

## Introduction

- Although **pharmaceuticals** are essential for the survival of humankind and the improvement of the quality of life, they actually represent an **environmental threat** and are considered among the most critical **emerging contaminants of the aquatic environment**.
- Since wastewater treatment plants (WWTPs) are not able to keep up with the production of pharmaceuticals, complete removal of metabolites and parent compounds from **domestic and hospital wastewater** is still not achievable, making it the **primary source of pharmaceuticals in the environment**.
- **Lebanon** is a Middle Eastern country bounded by the Mediterranean Sea with a coastline length of about 225 km.
- Despite its small area (10,452 km<sup>2</sup>), Lebanon is privileged with **plentiful water resources**.
- However, the current Lebanese water crisis indicates differently. This is mainly due to the excessive **mismanagement of water resources**.
- The **deteriorated quality** of the Lebanese water resources has previously resulted in numerous waterborne disease outbreaks such as cholera, typhoid fever, shigella infection and hepatitis A & E.

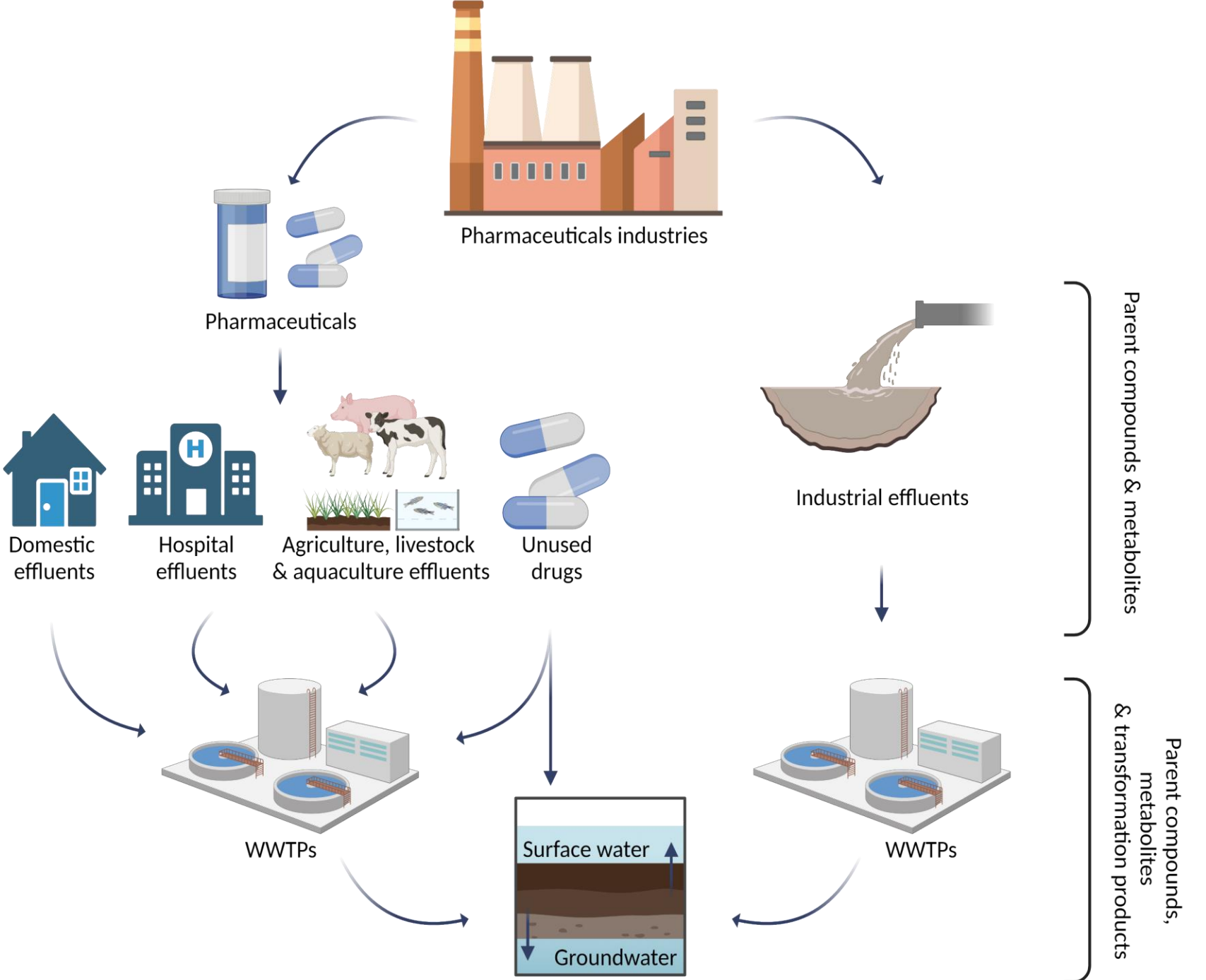


Figure 1 Major sources of pharmaceuticals in the aquatic environment.

Ref: <https://doi.org/10.1016/j.cogsc.2018.11.001> -- <https://doi.org/10.2166/wh.2007.047>

## Objectives

- Almost 90% of the generated wastewater, in Lebanon, is discharged without any treatment into the aquatic environment, including rivers and coastal outfalls. The scarcity of studies in the literature investigating the occurrence of pharmaceuticals in the Lebanese aquatic environment, and the progressive increase of cancer incidence rates in Lebanon, were a motive to conduct this dedicated research to **understand the fate of anticancer drugs in the aquatic environment and their potential adverse effects to the aquatic fauna**.

## Methods

- Conduct a **survey** of Lebanese hospitals personnel to assess their knowledge and identify gaps in terms of **anticancer drugs disposal methods and waste and wastewater management** in the oncology, pharmacy, and maintenance departments.

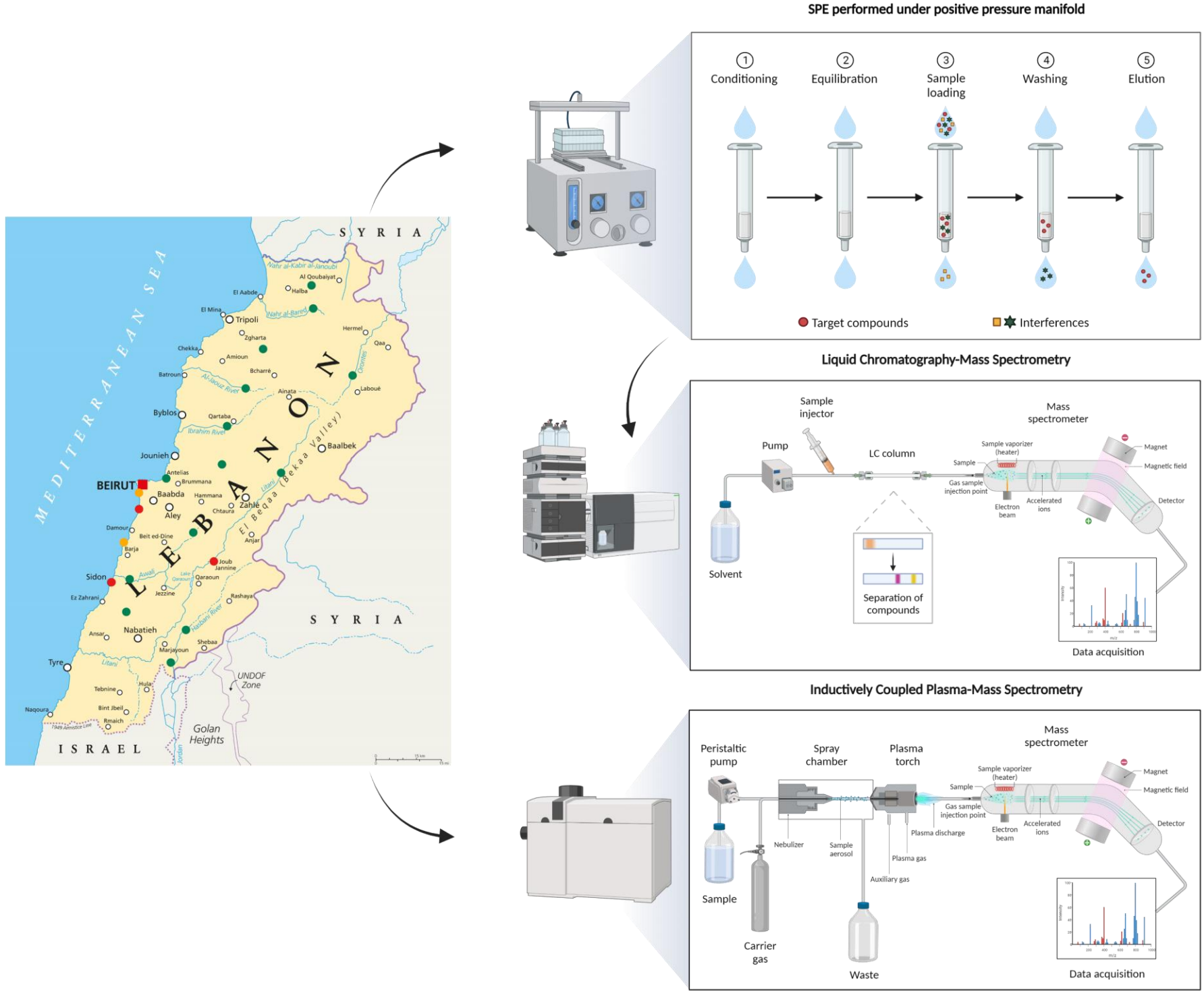


Figure 2 Water samples collection points, sample preparation method and analytical techniques used for the detection of anticancer drugs and platinum.

- Develop and validate SPE techniques, LC-MS/MS methods, and an ICP-MS method for the **analysis of the selected anticancer drugs in Lebanese water samples** collected from 14 rivers across the country, three wastewater treatment plants and two sewage outfalls.
- Evaluate the suitability of **Daphnia pulex** as a test species for the **toxicity assessment of Lebanese-treated wastewater**.

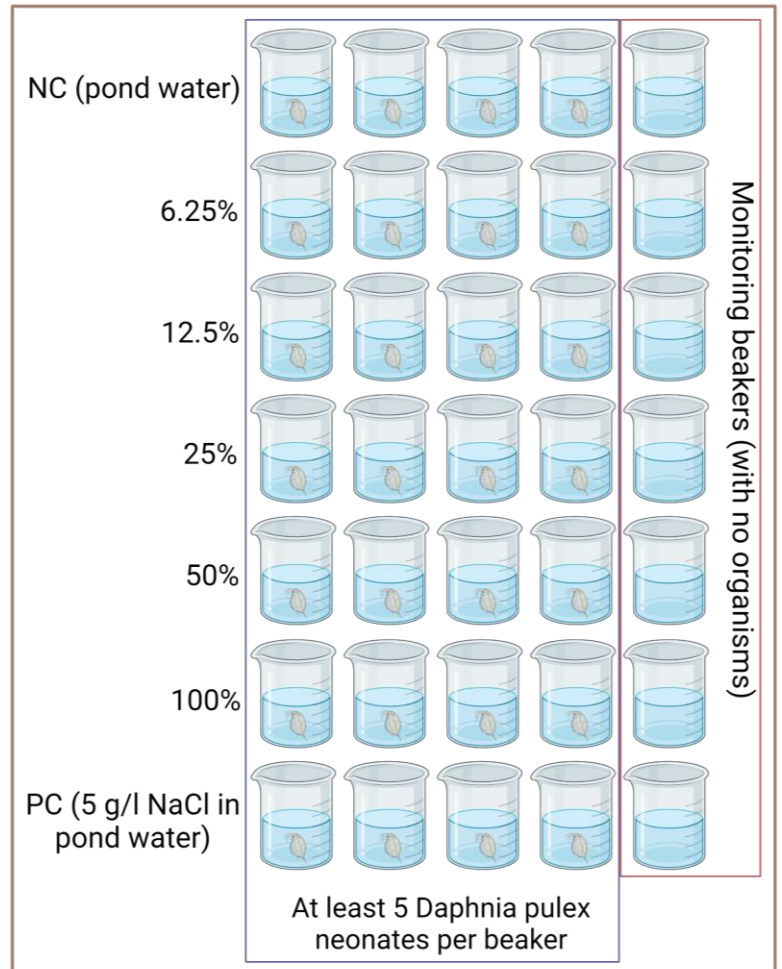


Figure 3 Daphnia pulex acute toxicity test set up.

## Results

- According to results obtained from the 53 participating hospitals, there appeared to be a **lack of awareness and knowledge** regarding anticancer drug disposal and wastewater treatment. This was highlighted by the **improper segregation** of anticancer drugs in addition to the **lack of clear and extensive regulations for waste management**.
- The information provided for wastewater management was **inconsistent and insufficient** to determine the actual conditions and derive conclusions.
- Three anticancer drugs were detected, **5-fluorouracil, methotrexate, and cyclophosphamide**, with a concentration range of 1 to 305 ng/l.
- **Total dissolved platinum** was detected in the samples with a concentration range of 22 to 53 ng/l.
- At the levels detected, these drugs will not cause adverse effects on the aquatic biota; however, the acute toxicity assay suggested that the sewage samples, as a whole, induced **acute toxicity to Daphnia pulex**.

## National and International Recommendations

- In **developing countries**, such as Lebanon, waste management is often disregarded. If no stringent actions are taken, this can lead to the deterioration of the water resources, affect the aquatic ecosystem and human health, and extend to neighbouring countries. For this reason:
  - ✓ **A national healthcare waste plan should be established and enforced** by the authorities with **regular supervision and auditing**.
  - ✓ **Healthcare workers should be trained regularly** to maintain sustainable practices, promote source reduction, and increase the level of awareness.
  - ✓ It is essential to create **public awareness** of the potential risks and promote engagement.
- As these issues are also still emerging on an **international level and in developed countries**, implementing a global action plan is necessary for the reduction of water pollution by **awareness raising, establishing an effective waste management plan, considering hospital wastewater as hazardous waste, developing cost-effective treatments to be implemented in hospitals and municipal WWTPs**.