UDC 656.71:504.43(045)

G.M. Franchuk, Dr. Sci. (Eng.)
A.M. Antonov, Cand. Sci. (Phys. and Math.)
S.M. Madzhd
Ya.V. Zagoruy

ANALYSIS OF POLLUTION OF GROUND WATERS IN THE AIRPORT ZONE

NAU Institute of Ecology and Design, e-mail: yarya-zag@yandex.ru

Negative aspect of airport's activity, which is its harmful influence on the environment, is described, with the emphasis on the ground waters pollution. The pollution of ground waters of the Nyvka river in the zone of international airport Kyiv is analyzed. The levels of waste emission into the river are determined.

Introduction

It is historically established that airports are located directly in the proximity of densely populated areas of a city. With the development of aviation and the city growth, the problem of coexistence of the city and the airport arises..

In regulating aircraft and airports, several compelling interests compete: safety, international commerce, and environmental quality. Of these, safety issues receive perhaps most of the attention, yielding headlines in the wake of airplane accidents. But the issue of the effect of the airports on the environment and human health has heated up in recent years, as public interest and citizen groups contest airport expansion on environmental and health grounds, and the airline and airport industries attempt to meet increasingly stringent regulations in these areas [1; 2].

Airports are known to be major sources of noise, water, and air pollution. They emit carbon dioxide CO_2, volatile organic compounds VOCs, and nitrogen oxides NO_x into the atmosphere, as well as dump toxic chemicals – used to de-ice the airplanes during winter storms – into waterways [3]. However, determining the extent of the aircraft contribution to local, national, and international levels of pollution is difficult, since cars and airplanes during the landing or the takeoff produce roughly equivalent quantities of ozone precursors. In addition, auxiliary power units (APUs), which are small jet engines in the tail of the plane that power appliances while the planes are at the gate, as well as ground support vehicles produce a large amount of pollutants. Moreover, competing local and national political forces make airport pollution hard to regulate, since the air pollution is mostly controlled by local authorities, while automobile and airplane emissions are regulated at the national and international level.

The growth of air traffic further increases the risk of the environmental problems. Air traffic is expected to double in the US by the year 2017 and internationally by 2010, according to the Federal Aviation Administration (FAA) of the USA.

At least 32 of the 50 busiest U.S. airports have plans to expand operations, according to a survey conducted by the Natural Resources Defence Council (NRDC), published in the environmental group's October 1996 report "Flying Off Course: Environmental Impacts of America's Airports". According to the FAA, 60 of the 100 largest airports plan to build or extend runways [4].

Ukrainian airports are not an exception. For example, the country's largest airport Boryspil expands its activity and accordingly, increases its negative influence on the environment. Thus, the environmental pollution caused by the airport becomes more and more actual for our country and the capital city of Kyiv, where the international airport Kyiv and (in a few tens of kilometres) the main airport of the country – international airport Boryspil – are located.

Literature overview

It is necessary to analyze all aspects of the environmental pollution caused by the airport activity.

Noise pollution. Noise can harm health and interfere with learning. Aircraft is the major source of noise pollution.

Most airports are not solicitous of the people who live around the flight paths. Moreover, protecting neighbours from the airport noise is largely optional for the airports. Airports may apply for a grant from the FAA under the "Part 150" program (described in Part 14, Section 150 of the Code of Federal Regulations) that provides funds for buying out homes from homeowners or soundproofing their homes if the noise level exceeds a threshold of 65 day-night average sound level (DNL) [4]. Sound levels are averaged over both night and day hours, and at night 55 dB counts as 65 dB to account for the fact that people are sleeping.

To mark the boundary of the threshold, a contour is drawn around the airport, similar to the contours on a topographic map. Out of more than 500 commercial airports in the United States, 231 have participated in Part 150, according to the FAA. Fourteen of the 50 busiest airports are not

participating, including LaGuardia airport, which affects 195,000 people living inside its contour, and Miami International airport, which affects 163,234, according to the NRDC.

Critics charge that the 65 DNL is based on expediency; that is, what regulators feel can be accomplished without too much expense or difficulty. Complaints of noise abound from people outside of the contour.

The FAA requires airports to file environmental impact statements when they seek federal funds to expand, and such reports may be used in applications for Part 150 grants for noise reduction measures. The environmental statements are mostly directed towards helping the public understand the impact of the proposed action. The FAA is required to consider public comments in response to environmental statements in making decisions, but has never rejected a proposed expansion because of an environmental statement.

Air pollution. In 1993, aircraft emitted 350 million pounds of VOCs and NO_x during landing and takeoff cycles, more than double 1970 levels, according to the NRDC report. These two classes of compounds are precursors of the ground-level ozone, which can interfere with lung function. During the summer ... between 10 and 20 % of all East Coast hospital admissions for respiratory problems may be ozone-related [4].

Airports are among the largest sources of local air pollution. In a major airport, idling and taxiing planes can emit hundreds of tons of VOCs and NO_x annually.

The VOCs emitted by the airports may comprise a variety of toxic chemicals, according to a 1993 study by the EPA. Chicago's Midway Airport released more benzene and formaldehyde than most Chicago factories. In the world of ozone precursor emissions, those from the airports are of little significance. McCarran's VOC emissions [for 1993] were equivalent to those [produced by] the motor vehicles used by less than 9 % of the non-attainment basin's households [4]. Similarly, a 1991 study by Argonne National Laboratory, funded by the FAA, concluded that "the impact of airport emissions on the surrounding air quality was not significantly larger than that of the background emissions. This implies that on a per-unit area of ground surface basis, the airport emissions are roughly comparable to those of the surrounding urban/suburban areas and roadways."

And, in fact, ground access vehicles such as passenger cars and buses just entering and leaving airports often exceed airplanes as the dominant sources of air pollution at airports. Nationally, ground access vehicles emit 56 % of VOCs, while aircraft taking off and landing give off only 32,6 % (including emissions from APUs), according to the EPA. Ground access vehicles emit 39,3 % of NO_x, trailing closely behind emissions by aircraft and APUs of 46,3 %.

Ground service equipment is responsible for 10,9 % of airport-generated VOCs and 14,3 % of NO_x nationally, according to the EPA. National figures for APUs were not available, but in southern California in 1990, APUs gave off less than 1 % of hydrocarbons and about 6 % of NO_x, according to the California Air Resources Board.

States that include non-attainment areas must develop state implementation plans for cleaning their air. But states have scant leverage to deal directly with airport pollution. States cannot regulate aircraft emissions for the same reason they cannot regulate automobile emissions [2].

One measure that could reduce emissions is single-engine taxiing. Single-engine taxiing saves fuel and reduces emissions substantially.

The sources of air pollution during parking of the aircraft, in particular, are exhaust gases of the aircraft engines and of special motor transport. As they contain oxides of nitrogen in a zone of the aircraft maintenance service, there are conditions for formation of highly toxic products in abundance. Atmospheric air at a parking becomes contaminated by the steams of fuel of high concentration, formed during refueling of fuel tanks. The boiler installations that utilize liquid black oil, firm fuel, etc are also a significant source of pollution of the airports.

Now we will discuss in detail the water pollution caused by the airport.

More than 4 million gallons of glycols were used for the aircraft de-icing at 93 American airports during 1989–1991, according to a survey by the FAA. Glycols are the most voluminous water pollutants from airports. As there are over 500 certified airports in the United States, the actual amount emitted may be much higher.

During de-icing, the airlines mix 55 % glycol and 45 % water, heat the mixture to about 185° F, and spray the planes. Without the efforts to recapture the used mixture, 50–80 % of the glycols may end up in the local waterways, says Mark Williams, assistant environmental program manager for the Maryland Aviation Administration. Forty-five of the 50 busiest airports in the United States are within 3 miles of a major waterway, according to the NRDC report. Other chemicals besides glycols that are used at airports may get into waterways, but information about these is sketchy.

At Kennedy airport, there are two underground lakes of jet fuel, estimated to contain 3–5 million and 6–9 million gallons, respectively, according to the NRDC report [4].

However, glycols receive the most attention. Ethylene glycol is both more effective and more toxic than propylene glycol. The lethal dose for humans of ethylene glycol is a little over three ounces, according to a report prepared for the EPA. Smaller doses can damage kidneys. Propylene glycol is relatively innocuous. However, both ethylene glycol and propylene glycol consume high levels of oxygen during decomposition, according to the Airports Council International, a trade group in Washington, DC. This can deplete waterways of oxygen and kill fish.

The NRDC complains that regulations for disposal of de-icing chemicals lack teeth. The stormwater pollution prevention plans (SWPPPs) required of states under the Clean Water Act should greatly reduce contaminated stormwater discharges from the airports if implemented as required, according to the NRDC report. It is not clear when, or if, the plans are inspected by a regulatory agency. In addition, SWPPPs must be made available only to regulatory agencies, not the public, which impedes the ability of citizen groups to ensure proper implementation [4].

A small number of airports recaptures used glycols very successfully. According to the Airports Council International, 14 of 48 airports surveyed had containment systems for recapturing used glycols. Six airports prepared them to be recycled for other uses [3].

O'Hare used only 750,000 gallons (approx.) of fluids in 1996. According to IEPA records, O'Hare discharged at least 3,1 million gallons of de-icing/anti-icing fluids in the last year for which the IEPA could provide us with data (1995 report; 1993 and 1994 data). Both estimates appear to be too low, and the amount of de-icing/anti-icing fluids used at O'Hare property is in question, based on amounts used at other airports and other information. It takes about 300–400 gallons of de-icing/anti-icing fluids per aircraft. According to numbers released by the Federal Aviation Administration, there were approximately 2,600 operations per day at O'Hare. Bob Keyes, Chicago Air Traffic Controller, claims that the new figure is 2,700 operations per day. The number of de-icing days was estimated for us by the IEPA (unofficially and off the record) as "about 60 days". Thus, the minimum amount of de-icing/anti-icing fluids used could be 27,825,000 gal. (350 gal. × 1,325 ops. per day × 60 days). We estimate the fluids are used at the aircraft at O'Hare during at least 209 days/year. This is based on over 2005 de-icing days at both Baltimore-Washington and Seattle-Tacoma airports, our cooler local climate, climate at 36,000+ feet and the fact that certain types of aircraft (due to safety concerns) have to be anti-iced well into late spring [5].

A technological fix that could render de-icing chemicals partially obsolete is the use of infrared rays to heat the exterior of the plane. In such a process, immediately before takeoff the plane would pull into a hangar-like structure outfitted with the infrared energy process units and park there for approximately six minutes while the de-icing takes place.

Among the numerous pollutants, heavy metals and oil products are of special importance.

Statement of the problem

Modern airport is a complex pollutant of the environment: aviation noise, emission of polluted substances, electromagnetic radiation, pollution of soil and ground waters. Nowadays, for many airports, these factors limit further development of the airport.

Thus, complex analysis of emission of the pollutants and effective means of lowering this emission are a problem awaiting solution.

One of the most important directions in the monitoring of the environment is the control of the state of ecosystem and prognosis of its change in the future. It is obvious that one of the most powerful disturbing factors that influence the state and development of natural ecosystems is human activity: industrial, agricultural, etc.

Our task was to estimate the anthropogenic and technogenic influence on the state of ground waters in the zone of airport Kyiv.

Investigation of water pollution was carried out in the zone of airport Kyiv. The airport occupies territory with the area of 265 hectares, has one runway whose length is 1800 m and width – 49 m. It also includes the buildings and other auxiliary constructions.

The Nyvka river, which is a small river running through Kyiv area adjacent to the airport, became the object of our research.

The Nyvka river starts at 0,5 kms from settlement Vyshneve and runs into the Irpin' river, which, in turn, runs into Dnipro. The channel of Nyvka is poorly twisting, and at some sites it completely grows.

The width of a river channel makes 2–3 m, and depth – 0,1–0,7 m. Mid-annual consumption of Nyvka equals 0,17 m^3/s, and the best predicted intensity of flow can attain 35,1 m^3/s [6].

Taking into account that airport Kyiv is not taken out from the city limits, has no precisely fixed sanitary buffer, and that a human settlement (village of Zhuljany) is in its borders, the problem of water pollution is actual and requires ecological research.

In order to solve this problem, we need to determine the state of pollution of ground waters in the territory adjacent to the airport.

In particular, we took the samples of waste and those of ground waters of the Nyvka river with the purpose of determining the concentration of chemical elements, in particular, heavy metals and oil products, as well as the toxicity level.

Investigations of environmental pollutants in the zone of airport Kyiv were carried out in 2002–2003. Sample drawing was carried out in radius of 2 kms.

The ecological evaluation was carried out using atomic absorption spectral and spectrophotometric analysis and methods of biotesting.

Analysis of pollution of ground waters in the zone of airport Kyiv

Our monitoring research of the environmental pollutants at the international airport Kyiv has shown that the major pollutants of ground waters of the river Nyvka, which flows on its territory, are heavy metals such as Mn, Zn, Cu, Pb, Ni, Cr^{+6}, Fe and oil products, whose concentration exceeds maximal allowed limits by several times (table).

In order to determine the conditions of waste emission into the river from the results of our monitoring research the following calculations must be performed.

The multiplicity of necessary dilution of waste is calculated using the formula:

$$n = \frac{Qz + q}{q},$$

where z is the coefficient of mixing of waste with the river water, that shows the part of the river water Q participating in dilution of waste with the consumption q.

The coefficient z is calculated by formula [7]:

$$z = \frac{1-\beta}{1+\frac{Q}{q}\beta},$$

$$\beta = e^{-\alpha\sqrt[3]{L}},$$

where α is the coefficient that takes into account hydraulic conditions of mixing.

It is defined by formula:

$$\alpha = \varepsilon\varphi\sqrt[3]{E/q},$$

where ε = 1 for the emission of waste near the bank of the river; ε = 1,5 for the emission of waste in the middle of the river; φ is the coefficient of tortuosity of the river, which is equal to correlation between the distance far away from the place of waste emission and the range of the nearest point of water management L and distance to this point on the straight line L_{str}:

$$E = \frac{V_m H_m}{200},$$

where V_m is the mean speed of flow of the river, m^3/s; H_m is the main depth of the river, m.

For the conditions of waste emission with the consumptions q=0,01 m^3/s into the Nyvka river with the consumptions Q=0,17 m^3/s by L=1000 m, mean depth of the river H_m=0,1 m and its speed of flow V_m=0,3 m/s the coefficients α, β take values of: α=0,246, β=0,085.

Then the coefficient of mixing equals: z=0,53.

In this case the multiplicity of dilution is:

$$n = \frac{Qz + q}{q};$$

$$n = \frac{0{,}17 \cdot 0{,}53 + 0{,}01}{0{,}01} = 10.$$

The necessary extent of waste disposal is calculated using the formula [8]:

$$C_{sew.per} = \frac{zQ\left(C_{EPC} - C_r\right)}{q} + C_{EPC},$$

where $C_{sew.per.}$ is the allowed concentration of pollutants in the waste, mg/l; C_{EPC}, C_r are maximal allowed and measured concentration of these pollutants in the river, respectively, mg/l.

An example of calculation of the condition of emission of oil products follows:

$$C_{sew.per} = \frac{0{,}53 \cdot 0{,}17\left(0{,}05 - 0{,}01\right)}{0{,}01} + 0{,}05 = 0{,}41 \text{ mg/l}.$$

Levels of heavy metals and oil products obtained from the analysis of ground waters of the Nyvka river in the zone of airport Kyiv

Samples	Oil products, mg/l	Heavy metals, mg/l						
		Mn	Zn	Cu	Pb	Ni	Cr^{+6}	Fe
Pond, river Nyvka	4,1	17,5	3,5	1,2	4,5	0,03	0,3	2,3
Pipe	38,5	31,3	7,7	2,6	12,9	0,05	0,8	14,6
River Nyvka in the village	2,3	11,0	2,1	0,6	6,6	0,03	–	2,6
Maximal allowed concentration	0,05	0,01	0,01	0,01	0,1	0,01	0,005	0,1

Conclusion

Monitoring of the state of ground waters in the zone of airport Kyiv is very important due to proximity of the village Zhulyany, whose population uses water for cooking, drinking and household needs.

Our calculations have shown that the real levels of pollution of the river considerably exceed the allowed levels of pollution. This indicates necessity of carrying out subsequent research of the state of water and developing measures that would lower the level of pollutants in the airport zone. Thus, the main aim of safety issues, which are provided by the administration of the airport, must be directed to the decrease of technogenic load on the environment, especially on hydrosphere.

Literature

1. *Davis M., Cornwell D.* Introduction to Environmental Engineering. – New York: McGraw-Hill, 1991. – 339 p.

2. *Harrison R.* Pollution Causes, Effects and Control. – London: Royal Society of Chemistry, 1990. – 480 p.

3. *Eckenfelder W.* Industrial Water Pollution Control. – New York: McGraw-Hill, 1989. – 192 p.

4. *Holzman D.* Plane Pollution // Environmental Health Perspectives. – Vol. 105, N 12. – 1997. – P/ 58-61.

5. *Paula F. Covan.* Water Pollution – Chicago International Airport. – Chicago: Alliance of Residents Concerning O'Hare, 1997. – 7 p.

6. *Маджд С.М., Загоруй Я.В., Франчук Г.М., Антонов А.М.* Математичні розрахунки забруднення поверхневих вод р. Нивки важкими металами та нафтопродуктами // Наука і молодь. Приклад. сер., Міжнар. наук. конф. студ. та молодих учених «Політ-2004». – К.: НАУ, 2004. – С. 175–178.

7. *Запольський А.К., Салюк А.І.* Основи екології. – К.: Вища шк., 2001. – 358 с.

8. *Франчук Г.М., Ісаєнко В.М., Запорожець О.І.* Урбоекологія і техноекологія. – К.: НАУ, 2004. – 200 с.

The editors received the article on 16 April 2005.

Г.М. Франчук, А.М. Антонов, С.М. Маджд, Я.В. Загоруй
Аналіз забруднення поверхневих вод у зоні аеропорту
Розглянуто негативний аспект діяльності аеропорту – його шкідливий вплив на навколишнє середовище, зроблено акцент на забрудненні поверхневих вод. Проаналізовано забруднення поверхневих вод р. Нивки в зоні міжнародного аеропорту Київ. Визначено умови скидання стічних вод у ріку.

Г.М. Франчук, А.М. Антонов, С.М. Маджд, Я.В. Загоруй
Анализ загрязнения поверхностных вод в зоне аэропорта
Рассмотрен негативный аспект деятельности аэропорта – его вредное влияние на окружающую среду, сделан акцент на загрязнении поверхностных вод. Проанализировано загрязнение поверхностных вод р. Нивки в зоне международного аэропорта Киев. Определены условия сброса сточных вод в реку.