Extraction of nutrient substrate from highly concentrated poultry processing plants effluents

V I Korchagin, Yu N Dochkina, L V Popova and E A Denisova-Barabash

Voronezh State University of Engineering Technologies, 19, Revolutsii Ave., Voronezh, 394036, Russian Federation

E-mail: dochkina.j.n@yandex.ru

Abstract. The purpose of this work is to study the efficiency of extracting secondary raw materials from highly concentrated poultry processing enterprises effluents (VKSV) by electroflotation (EF). The main task is to extract biologically active substances in the form of a foam product from the drain, taking into account the achievement of optimal qualitative and quantitative indicators of the treated water that subsequently enters the biological treatment line, and to prevent secondary pollution. The research objects are the poultry processing enterprise VKSV. We determined the qualitative and quantitative indicators of valuable EF extraction by the reagent-free method from VKSV. It has been found that the VKSV alkalization to pH = 9.5 increases the foam extraction efficiency product and reduces the pollutants concentration in the runoff. Increasing the temperature from 25 to 50 °C provides an increase in the efficiency of extraction of biologically active components, but leads to protein denaturation of the runoff particles. The HCV treatment with iron chlorides over 0.15 g/dm³ is accompanied by a sharp increase in the iron content and chlorine ions, while reducing the value COD index below 300 mgO₂/dm³, contributes to the depressing.

1. Introduction
One of the key problems of modern ecology is reducing pollutants from wastewater extraction, which leads to violations in the biological treatment line operation and excessive discharge of wastewater into water bodies, up to 70-80 % [1]. Wastewater from food industry enterprises is highly concentrated and requires additional treatment [2]. However, during processing, a large number of sediments and slurries can be formed that contain valuable components – protein-lipid compounds that are subject to accelerated rotting and fermentation [3], and the isolation processes and concentration are quite expensive [4].

To date, the most promising methods for extracting valuable organic components from highly concentrated effluents are electrochemical and electrophysical methods [5]. The electrocoagulation method is widely used along with electrodes made of various metals (graphite, titanium or ruthenium oxide, etc.) with an efficiency in terms of chemical oxygen consumption (COD) up to 65% at pH = 7 [6], as well as processing using the SO₄-anion and OH - radicals generated from sunlight in titanium oxide [7]. There are widely used methods of involving reagent runoff treatment: Ca(OH)₂ under the ultrasonic action with a power of 1-3x10² W/m² and a frequency of 22 kHz influence [8], cationic flocculants and binary systems (coagulant + flocculant) [9].
2. Problem statement
The electroflotation wastewater treatment method is the most studied one in relation to fat and oil-containing effluents. The essence of the method is to extract particles from the drain during their adhesion to air bubbles. The flotation complex floats to the surface, forming a foam layer, which creates a high extracted components concentration [3]. The electroflotation efficiency depends directly on the gas bubble size [10, 11] and treated water pH [12]. The gas bubbles size directly depends on a number of factors: the current density, the electrode surface and shape properties, and the medium temperature [13]. Float silt and sediment formed as a result of EF can be used as multicomponent fertilizers components [14], compost [15], food additives in feed of agricultural animals and birds, as well as the nutrient substrate in the biotechnological processes basis for various purposes.

The purpose of this work is to study the efficiency of extracting secondary raw materials from highly concentrated poultry processing enterprises’ effluents (VKSV) by electroflotation (EF).

The main task is to extract biologically active substances in the form of a foam product from the drain, taking into account the achievement of optimal qualitative and quantitative indicators of the treated water that subsequently enters the biological treatment line, and to prevent secondary pollution.

3. Research objects and methods
The research objects are the poultry processing enterprise. There is highly concentrated poultry processing enterprise wastewater (VKSV), which the studied runoff characterized and presented in tables 1 and 2.

The precipitate determination mass was determined by weighing. The suspended substances content determination was carried out in accordance with RF standard PNDF 14.1:2.4.254–2009. The dry residue amount was determined in accordance with RF standard PNDF 14.1:2:4.261-2010. Iron concentration determination was performed in accordance with RF standard PNDF 14.1:2. 3.2-95. The indicator COD was determined by RF standard PNDF 14.1:2.100–97. The chloride content determination in analysed samples was carried out in accordance with RF standard PNDF14.1:2:3.96-97. Colour and transparency were determined visually.

4. Results discussion

| № | Indicator | Initial VKSV values | Temperature, °C | pH value, CONV. food | 6 | 8.5 | 9.5 | 10.5 |
|---|-----------|---------------------|-----------------|---------------------|---|-----|-----|------|
| 1 | Suspended solids, mg/dm³ | 1184.0 | 25 | 450.0 | 446.0 | 428.0 | 280.0 |
| 2 | Dry residue, mg/dm³ | 3360.0 | 50 | 556.0 | 480.0 | 470.0 | 410.0 |
| 3 | COD, mgO₂/dm³ | 1230.0 | 25 | 960.0 | 876.0 | 722.0 | 602.0 |
| 4 | The mass of sediment, g | - | 25 | 1220.0 | 1000.0 | 920.0 | 880.0 |
| 5 | The weight of foam, g | - | 50 | 720.0 | 450.0 | 570.0 | 630.0 |
| 6 | Colour | grey-brown | 25 | 480.0 | 240.0 | 240.0 | 230.0 |
| 7 | Transparency | muddy | 50 | 60.06 | 67.0 | 81.0 | 75.0 |

*The tables show the average runoff values indicators based on the series experiments results.

In the research course there were two main ways to EF VKSV, containing biologically active treatment: reagent-free EF and reagent EF using iron (III) chloride FeCl₃. Also, a study was conducted
on the reagent-free extraction efficiency of components from VKS that have previously passed the heating procedure up to 50 °C. During reagent flotation, the wastewater sample was pre-mixed with iron (III) FeCl₃ chloride at concentrations of 0.1; 0.15; 0.2 g/dm³.

To carry out the EF process, a wastewater sample with a volume of 0.5 dm³ was placed in the EF installation container. The process was carried out at a current of 2A for 10 minutes. During the process, foam was formed on the drain surface, and flocculation was visualized in the water column. After the EF, the foam was removed, the wastewater was drained and the sediment was allowed to settle.

Due to the fact [16] that the electrophysical biologically active components extraction from VKSV the poultry processing plant is most effective in a more alkaline environment, the analyzed waste water samples were alkalinized with a 50% solution of sodium hydroxide (NaOH). The results are presented in tables 1 and 2.

**Table 2. Qualitative and quantitative reagent of EF extraction indicators depending on the content of iron chloride at different pH values**

| № | Indicator                        | Initial VKSV values | Density FeCl₃, g/dm³ | pH value, CONV. food | 6     | 8.5    | 9.5    | 10.5   |
|---|----------------------------------|---------------------|---------------------|---------------------|-------|--------|--------|--------|
| 1 | Suspended solids, mg/dm³         | 1184.0              | 0.1                 | 280.0               | 275.0 | 272.0  | 248.0  |
|   |                                  |                     | 0.15                | 352.0               | 315.0 | 304.0  | 252.0  |
|   |                                  |                     | 0.2                 | 328.0               | 319.0 | 314.0  | 272.0  |
|   |                                  |                     | 0.1                 | 646.0               | 625.0 | 584.0  | 556.0  |
| 2 | Dry residue, mg/dm³              | 3360.0              | 0.15                | 674.0               | 654.0 | 640.0  | 573.0  |
|   |                                  |                     | 0.2                 | 720.0               | 716.0 | 680.0  | 637.0  |
|   |                                  |                     | 0.1                 | 660.0               | 650.0 | 610.0  | 530.0  |
| 3 | COD, mgO₂/dm³                   | 1230.0              | 0.15                | 500.0               | 480.0 | 415.0  | 410.0  |
|   |                                  |                     | 0.2                 | 308.0               | 294.0 | 250.0  | 220.0  |
|   |                                  |                     | 0.1                 | 1.15                | 1.2   | 1.31   | 1.33   |
| 4 | Iron, mg/dm³                     | 0.89                | 0.15                | 1.76                | 1.67  | 1.64   | 1.71   |
|   |                                  |                     | 0.2                 | 2.44                | 2.3   | 2.18   | 1.97   |
|   |                                  |                     | 0.1                 | 205.0               | 210.0 | 225.0  | 258.0  |
| 5 | Chlorides, mg/dm³               | 90.39               | 0.15                | 216.0               | 220.0 | 237.0  | 281.0  |
|   |                                  |                     | 0.2                 | 241.0               | 242.0 | 244.0  | 303.0  |
|   |                                  |                     | 0.1                 | 2.04                | 2.1   | 2.32   | 2.76   |
| 6 | Sludge mass, g                   | -                   | 0.15                | 2.3                 | 2.6   | 2.65   | 3.08   |
|   |                                  |                     | 0.2                 | 2.5                 | 2.8   | 3.04   | 4.0    |
|   |                                  |                     | 0.1                 | 55.65               | 85.02 | 88.08  | 80.94  |
| 7 | Foam weight, g                   | -                   | 0.15                | 62.4                | 90.08 | 97.05  | 98.16  |
|   |                                  |                     | 0.2                 | 73.05               | 87.04 | 93.15  | 103.17 |
| 8 | Colour                           | grey-brown          | 0.15                | grey-yellow         |       |        |        |
|   |                                  |                     | 0.2                 | clear               |       |        |        |
| 9 | Transparency                     | muddy               | 0.15                | clear               |       |        |        |

The tables show the average runoff values indicators based on the series of experimental results.

The analysis results shows that the reagent-free EF and alkalinization wastewater to pH = 9.5 ÷ 10.5 contributes to the qualitative foam product as a nutrient substrate extraction, and as a result is accompanied by an increase in the VKSV purification efficiency. A slight increase in temperature from 25 to 50 °C increases the efficiency of wastewater treatment when extracting biologically active
components, but leads to a decrease in the amount of foam product, while there is a partial denaturation of the extraction process drain—the target components protein particles. It should be noted that the temperature increase during EF extraction is limited not only by energy consumption, but also by the standard indicator of discharge to biological treatment facilities. The reagent use of EF contributes to a reduction in overall pollution—GIC, and removing a froth product, but there is an increase in the content of iron ions in the effluent, i.e. there is secondary the treated effluent breakdown products pollution of ferric chloride (III) $\text{FeCl}_3$: iron ions, and chlorides. Tabular data shows analysis that treatment of HCV with iron chlorides over $0.15 \text{g} / \text{dm}^3$ is accompanied by a sharp increase in the iron content and chloride ions, while the COD index value at the level of 300 $\text{mgO}_2/\text{dm}^3$ is noted. This is also undesirable when effluents are discharged to biological treatment facilities due to the insufficient content of nutrients for active silt, i.e. "depleted" effluents are formed. It is worth noting that reagent EF extraction at a pH $> 10$ and an iron chloride more than $0.15 \text{g} / \text{dm}^3$ consumption not only contribute to the "depleted" effluents formation, but can have a depressing effect on the biocenosia of active silt. The content of biologically active substances in the foam product is proteins - 3.8 %, fats - 1.5 %.

Based on the wastewater indicators analysis that passed EF treatment, it is possible to indirectly judge the qualitative and quantitative composition of the resulting foam product and sediment. The resulting float silt and cleaning sediment contain valuable nutritional components: protein-fat part, mineral components, animal fibers, and promising nutritional substrates containing high concentrations of biologically active substances. Determining the application areas of protein and fat-containing flotsam and sediments, obtained as an EF processing poultry result, is of great scientific interest and requires further study.

5. Conclusion
The energy-optimal and cost-effective way to extract biologically active compounds from the poultry processing enterprise VCS is a reagent-free EF with alkalinization to pH = 9.5 at a temperature of about $25 \, ^\circ\text{C}$. This method will make it possible to extract the target components as efficiently as possible, while ensuring the wastewater quality that has passed EF treatment, which is necessary for further biochemical oxidation on the biological treatment line with activated sludge.

References
[1] Ignatkina O D, Pozdnyakov A P, Moskvicheva V A, Moskvicheva V E and Voityuk A A 2019 Theoretical justification of the applicability of the electrochemical method of wastewater treatment for food industry enterprises Bulletin of Volgograd state University of architecture and construction series: Construction and architecture 1 (74) 88–96
[2] Polivanova T V, Chernyshev M A and Grigorieva E V 2017 Optimization of wastewater treatment technology for livestock complexes Youth and Knowledge—a Guarantee of Success 23 (2) 64–8
[3] Eremina T V and IGumnov O V 2014 Means of wastewater treatment at livestock complexes Bulletin of ESSUTM 6 (51) 79–85
[4] Brodsky V A, Kisilenko P N, Kolesnikov V A and Gordienko M G 2016 Electroflotation extraction of protein suspensions from aqueous solutions Advances in chemistry and chemical technology 3 (30)46–8
[5] Golovko A N and Bondarenko A M 2018 Prospects for using electrical methods for cleaning liquid organic animal waste Bulletin of agricultural science of the Don 1 (41) 52–7
[6] Mervat A Sadik 2019 Removal of Reactive Dye from Textile Mill Wastewater by Leading Electro-Coagulation Process Using Aluminum as a Sacrificial Anode Scientific Research Publishing 9 182–193
[7] Ghermaout D and Elboughdiri N 2019 Electrochemical Technology for Wastewater Treatment: Dares and Trends Open Access Library Journal 4 1–17
[8] Savchuk L, Znak Z, Kurylets O, Mnykh R and Olenych R 2017 Research into processes of wastewater treatment at plants of meat processing industry by flotation and coagulation Eastern-European Journal of Enterprise Technologies 3/10 (87) 4–9

[9] Makhlay K, Tseitlin M and Raiko V 2018 A study of wastewater treatment conditions for the poultry meat processing enterprise Eastern-European Journal of Enterprise Technologies 3/10 (93) 15–20

[10] Evseev E P, Nenno V E, Shalimov Yu N, and Zakharov P D 2016 Electroflotation wastewater treatment in comparison with other local treatment methods Russian engineer 2 (5) 22–31

[11] Evseev E P, Nenno V E, Stupin V I 2004 RU, Patent No. 2226180 Device for electrochemical disinfection of liquid

[12] Perfileva A V, Malkova Yu O, Brodsky V A, Matveeva E V and Gubin A F 2017 Influence of the pH of the medium on the physical and chemical properties and efficiency of joint electrofloation extraction of the dispersed phase of low-soluble heavy metal compounds from aqueous solutions Advances In chemistry and chemical technology 9 (31) 80–2

[13] Kolesnikov V A, Ilyin V I, Brodsky V A and Kolesnikov A V 2017 Electroflotation in the processes of water treatment and extraction of valuable components from liquid technogenic waste. Overview Theoretical foundations of chemical technology 4 (51) 361–375

[14] Bryndina L V, Korneeva O S and Polyansky K K 2015 Possible ways of using sewage sludge Food security: scientific, personnel, information support 509–13

[15] Korchagin V I, Enyutina M V, Tarasevich T V and Kostyleva L N 2014 Compost mixtures based on industrial waste Ecology and industry of Russia 1 21–23

[16] Korchagin V I, Dochkina Yu N, Denisova-Barabash E A and Plyakina A A 2020 Comparative evaluation of the effectiveness of coagulation methods for extracting biologically active components from highly concentrated effluents Vestnik VGUIT 82 (1)