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# Trend Analysis of Precipitation, Groundwater Level and Flow Rate Data by using Mann-Kendall and Sen's Slope Estimator Statistical Tests in the Petorca Communer

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**Abstract:** This article analyses one of the most complex socio-environmental conflicts in Chile: The Petorca water crisis. Petorca has been experiencing a shortage of water for several years. The cause of these variations has not yet been completely analyzed and the problem has remained unchanged. This paper evaluates hydrology variables to identify, quantify and demonstrate the cause of water shortages in the study area. Mann-Kendall and Sen's slope test statistically are applied to evaluate records of rainfall monitoring stations, water level and flow rate. To determine the existence of trends over time and quantify its magnitude. A total of 760 years of data were used by analyzing 4974 precipitation events, 788 water level and 1384 flow rate records. The results indicated that (1) There is no positive or negative trend in precipitation data over the years; (2) four well-monitoring stations have a positive trend but with an insignificant magnitude; (3) all flow-monitoring stations have a negative trend. Likewise, it was evidenced that water levels and flow rates have been affecting abruptly since 2014, obtaining null records and remain constant over time. For the same period, there is no evidence of precipitation anomalies. As a result, water resources face a host of serious threats, all of which are caused primarily by human activity. Finally, the community of Petorca is experiencing a water shortage event, which is evidenced for the first time with this scientific article.

**Keywords:** Petorca, Trend Analysis, Mann-Kendall Test, Sen's Slope Estimator

## Introduction

Due to climate change and inappropriate management of water resources; there are millions of people all over the world who do not have access to clean drinking water. The lack of access to fresh water is the biggest problem of our time, promoting hunger and poverty in the world (Mishra and Singh, 2010). The environmental changes of the planet are due mainly to human activity (Khetrapal, 2018). Although there is still no global water shortage, the imbalances between the availability of fresh water and the population are latent; the future is not promising (Kummu *et al*., 2016). All this worries us and urges us to look for solutions around this problem. The reduction of water scarcity is a goal of many countries and governments (Wilhite *et al*., 2014). Human society has become increasingly vulnerable to natural threats. Drought is a hydrometeorological threat, which can be exacerbated by the intervention of human actions and become a common natural threat (Lu *et al*., 2019). Drought appears as a deficit or poor distribution of rainfall over the expected. As a result, it is insufficient to satisfy the consumption of water by people, which can cause economic, social and environmental impacts (Mishra and Singh, 2010). Also, anthropogenic alteration of the landscapes generate potential consequences in groundwater recharge rates, including quality and quantity of water (Burri *et al*., 2019). Agriculture, urbanization or industrialization impact the physical and chemical environmental processes such as water level, salinization, nutrient loads or soil degradation, affecting the ecosystem (Han *et al*., 2017).

### *Petorca*

Commune of Petorca is located in the northern area of the Valparaíso region. It has an area of 1,516.6 km$^2$, with a population density of 6.22 habitants·km$^{-2}$. The altitude varies between 600 and 2,700 m above sea level and is framed from north to south between 32°05' and 32°40' south latitude and 70° west longitude. This area is located about 220 kilometers north of the capital city of Santiago and 190 kilometers east of Valparaíso. Due to its condition as an interior province, close to the pre-cordillera, it has a semi-arid climate where the average temperature is usually 15.2° Celsius (INE, 2007). Also, it has microclimates and soil with good structure that improve the quality of fruit crop production that has been recognized in international and national markets.

The economically active population of the commune of Petorca has historically performed in mining (copper, gold and silver) and the importation of non-metallic minerals (Camus *et al*., 1991; Cuadra and Dunkerley, 1991). Nevertheless, over the years, the situation has changed. In recent years, most of the economically active population is performing activities related to agriculture and livestock since the decline of mining. Currently, the main economic activity in the commune of Petorca is agriculture. The production of fruit trees such as avocados and lemons are the most important for the province, becoming one of the areas that most exports these types of products, representing 35% of the Chilean Hass planting (Hofshi, 2002). In this context, the average global blue water footprint of the avocado crop is 823 m$^3$·ton$^{-1}$, referring to the necessary consumption of surface and underground water for cultivation (Mekonnen and Hoekstra, 2011). The technified irrigation systems are a factor that has allowed to continued cultivation in areas with lower water resources (Panez-Pinto *et al*., 2018).

### *Petorca Water Crisis*

Eight years ago, the commune of Petorca was declared a water stress area. The measure has been established fourteen consecutive times since 2010. Once again, on June 25, 2018, the Regional Director of Hydraulic Works of Valparaiso requested that the commune of Petorca maintain the same status for another 6 months. The period can be prolonged if the scenario does not change. Drought conditions were confirmed by the Hydrometeorological Conditions Report, Province of Petorca, Region of Valparaiso (Decreto MOP Nº 114, 2018). For a long time, residents of Petorca have organized to denounce that the lack of water in the area is due, in its majority, to the usurpation of the water resources by the big entrepreneurs of the agro-industry. As a consequence of the shortage of water, residents have left the area.

Governmental authorities had performed inspections to verify that water was not being used excessively by agricultural activities. In October 2018, the government of Chile approved a special regulation and implemented monitoring wells for the community, to reduce and evaluate water scarcity in the area (Decreto MOP N° 114, 2018; Resolución DGA Región de Valparaíso N° 1588, 2018). The penalties were put into effect in August 2018 and the offenders could pay a fine up to 71,000 dollars (Código de aguas, 1981). It is possible to assess the water scenario of Petorca by performing a statistical analysis. In this context, the factors that are affecting the community could be identified.

## Methodology

### *Study Sites, Rainfall Data and well Water Level*

All the information from the different stations are part of the national monitoring network by the Dirección General de Aguas (DGA). Figure 1 shows all the stations used in this research. The monthly precipitation records were obtained from nine meteorological stations. The precipitation data were recorded between 1978 and 2018. Frutillar station was the only exception because its registrations begin since 1979. In total, 4,974 events were used. Table 1 shows the geographic characteristics and details of the weather station sites used in the study. Likewise, the records of the groundwater levels were obtained from nine stations. The records cover from 1995 to 2018. In total, 788 events were used. Table 2 shows the details of the monitoring wells sites used in the study. The static levels of the well data were recorded between 1993 and 2018. The commune of Petorca has only three flow rate stations. The records begin from 1962 to 2018. In total, 1,384 events were used. The characteristics of each station are detailed in Table 3.

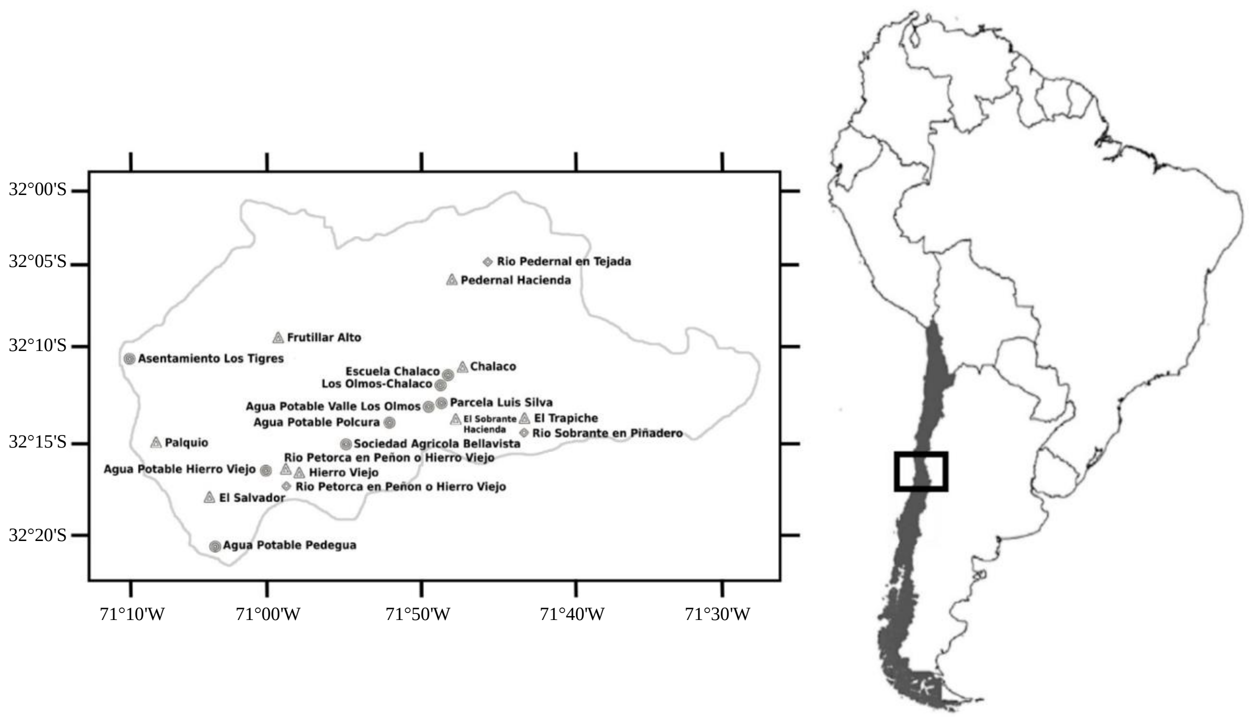


**Fig. 1:** Spatial distribution of the meteorological stations (∆), groundwater monitor wells (○) and flow monitor stations (◊) that were used in the study

**Table 1:** Geographic characteristics and details of the weather station sites used in the study.

| Nº | Station | BNA Code | Latitude (S) | Longitude (W) | Elevation (m.a.s.l.) | Observation Period | Observation (n) | Observation missing data | Min. (mm) | Max. (mm) | Mean (mm) | Std. deviation (mm) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Chalaco | 05101006-K | 32°10'44" | 70°47'15" | 880 | 1962-2018 | 662 | 22 | 0 | 323.900 | 17.98036 | 36.47819 |
| 2 | El Salvador | 05111004-8 | 32°18'23" | 71°04'38" | 340 | 1972-2018 | 529 | 35 | 0.000 | 338.900 | 20.199 | 39.154 |
| 3 | El Sobrante Hacienda | 05100006-4 | 32°13'46" | 70°47'41" | 810 | 1957-2018 | 866 | 34 | 0.000 | 323.900 | 17.136 | 33.041 |
| 4 | El Trapiche | 05100005-6 | 32°13'45" | 70°44'15" | 1180 | 1962-2018 | 640 | 44 | 0.000 | 346.000 | 18.555 | 35.711 |
| 5 | Frutillar Alto | 05111002-1 | 32°08'58" | 70°59'53" | 780 | 1979-2018 | 461 | 19 | 0.000 | 497.500 | 22.338 | 49.518 |
| 6 | Hierro Viejo | 05110003-4 | 32°16'53" | 70°58'37" | 440 | 1978-2018 | 472 | 20 | 0.000 | 343.000 | 16.282 | 35.550 |
| 7 | Palquico | 05111001-3 | 32°5'10" | 71°08'19" | 450 | 1972-2018 | 542 | 22 | 0.000 | 407.000 | 21.210 | 43.872 |
| 8 | Pedernal Hacienda | 05101005-1 | 32°05'34" | 70°47'56" | 1100 | 1962-2018 | 629 | 55 | 0.000 | 461.100 | 21.134 | 48.779 |
| 9 | Rio Petorca en Peñon o Hierro Viejo | 05110002-6 | 32°16'43" | 70°59'20" | 450 | 2003-2018 | 173 | 19 | 0.000 | 117.000 | 10.277 | 20.375 |

**Table 2:** Geographic characteristics and details of the monitoring wells sites used in the study.

| Nº | Station | BNA Code | Latitude (S) | Longitude (W) | Elevation (m.a.s.l.) | Observation Period | Observation (n) | Min. (m) | Max. (m) | Mean (m) | Std. deviation (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Agua Potable Hierro Viejo | 05110005-0 | 32°16'51" | 71°00'45" | 403 | 1995-2018 | 111 | 0 | 10.720 | 3.285 | 1.515 |
| 2 | Agua Potable Polcura | 05110004-2 | 32°14'01" | 70°52'13" | 556 | 1995-2018 | 76 | 0.000 | 15.800 | 3.520 | 2.394 |
| 3 | Agua Potable Valle Los Olmos | 05100008-0 | 32°13'04" | 70°49'11" | 753 | 1995-2017 | 47 | 0.000 | 6.170 | 2.259 | 1.700 |
| 4 | Asentamiento Los Tigres | 05120011-K | 32°20'03" | 71°18'24" | 0 | 1997-2018 | 71 | 0.000 | 13.870 | 3.989 | 3.571 |
| 5 | Asentamiento Los Tigres 2 | 05120007-1 | 32°10'15" | 71°10'10" | 0 | 1995-2018 | 82 | 0.000 | 13.170 | 2.981 | 2.298 |
| 6 | Escuela Chalaco | 05100010-2 | 32°11'14" | 70°48'16" | 775 | 1996-2018 | 66 | 0.000 | 14.200 | 4.306 | 2.452 |
| 7 | Los Olmos-Chalaco | 05101007-8 | 32°11'50" | 70°48'44" | 688 | 1995-2018 | 114 | 0.000 | 14.230 | 5.025 | 3.260 |
| 8 | Parcela Luis Silva | 05100009-9 | 32°12'60" | 70°48'43" | 770 | 1995-2018 | 121 | 0.000 | 7.260 | 4.901 | 1.402 |
| 9 | Sociedad Bellavista Agricola | 05110006-9 | 32°15'14" | 70°55'16" | 580 | 1995-2018 | 100 | 0.000 | 5.940 | 2.607 | 1.139 |

**Table 3:** Geographic characteristics and details of the flow monitoring sites used in the study.

| Nº | Station | BNA Code | Latitude (S) | Longitude (W) | Elevation (m.a.s.l.) | Observation Period | Observation (n) | Observation missing data | Min. ($m^3/s$) | Max. ($m^3/s$) | Mean ($m^3/s$) | Std. deviation ($m^3/s$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Río Pedernal en Tejada | 05101001-9 | 32°04'31" | 70°45'29" | 1080 | 1984-2018 | 338 | 82 | 0.000 | 4.810 | 0.285 | 0.560 |
| 2 | Río Petorca en Peñon o Hierro Viejo | 05110002-6 | 32°16'43" | 70°59'20" | 450 | 1979-2018 | 407 | 73 | 0.000 | 22.700 | 1.296 | 2.795 |
| 3 | Río Sobrante en Piñero | 05100001-3 | 32°13'45" | 70°42'59" | 1300 | 1962-2018 | 639 | 45 | 0.060 | 13.630 | 0.956 | 1.371 |

### *The Mann-Kendall Test*

The Mann-Kendall test is a non-parametric test based on the rank correlation that allows to evaluate the meaning of a trend. In addition, the null hypothesis states that the data of a time series are independent and identically distributed (Mann, 1945; McLeod, 2005). The Mann-Kendall test statistic(S) of a sample is calculated as:

$$S = \sum_{i=1}^{n-1} \sum_{j=t+1}^{n} \operatorname{sgn}\left(x_j - x_i\right) \quad (1)$$

where:

$$\operatorname{sgn}\left(x_j - x_i\right) = \begin{cases} +1, \left(x_j - x_i\right) > 0 \\ 0, \left(x_j - x_i\right) = 0 \\ -1, \left(x_j - x_i\right) < 0 \end{cases} \quad (2)$$

When the sample has a large sizes ($n \geq 40$), the standard deviation presents an asymptotically normal distribution. In this context, mean of0 and variance is computed as:

$$Var(S) = \frac{n(n-1)(2n+5) - \sum_{i=1}^{m} t_i \left(t_i - 1\right)\left(2t_i + 5\right)}{18} \quad (3)$$

Finally, the standard normal distribution ($Z$) is a normal distribution with a mean of 0 and a standard deviation of 1, it can be computed as follows:

$$Z = \begin{cases} \dfrac{S-1}{\sqrt{Var(S)}}, if\ S > 0 \\ 0, if\ S = 0 \\ \dfrac{S+1}{\sqrt{Var(S)}}, if\ S < 0 \end{cases} \quad (4)$$

The ascending tendencies are represented by a positive value of *Z*, while the descending ones are represented by a negative value of *Z*.

### *Sen's Slope*

Sen's slope estimator is a nonparametric procedure that estimates changes per unit of time in a series when a linear trend exists in it. It is used to estimate the slope in a univariate and nonparametric time series. In this context, when your trend analysis gives you a significant trend (positive or negative) Sen's slope is then to capture the magnitude of that trend (Kahya and Kalayci, 2004; Sen, 1968). For N data pairs, Sen's slope is estimated as follows:

$$Q_i = \frac{x_j - x_k}{j - k} \ for\ i = 1, 2, 3, ..., N \quad (5)$$

where, $x_j$ and $x_k$ are data at times *j* and *k* (*j*>*k*), respectively.

## Result and Discussion

Table 4 to 6 shows the results obtained to perform an analysis using the Mann Kendall method and Sen's slope. The results vary depending on the events recorded. Statistical analysis results from meteorological stations with a range of observation of events between 1962 and 2018 indicate that it cannot be rejected that there is no trend in the series. No station gave indications that the precipitation events have suffered a positive or negative trend over time. The highest rainfall events were recorded in the 80s. Also, the biggest magnitude events were recorded in July 1987, obtaining 497.5 mm in the Frutillar Alto station. Evaluating all the stations it can be indicated that the average total maximum precipitation is 351 mm, the average total precipitation is 18 mm and the average total standard deviation is 38 mm. The results obtained indicate that the study area has a significant variability. Although they are currently experiencing water shortage, they should be prepared for unusual precipitation events. The monitoring station with the highest number of observation data is El Sobrante Hacienda with 866 events. In addition, Rio Petorca en Peñon o Hierro Viejo station has the lowest number of registered events (173). This is explained by the fact that the monitoring range of each station is shorter in comparison with the other stations. The total average of recorded events is 553 per station. On the contrary, Pedernal Hacienda station has higher missed events (55). Also, the station with a lower quantity of missing events is Frutillar Alto and Rio Petorca en Peñon o Hierro Viejo, both with 19 events. The total average of missing events is 30 per station.

In the same way, the results of the statistical analysis of well stations with the range of event observations between 1995 and 2018 indicate that only four out of nine monitoring stations have a positive trend. Nevertheless, it was interrupted by a relatively abrupt decrease in each station. The results indicate that water levels are rising. However, the magnitude of that trend (slope of Sen) is minimal (a factor of $10^{-4}$). On the contrary, the other five stations do not show a positive or negative trend. The results could indicate that the measures imposed by the government could be having a positive impact on some stations. However, between 2014 and 2015 in all monitoring stations there is a period in which the groundwater level undergoes a drastic change, obtaining zero values. In some stations, the record remains constant until 2017 (Fig. 2). It is unusual that before drought events, there was a positive trend in the water levels. The most significant magnitude events were recorded in October 2017, obtaining 15.8 m at the Agua Potable Polcura station. Evaluating all the stations it can be indicated that the average total maximum water level is 11.26 m, the average total water level is 3.65 m and the average total standard deviation is 2.91 m. The results indicate that the study area has significant variability in water level, evidenced by the average and standard deviation results. The monitoring station with the highest number of observation data is Parcela Luis Silva with 121 events. On the other hand, Agua Potable Valle Los Olmos station has the lowest number of registered events (47). The stations have similar monitoring ranges, evidencing concise monitoring practices. The total average of recorded events is 86 per station. Water levels are monitored sporadically without having been previously programmed in the calendar.

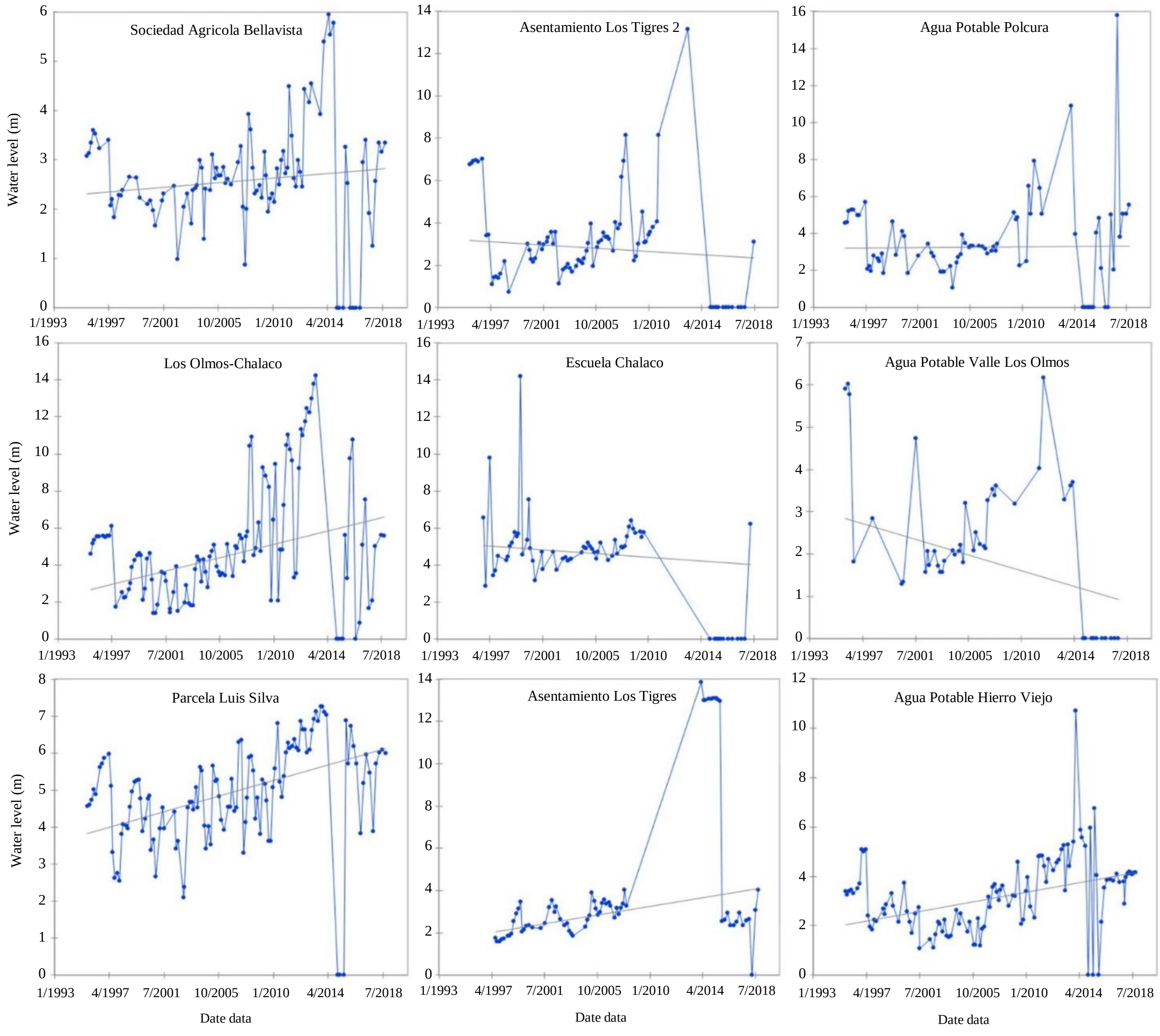


**Fig. 2:** Seasonal variation of ground water level at the commune of Petorca. Sen's slope is represented with a grey line in each plot

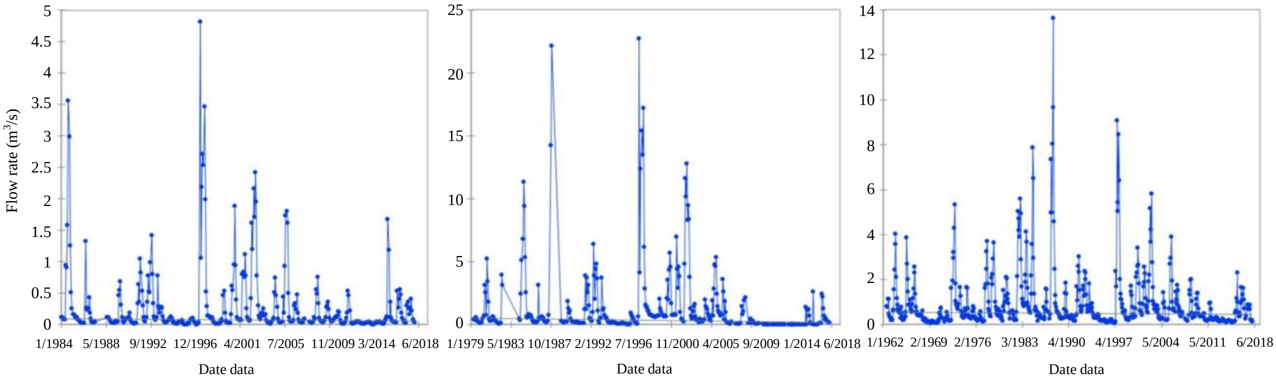


**Fig. 3:** Seasonal variation of flow rate at the commune of Petorca. Sen`s slope is represented with a grey line in each plot

**Table 4:** Results of the statistical tests of the weather station sites.

| Nº | Station | Kendall's tau | S | Var(S) | p-value (Two-tailed) | alpha | Sen's slope | Sen's interept | Trend |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Chalaco | -0.019 | -3.67E+03 | 2.91E+07 | 0.497 | 0.05 | -6.19E-06 | 1.83 | No |
| 2 | El Salvador | -0.013 | -1.58E+03 | 1.41E+07 | 0.675 | 0.05 | -3.09E-06 | 0.13 | No |
| 3 | El Sobrante Hacienda | -0.007 | -2.17E+03 | 6.55E+07 | 0.789 | 0.05 | -4.23E-06 | 2.13 | No |
| 4 | El Trapiche | 0.002 | 3.90E+02 | 2.64E+07 | 0.940 | 0.05 | -3.60E-06 | 2.10 | No |
| 5 | Frutillar Alto | -0.031 | -2.89E+03 | 9.63E+06 | 0.352 | 0.05 | 0.00E+00 | 1.00 | No |
| 6 | Hierro Viejo | -0.028 | -2.70E+03 | 1.03E+07 | 0.399 | 0.05 | 0.00E+00 | 0.05 | No |
| 7 | Palquico | -0.008 | -1.07E+03 | 1.59E+07 | 0.788 | 0.05 | -1.17E-05 | 1.42 | No |
| 8 | Pedernal Hacienda | 0.040 | 6.93E+03 | 2.47E+07 | 0.163 | 0.05 | -3.04E-06 | 0.62 | No |
| 9 | Rio Petorca en Peñon o Hierro Viejo | -0.081 | -1.10E+03 | 5.41E+05 | 0.136 | 0.05 | 0.00E+00 | 0.20 | No |

**Table 5:** Results of the statistical tests of the monitoring wells sites

| Nº | Station | Kendall's tau | S | Var(S) | p-value (Two-tailed) | Alpha | Sen's slope | Sen's interept | Trend | +/- |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Agua Potable Hierro Viejo | -0.019 | -3.67E+03 | 2.91E+07 | 0.497 | 0.05 | -6.19E-06 | 1.83 | No | |
| 2 | Agua Potable Polcura | 0.310 | 1.89E+03 | 1.54E+05 | <0.0001 | 0.05 | 2.49E-04 | -6.66 | Yes | + |
| 3 | Agua Potable Valle Los Olmos | -0.126 | -1.33E+02 | 1.18E+04 | 0.224 | 0.05 | -2.39E-04 | 11.23 | No | |
| 4 | Asentamiento Los Tigres | 0.360 | 8.93E+02 | 4.06E+04 | <0.0001 | 0.05 | 2.65E-04 | -7.39 | Yes | + |
| 5 | Asentamiento Los Tigres 2 | -0.068 | -2.23E+02 | 6.21E+04 | 0.373 | 0.05 | -9.77E-05 | 6.59 | No | |
| 6 | Escuela Chalaco | -0.105 | -2.23E+02 | 3.25E+04 | 0.218 | 0.05 | -1.31E-04 | 9.70 | No | |
| 7 | Los Olmos-Chalaco | 0.221 | 1.42E+03 | 1.67E+05 | 0.001 | 0.05 | 4.65E-04 | -13.58 | Yes | + |
| 8 | Parcela Luis Silva | 0.337 | 2.44E+03 | 1.99E+05 | <0.0001 | 0.05 | 2.72E-04 | -5.67 | Yes | + |
| 9 | Sociedad Bellavista Agricola | 0.108 | 5.33E+02 | 1.13E+05 | 0.113 | 0.05 | 6.06E-05 | 0.19 | No | |

**Table 6:** Results of the statistical tests of the flow monitoring sites

| Nº | Station | Kendall's tau | S | Var(S) | p-value (Two-tailed) | alpha | Sen's slope | Sen's interept | Trend | +/- |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Río Pedernal en Tejada | -0.093 | -6.82E+03 | 6.50E+06 | 0.007 | 0.05 | -2.77E-06 | 0.181 | Yes | - |
| 2 | Río Petorca en Peñon o Hierro Viejo | -0.205 | -1.67E+04 | 7.50E+06 | <0.0001 | 0.05 | -2.14E-05 | 1.101 | Yes | - |
| 3 | Río Sobrante en Piñero | -0.052 | -1.05E+04 | 2.86E+07 | 0.049 | 0.05 | -4.98E-06 | 0.658 | Yes | - |

In addition, the flow rate records obtained from the monitoring stations show that all stations have a negative trend. Moreover, null flow rate values were recorded from 2009 to 2016 approximately (Fig. 3). Evaluating all the stations it can be indicated that the average total maximum flow rate is 22 $m^3/s$, the average total flow rate is 0.85 $m^3/s$ and the average total standard deviation is 1.57 $m^3/s$. In this context, a higher standard deviation indicates that more of the data are more spread out. The monitoring station with the highest number of observation data is Río Sobrante en Piñero with 684 events. In addition, Río Pedernal en Tejada station has the lowest number of registered events (420). The total average of recorded events is 461 per station. On the contrary, Río Pedernal en Tejada station has the higher missed events (82). Also, the station with the lower quantity of missing events is Río Sobrante en Piñero with 45 events. The total average of missing events is 67 per station. Accordingly, the monitoring data stated that the groundwater levels and flow rate values have been getting a predominantly negative trend for 5 years. In this context, drought events do not correlate with rainfall events because the precipitation records do not show a trend, indicating that there has been no significant variation over time. Consequently, the events of groundwater level and flow rate decrease could be caused by human activities because there is no dramatic change in rainfall over the years. The result proves water stress conditions that the community has been living in.

*The Limitations of the Study*

Although we used a Government database to obtain all the data for each station, the information about the methodology used to register data in each station is unknown. We applied to government information requests for methodology Information, but we did not get the necessary information. Likewise, there is no reliable information about the operating time of each station. In other words, it is unknown why they closed some stations. This information is necessary to analyze the data more reliably.

## Conclusion

This study showed that rainfall events do not have a positive or negative trend, indicating that significant changes are not perceived over time. In addition, all well monitoring stations have significant changes in groundwater levels since 2014, obtaining zero values. However, four well monitoring stations have a positive trend, meaning that government practices could be helping in the recovery of groundwater levels. In addition, all flow monitoring sites have a negative trend. In other words, the measurement values will decrease in the future, increasing the water resource problems.

The statistical analyses indicate that Petorca has experienced significant variability in the magnitudes of water level and flow rate over time. Moreover, precipitation events with a greater magnitude were registered 40 years ago. In this context, Petorca has been experiencing a negative impact on its water resources for several years ago. Consequently, it has been observing that the water level monitoring stations a significant variation in the measurement since 2014, registering null values. Therefore, if we consider that there are no significant changes in precipitation events, but they do exist in surface and groundwater levels. It indicates that human activities in the area have generated an impact on water resources, or the cause of water scarcity is more complex than we think. Either way, the present study demonstrates through a statistical analysis of the flow rate that groundwater levels have been negatively affected, indicating the state of water scarcity experienced by the inhabitants. As a result, it is necessary that public authorities decree-laws and execute inspections to regulate and promote the correct use of water.

## Author's Contributions

**Héctor L. Venegas-Quiñones:** Conceived the study and drafted the introduction and discussion, led data processing, statistical analyses and drafted the methods and results.

**Mark Thomasson and Pablo A. Garcia-Chevesich:** Conceived the study and drafted the introduction and discussion, significantly to the introduction and discussion.

All authors contributed to the study design, read and edited the manuscript, and approved the final version.

## Ethics

This article is original and contains unpublished material. The corresponding author confirms that all of the other authors have read and approved the manuscript and no ethical issues involved.

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