

# Green analytical chemistry in the determination of organic pollutants in the aquatic environment

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**We present the latest advances in green analytical chemistry for application to organic-pollution analysis in aquatic environments. We review the main strategies to reduce toxic reagents, solvent wastes and energy consumption. We pay special attention to new approaches to environmental analysis, allowing automation, miniaturization, and on-site, on-line and direct analysis (e.g., biosensors).**

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**Keywords:** Aquatic environment; Automation; Direct analysis; Environmentally-friendly method; Green analytical chemistry; Miniaturization; Biosensor; Organic pollution; Toxic reagent; Solvent waste

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## 1. Introduction

Due to scientific and public concern about environment pollution, environmental-friendly practices have been introduced in different areas of society, especially research. The main objectives of green analytical chemistry (GAC) are to obtain new analytical technologies or to modify an old method to incorporate procedures that use less hazardous chemicals or use smaller amounts of hazardous chemicals. Malissa first presented the basis of GAC in Paris, and, 15 years ago, de la Guardia et al. [1] first introduced the topic of environmental analytical chemistry as a model of analytical practices in an integrated approach to analytical chemistry that also considered environmental side effects of analytical practices.

Since then, this concept has been gaining interest [2], but it was in recent years that a great effort of development was made to obtain analytical technologies able to do direct analysis, using miniaturized equipments, reduced amounts of solvents, and on site, and reducing energy costs and wastes. These improvements were linked to advances in other research areas (e.g., microelectronics, material sciences, biochemistry, and, recently, nanotechnology).

This review provides the state of the art of GAC for environmental analysis of organic pollution in aquatic environments with special emphasis on strategies for reducing, or even eliminating, sample pre-treatment with novel approaches based on biosensors.

## 2. Sample preparation

Sample pre-treatment can be considered the most polluting step of the whole analytical process because it deals with the crude sample, in which the analytes may exist in 1000-fold smaller quantities than bulk constituents, so, often, the use of organic solvents is required to enrich the target compounds selectively and remove potentially interfering matter. An ideal GAC protocol avoids sample pre-treatment. However, in the majority of the cases, this is not feasible, so a plethora of strategies have been developed to obtain greener approaches.

### 2.1. Techniques for reducing solvent use

Sample-preparation techniques for environmental analysis can be classified according to the types of matrix to be analyzed, so these strategies can be grouped into those for solid samples and

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