Chapter 6
Water Chemistry and O–H–N Stable Isotopes Pattern for Tracing Contaminant Sources

Roxana Elena Ionete
National Research and Development Institute for Cryogenics and Isotopic Technologies, Romania

Diana Costinel
National Research and Development Institute for Cryogenics and Isotopic Technologies, Romania

Oana Romina Botoran
National Research and Development Institute for Cryogenics and Isotopic Technologies, Romania

ABSTRACT

Tracing contaminant in surface and groundwater remains an issue of significance. Nitrate is one of the parameters to be monitored identifying the source and biogeochemical transformations of the nitrogen of interest for the management of water resource. Increasing the inorganic nitrogen concentrations in surface waters can be due to upstream discharge or ammonium sewage effluents, leaching from agricultural land, discharge of farm or industrial effluents, and/or seasonal effects. An effective tool to identify the origin of pollutants are the stable isotopes. Environmental isotopes (O-H-N-O) are great tracers for the physical processes affecting water and considered key parameters to assess the origin, path, and history of a water source. Stable water isotopes (δ18O and δ2H) are affected by meteorological processes that provide a specific fingerprint of their origin. The stable isotopes in nitrate (δ15N and δ18O) are fundamental to identifying the sources of nitrate contamination. Theoretical principles of stable isotopes and isotopic effects are discussed.

DOI: 10.4018/978-1-7998-7356-3.ch006

INTRODUCTION

Water is ubiquitous on the Earth's surface, where it undergoes phase transformations, interacts with minerals and the atmosphere, and participates in complex metabolic processes that are essential to life. Availability of water, especially drinking water, is today one of the biggest challenges facing humanity due to population growth and consequently the need for water for consumption, agriculture and industrial processes. As a result, water sources require continuous management in terms of water quality and quantity, which leads to the development of hydrological research.

The enhancement in human activities has led to the loading of the hydrological network with various pollutants (e.g., nitrogen and phosphorus compounds, heavy metals, agrochemicals, etc.), which has caused a rapid deterioration of water quality. Consequently, with increasing anthropogenic factors leading to high demand for water resources, but also pollution, the detection of contaminants in surface and groundwater remains a significant challenge. Nitrate is one of the water quality parameters to be monitored and therefore identifying the source and biogeochemical transformations of the nitrogen is often of significant interest for the management of water resource (Segal-Rozenhaimer et al., 2004; Aggarwal et al., 2005; Hoefs, 2009). High concentrations of nitrates in water bodies can lead to ecological disturbances with a negative impact on organisms at all trophic levels. If reaches drinking water sources, at levels greater than 10 mg/L the nitrate also pose danger to human health.

As a result, water sources require constant monitoring of their quality and the identification of sources of contamination in order to put in place measures to reduce pollution. Contamination of water can derive from various sources which may carry a distinct "fingerprint" that allows to identify the pollution source or the process which gave rise to the contamination (Figure 1). Increasing the inorganic nitrogen concentrations in surface waters can be due to upstream discharge of high nitrate or ammonium sewage effluents, leaching from agricultural land during high precipitation, discharge of farm or industrial effluents and/or seasonal effects (Ging et al., 1996; Popescu et al., 2015). Contaminants, in particular nitrate which is highly mobile and primarily originates from nonpoint source pollution, can be discharged directly into the stream water, but if they are recharged into groundwater and then indirectly passed into streams, groundwater can also significantly contribute to stream water quality (Jung et al., 2020).

The chemical composition of most natural and injected fluids may not be sufficiently different to identify the source(s) of the materials present in surface water and groundwater. Therefore, complementary tools have to be found to trace the source of contamination.

Environmental isotopes have been shown to be useful in identifying sources of pollution, as the isotopic composition of the contaminant together with the spatial and temporal variations of its concentration give information about the source and the processes it undergoes (Brčeski and Vaseashta, 2021). By their nature, environmental isotopes are great tracers for the physical processes affecting water, and considered key parameters to assess the origin, path and history of a water source. For instance, stable isotopes of hydrogen and oxygen in water molecule are applied to characterize the origin of water, but also evaporation and mixing processes within a watershed, while stable isotopes nitrogen and oxygen in nitrate are used to identify nitrate sources (e.g., from agriculture, industrial pollution or wastewater treatment plants) as well as denitrification, nitrification, and assimilation processes.