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CHANGES IN SOIL CHEMICAL AND PHYSICAL PROPERTIES AFTER A FLOODING EVENT IN CHILE

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Abstract.

During the winter of 2023, ridges were made to plant French prunes (Prunus domestica). After building the ridges, the soil was surveyed using gamma radiation technology (SoilOptix technologies, Ontario, CA). Due to the intense rains that occurred at the end of august 2023, the Cachapoal River, the main water supply of the O'Higgins region, left its course and flooded several fields, including the one where the ridges had been built, destroying them. Ridges were washed out and sediments were left on top of them. After the flooding ridges were rebuilt to recover their height and shape. To study the changes on soil quality caused by the flooding a new detailed soil survey was performed in October 2023 using the same mapping technology. An area of approximately 12 ha was surveyed. Detailed soil maps (3 x 3 m) of soil properties before and after flooding were produced and absolute percent change over the original situation were calculated. There were important changes on soil properties with the flooding which varied from 3 to 96% for Ca saturation and extractable S, respectively. Flooded caused a decrease in the following soil properties: K extractable > gamma radiation > loamability > Cu-DTPA> S extractable > silt > leakability > clay > available N > effective CEC > Zn-DTPA > exchangeable Ca, and organic matter, among others. On the other hand, the following properties increased with flooding: sand > Olsen P > pH. After identifying the changes, chemical, organic and microbiological amendments were made before planting to achieve an adequate plant growth.

Keywords.
flooding, soil properties, gamma radiation, changes, soil quality.

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Introduction

Chile currently has, approximately, 353,000 hectares of fruit plantations (ODEPA-CIREN, 2021). To obtain high-quality fruit production, well-drained soils are needed, with an effective depth of about one meter. Besides, soils should have near neutral pH, low electrical conductivity (<1 dS m^{-1}), good organic matter content, and a proper sum of bases and CEC (Vidal, 2019). However, many soils devoted to fruit production present limiting factors that must be corrected before planting (Ortega, 2015). These factors may be physical: shallow soils, clay texture, drainage problems, etc. or chemical: low pH, low organic matter content, P and K deficiencies, etc. To improve the soils before planting, an intensive soil preparation is usually performed, and ridges are built, with the main objective of improving soil drainage and assuring a proper soil depth. The height of the ridges varies between 50 to 80 cm with a base of 1.5 to 2 m (Carrasco, 2010). Chemical and organic amendments are usually performed at this stage (Ortega, 2015).

Ridge construction provokes changes in soil quality, which have been studied by Poblete and Ortega (2022), using the proximal sensor SoilOptix. Results have shown that important changes in Soil Organic Matter are produced, along with nutrient content levels, which may be positive or negative. Meteorological events such as flooding alter soil quality by washing the ridges and depositing sand and silt particles on soil surface. The present study had the objective of evaluating the changes in soil quality after a flooding event.

Materials and methods

2.1 Location

The study was performed in Peumo commune (Rapel Valley, Chile) located at the coordinates 34°19'34.92'' South and 71°15'23.67'' West. The study area corresponds to a semi-arid, Mediterranean region, with a temperate climate. The soil belongs to the order Mollisol, which presents a silt loam texture, neutral pH, low organic matter content (~2%), and medium fertility. Temperatures are in the range of 5.5 to 27.6 ºC, while precipitation varies between 400 and 420 mm yr^{-1}.

2.2 Experimental design

A detailed soil mapping using SoilOptix technology ™ was performed at two times: 1) over bare soil after building the ridges and 2) after a flooding event that happened in august 2023. Twenty-nine soil layers were produced in each case and compared pixel to pixel.

Intense rains happened during the month of august 2023 accompanied by a zero-isotherm located above 3000 m a.s.l., which caused floods in different parts of the central area of the country.

2.3 Statistical analyses

Maps were produced at the same pixel size (3 x 3 m) for each evaluation time.

The changes in soil properties before and after the flooding were evaluated using the following analyses:

- Mean and coefficient of variation (CV) before and after flooding, mean change (%), and CV change (%).

$$\%change = \frac{(before - after)}{before} * 100$$

- Correlation analysis for each property before and after flooding

- RMSE and % change according to the following equations:

$$RMSE = \sqrt{\frac{\sum(before - after)^2}{n}}$$

$$\%\,RMSE\ change = \frac{RMSE}{before} * 100$$

Results and discussion

In absolute terms, the properties that, on the average, changed the most after the flooding, in decreasing order, were DTPA-Zn > EC > B > SOM. On the other hand, properties changing the less on the average, in increasing order, were Ca saturation, DTPA-Fe, and extractable S (Figure 1, Table 1). Flooded soils lost Zn and soil organic matter (SOM), and decreased EC, as soils were leached. On the other hand, soils gained sand and P (Table 1, Figures 1 and 2).
Overall, the field had losses in 22 out of the 28 soil properties measured (79%), while it had gains on 6 of them (21%). On the other hand, on the average, in absolute terms, losses were larger than gains (Figure 3).

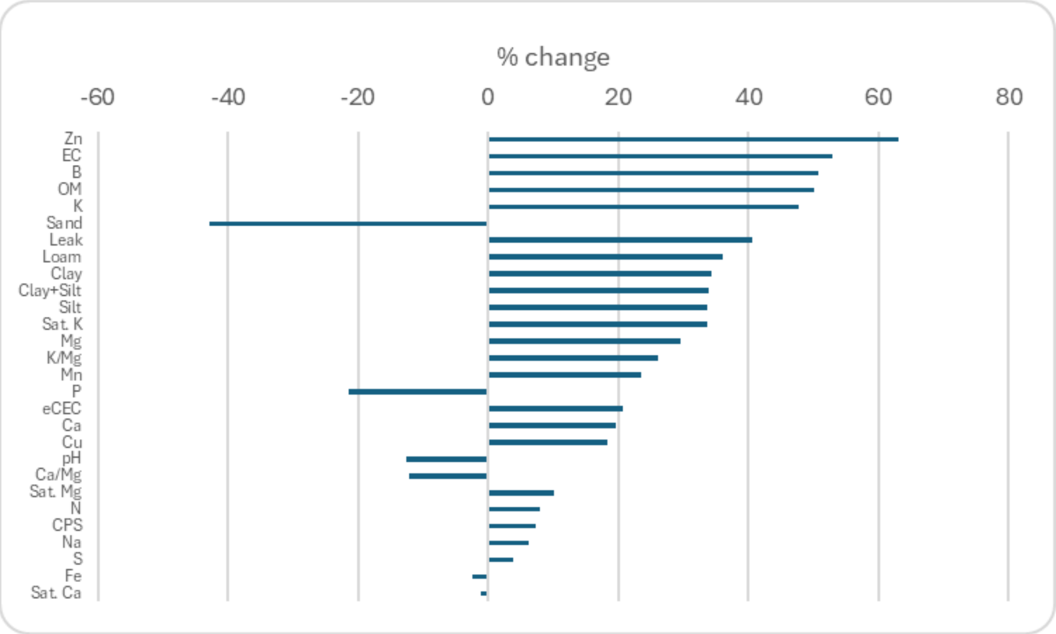

Figure 1. Gain and losses in soil properties due to the flooding event.

Table 1. Pixel to pixel change after flooding as estimated by % change and CV of that change.

Variable	Average	Std. Dev.	CV
	------------------------%	-------------------------	
DTPA-Zn (ppm)	63.1	14.9	23.5
EC (dS/m)	53.0	23.6	44.6
Extractable B (ppm)	50.8	15.5	30.5
SOM (%)	50.0	15.0	30.1
Extractable K (ppm)	47.7	9.8	20.5
Sand (%)	-42.9	27.5	-64.2
Leakability(unit)	40.5	14.7	36.2
Loamability(unit)	36.0	18.2	50.6
Clay (%)	34.3	28.0	81.6
Clay+Silt (%)	33.8	22.2	65.8
Silt (%)	33.7	20.5	61.0
Sat K(%)	33.6	7.9	23.4
Mg (cmol/kg)	29.6	8.4	28.2
K/Mg (unitless)	26.1	8.0	30.6
DTPA-Mn (ppm)	23.4	19.7	84.1
Olsen-P (ppm)	-21.4	42.2	-197.2
eCEC (cmol/kg)	20.8	15.8	76.2
Ca (cmol/kg)	19.7	17.8	90.8
DTPA-Cu (ppm)	18.3	14.0	76.9
pH (unit)	-12.7	3.0	-23.3
Ca/Mg (unitless)	-12.0	12.3	-101.9
Sat Mg (%)	10.0	7.1	70.5
Available N (ppm)	8.0	55.5	697.7
Counts per second ((1)/s)	7.4	4.7	63.8
Na (cmol/kg)	6.2	10.4	169.3
Extractable S (ppm)	3.9	192.2	4907.9
DTPA-Fe (ppm)	-2.5	24.7	-985.0
Sat Ca (%)	-1.1	2.9	-276.9

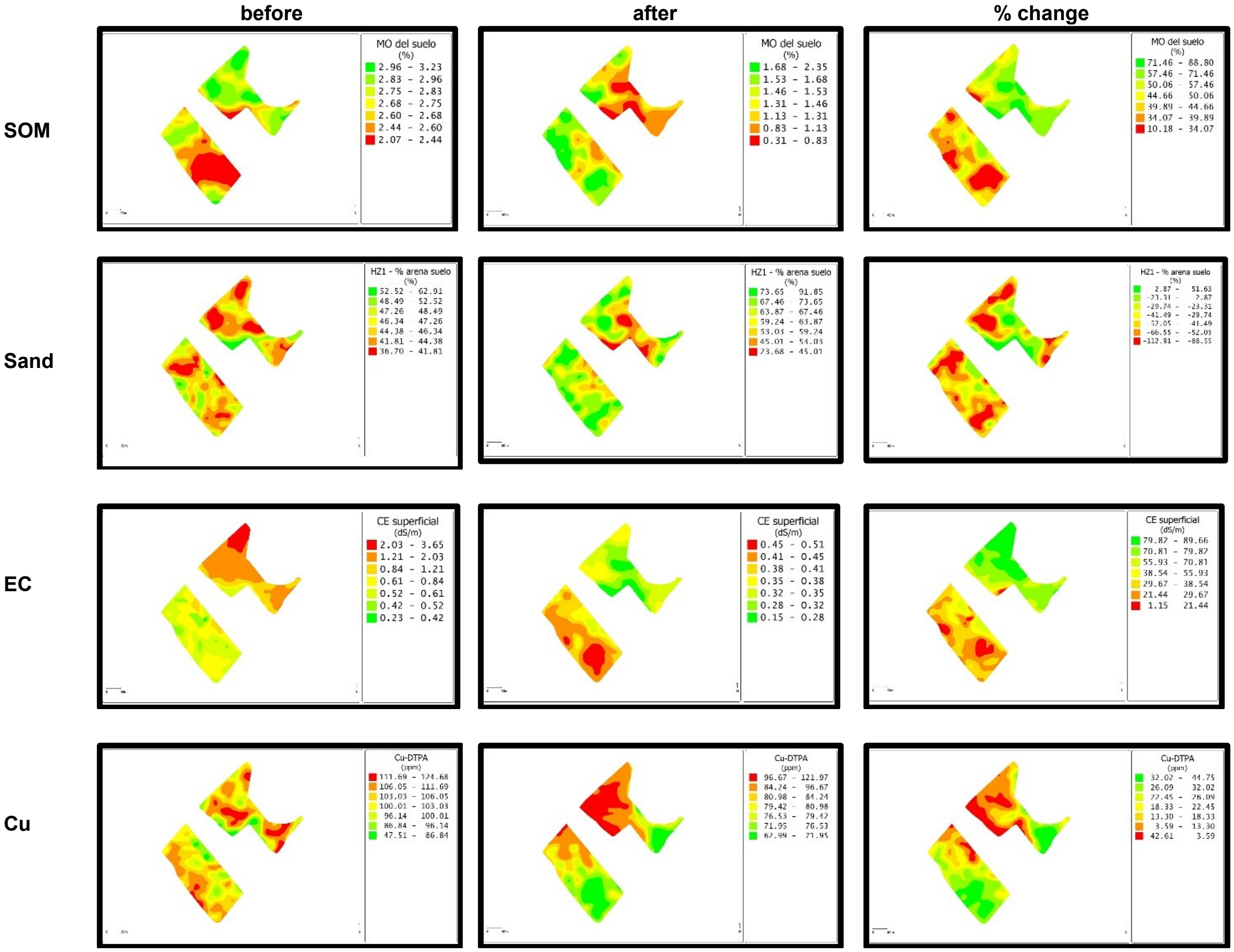

Figure 2. Change in selected soil properties after a flooding.

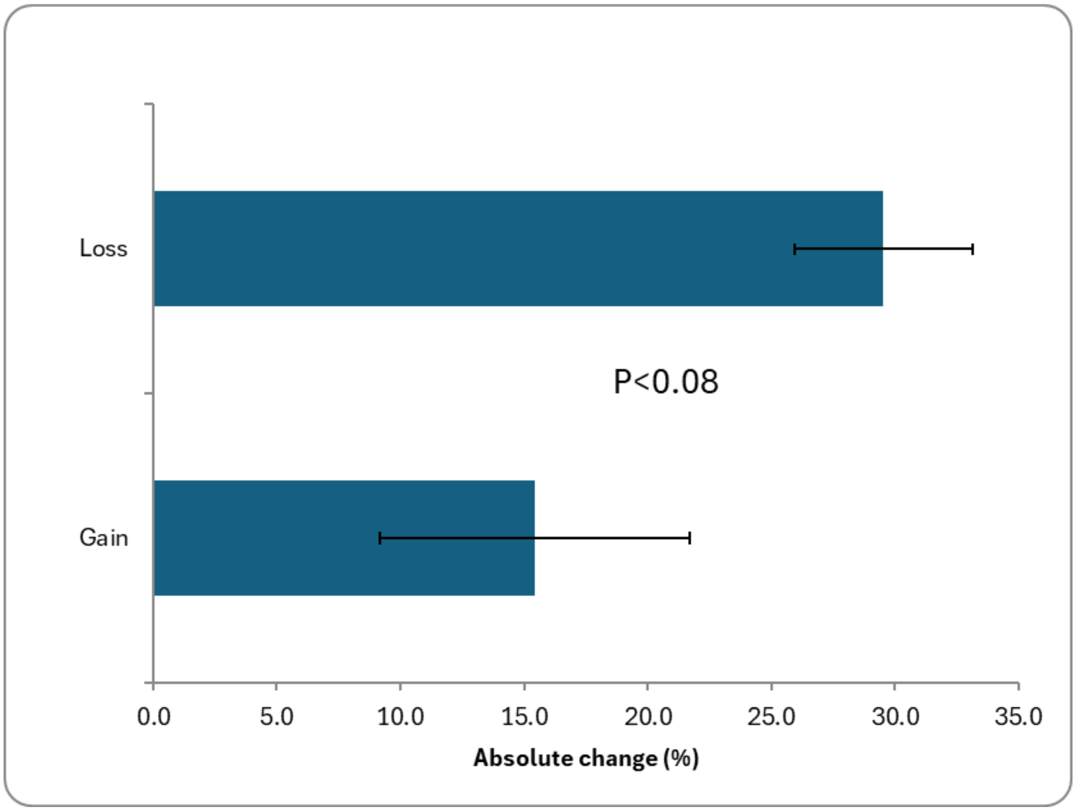

Figure 3. Average of gains and losses of the evaluated soil properties.

When using RMSE as change indicator, the order of magnitude of change among properties varied, with extractable S, EC, and available N changing the most, while Mg saturation, counts per second and Ca saturation varied the less (Table 2). However, a good relationship between absolute average change and RMSE change was observed, with available N and S as outliers (Figure 4).

Table 2. Pixel to pixel change after flooding as estimated by RMSE and % RMS change.

Soil property	MSE	RMSE	% RMSE change
Extractable S (ppm)	652.86	25.55	96.06
EC (dS/m)	0.83	0.91	88.64
Available N (ppm)	112.39	10.60	78.47
DTPA-Zn (ppm)	12.62	3.55	77.77
Extractable B (ppm)	0.59	0.77	55.77
SOM (%)	2.05	1.43	53.25
Extractable K (ppm)	11510.76	107.29	50.24
Sand (%)	0.08	0.28	50.24
Olsen-P (ppm)	501.41	22.39	49.44
Clay (%)	35.02	5.92	45.18
Leakability (unit)	32.03	5.66	44.46
Loamability (unit)	83.18	9.12	43.87
Clay + Silt (%)	660.20	25.69	40.94
Silt (%)	501.41	22.39	40.93
DTPA-Mn (ppm)	282.47	16.81	40.04
Sat K (%)	2.39	1.55	37.53
Mg (cmol/kg)	1.82	1.35	36.31
K/Mg (unitless)	0.30	0.55	31.01
Ca (cmol/kg)	0.01	0.09	28.96
eCEC(cmol/kg)	10.91	3.30	26.78
DTPA-Fe (ppm)	15.30	3.91	26.29
DTPA-Cu (ppm)	36.63	6.05	24.86
Ca/Mg (unitless)	587.74	24.24	23.46
Na (cmol/kg)-	3.64	1.91	16.33
pH (unit)	0.00	0.01	13.08
Sat Mg (%)	0.77	0.87	12.92
Counts per second ((1)/s)	2.32	1.52	12.71
Sat Ca (%)	6373.74	79.84	8.93

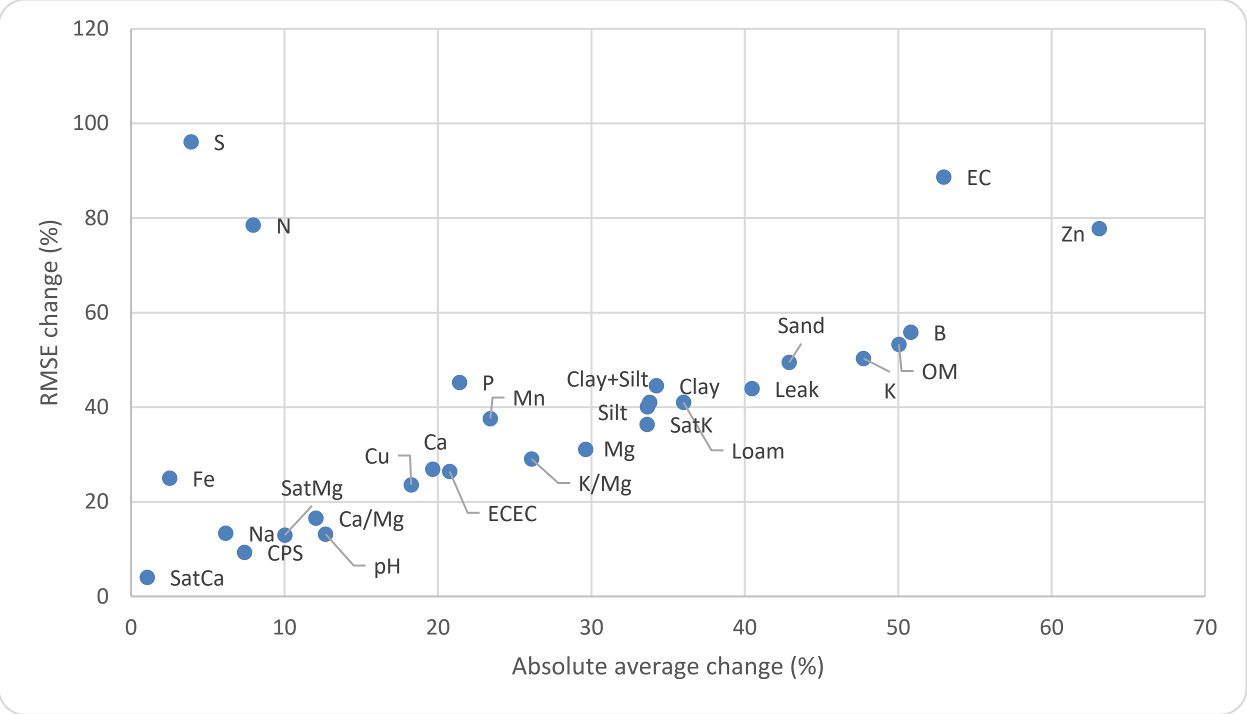

Figure 4. Relationship between absolute mean change and RMSE change.

Conclusions

Flooding caused by the Cachapoal river modified soil quality. Soil lost quality in most evaluated properties.

Percent change or RMSE change are equally efficient to determine pixel to pixel changes in soil properties.

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