THE INFLUENCE OF THE WAY OF SEWAGE SLUDGE TREATMENT ON AMMONIUM NITROGEN CONTENT IN THE RETURN WASTEWATER FLOW

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Wastewater treatment facility receives, in addition to the influent, the return flow after sewage sludge treatment. Thus, the organic load on the facility increases as well as the nitrogen and phosphorus content load. There was studied the effect of different stages of sewage sludge treatment (sludge thickening, mechanical dewatering, storage on the grit bays and in the gathering ponds) on ammonium nitrogen content in the incoming flow. It is established that the most concentrated water by ammonium nitrogen is the return water from the gathering ponds, but the less concentrated is the supernatant water from sludge lagoons. Taking into account volume of the return flow the secondary ammonium nitrogen load from the every stage of sewage sludge treatment is calculated. It is revealed the seasonal and climatic impact on the gathering ponds return flow composition; it is shown that the biggest fluctuations occur in spring-summer period. The dependence of ammonium nitrogen content in the return flow on sludge thickening process time in the sludge lagoons is determined. The load contribution on the treatment facility by ammonium nitrogen in the return flow was 3% in the relation to this in the influent. The conclusion was made that with the existing technology of sewage sludge treatment the isolated scheme of return water treatment is not required. The comparative analysis on the effect of thermophilic and mesophilic conditions of anaerobic sewage sludge treatment on ammonium nitrogen content in the liquor was carried out. It was found that the higher ammonium nitrogen secondary load is created by the liquor of thermophilically treated sewage sludge: it is 16,4% versus 11,8% of mesophilically treated. Hence, the including of anaerobic sewage sludge treatment in the scheme significantly increases the load on treatment facility by ammonium nitrogen. In the conditions of cascade denitrification the distribution of incoming in the denitrification zones water flow is of great importance for providing required content of readily available organic substances. The change of ammonium nitrogen content in this flow will require the adjustment of its volume.

Keywords: *ammonium nitrogen, anaerobic treatment, filtrate water, return flow, sewage sludge, sludge thickening*

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1. Introduction

Biogenic elements content in the return flow is dependent on accepted technology of sewage sludge treatment. Observations of authors has shown that amount of pollutants carried with supernatant is dependent on dewatering mode (operational parameters of dewatering equipment) (Ivanenko, 2015). Dewatering of sewage sludge mix on cetrifuges and centripresses forms approximately equal background of dissolved nitrogen compounds. Aerobic and anaerobic sludge stabilization processes produce the appearance of secondary pollutants in the form of ammonium nitrogen and nitrates; the including of such processes in the scheme of sewage sludge treatment is not preferred (Solov'yeva, 2016). Authors carried out the quantitative assessment of load change on municipal facility after implementation of sewage sludge treatment complex in application to treatment facility of Gomel (Novikova et al., 2020). In accordance with predictable concentrations of pollutants of incoming wastewater and taking into account the return flow of sludge liquor the load on the facility will increase by 12,8-26,8% (particularly by 20% for total nitrogen). This will disrupt the denitrification stage performance provided for in the reconstruction project. To solve the problem of treatment facility overload the authors consider integration of sludge liquor treatment module of necessity.

The aim of the work was to investigate the effect of different stages of sewage sludge treatment of existing technology on ammonium nitrogen content in the incoming return flow and to assess the load increasing by ammonium nitrogen in anaerobic sewage sludge treatment performance.

2. Materials and Methods

The object of the research was municipal wastewater return flow; the scheme of its formation is represented in Fig. 1.

2.1 Ammonium content in the return flow

During 2020 the ammonium nitrogen content in the influent and supernatant water from sludge lagoons was determined weekly; return water from grit bays and gathering ponds and filtrate water was analyzed monthly.

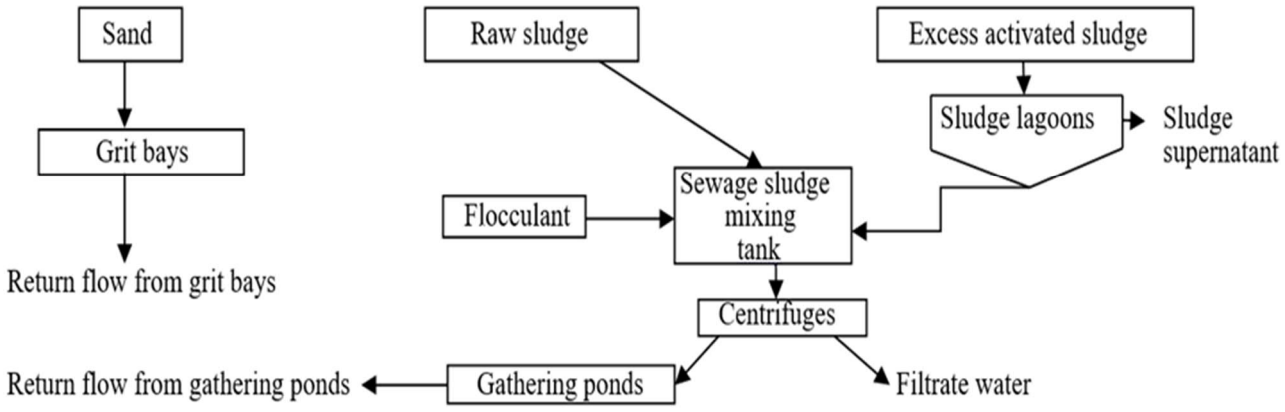

Fig. 1. *Scheme of return flows formation on treatment facilit*

2.2 Sewage sludge treatment

Anaerobic sewage sludge treatment in mesophilic and thermophilic conditions was per-formed on the pilot-scale experimental unit. The pilot unit comprises four reactors each with work volume capacity of 80 dm^3. The reactors of pilot-scale experimental unit were filled daily with 4 kg of sewage sludge mix (thickened excess sludge and raw sludge from primary settlers). The same quantity was discharged from reactors. In the liquid phase of mesophilically and thermo-philically treated sewage sludge ammonium nitrogen concentration was determined.

3. Results and Discussion

2.1 Ammonium content in the return flow

Concentration of ammonium nitrogen in the return flow was increasing in the following sequence: sludge supernatant from sludge lagoons, influent, filtrate water, grit bays return flow, gathering ponds return flow.

Data of mass quantities of ammonium nitrogen with the regard of volume of secondary flow is represented in Fig.2. Filtrate water creates the highest secondary load by ammonium nitrogen, the return flow from gathering ponds creates the lowest load.

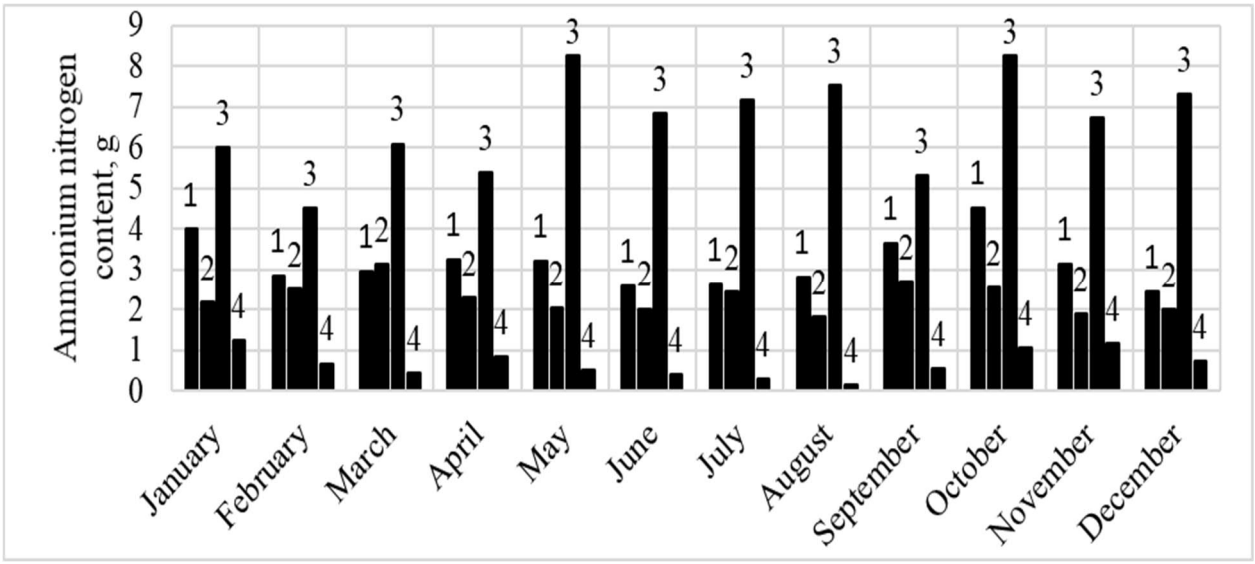

Fig. 2. *Mass content of ammonium nitrogen in the return flow of wastewater by months of 2020: 1 – return water from grit bays; 2 – sludge supernatant from sludge lagoons; 3 – filtrate water; 4 – return water from gathering ponds*

Contribution of monthly average load for 2020, total for all return flows, was 3% in relation to that in influent.

Figures 3 represents the data on the secondary load by ammonium nitrogen brought with return flow of different stages of sewage sludge treatment for years 2018-2020 for every season. Significant fluctuations for return flow from gathering ponds (Fig. 3d) as the most influenced by seasonal and climatic conditions are noted.

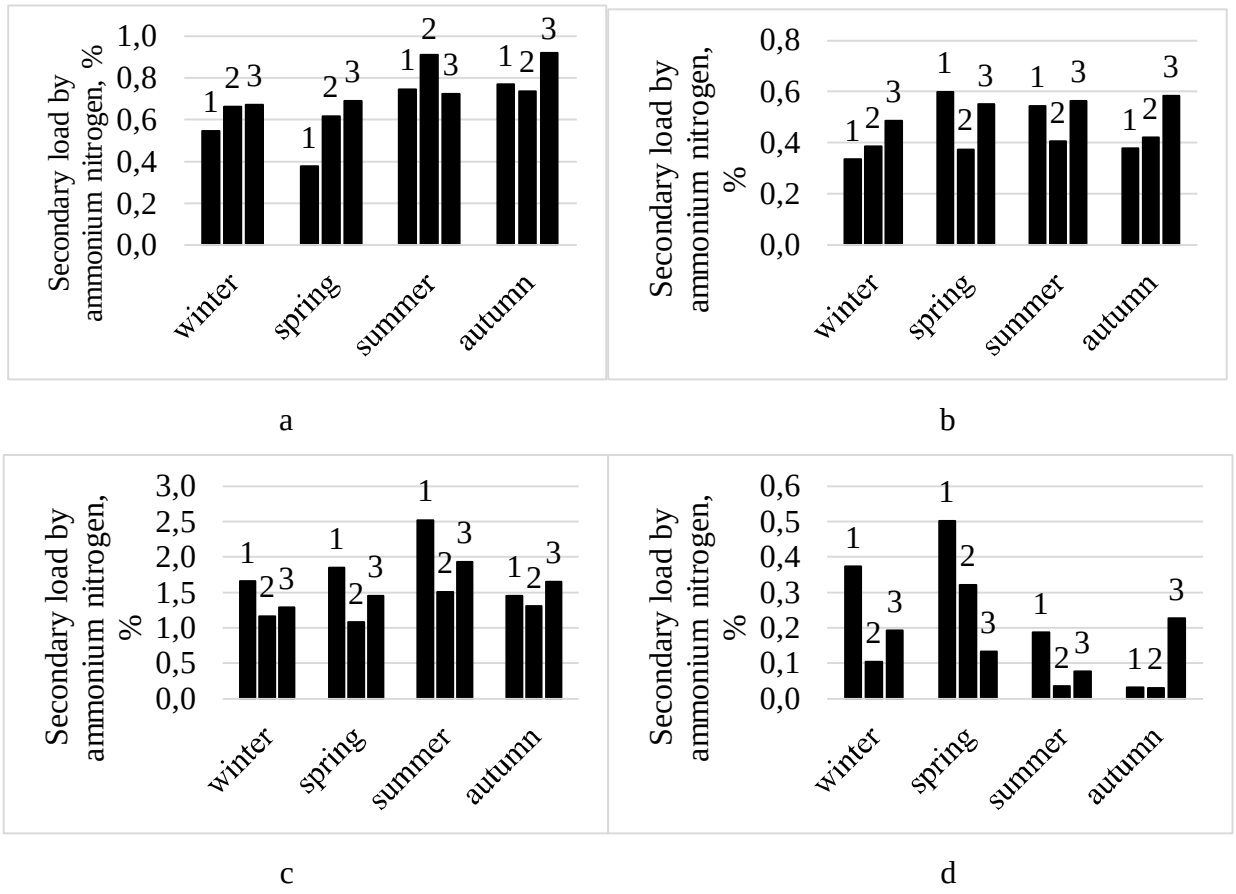

Fig. 3*. Secondary load by ammonium nitrogen brought with return water from grit bays (a) and sludge lagoons (b), filtrate water (c) and with return flow from gathering ponds (d) for each season: 1 – 2018; 2 – 2019; 3 – 2020 years*

For the stage of sludge thickening in sludge lagoons it was examined the effect of thickening process time on ammonium nitrogen content in the sludge supernatant. Unthickened excess sludge was exposed for 12 h in a measuring cylinder with the volume of 1 dm^3. Sludge supernatant was sampled every 2 h, filtered and ammonium nitrogen content was determined in the filtrate (Fig. 4).

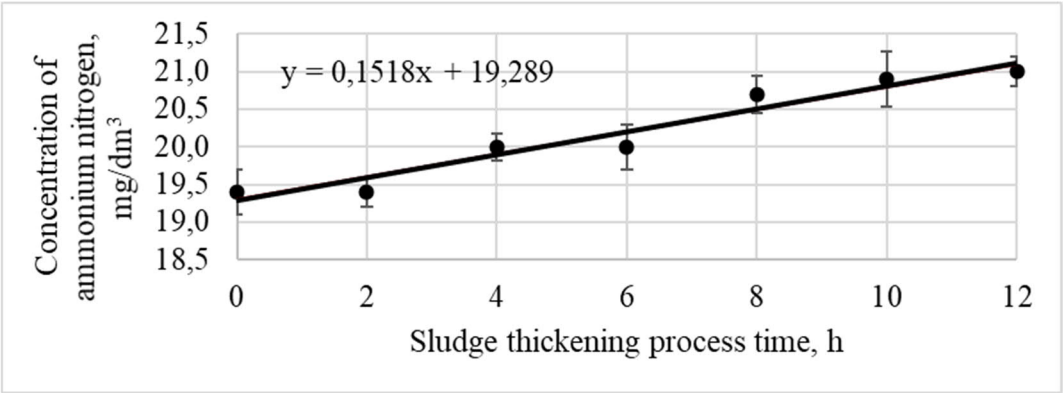

Fig. 4. *Concentration change of ammonium nitrogen in sludge supernatant depending on thickening process time*

Analyzing the data it can be noted an almost linear dependence of ammonium nitrogen concentration in the sludge supernatant on thickening process time.

2.2 Sewage sludge treatment

The average concentration of ammonium nitrogen in the liquid phase of mesophilically treated sewage sludge was 496,2 mg/dm^3; for thermophilically treated sewage sludge it was 689,1 mg/dm^3. With the regard of the quantity of liquid phase the secondary load on the treatment fa-cility by ammonium nitrogen will be 11,8% for mesophilic and 16,4% for thermophilic treatment mode.

4. Conclusions

The most concentrated by ammonium nitrogen is the return water from the gathering ponds, the less concentrated one is the sludge supernatant from sludge lagoons. Contribution of the load on treatment facility by ammonium nitrogen was 3% in relation to that in influent.

Ammonium nitrogen content in the return flow is influenced by seasonal and climatic conditions and activated sludge thickening process time.

Including of anaerobic stage in the scheme of sewage sludge treatment with biogas pro-duction significantly increases the load on treatment facility by ammonium nitrogen: 16,4% and 11,8% for thermophilic and mesophilic conditions respectively.

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ВПЛИВ СПОСОБУ ОБРОБКИ ОСАДУ НА ВМІСТ АЗОТУ АМОНІЙНОГО В ЗВОРОТНИХ ПОТОКАХ СТІЧНИХ ВОД

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На споруди очищення стічних вод крім основного потоку надходять зворотні потоки після обробки осадів. При цьому збільшується навантаження на споруди як за органічними речовинами, так і за вмістом сполук азоту і фосфору. Вивчено вплив різних стадій обробки осадів (мулоущільнення, механічне зневоднення, депонування на піскоплощадках і в ставках-накопичувачах) на вміст азоту амонійного у зворотних водах. Встановлено, що найбільш концентрованими за азотом амонійним є зворотні води зі ставків-накопичувачів, а найменш – надмулові води з мулоущільнювачів. З урахуванням обсягу вторинних потоків було розраховано вторинне навантаження по азоту амонійному для кожної стадії обробки осадів. Виявлено сезонно-кліматичну залежність складу зворотних потоків зі ставків-накопичувачів, показано, що найбільші коливання спостерігаються у весняно-літній період. Визначено залежність вмісту азоту амонійного у зворотних водах від тривалості ущільнення осадів у мулоущільнювачах. Внесок азоту амонійного зі зворотними потоками склав 3% по від вмісту, що надходив з вихідними стічними водами. Зроблено висновок, що при існуючій технології обробки осадів стічних вод, не є потрібною окрема схема для очищення зворотних вод. Проведено порівняльний аналіз впливу термофільних та мезофільних умов анаеробної обробки осадів на вміст азоту амонійного у рідкій фазі. Виявлено, що використання термофільного режиму обробки осадів спричинює вище вторинне навантаження по азоту амонійному, а саме 16,4% проти 11,8% за мезофільних умов. Таким чином, включення в схему анаеробної обробки осадів значно збільшує навантаження на очисні споруди за таким показником, як азот амонійний. В умовах каскадної денітрифікації важливе значення має розподіл потоків стічних вод, що надходять до зони денітрифікації, для забезпечення необхідного вмісту легкодоступних органічних речовин. Зміна концентрації азоту амонійного в цих потоках робить потрібним коригування їх об'ємів.

Ключові слова: *азот амонійний, анаеробна обробка, зворотні потоки, мулоущільнення, осади, фугат.*