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## INFLUENCE OF REDOX POTENTIAL OF DIFFERENT WATER QUALITY ON THE HUMAN BLOOD

Досліджено вплив дистильованої, водопровідної та мінеральної води «Поляна Квасова» (Україна) з від'ємним окисно-відновним потенціалом на стан крові людини. Воду не сичувати воднем бо ктивувати в електроктиваторі. Доведено позитивний вплив такої води на стан крові людини. Насичення водопровідної води воднем може розглядатися як метод поліпшення якості питної води, отже здоров'я людини.

**Ключові слова:** питна вода, окисно-відновний потенціал, насичення воднем, електроктиватори.

### 1. Introduction

The quality of the water consumed by a human is the determining factor in the health of the population of any country in the world. Compliance of drinking water quality indicators to state regulations are not always shows its best composition and properties for human health.

The most important indicator of drinking water properties is the redox potential (RP). Previous studies were found that the consumers of the drinking water in Lviv have drinking quality water. However, during the research of water RP isn't determined [1]. The influence of different water hardness on human blood revealed that condition of the blood does not change significantly for consumption of tap water. An almost perfect blood conditions is observed for the human consumption of natural mineral medical-table water «Polyana Kvasova» [2].

In view of the above-mentioned, research of the effect of water RP with different salt content on human blood is relevant.

### 2. The object of research and its technological audit

*The object of research* is distilled tap mineral water with different RP values and its influence on the human blood.

Technological audit that would aim to determine an influence of water with different RP values on the human blood should be done on the basis of regulations governing the relevant state-level standards. Therefore, the most appropriate should be considered use of recommendations of the World Health Organization (WHO), which recommends to use the water with RP no more than 60 mV. Redox potential of the internal environment of the human body is normally always less than zero and is in the range of  $-100$  to  $-200$  mV. In [3] the authors suggest that the optimal water for the human health is drinking water with negative RP value. However, people consume water with the RP within 100–400 mV. Human consumes extra energy to adapt the redox potential of drinking water and the internal environment.

In Ukraine, the process of water treatment is not considered this factor. Moreover, RP value of bottled and

other water isn't standardized by DSanPiN 2.2.4-171-10 «Hygiene requirements for drinking water intended for human consumption».

Water with negative RP and its quality indicators may vary depending on the treatment method.

### 3. The aim and objectives of research

*The aim of research* is determination of the effect of the redox potential of different water quality on the state of human blood.

To achieve this aim there are the following tasks:

1. Analyze the compliance of quality indicators (RP, common salt content, pH) of source (distilled, tap, mineral) water with standards for drinking water.
2. Analyze the compliance of quality indicators (RP, common salt content, pH) of analyzed (activated and hydrogen-saturated) water with standards for drinking water.
3. Evaluate the change of human blood state after water consumption of different composition with different RP.

### 4. Research of existing solutions of the problem

Over the life a person is exposed to harmful factors, including consumption of unsafe drinking water. This contributes to the destruction of redox regulation system of the body at the cellular level. The immediate cause of injury and death of cells may be free radicals.

Metabolic and energy disturbances, accumulation of free radicals, reactive oxygen intermediates are called oxidative stress. During oxidative stress, together with an excess of free radicals, a decrease in the activity of antioxidant defense system is observed. For example, diabetes is characterized by increased formation of reactive oxygen intermediates and a sharp decrease in antioxidant defense of the body [4]. Oxidative stress is also associated with physiological degeneration that accompanies Parkinson's and Alzheimer's diseases, cardiovascular, oncological diseases and aging [3].

Recently, scientists have identified a new risk factor for ill health of the population – lack of electrons in the environment and drinking water, and consequently in the human body. This, in turn, disturbs cellular metabolism and

provokes the emergence of «diseases of civilization» (cardiovascular disease, diabetes, obesity, osteoporosis, malignant tumors, etc.) and aging. Human blood is a multiphase and polydisperse system, spatial stability of which is caused by electrical charges of corpuscular elements. The surfaces of red blood cells, platelets and white blood cells are negatively charged. Stability of blood electrostatic system is lost in the case of charge deficiency that leads to the unification of particles and their coagulation. So, long electron deficiency causes abnormal endogenous electric exchange reduces electric potentials of the blood particles, colloids, cells, tissues and organs and disturb a metabolism [5].

The antioxidant system of the human body is balanced antiradical network of antioxidant agents. They transfer electrons and protons from metabolites – participants of enzyme oxidation to free radicals. Transfer activity of protons and electrons regulates the PR [6]. Balance of redox regulation system is normalized using antioxidants. Strong antioxidant is water with a negative RP value [3, 7].

Reducing the water RP is possible by its electrochemical activation using electric activator or hydrogen saturation.

The first information that molecular hydrogen can be an antioxidant was in 2007 [8]. Before it, studies on this subject were isolated. During the last decade research of the effect of hydrogen on living organisms are greatly intensified mainly in China, Japan and the USA. Researches were conducted on animals (especially rodents), plants and peoples. The dominant form of hydrogen injection in the body is hydrogen-saturated physiological solution or water, and hydrogen gas. The positive therapeutic effect is found in almost all bodies that cover 31 type of diseases caused mainly by oxidative stress and inflammation [9].

Human consumption of hydrogen-saturated water improves lipid and glucose metabolism in patients with type 2 diabetes or impaired glucose tolerance [10]. The positive therapeutic effect is proved during the research for people who suffer from metabolic syndrome [11].

Consumption of such water improves the quality of life of patients during radiation therapy of liver [12]. It can complement traditional therapy in rheumatoid arthritis [13], chronic hepatitis B [14], Parkinson's disease [15] and atherosclerosis [16] due to reduction of oxidative stress.

The results of the above-mentioned researches show a positive therapeutic effect. However, the mechanism of action of such water on the human body isn't fully explained. This requires further large-scale studies on this topic. In particular, an influence of different quality water with negative RP in the human body isn't analyzed.

## 5. Methods of research

**5.1. Analyzed materials and equipment used in the experiment.** Potentiometric method for determining quality of source and analyzed water was used during research. Redox potential was measured by portable RP meter ORP-2069 (China), the total salt content and temperature – by water quality portable analyzer – TDS-meter TDS-3 M (China), pH – by portable pH meter PH-2011 ATC (China). Accuracy of measuring instruments is under –  $\pm 5$  mV,  $\pm 2$  % and  $\pm 0,01$  pH unit.

Water with a negative RP value was received by:

- Activation of source water using an electric water activator ЭАВ-3 («Ecovod», Ukraine) (Fig. 1).
- Saturation of source water with molecular hydrogen.



Fig. 1. External appearance of electric water activator ЭАВ-3

Using electric water activator ЭАВ-3, 2,75 dm<sup>3</sup> of source water was activated for 1 hour 10 minutes. 1,0 dm<sup>3</sup> of catholyte was used for the experiments.

Hydrogen obtained by electrolysis of 30 % aqueous KOH solution was used in experiments using pure hydrogen generator H2-13B2 («Vodorod», Ukraine) (Fig. 2).



Fig. 2. External appearance of electric hydrogen generator H2-13B2

Source water was saturated with molecular hydrogen under the next scheme. Plastic bottle volume of 1,5 dm<sup>3</sup> was filled with source water to the top. Bottle neck was closed by the lid. Then the bottle was lowered upside down into a bath of source water 3. Lid was opened under water. 0,5 dm<sup>3</sup> of hydrogen was injected through the tube from the electrolyzer in the bottle. Any hydrogen purification wasn't performed (Fig. 3).

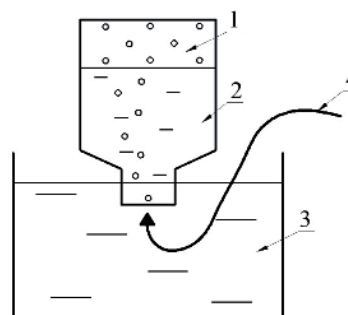


Fig. 3. Scheme of source water bottle filling with hydrogen:  
1 – hydrogen-filling bottle volume; 2 – source water bottle; 3 – source water bath; 4 – hydrogen supply

Bottle was closed under water after entering the required amount of hydrogen. Hydrogen-filling bottle was removed from the bath and kept upside down or on its side for 24 hours.

The blood state of experimenter was measured by live blood analysis (instantaneous research of drop of capillary blood under the microscope at a magnification of 4,5 thousand times) in health and rehabilitation center of biological Medicine «Sidus» (Lviv, Ukraine) (license of MON of Ukraine series AG № 600865 from 04.07.2012).

**5.2. Method of water RP influence on the state of human blood.** The method of research was in the next – quality indicators of source water were defined, then it was activated or saturated with hydrogen. 1 hour before selecting a drop of blood experimenter determined the quality of analyzed water and drank 1 dm<sup>3</sup> of analyzed water. Blood conditions were examined by live blood analysis of and compared with blood examples. Six series of experiments were performed.

*The first series of experiments* (reference blood state) were performed on an empty stomach for accustomed food and water consumption.

*The second series of experiments* were performed after consumption of tap settled water within 24 hours. Tap is located at: Ukraine, Lviv, Kolberg st., 6.

*The third series of experiments* were performed after catholyte consumption. Tap settled water within 24 hour was used as source water. Tap is located at: Ukraine, Lviv, Kolberg st., 6

*The fourth series of experiments* were performed after consumption of distilled hydrogen-saturated water.

*The fifth series of experiments* were performed after consumption of hydrogen-saturated water taken from the tap 105 of 2-th academic building of «Lviv Polytechnic» (Ukraine, Lviv, Karpinski st., 6).

*The sixth series of experiments* were performed after consumption of natural mineral hydrocarbonate sodium boric medical-table hydrogen-saturated water «Polyana Kvasova».

## 6. Research results

Research results of quality indicators of source and analyzed water are shown in Tables 1 and 2.

The result of experimenter's blood change after consumption of water of different quality is microphotographs of the fragments of blood samples (Fig. 4).

Research results of source water quality indicators shown that the total salt content in the samples of the source water range from 0,01 mg/dm<sup>3</sup> (distilled water) to 2700 mg/dm<sup>3</sup> («Polyana Kvasova» mineral water). The value of the total salt content in tap water samples (202–206 mg/dm<sup>3</sup>) meet the indicator of physiological full value of the mineral composition of drinking water (200–500 mg/dm<sup>3</sup>). Distilled water is unsuitable for drinking purposes in the absence of dissolved salts. The value of the total salt content in «Polyana Kvasova» mineral water (2700 mg/dm<sup>3</sup>) is far exceeds the standard value of allowable salt content in drinking water intended for human consumption. It can be used only for medical purposes, as provided by the manufacturer of the product.

**Table 1**

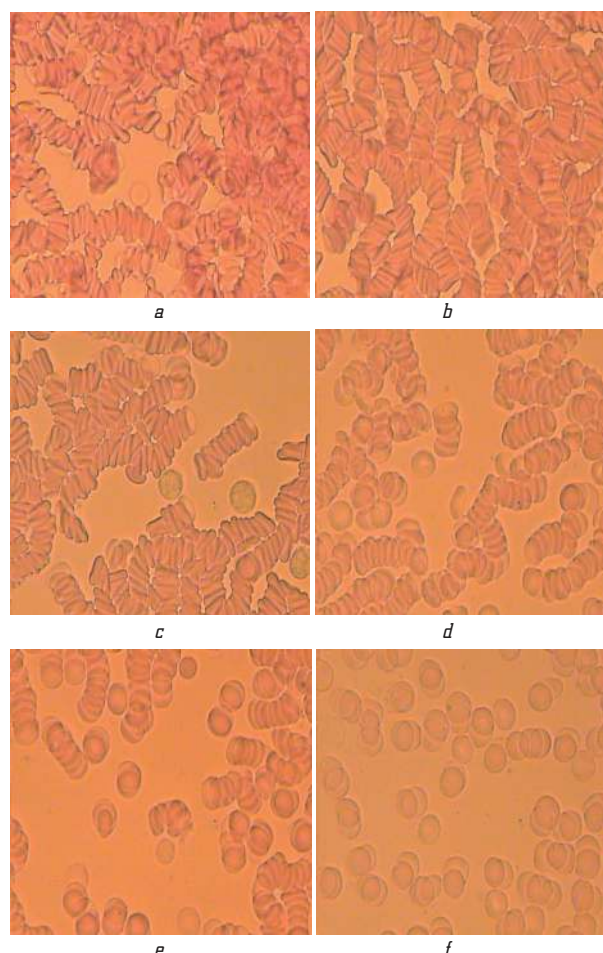
Quality indicators of source water

Series of experiment	Type of source water	Redox potential, mV	Total salt content, mg/dm <sup>3</sup>	Temperature, °C	pH
II	tap	205	204	19	7,63
III	tap	149	206	17	7,68
IV	distilled	151	0,01	19	5,79
V	tap	260	202	17	7,48
VI	mineral	60	2700	19	6,60

**Table 2**

Quality indicators of analyzed water

Series of experiment	Type of source water	Redox potential, mV	Total salt content, mg/dm <sup>3</sup>	Temperature, °C	pH
III	catholyte	-162	115	27	10,40
IV	distilled, hydrogen-saturated	-168	0,01	19	5,85
V	tap, hydrogen-saturated	-210	208	21	7,40
VI	mineral, hydrogen-saturated	-103	2680	22	6,84



**Fig. 4.** Microphotographs of the fragment of blood sample: *a* – taken as the standard; after consumption: *b* – tap water; *c* – catholyte; *d* – distilled hydrogen-saturated water; *e* – tap hydrogen-saturated water; *f* – «Polyana Kvasova» mineral hydrogen-saturated water

pH of the source water varies from 5,79 (distilled water) to 7,68 (tap water). All water samples in accordance with pH value, except distilled water, meet drinking water quality indicators.



RP values of source water samples vary in the range of 60 mV («Polyana Kvasova» mineral water) to 260 mV (tap water). According to WHO recommendations most favorable to the human body for this indicator is «Polyana Kvasova» mineral water. Other water samples don't meet these recommendations.

Research results of water quality indicators of analyzed water indicate that the saturation of the source water with molecular hydrogen and activation in electric activator can reduce its redox potential for negative values from  $-103$  mV («Polyana Kvasova» mineral water) to  $-210$  mV (tap water). This water is favorable for the human body.

The values of the total salt content and pH of the hydrogen-saturated water aren't changed (within the measurement error). However, this is not for the tap water, activated in electric activator. The value of total salt content for catholyte is reduced from 206 to 115 mg/dm<sup>3</sup>, which doesn't comply meet the physiological full value of mineral composition of drinking water. pH of the catholyte is increased from 7,68 to 10,40, exceeding the standard value of acceptable pH of drinking water.

The results of the first series of experiments (reference blood state) indicate that red blood cells and white blood cells are aggregated and tight to each other. Limited plasma and not enough oxygen are found in blood. Blood is acidified.

The results of the second series of experiment (municipal tap) indicate a massive aggregation of red blood cells and insufficient amount of plasma. Blood is acidified. Blood state is not very different from the reference.

The results of the third series of experiments (catholyte) indicate that red blood cells in the blood of experimenter are aggregated in columns, white blood cells have a regular shape and plasma is the cleaner. There is more immunomodulatory effect than antioxidant.

The results of the fourth series of experiments (distilled hydrogen-saturated water) indicate that the columns of aggregated red blood cells break down, amount of plasma is close to normal, single leukocytes acquire the correct form.

The results of the fifth series of experiments indicate powerful antioxidant effect of tap hydrogen-saturated water. In the blood there are few columns of aggregated red blood cells, white blood cells have a regular shape and sufficient amount of plasma.

The results of the sixth series of experiments («Polyana Kvasova» mineral hydrogen-saturated water) indicate that the blood of experimenter is enriched with oxygen, all of white blood cells and red blood cells become regular shape, separate and start a normal operation. Thus, this blood state is close to ideal.

## 7. SWOT analysis of research results

*Strengths.* The research states the positive effects of water with different salt content and negative RP value on the state of human blood. Qualitatively blood condition improves with increasing salt content of water. Water is considered as a multicomponent mixture. The analysis of the literature indicates that these data are absent today.

Saturation of water with hydrogen doesn't change the value of its salt content and pH. Such water is characterized by a strong antioxidant effect. This can be seen as a method of improving drinking water quality and, thus, human health.

*Weaknesses.* Tap water is activated in electric activator (catholyte) doesn't meet the indicators of drinking water. But it is characterized by immunomodulatory effect.

*Opportunities.* A promising for future research is to determine the optimal ranges of technological parameters of drinking water quality improvement – an optimal time of water saturation with hydrogen, RP relaxation time, etc. It is reasonable to conduct more detailed studies of RP changes of tap water in Lviv depending on its salt content, presence of microelements, etc. Consumption of such water offset the effect of adverse environmental factors on human health and, thus, reduces government costs in the health sector.

*Threats.* Difficulties in the implementation of the results are due to lack of research involving people, absence of the standard RP value for drinking water. Implementation of this technology in the public utilities will require additional costs and, thus, increase the cost of water treatment.

## 8. Conclusions

1. Tap distilled water (the central part of Lviv) and natural mineral medical-table water «Polyana Kvasova» is analyzed as source water. Distilled water is unsuitable for consumption because it doesn't contain dissolved salts. The value of the total salt content of «Polyana Kvasova» mineral water far exceeds the standard value of allowable salt content in the water. Tap water is characterized by physiological usefulness of mineral composition. All water samples in accordance with pH value, except distilled water, meet drinking water quality indicators. The value of the redox potential is most favorable to the human body for «Polyana Kvasova» mineral water.

2. The source water saturation with molecular hydrogen and activation in electric activator can reduce its redox potential for negative values. Change of the quality parameters for activated water (catholyte) indicates their non-compliance with drinking water indicators. Quality of hydrogen-saturated water hasn't changed.

3. Water consumption with negative redox potential improves blood condition of the experimenter compared to the reference. Blood condition improves qualitatively with increasing salt content of water. The powerful antioxidant effect of hydrogen-saturated water is indicated. Consumption of activated water (catholyte) has immunomodulatory effect rather than an antioxidant effect. Blood state close to ideal is observed after consumption of natural mineral medical-table hydrogen-saturated water «Polyana Kvasova».

Saturation of water with hydrogen can be considered as a method of improving drinking water quality and, thus, human health.

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#### ВЛИЯНИЕ ОКИСЛИТЕЛЬНО-ВОССТАНОВИТЕЛЬНОГО ПОТЕНЦИАЛА ВОДЫ РАЗНОГО КАЧЕСТВА НА КРОВЬ ЧЕЛОВЕКА

Исследовано влияние дистиллированной, водопроводной и минеральной воды «Поляна Кв. сов.» (Украина) с отрицательным окислительно-восстановительным потенциалом на состояние крови человека. Воду насытили водородом или кативировали в электрокативаторе. Доклад о положительном влиянии той воды на состояние крови человека. Насыщение водопроводной воды водородом может протестироваться как метод улучшения качества питьевой воды, следовательно и здоровья человека.

**Ключевые слова:** питьевая вода, окислительно-восстановительный потенциал, насыщенная водородом вода, электрокативированная вода.

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