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Research Note

Regression and correlation analyses between water chemical traits of acidity (pH) and electrical conductivity

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Experts and researchers in soil, plant and water science seek to understand the nature of the relationship between soil salinity and its effect on its acidity. Each plant has a tolerance range of salt and an ideal acidity level to live and grow in. 5 irrigation water samples were taken from 5 random sources in Zarqa, Jordan, in 2018 and 2019, where salinity and acidity were measured using specialized electronic probes. The regression and correlation analysis showed a weak dependency of irrigation water pH on total dissolved salts (TDS) to the point that it is a positively negligible relationship. The study recommends taking a large and random number of soil and irrigation water samples to confirm or deny this scientific observation.

Key words: acidity, conductivity, regression, salinity

INTRODUCTION

Modern science has proven a relationship between soil acidity (pH) and nutrients absorption and readiness for plants (Ketterings et al., 2005). Amacher et al., (2000) stated that nitrates, potassium and gypsum are essential nutrients for soil salinization. Other research conducted on crops demonstrates the effect of sodium chloride (NaCl) as a salinity agent on plants (Zhou et al., 2010). As in the case of acidity, salinity is detrimental for the growth of crops and there is a certain extent for both factors and for each plant that can support and produce the best yields. This scientific paper is a research note and is not about the effect of salinity and acidity on plant growth. Rather, it is about proving that that there is a weak mathematical relationship between salinity and acidity in irrigation water through which it is possible to predict (forecast) the amount of a change in a factor (water acidity) based on a change of the water salinity at least in a limited range of readings.

MATERIALS AND METHODS

Two electronic sensors (brand name Pancellent) were used to measure total dissolved salts (TDS in ppm) and the pH of water. Five random samples of water from different resources were collected in Jordan during 2018 and 2019 (Table 1).

Table 1. Five random water samples and their chemical traits

Sample No.	Source	Irrigation Water Salinity TDS (ppm)	Irrigation Water Acidity pH
1	Saline Well/Zarqa Area	1091	6.59
2	Distilled Water	29	6.88
3	Tap Water	372	7.6
4	Saline Well/Azraq Area	1908	7.53
5	Saline Well/Hashmyahh Area	1554	6.95

* TDS & EC meter was calibrated for the Hygro-Thermometer (EX-Tech). The temperature is only 1% different.
* pH meter is separate.

RESULTS AND DISCUSSION

Carlberg (2014) used to tabulate data using Excel (2013) as follows (Table 2):

Table 2. Excel (2013) data tabulation

Independent (TDS) ppm	Dependent (pH)	Mean of Xi	Mean of Yi	Xi-Mean	Yi-Mean	(Xi-µ)(Yi-µ)	(Xi-X)^2	(Yi-Y)^2
Xi	Yi	**X**	**Y**	**(Xi-X)**	**(Yi-Y)**	**(Xi-X)(Yi-Y)**		
1091	6.59	990.8	7.11	100.2	-0.52	-52.104	10040.04	0.2704
29	6.88	990.8	7.11	-961.8	-0.23	221.214	925059.24	0.0529
372	7.6	990.8	7.11	-618.8	0.49	-303.212	382913.44	0.2401
1908	7.53	990.8	7.11	917.2	0.42	385.224	841255.84	0.1764
1554	6.95	990.8	7.11	563.2	-0.16	-90.112	317194.24	0.0256
Total				**0**		**161.01**	**2476462.8**	**0.7654**

X: Mean of Xi, Y: Mean of Yi

Excel used the following formulas (table 3):

Correlation = COV/STD (X)*STD (Y)

Standard Deviation = σ

Covariance (COV) = (Xi-X)(Yi-Y)/n-1 (n-1 for sample not population, n for population).

STD = σ = √Var or (Var)^0.5

Variance (X) = Σ (Xi-X)^2/n-1 (n-1 for sample, n for population).

Variance (Y) = Σ (Yi-Y)^2/n-1 (n-1 for sample, n for population).

Table 3: Statistical analysis for data

Statistical Indicator	Value
Correlation	0.117
Covariance	40.2525
Standard deviation (Xi)	786.839056
Variance (Xi)	619115.7
Standard deviation (Yi)	0.43743571
Variance (Yi)	0.19135

Covariance (40.2525) is a measure of the relationship between two random variables in mathematics and statistics. The metric assesses how much variables change together (Table 3). In other words, this is essentially a measure of the variance between the two variables. The metric does not, however, assess the dependence between variables.

In statistics, any statistical association, whether causal or not, between two random variables or bivariate data is correlation or dependency. Correlation is a mathematical method that can explain when pairs of variables are related and how strongly. The correlation value (0.117) is defined as a positive correlation that is negligible. That is, the dependence of the pH of irrigation water on total dissolved salts (TDS) is so small that it is negligible in a positive way. In the next table, the value for correlation is Multiple (R) (0.116947978). Regression analysis as produced by Excel (2013) is shown in Table (4) that F (0.851437329) is more than (0.05). There is no important distinction and the null hypothesis is accepted (confidence is lower than 95 percent). P-value equals the meaning of F.

Null Hypothesis: H_0: There is no relationship between dependent factor (Y) and independent factor (X).

Alternative Hypothesis: H_a: There is a relationship between dependent factor (Y) and independent factor (X).

The dependent factor (pH irrigation water) is not significantly affected by an independent factor (water total dissolved salts). The best expectation of regression is the value of F. (0.041599437). The R-Square value (0.01367683) is very low, indicating that the variance in the dependent variable (irrigation water pH) due to the total water dissolved salts factor is very low. Also, the adjusted R-Square (-0.315097561) is the same as the R-Square, but after removing additional variables. Assume the adjusted R-Square is 0.99, which indicates that 99 percent of the variance in the dependent factor (Y) is

Table 4. Regression statistics and ANOVA using Excel (2013)

Summary output

Regression Statistics

Multiple R	0.116947978
R square	0.01367683
Adjusted R square	-0.315097561
Standard error	0.501641225
Observations	5

ANOVA

	Df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.010468245	0.010468245	0.041599437	0.851437329
Residual	3	0.754931755	0.251643918		
Total	4	0.7654			

SS: Sum of Squares, df: Degrees of Freedom, MS: Mean of Squares, F Significance

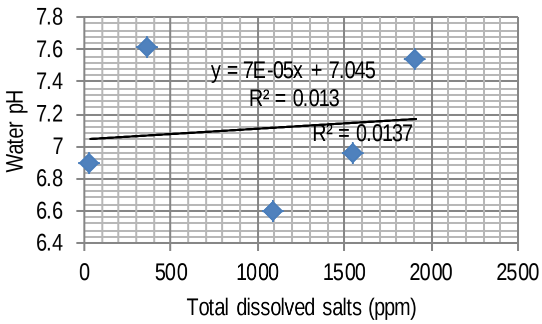
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	7.045582029	0.387404098	18.18664816	0.000362665	5.812689288	8.278475	5.812689288	8.27847477
X Variable 1	6.50161E-05	0.00031877	0.2039594	0.851437329	-0.000949452	0.001079	-0.000949452	0.001079484

explained by the independent factor after the removal of the additional variables. The most important part is coefficients (intercept and slope) which are used for forecasting the dependent factor (Y) in the future based on the value of the independent factor (X). Assume that X equals (4). Then, the intercept is (7.045582029), and slope (6.50161E-05). Thus, the value of Y (irrigation water pH) will be:

Y= a+bX

Y= 7.045842

If irrigation water has total dissolved salts of 4 ppm, then the water pH will be 7.045. Figure (1) shows the regression of irrigation water pH and water total dissolved salts (R^2=0.013).



CONCLUSION

It is possible to predict using regression analysis the existence of a negligible positive correlation between water acidity and salinity. The dependency of irrigation water pH on total dissolved salts (TDS) is so weak to the point that it is positively negligible. In any case, lengthy research is required on a huge number of samples of soils and irrigation water to devise the necessary relationship to prove this prediction.

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AUTHOR CONTRIBUTIONS

Mohunnad Massimi conducted the experiments, statistical analysis, writing an introduction, discussion, and presentation of results. Aseel Yahia organized the study and provided references for the introduction.

COMPETING INTERESTS

The author has declared that no competing interest exists.

ETHICS APPROVAL

Not applicable.

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