

THE ASSESSMENT OF GROUND WATERS POLLUTION WITH PETROCHEMICALS AROUND CIVIL AVIATION ENTERPRISES

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Abstract. *In the article we determine the level of ground waters pollution with oil hydrocarbons around the enterprises of aviation machines exploitation and repair. The calculations of the sample size required to achieve 95 % confidence probability of petrochemicals content analysis have been resulted. The sanitary hygienic assessment of drinking water from the wells around the civil aviation enterprises has been conducted.*

Keywords: environmental protection; environmental safety of aviation enterprises; ground waters pollution; petrochemicals.

1. Introduction

The problem of water quality has always been one of the most important problems of mankind.

The sanitary hygienic situation in Ukraine shows that the use of surface and ground water from centralized and decentralized water supply sources is a risk factor for humans and their surroundings [1]. Centralized and decentralized use of water causes the need for underground water monitoring to determine pollution levels.

The assessment of ground water quality acquires the specific character under complex natural and anthropogenic conditions, when various pollution factors influence simultaneously on water quality in underground part of hydrosphere [1-3]. The problem of environmental pollution analysis at the territories impacted by air transport processes is urgent in the whole world. Airport activity and its impact on ground water condition require serious and thorough study and application of pollution prevention measures.

Groundwater pollution is not local process, it is closely linked to pollution of the whole natural environment: atmosphere, surface water, soils. The pollution of surface and ground waters resulted from air transport processes occurs due to poorly treated waste water discharge, surface runoff formed with rain and melt snow water, and runoff of wet cleaning in premises with artificial surfaces. The surface runoff from aviation enterprise territory accumulates various pollutants: residues of cleaning, anti-infective, anti-icing agents, wastes, petrochemicals, etc.

Precipitation as groundwater pollution source is a carrier of anthropogenic pollutants released from the atmosphere. Atmospheric and melt water captures

organic and mineral compounds from soil during runoff especially in the spring freshet period, that leads to seasonal worsening of drinking water quality characteristics [3]. Precipitation and air vapor impact intensively on groundwater. It causes water infiltration into pores, fissures and other cavities in the rocks [1, 4].

The content and amount of precipitation income to groundwater depend on season of year, amount of precipitation and evaporation conditions. The quality of groundwater is significantly conditioned by climate, soil structure, plantations, territory relief, which causes redistribution of precipitation [2, 5].

The natural waters of the civil aviation enterprises impact zone are also polluted as a result of dry pollutants sedimentation from the atmosphere and pollutants migration from soil.

Polluted soils play double role in the processes of groundwater pollution: perform protective functions for groundwater horizon, but if already polluted they can become pollution source for a long period even after liquidation of the main anthropogenic pollution source.

Although contaminated soil impact on groundwater condition is studied poorly, it is forecasted to be significant and it can't be neglected [5].

2. The problem statement

According to The Water Code of Ukraine [6], the water quality is characteristic of water composition and features, and it determines water availability for particular type of water consumption.

In 1997 Ministry of Healthcare of Ukraine approved the State sanitary requirements and standards "Drinking water. Hygienic requirements to water quality of centralized household water supply" [7], where more strict requirements were established

for pollutants content and they are close to the standards of the World Health Organization.

Liquidation of groundwater pollution is complex and expensive activity and sometimes it is simply inapplicable. Therefore, the groundwater intakes protection has to provide various preventive and other protective measures [2, 4, 5].

3. Analysis of the latest research and publications

As analytical survey of literature has shown the air transport processes chemical impact is poorly researched quite a little, the experimental studies prevail among the papers.

The little-studied aspect of civil aviation enterprises impact on the environment is changes of qualitative and quantitative characteristics of groundwater condition.

Under modern conditions waters of the aviation sector impact zone are under intensive anthropogenic impact, accompanied with change of hydrogeological, hydrochemical and hydrobiological conditions.

Franchuk G. M. [8] states that discharge of 1 m^3 of industrial wastewater pollutes about 60 m^3 of natural water on average. The author states, that runoff treatment in big airports has to be differentiated due to its unequal distribution.

First of all it is necessary to treat runoff from maintenance service areas (including areas of aircraft cleaning and anti-icing treatment; degassing of aircrafts and equipment used in aviation chemical operations; removal of aircraft paint-and-lacquer coatings and paintings; cleaning of autotransport and special technique). It is necessary to treat runoff of aviation enterprises areas with intensive traffic of aviation transport and aerodrome technique, these areas form about 25 % of aerodrome artificial surfaces.

The aim of study is determination of oil hydrocarbons pollution level in groundwater wells of residential area, impacted by civil aviation enterprises.

4. The assessment scheme of groundwater pollution with oil hydrocarbons around civil aviation enterprises

The study object has borders with agricultural lands to the southeast; residential buildings to the north-east and north; industrial area to the south-west and west; Kyiv-Zhytomyr highway and south-west railway to the west; the village of Zhuliany to the southeast and south.

Technical-environmental and structural parameters of airport production services include such objects: air

transport; aviation-technical base, which consists of welding station, battery department, air equipment painting and washing department; special transport service, which includes lorry-loads, busses, passenger and special official cars, welding stations, painting, battery department; repair and constructional department, welding post; chief mechanics service, which includes welding and painting station, battery department; services of thermal engineering systems; base of the radio electro-engineering provision of airplanes flights; airfield service; fuel and lubricating materials service, which includes filling station, warehouse [4].

The sampling according to the suggested scheme was conducted during 8 years to analysis of groundwater condition in terms of petrochemicals content. This research has been conducted for the chosen object for the first time.

During the research the wells water quality has been analyzed with the samples taken at various distance from the runway of airport "Kyiv" and aircraft-repair plant №410 in the residential area.

Drinking water has been sampled according to the requirements to groundwater sampling of ISO 5667-18:2005 [9].

Drinking water has been sampled at the distance of 20 m, 250 m, 500 m, 1000 m, 1500 m in the sanitary protective zone of aviation enterprises seasonally from 5 wells.

The water layer depth was 5–5,5 m in the well at the 20 m distance from the airport. In the second well, situated at the distance of 250 m, the groundwater layer was 6–6,5 m. In the well in Zhuliany residential area at the distance of 500 m from aviation enterprise the groundwater were localized at 7–7,5 m depth. The fourth well was situated at 1 km distance from the airport. The groundwater level reached 4 m in it. The groundwater level in the well of the residential area at 1.5 km distance was also 4 m.

All investigated wells were protected from precipitation income at the top and from the sides.

The sampler has been dipped to the groundwater layer, filled with water and lifted in every well.

The water volume taken for analysis from each well was 2 l.

All samples were registered in the journal and numbered.

The controlled territory passport and the well description have been made according to research data and available documentation.

The oil hydrocarbons content has been determined in water samples of air transport processes impact zone according to GOST 2874–73 [10].

The water samples (11) have been acidified to pH = 2, 2 g of NaCl has been added per 1 l of solution, then the extraction of carbone tetrachloride in the sepatatory watering can has been made, the solvent has been added in little portions, after 10 minutes the extract has been separated in the flask with glass stopper. The extraction was conducted with 60 ml of extractant every time. Extract has been dried with fried sodium sulfate, it has been picked in a quantity of 50 ml and it has been passed through the column with aluminum oxide. The received eluate in 100 ml graduated flask has been passed through the column of fine CCl₄; and the solution volume has been increased to the mark 45 ml with the same dissolvent.

Infrared spectrum of received solution has been defined with the cell 50 mm thick. Optical density has been measured at the wavelength of 2926 cm⁻¹.

The content of petrochemicals in the water (X) in mg/l has been determined according to formula:

$$X = (K \cdot D \cdot 100 \cdot 60) / (l \cdot V \cdot 50),$$

where *K* – index, which equals 0,437 at analysis of water without volatile petrochemicals and 0,542 at analysis of water with non-volatile and volatile petrochemicals; *D* – optical density; 100 ml – volume of CCl₄ after dilution, ml; 60 – volume of CCl₄ taken for extraction; *l* – cell thickness, cm; *V* – water volume for analysis, l; 50 – volume of portion, ml.

The frequency of sampling has been determined preliminarily with statistical data processing.

According to the calculation results the confidence interval equals 25 % for oil hydrocarbons in groundwater samples near civil aviation enterprises.

To achieve reliable data and 95 % confidence interval the necessary quantity of groundwater samples for oil hydrocarbons content definition has been determined according to the requirements of GOST 17.1.5.05–85 with formula [11]:

$$S = \sqrt{\frac{\sum_{i=1}^n (x_i - \bar{x})^2}{n-1}} = \sqrt{\frac{1}{n-1} \left[\sum_{i=1}^n x_i^2 - \frac{1}{n} \left(\sum_{i=1}^n x_i \right)^2 \right]},$$

where *S* – mean square deviation; *n* – quantity of samples; *x_i* – values.

Calculation results show that to achieve 95 % confidence interval it is necessary to bring the groundwater samples quantity for oil hydrocarbons to 7.

5. Results of petrochemicals determination in groundwater samples around aviation enterprises

The groundwater around enterprises of aviation technique exploitation and repair are impacted by

urbanization and intensive anthropogenic pollution from air transport processes.

The term “petrochemicals” in water analysis is defined as a sum of nonpolar and low-polar substances dissolved in hexane, i.e. it is the sum of oil hydrocarbons (aliphatic, acyclic, aromatic).

Oil hydrocarbons undergo bacterial oxidation 10 times slower in groundwater than in surface water. In water ambient about 40 % oil precipitates on the bottom, 40 % stays in water in the form of emulsion and 20 % stays on water surface in the form of film (0.5 mm thick) that complicates water aeration.

Natural purification of water from oil goes very slowly. After 2–7 days the content of emulsified petrochemicals in water can decrease by 40 % at 20°C and only by 15 % at 5°C.

Due to petrochemicals presence water gains specific taste and smell, its colour and pH change, gas interchange with atmosphere worsens.

Hydrocarbons, which are petrochemical components, cause toxic and sometimes narcotic influence on living organisms, damaging cardiovascular and nervous systems, therefore drinking water must not contain petrochemicals and oil according to the Sanitary Requirements and Standards № 136/1940 [7].

Research results of petrochemicals content in the groundwater samples at the civil aviation enterprises impact zone are given at fig. 1.

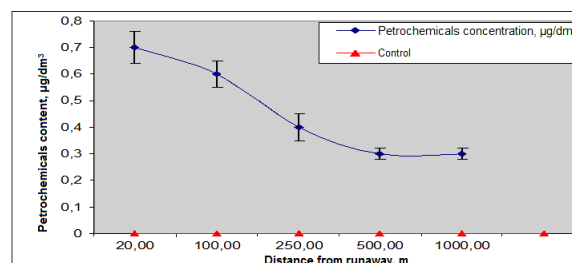


Fig. 1. Petrochemicals content in the drinking water, $M \pm m$; $n = 12$

The highest oil hydrocarbons concentrations have been detected in the drinking water along the runway.

The concentration of oil hydrocarbons doesn't meet standards, their content in water decreases dramatically up to 500 m distance from runway, and then it turned to be stable.

The decreasing tendency of petrochemicals concentration in water is observed with the distance from the pollution source.

High pollution levels of groundwater is caused by the fact that in most cases the depth of wells is 3,5–4,5 m. It means that they are supplied with

surface horizon water, which has significantly worse quality comparing with underground water.

According to the received results the well water is classified as “moderately polluted” – 3rd class (1000 m and 1500 m from runaway) and as “polluted” and “very polluted” – 4-5 class (500 m, 250 m, 100 m and 20 m from runaway).

Based on petrochemicals content the well groundwater is defined as unsuitable for consumption according to the standard document.

6. Conclusions

Research results show that significant groundwater pollution occurs at civil aviation enterprises activity zone as a result of air transport processes.

Analysis of the **taken samples, taken** in the impact zone of aviation technique repair and exploitation processes, has shown the significant exceedance of petrochemicals content in relation to control samples.

The clear dependance between decrease of oil hydrocarbons concentration and distance from pollution source has been also determined.

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Based on petrochemicals content, the well groundwater is defined as unsuitable for consumption according to the standard document.

Received results prove the need to pay attention to petrochemicals content in well groundwater around civil aviation enterprises and to conduct further study.

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С. М. Маджд. Оцінка рівня забруднення ґрунтових вод нафтопродуктами поряд з підприємствами цивільної авіації

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Встановлено рівень забруднення ґрунтових вод нафтовими вуглеводнями поблизу підприємств з експлуатації та ремонту авіаційної техніки. Представлено результати розрахунку необхідної кількості відбору проб для нафтопродуктів, для досягнення довірчого рівня 95 %. Проведено санітарно-гігієнічну оцінку стану питної води з криниць розташованих поряд з підприємствами цивільної авіації.

Ключові слова: екологічна безпека авіапідприємств; забруднення ґрунтових вод; захист довкілля; нафтопродукти

С. М. Маджд. Оценка уровня загрязнения грунтовых вод нефтепродуктами вблизи предприятий гражданской авиации

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Установлен уровень загрязнения грунтовых вод нефтяными углеводородами вблизи предприятий по эксплуатации и ремонту авиационной техники. Представлены результаты расчета необходимого количества отбора проб для нефтепродуктов для достижения доверительного уровня 95 %. Проведена санитарно-гигиеническая оценка состояния питьевой воды из колодцев расположенных вблизи предприятий гражданской авиации.

Ключевые слова: загрязнение грунтовых вод; защита окружающей среды; нефтепродукты; экологическая безопасность авиапредприятия.

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