

Environment

Pollution of Guanabara Bay: sanitary sewage and effluents

Poluição da Baía de Guanabara: esgoto sanitário e efluentes

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ABSTRACT

Guanabara Bay is a natural heritage, which needs monitoring not only for water, but for fauna and flora. Every decade, degradation by domestic and industrial sewage increases, with boats and dumps placed on its banks. This study aimed to identify, in scientific productions focused on the pollution of Guanabara Bay, responses to water quality and problems related to the non-treatment of sanitary sewage and effluents. The research was carried out in the electronic collection of the Virtual Health Library, SciELO and Google Scholar Database, and evidenced articles, bulletins, manuals and government websites, in a floating search from 2012 to 2021. The discussion and results showed how important the Bay is and that its degradation harms the ecosystem and human life, making it necessary to structure intervention plans in this local environment. We concluded that a more effective and punitive inspection of the companies and compliance with the basic sanitation legislation by the municipal governments is required.

Keywords: Environment; Guanabara Bay; Sanitary sewage; Industrial effluents; Sea pollution

RESUMO

A Baía de Guanabara é um patrimônio natural, que necessita de monitorização não só da água, mas da fauna e da flora. A cada década, aumenta a degradação por esgoto doméstico e industrial, com embarcações e lixões colocados em suas margens. Este estudo objetivou identificar, nas produções científicas voltadas para a poluição da Baía de Guanabara, respostas para a qualidade da água e problemas ligados ao não tratamento de esgoto sanitário e efluentes. A pesquisa foi realizada no acervo eletrônico da Biblioteca Virtual em Saúde, Scielo e Banco de Dados do Google Acadêmico, e evidenciou artigos, boletins, manuais e sites governamentais, em uma busca flutuante no período de 2012 a 2021. A discussão e os resultados mostraram o quão a Baía é importante e que sua degradação prejudica o ecossistema e a vida humana, sendo necessário estruturar planos de intervenção nesse meio ambiente local. Conclui-se que é necessária uma fiscalização mais efetiva e punitiva das empresas e cumprimento da legislação do saneamento básico pelos governos municipais.

Palavras chaves: Meio ambiente; Baía de Guanabara; Esgoto sanitário; Efluentes industriais; Poluição do mar

1 INTRODUCTION

Water resources in urban centers are important, but when demand increases, there is an association of decreased water quality, resulting from the release of untreated domestic and industrial effluents, which leads to a scenario of conflict of resources, especially used in developing countries (VARGAS *et al.*, 2019).

The sewage that has domestic, hospital or industrial origin, among others, contains about 99.9% of water and 0.1% of organic and inorganic solids, and it usually transmits waterborne diseases due to the presence of pathogenic microorganisms, as well as organic materials, chemical substances toxic to man and other animals (RODRIGUES; VIEIRA; MENDES, 2021; PIMENTA *et al.*, 2002).

The effluents discharged in Guanabara Bay can be reused after their due treatment, and are classified according to the type (IBGE, 2011) as follows: Industrial (refrigeration, boiler feed, processing water, among others); Irrigation (landscape irrigation of parks, cemeteries, golf courses, residential lawns, etc.); Agriculture (irrigation of fields for cultivation); Urban highway cleaning, firefighting services, etc.; Aquaculture (breeding aquatic animals and plants).

In this context, we emphasize Federal Law no. 6.938 / 81, which seeks to preserve, improve and recover the environmental quality favorable to life, thus ensuring decent conditions for the socioeconomic development, the interests of national security and the protection of human life. (EPA WEBSITE, 2015; CERRI NETO; FERREIRA, 2009). According to Seixas Filho *et al.* (2020, p. 3), the “debate about water has been acquiring increasingly complex outlines, both worldwide and in the Brazilian reality”.

Guanabara Bay occupies an area of 384km², with islands in the interior that add up to 56km², water mirror of 328km², with 30km from north to south and 28km from east to west in length; the 1.6km entrance between Fort São João on the west bank and Fortaleza de Santa Cruz, holds an average water volume of 1.87x10⁹ meters³, depth ranging from 10 to 40 meters (RIO DE JANEIRO, 2016).

Currently, the “bay is considered one of the most polluted environments on the Brazilian coast” (RIBEIRO; SABOIA; SOUZA, 2015, p. 2836). The urban-industrial development process in the state of Rio de Janeiro, mainly chemical, pharmaceutical and refinery industries, emphasizing the grounding of areas around the Guanabara Bay, resulted in wastes thrown on a large scale contaminating the waters with oils, heavy metals, toxic substances and organic loads; also, urban and population expansion, without basic sanitation, contributed greatly to the pollution caused by domestic sewage, altering the flora, fauna, beaches, and making them unsuitable for bathing, and causing the decline of fishing (BRITO; QUINTSLR, 2020; VARGAS *et al.*, 2019).

The study is justified by the environmental concern. Garbage, faecal sewage or wastewater, which cause pollution, damage the environment and marine life, which includes animals and plants, as well as fishermen and residents of the banks, which requires serious treatment and political will (and also from the population), because with due care, everyone in the ecosystem benefits (PESSOA *et al.*, 2021; MACIEL FILHO, 1988).

Chart 1 - Sample Selection of Production Captured in Databases

GOOGLE SCHOLAR				
Title	Year	Journal	Author	Type of document
Social participation in the management of the Guanabara Bay	2021	Brazilian Journal of Development	DIAS; MADEIRA FILHO	Article
Trace elements in surface water and technosols as geoindicators of anthropogenic environmental changes in a river system of the Baixada Fluminense	2021	Revista do Departamento de Geografia	RODRIGUES; VIEIRA; MENDES	Article

Social and environmental relations in the mangrove areas in Magé city in Rio de Janeiro State	2020	Rev. Augustus	BARRETO <i>et al.</i>	Article
Social-environmental analysis of sewage pollution of Guanabara Bay of Rio de Janeiro	2020	Revista Valore	SEIXAS FILHO <i>et al.</i>	Article
Diagnosis of hydrography ecological station of Guanabara and region	2019	Ekomaq	ROBERTO	Hydrography diagnosis
The influence of land use and occupation on the water quality in Pedrinhas, Guarulhos (SP) watersheds	2019	Ciência e Natura	VARGAS <i>et al.</i>	Article
Impact of relative poverty communities in mangroves: invisible craft fisheries workers	2018	Rev. Augustus	SEIXAS FILHO <i>et al.</i>	Article
Diagnosis of the State of Guanabara Bay. Guanabara Bay Governance and Management Strengthening Program	2016	Secretaria de Estado do Ambiente	BRAZIL	Hydrography diagnosis
Evaluation of water balance and efficiency of a constructed waterland as an alternative treatment for domestic wastewater	2016	Ciência e Natura	SECCHI <i>et al.</i>	Article
Environmental Conditions of Guanabara Bay, Rio de Janeiro	2015	Frontiers in Microbiology	FISTAROL <i>et al.</i>	Artigo
Water Monitoring and Assessing Water Quality	2015	watersheds	EPA WEBSITE	Boletim
Consolidated Water Quality Bulletin of Hydrographic Region	2015	Instituto Estadual do Ambiente DIGAT/GEAG	BRAZIL	Boletim

V – Guanabara Bay – Guanabara Bay Basin 2015				
LILACs / BDEF				
Title	Year	Journal	Author	Type of document
Spatio-temporal sublittoral macrobenthic distribution and dominant species in Guanabara Bay, Rio de Janeiro, Brazil	2021	Braz. J. Biol.	PESSOA <i>et al.</i>	Article
Elaboration and analysis of social indicators as an instrument to support decision making in the process of depollution of the Guanabara Bay	2019	Saúde soc.	GUIMARÃES <i>et al.</i>	Article
Analysis of the environmental quality of the Roncador river, Magé – RJ	2012	UERJ	SACHETTO	Master's thesis
SciELO				
Title	Year	Journal	Author	Type of document
Guanabara Bay Water Quality Study for a Projection for Sports and Recreation Practices until 2016	2017	Escola de Contas e Gestão	SILVA; POLLERY	Final Report
From mud to chaos: an estuary called Guanabara Bay	2015	Cafajeste Metrop	COSTA	Article

2 MATERIAL AND METHODS

It is a literature review article, with a qualitative approach, which aimed to find answers to the problems formulated through publications. Thus, in order to obtain a theme parameter regarding the research of the waters of Guanabara Bay,

the electronic collections of the Virtual Health Library, SciELO and Google Scholar databases were used (CERVO; BERVIAN; SILVA, 2007).

In the process of searching for literary productions, the following inclusion criteria were considered: the monographic format of the texts, with articles, bulletins, government guidelines used to obtain the necessary support for the discussion and reflection of the theme. The research was limited to scientific archives in Portuguese and English related to the study's theme, in order to better delimit and address the discussion of the evidenced data.

Regarding the time frame, a fluctuating search was carried out from 2012 to 2021, in order to obtain the relevance of productions over the years. The search descriptors were: Guanabara Bay; Environmental health; Sewer; Industrial effluents; Sea pollution; Dissolved oxygen.

3 RESULTS

Fourteen scientific productions were surveyed. The data related to the title, year of publication, journal, database, author and type of document were analyzed, as shown in the table below:

The table above provides evidence of the productions from the databases used in the research, as follows: 12 productions on Google Scholar, from years 2021 (2), 2020 (2), 2019 (2), 2018 (1), 2016 (2) and 2015 (3); three productions based on LILACs / BDENF, being 1 in 2021, 1 in 2019 and 1 in 2012; and from the SCIELO database, two studies: 1 of 2017 and 1 of 2015 were used.

These studies showed that the theme is discussed in the academic environment, since it daily attests the impact of pollution on water quality, which harms marine life due to sanitary sewage and untreated effluents released in Guanabara Bay. It unveils future problems of non-treatment, such as the privation of benefits of clean and proper water for the environment, work and leisure activities for the population (DIAS; MADEIRA FILHO, 2021; RIO DE JANEIRO, 2016).

In view of these results, Chart 1 brought the evidence of 11 articles, 1 master's dissertation, 1 final report, 2 bulletins and 2 hydrography diagnosis related to the objective of the study, to strengthen the discussion.

4 DISCUSSION

Guanabara Bay, seen as one of the great symbols of Rio de Janeiro, also stands out for the unfavorable conditions of its water, resulting from multifactorial conditions, such as pollution by garbage, sewage and contaminated organic matter. It is also observed that the meeting of fresh water with oceanic creates so-called zones with little or no oxygen, affecting marine life that includes plants and animals (PESSOA *et al.*, 2021; SEIXAS FILHO *et al.*, 2020; CHESAPEAKE BAY PROGRAM, 2015).

Guanabara Bay is among the most degraded coastal ecosystems. The last representative stretches of mangroves on the eastern shore of Guanabara Bay, also known as "Guanabara Bay Reconcavo", has suffered constant deforestation for decades, currently covering 31% (81.5 km²) of the originally occupied area (261.9 Km²), and presenting very critical conditions regarding its ecological and geomorphological balance (BARRETO *et al.*, 2020, p. 94 - free translation).

The measure of the transparency of the water body is turbidity, due to the amount of solids and suspended particles of clay, sand, soluble inorganic and organic particles, planktons and others in the water, which happens with the erosion of the soil and the marginal strips of rivers and lakes, sediments that change the physical structure of aquatic organisms (RODRIGUES; VIEIRA; MENDES, 2021; SILVA; POLLERY, 2017; COSTA, 2015).

Thus, sewage release, runoff of surface water, plantations and forestry practices and intense proliferation of algae cause high turbidity, which affects the amount of oxygen, by limiting light, which restricts photosynthesis. The presence of a large amount of solid particles causes greater heat absorption, increasing the water temperature and decreasing the oxygen level. Sometimes, when the

suspended material settles to the bottom of a water body, unfavorable conditions for reproduction occur (GUIMARÃES *et al.*, 2019; SACHETTO, 2012; EPA, 2015; COSTA, 2015; MACIEL FILHO, 1988).

The impact of sewage, which is an anthropic source, is made by human and animal feces that release high concentrations of phosphorus and part of detergents such as sodium tripolyphosphate which is converted into orthophosphate by water, whose sewage treatment plants should remove this substance using water release control methods (FISTAROL *et al.*, 2015; BRASIL, 2011; SILVA; POLLERY, 2017; SECCHI *et al.*, 2016; SECCHI *et al.*, 2016).

Dissolved oxygen is one of the most representative environmental indicators in the assessment of water bodies. The concentration of dissolved oxygen is a primary indicator of water quality. Dissolved oxygen is the amount of oxygen present in the water. Water bodies produce and consume oxygen. Oxygen sources are the atmosphere and photosynthesis performed by aquatic plants and algae. In contrast, processes such as decomposition, animal respiration and chemical reactions consume oxygen. When the consumption rate is higher than the production rate, the dissolved oxygen levels decrease, affecting sensitive species and the balance of the ecosystem (EPA, 2015; SECCHI *et al.*, 2016).

Thus, the greater the amount of sewage in the water, the dissolved oxygen levels are affected, and this is due to the organic matter that consumes oxygen by the aerobic microorganisms; however, when oxygen is not satisfactory in aerobic decomposition, there may be an anaerobic microbiota, whose final metabolic product is highly unpleasant with toxic substances, such as the so-called swamp gas, which causes the greenhouse effect and can be evidenced by a comprehensive damage to the environment (RODRIGUES; VIEIRA; MENDES, 2021; FISTAROL *et al.*, 2015; BRASIL, 2011; KEHRIG *et al.*, 2011).

Metabolism is linked to pH, which can vary from 0 to 14: 7 is neutral, above 7 to 14 alkaline, and below 7, acidic. For this reason, monitoring must be controlled to have a balance between carbon dioxide, ions carbonate and bicarbonate, humic

and fulvic acids, maintaining the chemical and biological processes of water. However, when the pH is changed by chemical compounds dissolved by industrial effluents and depositions of substances that make up acids, there is a breakdown of the natural acid-base balance of the water body (SACHETTO, 2012; BRASIL, 2011; SILVA; POLLERY, 2017).

It is noteworthy that the change in pH, whether by alkalosis or water acidosis, is caused by the photosynthesis and respiration of algae in the waters, which indicate the presence of certain effluents hazardous to marine life, so much so that such conditions show high concentrations of phosphorus and excess nitrogen, which can be found in the form of inorganic or ammoniacal nitrogen in recent pollutions or nitrites and nitrates in remote pollutions (PESSOA *et al.*, 2021; FISTAROL *et al.*, 2015; COSTA, 2015; SECCHI *et al.*, 2016).

Nitrogen causes the growth and proliferation of marine plants, which when they die accumulate on the bottom of the Bay, which requires an oxygen demand for decomposition; therefore, there is a decrease in dissolved oxygen, impacting not only on marine animals, but also for human consumption, pointing out serious risks to public health (SACHETTO, 2012; GUIMARÃES *et al.*, 2019). Thereby:

The results of the oxygen biochemical demand parameter indicate pollution conditions related to the great presence of organic matter, whether of domestic or industrial origin. The biochemical demand for oxygen can reach conditions that are completely high reaching the point at which all dissolved oxygen is consumed, causing the death of underwater species that require oxygen for aerobic respiration. Therefore, the biochemical oxygen demand is a fundamental parameter for the characterization of the polluting content of water bodies (SACHETTO, 2012; SILVA; POLLERY, 2017).

Thus, an interesting fact would be related to the temperature that, when hot, retains less oxygen, as happens in the launch by the energy industries and factories, which use water to cool the equipment, and consequently release the hottest water in the environment (FISTAROL *et al.*, 2015; EPA, 2015).

This alters the physical and chemical part of the biological water processes, far beyond the evaporation and volatilization of the substances present in the metabolic rate, which are influenced by the increase in temperature by the greater aquatic chemical reactions, which consumes more oxygen and the decomposition of organic matter, which causes a release of various gases such as oxygen, nitrogen, carbon dioxide, methane, among others (DIAS; MADEIRA FILHO, 2021; GUIMARÃES *et al.*, 2019; SILVA; POLLERY, 2017).

In addition to these issues, in the characterization and evaluation of water quality there is the identification of pathogens such as viruses, bacteria, protozoa and helminths, which cause diseases due to the release of sewage and / or feces in Guanabara Bay. The most used tests for the coliform group samples are *Escherichia coli* (that inhabits the human and animal intestinal tract) and *Aerobacter aerogenes* (common in soils, leaves and grains). The high levels of coliforms are associated with the inefficiency of the water supply, collection and treatment systems for water and sewage (DIAS; MADEIRA FILHO, 2021; SACHETTO, 2012; BRASIL, 2011; DAVIS; CORNWELL, 2008; MACIEL FILHO, 1988).

In the surroundings of Guanabara Bay, approximately 70% of the industries of the State of Rio de Janeiro agglomerate. Industrial waste, added to the domestic sewage load, as well as deforestation, transformed the region into one of the most polluted areas on the Brazilian coast. It is these factors that actively contribute to the permanence of this environment of environmental degradation (SEIXAS FILHO *et al.*, 2020, p. 2 – free translation).

Through the studies presented here, we realized that in order to reverse the degradation of the waters of Guanabara Bay, there must be governmental political will to comply with environmental laws, which defend this natural heritage, as well as inspection and programs. It also requires monitoring, which must be carried out to assess the environmental conditions of the waters and beaches of the Bay. The results also showed the existence of high levels of fecal coliforms, waste and debris loads (FISTAROL *et al.*, 2015; BRASIL, 2011; GUIMARÃES *et al.*, 2019; BARRETO *et al.*, 2020).

The analytical results of the National Science Foundation's Water Quality Indexes show monitoring information, mainly by the 21 monitoring stations in the Bay and its rivers, by the Instituto Estadual do Ambiente [Environment State Institute], in which the data collected evaluate water quality parameters related with pollution and contamination, as for: dissolved oxygen, biochemical oxygen demand, thermotolerant coliforms, total phosphorus, nitrates, nitrites, ammoniacal nitrogen, pH, turbidity, total dissolved solids, enterococci, orthophosphates, phytoplankton (qualitative and quantitative). These data are analyzed with a bimonthly frequency, and cyanides, phenols, metals are measured every six months, disclosed in the Conformity Index (DIAS; MADEIRA FILHO, 2021; GUIMARÃES *et al.*, 2019; SILVA; POLLERY, 2017; SECCHI *et al.*, 2016; FISTAROL *et al.*, 2015; INEA-DIGAT / GEAG, 2015).

INEA also publishes some other thematic maps and graphs with time series for specific parameters measured at the monitoring stations in Guanabara Bay. Some other parameters that could be found were thematic maps and developed time series (RIO DE JANEIRO, 2015, p. 27 – free translation).

Environmental monitoring can assess and analyze water trends, such as changes in the decades, to offer the necessary support for planning and results that generate actions, such as environmental and sanitation works, when thinking about water quality specifically in the adjacent water bodies in the intervention areas (DIAS; MADEIRA FILHO, 2021; COELHO, 2007).

The Environmental Sanitation Program of the Municipalities Surrounding the Guanabara Bay [Programa de Saneamento Ambiental dos Municípios do Entorno da Baía de Guanabara – UEPSAM] monitors 20 stations in the Guanabara Bay Hydrographic Basin, considering the improvements in the sanitary sewage system of Alegria, Pavuna and Alcântara in the short, medium and long term. Such places show signs of degradation, eutrophication problems and sewage discharges, caused by industries, oil spills, toxic substances and coming from considerably polluted rivers (RIO DE JANEIRO, 2016; COELHO, 2007).

5 CONCLUSION

The study showed the degradation of Guanabara Bay, in which the biochemical components such as pH, turbidity, dissolved oxygen, among others, are altered by the presence of sewage, heavy metals and materials from ships, residents around and by organic and solid garbage.

Despite government monitoring, the degradation has a serious impact on the conditions of plants and mangroves, marine animals, water bodies and even the soil, as it interferes with the circulation of the marine current.

Thus, during the study, it was observed that it is necessary to implement state public policies consolidated with laws and programs for the inclusion of slum dwellers in the surrounding areas of Guanabara Bay, together with the restructuring of basic sanitation and sewage treatment.

In order to strengthen the recovery of Guanabara Bay, the Ministry of the Environment must plan and implement punitive inspection projects for those who contribute to the degradation of this cultural and tourist symbol, fully valuing its importance for nature and the ecosystem, so that all beaches are again suitable for use.

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