Evaluation of distilled water pH measurement with electrolyte methods in cultivated soils of Nepal

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ABSTRACT

Soil pH is most routinely measured parameter among all others in soil chemistry laboratory. There are various methods developed for pH measurement, although we using only distilled water from the beginning. In Nepal, there do not have database for showing performance of the methods. The three methods namely; H_2O, KCl and $CaCl_2$ with their soil:solution ratios (1:1, 1:2 and 1:2.5) were used. The total 115 samples were collected randomly at a depth of 0-20 cm from the hill and terai regions of Nepal. The collected samples were analyzed following mentioned methods, separately. The various statistical tests (F-test, mean separation, correlation, and regression model) were performed for comparison. Moreover, model validation parameters were also calculated for relating H_2O with electrolyte method. The three models linear, quadratic and cubic were used for this task. The result revealed the effect of methods on pH measurement was significantly different in the entire ratio. The pH_{H2O} was 0.57, 0.56 and 0.67 units higher than pH_{CaCl2} in 1:1, 1:2 and 1:2.5 ratios, respectively. Whereas, 1.24, 0.99 and 0.95 units higher than pH_{KCl} in respective ratio. Moreover, regarding timing to reach stable during measurement were in the order pH_{H2O} (89.44 sec) > pH_{CaCl2} (54.29 sec) > pH_{KCl} (33.08 sec). Similarly, relating modeling quadratic and cubic model showed nearly equal performance (lower RMSE, MAE and higher R^2 and d) for predicting pH_{CaCl2} and pH_{KCl} from the pH_{H2O} in each soil solution ratio. The determined database can be useful for comparing used three different methods of soil pH measurement under Nepalese context.

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1. Introduction

Soil pH is important chemical characteristic of soil that influences many physical, chemical and biological properties [1]. The crucial information relating nutrient availability, aluminum and heavy metal equilibria, organic matter decomposition, lime and gypsum requirement, and microbial activity can be determined from the soil pH. Soil chemists believe this as a “master variable” because it plays important role for controlling ion exchange, dissolution-precipitation, reduction-oxidation, adsorption and complexation reactions [2].

Soil pH measurement is a basic for all measurement in soil chemistry lab. In other word, this parameter is most commonly measured parameter among other test parameters. Soil pH is usually measured potentiometrically in a slurry system using an electronic pH meter [3]. There are various method developed for soil pH measurement [4]. The common methods used worldwide for soil pH determination are distilled water, 1N KCl, and 0.01M $CaCl_2$. The uses of different methods have different aspects for the measurement. White [5] and Kissel et al. [6] suggested electrolyte solution of $CaCl_2$ or KCl for soil pH measurement as it is less affected by soil salt concentration and thus provides a more consistent measurement for soils whose salt content may fluctuate as a result of seasonal conditions or crop residues. Slattery and Ronnfeldt [7] reported seasonal variation in pH_{H2O} for a particular soil from the field may be up to 0.6 unit in one year. But in the world, distilled water and 0.01 $CaCl_2$ is usually used for soil pH measurement [8].

In Nepal, most of the lab using distilled water as a measuring solution. Moreover, we do not thinking about other method that persist for measurement. There do not possess any study record relating relationship between different methods of pH measurement from soil. Considering this, we have done this work by relating two objectives as (i) compare and contrast soil pH methods; and (ii) develop a regression model relating the pH_{H2O} to the pH_{CaCl2} and pH_{KCl}.

2. Materials and Methods

2.1. Soil sampling

The total 115 samples were collected from the four sites namely; Thaha Municipality (Daman and Palung) of Makwanpur district and Shivaraj Municipality (Kharendrapur and Baraipur) of

Kapilvastu district during November, 2018 and February, 2019, respectively. The soil sampling area lies on both terai and hilly region of Nepal. The soil samples were collected at 0-20 cm depth using soil sampling auger.

2.2. Laboratory measurement

The collected samples were analyzed in the lab of National Soil Science Research Centre, Khumaltar, Lalitpur, Nepal. The three different solutions were used individually for analyzing all the samples in used methods (Tab. 1). Similarly, three different soil solution ratio namely; 1:1, 1:2 and 1:2.5 were used for study. For measurement digital bench-top pH meter was used. Each sample was replicated twice during measurement.

Table 1
Different methods and chemical used for soil pH determination in lab

SN	Method	Chemical	Standing time
1.	Distilled water	only distilled water (no use of any chemicals)	30 minutes
2.	0.01 M $CaCl_2$	Calcium chloride dihydrate (1.47 g/ltr)	30 minutes
3.	1 N KCl	Potassium chloride (74.56 g/ltr)	10 minutes

2.3. Statistical analysis

Data from each method was analyzed independently. Measurement methods were considered as a factor. R statistical software was used for analysis of variance and correlation. Significant means were separated using Least Significant Difference (LSD) Test as described by Gomez and Gomez [9]. The absolute value of correlation coefficient (r) was also categorized accordingly suggested by Evans (1996) as 0–0.19 (very weak), 0.20–0.39 (weak), 0.40–0.59 (moderate), 0.60–0.79 (strong) and 0.80–1.0 (very strong).

Similarly, three model techniques (linear, quadratic and cubic) were used to predict pH_{CaCl2} and pH_{KCl} from pH_{H2O}. To evaluate the performance of the models, we used the R^2 value (coefficient of determination) for determining variability on dependent factor due to independent factor, the RMSE (root mean squared error) to indicate the accuracy of the model, and the MAE (mean absolute error) to indicate the bias in the model. In addition to this, index of agreement (D) also calculated to determine relationship between observed and predicted value. The statistic tool used for testing model fit is calculated as:

RMSE=$\sqrt{\frac{1}{N}\sum_{i=1}^{N}(ypred - yobs)2}$; where smaller value of RMSE indicated better fit the model;

MAE =$\frac{1}{N}\sum_{i=1}^{N}|ypred - yobs|$; where positive value of MAE indicates over-prediction, while a negative value indicates under-prediction;

D=1- $\frac{\sum_{i=1}^{N}(ypred-yobs)2}{\sum_{i=1}^{N}|(ypred-yav)|+|(yobs-yav)|2}$; where higher value indicates better relationship between observed and predicted value [10], whereas, y_{pred}= predicted value; y_{obs}= observed value;

Goodness of Prediction Statics (G) =1- $\{\frac{\sum_{i=1}^{N}(ypred-yobs)2}{\sum_{i=1}^{N}(yobs-yav)2}\}$; where higher value indicates better relationship between observed and predicted value [10].

3. Results

3.1 Soil pH Distribution

The soil pH_{H2O} ranged from 4.09 to 8.78, 3.88 to 9.07 and 3.84 to 9.08, respectively for 1:1, 1:2 and 1:2.5 ratios. Similarly, soil pH_{CaCl2} varied from 3.74 to 7.81, 3.68 to 8.19, and 3.76 to 7.90, respectively for 1:1, 1:2 and 1:2.5 ratios. Moreover, soil pH_{KCl} ranged from 2.91 to 7.61, 3.16 to 7.82, and 3.22 to 7.97, respectively for 1:1, 1:2 and 1:2.5 ratios (Table 2; Table 3; Table 4). Furthermore,

distribution of pH due to methods in three soil solution ratio (1:1, 1:2 and 1:2.5) is shown in the Figure 1 to 3.

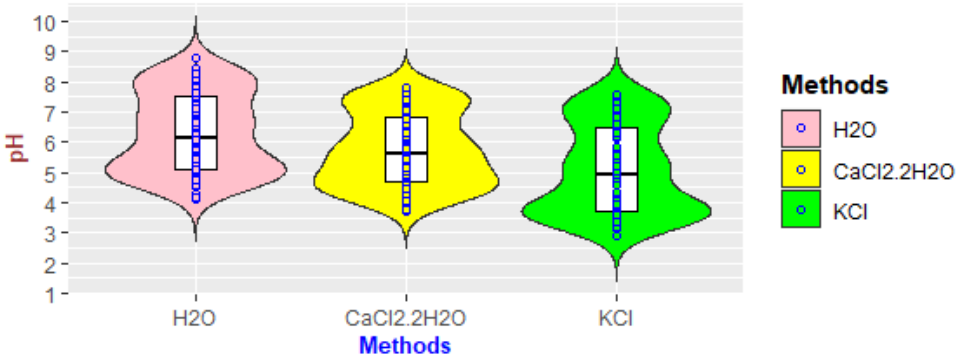

Figure 1. *Distribution of soil pH on different methods in 1:1 soil solution ratio*

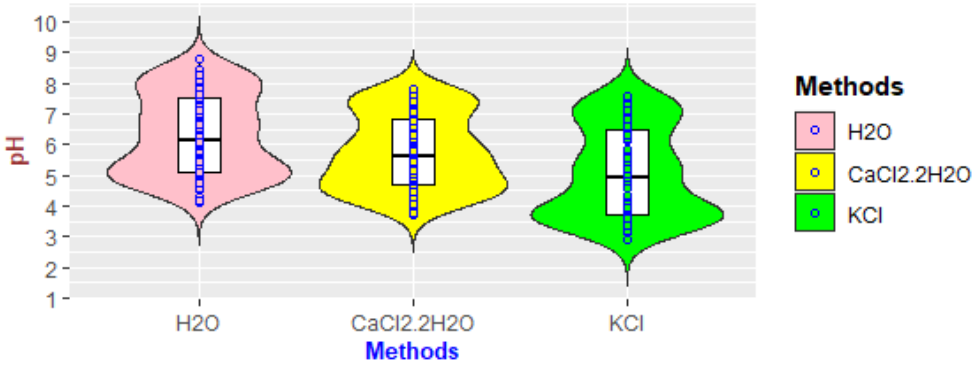

Figure 2. *Distribution of soil pH on different methods in 1:2 soil solution ratio*

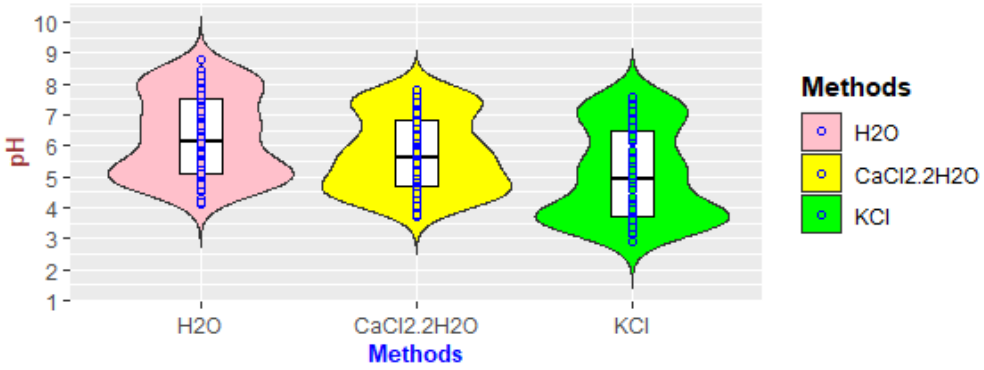

Figure 3*. Distribution of soil pH on different methods in 1:2.5 soil solution ratio*

3.2. Effect of methods on soil pH measurement for various pH range soils of Nepal

The data regarding effects of methods on pH measurement in three soil solution ratios (1:1, 1:2 and 1:2.5) are shown in Tab. 2 to 4. The effect of method was significantly difference for the soil pH measurement. The highest was determined by pH_{H2O}, followed by $pH_{CaCl2,}$ while lowest in pH_{KCl}. The pH_{CaCl2} (1:1) was 0.57 units lower than pH_{H2O} (1:1), while 1.24 units lower for pH_{KCl} (1:1). Similarly, pH_{H2O} (1:2) was 0.56 and 0.99 units higher than pH_{CaCl2} (1:2) and pH_{KCl} (1:2) measurement, respectively. Likewise, pH_{CaCl2} (1:2.5) and pH_{KCl} (1:2.5) was 0.67 and 0.95 units lesser than pH_{H2O} (1:2.5), respectively. The correlation between soil pH of all the methods was significantly very strong and positive in among all the ratios (Tab. 5).

Table 2

Effect of methods (1:1) on soil pH determination for various soils of Nepal

Methods	Soil pH	$\Delta pH_{H2O\ -CaCl2/KCl}$	Range
H_2O	6.31[a]	—	4.09-8.78
$CaCl_2.2H_2O$	5.74[b]	0.57	3.74-7.81
KCl	5.07[c]	1.24	2.91-7.61
LSD	0.34**	—	—
Grand Mean	5.70	—	—
CV%	23.29	—	—

Treatment means separated by Least Significance Difference (LSD) Test and columns represented with same letter (s) are not significantly different among each other at 5% level of significance, and vice-versa; ** means significant at the 1% probability levels; H_2O= Distilled water; $CaCl_2$= Calcium chloride; KCl= Potassium chloride

Table 3

Effect of methods (1:2) on soil pH determination for various soils of Nepal

Methods	Soil pH	$\Delta pH_{H2O\ -CaCl2/KCl}$	Range
H_2O	6.31[a]	-	3.88-9.07
$CaCl_2.2H_2O$	5.75[b]	0.56	3.68-8.19
KCl	5.32[c]	0.99	3.16-7.82
LSD	0.37**		
Grand Mean	5.79		
CV%	24.31		

Treatment means separated by Least Significance Difference (LSD) Test and columns represented with same letter (s) are not significantly different among each other at 5% level of significance, and vice-versa; ** means significant at the 1% probability levels; H_2O= Distilled water; $CaCl_2$= Calcium chloride; KCl= Potassium chloride

Table 4

Effect of methods (1:2.5) on soil pH determination for various soils of Nepal

Methods	Soil pH	$\Delta pH_{H2O\ -CaCl2/KCl}$	Range
H_2O	6.30[a]	-	3.84-9.08
$CaCl_2.2H_2O$	5.63[b]	0.67	3.76-7.90
KCl	5.35[b]	0.95	3.22-7.97
LSD	0.36**		
Grand Mean	5.76		
CV%	23.91		

Treatment means separated by Least Significance Difference (LSD) Test and columns represented with same letter (s) are not significantly different among each other at 5% level of significance and vice-versa; ** means significant at the 1% probability levels; H_2O= Distilled water; $CaCl_2$= Calcium chloride; KCl= Potassium chloride

Table 5

Pearson correlation coefficient (r) between various soil pH measurement methods

	H_2O (1:1)	$CaCl_2.2H_2O$ (1:1)	KCl (1:1)	H_2O (1:2)	$CaCl_2.2H_2O$ (1:2)	KCl (1:2)	H_2O (1:2.5)	$CaCl_2.2H2O$ (1:2.5)	KCl (1:2.5)
H_2O (1:1)	1								
$CaCl_2.2H_2O$ (1:1)	0.98**	1							
KCl (1:1)	0.99**	0.98**	1						
H_2O (1:2)	1**	0.97**	0.99**	1					
$CaCl_2.2H2O$ (1:2)	0.98**	0.97**	0.98**	0.98**	1				
KCl (1:2)	0.98**	0.98**	0.99**	0.98**	0.97**	1			
H_2O (1:2.5)	0.99**	0.97**	0.99**	1**	0.98**	0.98**	1		
$CaCl_2.2H_2O$ (1:2.5)	0.97**	0.97**	0.97**	0.97**	0.94**	0.98**	0.97**	1	
KCl (1:2.5)	0.98**	0.98**	1**	0.98**	0.98**	1**	0.98**	0.98**	1

* means correlation is significant at the 5% probability levels (2-tailed); ** means correlation is significant at the 1% probability level (2-tailed)

3.3. Effect of methods on soil pH determination (stable) timing under laboratory conditions

The data regarding effect of methods on soil pH measurement time (stable) are shown in Table 6. The effect of method was significantly difference for the soil pH measurement timing in lab. The highest time (89.44 sec) was taken by pH_{H2O}, while lowest time (33.08 sec) by pH_{KCl} method.

Table 6
Effect of methods on soil pH determination time under laboratory conditions

Methods	Time (sec)	$\Delta pH_{H2O\ -CaCl2/KCl}$	Range (sec)
H_2O	89.44[a]	-	48.82-136.89
$CaCl_2.2H_2O$	54.29[b]	35.15	31.81-76.03
KCl	33.08[c]	56.36	25.95-45.47
LSD	15.98**		
Grand Mean	58.94		
CV%	29.54		

Treatment means separated by Least Significance Difference (LSD) Test and columns represented with same letter (s) are not significantly different among each other at 5% level of significance and vice-versa; ** means significant at the 1% probability levels; H2O= distilled water; $CaCl_2$= Calcium chloride; KCl= Potassium chloride

3.4. Effect of models for relating distilled water (H_2O) with electrolytes ($CaCl_2$ and KCl) methods in 1:1 soil solution ratio

The studied all the regression model of the pH_{CaCl2} and pH_{KCl} on pH_{H2O} showed highly significant relationship (Tab. 7; Tab. 8; Fig. 4; Fig. 6). Regarding pH_{H20} vs. pH_{CaCl2}, quadratic and cubic model observed equal with highest R^2 (95.7) and D (0.99), but slightly lowest (by 0.01 units) RMSE (0.25) and MAE (0.19) in quadratic model. Whereas, linear regression model determined slightly lower R^2 (95.6) and D (0.98), while RMSE and MAE was comparatively higher. Similarly, for pH_{H20} vs. pH_{KCl}, cubic model observed highest R^2 (98.4), while quadratic model contained lowest RMSE (0.20) and MAE (0.15). But in linear model possessed slightly lower R^2 and D, while RMSE and MAE was comparatively higher. The index of agreement (D) was equal in quadratic and cubic model.

Based on all the measured statistical tools, quadratic model was slightly strong on power for forecasting pH_{CaCl2} and pH_{KCl} from pH_{H2O} (Fig. 5; Fig. 7), but cubic model also had nearly equal performance.

Table 7
Regression model $pH_{H2O\ (1:1)}$ Vs $pH_{CaCl2(1:1)}$

Model	Equation	R^2	RMSE	MAE	D	P value
Linear	pH_{CaCl2}= 0.12+0.89pH_{H2O}	95.6	0.35	0.29	0.98	<0.001
Quadratic	pH_{CaCl2}= 1.75+0.36pH_{H2O}+ 0.04 pH_{H2O}^2	95.7	0.25	0.19	0.99	<0.001
Cubic	pH_{CaCl2}=0.83+0.81pH_{H2O}-0.03pH_{H2O}^2+0.004pH_{H2O}^3	95.7	0.26	0.21	0.99	<0.001

R^2= Coefficient of determination; RMSE= Root Mean Square Error; MAE= Mean Absolute Error; D= Index of Agreement

Table 8
Regression model $pH_{H2O\ (1:1)}$ Vs $pH_{KCl(1:1)}$

Model	Equation	R^2	RMSE	MAE	D	P value
Linear	pH_{KCl}= -1.83+1.10pH_{H2O}	97.7	0.23	0.18	0.994	<0.001
Quadratic	pH_{KCl}= 1.14+0.132pH_{H2O}+ 0.075pH_{H2O}^2	98.2	0.20	0.15	0.995	<0.001
Cubic	pH_{KCl}=11.24-4.81pH_{H2O}+0.861pH_{H2O}^2-0.041pH_{H2O}^3	98.4	0.21	0.16	0.995	<0.001

R^2= Coefficient of determination; RMSE= Root Mean Square Error; MAE= Mean Absolute Error; D= Index of Agreement

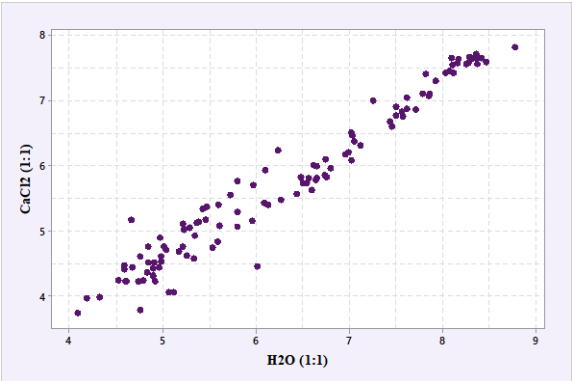

Figure 4. *Relationship between $CaCl_2$ (1:1) and H_2O (1:1) soil pH measurement*

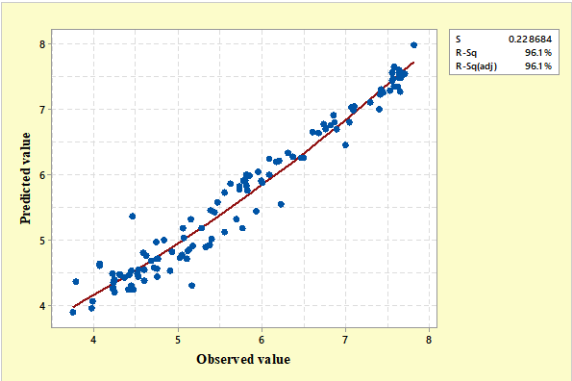

Figure 5. *Comparison of observed versus predicted pH_{CaCl2} (1:1) from quadratic model*

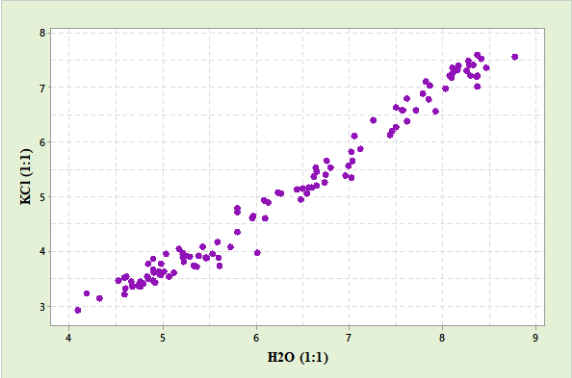

Figure 6. *Relationship between KCl (1:1) and H_2O (1:1) soil pH measurement*

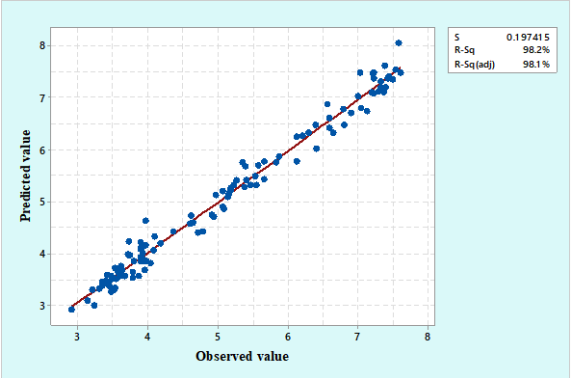

Figure 7. *Comparison of observed versus predicted pH_{KCl} (1:1) from quadratic model*

3.5. Effect of models for relating distilled water (H_2O) with electrolyte ($CaCl_2$ and KCl) methods in 1:2 soil solution ratio

The studied all the regression model of the pH_{CaCl2} and pH_{KCl} on pH_{H2O} showed highly significant relationship (Tab. 9; Tab. 10; Fig. 8; Fig. 10). Regarding pH_{H20} vs. pH_{CaCl2}, cubic model possessed lowest RMSE (0.23) and highest R^2 (97.2) and D (0.993). On the other hand, linear and quadratic model contained similar R^2 (96.7) and RMSE (0.25). The quadratic and cubic model contained equal MAE (0.18). Similarly, for pH_{H20} vs. pH_{KCl}, cubic and quadratic model observed lowest and equal RMSE (0.25), but slightly highest (by 0.01 units) R^2 (96.7) was determined in cubic model. Whereas, lowest MAE (0.19) was determined in quadratic model. For studied all the cross-validation parameter linear model showed comparatively weak performance.

Considering the entire cross-validation factor cubic model showed consistent result for forecasting pH_{CaCl2} and pH_{KCl} from pH_{H2O} (Fig. 9; Fig. 11), but quadratic model also had nearly equal performance.

Table 9
Regression model $pH_{H2O\ (1:2)}$ Vs $pH_{CaCl2(1:2)}$

Model	Equation	R^2	RMSE	MAE	D	P value
Linear	pH_{CaCl2}=-0.003+0.912pH_{H2O}	96.7	0.25	0.19	0.991	<0.001
Quadratic	pH_{CaCl2}=0.702+0.68pH_{H2O}+ 0.018pH_{H2O}^2	96.7	0.25	0.18	0.992	<0.001
Cubic	pH_{CaCl2}=11.86-4.81pH_{H2O}+0.892pH_{H2O}^2-0.045pH_{H2O}^3	97.2	0.23	0.18	0.993	<0.001

R^2= Coefficient of determination; RMSE= Root Mean Square Error; MAE= Mean Absolute Error; D= Index of Agreement

Table 10
Regression model $pH_{H2O\ (1:2)}$ Vs $pH_{KCl(1:2)}$

Model	Equation	R^2	RMSE	MAE	D	P value
Linear	pH_{KCl}=-0.271+0.887pH_{H2O}	95.2	0.29	0.24	0.988	<0.001
Quadratic	pH_{KCl}= 3.46-0.335pH_{H2O}+ 0.095pH_{H2O}^2	96.6	0.25	0.19	0.991	<0.001
Cubic	pH_{KCl}=6.66-1.91pH_{H2O}+0.345pH_{H2O}^2-0.013pH_{H2O}^3	96.7	0.25	0.20	0.991	<0.001

R^2= Coefficient of determination; RMSE= Root Mean Square Error; MAE= Mean Absolute Error; D= Index of Agreement

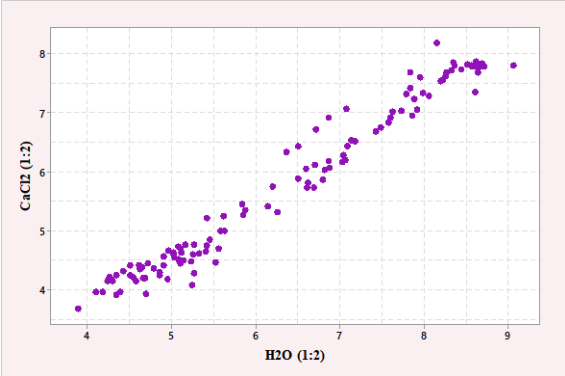

Figure 8. *Relationship between $CaCl_2$ (1:2) and H_2O (1:2) soil pH measurement*

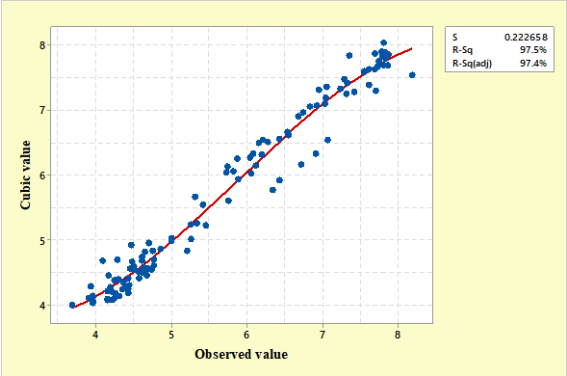

Figure 9. *Comparison of observed versus predicted pH_{CaCl2} (1:2) from cubic model*

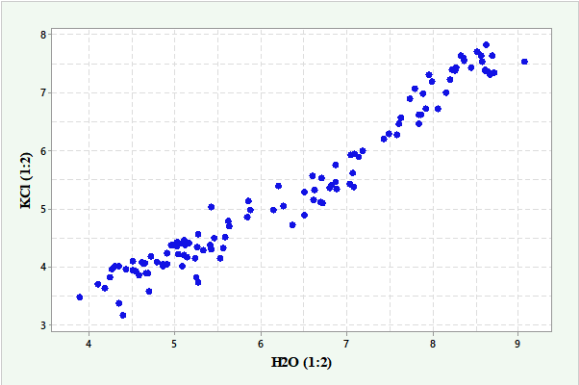

Figure 10. *Relationship between KCl (1:2) and H2O (1:2) soil pH measurement*

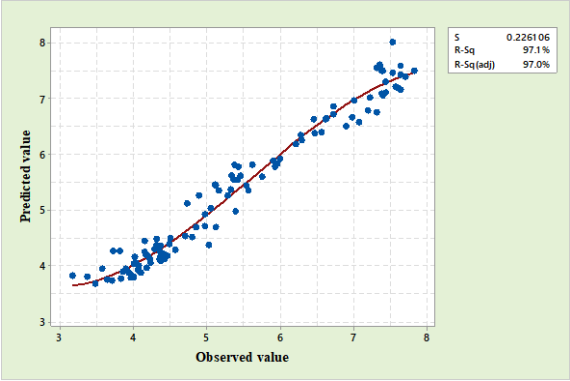

Figure 11. *Comparison of observed versus predicted pH_{KCl} (1:2) from cubic model*

3.6. Effect of models for relating distilled water (H_2O) with electrolyte ($CaCl_2$ and KCl) methods in 1:2.5 soil solution ratio

The studied all the regression model of the pH_{CaCl2} and pH_{KCl} on pH_{H2O} showed highly significant to respective model (Tab. 11; Tab. 12; Fig. 12; Fig. 14). Concerning pH_{H20} vs. pH_{CaCl2}, quadratic and cubic model obsessed highest R^2 (94.1), but slightly lowest (by 0.01 units) RMSE (0.31) was determined in quadratic model. For studied all the cross-validation parameter linear model determined slightly weak performance (R^2=93.2; RMSE= 0.33). Similarly, for pH_{H20} vs. pH_{KCl}, cubic and quadratic model determined equal RMSE (0.18) and R^2 (98.4). But in linear model comparatively lower R^2 (96.9) and highest RMSE (0.25) observed.

Considering the entire cross-validation parameters quadratic model showed consistent result for forecasting pH_{CaCl2} from pH_{H2O} (Fig. 13), but cubic model also had nearly equal performance. Moreover, quadratic and cubic model were better for forecasting pH_{KCl} from pH_{H2O} (Fig. 15; Fig. 16).

Table 11
Regression model $pH_{H2O\ (1:2.5)}$ Vs $pH_{CaCl2(1:2.5)}$

Model	Equation	R^2	RMSE	MAE	D	P value
Linear	pH_{CaCl2}=0.212+0.859pH_{H2O}	93.2	0.33	0.25	0.982	<0.001
Quadratic	pH_{CaCl2}=3.22-0.122pH_{H2O}+ 0.076pH_{H2O}^2	94.1	0.31	0.22	0.985	<0.001
Cubic	pH_{CaCl2}=6.99-1.98pH_{H2O}+0.372pH_{H2O}^2-0.015pH_{H2O}^3	94.1	0.32	0.20	0.984	<0.001

R^2= Coefficient of determination; RMSE= Root Mean Square Error; MAE= Mean Absolute Error; D= Index of Agreement

Table 12
Regression model $pH_{H2O\ (1:2.5)}$ Vs $pH_{KCl(1:2.5)}$

Model	Equation	R^2	RMSE	MAE	D	P value
Linear	pH_{KCl}=-0.754+0.968pH_{H2O}	96.9	0.25	0.20	0.992	<0.001
Quadratic	pH_{KCl}= 3.43-0.395pH_{H2O}+ 0.106pH_{H2O}^2	98.4	0.18	0.13	0.996	<0.001
Cubic	pH_{KCl}=6.39-1.85pH_{H2O}+0.338pH_{H2O}^2-0.012pH_{H2O}^3	98.4	0.18	0.13	0.996	<0.001

R^2= Coefficient of determination; RMSE= Root Mean Square Error; MAE= Mean Absolute Error; D= Index of Agreement

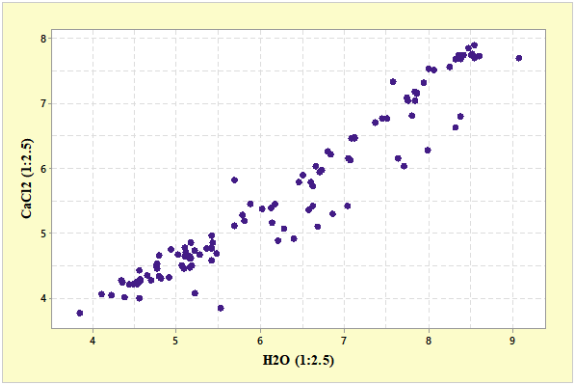

Figure 12. *Relationship between $CaCl_2$ (1:2.5) and H_2O (1:2.5) soil pH measurement*

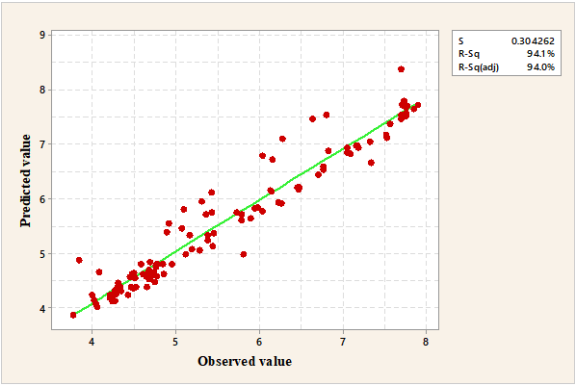

Figure 13. *Comparison of observed versus predicted pH_{CaCl2} (1:2.5) in quadratic model*

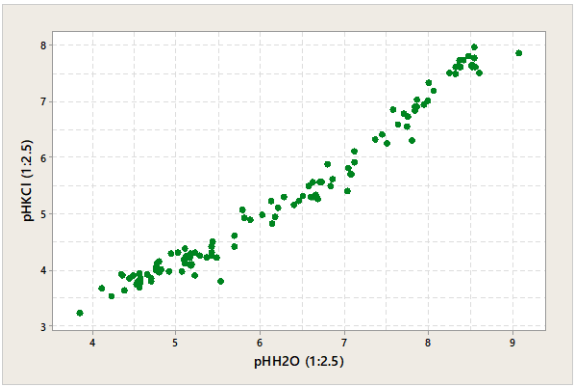

Figure 14. *Relationship between KCl (1:2.5) and H_2O (1:2.5) soil pH measurement*

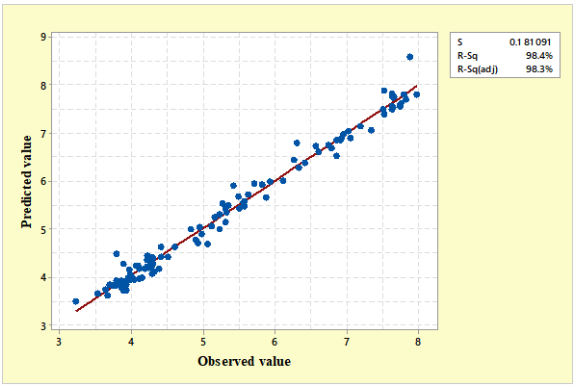

Figure 15*. Comparison of observed versus predicted pH_{KCl} (1:2.5) in quadratic model*

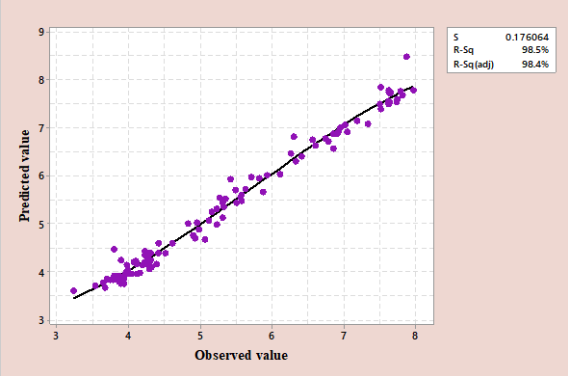

Figure 16. *Comparison of observed versus predicted* pH_{KCl} *(1:2.5) in cubic model*

4. Discussion

The soil pH determined by distilled water was higher than used electrolytes namely calcium chloride and potassium chloride. The corresponding result (pH_{H2O}>pH_{CaCl2}>pH_{KCl}) was also determined by various researchers [4, 11-14] in different sites of world. When using electrolyte solution ($CaCl_2$ or KCl), the cation becomes introduced into the diffuse layer and substitutes the protons (H^+/ Al^{3+}) strongly bonded to the soil colloids [13; 15]. The release of more amounts of low pH inhabiting ion might be the cause of lower content of pH in electrolyte extracting sample than distilled water. Correspondingly, pH in distilled water denotes only acidity of the soil solution, while pH in KCl refers summation of soil solution acidity and reserve acidity in the colloids [16] might also be the cause of low value in pH_{KCl}.

Moreover, regarding correlation among the methods, similar (significant and positive) relationship was determined by Gavriloaiei [13] in Romania. The determined data revealed with the increase in pH content by one method also increases in other method, and vice-versa. On the other study timing for stable reading, electrolyte (KCl and $CaCl_2$) method observed lowest time than sole distilled water (H_2O) might be due to instant contact between soil solution and electrode solution.

The comparison of three regression model (linear, quadratic and cubic) for relating pH_{H2O} to pH_{CaCl2} and pH_{KCl} determined nearly equal performance in quadratic and cubic model in studied three soils and solution ratio. Among them, linear model showed weak prediction.

5. Conclusion

Measuring pH is prerequisite for soil fertility assessment. There are various methods developed for soil pH determination in lab. The different methods possessed different behavior for measurement. Regarding soil pH, the highest date was determined in pH_{H2O} followed by pH_{CaCl2} and pH_{KCl}. Moreover, regarding timing for being stable during measurement were in the order pH_{H2O}(89.44 sec) > pH_{CaCl2}(54.29 sec) > pH_{KCl}(33.08 sec). Similarly, relating modeling quadratic and cubic model showed nearly equal performance (lower RMSE, MAE and higher R^2 and d) for predicting pH_{CaCl2} and pH_{KCl} from the pH_{H2O} data in each of three different ratio. The determined database can be useful for comparing three methods of soil pH measurement under Nepalese context.

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Оцінка вимірювання pH водного розчину та електролітними методами в окультурених ґрунтах Непалу

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РН ґрунту є найбільш рутинним вимірюваним параметром серед усіх інших у ґрунтовій хімічній лабораторії. Існують різні методи, розроблені для вимірювання pH, хоча ми спочатку використовуємо лише дистильовану воду. У Непалі немає бази даних для показу ефективності різних методів. У дослідженнях використовували три методи: H_2O, KCl та $CaCl_2$ витяжки з їх співвідношенням ґрунт : розчин як 1:1, 1:2 та 1:2,5. Всього було відібрано 115 зразків випадковим чином у шарі ґрунту 0-20 см з різних за рельєфом регіонів Непалу. Зібрані зразки аналізували за зазначеними методами окремо. Для порівняння були проведені різні статистичні тести (F-тест, середній поділ, кореляційна та регресійна моделі). Крім того, параметри перевірки моделі були також розраховані для зв'язку методу H_2O з електролітним методом. Для цього завдання були використані три моделі: лінійна, квадратична та кубічна. Результат показав, що вплив методів на вимірювання pH істотно відрізнявся у всьому співвідношенні. pH_{H2O} був на 0,57, 0,56 та 0,67 одиниць вище за pH_{CaCl2} у співвідношенні 1:1, 1:2 та 1:2,5 відповідно. Тоді як на 1,24, 0,99 та 0,95 одиниць вище pH_{KCl} у відповідному співвідношенні. Більше того, щодо часу досягнення стабільності під час вимірювання порядок був таким: pH_{H2O} (89,44 сек) > pH_{CaCl2} (54,29 сек) > pH_{KCl} (33,08 сек). Аналогічно, співвідношення квадратичної та кубічної моделі продемонструвало майже однакову продуктивність (нижчий RMSE, MAE та вищі R^2 і d) для прогнозування pH_{CaCl2} та pH_{KCl} за pH_{H2O} у кожному співвідношенні ґрунтового розчину. База визначених даних може бути корисною для порівняння використаних трьох різних методів вимірювання pH ґрунту в Непалі.

Ключові слова: кальцію хлорид; дистильована вода; калію хлорид; вимірювання pH ґрунту.

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