ISOS|2023

Simposio Internacional sobre Sistemas de Emisarios 2023

International Symposium on Outfall Systems 2023

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ASSESSING ENVIRONMENTAL IMPACTS OF SEA OUTFALL SYSTEMS

SÃO PAULO STATE EXPERIENCE - BRAZIL

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CLAUDIA C. LAMPARELLI

CETESB

THE ENVIRONMENTAL AGENCY OF SAO PAULO STATE - BRAZIL

CETESB

- CETESB - was created in 1968 and its activities are funded by the state government.
- CETESB's mission is to improve and to assure environmental quality of Sao Paulo State in order to achieve social and economic sustainable development.
- Is responsible for the environmental monitoring, licensing and pollution control
- CETESB has **46 offices** distributed in the state with around **2000 employees**, most of them graduated, including engineers, biologists, chemists, etc.

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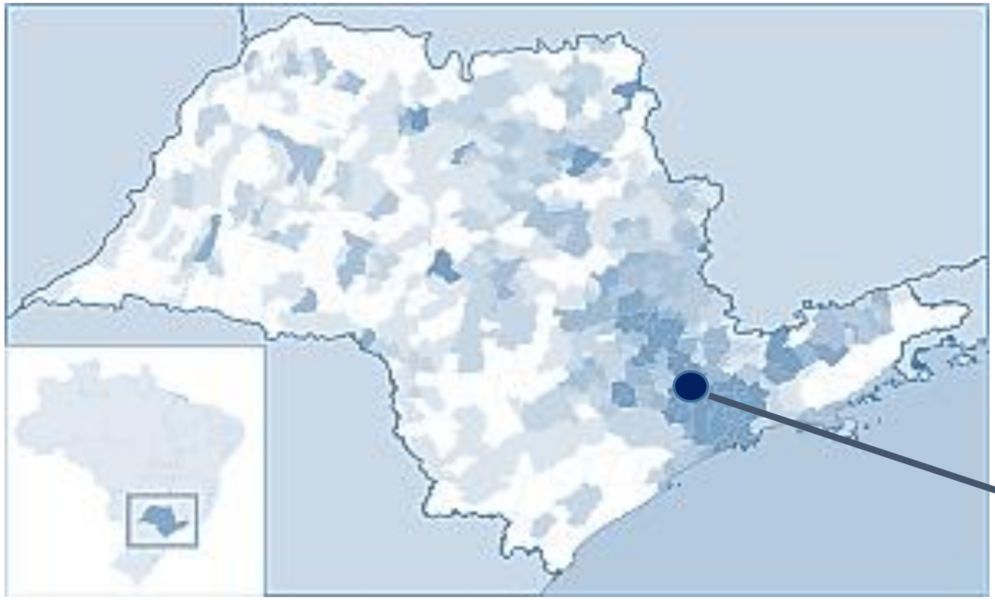
SÃO PAULO STATE - CHARACTERISTICS



Brazil
8.5 million Km^2
211 million inhabitants

State of São Paulo
248.000 Km^2
3% Brazilian territory

46 million inhabitants
22% of Brazil's population

City of São Paulo: 12 million inhabitants

Metropolitan Region: ~202million
Almost half of the state population

São Paulo State Economy :

Is the 21th largest economy in the world and the 3rd in Latin America.

Has the largest port of Latin America and

In Brazil is responsible for 37% of industrialized products exportation

Sea Outfalls

- Brazil: ~20
- São Paulo: 10

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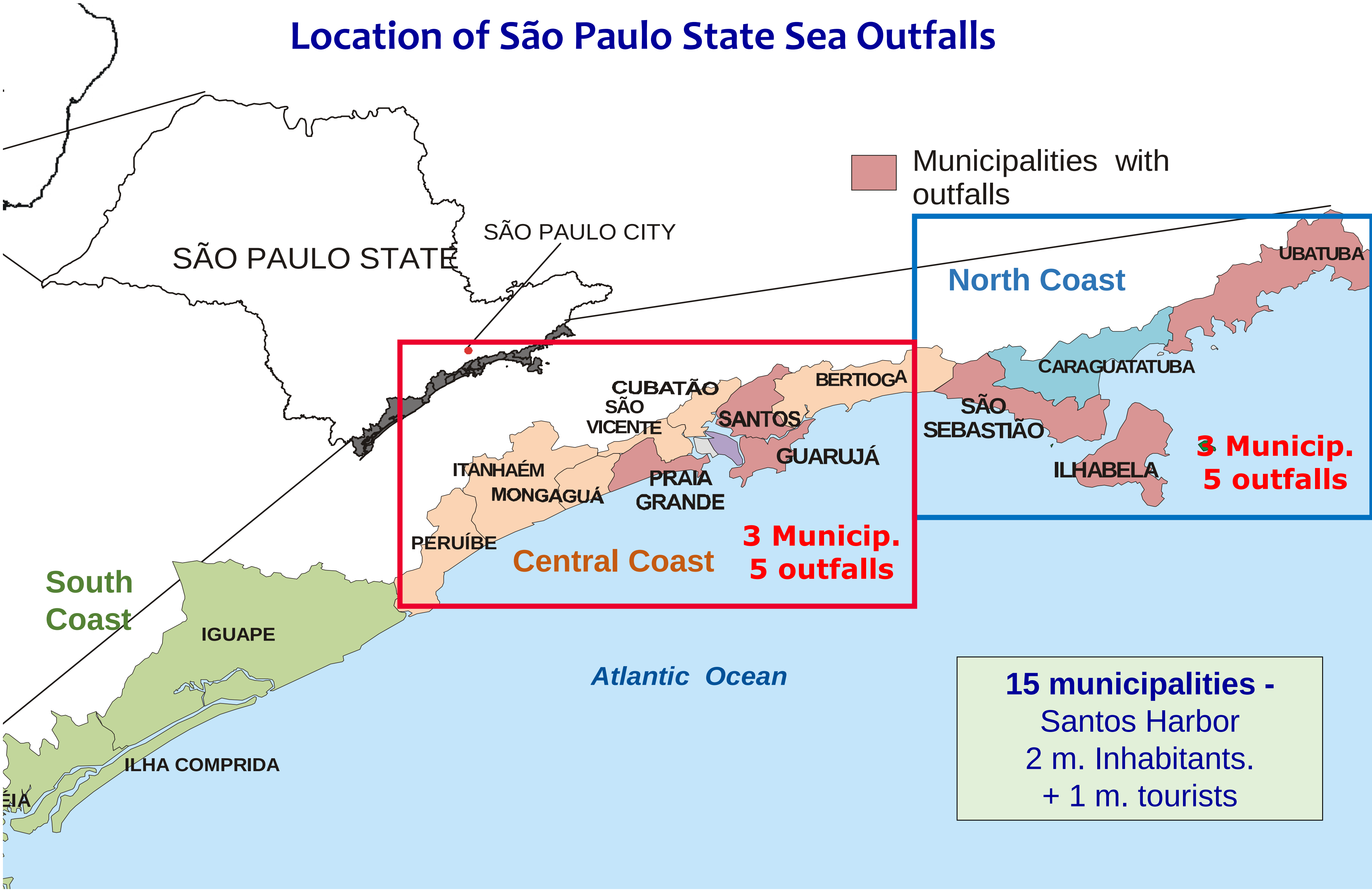
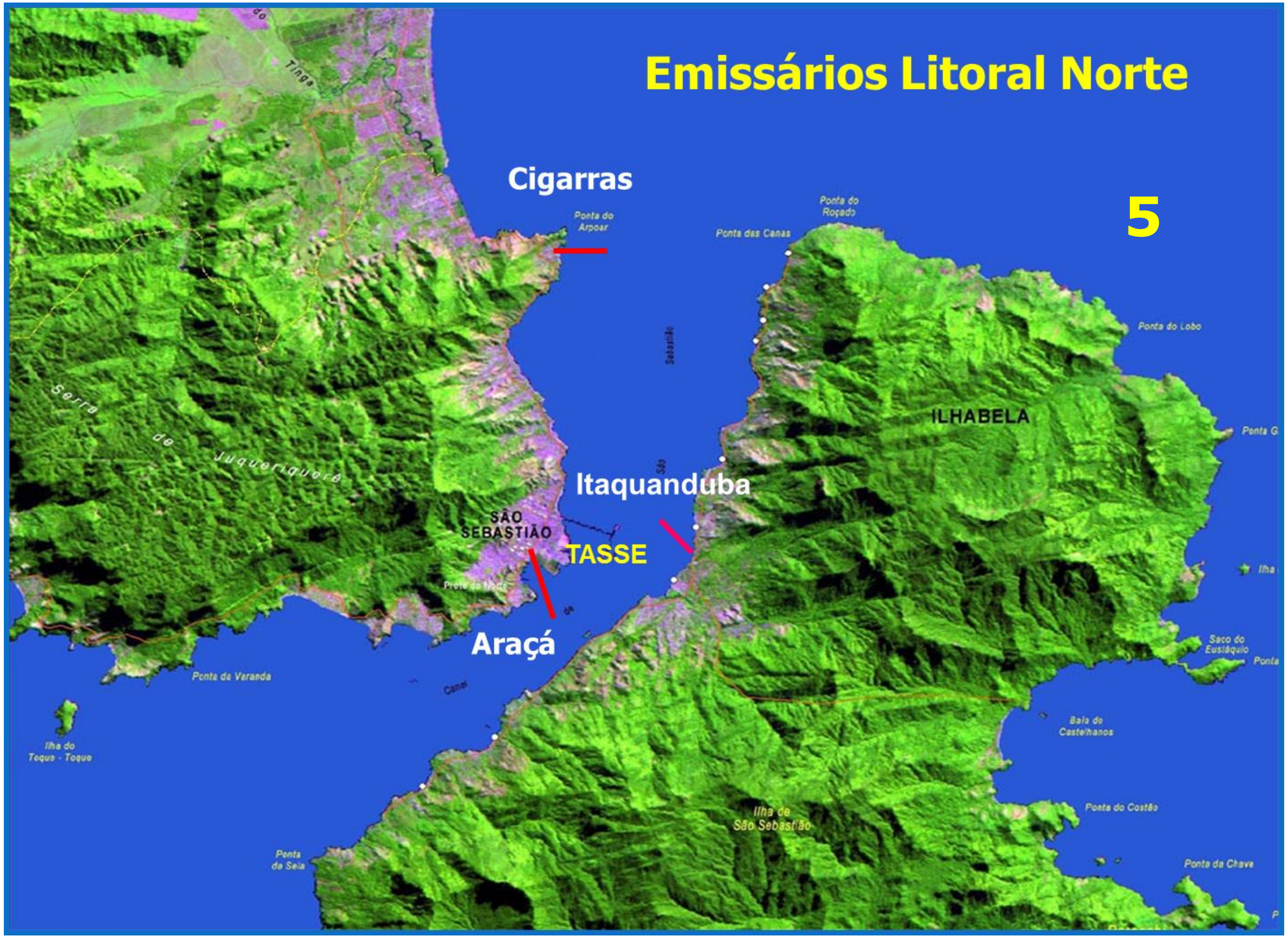
Location of São Paulo State Sea Outfalls



LOCATION OF SEA OUTFALLS IN SÃO PAULO NORTH COAST



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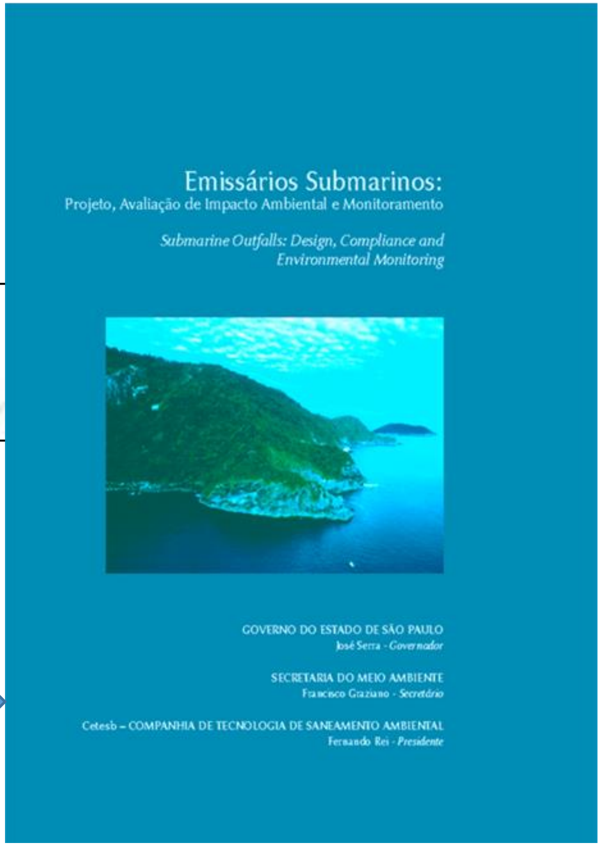
LOCATION OF SEA OUTFALLS IN SÃO PAULO CENTRAL COAST

SEA OUTFALL SYSTEMS LICENSING AND MONITORING

- First outfall – Santos 1979
- First environmental commissioning – 1996 – Ilhabela
- First International Workshop - 2003

PUBLICATION



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DEFINITION OF LICENSING PROCESS AND MONITORING METHODOLOGY
-STUDIES REQUIRED -

PREVIOUS STUDIES

- Effluent dispersion Modelling
- Location justification – water uses, distance of the coast, depth ...
- Treatment level justification
- Outfall design - diffusers

BEFORE INSTALLATION AND DURING OPERATION

- **Field Monitoring** (1 year previous the installation/and follow up)
- Effluent Monitoring
- Beach monitoring
- Monitoring of other pollution sources (streams; rivers)
- Marine area near the discharge (Water, Sediment, Aquatic organisms)

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IMPORTANT TOOLS FOR SEA OUTFALLS LICENSING

➢ **MODELLING -** PREVENTIVE

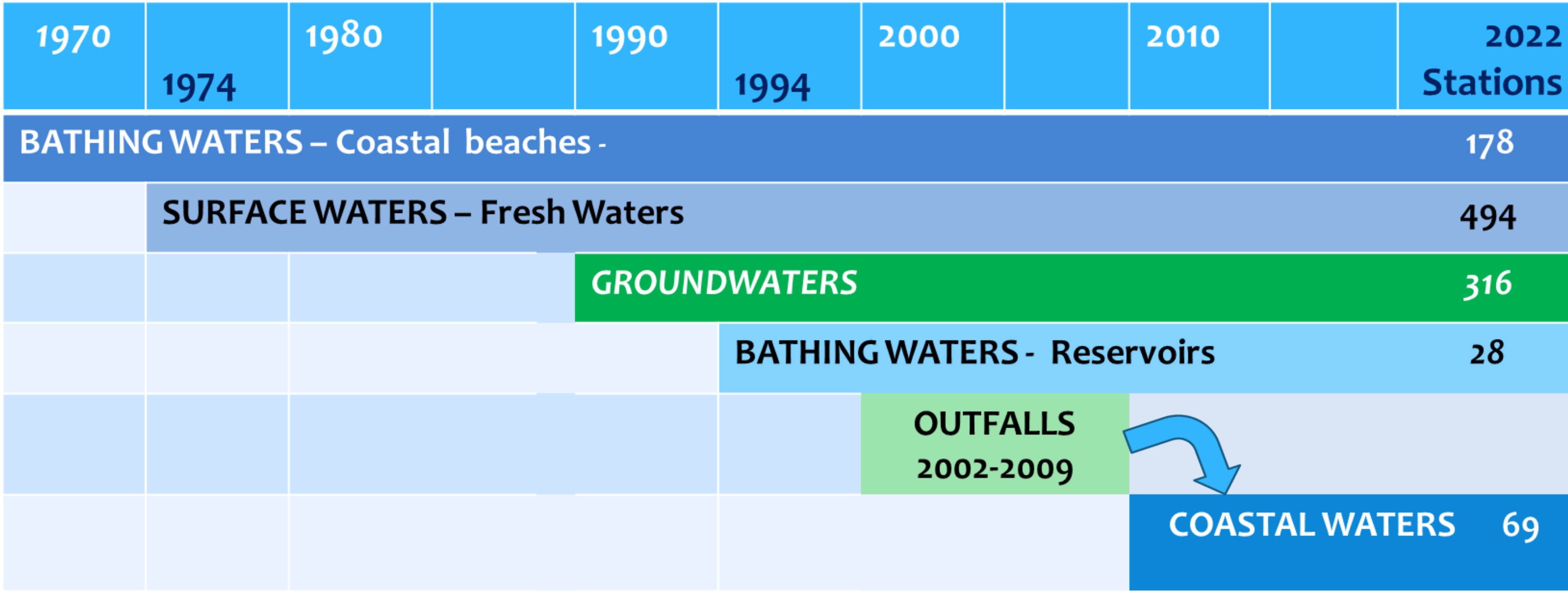
Prediction of environmental conditions and effluent dispersion

➢ **MONITORING** – CONFIRMATORY

Environmental assessment

Sampling – Laboratory analyses - Results – Data Set

WATER QUALITY ASSESSMENT PROGRAMS



COASTAL WATER QUALITY MONITORING PROGRAMS

1 - BEACH QUALITY ASSESSEMENT – Since 1970

Microbiological quality – Weekly – 178 sampling stations

GOAL: To assess the compliance for recreacional use

2 - COASTAL WATERS QUALITY – Since 2010

Multiples Water and sediments quality variables

GOAL: To assess the compliance for different uses

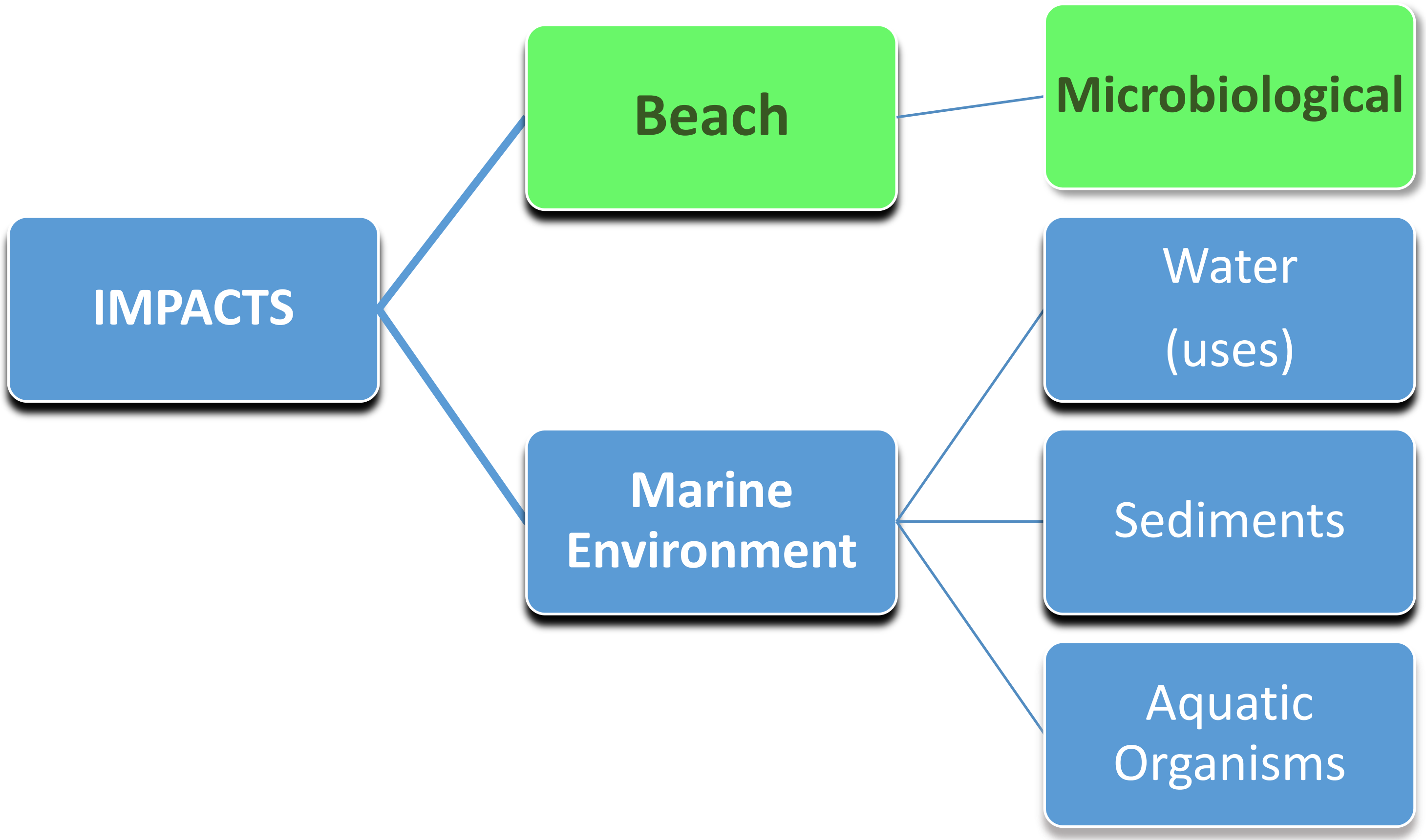
ANNUAL ENVIRONMENTAL QUALITY REPORTS

http://cetesb.sp.gov.br/publicacoes-relatorios/

http://cetesb.sp.gov.br/praias/publicacoes-relatorios/

http://cetesb.sp.gov.br/aguas-costeiras/publicacoes-e-relatorios/

SEA OUTFALL DISCHARGES POSSIBLE IMPACTS



1. BEACH QUALITY ASSESSMENT IN SÃO PAULO

158 Beaches

175 Sampling *Stations*

Weekly

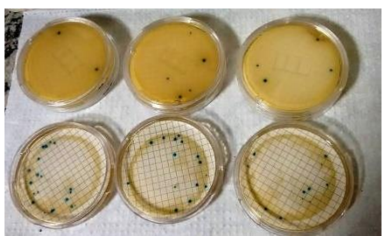
sea water sampling for microbiological analyses

Classification

National criteria

Public Information

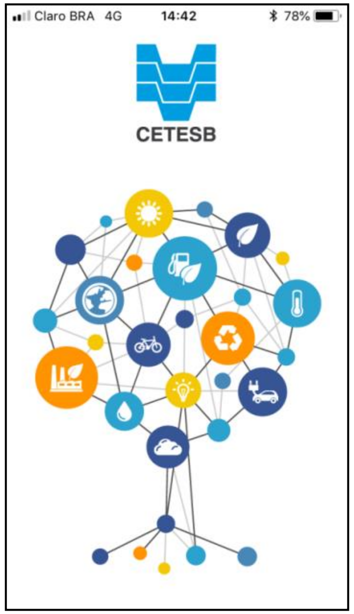
Pollution Control and prevention



COMMUNICATION

IN SÃO PAULO STATE

1. Beach Flags
2. Weekly bulletins
3. Web: www.cetesb.sp.gov.br
4. Mobile App
5. Annual Reports



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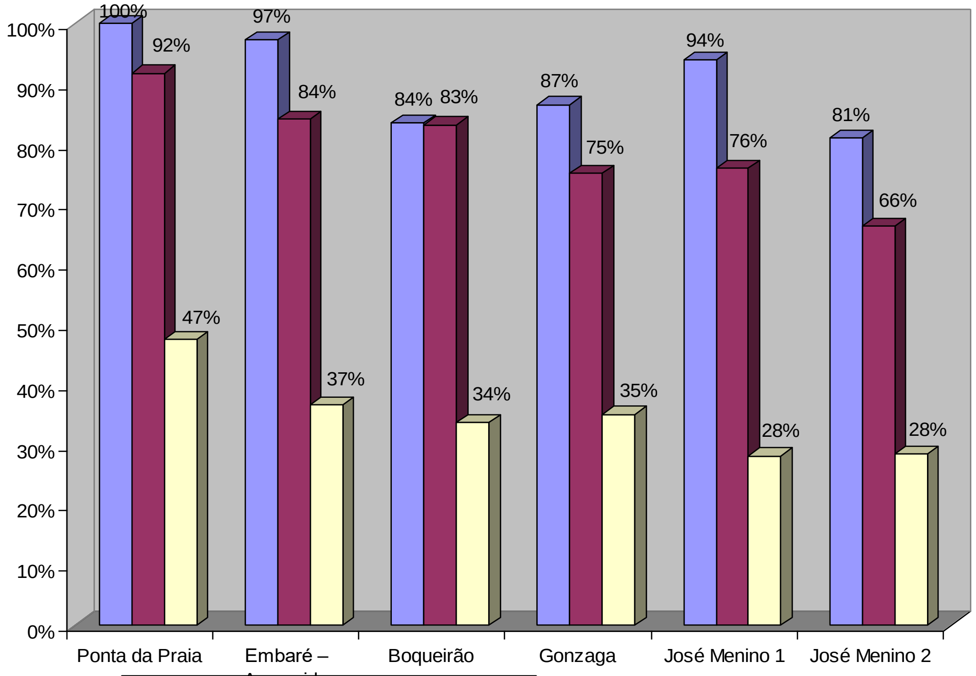
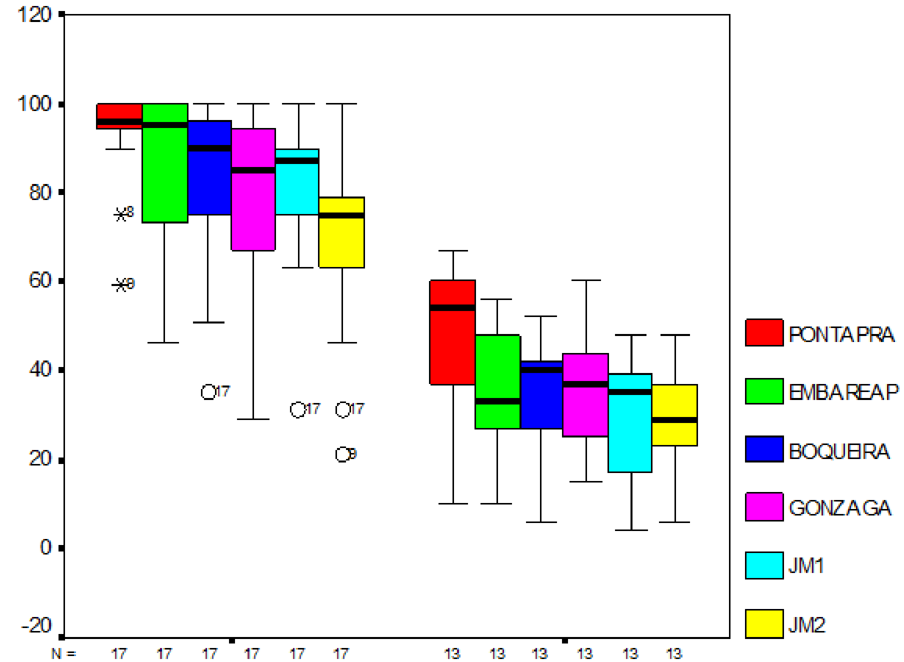
BEACH QUALITY IMPROVEMENT – SANTOS

BEACHES NON-COMPLIANCE FROM 1976 - 2005
OUTFALL – 1979 / FLOODGATES 1992



Before the outfall
After the outfall
After the floodgates



Before the and After the floodgates

The drainage channels in the city of Santos are responsible for storm water runoff into the sea.

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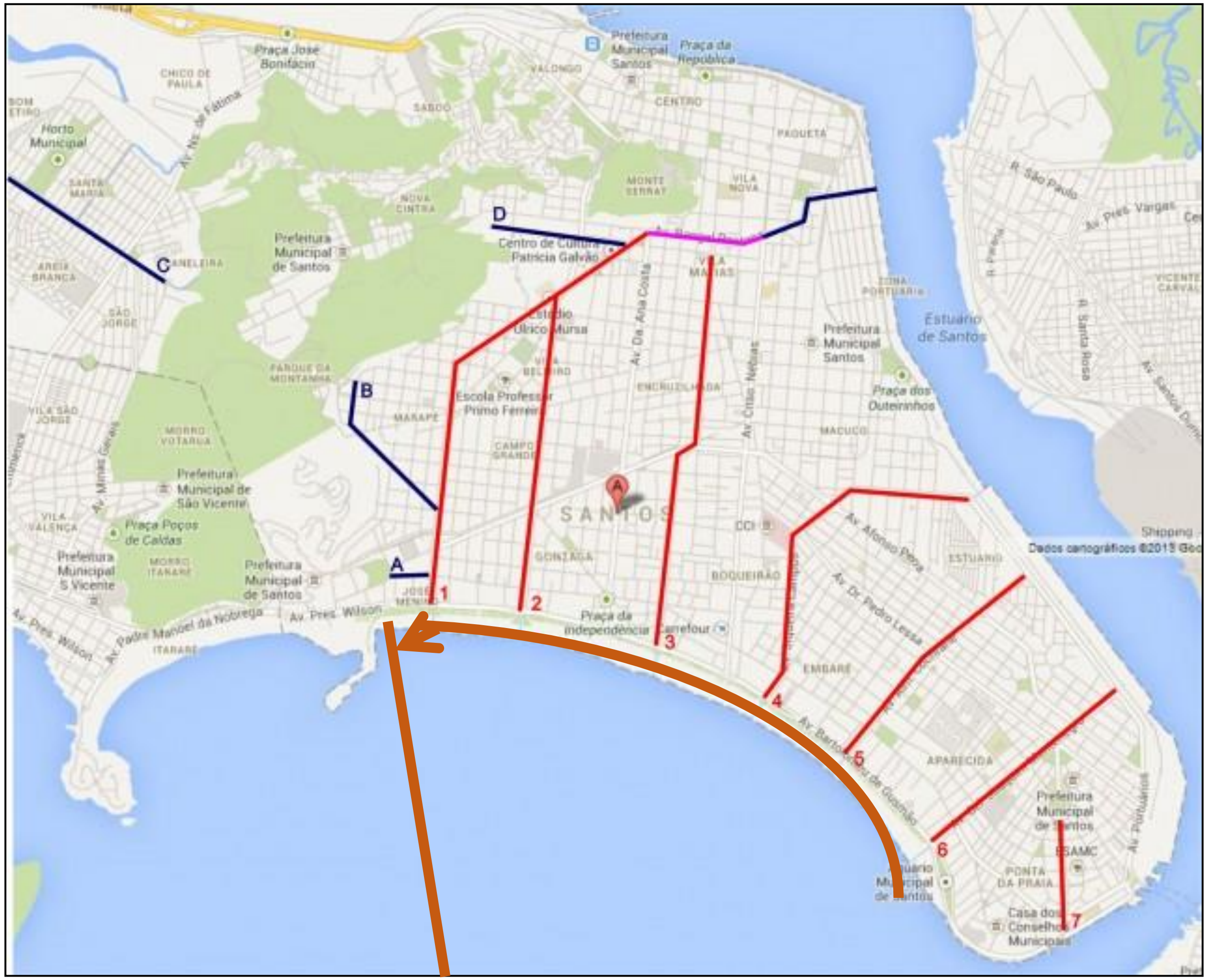
SANTOS'S DRAINAGE CHANNELS

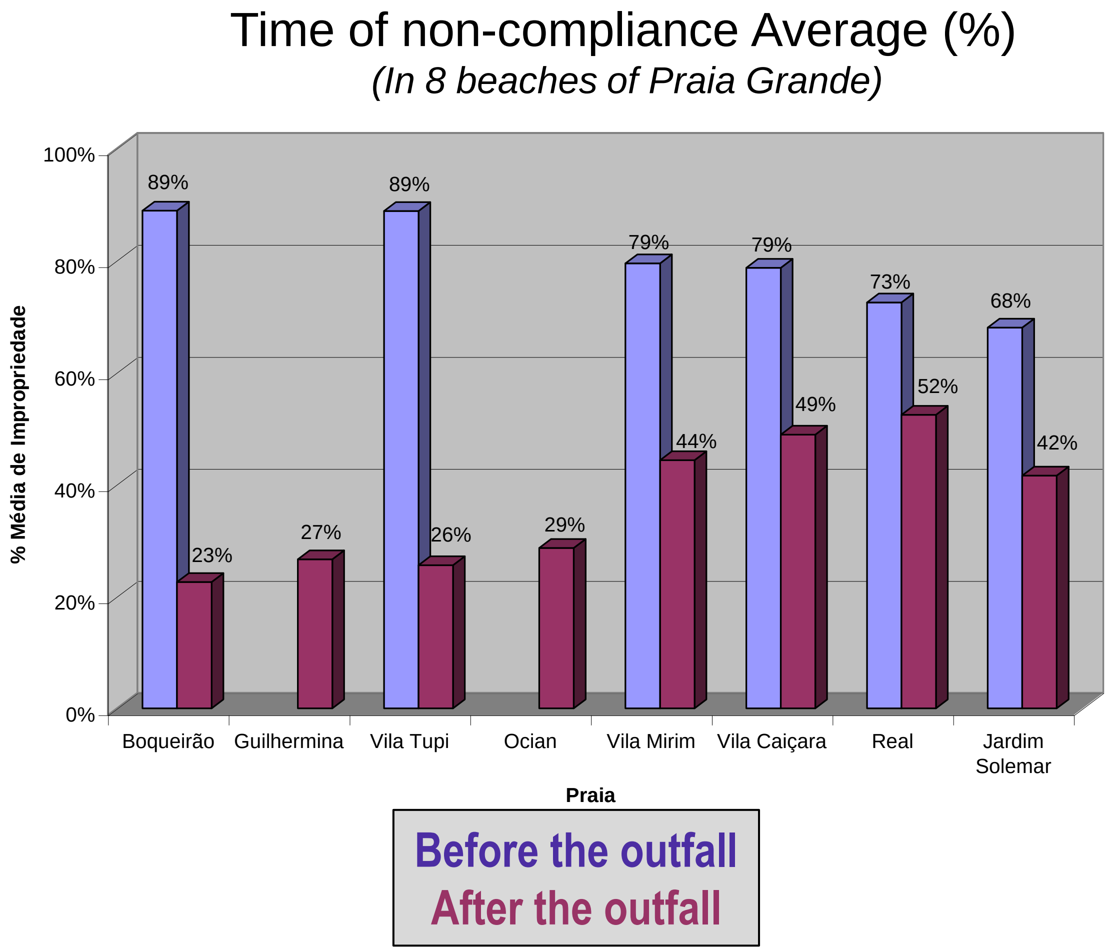


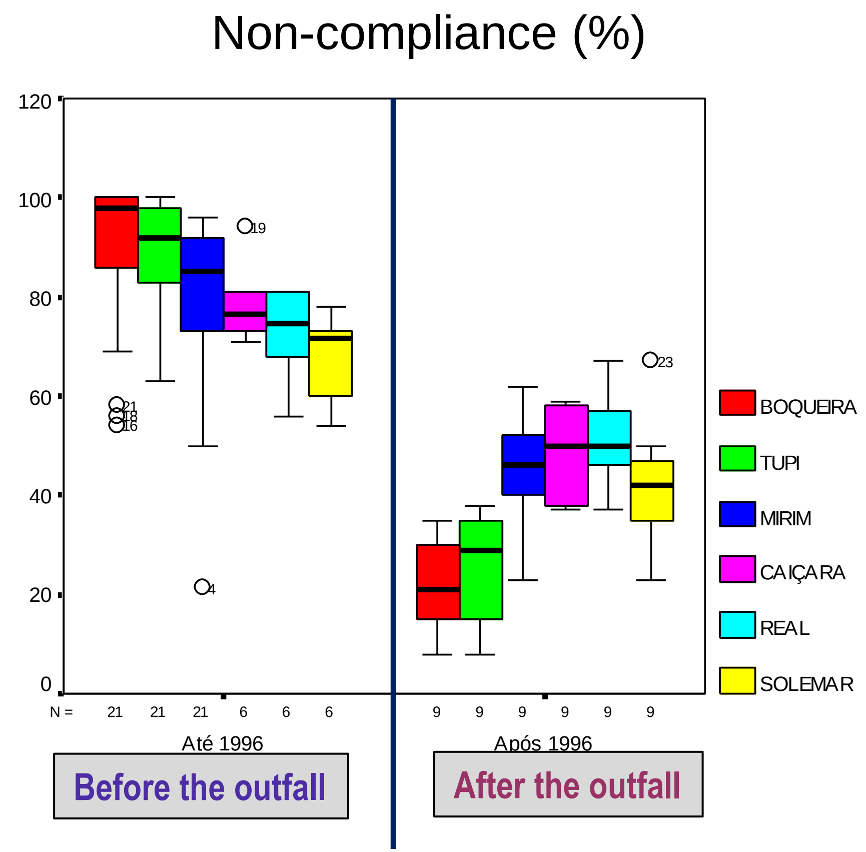
Other pollution sources

Diffuse pollution

Rainfall - runoff

BEACH QUALITY IMPROVEMENT - PRAIA GRANDE





MARINE ENVIRONMENT: COASTAL WATER QUALITY MONITORING PROGRAM

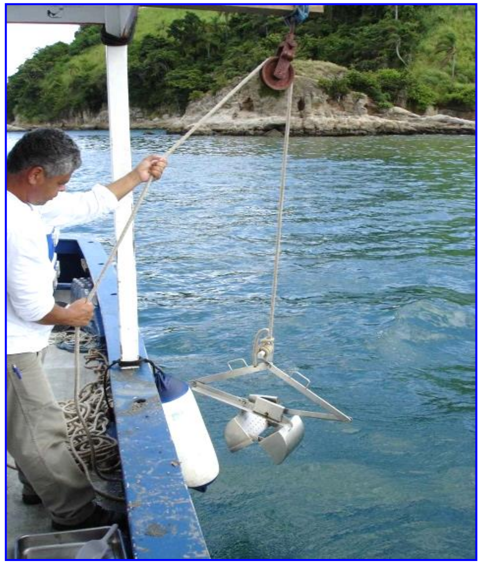
* **COASTAL WATERS QUALITY – Since 2010**

  69 sampling stations in 21 areas

  Twice a year

  35 variables analyzed

  Water & Sediments



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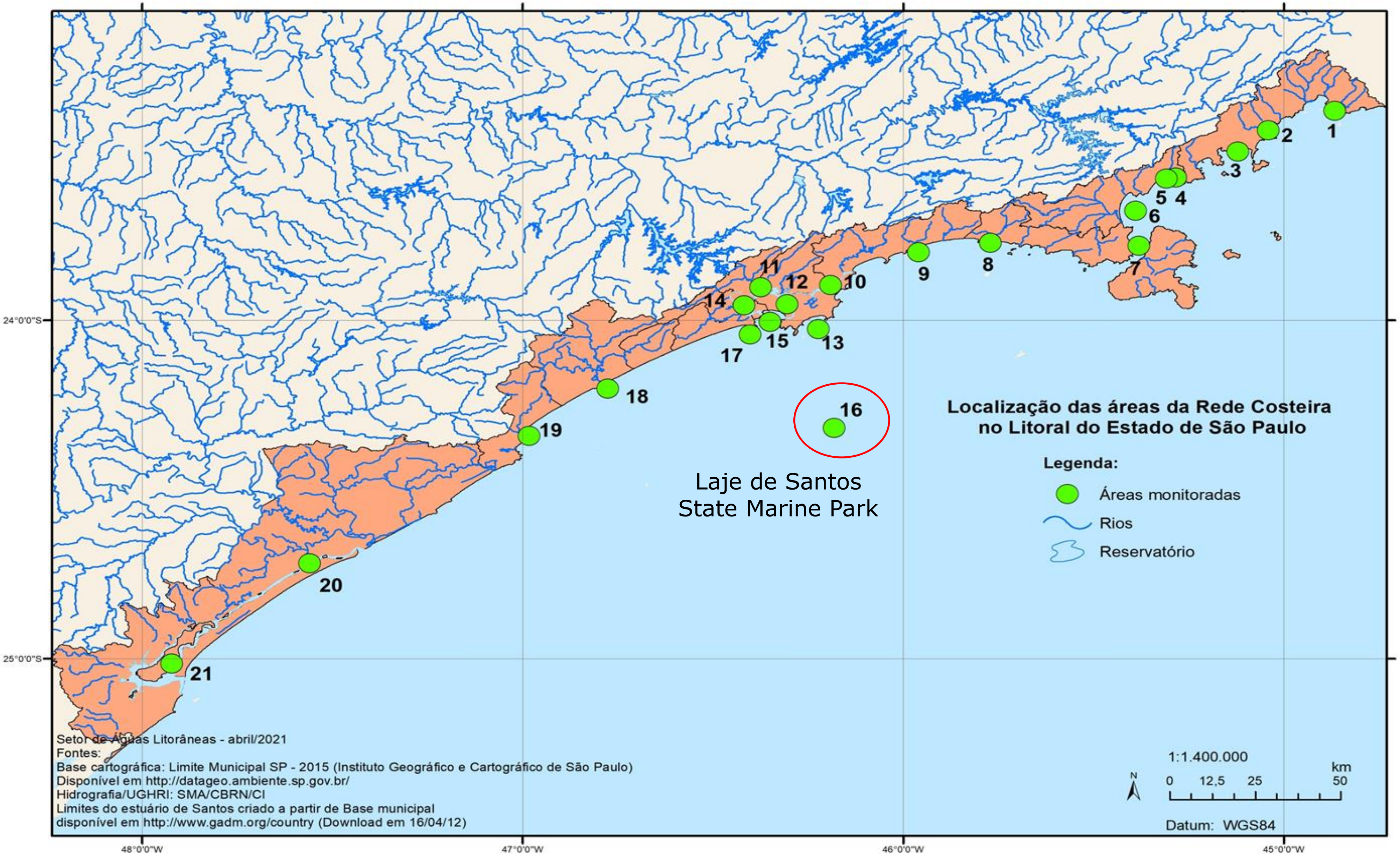
SAMPLING AREAS DISTRIBUTION – COASTAL WATER MONITORING



WATER AND SEDIMENT QUALITY PARAMETERS AND INDEXES

Variables analyzed

- ✓ Physical and chemical
- ✓ Hydrobiological
- ✓ Ecotoxicological
- ✓ Microbiological

Variables:
Dissolved Oxygen
TOC
Phosphorus
Nitrogen

COMPARISON TO LEGAL QUALITY STANDARDS TO EVALUATE COMPLIANCE

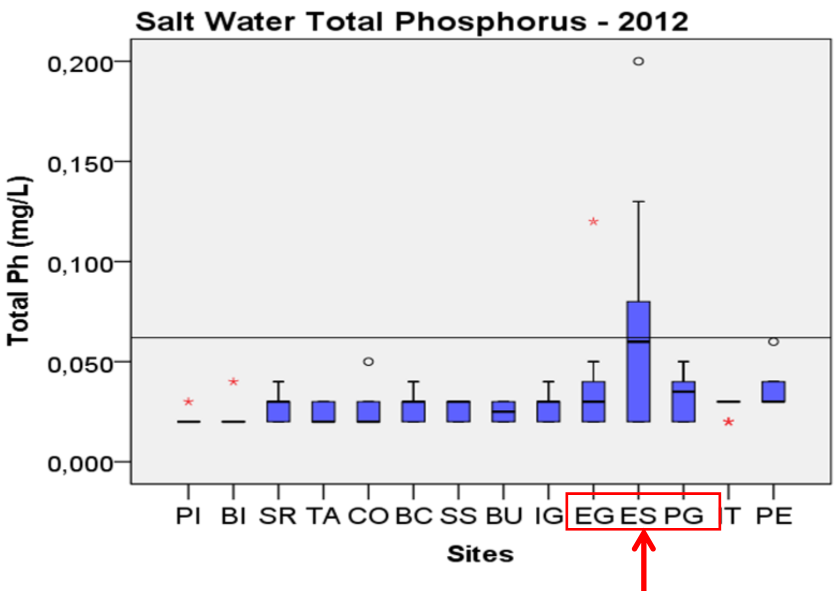
INDEX CALCULATION

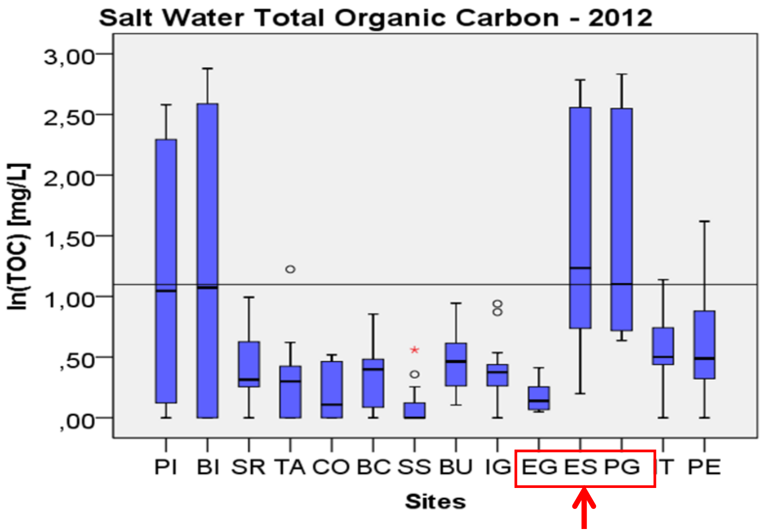
- ✓ IQAC- Quality Index
- ✓ IETC - Trophic Index
- ✓ Microbiological Index

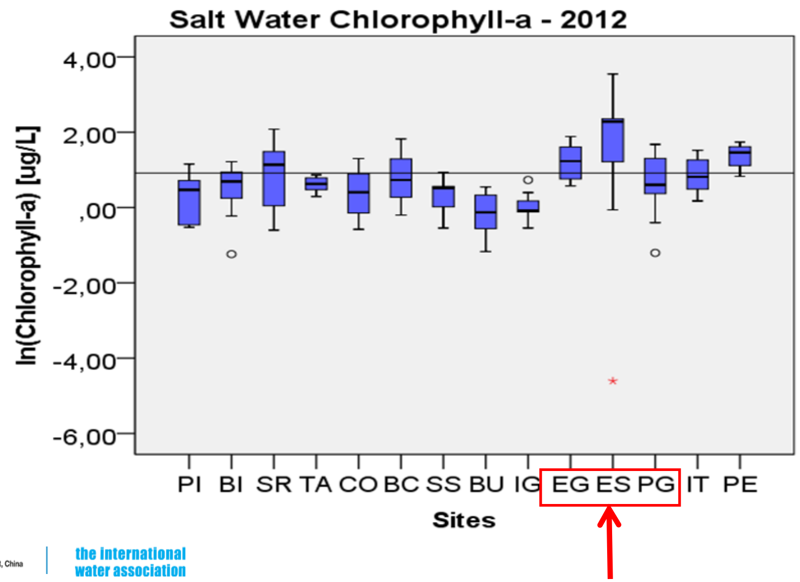
ENVIRONMENTAL DIAGNOSIS,
IDENTIFICATION OF HOT SPOTS
SPATIAL DISTRIBUTION
TEMPORAL TRENDS

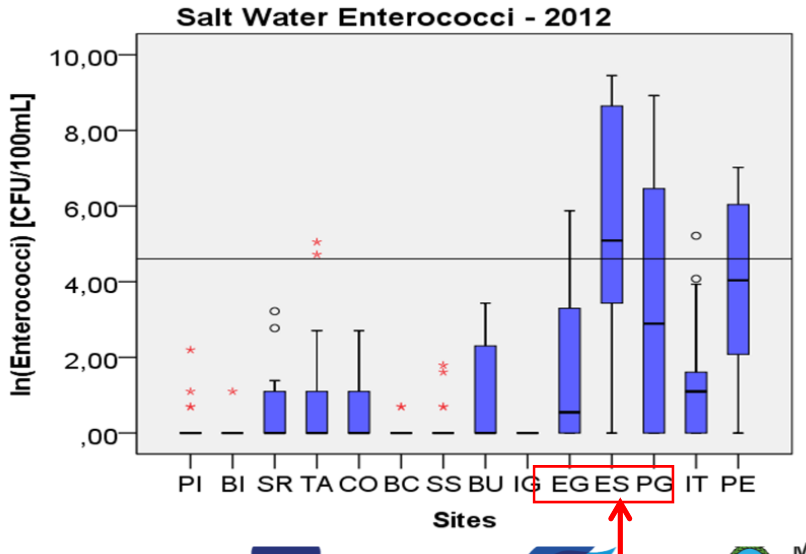
MARINE ENVIRONMENT

- WATER QUALITY









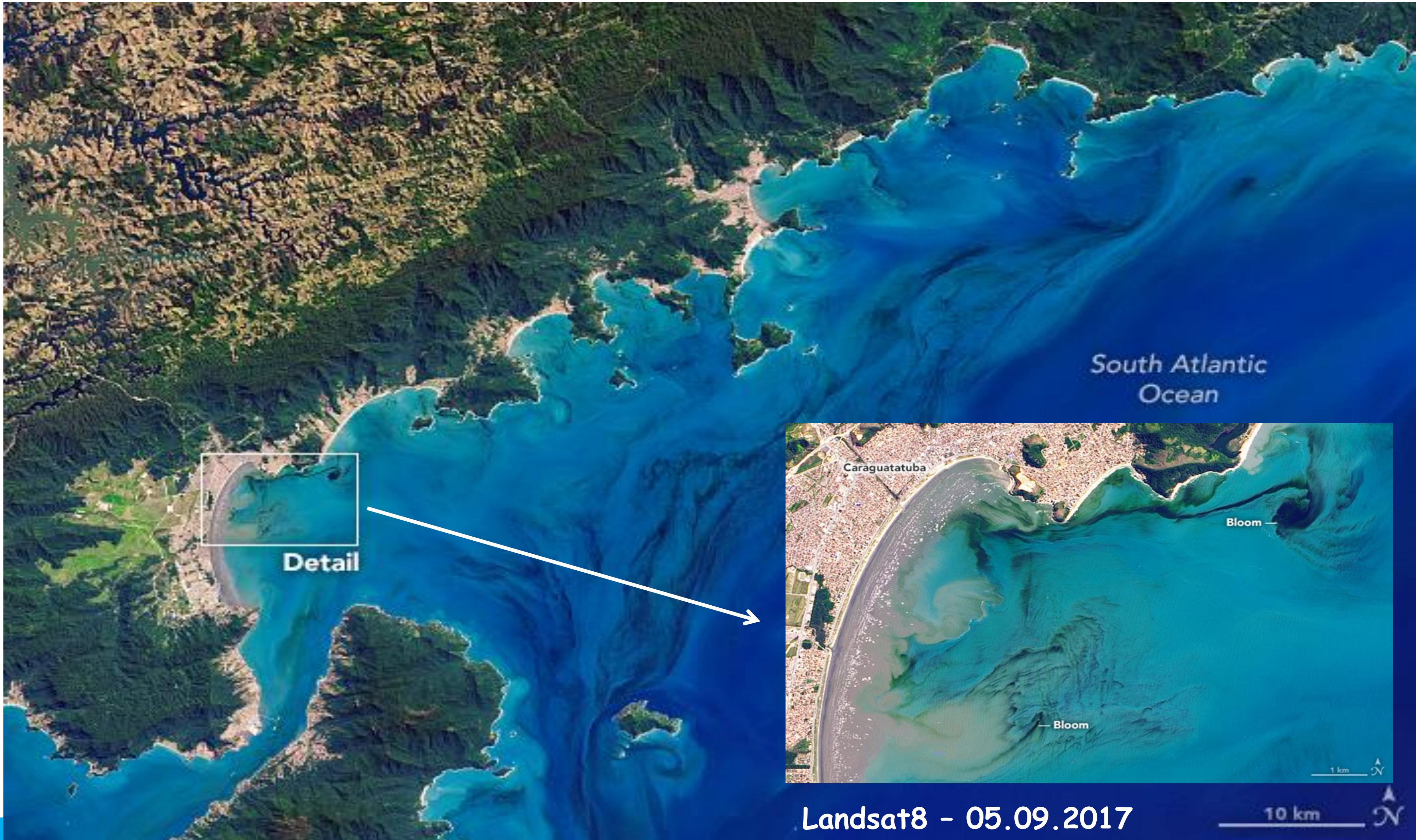
EVOLUTION OF THE COASTAL WATER QUALITY INDEX - IQAC

Excellent
Good
Regular
Poor
Very Poor

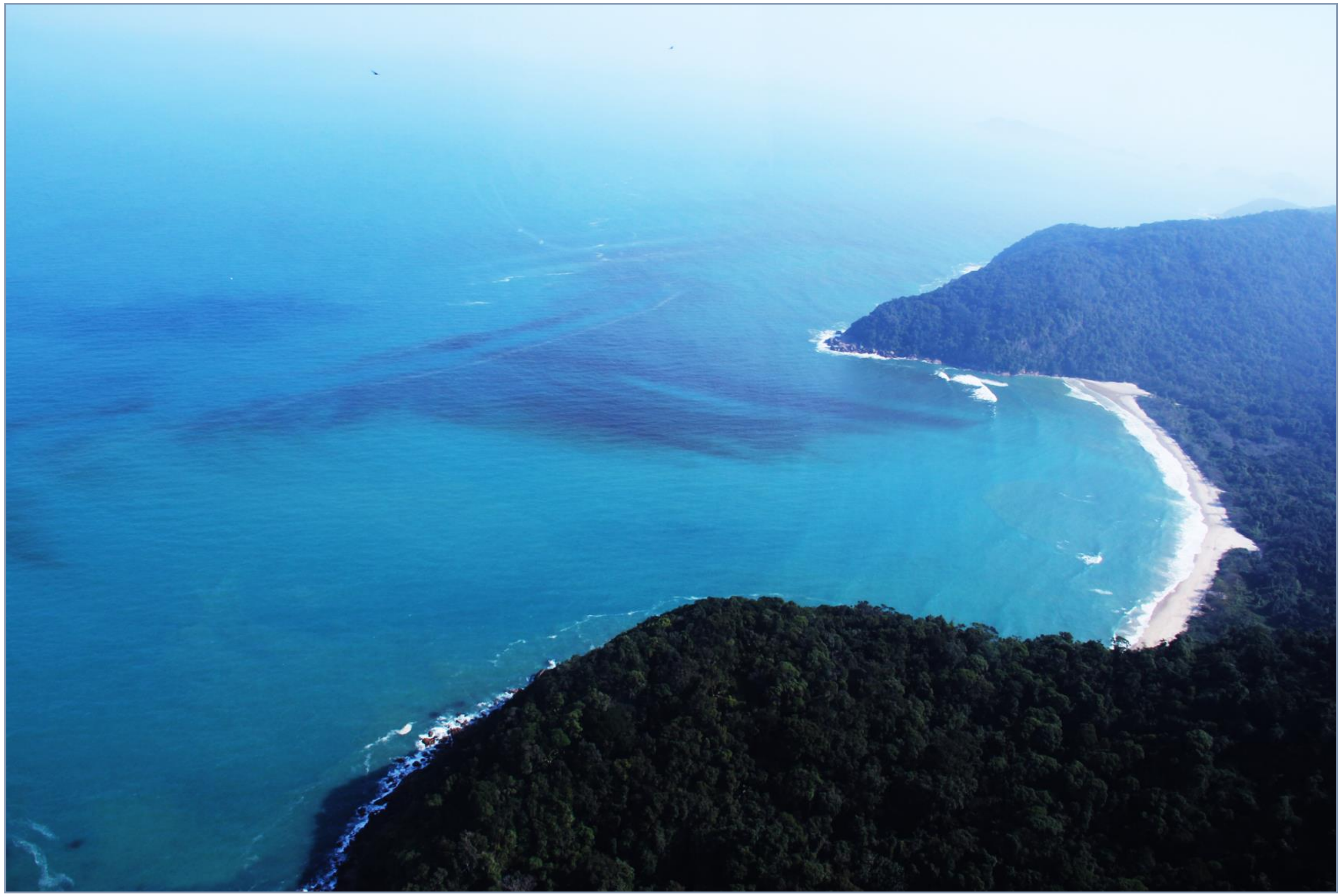
Region	Sampling area	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Activities
North Coast	Pinciguaba	77	99	85	97	99	79	97	99	92	99	92	Turism
	Baía de Itaguá	73	85	90	95	93	79	97	94	99	85	88	
	Saco da Ribeira	89	87	92	83	96	97	97	99	99	99	89	
	Tabatinga	92	99	99	90	96	97	97	97	92	99	81	
	Cocanha	95	99	99	88	97	99	90	97	99	93	90	
	Baía de Caraguatatuba	90	97	99	97	99	86	85	80	92	99	88	
	Canal de São Sebastião	98	98	95	95	92	90	89	88	83		88	
	Barra do Una	93	90	90	88	92	86	88	83	83	93	71	
	Rio Itaguaré	93	90	90	88	92	86	88	99	83	85	76	
Central Coast	Laje de Santos									99		78	Marine Park
	Canal de Bertioga	69	58	69	57	75	70	55	66	83	71	80	Estuary, Industries and Port
	Canal de Santos	59	46	47	73	59	55	62	58	59	76	63	
	Canal de Piaçaguera				58	58	40	60	51	67	67	63	
	Canal de São Vicente	53	43	39	37	54	46	54	50	58	85	81	
	Emissário Guarujá	83	80	81	81	78	83	77	75	67	85	47	Sea outfalls
	Emissário Santos	39	70	47	54	49	47	65	50	83	53	75	
	Emissário Praia Grande 1	60	76	85	71	74	75	78	61	75	85	56	
	Rio Itanhaém	87		82	79	87	79	76	83	75	78	80	
	Rio Preto	71	92	88	80	83	76	74	67	83	93	75	
South Coast	Mar Pequeno	68	67	68	78	62	76	80	66	92	85	85	Turism agriculture
	Mar de Cananéia	69	85	84	84	91	85	81	86	92	92	85	

The WQI has been an adequate tool in the evaluation and communication of coastal water quality in São Paulo State

ALGAL BLOOMS – HAVE BEEN FREQUENT SINCE 2016
- PHYTOPLANKTON MONITORING



ALGAL BLOOM: UBATUBA /SÃO PAULO NORTH COAST -06/09/2017-



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MARINE ENVIRONMENT

- SEDIMENT QUALITY

Negative Redox Potential indicates anaerobic organic matter decomposition (before improvements in Araçá sea outfall)

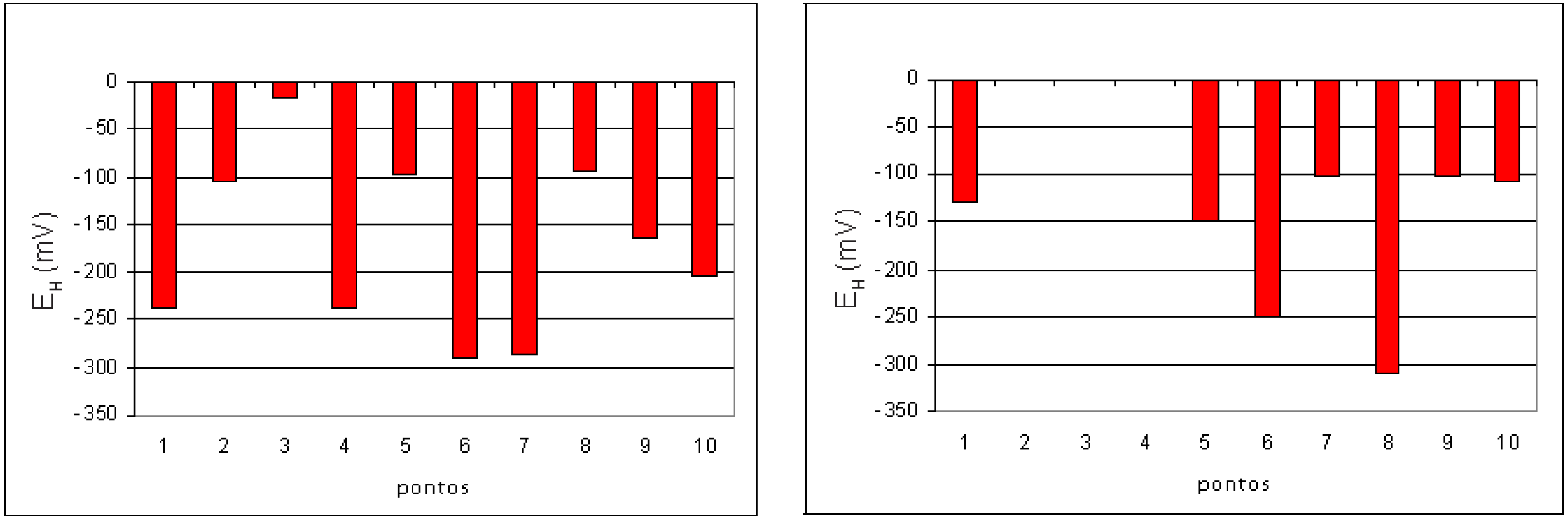
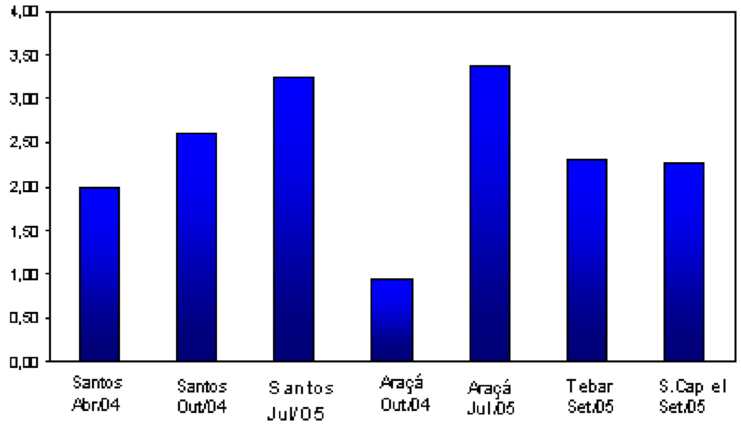


Figura 54: Valores de E_H dos sedimentos da área de influência do emissário do Araçá (mar. e out. 2004).

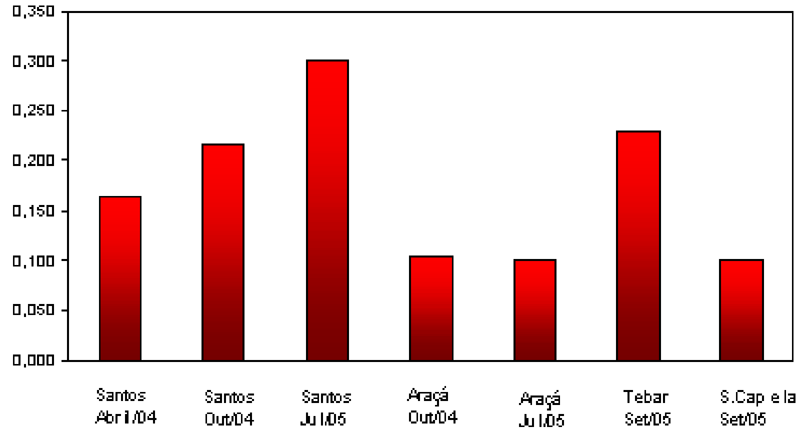
MARINE ENVIRONMENT

▪ SEDIMENT QUALITY

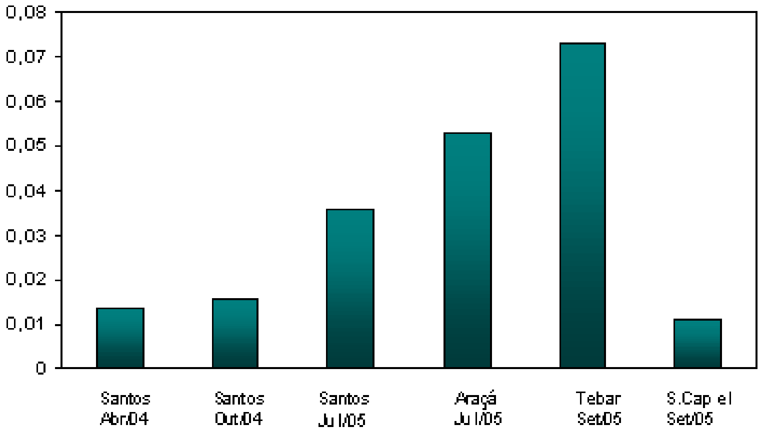
T O Carbon



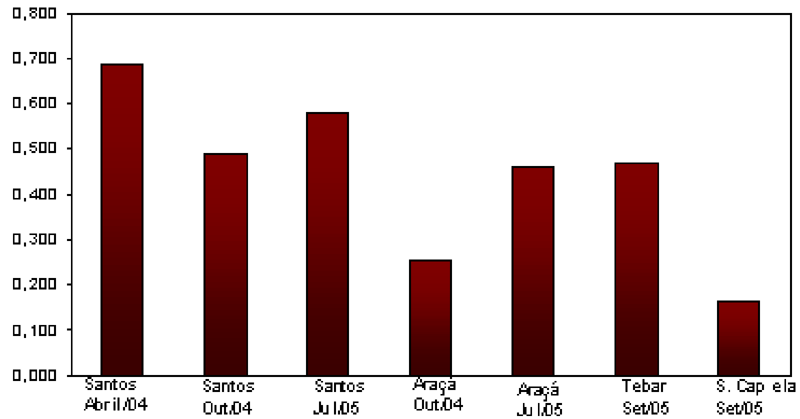
T Nitrogen



O Phosphorus



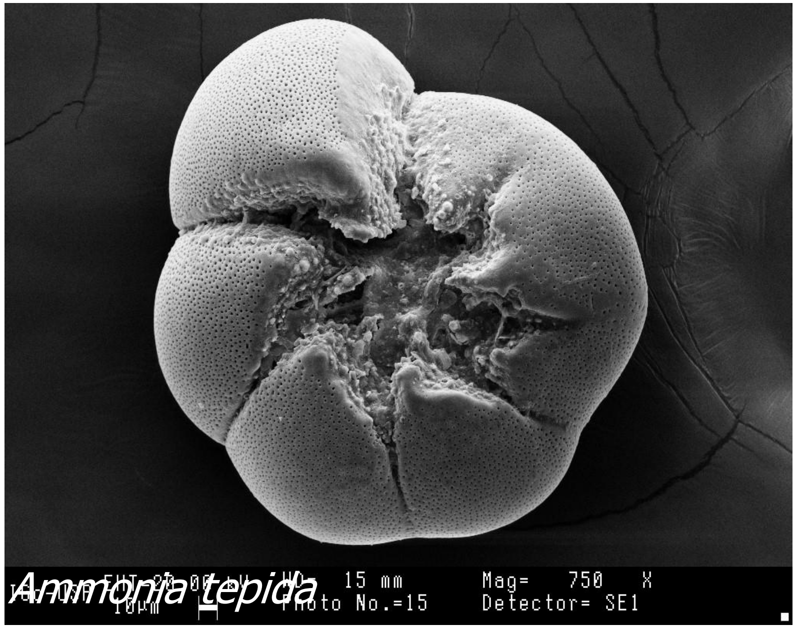
T Sulfur



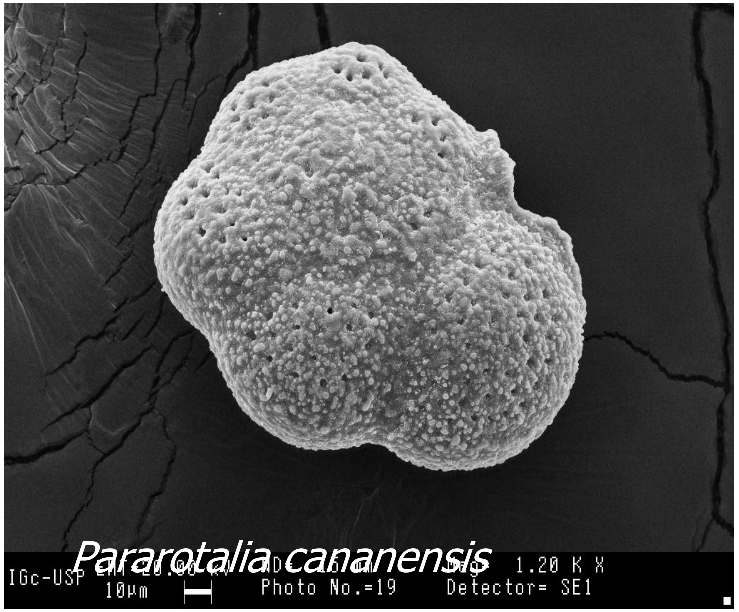
Maximum values (%) of nutrients in sediments near 3 sea outfalls (results from2004/2005)

Before Improvements

AQUATIC ORGANISMS (BENTHIC): FORAMINIFERA AS BIOINDICATORS



Ammonia tepida



Pararotalia cananensis

- **The most abundant species are indicators of impacted locations**
- **The low density of organisms can indicate the impact of the discharges**

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CONCLUSIONS OF MONITORING

- In most cases sea outfalls lead to the improvement of beach quality
- Monitoring of coastal waters influenced by sea outfall discharges was useful to understand which impacts would be expected from this kind of disposal.
- The results showed that alteration in water quality, mainly nutrient enrichment was observed in Santos's bay probably due to hydrodynamic conditions
- the major issue was the observed changes in sediment quality due to the deposition of particulate organic matter that was not removed in the preliminary treatment. Resulting in Dissolved Oxygen depletion with anaerobic decomposition of OM.
- additional removal of suspended solids was required for some outfalls, as well as improvements in treatment and diffusers for the existing ones.

CHARACTERISTICS OF SEA OUTFALLS IN SÃO PAULO COAST

(MODIFIED FROM MARCELLINO, 2000)

Municipality	Location	Operation start	Operation start after Improvements	Max population (inhabitant)	Max flow (m^3/s)	Discharge depth (m)	Outfall length (m)	Diameter (m)
Praia Grande	PG1 Boqueirão	1996	2021	253,755	1.118	12.5	3,300	1,00
	PG2 Vila Tupi	1996	2021	348,635	1.361	13	3,415	1,00
	PG3 V.Caiçara	2011		559.103	1.400	12	4,000	1,00
Santos - SV	J. Menino	1979	2009	1322,100	7.267	10	4,000	1,75
Guarujá	Enseada	1998		445,858	1.447	14	4,500	0,90
São Sebastiao	Araçá	1991	2014/2019	21,396	0.140	8/17	1,061	0,40
	Cigarras	1985	2014	1,600	0.012	8.5	1,068	0,16
Ilhabela	Itaquanduba	2010		30,000	0.150	37	800	0,40
Ubatuba	P. da Enseada	1990	2014	4,500	0.015	5	300	0,20

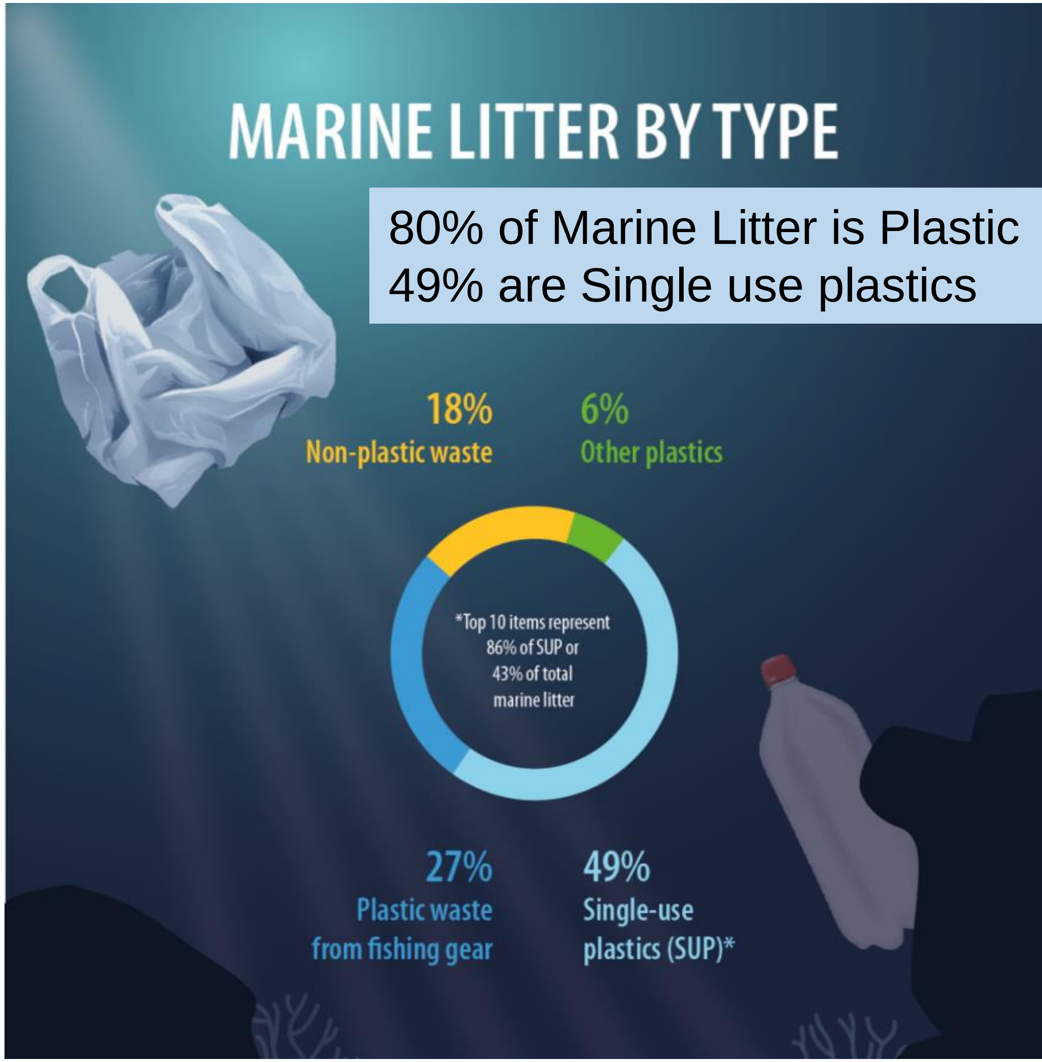
CHALLENGES AND DIFFICULTIES

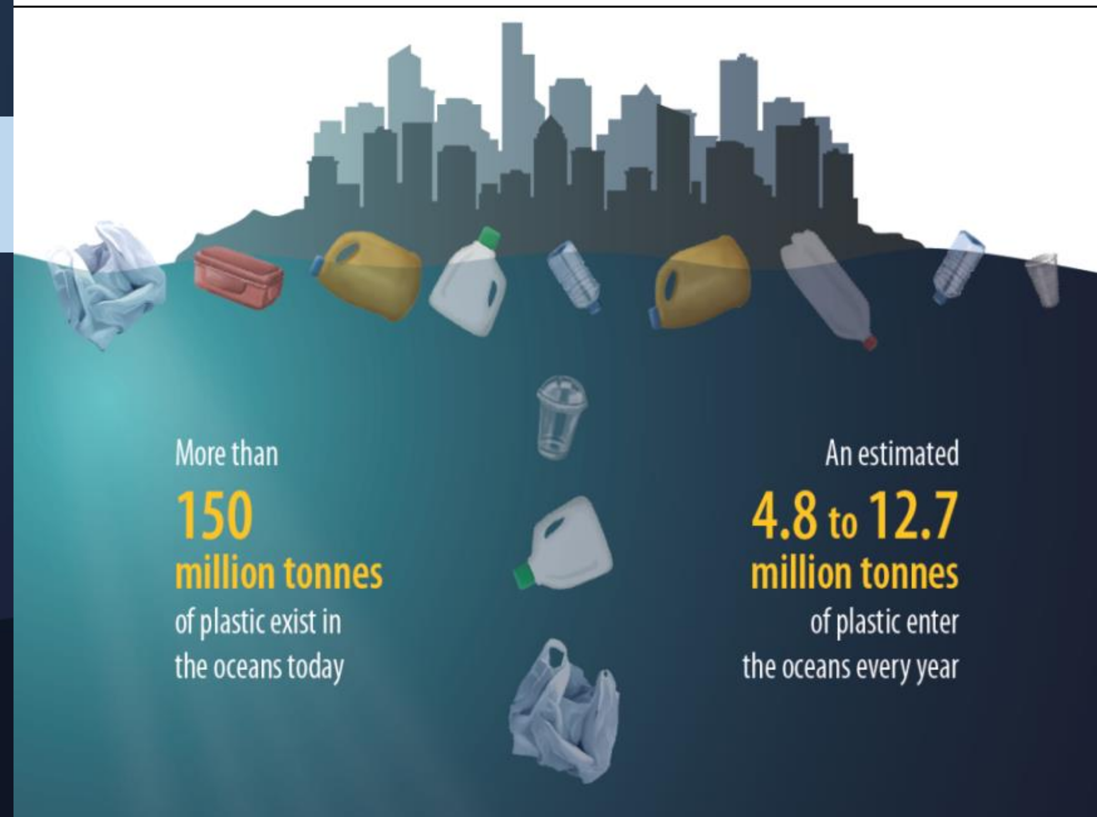
- Lack of environmental data in developing countries
- High costs of marine monitoring (equipment's and activities are often very expensive).
- Variability of marine environment
- Long term monitoring
- Legal mixing zone definition
- Sediment transport modelling
- Climate Change: sea level rise, extremes events of rainfall, changes in temperature and pH
- Emerging pollutants ⟶ PLASTIC POLLUTION

The US EPA (United States – Environmental Protection Agency) defines emerging pollutants as new chemicals without regulatory status and which impact on environment and human health are poorly understood.

PLASTIC POLLUTION IN THE MARINE ENVIRONMENT

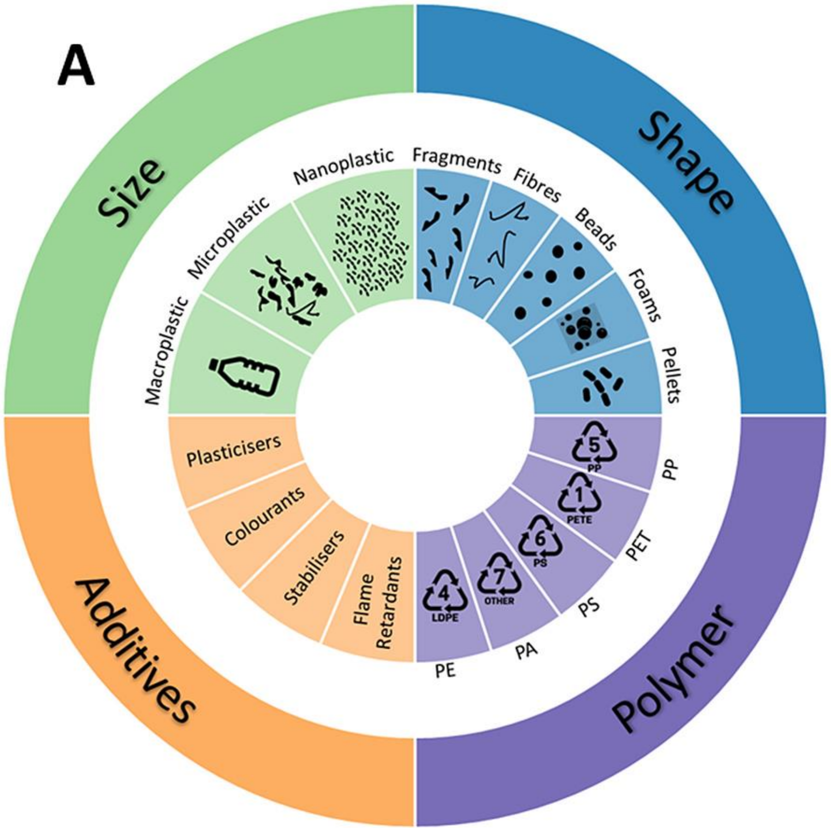
80% of Marine Litter is Plastic
49% are Single use plastics





Source: European Parliamentary Research Service
europarl.europa.eu

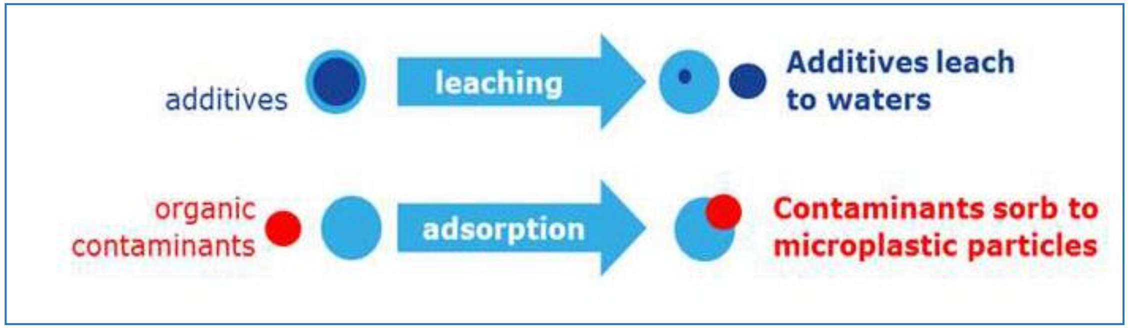
PLASTIC POLLUTION



Schematic representation of the composition of plastic pollution such as sizes, shapes, additives and polymers (including, but not limited to, PE = polyethylene, PA = polyamide, PS = polystyrene, PET = polyethylene terephthalate, PP = polypropylene)

Tuuri, E.M. & Leterme, S.C. - Environmental Pollution 321 (2023) 121156

PLASTIC + CHEMICAL ADDITIVES + CHEMICALS ADSORBED



European Commission Factsheet – December 2017

MICROPLASTICS

Are tiny plastic particles
(5mm or less in size)

Their small size and pervasive nature make them extremely difficult to clean up.

*https://www.surfrider.org/ **Header image: Samuel Bollendorff - Tara Expeditions Foundation***

- **Primary microplastics** are plastics directly released into the environment in the form of small particulates.

- **Secondary microplastics** are microplastics originating from the degradation of larger plastic items into smaller plastic fragments once exposed to marine environment.

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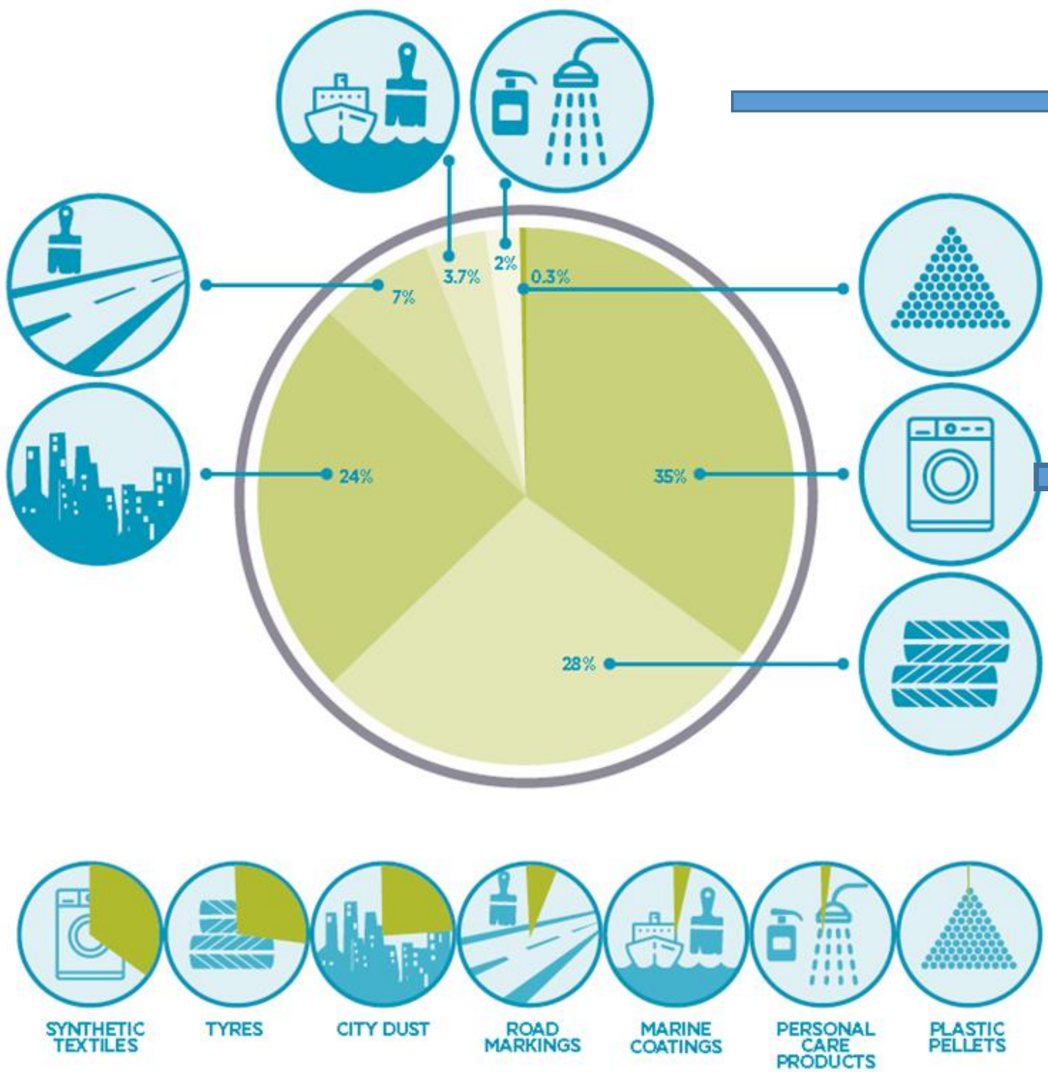
GLOBAL RELEASES OF PRIMARY MICROPLASTICS TO THE WORLD OCEANS

(Boucher,J. & Friot D. IUCN, 2017)

BY SOURCE (IN %).



Personal Care 2%

37%

WASTE WATER

Syntethic tissue fibres 35%

City dust 24%
Tyres 28%

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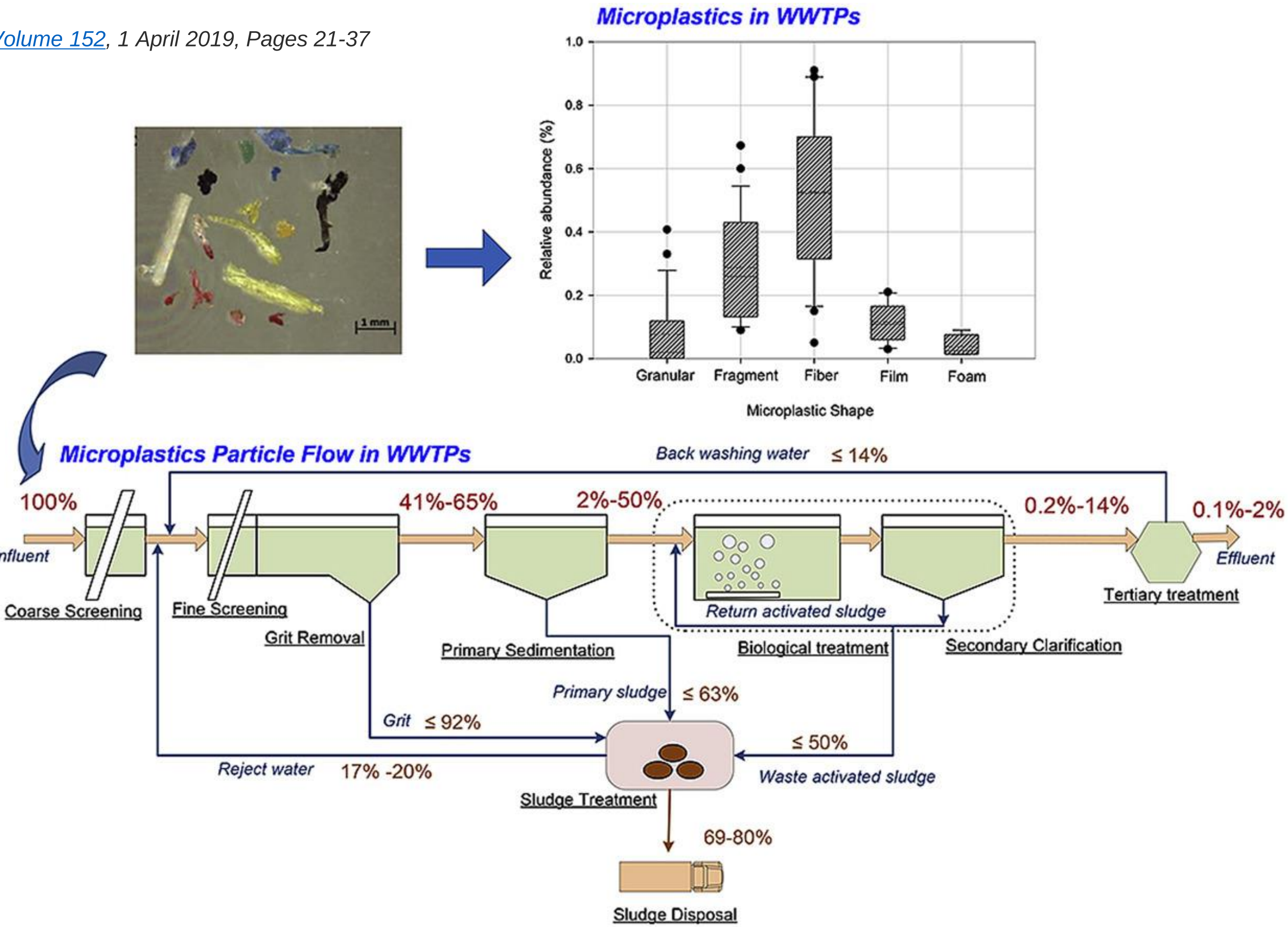
MICROPLASTICS IN WASTEWATER

Water Research Volume 152, 1 April 2019, Pages 21-37



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MICROPLASTICS IN WWTPS

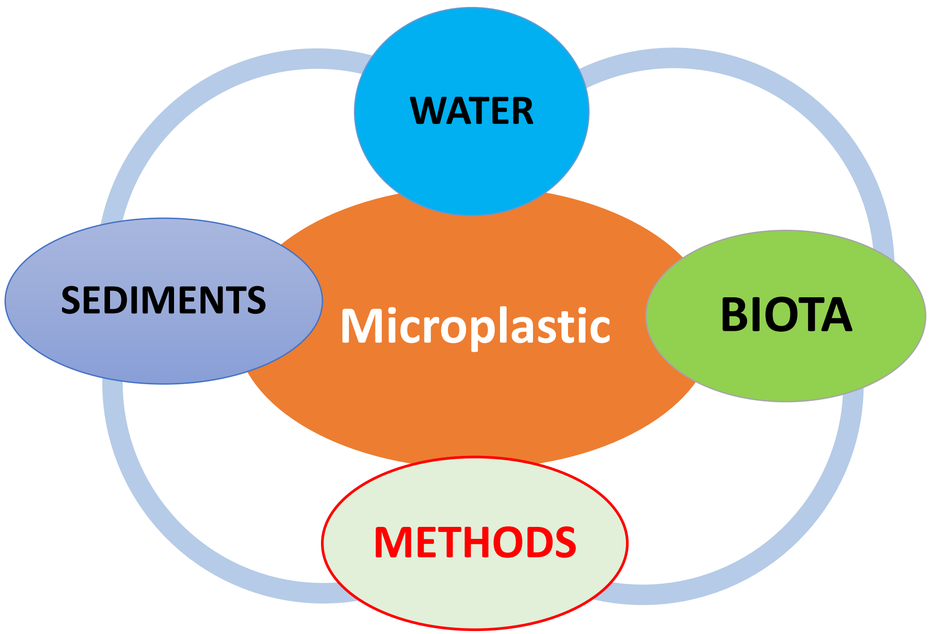
- Wastewater treatment plants (WWTPs) are an important route for microplastics to enter aquatic environments. Microplastics have been recently identified in sewage samples in Russia, Sweden, France, Finland, USA, UK, Netherlands, Germany, Canada, Australia, Italy, Turkey, Denmark, Poland, China and South Korea.
- The aim of this study was to examine and quantify the removal efficacy of microplastics by WWTPs. Experimental methods employed in sampling, analysis and quantification of microplastics vary widely between studies. Microplastic removal rates in 21 studies were compared.
- Secondary and tertiary WWTPs removed an average of 88% and 94% of microplastics, respectively. The majority of microplastics, 72% on average, were removed during preliminary and primary treatment.

Environ. Sci.: Water Res. Technol., 2020, 6, 2664

MICROPLASTICS MONITORING

FIRST STEPS... BUILDING CAPACITY

How to incorporate microplastic Assessment in existent Monitoring Programs ?



1. Studying available methodologies
2. Workshop organization in 2019
3. Partnership with Universities
4. International Technical Cooperation Projects

FINAL CONSIDERATIONS …… *TO HAVE IN MIND*

- Chlorination is always necessary ?
- Preliminary treatment is always adequate ?
- Long term duration and uncertainties in results of marine environment monitoring would not recommend a more conservative decision ?
- Staging is a possible solution ?
- As wastewater contains not only degradable compounds, dilution and water bodies' depuration are sufficient ?
- Microplastics studies and monitoring in sea outfall systems are needed

Thank you for your attention!

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Simposio Internacional sobre Sistemas de Emisarios 2023

International Symposium on Outfall Systems 2023