BIOLOGICAL POPULAION OF POLLUTED STREAMS IN PUERTO RICO

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INTRODUCTION

The biological aspects of stream pollution have been extensively studied over the years in non-tropical countries. However, the vast number of factors which influence the aquatic biota in a stream, and the lack of knowledge of the normal water quality requirements corresponding to potential indicator organisms, have precluded the possibility of establishing reliable biological indices to characterize pollution. [1]

This paper reports the biological findings in a study which was undertaken to measure the self-purification rates of polluted streams in Puerto Rico, and which showed that natural purification occurred at rates equivalent to those which had been observed elsewhere under non-tropical environments. The rivers included in the study were chosen to represent both sewage and industrially polluted streams, and they were examined at stations located both upstream and downstream from the points at which contaminants reached them.

Samples for chemical and physical analyses were gathered daily at each station over a 15-day period, with measurements of depth, flow rate, and velocity made simultaneously. Table 1 summarizes the data obtained.

Collections for biota studies included bottom material and plankton, and most of the identifications were made in the laboratory while the organisms were still alive. Population densities were not established, except in the case of Escherichia coli, for which the most probable numbers per unit volume were determined. Isolation of other bacteria was not completed, and fungi species remained unidentified.

Two of the seven streams surveyed reached anaerobic conditions upon receiving industrial wastes, one of them from a sugar mill and the other from both a sugar and a paper mill. Out of the other five streams considered four represented sewage polluted waters which at all points contained dissolved oxygen, while the last river received contaminants from a sugar mill but did not reach anaerobic conditions.

DESCRIPTION OF THE BIOTA

Over 300 different species of organisms were identified in this study. Most of them were present both in sections of streams representing "clean" waters as well as in polluted and recovery zones, thus not permitting their use as indicators of the degree of stream contamination. Many species cited in the literature as characteristic of a given stream condition were found in this work to be present in zones of both the same and opposite qualities to those specified.[2-7] The data gathered do not therefore constitute a biological index of stream pollution, but rather a description of the changes in population variety brought about by pollution under tropical conditions.

Table 2 summarizes the distribution of recognized genera and species of plants and animals detected in the rivers examined in this work.

DISCUSSION OF RESULTS

No biological indices of pollution are defined by the data gathered in this study, since most of the organisms identified were common to all pollutional conditions as represented by the clean, polluted, and recovery zones. Table 3 enumerates the organisms found to be present indistinctly in these three zones and those detected only in the polluted or in the clean regions.

Some trends in population varieties are shown by the results described in Table 2. The diversification in algae species was larger than that in each of the other genera of organisms at the first station of each of the rivers examined, at points upstream from those at which the pollutional loads entered them. The first stations inmediately downstream from the pollutional discharges showed in four of the rivers an increase in the percentage of species corresponding to protozoans, as expected from the increased bacterial population, while the other three streams showed no significant change. The increase was most striking in the two rivers which eventually reached septic conditions. Farther downstream, at stations No. 3, the percentages of algae especies went up in all the rivers, while those of protozoans decreased in all cases except in river No. 5 in which the bacterial population kept increasing throughout the zone under study.

The variety in metazoan population showed an initial tendency to go up upon receipt of the pollutional load, and then to decrease downstream as distance increased. The variety changes found in the species of arthropoda, mollusca, and pisces were not significant enough to point out definite trends. The rate of coliform bacteria removal is slowed down by the presence of cane sugar wastes.

Some singularities observed in the biota are worth mentioning. The blue-green algae Spirulina Turpin was consistently found throughout all the stations of each of the rivers examined. The organisms Itacaguascon Barros and Dinamoeba horrida were only found at station No. 3 of the last river, in which septic conditions prevailed. Biomphalaria glabrata, the bilharzia-bearing snail found only in some tropical countries, was detected in small concentrations at station No. 1 of river No. 6 and at stations No. 4 of both rivers No. 1 and 2, all of which harbored emerging vegetation or floating plants and showed oxygen saturation levels of over 75%.

SUMMARY

The biological populations at selected points in six polluted streams of Puerto Rico were examined. The changes in the diversification of species present which occurred as the waters went through zones of different degrees of contamination were established.

TABLE 1

CHARACTERISTICS OF THE RIVERS STUDIED

Name and number of River	Flow Pattern	Type of contamination	Station Number	Distance from source of Contamination	Temp. ºC	Oxygen percent seturation	B.O.D. p.p.m.	Coliform, MPN/100 ml.	pH	Chlorides p.p.m.
Guanajibo River (No.1), by San Germán	Swift, riffles, shallow (0.72 feet deep)	Sewage from municipal septic tank	1	1000ft. upstream	28.1	96	1.0	3,500	7.4	18
			2	500ft. downstream	29.0	74	4.1	92,000	7.0	20
			3	1500ft. downstream	28.0	76	4.0	160,000	6.9	20
			4	7900ft. downstream	28.0	79	1.6	7,600	6.9	20
Culebrinas River (No.2)	Swift, riffles, shallow (0.93 feet deep)	Cane sugar wastes from Plata sugar mill	1	500ft. upstream	26.4	100	1.1	24,000	7.2	13
			2	6,750ft. downstream	28.1	73	8.5	17,500	6.7	15
			3	18,000ft. downstream	28.1	76	6.9	16,000	6.7	15
			4	52,650ft. downstream	28.1	86	1.3	11,000	7.1	15
Rosario River (NO.3), by Maricao	Swift, riffles, shallow (0.75 feet deep)	Sewage from municipal septic tank	1	1200 ft. upstream	24.2	93	0.7	3,500	7.6	17
			2	2500 ft. downstream	25.5	84	3.2	35,000	6.7	21
			3	10,600ft. downstream	25.4	93	1.0	5,400	6.9	21
			4	73,750ft. downstream	25.5	96	0.8	9,400	7.5	21
Rosario River (No.4), by Hormigueros	Swift, riffles, shallow (1.1 feet deep)	Wastes from Eureka sugar mill	1	1,000ft. upstream	24.0	72	31.0	2,400	7.7	19
			2	250ft. downstream	37.0	28	188.0	350,000	7.4	18
			3	500ft. downstream	32.0	8	185.0	920,000	7.0	19
			4	1,000ft. downstream	30.0	2	170.0	2,400,000	6.9	19
Guanajibo River (No.5), south of Hormiguero	Swift, riffles, (1.1 feet deep)	Sewage from municipal septic tank	1	250ft. upstream	25.5	51	69.0	130,000	7.5	20
			2	250ft. downstream	26.0	13	73.1	540,000	7.4	21
			3	500ft. downstream	26.2	10	84.7	1,600,000	7.1	21
			4	750ft. downstream	26.4	2	94.0	2,400,000	7.1	20
Grande de Arecibo River (No.6)	Sluggish, pools, (3.0 feet deep)	Wastes from Cambalache sugar mill plus those from a paper mill	1	800ft. upstream	25.8	104	1.5	2,200	7.9	15
			2	200ft. downstream	28.0	18	130.0	240,000	6.9	64
			3	5,000ft. downstream	29.0	0	121.5	1,300,000	6.7	402
Grande de Añasco River (No.7)	Sluggish, pools, (5.2 feet deep)	Wastes from Igualdad sugar mill	1	500ft. upstream	28.7	101	1.5	1,300	8.1	10
			2	600ft. downstream	32.0	37	102.3	54,000	7.4	26
			3	9,000ft. downstream	31.0	0	91.5	350,000	6.5	115

T A B L E 2

DISTRIBUTION OF RECOGNIZED GENERA AND SPECIES OF PLANTS AND ANIMALS

			NUMBER OF DIFFERENT SPECIES DETECTED																									
			River No. 1				River No. 2				River No. 3				River No. 4				River No. 5				River No.6			River No.7		
	STATION NUMBER		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	1	2	3
PLANTS	ALGAE	DIATOMS	1	1	4	0	4	14	0	6	2	7	0	1	1	1	5	5	2	2	2	2	4	2	0	1	0	1
		FLAGELLATES	1	2	2	2	3	3	0	0	0	0	0	0	0	0	3	3	5	3	3	3	4	3	1	0	0	4
		BLUE-GREEN	1	1	2	1	5	3	1	2	1	2	2	2	2	2	1	1	3	3	3	3	2	2	2	2	2	3
		GREEN	3	2	2	1	4	9	0	2	3	6	1	1	0	0	0	0	6	6	6	6	2	0	0	0	0	1
	HIGHER PLANTS	ANGIOSPERMS	2	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
	FUNGI	PRESENT (+), ABSENT (-)	+	-	-	+	+	+	-	+	-	-	-	-	-	-	-	-	+	+	+	+	-	-	-	-	-	-
ANIMAL SPECIES	PRO-TOZOA	AMOEBOID	0	3	0	2	2	3	0	3	0	4	0	0	0	0	0	0	4	5	4	4	0	1	0	0	1	2
		FLAGELLATES	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		CILLIATES	2	5	4	4	6	10	0	7	1	7	0	0	2	2	0	0	9	8	8	8	2	8	2	0	12	12
	ME-TAZOA	ANNELIDA	0	0	0	0	0	2	0	0	0	1	0	0	0	0	0	0	1	3	2	2	0	2	0	0	4	0
		ROTATORIA	1	1	1	1	1	1	0	1	0	1	0	0	0	0	0	0	1	2	1	1	0	0	C	0	1	2
		GASTROTRICHA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0
		PLATYHELMINTHES	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
		NEMATODES	1	1	0	0	0	0	0	1	0	1	0	0	1	1	0	0	0	0	0	0	1	1	0	0	1	0
	ARTHRO-PODA	CRUSTACEA	0	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TARDIGRADA	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
		INSECTA	3	1	2	1	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
	MOLLUS-CA	TOTAL AT STATION	2	0	C	3	1	1	0	1	0	0	0	0	2	1	1	1	0	0	0	0	3	0	0	0	0	0
	PISCES	TOTAL AT STATION	1	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TABLE 3

DISTRIBUTION OF THE BIOTA IN THE DIFFERENT POLLUTIONAL REGIONS

Species detected in clean, in polluted, and in recovery zones	ALGAE: Cocconeis E.*, Cyclotella stelligera, Cymbella Ag., Distoma Grun, Gomphonema Hust, Gyrosigma Grun, Melosira Kutz, Meridion Ag., Navicula Bory, Nitzchia Hass, Synedra E.*, Chlamydomonas E.*, Euglena E*, Euglena tripteris D*; Gymnodinium Stein, Phacus D*; Pyrotrobis Arnoldi, Spirulina Turpin, Oscillatoria Vaucher, Coccochloris Sprengel, Arthrospira Stizembergen, Rhizoclonium K*; Spirogyra Link, Palmellococcus Chodat, Protoderma K*; PROTOZOANS: Arcella E*; Diffuglia Leclerc, Chaos L; Pelomyxa Greef, Pelomyxa palustris, Dinamoeba mirabilis, Vorticella campanulata, Paramecium Hill, Spirostomun E*; Euplotes E*; Trachelophylum C & L*; Urocentrum Nitzch, Halteria D*; Aspidisca E*; Paramecium cf. bursania E*; Caenomorpha Perty, Didinium Stein, Chilodonella Strand, Uronoma Largerheim, Strobilidium Schewarkoff, Coleps Nitzch ; METAZOANS: Nais Muller, Aulophorus Schmarda, Colurella Bory de Saint Vincent, Rotifer vulgaris, Philodina E*; Rotaria Scopolis, Chaetonotus E*; Planaria Kerk; MOLLUSCA: Thiara granifera, Physa cubensis, Biomphalaria glabrata; ARTHROPODA: Insecta: Enallagma Charpentier, Tendipes Meigen, Erythrodiplax cf. umbrata L.
Species detected only in clean zones	ALGAE: Lepocynclis Perty, Pedinomonas Korschikov, Pleurodiscus Largerheim;
Species detected only in polluted zones	ALGAE: Ulothrix Kutzing; PROTOZOANS: Thecamoeba Fromentel, Stentor Oken, Lacrymaria E*. METAZOANS: Dugesia Girard

* E = Ehrenberg, K = Kutzing; D = Dujardin, C & L = Clapereda & Lachman.

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