Study of factors affecting the reliability and efficiency of the heat supply system

P A Gorshkalev, M D Chernosvitov, E G Porshina
Water Supply and Wastewater Disposal Chair, Academy of Construction and Architecture, Samara State Technical University, 194, Molodogvardeyskaya St, Samara 443001, Russia

E-mail: kafvv@mail.ru

Abstract. The paper describes the history of creating the concept of a sanitary protection zone (SPZ) designed for population protection from the negative impact of industrial enterprises. It proposes a classification SPZs by their size and develops an approach to calculating a hazard class of industrial enterprises over time. It also describes the procedure of establishing a SPZ in accordance with current legislation applicable to all production facilities, including water supply community facilities. The research considers problems of establishing SPZs for wastewater disposal organizations (WDO) located in historical building developments, as well as for water supply and sanitation facilities where reconstruction is planned. The paper reveals the shortage of a regulatory and procedural framework for calculating emissions from WDO facilities, using the example of a specific structure.

1. Introduction
To protect the population from the negative impact of industrial enterprises and industrial facilities in the early twentieth century it was decided to establish sanitary protection zones (SPZ) for enterprises, limiting the residence of people on their territory [1]. In the first classification of enterprises according to their SPZs types, there were only three types of production facilities: 1) enterprises with no SPZ, and therefore their placement was allowed in residential areas; 2) enterprises with 250-meter-SPZ size; 3) enterprises with SPZ of 2000 meters. By the end of the 30s of the last century, a new classification of production facilities was adopted. It included six types of enterprises with their SPZ sizes being 0, 100, 300, 500, 1000 and 2000 meters. This classification was based on research conducted from 1932 to 1939. The developed classification included 259 enterprises from various industries. The list of production facilities included into the classification is being constantly updated and expanded [2]. Sanitary rules and other regulatory documents are also being updated [3-6].

2. Problem specification
At the moment, the main document regulating the SPZ size is the sanitary rules and regulations [6], which include 525 different industries and industrial enterprises with their SPZ sizes of 50, 100, 300, 500 and 1000 meters, which corresponds to the V, IV, III, II and I hazard classes. SPZ size of other industrial enterprises and construction facilities depends on their specific characteristics. For construction projects that are not included into the sanitary classification, the SPZ size should be set individually depending on this specific object characteristics. To determine the SPZ size of an
enterprise which is not included into the list [6], a SPZ project is developed, which includes information about the negative impact of the enterprise on the atmospheric air, the levels of physical impacts, etc. After the implementation of the SPZ project and the establishment of approximate boundaries, measurements of atmospheric air pollution and physical factors at the border of the calculated SPZ should be carried out. After performing all measurements and confirming that there is no negative impact of the enterprise on the calculated border of the SPZ, the established SPZ has to be approved either by the Chief State Sanitary Doctor of the Russian Federation or by the Deputy Chief Doctor.

Sanitary rules and regulations [6] do not define the procedure for accepting the hazard class of production facilities, enterprises and other objects. Besides, neither quantitative characteristics of the criteria for the classification of enterprises nor the procedure of establishing the approximate size of their SPZ officially exist, so it is not possible to use these criteria in practice [7-9].

The hazard class of an enterprise is important not only during the construction and operation of the production facility, but also at the design stage, as well as at the pre-project stage, when selecting the site for the object, since the subsequent design, construction (reconstruction) of the enterprise may be useless due to the inability to establish a SPZ with the required size [9]. A similar question arises when reconstructing an object which is located in a historical building development. The project documentation for the reconstruction of such an object will not be approved by the state expertise until the establishment of the sanitary protection zone of the reconstructed object, and the minimum requirement for the SPZ approval is the absence of objects with specified parameters in this area. It means that though the SPZ size of a particular enterprise and its hazard class can be changed, it is still actual to create a proper sanitary classification of industrial enterprises and other production facilities. It is also important to adopt specific criteria that determine the hazard class of industrial enterprises and other production facilities and, consequently, the size of their SPZs. This problem remains pressing for all enterprises no matter if they have been included into the classifications of industries and industrial enterprises mentioned above.

3. Methodology

It is possible to determine a hazard class of a certain enterprise by various methods. The use of quantitative criteria (power, volume or emissions discharge) with account of the maximum permissible concentrations of substances is one of the main methods [10-12]. Therefore, to properly assess a certain enterprise with regard to the criterion of its emissions efficiency, it is important to use the reference concentrations of pollutants in emissions, established with account of the health status of the population [9,13,14].

4. Discussion

At the moment, the procedure for approving SPZs has been established. It was introduced by Resolution [16] (hereinafter the Rules). When establishing a sanitary protection zone, the main problem for a WDO enterprise is the implementation of Article 5 of the Rules. This article does not allow the use of land plots within the boundaries of the SPZ for certain purposes, such as: housing development, recreational areas and gardening; placement of water supply systems for the preparation and storage of drinking water, etc.

Thus, in SPZ zone boundaries it is not allowed to provide land for housing and residential construction (the data are available from public cadastral maps), but there might be houses in this zone which are not registered in the cadaster of real estate. It should be noted that sanitary inspectors who carry out the formal expert examination and are familiar with the site will not allow to locate object with specified parameters (not even those which are not registered) within the boundaries of the SPZ. Restrictions on the placement of residential areas are more accurately reflected in Paragraph 5.1 of the Sanitary Norms and Rules [6] "it is not allowed to place residential buildings, including individual residential buildings, in the sanitary protection zone..."
"Residential development" and "use of land for housing development" are two totally different things. According to the Rules, the SPZ project should contain a list of prohibitions that should be imposed on the territory of the SPZ. The sanitary norms and rules [6] also prohibit the placement of such a group as "other territories with normalized indicators of habitat quality" in the SPZ. Thus, definitions of "children's recreation organizations" and "playgrounds" make it possible to conclude that SanPiN (Sanitary Regulations and Standards), in contrast to the Regulations, prohibits establishing a site where children can play inside any sanitary protection zone.

At present, Rospotrebnadzor (*an abbreviation for Federal Service for Surveillance on Consumer Rights Protection and Human Well-being) Administration Office issues sanitary and epidemiological conclusions on SPZ projects and Decisions on the SPZ determination. In this case, it is not required to confirm the size of the SPZ by measurements.

Resolution of the government of the Russian Federation [16] uses only the term SPZ. It does not mention such notions as "preliminary", "calculated" and "final (established)" SPZs which means that a sanitation-and-epidemiological conclusion report for a preliminary sanitary protection zone is not required. SPZs are established based on the "Decision".

In practice, when a SPZ for constructed water supply community facilities (WDO) is being established, one has to face the fact that such structures are often surrounded by land plots for gardening (until 2019 they were referred to as "allotment gardens"), as well as by plots for individual residential development. This happens because the presence of SPZs in this territory is not checked when it is assigned to the cadaster, because they are not assigned to the cadastral register, even if there is an enterprise with an approximate SPZ on the general lay-out of the location.

Here, sewage facilities located on the territory of a village located in the economic zone of a specially protected natural area (a national Park) attract attention most of all. This zone is intended for carrying out activities aimed at the life support of citizens living on the territory of the national park [17].

There is a situation when the presence of the enterprise is quite acceptable on the territory that can not be located within the boundaries of the SPZ.

To make decisions on the establishment or termination of the existence of preliminary calculated SPZs, owners were required to apply to the competent public authorities with a package of relevant documents (according to Part 13 of Article 26 of the Federal Law [18]). At the same time, confirmation of compliance at the border of maximum permissible concentrations (MPC) and maximum permissible levels (MPC) was not required, but the inspection body required the presence of a measurement program.

To confirm the size of the SPZ, different organizations involved in the examination of SPZ projects insist on including different requirements into the programme of measurements, e.g. to include only substances with the highest calculated concentrations, to include all substances with a concentration outside the territory of the enterprise greater than 0.1 percent of the MPC (MAC), etc.

The commitment to establish a SPZ in documents differs significantly (up to 10 times):
- for sources of impact on the environment and human health, for which the levels of pollution created outside the industrial site exceed 0.1 MAC and/or MPC [6];
- for sources of chemical, physical, biological impact on the human habitat in case of formation behind contours of objects of the chemical, physical and (or) biological impact exceeding sanitary and epidemiological requirements [16].

Regulatory documents do not define a hazard class for WDO objects, primarily for sewage facilities. It is not possible to determine it indirectly, since the SPZs of sewer structures also have dimensions of 15, 20, 30, 150, 200 and 400 meters that does not correspond to the classification.

The requirement to establish the same SPZ size for pumping stations and treatment facilities of industrial sewage as it is for industries that discard wastewater is in most cases overstated.

Sewage treatment plants are often surrounded by garden patches, which are places of mass recreation of the population (according to [19]). SanPiN [19] also requires regulatory compliance with no more than 0.8 share of maximum permissible concentration at the border of this territory, according
to Paragraph 2.2 [19]. At the same time, at the border of an SPZ one share of MPC is allowed. Regulatory compliance with 0.8 share of MPC at the border of SPZ is not required when establishing the SPZ, either. Nevertheless, this 0.8 share is required for sanitary examination.

The requirements of Paragraph B of Article 5 of the Rules are difficult to fulfill, as it is not clear how to assess whether there will be a violation of the quality and safety of funds, raw materials, water and products from the impact of the construction facility in question.

Current regulatory documents do not indicate what MPC should be applied while assessing SPZ (that is maximum one-time or daily average MPC). Approximate safe levels of impact (ASLI) are not determined, either. It can be considered as the absence of the need to consider substances with a specified ASLI at all.

Figure 1 shows an example of a regulatory SPZ for sewage treatment plants located in the Samara region (see Figure 1). Sewage treatment facilities (STF) capacity here exceeds 500 m³/day. According to SanPiN [12] their SPZ is supposed to be 200 m. The figure also shows that this regulatory SPZ includes land plots for individual residential development, gardening, etc. To reduce the negative impact on the environment, a number of measures were proposed to reduce the emissions of pollutants into the environment, which allowed setting the size of the SPZ along the STF land plot boundary.

Figure 1. Sewage treatment facilities layout plan, their surrounding area description and the marked regulatory boundary of their SPZ.

The only existing methodology of calculation of emissions from wastewater disposal enterprises is known as "Guidelines for the calculation of emissions of pollutants into the air from unorganized sources of wastewater aeration stations" [15]. The methodology uses the calculation method to determine emissions from the following unorganized sources of aeration stations: receiving chamber, mechanical wastewater treatment grids, sand catcher, primary strainer chamber, secondary strainer chamber, aeration tank, silt compactor, raw sludge reservoir, sand platform, silt platform, pre-aerator.
Sewage pumping stations are calculated with account of their receiving chamber. There are no such common facilities as biofilters (bulk and disk), sludge dehydration facilities, irrigation and filtration fields, biological ponds, septic tanks.

The inspection committee considers it illegal to use the calculation method intended for estimating emissions from oil traps of oil industry enterprises to calculate emissions from oil separators of sewage treatment plants of surface runoff. Thus, there is document defining the methodology for calculating emissions from oil separators of sewage treatment plants of surface runoff.

The sources of negative impact on the water treatment plants are mostly not technological but supporting processes / facilities. Water treatment plants are not included in the sanitary classification of enterprises. Impact sources at drinking water treatment plants are chlorination, ozonation, dry preparation and storage of reagents. It should also be taken into account that water and sewage treatment facilities often include boiler rooms and backup diesel generators, emissions from which must also be included into the calculation of dispersion when establishing a SPZ.

5. Conclusions
When establishing sanitary protection zones of existing WDO enterprises, one has to face a number of problems related to the presence of two "main" regulatory documents on establishing the size of the SPZ as well as the lack of methods for determining the negative impact on the environment for a number of types of structures.

It is necessary to make changes and additions to the legislative and bylaws governing the establishment of SPZs, to finalize the methods for calculating emissions for various WDO facilities.

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