International Journal of Plant & Soil Science

26(1): 1-6, 2018; Article no.IJPSS.45937
ISSN: 2320-7035

Study on Relationship among the Various Physico-Chemical Soil Properties and Identification of Soil Acidifying Components

Shayan Dey[1], Pramit Pandit[2*] and Sourav Roy[3]

[1]Department of Agricultural Chemistry and Soil Science, BCKV, Mohanpur, Nadia, India.
[2]Department of Agricultural Statistics, BCKV, Mohanpur, Nadia, India.
[3]Department of Vegetable Science, BCKV, Mohanpur, Nadia, India.

Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2018/45937
Editor(s):
(1) Dr. Yong In Kuk, Department of Development in Oriental Medicine Resources, Sunchon National University, South Korea.
Reviewers:
(1) Priscila Jane Romano de, University of São Paulo, Brazil.
(2) Aweng, ER, Universiti Malaysia Kelantan, Malaysia.
(3) Paul Benyamin Timotiwu, University of Lampung, Indonesia.
Complete Peer review History: http://www.sciencedomain.org/review-history/28161

Original Research Article

Received 08 October 2018
Accepted 20 December 2018
Published 05 January 2019

ABSTRACT

Soil acidity is one of the major obstacles to crop growth to a great extent. IN different districts of West Bengal, soil acidity has been reported as a considerable factor behind crop growth restriction. Hence, a comprehensive study has been conducted with a view to study the relationship among the various forms of soil acidity and other physico-chemical soil properties, covering Godkhali, Coochbehar and Purulia under investigation. Outcomes of the investigation clearly reveal that all the physico-chemical properties has been found to have significant influence on different forms of acidity. Along with this, it can be also inferred that among the forms of different soil acidity, for all the forms, significant positive linear association has been observed. It has been also obtained that hydrolytic acidity, extractable acidity and pH-dependent acidity can be considered as the most vital soil acidifying component.

Keywords: Soil acidity; soil physico-chemical properties; linear association; correlation coefficient; principal component analysis.

**Corresponding author: E-mail: pramitpandit@gmail.com;*

1. INTRODUCTION

Soil acidity is perceived as one of the major factors that restrict crop growth in large areas of the world [1]. Acidic soils occupy about 3.95 billion ha and account for 30 percent of the world's ice-free land area [2]. Out of the 328 million ha in India, nearly 145 million ha is cultivated. In West Bengal, out of a total net cropped area of about 5.57 m ha, about 2.2 m ha soils are acidic [3] and distributed from northern foot-hill soils (Entisols) to Western red and laterite soils (Alfisols) and goes up to southern coastal acidic sulfate soils. Soil acidity has become a major problem in some districts of West Bengal situated in different agroclimatic zones [4] and soil orders, leading to the severe toxicity of iron, aluminium, and manganese, accompanied by phosphorus deficiency and low microbial activity that affects yield of crops [5]. Hence, in the current study, a comprehensive attempt has been made to study the relationship among the various forms of soil acidity and other physico-chemical soil properties.

2. MATERIALS AND METHODS

2.1 Data Collection Procedure from the Selected Sites

Soil samples were collected from three sites viz. Godkhali, Coochbehar and Purulia located in three agroclimatic zones viz, costal saline zone, tarai alluvial zone, and red and lateritic zone of West Bengal (Fig. 1). From each acid soil regions, five sites were selected and from each site soil samples were collected from three different depth (0-20 cm, 20-40 cm and 40-60 cm) with a bucket auger. In each site, 5 representative samples were taken randomly in a zigzag manner and pooled together to make a composite sample. After hand crushing, the samples were air-dried in a shade and passed through the 2.0 mm sieve for analysis following standard methods. Additional triplicate samples were taken using a 3.8 cm length and 5.7 cm diameter core sampler for measurement of bulk density of the soils.

2.2 Methods of Analysis

Determination methods for various physico-chemical properties of soil and different forms of soil acidity are presented in Tables 1 and 2, respectively.

Simple correlation coefficients have been computed with a view to examine the linear association of the different forms of soil acidity and different soil physico-chemical properties [14]. The significance of the computed correlation coefficients have been tested by implementing t test [14,15]. Principal component analysis has been also employed in order to identify the most vital soil acidifying component [16,17].

Table 1. Methods for determination of some physico-chemical properties of soil

Physico-chemical property	Method
pH (pH_w and pH_{Ca})	Potentiometric method using digital pH meter [6]
Electrical Conductivity (EC)	Conductometric method using conductivity meter [6]
Cation Exchange Capacity (CEC)	Normal ammonium actate (buffered at pH 7.0) extraction method [6]
Effective Cation Exchange Capacity (ECEC)	CEC + Exchange Acidity (1N KCl extractable Al)
Free iron oxides (Fe_2O_3)	Citrate-bicarbonate-dithionite extractant method [7]
Free aluminium oxides (Al_20_3)	0.5 N NaOH extractant method [8]
Mechanical analysis	Hydrometer method [9,10]
Bulk Density (B.D.)	Core sampler method
Organic carbon	Wet digestion method [11]

Table 2. Methods for determination of forms of soil acidity

Forms of soil acidity	Method
Total acidity (TA)	NaOAc (pH 8.2) extraction method [12]
Hydrolytic acidity (HA)	TA – EA [13]
Extractable acidity	1.0 N NHOAc (pH 4.8) extraction method
Total potential acidity (TPA)	0.5 N $BaCl_2$-TEA (pH 8.2) extraction method [13]
pH-dependent acidity	TPA – EA
Nonexchangeable aluminium	EA - Extractable acidity
Freshly precipitated aluminium hydroxy compound (FPAHC)	Extractable acidity - Exchangeable Aluminium

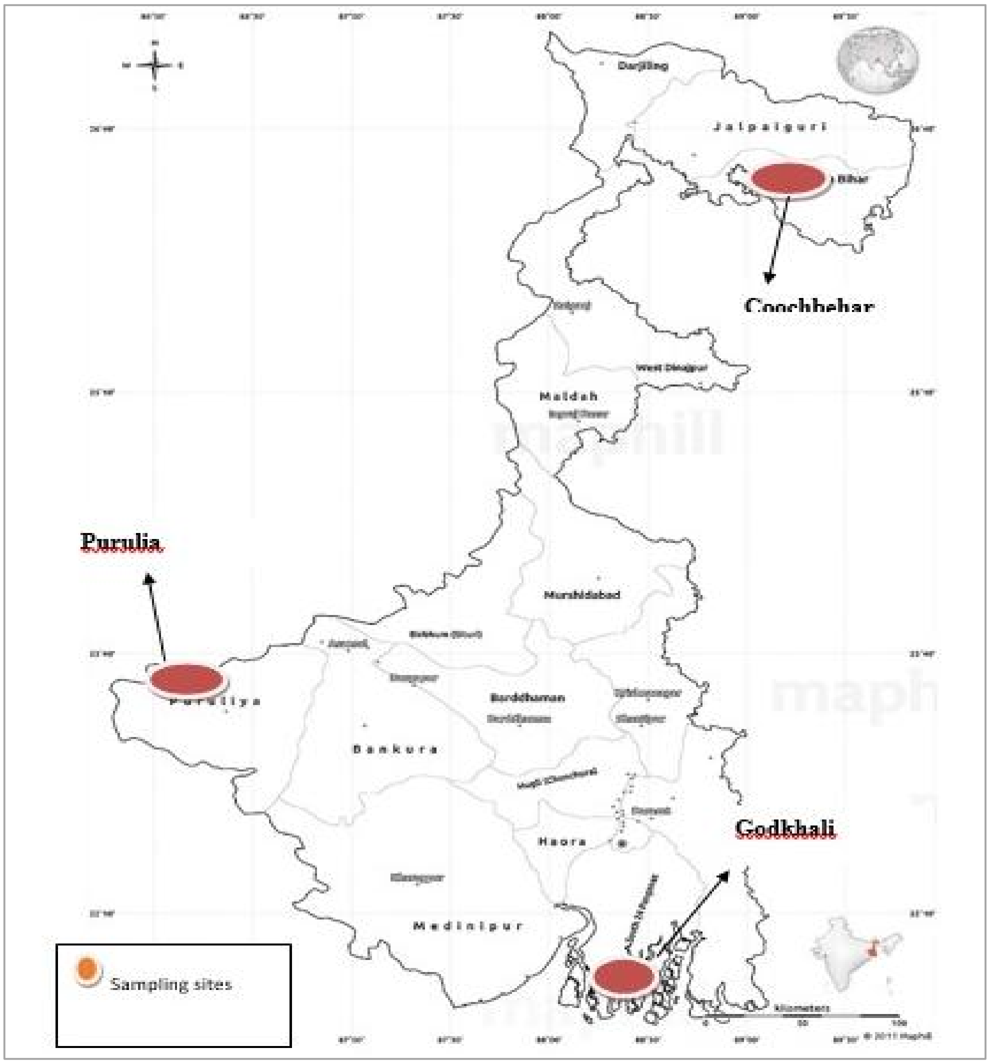

Fig. 1. Sampling stations in West Bengal

3. RESULTS AND DISCUSSION

All the physico-chemical properties has been found to have significant influence on different forms of acidity (Table 3). Only for pH (both pHw and pHCa) and sand, a significant negative correlations with different form of acidity have been found. However, for all other physico-chemical properties under investigation, viz. EC, CEC, ECEC, free Fe2O3, free Al2O3, silt, clay and organic carbon, significant positive correlation has been noticed with various forms of soil acidity.

For total acidity, highest positive correlation was recorded with free Al2O3 (r = 0.902**) followed by ECEC (r = 0.805**) and highest negative correlation was recorded with pHW (r = -0.827**) followed by pHCa (r = -0.822**). However, in case of hydrolytic acidity, highest positive correlation was observed with free Al2O3 (r = 0.902**) followed by ECEC (r = 0.809**) and highest negative correlation was observed with pHW (r = -0.850**) followed by pHCa (r = -0.845**). For extractable acidity, highest positive correlation was found with ECEC (r = 0.946**) followed by CEC (r = 0.945**) and highest negative correlation was found with sand (r = -0.924**) followed by pHW (r = -0.775*). In case of non-exchangeable Al3+, highest positive correlation was recorded with free Al2O3 (r = 0.899**) followed by silt (r = 0.897**) and highest negative correlation was recorded with pHW (r = -0.911**) followed by sand (r = -0.889**). For freshly precipitated aluminium hydroxide compound, highest positive correlation was found with both free ECEC (r = 0.962**) and CEC (r = 0.962**) and highest negative correlation was found with sand (r = -0.937**) followed by pHW (r = -0.779*). In case of total potential acidity, highest positive correlation was observed with free ECEC (r = 0.862**) followed by CEC (r = 0.860**) and highest negative correlation was observed with sand (r = -0.816**) followed by pHW (r = -0.772*). For pH-dependent acidity, highest positive correlation was recorded with both ECEC (r = 0.869**) and ECEC (r = 0.869**) and highest negative correlation was recorded with sand (r = -0.827**) followed by pHW (r = -0.809**).

Among the forms of different soil acidity, for all the forms, significant positive (at 1 percent level) linear association has been observed (Table 4). Highest positive association is observed between Total acidity and Hydrolytic acidity (r = 0.999**), followed by between Total potential acidity and pH-dependent acidity (r = 0.997**) and between Extractable Acidity and Freshly precipitated aluminium hydroxide compound (r = 0.995**).

Table 3. Correlation coefficients between forms of acidities and different soil properties

Soil properties	Total acidity	Hydrolytic acidity	Extractable acidity	Non-exchangeable Al^{3+}	Freshly precipitated aluminium hydroxide compound	Total potential acidity	pH-dependent acidity
pH_W	-0.827**	-0.850**	-0.775*	-0.911**	-0.779*	-0.772*	-0.809**
pH_{Ca}	-0.822**	-0.845**	-0.726*	-0.865**	-0.719*	-0.751*	-0.788*
EC	0.694*	0.703*	0.892**	0.885**	0.927**	0.776*	0.792*
CEC	0.804**	0.808**	0.945**	0.895**	0.962**	0.860**	0.869**
ECEC	0.805**	0.809**	0.946**	0.891**	0.962**	0.862**	0.869**
Free Fe_2O_3	0.770*	0.778*	0.910**	0.899**	0.922**	0.777*	0.792*
Free Al_2O_3	0.902**	0.902**	0.897**	0.821**	0.876**	0.823**	0.825**
Sand	-0.784*	-0.790*	-0.924**	-0.889**	-0.937**	-0.816**	-0.827**
Silt	0.743*	0.756*	0.866**	0.897**	0.882**	0.722*	0.744*
Clay	0.780*	0.783*	0.926**	0.855**	0.936**	0.841**	0.845**
Organic Carbon	0.632	00.642	0.742*	0.755*	0.754*	0.578	0.593

** significant at 5 percent level, ** significant at 1 percent level*

Table 4. Correlation coefficients among various forms of soil acidity

	Hydrolytic acidity (HA)	Extractable acidity (EA)	Non-exchangeable Al^{3+}	Freshly precipitated aluminium hydroxide compound (FPAHC)	Total potential acidity (TPA)	pH-dependent acidity (PDA)
Total acidity (TA)	0.999**	0.936**	0.846**	0.905**	0.968**	0.967**
Hydrolytic acidity (HA)		0.936**	0.866**	0.908**	0.965**	0.968**
Extractable acidity (EA)			0.908**	0.995**	0.954**	0.956**
Nonexchangable Al^{3+}				0.929**	0.848**	0.881**
Freshly precipitated aluminium hydroxide compound (FPAHC)					0.934**	0.940**
Total potential acidity (TPA)						0.997**

** significant at 5 percent level, ** significant at 1 percent level*

Table 5. Variability explained by principal components

Principal components (PCs)	Explained variability (Upto 5th decimal)	Cumulative explained variability (Approximated)
PC 1	0.9317	**0.9317**
PC 2	0.04295	0.97461
PC 3	0.01635	0.99096
PC 4	0.00818	0.99914
PC 5	0.00086	1.00000
PC 6	0.00000	1.00000
PC 7	0.00000	1.00000

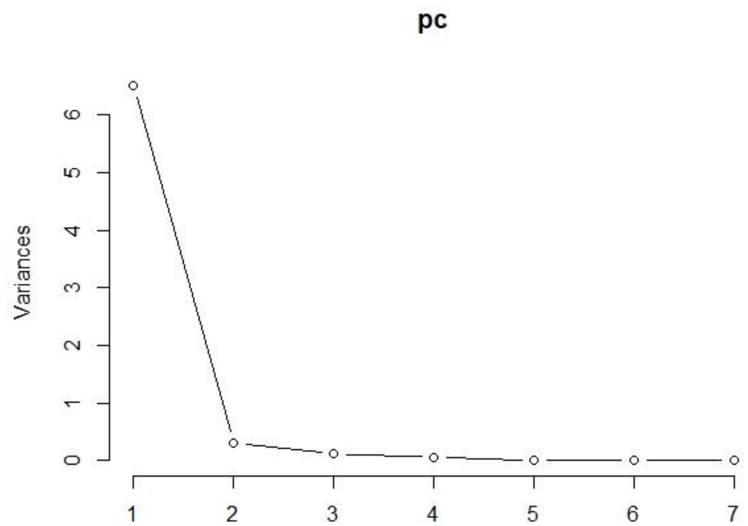

Fig. 2. Screeplot of principal components

Table 6. Coeffecients of the first principal component

Acidifying variables	TA	HA	EA	Non-exchangable Al^{3+}	FPAHC	TPA	PDA
Coefficients	0.25	0.58	0.57	0.25	0.24	0.14	0.37

The significance of the variable can be identified by the value (>0.3) of the factor loadings in each principal component, which were found to be significant [18,19]. Table 5 clearly suggests that the first principal component (PC 1) is enough to capture approximately 93 percent of soil acid variability. Screeplot representing principal components along with their explained variance is given in Fig. 2.

From Table 6, representing the variable coefficients of PC1, it can be noticed that hydrolytic acidity, extractable acidity and pH-dependent acidity can be considered as the most vital soil acidifying component.

Findings of this investigation in line with the outcomes of the studies conducted earlier, emphasized on soil acidity of West Bengal [20,21,22].

4. CONCLUSION

Results emanated from the current experiment clearly indicate that all the physico-chemical properties has been found to have significant influence on different forms of acidity. Along with this, it can be also concluded that among the forms of different soil acidity, for all the forms, significant positive (at 1 percent level) linear association has been observed. It has been also obtained that hydrolytic acidity, extractable acidity and pH-dependent acidity can be considered as the most vital soil acidifying component.

ACKNOWLEDGEMENTS

This research article is a part of Thesis work submitted for M.Sc. (Ag.) in Agricultural Chemistry & Soil Science by Mr. Shayan Dey to

BCKV in the year 2018. All co-operations received from the co-authors and all the support provided by BCKV is duly acknowledged.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Shainberg I, Sumner ME, Miller WP, Farina MPW, Pavan MA, Fey MV. Use of gypsum on soils: A review. New York, NY: Springer; 1989.
2. Von Uexküll HR, Mutert E. Global extent, development and economic impact of acid soils. Plant and Soil. 1995;171(1):1-15.
3. Das DK. Introductory soil science. 2nd Ed. New Delhi, India: Kalyani Publishers; 2003.
4. Das K, Sarkar D. Soil degradation: Status and Management Options in West Bengal. SATSA Mukhapatra. 2016;20:63-76.
5. Bandyopadhyay PK, Chattopadhyay GN. Nature of acidity in some Alfisols and Inceptisols of Birbhum district of West Bengal. Journal of the Indian Society of Soil Science. 1997;45(1):5-8.
6. Jackson ML. Soil chemical analysis. New Delhi: Prentice Hall India Pvt Ltd.; 1973.
7. Mehra OP, Jackson ML. Iron oxide removal from soils and clays by a dithionite–citrate system buffered with sodium bicarbonate. Clays and clay minerals: proceedings of the Seventh National Conference. 1960;317-327.
8. Hashimoto I, Jackson ML. Rapid dissolution of allophane and kaolinite-halloysite after dehydration. Clays and Clay Minerals: Proceedings of the Seventh National Conference. 1960;102-113.
9. Black CA. Methods of soil analysis. Part 1. USA: American Society of Agronomy Inc; 1965.
10. Black CA. Methods of soil analysis. Part 2. USA: American Society of Agronomy Inc; 1965.
11. Walkley A, Black IA. An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Science. 1934;37(1):29-38.
12. Kappen G. Popchvennaya Kislotnost, Selkhogiz, Moscow, Cf. Journal of the Indian Society of Soil Science. 1934;39: 246.
13. Peech M. Methods of soil analysis. Madison: Wisconsin; 1965.
14. Gupta SC, Kapoor VK. Fundamentals of mathematical statistics. 11th Ed. New Delhi: Sultan Chand & Sons; 2014.
15. Zar JH. Biostatistical analysis. India: Pearson India Education Services Pvt. Ltd; 2014.
16. Anderson TW. An Introduction to multivariate statistical analysis. 3rd Ed. New Delhi: Wiley India Pvt. Ltd.; 2009.
17. Rencher AC, Christensen WF. Methods of multivariate analysis. 3rd Ed. New Delhi: Wiley India Pvt. Ltd.; 2012.
18. Pal DP, Pal GP. Crop diversification: its causes and impacts on the farm economy. Indian Journal Agricultural Economics. 1986;45(3):323-332.
19. Halagundegowda GR, Nagaraja MS, Meenakshi HK. Statistical analysis on factors influencing on shift in cropping patterns in different agro-climatic zones of Karnataka. The Bioscan. 2015;10(3): 1395-1399.
20. Chand JP, Mandal B. Nature of acidity in soils of West Bengal. Journal of the Indian Society of Soil Science. 2000;48(1):20-26.
21. Badole S, Datta A, Basak, N, Seth A, Padhan D, Mandal B. Liming influences forms of acidity in soils belonging to different orders under subtropical India. Communications in Soil Science and Plant Analysis. 2015;1-16.
22. Ghosh S. Spatial variation of soil pH and soil phosphorous and their interrelationship in the plateau area of West Bengal, India. International Journal of Recent Scientific Research. 2015;6(3):3208-3212.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history/28161