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The research of complex fertilizers by ultraacoustic method

V.Janënas, O.Majauskienë, V.Kasperiûnas

Lithuanian University of Agriculture

Noreikiðkës, 4324 Kaunas District

In order to get a higher yield of cultured plants, soil is enriched with mineral fertilizers. Nowadays complex fertilizers-mixtures of various fertilizers, are widely used. When fusing in water salt splits into ions. Ions destroy the structure of water, and it means, that the hydrogen bonds of water molecules are made stronger or weaker. A lot of materials, existing in the soil structure destroyed by ions, start to fuse, and a plant can take them. Mineral salts, dissolved in ground water, help a plant to take not only the salt ions K^+, Na^+, Ca^+ and nitrogen, but also other dissolved materials, what results in quick growth of the plant. The aim of our research is to investigate the effect of $NaNO_3$, $Ca(NO_3)_2$ and $NaNO_3$, NH_4NO_3, dissolved separately and together at the temperature of 25 and 30 °C, on the structure of water, when the concentration of solutions is 0,5 m (0,5 m moles, of salt per 1 kg of water). The change of water structure is estimated by the changing compressibility of water around cation.

The layer of water molecules near cation is considered to be uncompressible. If the volume of the solution is V and the uncompressible volume in it is v_1, then the uncompressible part of the solution is equal to:

$$\alpha = \frac{v_1}{V}. \quad (1)$$

The uncompressible part of the solution (α) can be calculated out of the adiabatic compressibility coefficients of water and solution β_0 and β [1]

$$\alpha = \frac{\Delta\beta}{\beta_0} = \frac{v_1}{V}, \quad (2)$$

here $\Delta\beta = \beta_0 - \beta$.

The influence of anion NO_3^- on the structure of water is very small [2,3] and it is considered not to destroy the structure of water at all.

Formula (2) shows the uncompressible volume in the solution to be equal to

$$v_1 = \frac{\Delta\beta V}{\beta_0},$$

$V = \frac{m}{\rho}$, here m is the mass of the solution, ρ is the density of the solution. Then

$$v_1 = \frac{\Delta\beta m}{\beta_0 \rho}. \quad (3)$$

The uncompressible part of the solution consists of cations and anions. The cations have two layers of water molecules around them. The layers are of different structure. The anions have only one layer of water molecules of a different structure, except of NO_3^-, which does not destroy the structure of water at all. Only the water molecules, existing in the first layer around the cation, are polarized and deformed [4]. Van der Waals forces, which in a further distance destroy hydrogen bonds of water molecules, occur because of deformation. This phenomenon is called hydration.

The ions of some salts strengthen hydrogen bonds between water molecules, and the positive hydration appears. The other ions make the hydrogen bonds weaker - then the negative hydration appears. In the case of the positive hydration water compressibility decreases and in the case of negative hydration - increases [5].

The uncompressible volume of the polarization layer of ions and cations must be constant, when two nitrates are dissolved together and separately. Therefore, the change of uncompressible volume Δv, when dissolving nitrates together and separately, occurs only due to the hydration of ions. The change of a water compressibility can be determined by the measurements of the adiabatic compressibility coefficients of water β_0 and solution β. The difference of the uncompressible part of the solution when the salts are dissolved together and separately is calculated from the formula:

$$\Delta v = \frac{\Delta\beta m}{\beta_0 \rho} - \left(\frac{\Delta\beta_1 m_1}{\beta_0 \rho_1} + \frac{\Delta\beta_2 m_2}{\beta_0 \rho_2}\right), \quad (4)$$

where $\Delta\beta$ is the change of the adiabatic compressibility, when salts are dissolved together m and ρ are the mass and the density of the solution; $\Delta\beta_1$, m_1, ρ_1 and $\Delta\beta_2$, m_2, ρ_2 are correspoudingly the change of the adiabatic compressibility when both salts are dissolved separately, the mass and the density of the solution.

The coefficient of the adiabatic compressibility of the solutions is calculated from the formula $\beta = 1/(\rho \cdot v^2)$, where ρ is density of the solution, v is the speed of ultrasound in the solution. The speed of ultrasound in the solution is measured by an ultrasound interferometer at the frequency 10 MHz with accuracy 0.01%. The temperature in the chamber of interferometer is stabilized by an ultrathermostat to within ±0.1 °C. The density is measured by a pyknometer, volume - 50 cm^3, to within 0.001%. Chemically clear nitrates are used. The weighing of solutions and salts is done by scales to within ±0.05 mg. A bidistillate has been used in the preparation of solution. The mass of water in the solution is 100 g.

The results of the measurements of ultrasound speed v, density ρ, adiabatic compressibility coefficient β in the electrolytes of different nitrates and calculations v_1 and Δv are shown in the Tables 1-6.

Table 1. **The vallues of ultrasound speed v in water, water density ρ and adiabatic compressibility coefficient β, at the temperature of 25 and 30 °C**

t,°C	v, m/s	$\rho \cdot 10^{-3}$, kg/m^3	$\beta \cdot 10^{11}$, m^2/N
25	1497.0	0.99707	44.75
30	1509.5	0.99567	44.08

Table 2. **The numerical values of ultrasound speed *v*, density ρ, adiabatic compressibility coefficient β and uncompressible volume v_1 of the 0.5 m $NaNO_3$ - H_2O solution, at the temperature of 25 and 30 °C**

t,°C	v, m/s	$\rho \cdot 10^{-3}$, kg/m^3	$\beta \cdot 10^{11}$, m^2/N	$v_1 \cdot 10^7$, m^3
25	1517.8	1.0236	42.41	53.26
30	1529.0	1.0223	41.84	51.18

Table 3**. The values of ultrasound speed *v*, density ρ, adiabatic compressibility coefficient β and uncompressible volume v_1 of 0.5 m $Ca(NO_3)_2$ - H_2O solution, at the temperature of 25 and 30 °C**

t,°C	v, m/s	$\rho \cdot 10^{-3}$, kg/m^3	$\beta \cdot 10^{11}$, m^2/N	$v_1 \cdot 10^7$, m^3
25	1522.05	1.0550	40.91	88.81
30	1532.00	1.0526	40.47	84.19

Table 4**. The values of ultrasound speed *v*, density ρ, adiabatic compressibility coefficient β and uncompressible volume v_1 of 0.5 NH_4NO_3 - H_2O solution, at the temperature of 25 and 30 °C**

t,°C	v, m/s	$\rho \cdot 10^{-3}$, kg/m^3	$\beta \cdot 10^{11}$, m^2/N	$v_1 \cdot 10^7$, m^3
25	1508.89	1.0125	43.38	31.45
30	1520.56	1.0110	42.78	30.34

Table 5. **The values of ultrasound speed *v*, density ρ, adiabatic compressibility coefficient β and uncompressible volume v_1 of 0.5 m $Ca(NO_3)_2$ - 0.5 m $NaNO_3$ - H_2O solution, at the temperature of 25 and 30 °C**

t,°C	v, m/s	$\rho \cdot 10^{-3}$, kg/m^3	$\beta \cdot 10^{11}$, m^2/N	$v_1 \cdot 10^7$, m^3
25	1544.22	1.08017	38.82	137.96
30	1552.26	1.07599	38.56	130.89

Table 6. **The values of ultrasound speed *v*, density ρ, adiabatic compressibility coefficient β and uncompressible volume v_1 of 0.5 m $NaNO_3$ - 0.5 m NH_4NO_3 - H_2O solution, at the temperature of 25 and 30 °C**

t,°C	v, m/s	$\rho \cdot 10^{-3}$, kg/m^3	$\beta \cdot 10^{11}$, m^2/N	$v_1 \cdot 10^7$, m^3
25	1529.90	1.0363	41.23	82.18
30	1540.38	1.0348	40.73	79.52

The difference of the uncompressible part of the solution when nitrates are dissolves together and separately is estimated by Eq.4. 0.5 m $Ca(NO_3)_2$-0.5 m $NaNO_3$-H_2O and 0.5 m $Ca(NO_3)_2$-H_2O and 0,5 m $NaNO_3$-H_2O, at the temperature of 25 and 30 °C:

$$\Delta v_{25}=/137.96-(88.81+53.26)/10^{-7}=-4.11\cdot10^{-7}\ m^{3.}$$

$$\Delta v_{30}=/130.89-(84.19+51.18)/10^{-7}=-4.49\cdot10^{-7}\ m^3.$$

The difference of the uncompressible part of the solution when nitrates are dissolved together and separately is estimated by (4) formula 0.5 m $NaNO_3$-0.5 m NH_4NO_3- H_2O and 0,5 m $NaNO_3$-H_2O and 0.5 m NH_4NO_3- H_2O, at the temperature of 25 and 30 °C

$$\Delta v_{25}=/82.18-(53.26+31.45)/10^{-7}\ m^3=-2.53\cdot10^{-7}\ m^3,$$

$$\Delta v_{30}=/79.52-(51.18+30.34)/10^{-7}\ m^3=-2\cdot10^{-7}\ m^3 .$$

Calculations show that together and separately dissolved nitrates change structure of water almost in the same way. Temperature has a slight impact in the change of Δv. A conclusion can be drawn that the investigated complex fertilizers can be used in full. Fertilizers, spread either separately or together, give almost the same effect. The amount of certain fertilizers has to be taken according to the crops produced.

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V.Janënas, O.Majauskienë, V.Kasperiûnas

Kompleksiniø tràðø tyrimas ultraakustiniu metodu

Reziumë

Iðtirtas dviejø porø nitratø - $NaNO_3$ bei $Ca(NO_3)_2$ ir $NaNO_3$ bei NH_4NO_3 - poveikis vandens struktûrai, kai kiekvienos ið jø komponentai iðtirpinti atskirai ir kartu 25 ir 30 °C temperatûroje, esant tirpalø koncentracijai 0.5 m (0.5 molio druskos 1 kg vandens). Vandens struktûros pokytis ávertintas ið spûdumo pasikeitimo apie katijonà. Vandens spûdumo pokytis apie katijonà randamas iðmatavus vandens ir tirpalo adiabatinius spûdumus. Adiabatiniai spûdumai randami ultraakustiniu metodu, iðmatavus tirpaluose ultragarso greitá ir tirpalo tanká. Apskaièiavimai rodo, kad vandens struktûros suardymas, iðtirpinus nitratus kartu ir pavieniui, maþai skiriasi. Temperatûra taip pat silpnai veikia vandens struktûrà. Yra pagrindo teigti, kad kompleksines tràðas naudoti tikrai galima, nes beveik tas pats efektas gaunamas, ar jos barstomos atskirai, ar kartu, tik reikia parinkti tràðø kieká pagal auginamø kultûriniø augalø rûðá.