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L. Pavliukh, PhD, Associate Professor
National Aviation University
orcid.org/0000-0002-7715-4601
e-mail: lenyo@ukr.net

PERSPECTIVES OF WASTEWATER TREATMENT BY MICROALGAE AT AN AIRPORT

Introduction

Airports are critical pieces of infrastructure of the complex global aviation system that supports the movement of passengers and air cargo. However, in providing these essential services, airport operations have the potential to adversely affect the environment [1].

Consequently, airport environmental management has become a critical element in the global air transport industry development [2]. Airports all around the world are now increasingly focusing on sustainable water management as a key element of their environmental plans and strategies. This is because airports consume substantial amounts of water to maintain both their infrastructure and operations [3–8]. Large volumes of wastewater are also generated at airports. They can be divided into production, economic-household and surface.These wastewaters could have a negative impact on both soil and groundwater since they contain a relatively high concentration of contaminants [9].

Problem statement

Although airports are not usually considered as industrial complexes, daily activities, such as aircraft and ground vehicle washing and cleaning, fueling operations, aircraft maintenance and repair work (including painting and metalwork), engine test cell operations; de/anti-icing operations, and ground vehicle maintenance, are all sources of airport industrial wastes. Wastes generated by these activities are categorized as either industrial wastewaters or' hazardous wastes'.

Treatment technologies depend on the type of wastewater and can differ significantly [10–12]. A significant amount is formed at treatment plants that treat all types of wastewater hazardous sludge that also needs to be disposed of. Experience shows that modern drainage technologies are not always environmentally friendly. Settings for wastewater treatment is not always provided sufficient quality at the output (residual concentrations contaminants often exceed the established requirements), methods of sludge disposal often cause significant negative impacts on the environment. This leads to environmental risk sat aviation enterprise [10].

Therefore, the search for environmentally friendly methods of wastewater treatment at an airport and the development of energy efficient technologies is an urgent task today.

Analysis of previous research

The principal water pollutants and their sources at airports are the residual contaminants from different activities at the airport that are demonstrated by the Table 1 [13–16].

So, among the huge amount of pollutants in waste water, in this paper attention will be payed on biogenic compounds, such as nitrogen and phosphorus. In the Fig. 1 the scheme to reduce the accumulation of phosphorus and nitrogen in the hydrosphere is presented.

Table 1

The main sources of water contamination at the airport

The main sources of water contamination	residual contaminants from aircraft maintenance activities
	run-off of silt from airport-related construction sites
	chronic leakage or spills of aviation fuel
	aircraft and runway de-icing agents during winter periods to ensure safe aircraft and airport operations
	detergent formulations
	solids, oils, greases, residues, solvent residues
	discharge of fire-fighting foam in the event of aircraft emergencies

	contribution grease and detergents due to production of in-flight meals, restaurants, and staff
	biogenic compounds (phosphorous and nitrogen)in case of washing and cleaning products using

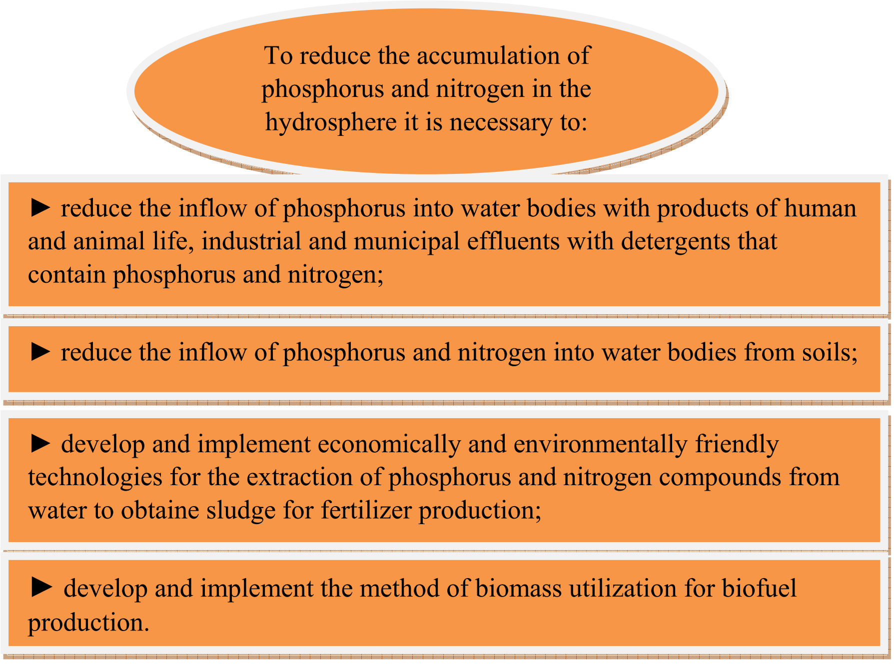

Fig. 1. Scheme for reducing of biogenic compound accumulation in the hydrosphere

Increasing concentrations of nitrogen and phosphorus compounds leads to natural waters eutrophication, which is manifested in the phytoplankton biomass increasing, "water blooming", and, as a result, water quality decreasing. This makes impossible to use water for recreation, fishing and domestic needs. The phytoplankton toxins can cause health problems through exposure to the human body after contact with the skin or the use of contaminated water for drinking.

Waste water treatment facilities include mechanical and biological stages. The goal of biological wastewater treatment is to create a system in which the results of decomposition are easily collected for proper disposal. Biological treatment is used worldwide because it's effective and more economical than many mechanical or chemical processes. Using mechanical and biological methods, treatment plants are not always able to provide sufficient purification of the water, especially when pollution content in received sewage water substantially varies. It is advisable to apply additional purification facilities for after treatment of sewage waters.

Methods of nature purification are often used for these purposes. In [17; 18], some of the most popular installations are used: special open oxidation ponds, where different aquatic organisms are cultivated; special agricultural tanks filled with hydroponics, where different aquatic plants are grown; special soil filter systems, where different soil plants can grow; and others [19].

One of the promising methods can be considered the use of wastewater for the microalgae cultivation [20; 21]. Microalgae are an alternative to wastewater treatment because they provide tertiary biotreatment combined with the production of potentially valuable biomass that can be used for several purposes.

Microalgae cultures offer an elegant solution for tertiary treatment and the final stage of wastewater treatment, due to the ability of microalgae to use inorganic nitrogen and phosphorus for their growth [22].

Research methodology

Two experimental sessions were held in the laboratory of the National Aviation University Faculty of Environmental Safety, Engineering and Technologies was chosen as the site of the experiment. For the experimental sessions, the summer period was chosen, since warm conditions are more favorable for the growth of algae.

Conditions for microalgae growing. It was decided to use transparent bottles for growing microalgae in order to create the most favorable conditions for growing. The average temperature in the laboratory was 22 degrees. The average pressure on the dates of the experiment was 746 millimeters of mercury.

The concentration of microalgae was equal to

1 liter of water per 200 ml of suspension of microalgae. *The first experimental session* included three parallel experiments for each type of water: one control without microalgae, one with wastewater and microalgae, one with a connected CO_2 generator in wastewater with microalgae.

The tanks were in a well-lit laboratory and had the same conditions. *The second experimental session* included four parallel experiments for one type of wastewater: the first control, the second in wastewater with microalgae, 3 and 4 identical samples with a connected CO_2 generator.

Measurement of nutrient rate. To measure the levels of nutrients (phosphates, nitrates and nitrites), the following measurement frequency was chosen:

1) in the first session — the first three days every day, then every two days;

2) in the second session — every 6 days.

Experiment progress. For the first experimental session, three reservoirs (bottles) were installed for each type of water (wastewater from a residential building in Kyiv before treatment, wastewater from a utility in Novograd-Volynsk before and after treatment). Totally 9 samples.

The initial hypothesis was that the bulk of nutrients will go away in the first three days, so measurements of nutrient levels were carried out for the first three days every day, and then every two days. Immediately after the installation of all tanks, phosphate, nitrate and nitrite levels were measured in order to record the initial data. To take measurements, it is necessary to follow this order:

1) to take an equal sample volume for all experiments;

2) to carry out a double filtration with paper filters (first time through a funnel with a filter, and separately a second time through a funnel with a filter);

3) to gently wash the cuvettes with distilled water and wipe the cuvettes without touching the walls with your fingers so as not to create an error in the measurement;

4) to take the necessary program on the spectrophotometer, and following the instructions add the reagent to the control sample;

5) to record the result;

6) to rinse the cuvettes with distilled water and take measurements for other samples of the experiment, also record the result;

7) at the end of the measurements, rinse all tubes, funnels and cuvettes with distilled water and dry.

For the second experimental session, four tanks were installed for one type of wastewater (wastewater from a residential building in Kyiv before entering the treatment plant): 1) control, 2) with microalgae, 3) and 4) identical with the connected CO_2 generator.

Since the initial hypothesis was not confirmed, it was decided to take measurements every 6 days. The measurement progress remained the same as in the first session.

Results and discussion

As a result of our experimentsthe ability of microalgae to reduce biogenic elements in wastewater was confirmed. In the Fig. 2 the results of measurement are presented.

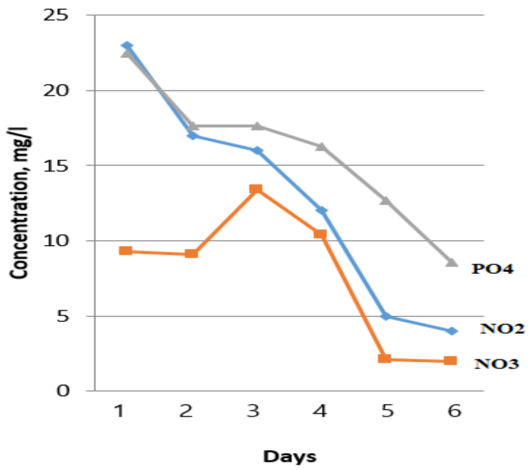

Fig. 2. Nitrogen and phosphorus compounds concentration changes in wastewater

As a result of experimental studies the concentrations of nitrogen and phosphorus compounds in waste water were decreased: NO_2 – by 5.75 times; NO_3 – by 4.65; PO_4 – by 1.45 times.

Due to experimental studies we can improve the classical technology of wastewater treatment by installing of bioreactor with microalgae and settler for microalgae removing.

It should be noted that the proposed technology is the next stage after mechanical and biological treatment, ie additional wastewater treatment (Fig. 3).

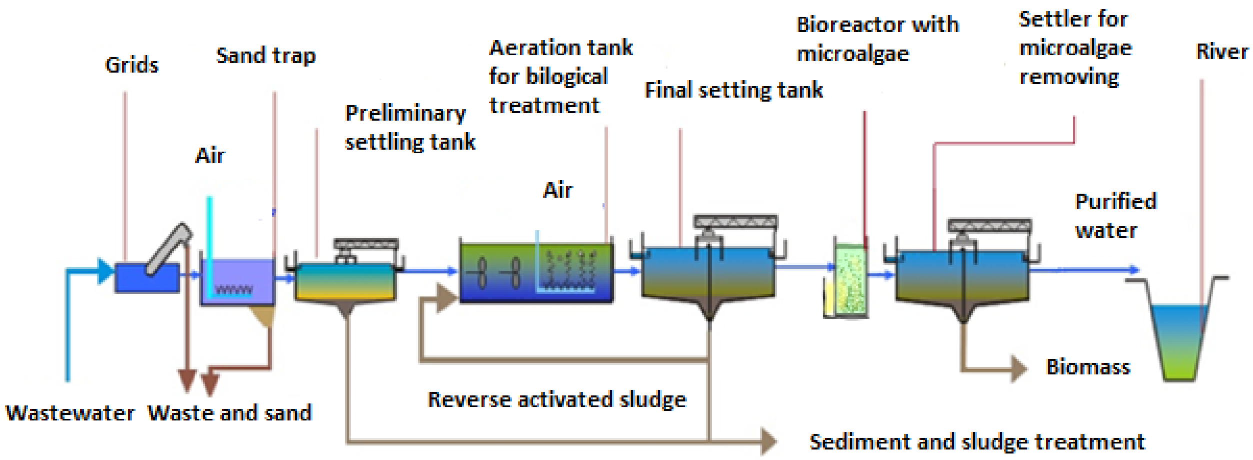

Fig. 3. Improved wastewater treatment system at the airport

After rough cleaning, the concentration of phosphorus and nitrogen compounds is equal to that in the primary contaminated wastewater. The presented scheme provides a process with activated sludge and secondary settling. In this case, nitrification is provided to convert ammonium nitrogen into nitrates. It does not provide complete removal of nitrogen as a result of gentrifications. Excess activated sludge is stabilized by aerobic fermentation. This technology provides the removal of phosphorus during cell synthesis. It was found that biogens in biomass are more bioavailable than after chemical precipitation in traditional schemes. Schemes of secondary treatment and treatment of the return flow of aerobic fermentation increase the efficiency of the process with activated sludge. In the case of their use, organic carbon and ammonium are removed, which reduces their content in the wastewater entering the process with activated sludge.

The final stage provides water treatment in a bioreactor by microalgae. Along with the potential benefits, there are currently certain obstacles to the practical implementation of these schemes, such as attracting additional land, providing phototrophic processes for the microalgae growing and removing for biomass utilization. The proposed advanced technology has significant advantages because it is cyclical and provides the possibility of producing biofuels from microalgae removed after the absorption of nutrients, as well as the production of biofertilizers from sludge.

It is important to note that considering the increasing pressure to reduce water consumption and conserve available water resources, airports must manage their activities and operations to reduce water consumption. Airports also need to protect both the surface and groundwater resources as well. To achieve these objectives, airports have implemented a range of methods including the following:

• Monitoring of water consumption at the airport;

• Monitoring the quality of the surface and groundwater;

• Protecting groundwater from pollution

• Re-using water, following treatment (wastewater and sewage treatment plants);

• Reduction in water consumption at the airport site.

Conclusions

It is experimentally confirmed that the appropriate method of additional treatment is the use of wastewater as a medium for the cultivation of energy microalgae inphotobioreactors with the subsequent production of liquid biofuels of the third generation.

An appropriate method of treatment and disposal of sludge formed during the purification process is anaerobic fermentation with the organization of the process incompliance with the kinetics of fermentation processes and the subsequent use of the fermented mass as an organic fertilizer. So, while wastewater treatment by microalgae has a long history, it's continuing to evolve in ways that make it more effective, efficient, and available.

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Павлюх Л.

ПЕРПЕКТИВИ ОЧИЩЕННЯ СТІЧНИХ ВОД МІКРОВОДОРОСТЯМИ В АЕРОПОРТУ

Вступ. *Управління охороною довкілля в аеропорту стало найважливішим елементом у світовому розвитку галузі повітряного транспорту. Аеропорти у всьому світі зараз дедалі більше зосереджуються на сталому управлінні водними ресурсами як ключовому елементі своїх екологічних планів та стратегій.* ***Постановка проблеми.*** *Досвід показує, що сучасні дренажні технології не завжди є екологічно чистими. Установки для очищення стічних вод не завжди забезпечуються достатню якість на виході (залишкові концентрації забруднюючих речовин часто перевищують встановлені вимоги), методи утилізації мулу часто спричиняють значний* *негативний вплив на навколишнє середовище. Це призводить до екологічних ризиків на авіаційному підприємстві. Тому, пошук екологічно чистих методів очищення стічних вод в аеропорту та розробка енергоефективних технологій є сьогодні актуальним завданням.* ***Методологія дослідження.*** *Для експериментальних досліджень був обраний літній період, оскільки теплі умови сприятливіші для росту водоростей. Середня температура в лабораторії становила 22 градуси. Середній тиск на період експерименту становив 746 мм рт. ст. Концентрація мікроводоростей дорівнювала 1 літру води на 200 мл суспензії мікроводоростей. Перша експериментальна серія включала три паралельних експерименти для кожного типу води: один контроль без мікроводоростей, один зі стічними водами та мікроводоростями, один із підключенним генератором CO_2 у стічних водах з мікроводоростями. Ємності знаходились у добре освітленій лабораторії та за однакових умов. Друга експериментальна серія включала чотири паралельних експерименти для одного типу стічних вод: перший контрольний, другий у стічних водах з мікроводоростями, 3 та 4 однакові зразки із підключеним генератором CO_2.* ***Результати та обговорення.*** *В результаті експериментальних досліджень концентрація сполук азоту та фосфору у стічних водах знизилась: NO_2 — у 5,75 рази; NO_3 — на 4,65; PO_4 — у 1,45 рази. Завдяки експериментальним дослідженням вдосконалена технологія є наступним етапом після механічного та біологічного очищення, тобто було запропоновано додаткове очищення стічних вод. Запропонована вдосконалена технологія має суттєві переваги, оскільки вона є циклічною та забезпечує можливість отримання біопалива з мікроводоростей, видалених після поглинання біогенних сполук, а також виробництва біодобрив зі шламу.* ***Висновки.*** *Експериментально підтверджено, що відповідним методом додаткової очистки є використання стічних вод як середовища для вирощування енергетичних мікроводоростей у фотобіореакторах з подальшим виробництвом рідкого біопалива третього покоління. Відповідним методом обробки та утилізації мулу, що утворюється в процесі очищення, є анаеробне бродіння з організацією процесу з дотриманням кінетики процесів бродіння та подальшим використанням ферментованої маси як органічного добрива. Отже, хоча очищення стічних вод мікроводоростями має давню історію, воно продовжує розвиватися таким чином, щоб стати більш ефективним, дієвим та доступним.*

Ключові слова: аеропорт; стале управління водними ресурсами; застосування мікроводоростей; біопаливо; біодобриво.

Pavliukh L.

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Introduction. *Airport environmental management has become a critical element in the global air transport industry development. Airports all around the world are now increasingly focusing on sustainable water management as a key element of their environmental plans and strategies.****Problem statement.*** *Experience shows that modern drainage technologies are not always environmentally friendly. Settings for wastewater treatment is not always provided sufficient quality at the output (residual concentrations contaminants often exceed the established requirements), methods of sludge disposal often cause significant negative impacts on the environment. This leads to environmental risk sat aviation enterprise. The refore, the search for environmentally friendly methods of wastewater treatment at the airport and the development of energy efficient technologies is an urgent task today****. Research methodology.*** *For the experimental sessions, the summer period was chosen, since warm conditions are more favorable for the growth of algae. The average temperature in the laboratory was 22 degrees. The average pressure on the dates of the experiment was 746 millimeters of mercury. The concentration of microalgae was equal to 1 liter of water per 200 ml of suspension of microalgae. The first experimental session included three parallel experiments for each type of water: one control without microalgae, one with wastewater and microalgae, one with a connected CO_2 generator in wastewater with microalgae. The tanks were in a well-lit laboratory and had the same conditions.The second experimental session included four parallel experiments for one type of wastewater: the first control, the second in wastewater with microalgae, 3 and 4 identical samples with a connected CO_2 generator.* ***Results and discussion.*** *As a result of experimental studies the concentrations of nitrogen and phosphorus compounds in waste water were decreased: NO_2– by 5.75 times; NO_3 – by 4.65; PO_4 – by 1.45 times. Due to experimental studies the improved technology is the next stage after mechanical and biological treatment, i.e. additional wastewater treatment was proposed. The proposed advanced technology has significant advantages because it is cyclical and provides the possibility of producing biofuels from microalgae removed after the absorption of nutrients, as well as the production of biofertilizers from sludge.* ***Conclusions.*** *It is experimentally confirmed that the appropriate method of additional treatment is the use of wastewater as a medium for the cultivation of energy microalgae in photo bioreactors with the subsequent production of liquid biofuels of the third generation. An appropriate method of treatment and disposal of sludge formed during the purification process is anaerobic fermentation with the organization of the process in compliance with the kinetics of fermentation processes and the subsequent use of the fermented mass as an organic fertilizer. So, while wastewater treatment by microalgae has a long history, it’s continuing to evolve in ways that make it more effective, efficient, and available.*

Keywords: airport; sustainable water management; microalgae applicaton; biofuel; biofertilizer.

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