A Salinity Detection Kit for Farmers in Salt-Affected Areas

Naphat Thongnoi, Setthawut Kongmongkon and Chutimawadee Lunthaisong Advisors: Nattapon Pontham and Supapong Niamthiang
Phimai Wittaya School, Nakhon Ratchasima, Thailand

Abstract

This study details the development of a simple, field-deployable soil salinity detection kit designed for use by farmers in Phimai District, Thailand. The kit addresses the critical need for timely and affordable on-site testing, which traditional laboratory methods do not provide. The detection kit is based on a classic chemical precipitation reaction between silver nitrate ($AgNO_3$) and sodium chloride (NaCl), which produces a white precipitate. The quantity of this precipitate is directly proportional to the salt concentration in the soil sample. To enhance visual interpretation, bromothymol blue was incorporated as a colorimetric indicator, producing distinct color changes corresponding to varying salinity levels. Field tests conducted with soil samples demonstrated that the kit's results, indicated by the color changes, were consistent with established electrical conductivity (EC) measurements. This confirms the kit's accuracy and effectiveness for on-site assessment. The developed kit provides a rapid and cost-effective tool, empowering farmers to make informed decisions regarding soil management, irrigation, and crop selection to mitigate salinity-related crop damage and foster sustainable agricultural practices.

Introduction

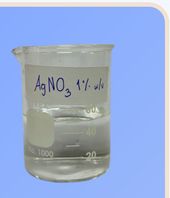
The salinity of the soil causes problems for farmers.

Salinity detectors are expensive and inconvenient to use.

A Salinity Detection Kit for Farmers

Materials and Methods

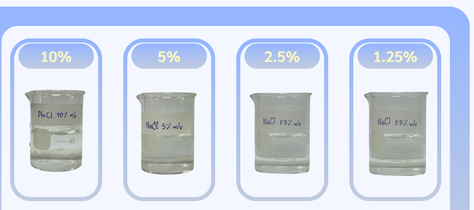
Solution Preparation



Prepare 1% (w/v) Silver Nitrate

Prepare 10% (w/v) Sodium Chloride

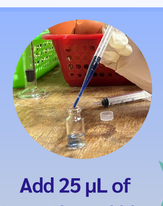
stock solutions of Sodium Chloride were create



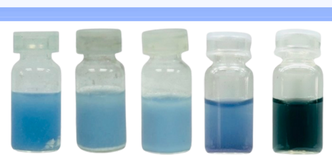
A series of dilutions of NaCl (w/v)

Method Validation

Prepare 1000 µL of 1% $AgNO_3$



Add 25 µL of Bromothymol blue



Add NaCl as the same concentration level as above 1000 µL each

Soil Sample Testing

Collect soil from four saline sites

Prepared 10g of soil in each site

Dissolved in water for 5 minutes

Use 1 mL of Silver Nitrate Solution with 25 µL Bromothymol Blue

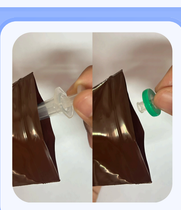
Highly Saline	Moderately Saline	Low Salinity	Non-Saline
			

Add 1 mL of filtered soil extract from each saline level

Test Kit Assembly

Add 1 mL of 1% $AgNO_3$ in 3 mL glass vials

Add 3 mL of bromothymol blue in dropper bottle



Put 5 mL syringes and syringe filter

Label the bottles of $AgNO_3$ and Bromothymol blue

Results

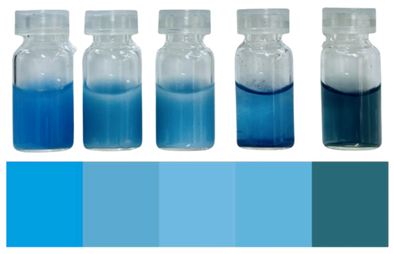
1 This study inform reaction between NaCl and $AgNO_3$ produced white cloudy precipitate.

A: Silver Nitrate tested with NaCl B: Silver Nitrate tested without NaCl

The reaction between NaCl and $AgNO_3$ produced a white, cloudy precipitate, consistent with AgCl formation.

$$AgNO_3(aq) + NaCl(aq) \rightarrow AgCl(s)\downarrow + NaNO_3(aq)$$

2 Used of Bromothymol Blue for visuals distinction.



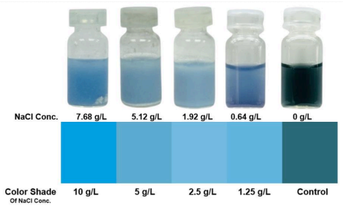
NaCl Conc.	10 g/L	5 g/L	2.5 g/L	1.25 g/L	Control
Color Code	#00A1E4	#5FAED	#76BFE4	#64B9E2	#2B6C7B

The variation in the color change of bromothymol blue (BTB) observed at different NaCl concentrations and color shades of each NaCl Concentration.

3 Soil Salinity Assessment Experiment

Table 1 This table shows the electrical conductivity, TDS (Total Dissolved Solids) and NaCl concentration dissolved in water from four soil samples.

NO.	EC (dS/m) ($\bar{X} \pm S.D.$)	TDS (mg/L)	Approx. NaCl (g/L)	Salinity Level
1	12±0.21	7,680	7.68	Moderately saline
2	7±0.14	5,120	5.12	Slightly Saline
3	4±0.16	1,920	1.92	Slightly Saline
4	1±0.12	640	0.64	Non Saline
control	0	0	0	Non Saline



The developed test kit was validated by comparing its results with those obtained from traditional electrical conductivity (EC) measurements of soil samples. The salinity levels identified by $AgNO_3$ and bromothymol blue were consistent with the corresponding EC values. The color changes observed in the soil samples also correlated with the established color scale from tests using standard NaCl solutions.

4 Developed Salinity Testing Kit and Its Applications

The prototype of soil salinity test kit including; Amber zip-lock bag, Clear vial 3 mL for $AgNO_3$ solution, Amber dropper bottle 5 mL, syringe 5 mL Filter and Color chart strip for estimating salt concentration.

Discussions

- The reaction between NaCl and $AgNO_3$ produced a white, cloudy precipitate, this is a classic example of a double displacement or metathesis reaction. This reaction results in the formation of a white precipitate of silver chloride (AgCl) and an aqueous solution of sodium nitrate ($NaNO_3$). (Brady& Holum, 1996)
- At high NaCl concentrations, Ag^+ is almost completely consumed during precipitation, leaving negligible free Ag^+ in solution. As a result, the interference of Ag^+ with BTB is minimized, and the indicator retains its normal pH-dependent color (blue/green). In contrast, at low NaCl concentrations, excess Ag^+ remains in solution, which can interact with BTB by oxidizing or disrupting its chromophore, producing more pronounced or atypical color changes than in the stoichiometric case (Doe et al., 2019).
- The soil salinity assessment experiment involved collecting soil samples from four different locations. These samples were analyzed for both their electrical conductivity (EC) and the concentration of dissolved NaCl. The findings indicate that the salinity level identified by the $AgNO_3$ and BTB test for each soil sample is consistent with its measured EC value. Furthermore, the color changes observed in the reactions correspond with those seen in the tests using standard NaCl solutions of varying concentrations. This demonstrated that the developed soil salinity test kit can effectively be used to assess and determine the level of salinity in a given soil sample.
- Saline soils pose a significant challenge to agriculture as high concentrations of soluble salts reduce soil fertility, impair water uptake, and hinder crop growth. Effective management strategies include leaching excess salts with good-quality irrigation water, applying gypsum or calcium-based amendments to displace sodium ions, and improving drainage to prevent salt accumulation. Additionally, planting salt-tolerant crops such as barley and sorghum can sustain yields in moderately saline soils, while long-term solutions involve integrated soil–water management and land-use planning. These approaches help restore soil productivity and enhance sustainable agriculture in salt-affected regions (Machado & Serralheiro, 2017; Qadir et al, 2014; Rengasamy, 2010).

Conclusions

4.1 The $AgNO_3$ and NaCl Reaction yields a white precipitate whose amount varies with salt concentration which can use to adap for test kit.

4.2 Bromothymol Blue Serves effectively as an indicator producing distinguishable color changes proportional to salt levels.

4.3 The field kit developed is rapid, cost-effective, user friendly, and accurately reflects soil salinity comparable to electrical conductivity menthod

Acknowledgement

This study was supported by Phimaiwittaya School, The Science, Math, Technology And Environment Programme (SMTE).

References

Brady, J. E., & Holum, J. R. (1996). Chemistry: The study of matter and its changes (2nd ed.). John Wiley & Sons.
Machado, R. M. A., & Serralheiro, R. P. (2017). Soil salinity: Effect on vegetable crop growth, management practices to prevent and mitigate soil salinization. Horticulture, 3(2), 30. https://doi.org/10.3390/horticulturae3020030
Qadir, M., Quillérou, E., Nangia, V., Murtaza, G., Singh, M., Thomas, R. J. & Noble, A. D. (2014). Economics of salt-induced land degradation and restoration. Natural Resources Forum, 38(4), 282–295. https://doi.org/10.1111/1477-8947.12054
Rengasamy, P. (2010). Soil processes affecting crop production in salt-affected soils. Functional Plant Biology, 37(7), 613–620. https://doi.org/10.1071/FP09249