SPATIAL AND TEMPORAL DISTRIBUTION OF NITRATES AND NITRITES IN THE FARMS' WATER OF TIMIS COUNTY, ROMANIA: A CASE-STUDY

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Abstract: The present study aimed to investigate the spatial and temporal distribution of nitrates and nitrites in the farms' water of Timis County. The sample for the study consisted of 4028 analysis bulletins of the nitrate and nitrite concentrations, measured in 41 farms and local water sources over two years (2016- 2242 and 2017- 1904 water samples) by the Surveillance Service, Public Health Direction, Timis. The data has been analysed with an observational case study of the spatial and temporal distribution of nitrate and nitrite concentrations in the farm water in Timis County. It has been found that the mean concentrations of nitrite and nitrate were lower than the standards, with a statistically significant difference ($t=8.11$, $Sig.< 0.001$) between the 2 years of study and with higher values recorded in 2016 than in 2017. A specific spatial distribution of the mean concentrations of these two substances was slightly high in old, polluted localities and pig farms in Timis County.

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Keywords: farms' water, nitrates, spatial and temporal distribution, case-study.

Introduction

Soil treatment for weed control and pigs' fecal contaminated water in livestock farms are the major sources of nitrate as a water pollutant in rural areas. Nitrate is stable compound and under special conditions (reduction processes), can transform into nitrite, which is more unstable. The level of these two pollutants: nitrate and nitrite, are also considered as significant indicators of water pollution Accurate assessment of nitrate concentration in drinking water is an integral part of epidemiological studies investigating the long-term adverse effects of water pollution on human health. A Danish study performed in public waterworks demonstrated that the nitrate concentrations at the endpoints of the waterworks are significantly related to the nitrate concentrations in the distribution system or at the consumers' taps. The study reported a low concentration of nitrite and ammonium within the distribution network compared to the endpoints of the waterworks due to nitrification (Schllehner et al., 2017). Many studies have reported a significant association between nitrate and nitrite concentration in drinking water and methemoglobinemia (blue baby syndrome) among children (Ward et al., 2018); congenital anomalies (Holtby et al., 2014); birth defects (Brender et al., 2013); gastrointestinal diseases (Jones et al., 2016); and gastric cancer, bladder, and kidney cancer (Song et al., 2015). In the area under study, wells are the only source of drinking water; therefore, health risks related to nitrate and nitrite contamination in well water is significantly high. Intensive agriculture practices were performed, and large pig farms were built in the area. After the revolution of 1989, soil pollution due to fertilisers gained more attention, and pig farms were also started getting monitored. Still, the villages continued the old practices, and concentration of nitrate and nitrite in farm water is still there. Therefore, the present study attempts to investigate the spatial distribution and temporal evolution of nitrate and nitrite concentrations in the farm water of Timis County, Romania, during 2016-2017.

Material and Method

The study consisted of a sample of 4028 analysis bulletins of the nitrate and nitrite concentrations collected from 41 farms and local water sources by the Public Health Direction, Timis, over two years (2016 and 2017). The water testing was done by RENAR accredited, Surveillance Service of the Public Health Direction (ISO: 13395:1996, 2017), Timis. They followed the SR EN ISO guidelines for the analysis. The primary goal of the study was to monitor nitrate and nitrite concentration in water (WHO, 2008). The permission to conduct the study was taken from the Leadership of Public Health Direction, Timis, and an agreement was made to access primary evidence i.e., analysis bulletins while maintaining confidentiality and compliance with the personal data protection law. The agreement of the "Victor Babes" University of Medicine and Pharmacy's Ethical Commission was requested and obtained for this study. Statistical analysis (frequency, means, independent sample test) was performed with the help of SPSS 20.

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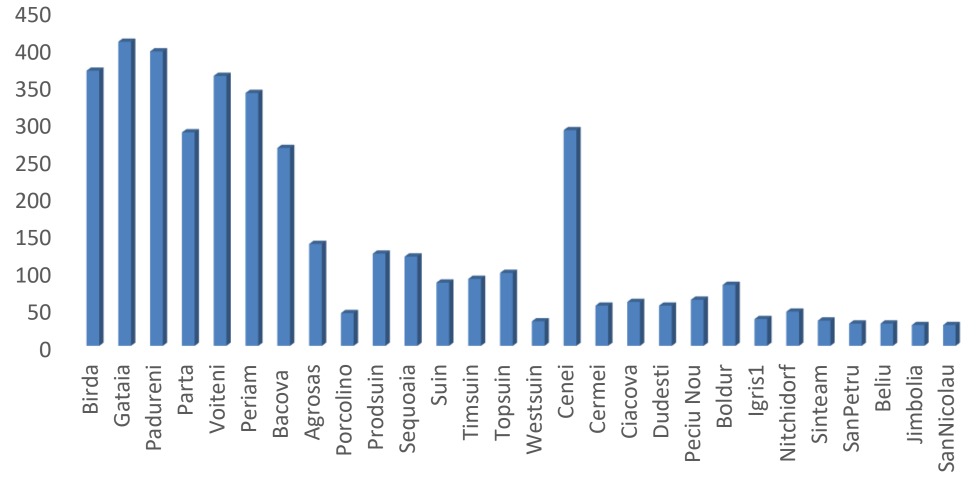
Results

Spatial distribution of the water testing

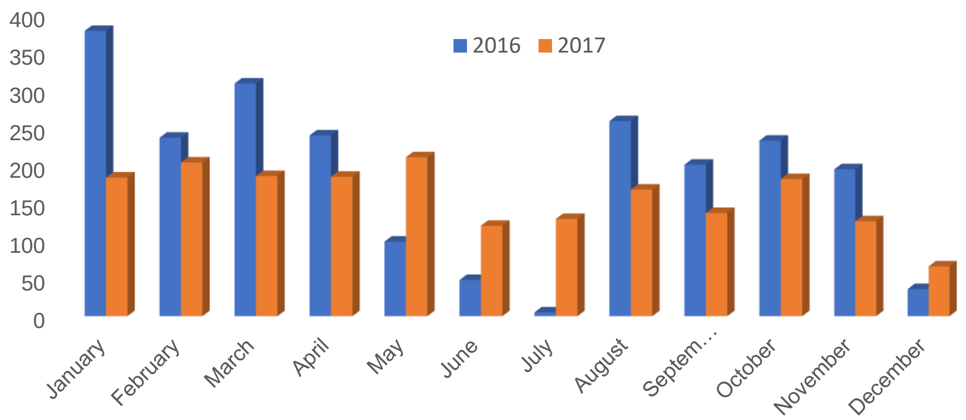
Water samples were tested for nitrate and nitrite concentrations in the 41 localities and pig farms of Timis County. The number of water tests conducted during the period are as follows: over 24 tests at 28 farms, over 100 tests at 11 farms from 28 locations, over 300 tests at 5 localities: Birda, Gataia, Padureni, Voiteni, and Periam and between 85 and 137 tests at 6 pig farms in Agrosas, Prodsuin, Sequoia, Suin, Timsuin, and Topsuin from the 11 localities (Figure 1).

Figure 1: Spatial distribution of the water sample testing frequency during the study period (2016-2017)



Source: Author (2022)

Figure 2: Time distribution of the frequency the water sample testing during the study period



Source: Author (2022)

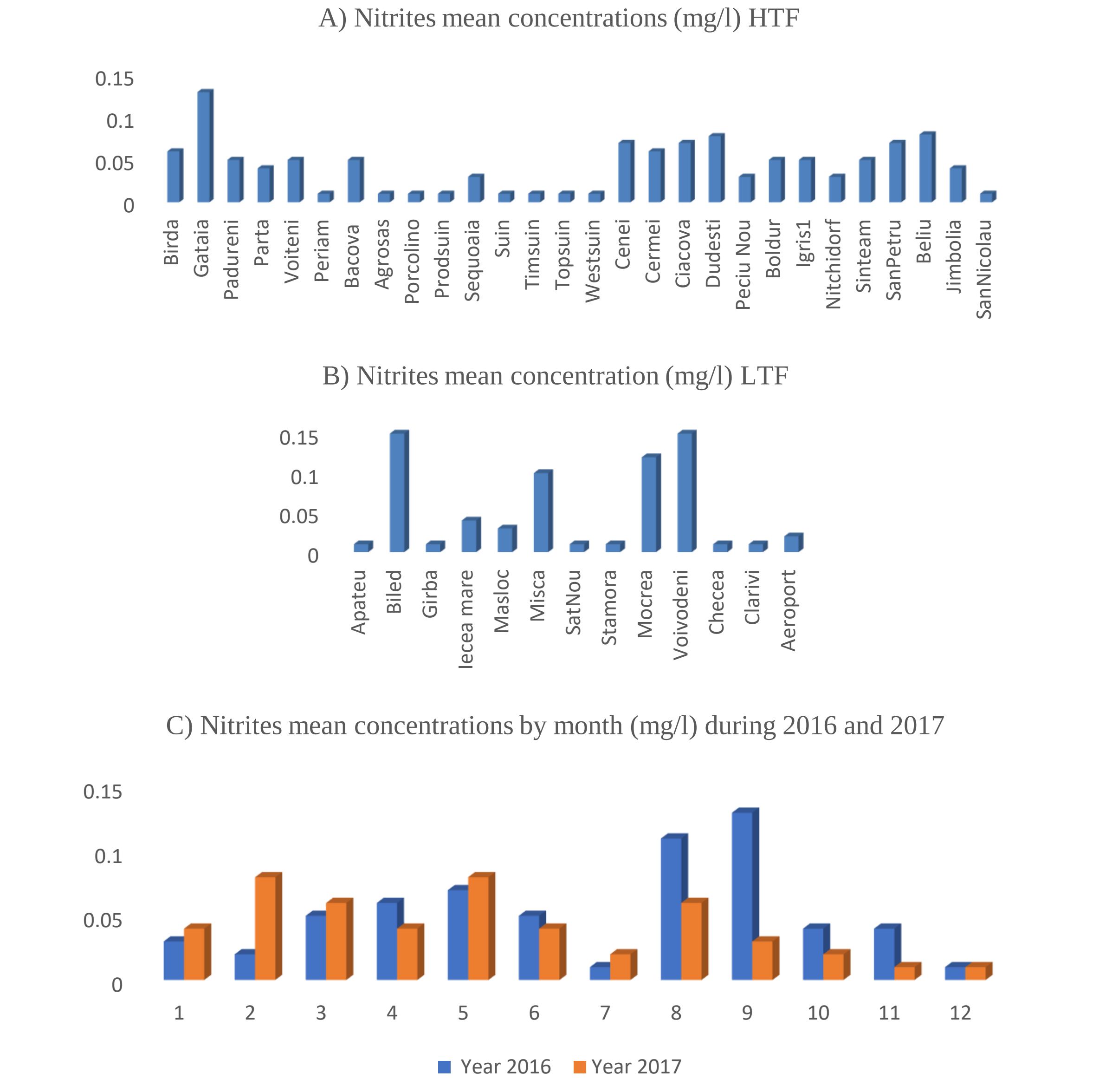
Temporal distribution of the water sample tests

Temporal distribution of water sample-test recorded higher frequency in 2016 than in 2017. Similarly, the variations in the testing frequency were higher in 2016 (from 36 in December to 379 in January) than in 2017 (from 66 in December to 211 in May) (Figure 2).

Spatial and temporal distribution of the nitrite mean concentrations

A slight increase of the nitrite concentrations (values below the standards) in the water was recorded in 7 farms and localities (concentration values ranged between 0.06-0.15 mg/l) with high testing frequency and in 5 farms and localities (values ranged between 0.07-0.15 mg/l) with low testing frequency (Figure 3, A and B). The mean concentration of nitrite varied between 0.01-0.5mg/l, and it was higher in 2016 than in 2017 (figure 3, C).

Figure 3: Spatial and temporal distribution of nitrite mean concentrations in: A) locations with high test frequencies (HTF); B) location with low test frequencies (LTF) and; C) the monthly mean concentrations during the study period (2016-2017)



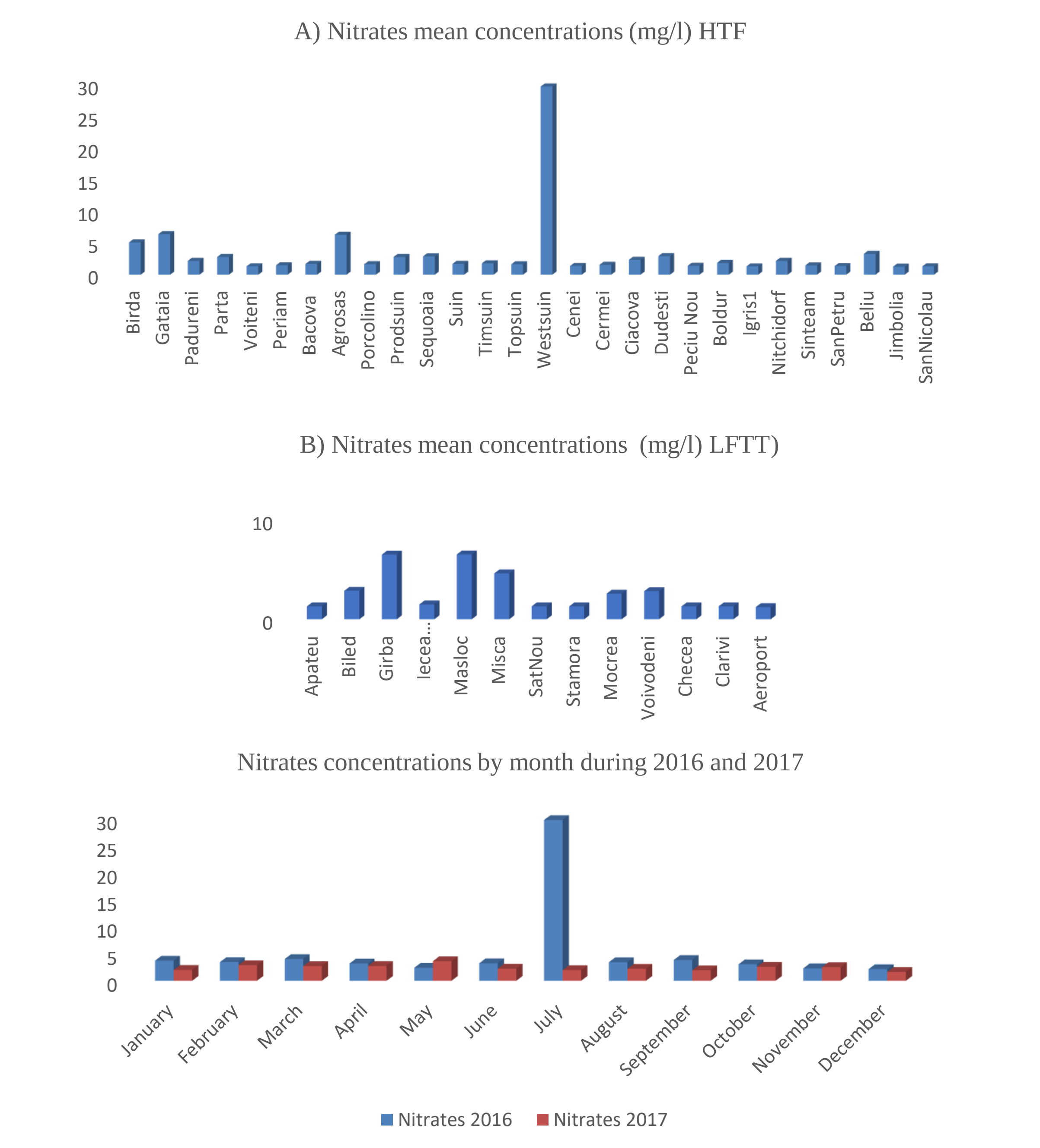
Source: Author (2022)

Spatial and temporal distribution of the nitrate's mean concentrations

Spatial distribution of nitrate indicated that the highest mean concentrations (5.1 to 29,78mg/l) were found in 6 localities and pig farms: Birda, Gataia, Agrosas, Westswin (locations with high test frequency) (Figure 4A), and Girbea, Masloc (locations with low test frequency) (Figure 4B) during the study period. Monthly mean concentrations of nitrates were under 5 mg/l, except in July 2016 (Figure 4C), when an accidental increase of nitrates concentrations was recorded in Westswin (Figure 4A), and it was observed that few water tests were conducted during the time (Figure 2).

While analysing the spatial distribution of nitrate each month during the study period highest nitrate concentrations were observed in Gataia, Padureni, Birda, Voiteni, Periam, and Parta, in almost all the months of the year, and higher concentrations were observed in 2016 than in 2017. Nitrate concentrations usually varied between 1-10 mg/l, and nitrite concentrations between 0-0.5mg/l. From September to December (2016 -2017), specific pig farms in Porcolino, Produsuin, Sequoaia, Timsuin, Topsuin, Westsuin, were frequently monitored, low concentrations of nitrates (4-6 mg/l) were recorded in September and October (2016-2017), and high nitrate concentrations (10-14mg/l) were recorded in November and December (2016-2017).

Figure 4: Spatial and temporal distribution of nitrate's mean concentrations in: A) locations with high test frequency (HTF), B) locations with low test frequencies (LTF) and C) the concentration recorded by month during the study period (2016-2017)



Source: Author (2022)

Mean concentrations of nitrites and nitrates were lower than the standards, with a statistically significant difference (t=8.11, Sig.< 0.001) between the two years of study and concentration values in 2016 were higher than in 2017.

Discussion

The present Spatio-temporal study investigated the pollution of drinking water in certain villages and pig farms by measuring the concentration of nitrite and nitrate in the farm water of Timis County during 2016-2017. Specific villages were more frequently monitored during the entire study period, and certain pig farms were more frequently monitored from September to December in both years. Many such studies are conducted in other countries and the results are discussed here. For e.g., Li et al. (2021) comprehensively studied the Spatio-temporal evolution of groundwater nitrate nitrogen levels and their potential human health risks in the Songnen Plain, Northeast China from 1995 to 2015. The study indicated that the nitrogen concentration in groundwater in the region was worsening. With increasing contamination of nitrates in the groundwater and the partially known risk of methemoglobinemia, it becomes necessary to prevent such contamination and inform the persons at risks, such as pregnant women and young mothers (Levallois & Phaneuf, 1994).

Another important finding of the study was that an accidental increase in the nitrate concentration was recorded on a pig farm at Westswin in July 2016. During this time, poor monitoring was observed due to the summer holiday. However, the maximum permissible concentration level of nitrate and nitrite were never reached, even during the accidental increase of nitrate concentration. Another study by Li et al. (2010) conducted in China recorded a peak value of nitrates in July highlighting a significant relation with the time distribution of fertilization rate and rainfall. Khan et al. (2019) reported a high nitrate concentration, 35-75 mg L^{-1}, in the shallow wells in Pakistan, and 70% of these samples contained nitrate concentration above the permissible limit of 50 mg L^{-1}. Similar seasonal patterns of nitrate concentrations were observed in deep wells, in the same area. The probable reason for increased nitrate level is the horizontal movement of groundwater along with the nitrate contamination during the vertical seepage of river water to the aquifers.

In line with the result of our study, a study in Egypt also reported that none of the analyzed samples of the nitrate and nitrite levels in rural and urban areas exceeded WHO guideline values aimed at preventing methemoglobinemia (Mortada & Shokeir, 2018). A study performed in Nigeria suggested that indiscriminate waste disposal and poor sanitation may further contribute to the nitrate pollution in the water supply (Nduka et al., 2010).

In other studies, high values of nitrates concentrations were found in plain areas. For example, in Iran, a higher nitrate quantity than the permissible limit was recorded in the water distribution network of Bushehr, Gilan, and Mazandaran Provinces. In addition, Talesh, Ardabil, Hashtgerd, Divandareh, and Kerman cities had high nitrate levels in more than 50% of their wells (Marhamati et al., 2021).

The findings of the study raise few questions like: “What is the nature of water pollution?”, “Does organic waste from pig farms cause it, or is it due to the use of soil fertilisers containing nitrate?”. A Spatial autocorrelation analysis identified the clustering of high nitrate areas in central, north, and southern India, specifically in areas with higher fertiliser usage (Sarkar et al., 2021). A positive correlation between the nitrate-N pollution of groundwater and the nitrogen fertilizer was found in a study performed in NE China (Zha et al., 2008). Bahrami et al., 2020 indicated that nitrate temporal trend increased significantly in most of the wells in Iran, and the spatial trend of area percentage of nitrate class 3 (not permissible limit of more than 50 mg L-1) was positive. The greatest quantities of this variable in groundwater samples detected in northern, western, and eastern areas of the plain had a direct relation with the fertilization of agricultural lands. In another study conducted in Iran the highest Chronic Daily Intake (CDI) of the studied contaminants was related to nitrate among children (range: 0.21-1.45, with an average value of 0.77 mg/kg-day) (Golaki et al., 2022).

Conclusion

Certain villages and pig farms with slightly increased concentrations of nitrates and nitrites were found in Timis county. Higher concentrations of nitrates and nitrites were recorded in 2016 compared 2017. During the study period, the recorded mean concentrations of the nitrates and nitrites did not surpass the maximum permissible concentrations. An accidental increase in nitrates concentrations was recorded on a pig farm at Westswin in July 2016. Future studies must identify the sources of water pollution caused by excessive nitrate and nitrite levels in Timis County’s plain area.

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