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INNOVATIVE METHOD OF WATER TREATMENT IN HYDROPONIC SYSTEM

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Abstract: The paper reviews existing methods of growing crops by hydroponic and shows the necessity to use them in the agriculture as perspective. Great attention was given to the water treatment in such hydroponic systems of different types. The purpose of these studies was to research the influence of the water treatment in recirculation hydroponic system by innovative nonreagent method such as alternating impulses of pressure for changing the pH of the hydroponics. Determination of change of potential of hydrogen of liquid samples of the model systems is carried out with use analogue pH-meter-millivoltmeter pH-150 M with external electrodes. Through researches increases pH of the pure water on 15% have been established, thus the hydrogen potential of the water prepared on technology for recirculating hydroponic system has raised on 15-16,5%. Investigational studies have shown that the method of the alternating impulses of pressure may be suitable for technology of water treatment in recirculation aquaculture-hydroponics system. As a result of research, it was found that the innovative technology of water treatment by alternating impulses of pressure can greatly reduce energy, power and resource consumption, increase efficiency of the growing crops.

Keywords: Hydroponic, Water, Treatment, Alternating impulses of pressure, Growing, Crops.

INTRODUCTION

Hydroponics is one of the fastest growing sectors of crops growing, and it could very well direct foodstuff production in the opportunity. Besides, hydroponics is a method that can help decreasing the environmental influence of food production. Hydroponics is a method of growing plants that takes advantage of this fact by providing all of the nutrients, in their inorganic form, in a liquid solution with or without solid media (McDowell SC, Akmakjian G, Sladek C, Mendoza-Cozatl D, Morrissey JB, Saini N, Mittler R, Baxter I, Salt DE, Ward JM, Schroeder JI, Guerinot ML, Harper JF., 2013). Substratum is aqua, organic nutrients, and all necessary manure for cultivating plants (Matthew T. Murphy, Fannie Zhang, Yukiko K. Nakamura, Stanley T. Omaye, 2011). The using of a hydroponic growth system is most advantageous in situations where the nutrient media need to be well controlled and when unbroken roots need to be harvested for downstream applications (Nga T. Nguyen, Samuel A. McInturf, and David G. Mendoza-Cózatl, 2016).

The hydroponic method of growing crops has much recompense, such as: space and other accessible resources; expected efficiency; availability of suitable growing medium; expected quality and safety of the produce – emergence, colour, free from harmful impurities, etc.

The main features of hydroponics growing are: the plant, growth medium or without it; water solutions which consist of water, nutrients, and fertilizers.

There are two types of hydroponic systems. It is passive, without any mechanical equipment and active systems, which includes pumps, timers and automatic complexes. There are many kinds of hydroponic systems. Some of them are:

- a wick system (passive system);
- a water culture (active system),
- a flood and drain(active system),
- the drip systems (active system),
- a nutrient film technique (active system),
- an aeroponic (active system).

In hydroponic systems, the potential of hydrogen is constantly changing as the plant grows. Therefore pH control is a requirement in hydroponic solutions, because the plant growth depends on this. The pH range from 5,5 to 7,5 is most favorable for the availability of nutrients from most water nutrient solutions. (Mamta D. Sardare, Shraddha V. Admane, 2013).

EXPOSITION

Investigation of the Components of Hydroponic System

The equipped examples of the different types of hydroponics from the greenhouses were used in recirculating hydroponic system for experimental investigations, it was hydroponic in recirculating technology of the growing cucumbers (*Cucumis sativus*) and hydroponic in recirculating technology of the growing lettuce (*Lactuca sativa*) fig. 1.

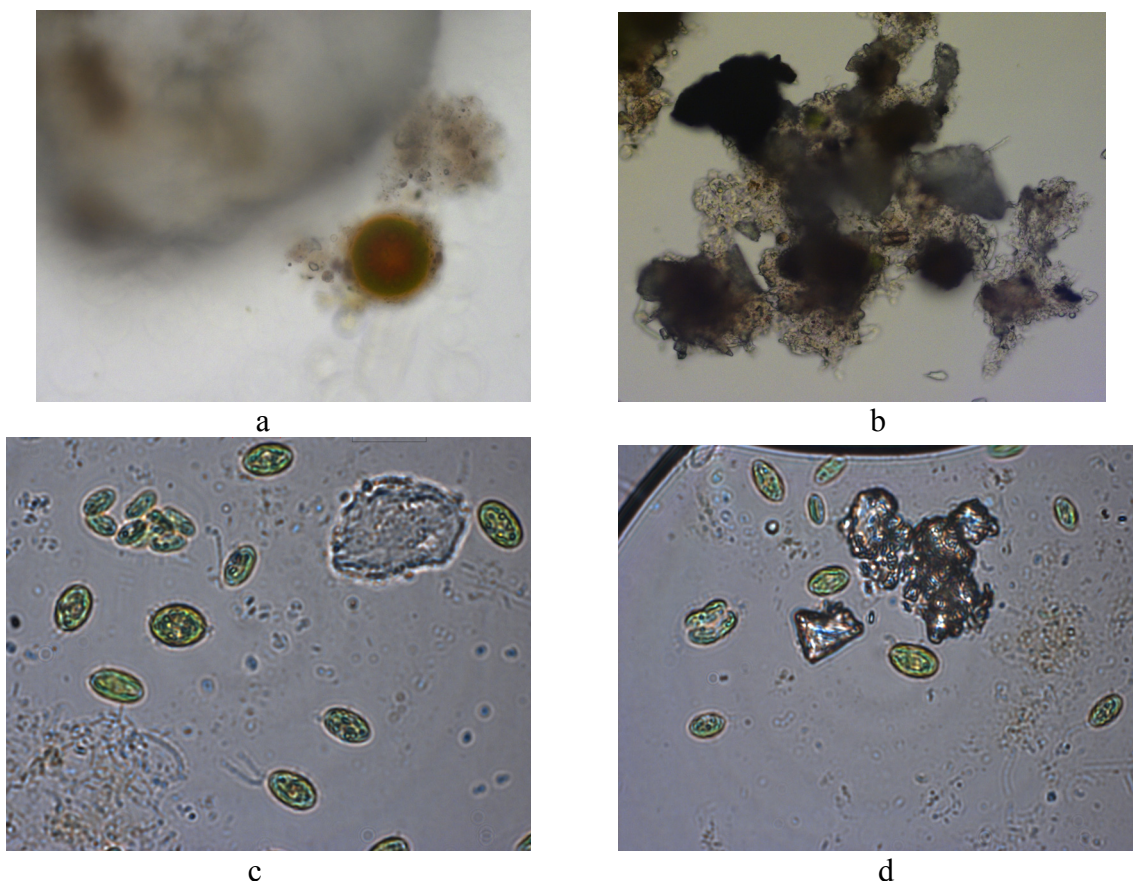


Fig. 1. The types of the hydroponics in recirculation technological schemes in greenhouse:
a, b – hydroponic in recirculating technology of the growing cucumbers (*Cucumis sativus*)(
640x microscope magnification);
c, d – hydroponic in recirculating technology of the growing lettuce (*Lactuca sativa*)(1200x
microscope magnification)

The hydroponic in recirculation technological schemes of the growing crops is incredibly multicomponent complex biological system which includes alive organisms.

The investigation of the examples of water solutions of the hydroponic from greenhouses were carried out by research microscope system Zeiss Axio Imager Vario. The samples were analyzed in

automatic mode in direct light which passes through the examples of water solutions of the different types of hydroponic.

At fig.1 we can see a single drop of the hydroponic magnified at 640 times (a,b) and a single drop of the hydroponic magnified at 1200 times (c, d) in recirculating systems. Hydroponic includes microscopic organisms: various bacteria, protists, algae and cyanobacteria. They are important members of aquatic communities.

Algae can give useful information about the productivity and health of recirculating hydroponic systems. For example, some forms of algae are indicative of low nutrient surroundings while others indicate high nutrient levels and some species favor acidic surroundings while others more basic. Many of the bloom-forming algae are cyanobacteria such as blue-green algae, some of which can potentially produce toxins that may have harmful effects on aquatic and hydroponic growing crops.

During the investigations at microscop we saw: clorella, it is a single-celled fresh water algae, small amoebas, fast-moving protists, chlamydomonas reinhardtii, diatoms, euglena gracilis, single-celled flagellate eukaryotes, and many other.

Investigational studies have shown that hydroponic is very perspective medium for research, because it gives us a possibility to analyse the conditions of the growing crops and to operate the duration and intensification of cultivation of the plants.

It is the beginning of the research work, that's why many investigations will be made in future, but all results help us to understand main mechanisms of the organization of the biological systems.

Investigation of a Water Treatment by Alternating Impulses of Pressure

This research investigation carried out at the pilot unit designed and created by the scientists, desiners and constructors at the Institute of Engineering Thermophysics of National Academy of Sciences of Ukraine, the main equipment of the unit give possibility to realize high hydrodynamic treatment and sway, such as alternating impulses of pressure (Dubovkina Irina, 2015).

The hydrodynamic treatment is a physical reagentless method, which can influence on structural transformations in complex aquatic systems on micro- and nano- altitude and gives opportunity to initiate physical and chemical changes in these aquatic systems (Dolinskij A.A., Basok B.I.,2005).

The basic character of a hydrodynamic treatment of water consists in that beginning permanently entered and any rank the energy distributed in working volume to accumulate in locally disconnected discrete points of system and further pulse to realise for achievement of necessary physical effects:

- forcing and dumping of pressure;
- adiabatic boiling;
- hydraulic blow;
- shock waves of pressure or depression;
- pressure of shift;
- local turbulence;
- cavitation effects.

Through the dispensation of water treatment in the conditions of alternating impulses of pressures the main parameters of the equipment represented:

- $\Delta P = 370$ kPa near an external surface of the internal rotor which rotates on the shaft;
- $\Delta P = 240$ kPa near an external surface stator;
- $\Delta P = 155$ kPa near an internal surface stator;
- $\Delta P = 190$ kPa near an internal surface of an external rotor which rotates on the shaft

Thus pressure of shift of a stream represented:

- 219,8 Pa the first rotor which rotates on the shaft;
- 235,5 Pa, the second rotor which rotates on the shaft.

Speeds of shift of a stream:

- $2,2 \times 10^5 \text{ s}^{-1}$ the first rotor which rotates on the shaft;
- $2,4 \times 10^5 \text{ s}^{-1}$ the second rotor which rotates on the shaft. (Dubovkina Iryna (2017)).

The liquid model systems such as distilled water and pure water were passed through rotating coaxial cylinders, one stator and two rotors with cuts on a surface and small clearances between them, which achieve 0,1mm instantaneously, which allowed spending this process by uninterrupted technological mode.

For shipping out of process of water treatment water solutions and distilled water gave in to processing during special time from 5s to 360s.

Influence of pilot processing of water with application of alternating impulses of pressures for technology of recirculating hydroponic system was studied.

Investigation of a Changing Potential of Hydrogen

The methods of express potentiometry such as ionometry were used for the researches and studies (Kenneth I. Ozomwona, 2007).

The outfitted examples of water and water solutions were used as the model mediums in recirculating hydroponic system for experiments.

Determination of change of potential of hydrogen of liquid samples of the model systems is carried out with use analogue pH-meter-millivoltmeter pH-150 M with unique external electrodes.

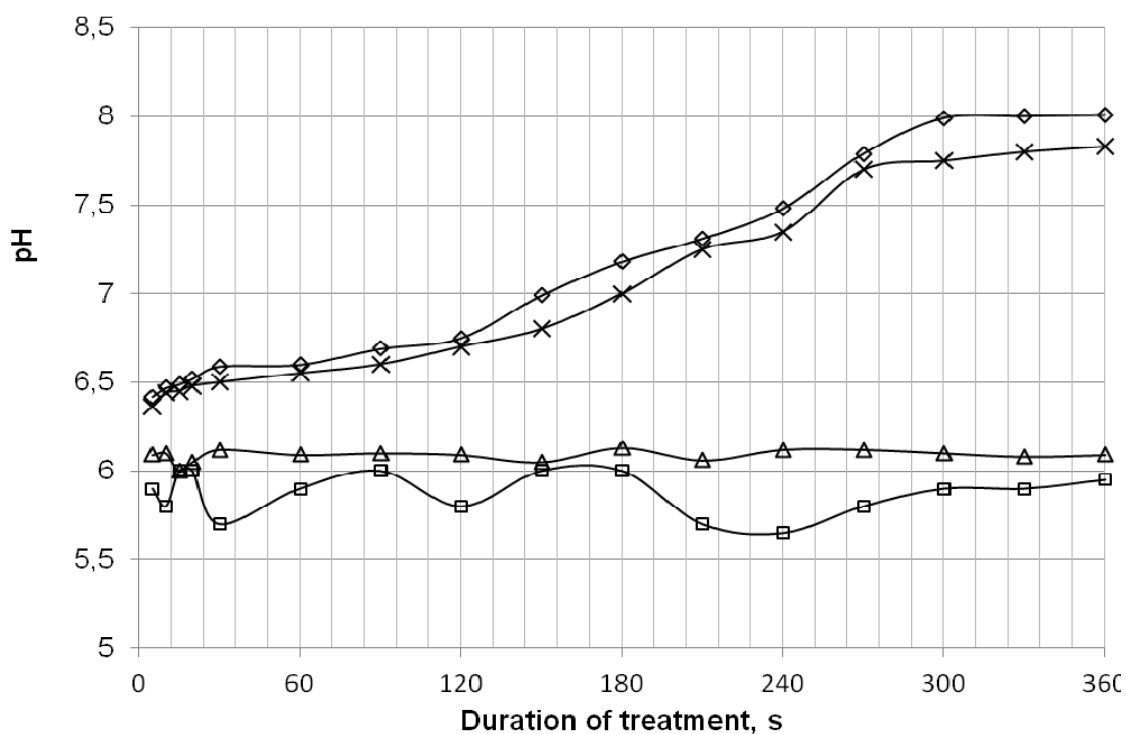


Fig. 2. The changing of potential of hydrogen by the influence of alternating impulses of pressure treatment in water: Δ - pure water before treatment

◇ - pure water after treatment □ - distilled water before treatment

x - distilled water after treatment

The changing of the potential of hydrogen value during the application of the alternating impulses of pressures is shown on fig.2.

During the investigational researches the pH of the distilled water increases on 15 % have been established, thus the hydrogen potential of the pure water prepared on technology of the greenhouses has raised on 14-16,5%.

It is give a possibility to change the pH without chemical reagents and other synthetic impurities. Such changes of pH give potential to receive water for hydroponic with improved

physical and chemical properties and parameters that need agricultural plants for intensive growing and food safety.

The mode of flowing treatment of water for hydroponic system gives capacity to reduce the energy expenditure of the technological processes of preparation liquid solutions for growing crops.

CONCLUSION

Investigational studies have shown that water treatment by the method of the alternating impulses of pressure may be suitable for technology of growing crops in recirculation hydroponics systems in greenhouses.

As a result of research work, it was found that the innovative technology of water treatment by alternating impulses of pressure can greatly reduce energy, power and resource consumption, increase efficiency of the growing crops.

REFERENCES

- Matthew T. Murphy, Fannie Zhang, Yukiko K. Nakamura, Stanley T. Omaye (2011), Comparison between Hydroponically and Conventionally and Organically Grown Lettuces for Taste, Odor, Visual Quality and Texture: A Pilot Study, *Food and Nutrition Sciences*, Volume 2, p. 124-127
- McDowell SC, Akmakjian G, Sladek C, Mendoza-Cozatl D, Morrissey JB, Saini N, Mittler R, Baxter I, Salt DE, Ward JM, Schroeder JI, Guerinot ML, Harper JF. (2013). Elemental Concentrations in the Seed of Mutants and Natural Variants of *Arabidopsis thaliana* Grown under Varying Soil Conditions. *Public Library of Science ONE*. Volume 8 Issue 5: p. 1-11.
- Nga T. Nguyen, Samuel A. McInturf, and David G. Mendoza-Cóatl (2016). The Hydroponics: A Versatile System to Study Nutrient Allocation and Plant Responses to Nutrient Availability and Exposure to Toxic Elements, *Journal of Visualized Experiments*, Volume 113: 54317
- Mamta D. Sardare , Shraddha V. Admane (2013). A Review on Plant without Soil – Hydroponics, *International Journal of Research in Engineering and Technology*, Volume 2, Issue 3, p. 299-304
- Dubovkina Irina (2015), The Features of Carrying Out of Mixing of Water and Spirit in the Conditions of Alternating Impulses of Pressure, *Technology audit and production reserves*, Volume 6/1(26), p. 42-45
- Dolinskij A.A., Basok B.I. (2005), Nanoscale Effects and Transformation by the Discrete-Pulsed Input of Energy, *Journal of Engineering Physics and Thermofysics*, Volume 78 Issue (1), p. 15-23.
- Dubovkina Iryna (2017). Change of physical and chemical parameters of the liquid binary systems by alternating impulses of pressure, *Ukrainian Food Journal*, Volume 6, Issue. 1, p. 142-154.
- Kenneth I. Ozomwna (2007), Recent Advances in Analytical Electrochemistry, *Transworld Research in Analytical Electrochemistry* ,available at: [network.http://www.researchgate.net/publication/266111111](http://www.researchgate.net/publication/266111111)