

# Cocaine is an emerging contaminant of concern in the Bay of Santos (Brazil), says researcher

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A pile of cocaine hydrochloride. Credit: DEA Drug Enforcement Agency, public domain

In addition to already known pollutants, the Bay of Santos—a city in the

state of São Paulo (Brazil) that is home to the largest seaport in Latin America—has been affected by an emerging contaminant that is now present not only in the water but also in sediments and marine organisms throughout the São Paulo coastal region: cocaine.

The drug causes serious toxicological effects in animals such as brown mussels (*Perna perna*), mangrove oysters (*Crassostrea gasar*) and fish (eels), according to the results of [laboratory analyses](#) carried out by researchers at the Federal University of São Paulo (UNIFESP). For this reason, it is now considered an emerging contaminant of concern.

"Cocaine today is, in fact, a contaminant of the Bay of Santos. We found drug contamination spread throughout the region," said Camilo Dias Seabra, a professor at UNIFESP, in a panel discussion on water during FAPESP Week Illinois, which took place April 9 and 10 in Chicago, in the United States.

The researcher, in collaboration with colleagues from UNIFESP and Santa Cecília University (UNISANTA), identified in 2017, for the first time, the accumulation of cocaine and other substances derived from medicines in surface water in the Bay of Santos and biological effects in environmentally relevant concentrations.

The researchers found ibuprofen, paracetamol, and diclofenac, among other medicines, in water samples collected in the region, as well as cocaine in a concentration equivalent to that of caffeine—a traditional indicator of contamination, since it is consumed not only in beverages such as coffee, tea, and soft drinks but also present in various medicines.

"It's a huge concentration of cocaine if we imagine the consumption of caffeine," Seabra compared. "These findings were very surprising," he added.

One of the hypotheses put forward by the researchers at the time to explain the high concentration of cocaine in the surface water samples from the Bay of Santos was the period in which they conducted the study: during Carnival, when the region receives a large number of tourists.

"We thought it might be a carnival phenomenon. But we did seasonal monitoring and found that, throughout the year, cocaine and its metabolites were present not only in the water but also in mussels, for example," Seabra stated.

Laboratory analyses showed that the bioaccumulation factor of cocaine in brown mussels was more than a thousand times higher than the concentration in water. "This is a high bioaccumulation factor. Therefore, the seafood in the Bay of Santos may be contaminated by cocaine, but not only by cocaine," Seabra noted.

The researchers also conducted studies to assess the effects of cocaine exposure on brown mussels. The results of the analysis showed that after one week of exposure, the animals had elevated levels of two neurotransmitters: dopamine and serotonin. This change was interpreted as a neuroendocrine response that could affect the reproductive system of these animals.

In order to evaluate this hypothesis, studies were conducted in other animals, such as eels. The analyses showed that chronic exposure to cocaine affects oogenesis (egg formation) and steroidogenesis (production of steroid hormones) in these fish.

"Eel eggs exposed to cocaine had a lower maturation rate. In this way, cocaine can be understood as an endocrine disruptor in these animals," Seabra said.

As part of a doctoral project, the researchers also analyzed the ecological risk of cocaine exposure in mangrove oysters using benzoylecgonine—a metabolite of the drug—as a biomarker.

The results indicated that the drug causes severe cytotoxic and genotoxic effects in these organisms. "We consider cocaine to be an emerging contaminant of concern," Seabra said.

When contacted about the report, the press office of the São Paulo State Environmental Corporation (CETESB) responded in a statement that "CETESB systematically monitors the quality of the state's coastal waters, including the area of influence of the Santos submarine outfall, and conducts ecotoxicological tests on samples from this area to assess the possible effects of the presence of contaminants on aquatic fauna. The monitoring results are available in the reports on the CETESB website."

"The study in question provided information for a better understanding of the region and, based on its results, it can be concluded that the concentrations found in the seawater of the Bay of Santos at that time would not have an effect on the mussel studied and would not pose a risk to bathers," the statement concludes.

## **Trafficking route**

According to Seabra, based on geochemical studies of estuarine sediment samples, it is estimated that cocaine has been accumulating in the Santos estuary since the 1930s, but concentrations of the drug in the region have skyrocketed in recent decades.

One explanation for this increase is that the region is one of the main drug trafficking routes from South America to Europe. In addition, the region, like other parts of the country and the world, is facing the

problem of an increase in the number of users of illicit drugs such as cocaine and crack.

Another problem is the lack of sewage treatment in the region, Seabra pointed out. "Untreated sewage may be related to the high concentrations of cocaine we find in the Bay of Santos. But we also have a public health problem in the region related to the use of crack and other drugs and public safety. It's a complex scenario for us to understand better the environmental and social risks involved," he said.

In order to better understand the extent of the problem, the researchers plan to start a wastewater-based epidemiological program to detect drug use.

One of the goals of such programs is to help identify health problems in the population related not only to illicit drugs but also to alcohol and smoking. "But there are many challenges to overcome if we're to implement such a program in the region," Seabra said.

In addition to cocaine, another emerging contaminant that the researcher and his collaborators have studied is atmospheric particulate matter—a compound of metallurgical origin that can precipitate in coastal regions and cause toxic effects in aquatic organisms, as well as bioaccumulating in fish.

"The 'black powder' contains metallic micro- and nanoparticles, including rare earths, whose effects are still unknown. These particles impact marine invertebrates and fish, and the first results we obtained ... are worrying," Seabra stated.

## **Geological marker**

In addition to illicit drugs and medicines, another group of researchers

from the Institute of Oceanography of the University of São Paulo (IO-USP) has been analyzing the presence of other chemical compounds, such as polycyclic aromatic hydrocarbons (PAHs) and organochlorine compounds, in sedimentary records from the estuarine systems of Santos and the neighboring municipality of São Vicente. The goal is to determine when human activities began to alter the natural dynamics of the region.

The results of the analyses of the records showed that the first concentration of these compounds in the region, which is one of the most populated and industrialized on the Brazilian coast, occurred between the 1940s and 1950s when the steel refineries were installed.

"Around the 1960s, the concentration of these contaminants began to increase in the region. We can say that the Anthropocene in the Santos and São Vicente estuaries began at that time," said César de Castro Martins, a professor at IO-USP.

A group of researchers from the State University of Campinas (Unicamp) analyzed the presence of the most commonly used pesticides in sugarcane plantations in surface and groundwater in São Paulo.

The results of the analysis indicated that, in surface waters, all 14 compounds studied were detected in at least one sample. Some compounds posed a potential risk to aquatic life.

"These contaminants are spread in low concentrations throughout our river basins, and it's very difficult to find their source. That's why we're studying their mobility in the soil and how they can reach groundwater," said Cassiana Carolina Montagner, a professor at Unicamp and coordinator of the project.

## **Origin of pathogens**

Identifying the source of contamination of disease-causing bacteria after natural disasters such as floods has been the aim of a group of researchers from the University of Illinois in Urbana Champaign. To achieve this goal, they have employed genetic sequencing tools.

In 2018, Hurricane Florence hit the coast of North Carolina, where coastal flooding from tropical storms is fairly common, and there is a high concentration of pig farms and private septic systems.

Three weeks after the hurricane, a team of researchers from the U.S. university took [water samples](#) from 25 water bodies downstream from pig farms in agricultural production areas, and 23 of them contained the bacterium *Salmonella enterica*.

The results of the genetic analyses of chromosomes and plasmids showed that the origin of the bacteria in the collected samples was not from animals or manure but from local rivers and streams.

"Studies like this are very important because they help to clearly identify and monitor the emergence of pathogens during [extreme weather events](#), which are expected to become more frequent with climate change," said Ana Barros, professor at the University of Illinois in Urbana Champaign.

Provided by FAPESP

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