# The groundwater diet: trade-offs and benefits of healthy dietary choices in the context of nitrate pollution

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## Abstract

Effects of dietary choices on groundwater pollution are often not considered in the context of sustainable and healthy diets. We used a large dataset of the National Minerals Policy Program of the Netherlands to gain more insight into shifts in dietary patterns in the context of groundwater pollution. We quantified a nitrate footprint per crop type based on groundwater monitoring results. This was linked to the nutritional contents and daily recommended intake levels of those crops. Next, a health-environment indicator was derived for optimization of healthy and sustainable diets. We found large differences between crops. Highest indicator values were found for celeriac and lowest for pea and asparagus. Based on the results we conclude that the dietary shift towards more plant based products could potentially lead to increased groundwater pollution.

Keywords: groundwater pollution, nitrate, dietary choices, health

## 1. Introduction

With an increasing concern about providing sufficient food for a growing world population, but also rising levels of obesity and climate change, a transition towards sustainable and healthy diets is eminent. A plethora of information exists on healthy and sustainable diets. Yet, sustainable aspects of food products often only quantify the effects for a single environmental compartment such as the global warming potential rather than an integrated approach. Consequences of dietary shifts for groundwater quality are often overlooked. The objective of this study was to quantify effects of food consumption on groundwater nitrate levels in concurrence with nutritional values.

## 2. Materials and Methods

Nitrate levels at crop level were obtained from an overlay of monitoring results from the National Minerals Policy Program of the Netherlands (RIVM, 2019a and the Dutch Crop Type Registration Program (RVO, 2019). Average yields per year were derived from Statistics Netherlands (2019). Data from targeted monitoring on open field vegetable crops and fruits was also included as these food products were not included in the standard monitoring program (Hooijboer et al., 2014). Next, average yields were divided by the nitrate concentration at crop level. All crop types were allocated to a food group category (cereals, fruits, vegetables). The daily recommended intakes were based on

the Dutch Dietary Guidelines (Kromhout et al., 2016), the Dutch Food Composition Database (RIVM, 2019b) and the Dietary Reference Values for adult women[1] (EFSA, 2019). An overview of the approach is summarized in Figure 1. We present results for the mineral zinc and the vitamins B6 and C[1]. The optimal dietary choice in terms of health and environment was calculated by dividing the mineral or vitamin content (expressed as percentage of daily recommended intake per 100 g) by the nitrate footprint ($NO_3$ leaching to groundwater in g $NO_3$ $l^{-1}$ per 100 g). In such way a health/environment ratio was calculated.

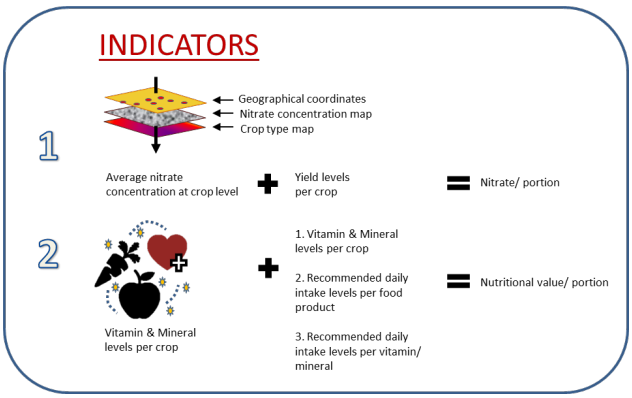


Fig 1: Indicators to quantify environmental and health aspects of the groundwater diet.

## 3. Results and Discussion

Highest levels of nitrate per kg of crop were found for pea and lowest levels for celeriac (Fig. 2). Lowest health/environment ratios were found for asparagus followed by pea (averaged over the three minerals and vitamins). Celeriac had on average highest values (Fig.3).

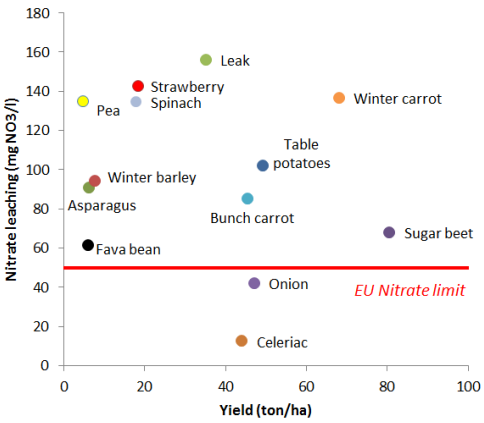


Fig. 2: Average measured nitrate leaching losses to groundwater and yield levels of different crops grown in the Netherlands.

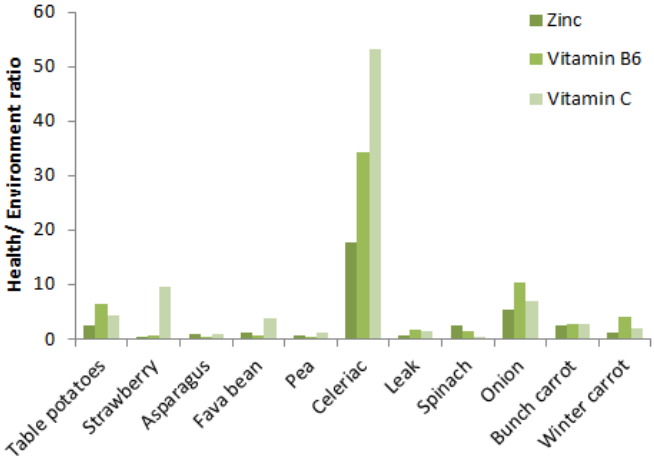


Fig. 3: Health/Environment ratios for a selection of products. The unit of the ratio is: the percentage of recommended daily intake of mineral or vitamin when 100 g of the product is consumed, divided by the $NO_3$ leaching losses per 100 g of product. N.B. To improve the readability we scaled the y-axis and divided all values by a factor of $10^4$.

Based on these results we conclude that environmental implications of dietary shifts towards more plant-based diets could lead to increased groundwater pollution under equal land management. During the presentation, we will discuss the methodology and the implications of the used approach taking into consideration the current and future dietary patterns as a whole.

## References

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[1] The selected gender, age group, minerals and vitamins were chosen as examples in this study for illustration purposes.