# Excessive N inputs elevate nitrate concentrations of shallow and deep well groundwater along the Indus River floodplain aquifer in Pakistan

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## Abstract

Excessive use of nitrogenous fertilizers causes nitrate contamination of surface and groundwater. We measured nitrate concentrations of 112 samples collected from shallow and deep groundwater wells at seven sites along the seasonally-flooded Indus river during the four sampling campaigns during 2016-2017. Nitrate concentrations of shallow wells were 15-54 and 20-45 mg $L^{-1}$ during the start and middle of dry season, respectively. However, at the end of the dry season, nitrate concentrations in 70% of both shallow and deep wells samples were above the permissible limits of 50 mg $L^{-1}$. δ18O data suggested lower recharge in deep well than shallow wells.

Keywords: nitrate pollution, groundwater, floodplain

## 1. Introduction

Fertilization intensity and irrigation management of agricultural fields are major drivers of nitrate pollution to aquifers. Excessive N coupled with irrigation encourage nitrate mobility both horizontally and vertically with water. Nitrate migrates conservatively in the direction of groundwater flow in the absence of denitrification processes (Gu et al., 2015).

## 2. Materials & methods

During October 2016 to May 2017, four sampling campaigns were conducted to collect 112 shallow (30-40 ft) and deep (120-150 ft) well samples from seven sites along the floodplain area along the Indus River (Fig. 1a). Analyses on nitrate concentrations and other physico-chemical parameters were performed. Stable isotopes of water were determined using a Picarro Cavity Ring-Down Spectrometer (CRDS) L2120-i on the Geological Survey of Denmark and Greenland (GEUS).

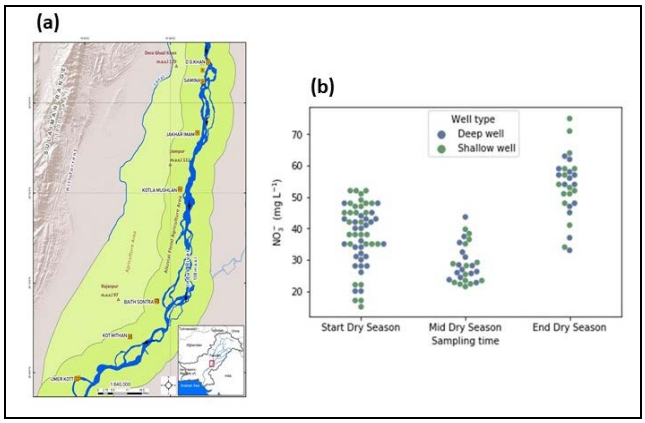


Fig. 1: a) Map of study location, and b) nitrate concentrations of shall and deep wells.

## 3. Results & discussion

Nitrate concentrations were higher in shallow than in deep wells and followed strong spatial and temporal patterns (Fig. 1b). Nitrate concentrations decreased from the beginning to the mid dry season and increased from mid to end dry season. Nitrate concentrations at the beginning of the dry season were more variable in the shallow wells than the deep wells.

The data show that the $\delta^{18}O$ value of Indus River is -12.5‰ and *d*-excess value is 14‰ at the start of dry season and at the end of dry season $\delta^{18}O$ was -7.8‰ and *d*-excess was 11‰ (Fig. 2).

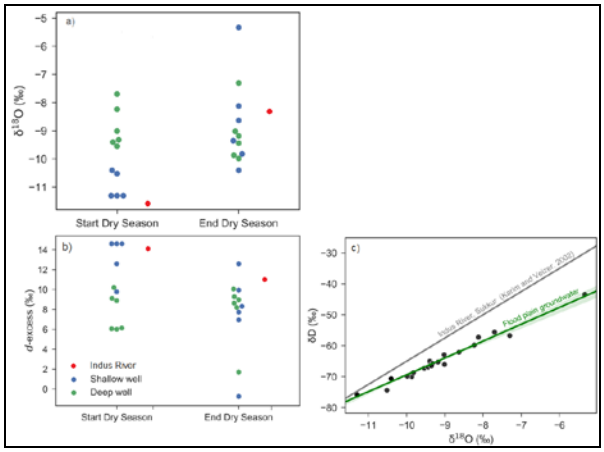


Fig. 2: Swarm plot showing a) $\delta^{18}O$ and b) *d*-excess values over the sampling time during the progression of the dry season. Panel "c" shows relationship of $\delta D$ with $\delta^{18}O$ of samples.

We used the nitrate concentrations as a proxy to compare the pollution levels between shallow and deep groundwater samples. Shallow wells were more contaminated than deep wells amd more than 90% of groundwater was not suitable for drinking at the end of dry season. Extensive but varied N application in different crops were linked to elevated nitrate concentrations in shallow and deep wells (Gutierrez et al., 2018). Indus River water is not evaporated evidently and had higher *d*-excess values during any season. Similar isotopic signatures of shallow and deep water at the end of dry season indicated mixing effect due to high pumping during cropping season. Isotopic values also at the start of dry season also suggested higher recharge in shallow wells than the deep wells.

## References

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