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NITRATE POLLUTION AND HEALTH RISK ASSESMENT OF GROUNDWATER IN RURAL AREAS FROM BOTOSANI, ROMANIA

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Introduction

The use of groundwater for drinking purposes in rural areas without centralized water supply systems, without understanding the possible consequences on human health, is a growing problem on a global scale in recent years.
Nitrate pollution because of fertilizer use in irrigated fields is closely related to the modification of nitrogen-fixing crops in natural vegetation, the burning of fossil fuels and the discharge from domestic and industrial sewage systems. As result of harmful effects on humans at high doses, national directives and international guidelines regulate nitrate concentrations in water used for drinking purposes. The World Health Organization has defined the maximum level of nitrate in drinking water as 50 mg/L. The objectives of this study were:
(1) to analyses the chemistry of groundwater; (2) to evaluate regional nitrate concentrations; (3) to investigate potential non-carcinogenic risks to human health from groundwater exposure to nitrate using the model recommended by the US Environmental Protection Agency.

Materials and methods

Studied area of Botosani County is crossed by two main rivers and presents different water accumulations (lakes and ponds). The climate is temperate-continental, strongly influenced by air masses from the east of the continent with predominant winds from the north-west and south-west. The soil consists of crystalline, migmatitic and eruptive rocks, olitic limestones and friable limestone rocks.
Water samples were collected in polyethylene bottles. The analysis of major ions (Ca, Mg, Na, K, NO_3^-, NO_2^-, F^-, Cl^-, SO_4^{2-}, HCO_3^-) were performed in the laboratory using standard methods regulated by the Romanian Standard Association on the quality of drinking water for human consumption. In order to verify the reliability of the analysed data set the cation-anion balance was performed. The calculation of groundwater quality results can be good if the charge balance error is less than ± 5%.

The spatial distribution of nitrate concentrations was evaluated using the inverse distance weight interpolation technique, IDW and ArcMap10.5. Descriptive statistical data were analysed using XLSTAT 2020, Excel 2019.
Consumption of groundwater can cause a serious threat to humans through two paths of exposure: oral, as result of drinking water ingestion or via skin contact. Health risk estimation is the systematic support for estimating the probability of adverse health effects in exposed populations that may be susceptible to specific harmful substances in polluted environmental systems. The estimated daily intake (EDI) is an index referred to daily intake (IN mg/kg/day). The water intake rate is 2.5L/day for adults, respectively 1L/day for children, body weight (BW) being different (children BW=15kg; women BW=55kg; men BW=78kg). According to the Integrated Risk Information System Guidance Database, the reference dose for nitrate (RFD, mg/kg body weight per day) is 1.6 mg/kg BW day in the digestive tract. The non-carcinogenic risk to human health is given by the hazard index value (HQ). HQ value higher than 1 indicates the potential risk from nitrate contamination.

Results and conclusions
The quality analysis of the groundwater samples indicates conductivity (EC) values between 455÷1976 µS/cm, pH values ranged between 7.4 and 8.3. Total dissolved solids (TDS) values ranged between 302÷1272 mg/L. Nitrate concentration values ranged from 3.8÷238 mg/L, with an average of 53.4 mg/L. Analysis of groundwater sample data indicated that 41.7% of the samples exceeded the limits of the Romanian Drinking Water Quality Standard regarding nitrate values. Among the cations, Na^+ was predominant, followed by $Ca^{2+}>Mg^{2+}>K^+$. Among anions, HCO_3^- was observed as predominant, followed by $NO_3^->Cl^->SO_4^{2-}$. The concentration of Cl^- was observed in the north-east of the studied area with values between 28.3÷104 mg/L, the highest concentrations of SO_4^{2-} were observed in the south-west of the studied area, with values between 10.6÷68.2 mg/L. The heterogeneous distribution of the analyzed groundwater variables showed discrepancy in the values of the coefficient of variation (CV%). The CV of some indicators is higher than 100%, demonstrating the potential pollution by anthropogenic activities in the study area: 112% (NO_3^-), 104% (SO_4^{2-}).
Health risk assessment was performed in three groups including children, women and men to investigate the non-carcinogenic risk of nitrates. The effect of probability estimation indicated that HQ levels in the studied groups increase in the order child>women>men. HQ value higher than 1 (1.01÷8.43) for the child group, (1.04÷6.76) for the female group and (1.20÷4.77) for the men group. According to the obtained results, 66.6% (children), 58.3% (women) and 41.7% (men) of the analyzed groundwater samples indicate an increased probability of non-carcinogenic risk and increased adverse effects of water consumption.
It is recommended that groundwater resources should be monitored and controlled more precisely to prevent adverse effects on human health.

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