Tocation 15.0652

Error 50 163625, 4.600 2.57

---Page Break---

Appendix

Table 2h. Analysis of Variance, Single Way Classification, Results

from the Variables Tested et Grassland Station:

Variabtes Source as Mean Square _F Fo.05

?Teaperature Location 2 1.8936

Error 3B 2re2ks 0.6 2.29

Diseolvea Location 2 0.3803

oxygen Error 3 011106 34438 2.29

carbon Tocation 2 3.2067

Dioxide Error 2 013383 9.03.35

Salinity Tocation B52. 8159)

Error 30 48.2880 9.3rr 3.32

Sodium Location 2 23.0082

Error 3B 015959 M38 2.29

Potassium Location 2 o.can.

Brror 33 0.0029 Tet 2.29

Cateium Location 2 3.280

Error 33 Oroshk S72 2.29

Magnesium Location 2 36.7006

Brror 3B OLhW59 37.5 2.29

chtoriae Location 219.3323,

Brrr 30 31221 5.22 3.38

SEER

---Page Break---

: ?Appendix

Table 95. Analysis of Variance, Single Way Classification, Results

from the Variables Tested =t Grassland Stations including

: Station 3.

. variapies Source ar Mean square £ Fo.05

Temperature Location 3 4.699

. Rrror ub 2.1938 2.ahe 2.82

: Discotvea Location 3 o.3a04

Oxygen Error a o.ie77 2.039 2.82

Carbon Tocation 3 2.9510

Dioxide Error % 0.3314 oer 2.86

salinity Tocation 3 932.7090

?ror 0 42,3959 12.869 2.84

Sodium Tocation 3 26.9935

Reror a ont 60.341 2.82

Potassium Tncation 3 0.0316

Yevor ais o.00et 33.430 2.82

catesun 3 3.7508

Mi vols 84.700 2.82

Magnestun Yoeation 3 21.0830

hrror ais 0.3596 58.603 2.82

omoriae Lweation 316.5198.

Srror 40 2h20i2 6.603 2.84

---Page Break---

Appendix

Table 27. Drinking Water Standards for the United States and Europe.

?Taken tron the Encyclopedia of Geochentstry and Hnviren=

mental Selences, Volune IVA. Van Nostrand Reinhold Company,

New York, 1972.? Page 320.

Hi

Determination ves wa Limit (eke

Coliform bacteria, per 100 ml Bacterial

1.0 0.058

ap

Prystcal

Turbidity, sitive seaie units 3 -

Color, cabalt scale units B

Odor," sascimum threshold number 3 2

Chemical (ng/1iter)

?Ay benzene sulfonate 0.5 -

Ammonia : ose

aroente 0.28,

Barium :

cadmitsn 0.50

cateiun 200% 20

carton chloroform extract

Chloride 3500 500

Chromits (hexavalent) 0.050,

oppor 3.00 10

cyanide o1aa,

Fluoride 15a 15

?ron Lo 19

ead ona,» ont

Magneotun 1258 325

Magnesium + sodium sul tute 300

Marganese Ota oa

Nitrate, as N03 508

Phenol Le compounds ?0.0018

(Potassium) 5008

Selenium o.0le 0.054,» 0.05

Silver 0:05e :

Godin) 5008

sulfate 250 2508

(Guiter) 008

Total Solids 500 3500

ine 5.0 5. 5.0

Radiological. (pe/1iter)

aaium206 3e -

Nipba emitters : aasb

Strontiun-90 360 :

Beta Bnltiers 0008 208,

a Wi European Standards of 1961.

WI International Standards of 1958,

© Mandatory, Others are recomended by USPS

4 Does not appear as cuch In original list.

1m

---Page Break---

---Page Break---