POTASH ESTIMATION IN SOIL USING RF TECHNIQUE

Sulaxana R.Vernekar, IngridAnne Nazareth, Jivan S. Parab, Gourish M. Naik
Department of Electronics, Goa University, India.

ABSTRACT

The paper describes RF spectroscopic technique for soil potash sensing. The system consists of a cell designed and constructed to find the RF response of potash over a frequency range of 10MHz-4GHz. The cell is well shielded so as to make the RF response of potash immune to external electromagnetic interferences. The signal is applied to the potash sample cell using tracking signal generator and the response of the sample is measured using RF spectrum analyzer. The RF spectra thus obtained shows attenuation at specific frequencies and has flat response at other frequencies. The spectra also shows a proportional change in attenuation depending upon the concentration of potash sample. Though it is possible to predict the unknown potash sample concentration by qualitative analysis, a quantitative analysis using multivariate algorithm can be more useful for the development of a better instrumentation. The paper proposes Partial Least Square (PLS) based multivariate analysis system for potash concentration estimation.

KEYWORDS: *precision agriculture, multivariate.*

I. INTRODUCTION

Soil nutrient management plays a vital role in achieving sustainable agriculture and increasing the crop production. At the same time it can minimize the economic losses and environmental impacts [1] (Goulding *et al*., 2008). Recent advances in technology show that efficient nutrient management in crop fields can be attained through the use of Precision Agriculture (PA)-based technologies. Variable-rate fertilizer application, one of the basic principle of PA, has been shown to optimize fertilizer use efficiency by overcoming the problem of over- and under-fertilization [2] (Schirrmann and Domsch, 2011). There have been great interest in soil sensing by developed countries, but their technique and developmental work are patented and not available in open journals. The advance research work carried out by University of Nebraska at Lincoln can be seen in their website [3]. Similarly the researchers are developing single chip soil nutrient analyzer for NPK (Nitrogen, Potassium and Phosphate) [4]. The spatial and temporal variability of soil properties if not taken into account can cause wastage of resources. Conventional methods for finding the spatial and temporal variability of soil nutrients are based on rigorous soil sampling followed by laborious soil testing both which can be time consuming and costly. Thus, at present the development of soil sensors to measure soil properties at the scale required for accurate mapping of within-field variability is a necessity. A large number of on-the-go soil sensors are being developed to measure various soil properties and which can be broadly classified into the following categories:

1. **Electrochemical sensors:** Electrochemical sensors are capable of assessing spatial variability of different soil chemical properties directly or indirectly.
2. **Electrical and electromagnetic sensors:** Electrical and electromagnetic sensor technology uses various measurement systems based on electrical circuits to determine the ability of soil media to conduct or accumulate electrical charge.
3. **Optical and radiometric sensors:** Optical sensing technology uses visible and near-infrared wavelength ranges to rapidly quantify soil properties.
4. **Acoustic sensors:** Acoustic sensors are usually equipped with a sound-recording device (i.e., microphone) that records sound produced through interaction of the soil and the shank having a rough surface and hollow cavity. This approach is ideal for differentiating between mechanical and physical characteristics of soil.

5. **Mechanical sensors:** Mechanical soil sensors are designed to measure soil strength, which is conventionally done by measuring mechanical resistance [5] (Bah *et al*., 2012).

The paper describes an RF technique for the estimation of potash in soil based on multivariate system. Section II of the paper describes the design and construction of the cell. Section III presents the results in the form of graphs and tables and also the discussion about the results obtained. The concluding section discusses about the present and future scope of the work.

II. EXPERIMENTAL SETUP

The cell design is based on dielectric loss technique. The cell is made up of PMMA sheet and has rectangular shape. The outer dimensions of the cell are 13cmx2cmx2.5cm while the liquid capacity is approximately 15ml. A copper wire runs through the centre of the cell from input connector to the output connector. The inner surface of the cell is fully lined with copper foil and is connected to the outer shield of the connector. Sample solution of potash is placed in the cell and an RF signal from a tracking generator is injected into the cell through the central copper wire. Thus, the central wire, the outer copper shield and the sample solution act as a dielectric cell. As the RF signal propagates from the input end to the output end of the cell through the central wire, the strength of the signal reduces due to dielectric loss offered by the sample solution. The RF spectrum analyzer connected at the output end of the cell captures signal proportional to the dielectric loss due to the sample solution. A Signal Hound tracking generator USB-TG44A and a Signal Hound spectrum analyzer USB-SA124B were used for obtaining the RF response of potash. The cell was tested for external noise interference by repeatedly taking the measurements. From the observations it was seen that the RF response of potash samples remained constant. The experimental setup is as shown in figure1.

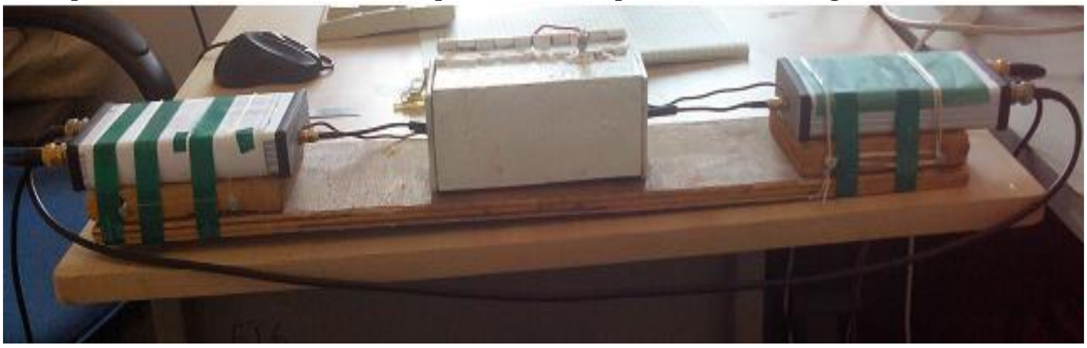

Figure1. Experimental setup

III. RESULTS AND DISCUSSIONS

The samples of potash were prepared as per the data obtained from agricultural department. Since the sample holding capacity cell is 15ml, the amount of potash to be added to 15ml of water was found to be 279.5mg. Four different concentrations of potash samples were prepared which were taken as 0.5 which is half the concentration of the normal value, 1 is the normal concentration, 2 is twice the normal concentration and 3 is three times the normal concentration.

The results obtained are as shown in figure 2.

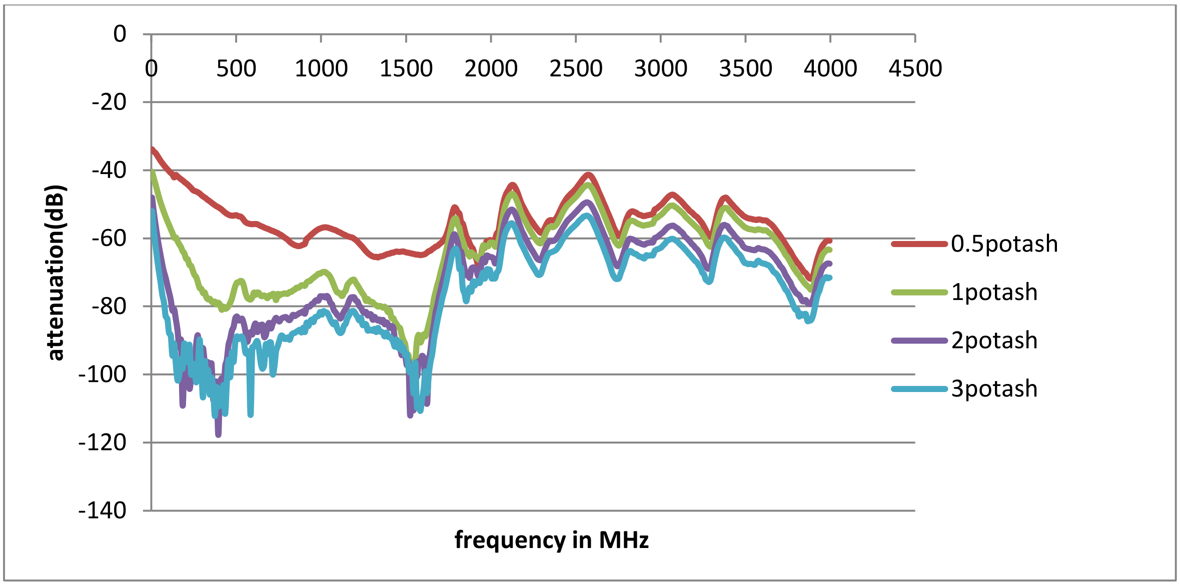

Figure 2. RF response of potash with different concentrations

The graph shows the RF response of potash with different concentrations. The x-axis represents the frequency and the y-axis represents the attenuation level in dB. As seen from the above graph, potash shows variation in the attenuation levels proportional to the concentration at various frequency points. The table 1 gives the attenuation of various sample concentrations at specific frequency. At other frequencies the variation is negligible or flat.

Table 1. Attenuation (dB) Levels of Potash

Concentrations	Frequency in MHz											
	815	915	1565	1785	2095	2175	2565	2705	3025	3245	3355	3925
0.5	-61.0	-60.2	-64.7	-50.9	-46.4	-49.0	-41.4	-54.3	-48.9	-55.6	-49.3	-65.7
1	-75.7	-72.9	-90.0	-54.2	-49.1	-51.9	-44.4	-57.8	-51.9	-58.8	-52.3	-68.6
2	-84.0	-80.3	-100.7	-58.7	-53.3	-56.8	-49.4	-63.8	-57.6	-65.6	-57.0	-72.3
3	-89.7	-84.7	-107.6	-63.3	-57.3	-61.1	-53.3	-68.5	-61.5	-70.1	-60.7	-76.5

From table 1, it can be seen that at the specified frequencies the attenuation levels change with the change in the concentration of potash. Thus, a multivariate system can be developed which can make use of this spectral data for the prediction of an unknown concentration of potash [6].

IV. Conclusion

The above results obtained are based on the preliminary study conducted to find out the RF response of potash. It is found that potash shows unique frequency variations. Hence, we can make use of this data in multivariate analysis for the prediction of an unknown concentration of potash. The same study is extended to finding the frequency response of other soil nutrients. The spectra's of the different soil nutrients can be combined together to predict the unknown soil nutrient. To find the correlation between the various soil nutrients, Partial Least Square Regression can be used. Partial least square (PLS) is a method for constructing predictive models when the factors are many and highly collinear.

V. Future Scope

The future scope for this work is to develop a proper algorithm for the prediction of potash concentration using multivariate system. Though, multivariate system is not a new mathematical tool but tuning the same matrix for nutrient concentration in the soil is quite challenging. The study is in progress to develop such a matrix for nutrient analysis.

REFERENCES

[1]. Goulding, K., S. Jarvis and A. Whitmore, 2008. Optimizing nutrient management for farm systems. Phil. Trans. Royal Soc. B., 363: 667-680. DOI: 10.1098/rstb.2007.2177
[2]. Schirrmann, M. and H. Domsch, 2011. Sampling procedure simulating on-the-go sensing for soil nutrients. J. Plant Nutr. Soil Sci., 174: 333-343. DOI: 10.1002/jpln.200900367
[3]. URL: http://www. cropwatch.unl.edu/ssm/sensing uploaded in 2014.
[4]. Martin Smolka, 2014. Lab on chip soil nutrient sensor – iMetos NPK. AgriFuture Days 2014 Conference at Villach, Austria June 16th-18th 2014.
[5]. Sulaxana R.Vernekar, Ingrid Anne P. Nazareth, Jivan S. Parab, Gourish M. Naik, 2014. Radio Frequency Technique for Analysis of Urea Content in Soil. International Journal of Advances in Engineering & Technology, Vol. 6, Issue 6, pp. 2686-2691, 2014.
[6]. Bah, A., S.K. Balasundram and M.H.A. Husni, 2012. Sensor Technologies for Precision Soil Nutrient Management and Monitoring. American Journal of Agricultural and Biological Sciences 7 (1): 43-49, 2012
[7]. Parab J.S, Gad R.S, Naik G.M, 2010. Non Invasive glucometer model using PLSR technique for human blood matrix. J. Applied Physics, vol. 107, Issue 10, p104701.

AUTHORS

Sulaxana R. Vernekar is currently pursuing her Ph.D. in Electronics at Goa University. She is Assistant Professor in the Department of Computer Science at GGPR College of Commerce, Ponda-Goa and has 17years of teaching experience. She has participated in number of symposium / workshops and presented her research work. Her areas of interest are agricultural electronics, microelectronics and digital signal processing.

Ingrid Anne Nazareth born in Sharjah, U.A.E. is currently a Ph.D. Scholar in the Department of Electronics, Goa University (India). She completed her Masters in Electronics having secured the 1st place and is an awardee of the 'IV SERC School in Physics Gold Medal'. She was appointed a project fellow in the project "Design of Hyperspectral Smart Sensors using soft-core processors and IP cores". She was also a visiting faculty at the Goa University. Her research interest is in the field of Biomedical Electronics. She has attended a number of National Symposiums and Conferences where she has presented her research work.

Jivan S. Parab, Born in Goa, India on 26th March 1983. Obtained Bachelor and Master degree in Electronics from Goa University, Goa, India. He worked initially as Research Student on project 'Non-Invasive Glucometer', funded by Indian Council of Medical Research, New Delhi. He completed his Ph.D on the same topic and is currently working as Assistant Professor, Department of Electronics, Goa University. He has co-authored two books with Springer (Netherland), in the area of Embedded System and programming. His areas of interest are Digital Signal Processing, Embedded Systems, Digital communication.

Gourish Naik obtained his Ph. D from Indian Institute of Science, Bangalore (1987) and served the institute as research associate in the areas of Optoelectronics and Communication till 1993. For the last 15 years, he is associated with Goa University Electronics Program. He is the founding head of University Instrumentation Center and established Fiber optic LAN & Wireless Communication Network at Goa University. He is also coordinator of DEITI (an educational broadcast studio supported by Indian Space Research). His other commitments are regulating digitization Center at Goa University to support the various Digital repository projects like DIGITAP (Digital Repository for Fighter Aircrafts Documentation) of Indian Navy, Million Book project of Ministry of Information Technology and Antarctica Study Center (NCAOR). He has to his credit around 50 odd research papers published in National and International Journals and has presented research works at various National and International Forums. He has delivered several key note addresses and invited talks at various institutes and also authored a book on Embedded Systems published by Springer (Holland). He is a member of Goa State Rural Development Authority and also advisor for Directorate of Education. He is also the chairman of Goa University Technical Advisory Committee. Presently he is the Head of Electronics and Instrumentation division at Goa University.