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THE ASSESSMENT OF THE FILLING STATIONS IMPACT ON THE ENVIRONMENT

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Abstract

The work is devoted to the environmental impacts of the filling station. Authors have shown that of pollutants, emitted from the filling station, are toxic substances, which often cause irreversible damage to the organism, including functional and system disorders, acute and chronic non-specific and specific effects. The analysis of soil acidity at typical gas stations was carried out, as well as sumpling in the area of filling stations operation. For determination the soils acidity samples were taken at 8 filling stations. Most of the analyzed sites have a soil reaction close to neutral, indicating the presence of pollution with petrochemicals. The drilling results show that there is a serious factor of soil pollution in the operation of filling station. As a result of the analysis of possible impacts at the filling station, recommendations were made for reducing their negative environmental impacts. The necessity of prevention of negative impacts of filling station was substantiated.

Keywords: environmental impacts; filling stations; pollution; soils acidity; toxic substances; petrochemicals

1. Introduction

The filling stations are among the main sources of environmental pollution at urban areas. At the same time, in recent years, the number of filling stations located in the suburbs, residential neighborhoods, directly near large shopping and an entertainment complex has increased significantly. The growing number of filling stations, as well as the volume of sold fuel, requires a detailed approach to the study of the filling stations impacts on the environment. The importance of such research is also connected with the increasing threats to the human health from the hydrocarbons and other pollutants entering the environment in the process of filling stations operation.

Therefore, the issues of environmental monitoring and control over these objects of oil products supply are of high relevance.

2. Literature overview

The filling stations according technological solutions are divided into the following types: traditional filling stations, modular filling stations, mobile stations and container filling stations [1]. They are also differentiated depending on the number of fuel dispensers, volume of storage tanks and fuel turnover.

The impacts of the filling station on the environment appear from the following main sources [2-4]:

- discharge of wastewater into municipal sewage system or free flow of rainwater to the surrounding soil;
- emissions into air due to evaporation during storage and pumping of products, as well as from the oil contaminated wastewaters accumulated in special vessels;
- consumption of water and electricity;
- product losses in case of receipt, storage and delivery to the consumer vehicles;
- accidents and emergency situations.

All together these impacts lead to the pollution of air, soil, ground and underground waters, as well as impact on the health of workers and residents of the adjoining territories.

Most of pollutants, emitted from the filling station, are toxic substances, which often cause irreversible damage to the organism, including

functional and system disorders, acute and chronic non-specific and specific effects [5]. Thus, these substances affect the following body systems:

- hematopoietic and immune systems (carbon monoxide, lead);
- central nervous system (CNS) and neuroendocrine system (gasoline and kerosene, nitrogen oxides, carbon monoxide (II), lead);
- musculoskeletal system (carbon monoxide (II), gasoline and kerosene);
- cardiovascular and respiratory systems (gasoline and kerosene, nitrogen oxides, carbon, sulfur dioxide, lead);
- gastrointestinal tract (gasoline and kerosene, nitrogen oxides, carbon monoxide (II), sulfur dioxide, lead) [6, 7].

Aim. Most of the previous studies have covered the issues of petroleum products emissions into the air; however, effects of filling stations are also significant in relation to soils and via them to ground waters. ***Methods.*** To cover these issues, it was decided to evaluate the possible impact of typical filling stations on soils and predict the consequences for the quality of ground and underground waters.

When entering the environment and, in particular, the soil, petroleum products cause a series of changes in its physical, chemical and biological properties and characteristics of the environment and violate the course of natural biochemical processes. At the same time, due to the contact with air, water, soil chemical components and microorganisms, petrochemicals go through a range of transformations

Dimensions of pollution zone are determined by the composition of petroleum products, their migration, type of relief and the type of landscape, as well as lithological characteristics of soils, geological and hydrogeological conditions of the area. In the process of natural separation of petroleum products on the fraction in the soil, light fractions are distributed throughout the profile, partially evaporating into the atmosphere and reach the groundwater [8].

The distribution of heavy fractions is associated with lowered relief elements, and therefore they do not form a solid surface: they accumulate mainly in the humus complex and remain in the soil for a long time [9]. Under their influence, phytotoxicity of soils increases, which leads to a violation of physiological processes and deterioration of the quality of plant products. Studies have shown that in contaminated soils, the activity of most soil enzymes is reduced [8, 10]. Soil breathing also reacts sensitively to pollution with petroleum products: first, when the microflora is suppressed by large amounts of petrochemicals, the intensity of respiration decreases and with the increase in the number of microorganisms grows again [10].

In contaminated soils, the accumulation of iron, manganese takes place and the content of phosphorus, potassium and magnesium decreases. The ratio between the amount of carbon and nitrogen is increasing, and the stability of soil ecosystems and fertility are reduced [11]. In addition, petroleum products cause leaching and reduce the hydrolytic acidity of soils. All of these effects together lead to a profound change in all parts of natural biocenoses – unequal change in the number and species diversity of pedobionts (soil meso- and microfauna and microflora). So, there is a mass death of the soil mesophane: three days after the spill, most types of soil animals completely disappear or make no more than 1% control. Changing environmental conditions also lead to inhibition of photosynthetic activity of plants. At the same time, soil microorganisms after short-term inhibition respond to pollution by increasing gross numbers and increasing activity [8]. The processes of natural regeneration of biocenoses are slow, and the pace of ecosystem restoration takes up to 10-15 years [11]. The abiotic degradation of petroleum products in the soil is very slow and ends up with the formation of compounds that are difficult to oxidize further. End products of metabolism of petroleum products in the soil are carbon dioxide, carbonates, water, oxygen compounds (alcohols, acids, aldehydes, ketones), insoluble solid high molecular organic-mineral and mineral complexes.

However, with the general decrease in the concentrations of petroleum products in the soil, the reduction of specific group components is uneven. Rather than other components, the relative and absolute content of methane-naphthenic fraction decreases. These substances are more likely to be biodegradable; moreover, they are more soluble in water [8]. At the same time, the content of resins increases due to their stability, reduction of the proportion of other components and generation in the process of other petroleum components transformation. The number of isoprene structures of the pristine and phytane type is increasing. The relative content of isoprenoids decreases: this fraction reduces the content of hydrocarbons of C_{20}-C_{24} fraction and increases the content of C_{27}-C_{31}.

Also, fractions of all groups of polycyclic aromatic hydrocarbons are gradually reduced [8].

In addition to chemical transformations, the decrease in the content of petroleum products in the soil is influenced by physical processes: the evaporation of light fractions and washing with water [12]. The ratio of these factors of self-purification and the efficiency of any soil remediation activity depends on the soil-climatic conditions, properties of oil products and the depth of their penetration into the soil [13]. As a result, in the process of oil and oil products transformation, even more toxic compounds can be formed, including those with carcinogenic and mutagenic potential and resistant to microbiological decomposition, and stay in the soil for a long time, creating the risk of ground and underground waters pollution.

Chronic petrochemical pollution of soils, which is typical for the impact area of filling stations, acquires the following forms:

1) In the porous medium – it is a vaporous and liquid form of petrochemicals, in free or dissolved water or water emulsion phase;

2) In the porous medium and cracks – it is free immovable form of petrochemicals, playing the role of solid cement between particles and aggregates of soil, or the sorbed form, which is associated with particles of rock or soil, including the humus component of soils;

3) In the surface layer of soil – it is the form of dense organic-mineral mass.

The combination of these pollutions considerably decreases the overall soil quality and negatively affects its fertility.

3. The main material

The purpose of the work was to assess the degree of influence of the filling station on the natural environment in Kyiv, in particular, on qualitative changes of soils around the filling station. Pollution of soil with petroleum products change oxidizing-reducing conditions of the media, therefore, the level of soil pH could be an indicator of such pollution. According to the acidity index, the soils are divided into classes: very strongly acidic - pH <4,0; strongly acidic - pH = 4,1-4,5; sour - pH = 4,5-5,0; slightly acidic - pH = 5,0-5,5; are close to neutral - pH = 5.5-6.0; neutral - pH = 6.0-7.0; alkaline - pH> 7.0.

For most plants, the optimal pH level is 6.0-6.5 and everything out of this range negatively affects plants conditions.

There are two methods for determining the pH: colorimetric and potentiometric.

Colorimetric is based on the properties of some substances called indicators (litmus, phenolphthalein, methyl orange, etc.) to change their color depending on the pH of the test solution. However, this method is highly evaluative and not suitable for accurate research. The most accurate method for determining the pH is potentiometric, which was used in research, as the change in pH levels due to pollution with petroleum products isn't very noticeable.

For determination the soils acidity samples were taken at 8 filling stations with the Rapitest 1835. As we see from the results of the research (Table), the influence of the filling stations on soil reaction is in the direction of increasing pH value to neutral and slightly alkaline reaction, which is seen from the comparison with background samples taken aside the area of impact at the soils of the same type and characteristics.

Table

Results of the acidity research of soils on selected objects

№	Name of filling station	Background sample pH	pH actual
1	#1 (Povitroflotsky Av.)	6,5	7,3
2	#2 (Povitroflotsky Av.)	6,4	7
3	# 3 (Chokolovsky Av.)	6,2	7
4	#4 (Volodymyra Getmana St.)	5,8	7
5	#5 (Peremogy Av.)	5,9	7,2
6	# 6 (Kosmonavta Komarova Av.)	6,6	7
7	# 7 (Kosmonavta Komarova Av.)	6,4	7
8	#8 (Lesia Kurbasa Av.)	6,4	7

Most of the analyzed sites have a soil reaction close to neutral, which indicates that plants can grow and develop normally, because most crops are adapted to the conditions of weak acidic, neutral or slightly alkaline environment. Among the sites chosen two filling stations are placed on embankments that enabled selection of soil and rocks samples by drilling, performed by the State Agency "Ukrgeophysics", to examine the vertical distribution of pollutants. The slopes were located in the rear part of the filling station, were unregulated

and had natural plant cover, which was formed during the time of existence of the filling station.

Although these embankments have an artificial origin, it should be taken into account that they were built mainly from local materials to level the territory of the filling station. Therefore, the detected pollution comes directly and solely from these filling stations:

Object A:

0,0 - 1,3 m – bulky clay soil, sandstone, grayish-brown;

1,3 - 1,8 m – soil-vegetative layer, humus sandy loam, dark gray;

1,8 - 2,8 m – loamy loess, yellow-gray, with layers of sand, with the smell of oil product;

2.8 - 6.5 m – sand gray, light gray, quartz, with layers of sandy loam, moist, with a smell of petroleum products;

6.5 - 8.5 m – alluvial loam, brownish-gray, with a smell of petroleum products;

8,5-12,3 m – gray and yellow sand, fine-grained, from the depth 11,6 m, saturated with oil and water.

Object B:

0,0 - 1,8 m – bulk sandy soil, with inclusions of rubble, yellow, with a smell of oil product;

1.8 - 3.2 m – alluvial soups, greenish-gray, with layers of black (buried) soils, with the smell of oil products;

3.2 - 3.9 m – alluvial loam, brown-gray, plastic, with a smell of petroleum products;

3.9 - 5.6 m – sand yellow, brownish-yellow, quartz, with a smell of petroleum products;

5.6 - 9.2 m – white sand, fine-grained, from the depth of 8.1 m it is saturated with oil and water.

The analysis indicates the decrease in the pollution intensity depending on soil and rocks grading: sandy soil easier pass oil and are free from pollution, but in case of substitution of sand with loam a kind of screen is formed, under which the mass fraction of oil is significantly lower. So, the assessment of soil condition clearly indicates the impact of the filling stations operation on the formation of soil pollution. According to data from open sources, aquifers in this area are free-flowing horizon, with free surface, and therefore are not protected from industrial pollution. The nutrition of these horizons is due to infiltration of atmospheric precipitation. Typically, the aquifer regime of Quaternary deposits is closely linked to meteorological and hydrological factors, and therefore has a seasonal nature. It is characterized with the main spring rise of groundwater caused by snowmelting. The rise of groundwater is threatened by the spread of pollution with oil products in the opposite direction, as well as the spread of pollution halo in the plan for a distance of several kilometers, as shown by studies in this area. Therefore, in order to guarantee the protection of groundwater from the technogenic influence of filling station, a thorough periodic inspection of the state of the equipment is required, and in the case of detecting faults of insulation, it is advisable to conduct monitoring drilling if ground and underground waters are in the zone of influence and are used by local population.

As a result of the analysis the recommendations were made for reducing the negative environmental impact from the filling station:

1) reduction of petroleum product losses due to spills during refueling and filling of reservoirs and due to leakage from fault equipment;

2) reduction of the volume of wastewater discharged into the city sewage;

3) increasing the degree of water recirculation;

4) raising the level of environmental education at the station staff;

5) avoiding soils pollution at the adjacent areas;

6) conduct remediation of soils from petroleum products after a certain period of operation of the filling station (aproximately 4-5 years);

7) develop general recommendations on the frequency, intensity of treatment, and also on the choice of methods and reagents that will ensure the achievement of optimal soil remediation [13];

8) conduct regular monitoring of soils pollution with petrochemicals in the area of filling stations influence.

4. Conclusions

Filling stations are able to produce diverse soil pollution which threatens soil biota, green plantations of the city and local population. There is also a considerable threat of ground and underground waters pollution due to pollution front downward progression. In order to assess the level of threat the samples of soil were taken for the analysis and drilling was conducted to determine the level of the formed pollution. Most of the analyzed sites have a soil reaction close to neutral, indicating the presence of pollution with petrochemicals. The drilling results show that there is a serious factor of waters pollution in the operation of filling station. As a result of the analysis of possible impacts at the filling station, recommendations were made for reducing their negative environmental impacts.

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Оцінка впливу автозаправних станцій на навколишнє середовище

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Робота присвячена впливам автозаправних станцій на навколишнє середовище. Методи: використовувались аналітичні, статистичні та експериментальні методи. Автори показали, що забруднювачі, що викидаються з автозаправних станцій – це токсичні речовини, які часто завдають

незворотної шкоди організму, включаючи функціональні та системні порушення, гострі та хронічні неспецифічні та специфічні наслідки. Проведено аналіз кислотності ґрунтів на типових автозаправних станцій, а також відбиранняпробу зоні експлуатації заправних станцій. Для визначення кислотності зразкиґрунтів відбирали на 8 заправних станціях. Більшість проаналізованих ділянок мають реакцію ґрунту, близьку до нейтральної, що свідчить про наявність забруднення нафтопродуктами. Результати відбирання проб показують, що в роботі автозаправних станцій є серйозний фактор можливого забруднення ґрунтів. У результаті аналізу можливих впливів АЗС були зроблені рекомендації щодо зменшення їх негативного впливу на навколишнє середовище. Обґрунтована необхідність запобігання негативному впливу автозаправних станцій.

Ключові слова: вплив на навколишнє середовище, автозаправних станцій, забруднення, кислотність ґрунтів, токсичні речовини, нафтопродукти

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Оценка влияния автозаправочных станций на окружающую среду
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Работа посвящена воздействиям автозаправочных станций на окружающую среду. Методы: использовались аналитические, статистические и экспериментальные методы. Авторы показали, что загрязнители, выбрасываемые из автозаправочных станций – это токсичные вещества, которые часто наносят необратимый вред организму, включая функциональные и системные нарушения, острые и хронические неспецифические и специфические последствия. Проведен анализ кислотности почв натипичных автозаправочных станций, а также отобраны пробы в зоне эксплуатации заправочных станций. Для определения кислотности образцы почв отбирали на 8 заправочных станциях. Большинство проанализированных участков имеют реакцию почвы, близкую к нейтральной, что свидетельствует о наличии загрязнения нефтепродуктами. Результаты отбора проб показывают, что в работе автозаправочных станций есть серьезный фактор возможного загрязнения грунтов. В результате анализа возможных воздействий АЗС были сделаны рекомендации по уменьшению их негативного воздействия на окружающую среду. Обоснована необходимость предотвращения негативного воздействия автозаправочных станций.

Ключевые слова: влияние на окружающую среду, автозаправочные станции, загрязнения, кислотность почв, токсичные вещества, нефтепродукты

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