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THE ASSESSMENT OF POPULATION EXPOSED TO THE RISKS OF FILLING STATIONS OPERATION

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The article investigates the environmental aspects of the operation of filling stations as significant sources of anthropogenic load on the urban environment. It was established that the main factors of influence are emissions of volatile organic compounds, pollution of soils and groundwater in case of fuel leaks, as well as noise pollution. Based on the analysis of scientific sources, it is shown that gas stations are objects of increased environmental hazard, which require strict regulation, systematic monitoring and implementation of modern environmental protection technologies. It is proposed to consider such aspects of the impact of filling stations on the environment as latent and residual risks, especially in terms of soil and groundwater pollution. The activities of gas stations of PJSC "Ukrnafta" in Kyiv were analyzed and individual spectra of environmental risks for each facility were determined. The most significant problems are an insufficient level of landscaping or structure of green spaces, placement in conditions that exacerbate negative impacts on the environment, and generally inadequate attention to the environmental aspects of filling station operation. It is shown that the modernization of filling stations often does not involve the replacement of technological equipment, which, together with the long period of operation of filling stations without regard to the associated environmental pollution, are prerequisites for the formation of latent and residual risks for the population. An assessment of the potential number of the population falling into the zone of influence of risks from filling stations activities was carried out. The main groups of the affected population were determined – inhabitants of residential buildings located in the zone of influence of filling stations, consumers of services and filling stations employees. Specific practical recommendations were developed to improve the environmental safety of filling stations, taking into account the planning features of the territories based on a combination of engineering and biofiltration solutions. The results obtained can be used to limit the negative impact on public health, especially during periods of difficult weather conditions and to modernize the fuel infrastructure in accordance with European standards. *Key words:* risk assessment, residual risks, latent risks, soil pollution, pollution control.

Оцінка експозиції населення до ризиків від експлуатації АЗС. Радомська М.М., Гузь В.В.
У статті досліджено екологічні аспекти функціонування автозаправних станцій як вагомих джерел антропогенного навантаження на міське середовище. Встановлено, що основними чинниками впливу є викиди летких органічних сполук, забруднення ґрунтів і підземних вод у разі витоків пального, а також шумове забруднення. На підставі аналізу наукових джерел показано, що АЗС належать до об'єктів підвищеної екологічної небезпеки, які потребують суворого регулювання, системного моніторингу та впровадження сучасних природоохоронних технологій. Пропонується розглядати такі аспекти впливу АЗС на довкілля як латентні та залишкові ризики, особливо в частині забруднення ґрунтів та підземних вод. Проаналізовано діяльність АЗС ПАТ «Укрнафта» у м. Києві та визначено індивідуальні спектри екологічних ризиків для кожного об'єкта. Найсуттєвішими проблемами є недостатній рівень озеленення або невдала структура зелених насаджень, розміщення в умовах, які посилюють негативні впливи на довкілля, та загалом неналежна увага до екологічних аспектів функціонування АЗС. Показано, що модернізація АЗС часто не передбачає заміну технологічного обладнання, що разом з тривалим періодом експлуатації АЗС без уваги до супутнього забруднення довкілля є передумовами формування латентних та залишкових ризиків діяльності АЗС для населення. Проведено оцінку потенційної кількості населення, що потрапляє в зону впливу ризиків від діяльності АЗС. Визначено основні групи ураженого населення – мешканці житлових будинків, що розташовані з зоні впливу АЗС, споживачі послуг та працівники АЗС. Розроблено специфічні практичні рекомендації для підвищення екологічної безпеки АЗС з урахуванням планувальних особливостей територій на основі поєднання інженерних і біофільтраційних рішень. Отримані результати можна використати для обмеження негативного впливу на здоров'я населення, особливо в передодни ускладнених метеоумов та для модернізації паливної інфраструктури відповідно до європейських стандартів. *Ключові слова:* оцінка ризиків, залишкові ризики, латентні ризики, забруднення ґрунту, контроль забруднення.

Relevance. Nowadays, high traffic intensity and dense urban development in Kyiv have led to a significant concentration of fuel filling stations within residential areas. Large fuel companies play an important role in the city's fuel infrastructure, but simultaneously create technogenic pressure on the urban environment, including air pollution, risks of soil and groundwater contamination and noise impact.

The relevance of the topic of filling station operation and efficient management is growing in connection with Ukraine's transition to energy independence and diversification of fuel sources. In modern economic conditions, when there is a gradual transition to environmentally friendly types of energy, filling stations are transformed into multimodal energy hubs. Along with traditional petroleum products, they increasingly offer alternative fuels – bioethanol, biodiesel, gas fuels (LPG, CNG), as well as charging stations for electric vehicles. In times of hostilities, interruptions in the import of petroleum products and intermittent power supply the demand for filling stations services grows dramatically. Despite this immense economic and social role, filling stations still undergo environmental regulation and their modernization needs considerable attention and rigorous analysis of outcomes and environmental impacts.

Problem statement. Today, the network of filling stations is not just fuel dispensing points, but modern infrastructure complexes that combine technological, commercial and service functions. They provide not only the sale of fuels, but also create a convenient space for consumers, combining fuel provision, trade and service sectors. The development of the filling station network is an important indicator of the level of urbanization, mobility of the population and transport intensity of the country [1]. In recent years, the number of filling stations has increased, which is associated with an increase in the motorization of the population, the expansion of networks of international operators and an increase in demand for high-quality energy resources. Moving towards potential clients, filling station are now often located in close proximity to residential and office buildings. Their operation is considered to be relatively safe for the population, but these claims must be based on sound research data and definitely be site specific, as potentially exposed population differs considerably just like hazards imposed by a filling station depend on multiple factors.

From the other perspective, assessing the environmental impact of filling stations operated by large companies is highly relevant for ensuring environmental safety and sustainable development of urban territories on the whole, since they are able to implement environmentally friendly solutions at large number of objects at the same time and thus affect big areas. However, there is an issue currently underestimated when considering the development of small industrial facilities: their modernization generally positive for the environment quality in the impact area might leave residual impacts and related risks for the population.

Literature review. A filling station is a complex engineering and technological facility designed for the safe reception, storage and release of motor fuels of various types. Its operation is ensured by the coordinated interaction of technological, energy, hydraulic and control systems, each of which has its own functional load. Therefore, a filling station should be considered a micro-technological complex in which physical and chemical processes take place that require strict control of pressure, temperature, density and tightness parameters. This in its turn means that they contain forces and media which impose certain health threats when released in the environment and the potential for their release is contained in the station as itself.

The technological scheme of filling station includes tank farm and storage systems, fuel reception unit, fuel supply system, fuel dispensers, as well as auxiliary systems like operator's room, control systems and service area (tire servicing systems, car washing, and areas for express maintenance of vehicle's). Most filling stations now include shops and cafes to provide all possible needs of the drivers and passengers.

The safety and security of filling stations is provided by environmental, ventilation and fire infrastructure. In particular, reservoir ventilation systems include breathing valves, which maintain stable pressure in the tank farm, preventing the formation of explosive concentrations of fuel vapors inside tanks. As a result of their operation a portion of hydrocarbon gases evaporated from the fuel inside the reservoir is displaced into the air and forms routine emissions from fuel filling stations. The height of the ventilation pipes is usually at least 4 meters from ground level, which ensures the dispersion of vapors in a safe layer of air [2]. Recovery of these vapors is also possible if such systems are installed at the station, which is not compulsory.

Accidental spills are also possible at the territory of the station, but they are minimized with the help of automated systems of filling used in reservoirs and car tanks.

But even with these precautions, each filling station is equipped with fuel outlets and an emergency system for collecting spilled fuel. The surface of these zones has a slight slope towards fuel wells or sealed trays, directing fuel to special collection tanks. This avoids the ingress of petroleum products into the soil, storm sewers or natural reservoirs. The collected fuel residues must be disposed of or returned for recycling. Also, fire outlets for surface runoff are mandatory, which direct water from foaming or draining to isolated storage tanks, preventing it from spreading [3].

To reduce the man-made load on the environment, local treatment facilities are used at filling stations, which purify flush and rainwater from oil products, mechanical impurities and suspended substances. Oil traps, sorption filters and coalescence units provide a cleaning efficiency of at least 80% and might be further improved with application of novel biological methods [4, 5]. After treatment, water can be discharged into the storm network or reused for technical needs, which corresponds to the principles of closed water circulation.

In addition, the environmental infrastructure includes gas analyzers, air monitoring and water pollution control systems, which provide automated records of gasoline, methane or carbon dioxide vapor concentrations in the working area.

An important role in creating barrier for the impacts of filling stations is played by green plantations, which are located around the perimeter of the territory of the filling station within their sanitary protection zone. They reduce noise levels, capture dust and partially absorb volatile hydrocarbons. According to the norms, the minimum sanitary distance from the border of filling stations to residential buildings must be at least 50 meters for medium-sized stations and up to 100 meters for large ones. Green plantings form a biofiltration screen of dense tree and shrub species that have a developed leaf surface (birch, maple, linden, spruce, thuja).

Being quite small industrial facilities, filling stations still produce a wide range of impacts on the environment. During the operation of filling stations, dozens of compounds of organic and inorganic origin enter the air. Their concentrations depend on the type of fuel, the volume of sales, the tightness of the systems, temperature conditions and the availability of recovery devices [6]. The greatest danger is posed by volatile organic compounds (petrol, toluene, xylene) that have carcinogenic, general toxic or irritating effect, as well as combustion products of car engines that enter filling stations, nitrogen oxides, carbon monoxide and aldehydes [7].

The second important factor in the negative impact of filling stations is the risk of contamination of soils and groundwater in case of violation of the tightness of technological equipment – tanks, pipelines, valves or drain connections. Even minor leaks of fuels can cause persistent and long-term pollution, since petroleum products are retained in the soil structure and bound to its elements [8]. Once in the soil, they will eventually reach the surface of groundwater and from there can get into water supply system or into surface water bodies. In water petroleum products and their derivatives interfere with natural aeration, reduce the concentration of dissolved oxygen and disrupts the processes of self-purification of the aquifer [9]. The same set of effects is valid for the soil contaminated with fuels: they reduce water permeability, gas exchange and the activity of microorganisms in soils [10]. This leads to the termination of the biological cycle, the death of the root system of plants, a decrease in fertility, and in case of contamination entering aquifers, to a deterioration in the quality of drinking water [10]. In addition to organic compounds, heavy metals (lead, copper, zinc) from anti-corrosion coatings of pipes and equipment, as well as surfactants, which slow down the natural biodegradation of hydrocarbons, can enter the water [11]. To prevent these processes, modern filling stations use double-walled tanks with inter-wall space control, waterproofed platforms, fuel collection trays and emergency spill containment systems.

The soil and subsequent water pollution are the greatest hazards for the environment from filing stations, since they are the least visible and controlled. Air pollution is given primary attention, because it is linked to direct losses of valuable resources sold to the customers, and it is the type of impacts which is provided with established methods of calculation and them included into regular formal reports to the environmental authorities. In case of soil and underground waters pollution there are no obligatory control over these media within responsibilities of filling stations operators. The general requirement is that observation control wells must be installed, which allow regular chemical analysis of groundwater for the presence of petroleum products. However, this is not always the case and the usual type of control conducted is visual examination of reservoirs only when they must be cleaned before the input of fuel, different from what were stored before. The defectoscopy of reservoirs' is supposed to be conducted every 5 years, while control of fuel dispensers is performed more often – every year. This by any means isn't enough for the declaration of filling stations safety. Rather it is possible to say that there exists latent risk from soils and underground waters pollution due to operation of filling stations.

Latent risk, mostly used in medical sciences, could be also applied to hidden environmental threats, which are not evident, but persistent and able to cause development of certain diseases in long-term perspective [12]. In this paper we refer to latent risks as a possibility of respiratory and cardiac diseases due to exposure to air pollutants (VOCs, dust and combustion products from filling stations). This unseen risk underscores the long-term health consequences associated with air pollution, emphasizing the importance of preventative measures and public health initiatives.

This latent risk is intrinsic to the technology of fuels storage and distribution, yet it differs considerably depending on a set of factors:

– volume of fuel reservoirs
– reservoirs turnovers;
– properties of soils, in particular, pH, salinity, microbial activity, humidity;
– hydrological conditions of the area and depth of the aquifers;
– age of the filling station.

The later factor might have a very profound effect: the longer a filling station exists and operates, the higher the probability of reservoir insulation failure. This would also mean deeper propagation of the pollution front and probability that it has reached the level of underground waters. Moreover, this pollution fringe might be travelling to deep to be detected yet still able to cause considerable degradation of water quality. Such probability especially relevant if the filling station is not used for certain time or when modernization or rebranding is conducted. Modernization doesn't always mean and inmost cases doesn't involve at all the change of reservoirs. Rather, it is limited to the renovation of surface structures, so that they convey the image of new facility, which offers improved service. This is usually true, but in terms of the environmental profile could be misleading: renovated appearance of the filling station makes most people think that it was fully remade, including change of reservoirs and other equipment, or that it employs the best and most modern solutions and equipment. This forms preconditions to the formation of residual risks, which are not evaluated and often omitted in the assessments. The concept of residual risks is also more typical for the medical studies and it is used to cover the possibility of patient condition deterioration even after optimal treatment of risk factors [13]. In this case we would like to apply this category to the hazards present in the environment even after the seizure of industrial activity due to pollution accumulated and retained in the environment.

But in case of full-scale modernization the residual risks are also relevant since the environmental audit of the territory is not conducted, being too expensive for such small enterprises. As a result, the residual soil pollution persists in the environment and potential contributes to the health risks formation.

The aim of the paper is to identify the potential residual risks from filling stations for the neighboring residential areas based on exposure assessment for selected filling stations and define general patterns of their environmental performance development.

Novelty. The paper applies the concept of residual and latent risks to the operation of filling stations, which is a new approach. Additionally, the environmental performance of the filling stations is considered on a time scale, thus providing insights into real interaction of industrial facilities of this type with the environment.

Applied importance. The results of assessment could be implemented in the development of recommendations on more efficient and safe management and environmental monitoring of filling stations, as well as planning environment revitalization activities, where it is found necessary.

Methods and Materials. As a part of the given research a range of filling stations were chosen for the analysis. All filling stations selected are located within the city of Kyiv and belong to JSC "Ukrnafta". They are distributed between different functional areas of the city allowing assessment of impacts depending on the intensity of traffic flows, building density, and planning features of the territory.

Each filling station was visited and the express assessment of its environmental performance was conducted. These included following issues:

- compliance with the sanitary protection zone (SPZ) requirements with particular attention to the presence of sensitive receptors (residential houses) within the SPZ;
- quality of landscaping within the SPZ: presence, structure, and condition of green spaces, as well as the share of SPZ under greenery, which is supposed to be 40%;
- visual control of equipment, focused on its integrity and operability and with special attention to the presence of any forms of leakage control systems;
- availability and validity of fuel quality documentation;
- noise levels produced by filling stations operation, which is basically sound produced by cars, coming to use services at filling stations.

The results were then evaluated in terms of potential human exposure, based on the approximation of population residing in the impact area. The approximation was performed within the standard risk assessment framework. The hazards and potentially affected population were defined, which is "Exposure assessment" step at the risk assessment process. Since exact concentrations of pollutants were not measured the health risks were not calculated.

The population under threat was evaluated based on the following assumptions:

1) The location of each filling station relative to nearby residential buildings was assessed, including the distance to apartment blocks, private housing, and mixed-use developments. The density of residential development within and adjacent to the sanitary protection zone was taken into account, as well as the number of potential permanent residents living in close proximity to the filling station who may be exposed to noise, air emissions, and other operational impacts on a daily basis.

2) The scale and capacity of each filling station were considered. The size of the station, number of fuel dispensers, types of fuel offered, and total turnover were used as indirect indicators of the potential number of clients served per day. Larger filling stations with higher traffic capacity were assumed to generate greater flows of vehicles and people, thereby increasing the number of individuals temporarily exposed to environmental and acoustic impacts.

3) The availability of additional services at filling stations was also accounted. The presence of convenience stores, cafes or food courts, car washes, service stations, and charging points for electric vehicles was considered a factor that prolongs the duration of customer stay on the site and attracts non-fuel-related visitors. Such multifunctional use was assumed to significantly increase the daily number of visitors and, consequently, the size of the population potentially affected by the station's operation.

4) The surrounding urban infrastructure was considered. The presence of shopping centers, office buildings, business centers, public transport stops, and other facilities in the immediate vicinity of filling stations was considered a factor contributing to increased pedestrian and vehicle traffic. Filling stations located near such infrastructure were expected to interact with a wider and more dynamic group of population.

Finally, the age of filling stations, changes in operations, including modernization, were considered factors, which contribute to residual risks formation, and thus were taken in consideration in the assessment.

Results and Discussion. All filling stations under consideration sell a wide range of fuels: A-92, A-95, A-95 with additives, and A-98 petrol, as well as diesel fuel (with additives). The capacity of filling stations ranges from approximately 9–11 m³ for small filling stations to over 100 m³ for the largest facilities. Such storage volumes create potential environmental risks, especially when continuous control over their potential effects is not provided. Moreover, high concentration of large tanks in densely populated areas increases health risks, due to air, soil, and water pollution.

The analysis of their environmental performance showed a range of drawbacks, which significantly increase their potential impact on the environment and contribution to risks formation. In particular, the most common gaps are insufficient landscaping or ill structure of the available plantations, as well as complicated location, which rises risks from their operation. However, certificates of all stations are valid and minimal requirements over the safety and security control are performed, which doesn't exclude the presence of issues. These gaps must be filled in an individual way:

1. The filling station 1, 9, 10, 13, 15 and 16 have sufficient space, a well-maintained sanitary protection zone, and equipment in good working order, but the level of greenery is below the norm, which reduces its protective properties. It is recommended to increase the proportion of green plantings to at least 40-60% and to install a double row of green barriers along the road and around the perimeter of the site. Since there are other buildings and a car shop nearby, it is advisable to strengthen noise protection and inspect drainage channels to prevent petroleum products from entering the storm sewer system.

2. The filling station 3, 4 and 6 have has sufficient greenery and a functional drainage and storm sewer system, but the tall trees (poplars in two cases) next to the tank farm pose a fire hazard. It is recommended to replace them with low-growing gas-resistant shrubs and trees. the drainage system should be regularly maintained to prevent fuel from entering the soil.

3. Filling stations proximal to residential and commercial buildings (5, 10, 14) requires strengthening the protective green belt. To improve environmental performance these facilities must be provided with automated air control systems and control of soil and ground waters pollution must be planned for then at least once per 3 years.

4. The filling station 5 at 9 Lugova Street in Kyiv has insufficient greenery and is located less than 40 m from a shopping center and residential building, which increases the impact of noise and fuel vapors on the population. It is recommended to create a dense green barrier between the station and the nearest buildings, provide noise protection, and modernize surface drainage. Transparency and accessibility of the tank farm should also be ensured to monitor the condition of the equipment.

5. The filling stations 8 and 12 have the worst environmental performance, since the almost or completely lack green plantations, lack modern drainage system and in case of the facility at 27b Perova Avenue the outdated technical equipment further increases negative impacts on the environment, which call for urgent actions.

A more sophisticated issue of all filling stations, which was defined via personal communication, is that its personnel take care and is well aware about fire hazards, but is almost uninformed about the environmental impacts produced by facilities.

To illustrate the intensity and spatial extent of potential impacts from these filling stations, the gross annual emissions of hydrocarbon vapors from reservoirs were calculated, using standard methodology. The highest values are characteristic of filling stations with the largest total fuel storage volumes (Fig. 1).

In the structure of emissions, the share of petrol is dominant for all sources of emissions due to its higher volatility and bigger turnover. The results of calculations demonstrate that impact area of filling stations is quite big and what is even more important, stretches well beyond the sanitary protection zone, especially at large stations. This affects the potential number of population exposed and thus health risks for them. The impact area for this assessment was therefore defined as double SPZ – 100 m.

The assessment of the population potentially affected by the operation of filling stations was carried out taking into account the functional characteristics of their surrounding areas (Table 1). Particular attention was paid to distinguishing between permanent and short-term exposure, which allows for a more realistic evaluation of the actual impact of filling stations on the population under urban conditions.

Permanent residential exposure was considered only for filling stations directly adjacent to residential buildings. For most filling stations located along major transport corridors, permanent residential population within the sanitary protection zone or in its close proximity is absent.

The number of office workers was estimated only for locations where business centers or shopping malls are directly adjacent to the filling station. The number of industrial and service workers was assessed based on average employment statistics for industrial and transport-related facilities in Ukraine, considering the number of workers simultaneously present within the impact zone. They represent three separate group with different intensity and duration of exposure, i.e. the dose they receive. Workers of the station are subjected to the highest impacts with maximal concentrations in the air of operation area, but working time duration and occupational standards set certain limits. On top of that their objective risk levels might be mitigated by the fact of awareness of being exposed and being informed they can take certain steps for protection and mitigation of health effects via medical services or life style. As for

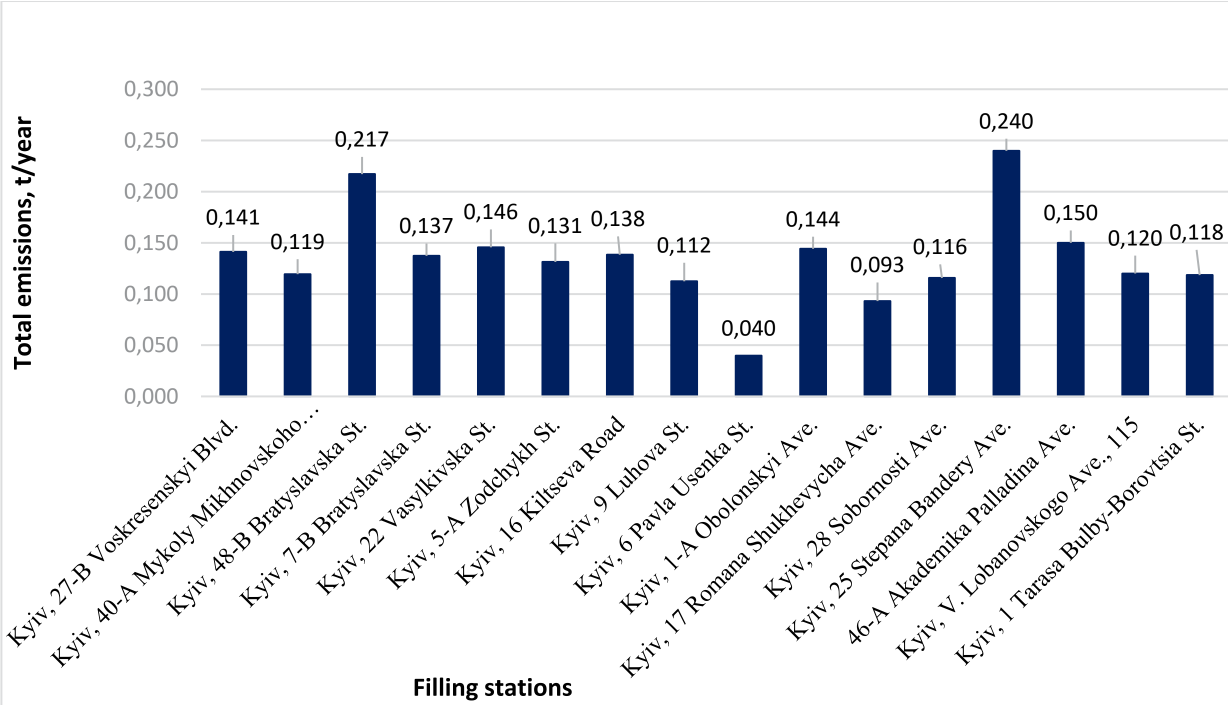

Fig. 1. Emissions of NMVOCs from the reservoirs of filling stations

Table 1

Assessment of potential population affected by Ukrnafta JSC filling stations in Kyiv

№	Filling station location	Category by capacity	Permanent residents	Office workers	Industrial / service workers	Customers (persons/day)
1	16 Kiltseva Road	III	0	0	250–500	1,500–2,000
2	5-A Zodchykh St.	II	0	0	80–150	1,200–1,600
3	1 T. Bulby-Borovtsia St.	II	0	0	80–150	1,200–1,600
4	46-A Akademika Palladina Ave.	III	0	0	150–300	1,400–1,900
5	9 Luhova St.	II	0	600–1,000	200–400	1,300–1,800
6	1-A Obolonsky Ave.	III	0	0	150–300	1,600–2,000
7	25 S. Bandery Ave.	III	0	0	250–500	1,800–2,000
8	27-B Voskresensky Blvd.	II	0	0	150–300	1,100–1,500
9	17 R. Shukhevych Ave.	II	0	0	80–150	800–1,200
10	48-B Bratyslavska St.	III	1,200–1,800	0	80–150	1,700–2,000
11	7-B Bratyslavska St.	II	0	0	80–150	900–1,300
12	6 Pavla Usenka St.	I	0	0	300–600	500–700
13	28 Sobornosti Ave.	II	0	0	150–300	1,000–1,400
14	40-A Mykoly Mikhnovskoho Blvd.	II	0	800–1,500	80–150	1,000–1,400
15	V. Lobanovskogo Ave., 115	II	0	0	150–300	1,000–1,400
16	22 Vasylkivska St.	II	0	0	300–600	1,200–1,600

the permanent residents in the impact area and office staff at commercial facilities they are much more numerous, though the dose they obtain is lower due to significantly decreased concentrations in the air. At the same time, these people are unaware of the possible risks and are additionally subjected to mobilization of pollution retained in soils and groundwaters via dusting and volatilization.

From the results of estimation, it is seen that the highest risks are imposed by filling stations 10 (48-B Bratyslavska St.) due to close location of residential buildings and 5 and 14 stations (9 Luhova St. and 40-A Mikhnovskoho Blvd.) with the business centers in the impact area. Thus, these facilities and areas around them must undergo additional control and monitoring to prevent additional morbidity.

The number of customers was estimated based on the typical daily fuel turnover of urban filling stations with regular daily fuel deliveries by tanker trucks and an average refueling volume of approximately 40 l per vehicle. This approach reflects real operating conditions of filling stations and allows for a realistic assessment of the population group with short-term exposure. They undergo the same set and intensity of effects as technological staff of a filling station, but the doses are lower due to shorter stay on site. However, the potential exposure of customers might be increased due to availability of additional services at some filling stations, such as car washes, food courts, coffee areas, shops, and related services. Such facilities significantly increase the time people spend at filling stations, as customers not only refuel (up to 10 minutes) but can also stay at the station for 30 minutes or longer. This means that people are exposed to the complex of the fuel station impacts for a longer time, enough to exert certain negative effects. Additionally, the presence of car washes further increases the level of aerosols, moisture, and chemical reagents in the air affecting consumers.

As for the acoustic pollution, noise measurements were carried out at the studied filling stations during periods of increased traffic intensity. Most filling stations are located near busy roads, which are the sources of constant background noise in the range of 65–80 dB, which is over sanitary standards for residential buildings. The work of equipment produces intermitted noise, which doesn't make significant contribution to the soundscape and is a matter of occupational safety, rather than environmental. However, noise at the vicinity of filling stations could be more intense, because vehicles are changing mode of engines work dramatically, have to perform complex turns and rounds to fit into filling and parking slots. For residents of houses located near such facilities, this can lead to chronic psychological discomfort, increased irritability, and deterioration in sleep quality and overall well-being. Since some filling stations (for example, 25 Stepan Bandera Avenue) are located near complex traffic junctions, the acoustic load is particularly high and constant.

All the filling stations considered were built in 2005-2008 and thus have already been operated almost 20 years, which is the period when the integrity of their reservoirs might start to deteriorate. This makes them all sources of latent risks for soil and groundwaters pollution.

The modernization of these filling stations was aimed at rebranding and thus didn't involve reconstruction of the equipment nor environmental quality assessment according to the official data on site. Moreover, since the time of their construction new residential buildings were built, moving residential area towards filling stations. The automation of technological and security control processes has progressed considerably over the last 20 years, so it is possible to assume that the new pollution from filling stations is limited to certain extent via the control of fuel losses via all pathways. Thus, the residual pollution of soil and groundwaters from previous period of exploitation is the potential source of residual risks for local population. The implementation of these risks is possible via dusting of polluted soils in dry summer season, as well as evaporation of pollution retained by soils and groundwaters. These factors are typically considered not significant, but their combination with pollution from highways in smog-prone periods is a factor of concern for local population and needs attention due to increased potential of the secondary pollution formation.

Conclusions. Based on a field survey of filling stations, it was found that their impact on the environment varies significantly depending on their location, the size of the sanitary protection zone, the condition of green plantings, the presence of drainage channels, the technical condition of equipment, and proximity to residential or industrial buildings. Each filling station has specific characteristics that determine the nature and scale of potential environmental threats – and thus their impact area and potential risk exposure for population varies considerably. That is why recommendations for different facilities cannot be universal: they must be developed individually, taking into account the actual condition of the territory and engineering infrastructure. Overall, the location of filling stations in Kyiv was were guided by economic considerations, rather than environmental or security reasoning. As a result, some objects are located too close to populated areas, or on complex relief forms, which created additional risks. Thus, the filling station at 40a Mikhnovskogo Street is located near a multi-story business center and on a hillside, which creates a risk of erosion and flooding, as well as expands the impacts area of the station due to pollution distribution. Obviously, relocation of filling stations outside the risk areas is out of the question, but their latent and residual risks, individual peculiarities of environmental impacts must not be ignored but meticulously studied and managed towards mitigation.

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