



## **Spatiotemporal Variation of the Phenol Level of the Ebrié Lagoon (Ivory Coast)**

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### **Authors' contributions**

*This work was done in collaboration between all the authors. Authors EL and ET led the study. Author TG carried out the study and wrote the first draft of the manuscript. Authors YZ and KHY helped in the correction of the manuscript. Author OL helped with the translation into English. All authors read and approved the final manuscript.*

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### **ABSTRACT**

Toxic compounds are frequently found in discharges (industrial and domestic effluents) with very variable biodegradability. Among those that are feared for the ecosystem are phenols. Phenol and its derivatives are considered by the Environmental Protection Agency as important pollutants. The objective of this study is the determination of the level phenol of the waters of the Ebrié lagoon. The water samples were collected in five sites of the Ebrié lagoon namely; Koumassi, Vridi, Plateau, Cocody, and Bingerville. The phenol values found for samples taken from the water range from 0.11 to 9.493 mg / L, exceeding the allowable standards. Pre-discharge purification is therefore essential given the toxicity of this type of compounds.

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## 1. INTRODUCTION

Sustainable development, ecological footprint and respect for the receiving environment have become major concepts within a population [1,2]. They reflect a search for a great harmony between economic growth, human development and respect for the environment [1]. Since the mid-nineteenth century, human activities have produced a very wide variety of chemical molecules used in industry, agriculture, metallurgy, transportation, consumer goods, medicine and construction [3]. These wastes are released into the atmosphere and soils. These pollutants are transported by sewerage networks and are found by runoff or filtration in rivers, groundwater to the coastal waters. Phenol (hydroxybenzene) is a colourless, crystalline substance of characteristic odour, soluble in water and organic solvents. Phenol is one of the first compounds inscribed into The List of Priority Pollutants by the uS environmental Protection Agency (us ePA) as one of the most toxic pollutants [4]. This pollutant is released from many different anthropogenic sources such as petroleum refinery, pesticide manufacturing plants, petrochemicals, organic chemical manufacture [5,6]. This pollutant penetrates ecosystems as the result of drainage of the municipal or industrial sewage to surface water [7]. By natural sources, phenol is a constituent of coal tar and is formed during decomposition of organic materials. Increased environmental levels may result from forest fires [8,9]. Various organizations such as the International Agency for Research on Cancer (IARC), and the Environmental Protection Agency for the Register of Toxic Substances and Diseases have indicated that the carcinogenic risk of phenol in humans is not aware. However, it has been clearly demonstrated that these compounds exhibit rapid absorption by ingestion and that their vapours may be corrosive to the eyes [5]. Skin and respiratory tracts as well as affecting the digestive system [10]. In order to improve the chemical status of aquatic environments, we must first make an inventory of the various pollutants affecting the environment, then identify the different sources of pollution namely industrial discharges, diffuse pollution, urban runoff and to propose solutions.

The objective of this study is to make a quantitative analysis of phenolic compounds in some berries of the Ebrié lagoon.

## 2. MATERIALS AND METHODS

### 2.1 Presentation of the Study Area

The Ebrié Lagoon, with an area of 566 km<sup>2</sup>, stretches for 125 km along the coast of Côte d'Ivoire, between 3°40' and 4°50' west longitude and 5°50' North latitude. The volume of this lagoon is about 25,109 m<sup>3</sup>, the average depth is 4.8 m and some pits near Abidjan exceed 20 m. This body of water communicates with the Atlantic Ocean by the Vridi channel, 2.7 km long and 0.3 km wide, with an average depth of 20 m. Work for its enlargement started in October 2015 is underway.

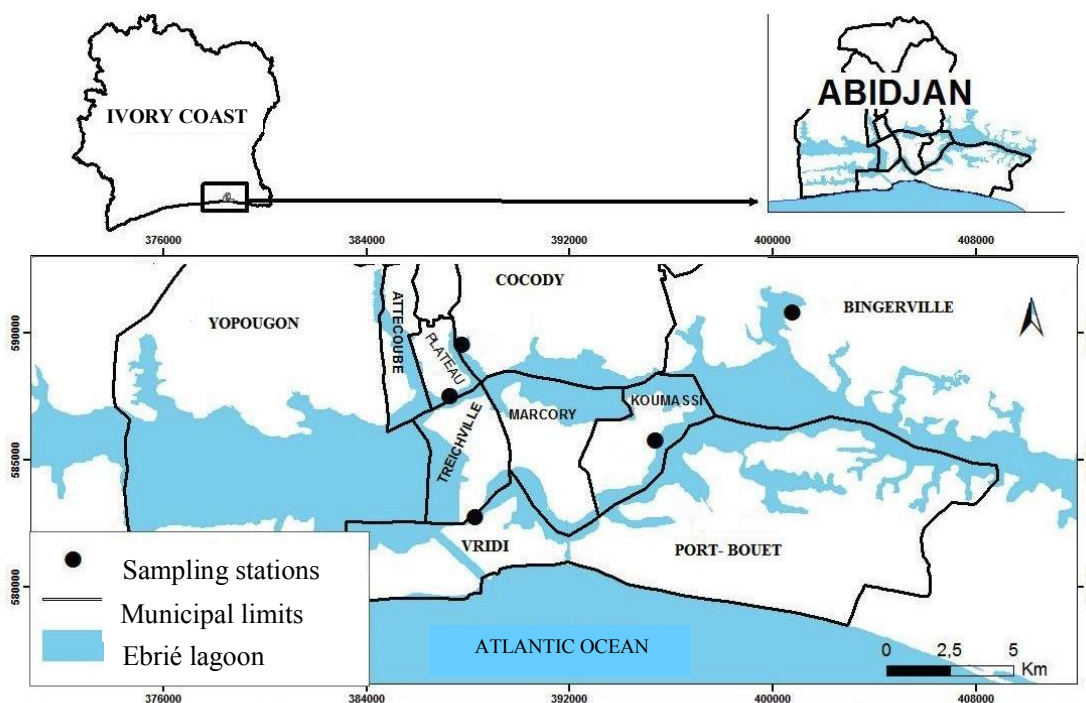
In low season, from January to April, the lagoon Ebrié is fed by the waters of the ocean through the Vridi canal. During this period, the marine influence is maximum. Then follows a rainy season from May to August during which the lagoon is influenced by rainfall and runoff from the forest area bordering the ecosystem. Finally a flood season from September to December during which we observe the dominating influence of freshwater streams whose main is Comoé river. According to [11], freshwater inflows account for more than four times the total volume of the lagoon, while marine inflows are fourteen times greater than the same volume. The city of Abidjan has a population of more than 4 million inhabitants in 2014. Many industries are concentrated there.

### 2.2 Sampling

The samples were collected from five sites in the Ebrié lagoon, including the sites of Koumassi, Vridi, Plateau, Cocody, subjected to abusive domestic and industrial discharges from Abidjan, and Bingerville, remote from direct discharges. (Fig. 1).

**Table 1. Geographical coordinates of the different sampling stations**

Stations	X	Y
Koumassi	5°17'55,43"N	3°56'38,26"W
Vridi	5°16'15,69"N	4°0'29,2"W
Plateau	5°18'51,32"N	4°1'2,43"W
Cocody	5°19'44,03"N	4°1'0,43"W
Bingerville	5°20'39,13"N	3°53'43,22"W



**Fig. 1. Location of the study area and sampling sites**

The sampling campaigns took place monthly, from January to December 2017. The water samples taken at the surface with polyethylene bottles that have been rinsed with the water to be examined. The samples are acidified with  $H_2SO_4$  to pH <2 then stored in a cooler at 4°C and transported to the laboratory.

### 2.3 Determination of Phenol Concentration

The concentration of phenol was determined by the 4-amino-antipyrine method [12]. 50 ml of sample are successively added 2 ml of buffer solution (pH = 9.5), 1 ml of potassium ferricyanide solution and 0.3 ml of 4-amino-antipyrine solution. The mixture is homogenized and allowed to stand for 2 minutes for the appearance of the coloring. The colored solution is analyzed by UV / Visible Molecular Adsorption Spectrophotometry (WFJ-752) at the wavelength of 510 nm. The test blank is made with ultra pure distilled water. The phenol concentration (mg / L) is determined from the pure phenol calibration curve.

## 3. RESULTS AND DISCUSSION

The results of our study show that the phenol concentrations found in the study area sites vary

between 0.11 and 9.49 mg / L. These values exceed the standards prescribed by WHO which are 1 µg / L in drinking water and 5 µg / L in the aquatic environment [13].

The highest concentrations were recorded at Vridi, Plateau and Cocody sites with a peak of 9.4935 mg / L at Vridi in November (Fig. 2).

Vridi is located in the port area and is home to several industrial activities including an oil refinery. These industrial installations discharge their effluents into the lagoon sometimes without any prior treatment. These releases, consisting of paints, machine oils, etc., contribute to enrich the receiving environment with phenolic compounds [14,15], and could explain the high concentration of phenol recorded at the Vridi site.

The values found on the Plateau site vary between 0.11 and 6.99 mg / L. These values are also high and could be due to the discharges resulting from the intense lagoon transport activity provided by water-buses and pinasses. This lagoon transport activity causes accidental releases of hydrocarbons [16].

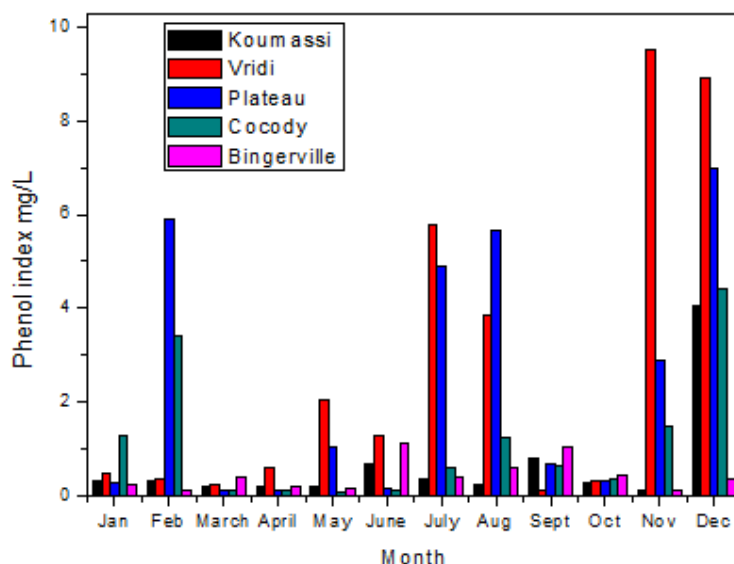


Fig. 2. Evolution of the phenol indices according to the sampling points of the Ebrié lagoon

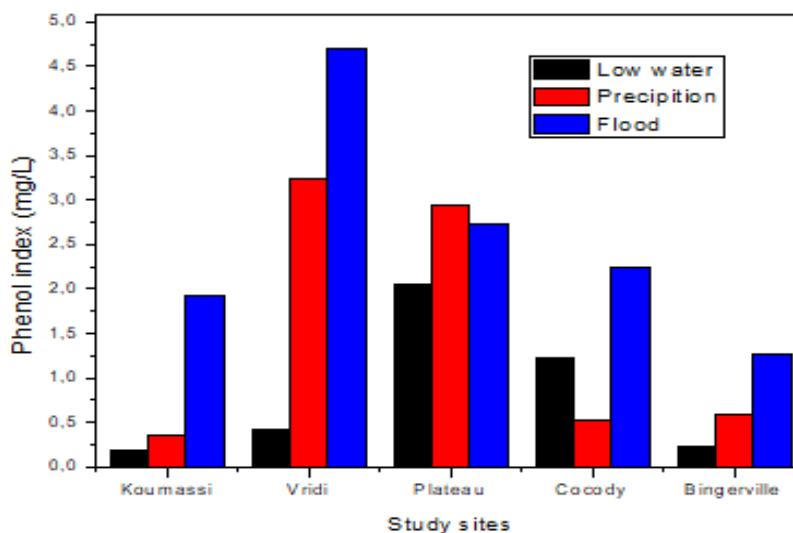


Fig. 3. Seasonal variation of phenols in the waters of the Ebrié lagoon

At the Cocody site, the average concentration is 1.1635 mg / L, with a maximum of 4.4337 mg / L in the month of December. This site is less subject to industrial activities and the relatively low levels observed compared to those of the plateau, could be related to domestic and hospital discharges. These discharges consisting of detergents, disinfectants, various pharmaceutical products reach the lagoon through the evacuation channels.

Compared to previous sites, the Koumassi and Bingerville sites have the lowest concentrations

of phenolic compounds. The levels on these sites vary on average between 0.6466 and 0.438 mg / L. These low levels can not only be explained by a weakness of generating activities but also by processes of biodegradation of phenolic compounds, due to a hostile environment.

In fact, bacteria from waste water and saponins found in plants are able to biodegrade phenolic compounds [17,18]. Bacteria as well as saponins from aquatic plants can help explain the low levels of Koumassi and Bingerville sites.

Fig. 3 presents the results from the seasonal analysis. The highest levels of phenolic compounds are observed during the flood season and the rainy season. This is explained by the fact that in these last two seasons, in addition to stationary sources, runoff water is added. Rainwater containing atmospheric pollutants builds up in impurities through the leaching of soils and pavements as they run down to the lagoon. These leached impurities may be used oils, hydrocarbons, chlorophenoxyacid herbicides, tire residues, urine and faeces of animals (herbivores) [19].

#### 4. CONCLUSION

In this study we evaluated the pollution of the Ebrié lagoon in phenolic compounds. It is clear from our experience that large quantities of phenolic compounds are introduced, endangering its ecological balance.

The recorded levels vary between 0.11 and 9.4935 mg / L. In most of our observations, the recorded levels exceed the maximum allowable concentrations, especially at the Vridi site where the concentration of 9.4935 mg / L is observed.

A more elaborate study using more sites and other analytical methods (HPLC, GC, etc.) could be used to evaluate a more representative level of pollution.

Taking into account the phenol pollution should contribute to strengthening the protection policy of the Ebrié lagoon. However it would be interesting to turn to less expensive methods of depollution such as adsorptions processes on local biomass.

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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