Idaho Groundwater Trends

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Introduction

Groundwater is an important resource throughout the state of Idaho. According to the Idaho Department of Environmental Quality, around nine billion gallons of ground water are withdrawn every day. About 60% of total groundwater withdrawn is used for agriculture and 4% is used for drinking water. Analyzing the trends in groundwater can help the state of Idaho and its citizens determine if the water is safe to drink, and if it can be beneficial or detrimental to their crops. Measurements on Idaho's groundwater characteristics, or analytes, were collected from a variety of locations across the state, from the years 1917 to 2016. The purpose of this analysis is to assess how the analytes are changing over time and whether they are increasing or decreasing at each of the monitoring locations. For the purpose of this analysis, the top five most measured analytes from 1990 to 2016 will be taken into consideration. These analytes include water temperature (°C), pH levels, arsenic and chloride levels (in mg/L), and the water's conductivity ($\mu S/cm$). In order to accurately estimate trend, only locations with more than 10 observations for a specified analyte were considered.

Statistical Methods

All statistical analyses were done in `R` (Version 3.6.3; R Core Team 2020). The `tidyverse` package (Wickham et al., 2019) was used for the cleaning, preparing, manipulation, and graphing of the data. Other packages used for statistical analyses were: `lubridate` (Version 1.7.8; Garret Grolemund and Hadley Wickham, 2011), `maps` (Version 3.3.0; Richard A. Becker et al. 2018), `mapdata` (Version 2.3.0; Richard A. Becker et al. 2018), and `mblm` (Version 0.12.1; Lukasz Komsta 2019). A Shapiro-Wilk's test was used to asses the normality of the analytes. The `mblm()` function was used to assess the trend of each analyte over time for each monitoring location. A confidence interval was applied to the slope to test if the trend was significant. All tests and confidence intervals were computed at the $\alpha = .05$ level.

Results

Since 1990, of the 845 monitoring locations analyzed for water temperature trends, 23.6% of the locations showed significant evidence of a decrease in water temperature, 19.4% of the locations showed significant evidence of an increase in water temperature, and 57% showed no significant change in water temperature, shown in Figure 1.

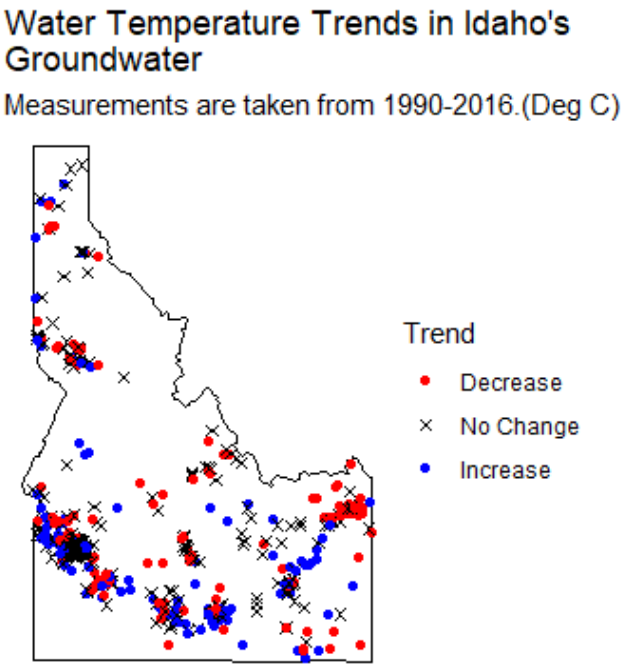

Figure 1

Demonstrated by Figure 2, 49.7% of the 656 monitoring locations showed significant evidence of a decreasing trend in pH levels, 9.6% showed significant evidence of an increase in pH levels, and 40.7% showed no significant change in pH levels.

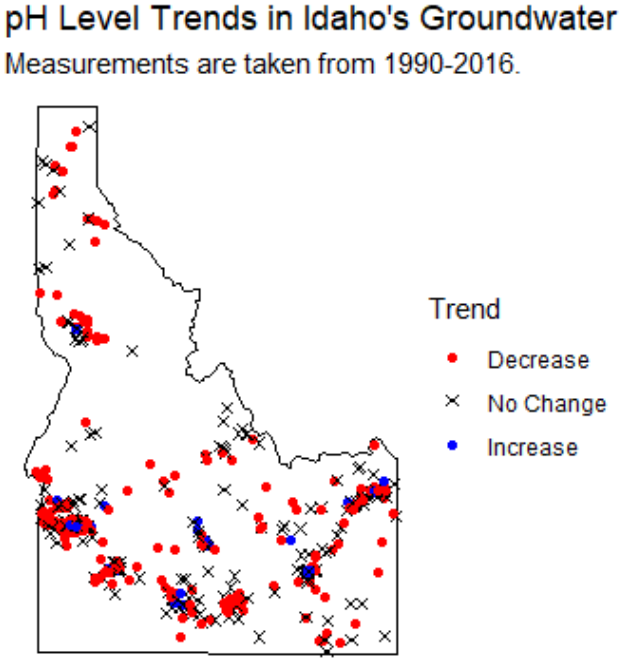

Figure 2

Based on Figure 3, 6.2% of the 387 monitoring locations showed significant evidence of a decreasing trend in mg/L of arsenic within the ground water, 16.8% of locations showed significant evidence of an increasing trend of Arsenic, and 77% of locations showed no significant evidence of a change in mg/L of arsenic, in the groundwater.

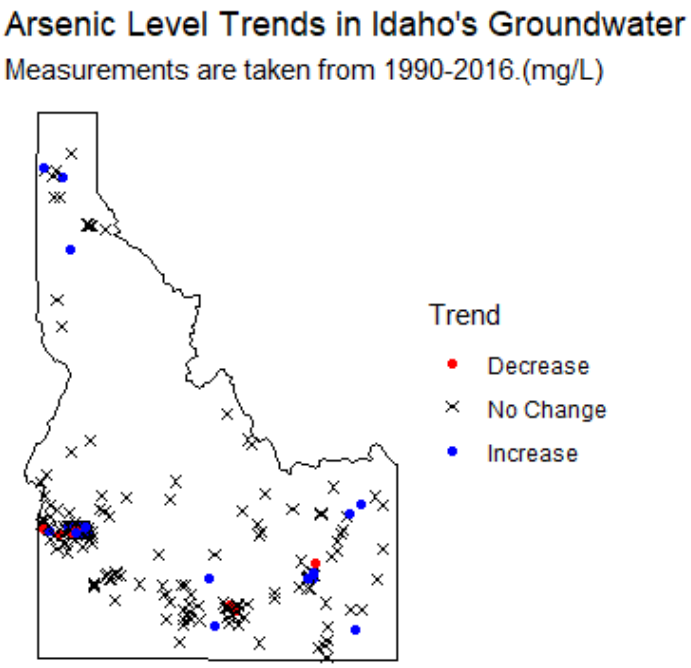

Figure 3

With respect to the amount of chloride in Idaho's groundwater(Figure 4), 35.5% of the 389 monitoring locations showed significant evidence of a decreasing trend, 23.7% showed significant evidence of an increasing trend, and the remaining 40.9% showed no significant evidence of an increasing or decreasing trend of chloride in the groundwater.

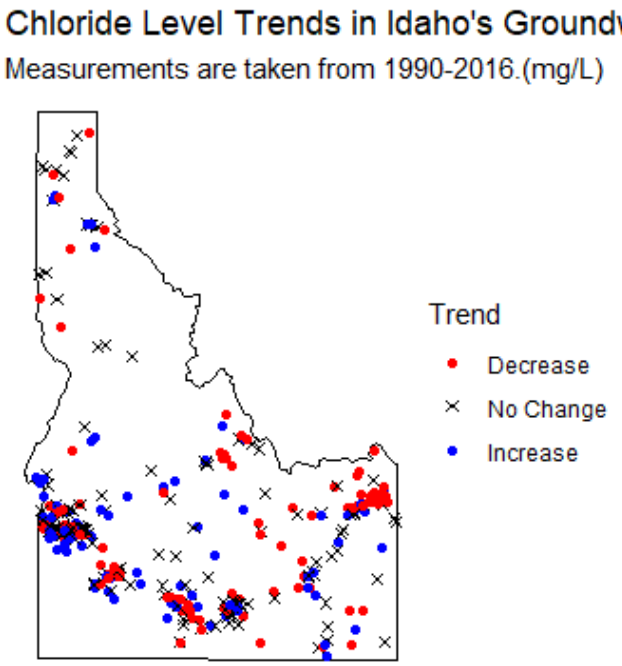

Figure 4

Figure 5 demonstrates that 37.5% of the 624 monitoring locations showed significant evidence of a decreasing trend in water conductivity, 26.3% of locations showed significant evidence of an increasing trend, and 36.2% showed no significant evidence of a decreasing or increasing trend in water conductivity.

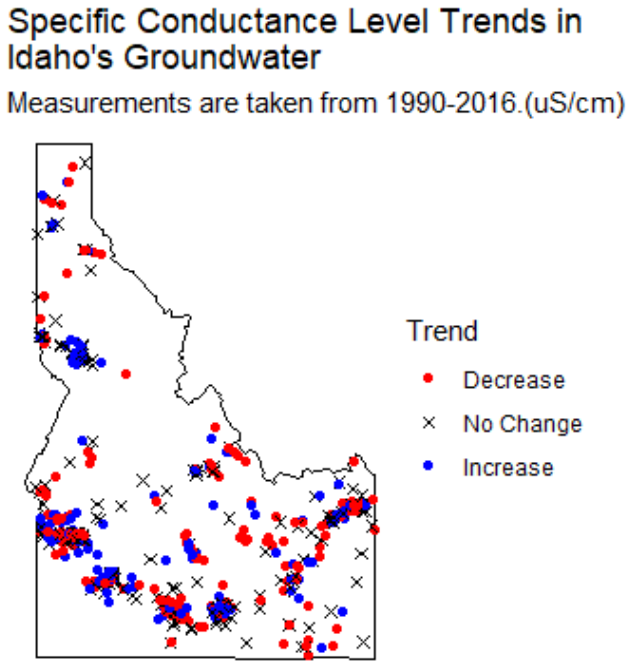

Figure 5

The average yearly change in an analyte, with respect to trend pattern and region of Idaho, is represented in Table 1.

Region	Trend	Water Temperature (°C)	pH	Arsenic (mg/L)	Chloride (mg/L)	Specific Conductance (µS/cm)
Central	Decrease	-2.65E-04	-7.42E-05	-9.14E-08	-2.41E-03	-5.02E-02
	Increase	6.37E-03	1.43E-04	2.02E-07	1.11E-03	2.90E-02
North	Decrease	-4.23E-04	-2.12E-04	NA	-4.29E-04	-9.52E-03
	Increase	4.22E-04	NA	1.03E-06	1.72E-03	1.65E-02
North Central	Decrease	-8.45E-04	-2.11E-04	NA	-4.30E-04	-5.72E-02
	Increase	7.28E-04	1.33E-04	NA	NA	3.62E-02
South Central	Decrease	-1.24E-03	-7.03E-05	-1.44E-07	-6.97E-04	-2.82E-02
	Increase	2.28E-04	4.06E-04	4.18E-07	6.79E-04	7.17E-02
Southeast	Decrease	-1.33E-04	-7.88E-05	-9.82E-07	-3.35E-03	-1.39E-02
	Increase	2.27E-04	7.50E-05	4.24E-06	1.01E-03	1.23E-02
Southwest	Decrease	-3.47E-04	-2.51E-04	-3.00E-05	-1.21E-03	-2.80E-02
	Increase	2.77E-04	1.44E-04	1.04E-06	1.52E-03	3.03E-02

Table 1

*Values of NA were given where there was no significant evidence of an increasing and/or decreasing trend within a specified region, for the analyte of interest.