Testing water quality in Puerto Rico's beaches: A volunteer experience

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Biographical sketch

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Recent Publications

1. *Navarro, A.* and E. Navarro. 2001. Guía Ambiental para Puerto Rico. Sea Grant College Program, Mayagüez. 35pp. UPRSG-G-76.
2. *Navarro, A.* 2001. Memorias del primer encuentro de organizaciones ambientales del oeste celebrado el 26 de agosto de 2000: Resumen de la problemática ambiental-social presentada por las organizaciones y grupos comunitarios. UPR Sea Grant publications.
3. *Navarro, A.* 2000. ¿Qué es MNP?. Boletín Marino. Vol. XXI (10-12). Oct. Dic. p 14-15.
4. *Navarro, A.*, Corredor, J., Morell, J. and R.A. Armstrong. 2000. Distribution of the cyanophyte *Trichodesmium* in the Eastern Caribbean Sea: Influence of the Orinoco River. Revista de Biología Tropical 48 Supl.1:115-123.
5. *Navarro, A.* 2000. Calidad de Aguas Costaneras I: Recopilación de datos de la JCA en el año 1998. Sea Grant College Program, Mayagüez. 32 pp. UPRSG-G-75.
6. *Navarro, A.* 1998. Optical properties of photosynthetic pigments and abundance of the cyanobacterium *Trichodesmium* in the Eastern Caribbean Basin. Ph.D. thesis. 125 p.
7. Fact sheets and web publications (http:\\seagrant.uprm.edu) 2000-2001: "Contaminación térmica en los sistemas acuáticos", "La sedimentación: enemiga de nuestras aguas", "Abastos de agua en Puerto Rico: historia y problemática", "Los manglares y la contaminación con petróleo", "Cuidado y limpieza de nuestras playas", "Tratamiento para las aguas usadas", "Eutroficación y descargas orgánicas", "Sitios en el internet relacionados con la calidad de las aguas", "Organizaciones ambientales de Puerto Rico", "Directorio de Agencias Ambientales Federales", "Directorio de Agencias Ambientales Estatales", "Constituyentes principales de las descargas de las plantas de tratamiento de aguas usadas".

Abstract

Volunteers of seven municipalities of Puerto Rico (Aguada, Aguadilla, Arecibo, Mayagüez, Cabo Rojo, Ponce, and Vieques) monitored their coastal waters highly impacted by sewage discharges. The volunteers collected and analyzed water samples for several months. They determined dissolved oxygen (DO), biochemical oxygen demand (BOD), pH, temperature, phosphates, nitrates and turbidity using La Motte Test kits. Fecal coliform counts were determined with the Coliscan easy gel kit (GREEN Earth Force).
Nutrient concentrations (32/80 times) and oxygen deficiencies (35/80) were the most common parameters affecting beach water quality in Puerto Rico. Fecal coliform counts (11/80) and pH (16/80) were another parameters that influenced the water quality in the sewage discharging areas. Microbiology Laboratory of the University of Puerto Rico at Mayagüez identified *Salmonella sp.* and *Escherichia coli* in Aguada samples. All the monitoring data will be published in the UPR Sea Grant home page under the outreach section (http:\\seagrant.uprm.edu).

Introduction

Beach water quality is a severe problem in Puerto Rico. Many coastal waters are too polluted for safe swimming (The Environmental Magazine, 1999) and beach water pollution threatens the public's health. Pathogens in sewage-contaminated waters can cause a wide range of diseases- including ear and nose infections, gastroenteritis, dysentery, hepatitis, throat problems and respiratory illness. The consequences of these swimming-associated illnesses can be greater for children, elderly people and those with weakened immune systems.

Puerto Rico has not implemented a regular beach water monitoring and public notification program, even though the national bacteria-monitoring program began in 1997 (EPA, 1998). Many public swimming areas in Puerto Rico are never monitored. Environmental Quality Board of Puerto Rico (EQB) conducts and analyzes water samples, six times a year, in 88 coastal stations, but the public is not informed about results, even if elevated levels of fecal coliform or enterococcus are found. In the United States, 85% of the beach closings and advisories in 2000 were based on elevated levels of bacteria. Usually due to sewage of storm water discharges, polluted runoff (rainfall) and sewage treatment plant failure. Nutrient loading is another source of anthropogenic input in our water bodies. It causes harmful effects that include phytoplankton blooms, sea grass bed declines and in extreme conditions, anoxia. EQB stated in the last water quality report (2000) that pathogens (fecal coliform and enterococcus) are the principal causes for coastal miles impairment and the pollution source is urban runoff and sanitary sewer outflows.

Monitoring is the best way to protect swimmers from polluted water until sources of beach water pollution are eliminated. Many environmental and community organizations in Puerto Rico have been requesting for an extensive beach water monitoring and public program. However, a concerted effort by all the stakeholders is vital for the solution to this problem. The Sea Grant College Program of the University of Puerto Rico assisted in this effort organizing and training volunteers during this project. The volunteers were trained in beach water collecting and analysis techniques and not only provided critical water quality data, but also became knowledgeable about the science and management of our coastal waters.

Methodology

Seven volunteer groups were trained to determine seven water quality parameters in beaches of Puerto Rico highly impacted by sewage discharges (Map 1). The volunteers were trained thru workshops, conferences and field visits. They measured dissolved oxygen, biochemical oxygen demand, pH, turbidity, phosphate, nitrate and fecal coliform bacteria (*Escherichia coli)* using La Motte Test kits and Coliscan easy-gel kits. The results were published in the newsletter "Monitoreando Nuestras Playas" and the Puerto Rico Sea Grant Internet site (http://seagrant.uprm.edu).

Results and discussion

The beach water quality data obtained by the volunteers are presented in Table 1. The water quality is mainly affected by high phosphate (1-4 ppm) and nitrate concentrations (5 ppm), oxygen deficiencies (low dissolved oxygen and high biochemical oxygen demand) and high pH values. Nutrients (phosphates and nitrates) and oxygen deficiencies were the main parameters affecting the coastal water quality.

A. Municipalities monitored by the volunteers :

Aguada (Beaches: Espinal (PE), Pico de Piedra (PP), Mameyito (M), Puntilla (P) and the sewage discharging area-WWTP).

The coast of Aguada is a high-risk zone in terms of ocean conditions. Erosion is a serious and ongoing problem. Multiple gabions and riprap were constructed in the shore to protect the road (Bush et al, 1995). The northeastern portion of Aguada includes the shoreline of the US military property where the primary treatment sewage plant (Aguadilla Plant) discharges less than 0.5 miles of the coast. The maximum treatment capacity of the plant is 8 million gallons per day (MGD) and serves a population of 50,000. Sometimes during storms, the plant exceeds the maximum capacity and the coastal impact of the sewage plant is rather serious. The Río Culebrinas estuary is located near the sewage discharging area.

Volunteer observations: High phosphate concentration (1-4 ppm), high nitrate concentration (5 ppm), high pH (9), high turbidity (60 JTU) and high fecal coliform counts (525-1,000 col/100 ml). Dissolved oxygen deficiencies were observed on the sewage discharging area. Presence of pathogenic bacteria (*Escherichia coli* and *Salmonella sp*.) was observed during the summer sampling. On July 2001, the septic tank of the public beach overflows and the Río Culebrinas floods.

Aguadilla (Beaches: Parque Colón (PC) and Crash Boat (CB))

Entire waterfront of Aguadilla is stabilized by old concrete seawalls and newer rock revetments. The road leading to Parque Colón is protected by riprap. This sector of the island was impacted by a Tsunami-associated wave in 1918 (Bush et al, 1995). Crash Boat is a well-known surfing beach of the north coast of Puerto Rico.

Volunteer observations: Low levels of dissolved oxygen (4 ppm) in both beaches that may be due to septic tanks.

Arecibo (Beach (P) and Dock (M))

Arecibo is a high-risk coastal zone. The coast is generally erosive and narrow. The entire shorefront of the city-the fourth largest city in Puerto Rico- is walled and rewetted; there are no beaches (Bush et al, 1995). The estuary of the Río Grande de Arecibo is located near the sewage discharge area. Therefore, the sewage is mixing all the time with the estuarine waters. The maximum plant capacity is 10 MGD and serves a population of 58,000.

Volunteer observations: High BOD values (4-6 ppm) and phosphates (1-2 ppm).

Mayagüez (Nautical Club- near discharging area of the sewage treatment plant)

Mayagüez Bay is surrounded by intense industrial, commercial, and residential development. Recently, several industries and commercial outlets moved from the area. The Bay is highly impacted by city runoff, septic tanks, tuna canneries and other industrial activities. A secondary treatment plant discharges more than 15 million gallons per day into the Bay. The Bay is also a riverine flooding area (Añasco, Yagüez and Guanajibo rivers). The plant capacity is 22.5 MGD and serves a population of 115,000. EPA denied a 301 (h) waiver and was updated to a secondary treatment plant.

Volunteer observations: Good water quality conditions during the sampling period (February-April, 2001).

Cabo Rojo (Boquerón Bay- discharging area of the sewage treatment plant)

The Boquerón Bay is one of the most popular places among tourists and marine users in the west coast of Puerto Rico. This Bay is part of the Boquerón Forest, a natural reserve that covers over 5,000 acres of mangroves and salt flats. A secondary treatment plant discharges 0.375 MGD into the Boquerón Bay. This plant serves to a 2,000 population in Cabo Rojo. Historically, the treatment plant (EPA, 2001), agricultural runoff, and the septic tanks near the shore, have contaminated the Bay.

Volunteer observations: Low levels of dissolved oxygen (4 ppm) and high pH values (9). Phosphates was high (2 ppm) in February and April, 2001. During this season, many Puerto Ricans go to the beach, especially during the Holy Week.

Ponce (Balneario El Tuque (BET), fisherman villages (VP) and the old sewage discharging area (WWTP)

Balneario El Tuque, a popular public beach, is a replenished coast; a rare occurrence in Puerto Rico. The adding of fill material to build the expressway (Route 2) drastically affected the shoreline- causing up to 7.2 meters per year erosion at one point. The protective breakwater also contributes to beach degradation (Bush et al, 1995). Ponce has a primary treatment plant that serves a population of 200,000. The plant discharges more than 15,000 MGD and the outfall was extended to offshore waters several years ago. However, the volunteers monitored the old coastal discharging area to followed recently sewage contamination.

Volunteer observations: High BOD values (6-8 ppm) in the three stations. Turbidity (50-60 JTU) and fecal coliform counts (400 col/100 ml) were high only in the WWTP area (April, 2001).

Vieques (Beach Esperanza (PE) and the sewage discharging area (WWTP))

Vieques is an island-municipality of the archipelago of Puerto Rico. It is a developed and populated island. Only one-third (middle section) is not part of the navy bases that encompass both the western and eastern parts of the island. Vieques was a popular tourist destination until three years ago, before the conflict between the US Navy and the government of Puerto Rico. The shorefront of Vieques is heavily developed and stabilized for commercial facilities, including the ferry dock. Villa Esperanza is a popular tourist area. The secondary sewage treatment plant of Vieques has a capacity of 0.5 MGD and serves a population of 4,000.

Volunteer observations: Low level of dissolved oxygen (4 ppm), high turbidity (60 JTU) and high phosphate concentrations (2-4 ppm) were observed in the sewage discharging area.

B. Presentations and outreach material produced

1. *Poster presentations*

   Navarro, A. 2001. Monitoring our beaches: Volunteers of Puerto Rico. Presented at the conference: Managing beaches in the Caribbean: Investing in our future. UPR Sea Grant College Program.

2. *Articles*

   Navarro, A. 2000. ¿Qué es el programa Monitoreando Nuestras Playas? Boletín Marino.UPR Sea Grant College Program. Vol. XXI Num. 10-12. P.14-15.

   Navarro, A and A. Rodríguez. 2001. Comunidades velando por la calidad de sus aguas. Boletín Marino. UPR Sea Grant College Program. Vol. XXII Num. 10-12. P.6-7

3. *Newsletter: Monitoreando Nuestras Playas* (http://seagrant.uprm.edu)

Number 1	Monitoreo Voluntario
Number 2	Grupos Voluntarios
Number 3	Calidad de Agua
Number 4	Playas aptas para natación designadas por el DRNA
Number 5	Datos de Calidad de Agua

Number 6	Datos de Calidad de Agua
Number 7	Datos de Calidad de Agua
Number 8	Datos de Calidad de Agua

Conclusion

This project initiated a volunteer monitoring program in several municipalities of Puerto Rico. The local communities were capacitated and made aware of beaches safety. The volunteers obtained baseline water quality data of some beaches that are not tested by the state agencies. As a result of this project, Ciudadanos Aguadeños Pro Conservación del Ambiente (CAPCA), an environmental group of Aguada, be part of an EQB Beach Grant thru the EPA BEACH Program for the year 2001-2002. Achieving a real participation of the local communities in the state (EQB) and federal (EPA) programs that protect the people's health and the safety of our coastal environments. CAPCA alerted the Puerto Rico Health Department about the relationship between pathogenic bacteria's in their beaches and an increase of *Salmonella* sickness in the children of Aguada during the summer. They stated that the Primary Treatment Plant and the septic tanks of the private houses in the maritime zone are the pollution source of these bacteria.

References

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4. EPA News. Region 2. 2001. EPA charges PRASA and Compañía de Aguas with thousands of violations at six treatment plants.
5. EPA. Volunteer Estuary Monitoring: A methods manual.1993. EPA 842-B-93-004. 176 pages.
6. Navarro, A. 2000. Calidad de Aguas Costaneras I: Recopilación de datos de la JCA en el año 1998. Sea Grant College Program, Mayagüez. 32 pages. UPRSG-G-75.
7. Testing the Waters: A guide to water quality at vacation beaches. 2001. National Resources Defense Council. Eleventh edition. 276 pages.
8. The Volunteer Monitor Newsletter. 1995-2002. Distributed by River Network, Portland, OR. Editor: Eleanor Elly (ellieely@earthlink.net).

Map 1. Municipalities of Puerto Rico monitored by the volunteers

Table 1. Water Quality Data obtained by the volunteers (Year 2001)

						Nutrients		Sediments	Pathogens
Date	Municipality	DO (ppm)	BOD (ppm)	Temp (C)	pH	PO4 (ppm)	NO3 (ppm)	Turb. (JTU)	*E. coli (col/100 ml)*
	EQB standars	**>5 ppm**		**<32.2 C**	**7.3-8.5**		**< 5 ppm**	**NTU**	**<200 col/100 ml**
2/10	Mayagüez	8	0	28	8	1	0	20	
2/17	Mayagüez	8	0	29	8	1	0	20	40
2/24	Mayagüez	8	0	28	8	1	0		20
3/3	Mayagüez	8	0	27	8	1	0	20	20
3/11	Mayagüez	8	0	28	8	1	0	20	20
3/18	Mayagüez	8	0	27	8	1	0	20	40
3/24	Mayagüez	8	0	27	8	1	0	20	40
3/31	Mayagüez	8	4	27	8	1	0	40	40
4/8	Mayagüez	8	0	27	8	1	0	40	20
4/14	Mayagüez	8	4	28	8	1	0	40	20
2/7	Cabo Rojo	4	0	28	9	1	0	0	60
2/22	Cabo Rojo	4	4		8	2	2	0	200
3/8	Cabo Rojo	4	4	28	9	1	0	60	
3/25	Cabo Rojo	8	0	27	9	1	0	20	300
4/16	Cabo Rojo	4	4	27	9	2		0	200
5/11	Cabo Rojo				8	1		20	
6/1	Cabo Rojo			27	7	1		20	
8/29	Cabo Rojo				8	2	0	20	400
2/25	Aguada (PE)	8	0	25	8	1	0	0	100
5/12	Aguada (PE)	8	0	28	8	1	0	20	100
6/22	Aguada (PE)			31	9	1	5	0	
7/6	Aguada (PE)				8	1	5	40	525
7/21	Aguada (PE)			30	9	2	5	20	241
8/4	Aguada (PE)			29	8	1	0	40	1000

3/11	Aguada (PP)	8	0	25	8	2	0	20	60
4/14	Aguada (PP)	8	0	25	8	2	0	20	60
6/22	Aguada (PP)			31	9	1	5	0	
7/6	Aguada (PP)				9	2	5	0	852
7/21	Aguada (PP)			30	9	1		20	105
8/4	Aguada (PP)	4	8	29	8	2	0	20	1000
3/25	Aguada (PP)	8	0	25	8	4	0	40	200
5/30	Aguada (PP)	8	0	28	8	4	0	40	200
6/22	Aguada (M)			31	9	1	5	0	
7/6	Aguada (M)				9	1	5	20	758
7/21	Aguada (M)			30.5	9	2		0	80
8/4	Aguada (M)			29	8	1	0	0	800
6/22	Aguada (P)			31	9	2	5	0	
7/6	Aguada (P)				8	2	5	40	1000
7/21	Aguada (P)			30	9	2		20	72
8/4	Aguada (P)			29	8	2	0	0	60
6/22	Aguada (WWTP)	4	4	31	9	1	5	0	
7/6	Aguada (WWTP)	4	4		6	1	5	60	249
7/21	Aguada (WWTP)	4		31	8	1		60	158
8/4	Aguada (WWTP)	4	8	29	8	2	0	60	1000
5/28	Aguadilla (PC)	4	0	30	8	1	0	0	
6/19	Aguadilla (PC)	4	0	29.5	8	1	0	0	
7/30	Aguadilla (PC)	4	0	28	8	1	0	0	
8/16	Aguadilla (PC)	4	0	28	8	1	0	0	
10/17	Aguadilla (PC)	4	0	29	8	1	0	0	
10/17	Aguadilla (CB)	4	4	29	8	1	0	0	
3/10	Arecibo (M)	5	6	24	8				100
3/31	Arecibo (M)	5	6	24	8				100
4/14	Arecibo (M)	7	4	21	8	2	0	20	100
4/28	Arecibo (M)	8	4	24	8	1	0	20	200
5/12	Arecibo (M)	7	4	25	8	2	1	20	100

5/26	Arecibo (M)	8	4	25	8	1	1	0	200
6/9	Arecibo (M)	8	0	26	8	1	0	20	100
6/23	Arecibo (M)	6	4	27	7	0	0	20	40
7/21	Arecibo (M)	7	4	27	8	1	0	0	200
6/23	Arecibo (P)	8	0	27	7	0	0	0	40
7/21	Arecibo (P)	8	0	26	8	0	0	0	200
3/10	Arecibo (P)	5	6	24	8				100
3/31	Arecibo (P)	5	6	24	8				100
4/14	Arecibo (P)	8	5	24	8	1	0	0	100
4/28	Arecibo (P)	8	4	25	8	1	0	0	200
5/12	Arecibo (P)	8	4	25	8	1	1	0	200
5/26	Arecibo (P)	8	0	26	8	1	1	0	200
6/9	Arecibo (P)	8	0	26	8	0	0	0	100
10/17	Arecibo (J)	4	0	29	8	1	0	0	200
4/16	Vieques (PE)	4	0	29	7	2	0	0	
4/24	Vieques (WWTP)	4	4	25	8	0			
4/24	Vieques (WWTP)	4	4	24	8	4			
3/16	Ponce (WWTP)	4	8	28	8	0	0	60	
4/5	Ponce (WWTP)	8	8	30	8	1	0	50	400
5/9	Ponce (WWTP)	8	8	28	8	1	0	30	100
3/16	Ponce (VP)	6	8	28	8	1	0	20	
4/5	Ponce (VP)	8	8	28	8	1	0	30	100
5/9	Ponce (VP)	8	8	28	8	1	0	30	100
9/13	Ponce (VP)	4	6	28	8	4	0	40	
9/13	Ponce (BET)	8	6	28	8	1	0	10	

Legend:

	poor	water	quality			
DO =	dissolved	oxygen		PO4 =	phosphates	
BOD =	biochem.	oxygen	demand	NO3 =	nitrates	
				Turb. =	turbidity	