Evaluation of background content of priority contaminating substances in atmospheric air at the pre-design stage of construction of landfill solid waste disposal

T G Sereda
Perm State Agro-Technological University named after academician D N Pryanishnikov, 23, Petropavlovskaja St., Perm, Russia, 614990
Russian Presidential Academy of National Economy and Public Administration. Perm branch, 10, Gagarina Boulevard, Perm, Russia, 614990

E-mail: iums@dom.raid.ru

Abstract. The article is devoted to experimental studies to determine the approximate values of background concentrations of pollutants in the ambient air in the area of the proposed construction of solid waste landfill. By preliminary calculations of dispersion priority substances for which it is necessary to determine their background concentration were identified. A number of situ measurements of concentrations in atmospheric air were carried out for the selected substances. According to the results of measurements, the most probable laws of distribution of random variables are determined. Also the quota of air pollution by solid waste landfill on the basis of existing sanitary standards of air quality is determined.

1. Introduction
The background level of air pollution and the forecast of changes in its quality in the implementation of this activity should be taken into account, when assessing the possibility of designing industrial and other economic facilities that have a harmful effect on air quality. This fact is reflected in the regulatory and methodological literature governing the design work, as well as in the fundamental legal documents – GOST 17.2.3.02–78 and Federal law RF of 04.05.1999 No 96-Fl.

2. Equipment and devices used in studies
Conducting field studies, the gas analyzer GANK-4 was used. Forecasting emissions of biogas emissions, a unified program for calculating atmospheric pollution UPRZA “ECO center-Standard” was used.

3. The results of the study and their discussion
Background concentration for an industrial facility is atmospheric pollution, created by other facilities, excluding this one, in the area where the facility is located. In the case of the designed object as the background is meant the concentration formed by existing objects [1]. Background concentration values can be determined by calculation or experimentation. In the vast majority of cases, it is not possible to calculate background concentrations using formulas, taking into account numerous sources of air pollution, including road transport, as well as transboundary pollutant flows. It is connected with the high degree of economic development of the territories, the complexity of dynamic accounting of
non-simultaneous operation of existing industrial and other facilities, as well as sources of air pollution within each facility of these types. Therefore, in such cases, background pollution is taken into account, determining it on the basis of experimental data in accordance with the existing state bodies in the field of Hydrometeorology, environmental control and healthcare.

The purpose of these studies was to assess the background concentrations of pollutants in the air at the pre-design stage of construction of the landfill and to determine the law of distribution of a random variable based on the experimental data.

The methodology for the calculation, regulation and control of emissions of pollutants into the atmosphere developed by the "research Institute Atmosphere" defines the condition that determines the necessity to take into account the background concentrations of substances:

\[ q_j > 0.1, \]

where \( q_j \) (in shares of MPC) is the maximal surface concentration of \( j \)-th pollutant that is emitted by (without background) emission of reporting entity at the boundary of the nearest residential development in the zone of influence of subject emissions.

According to the results of pre-calculation of dispersion of polluting substances in the atmospheric air to the landfill without taking into account background concentrations, substances, the concentration of which on the boundary of the nearest residential development in the zone of influence of emissions exceeds 0.1 MPC, are determined [2]. In each case, the list of such substances may be different; it depends on the capacity of the landfill, the morphological composition of the waste, waste disposal technology, the size of the calculated sanitary protection zone, geographical and meteorological conditions of the area and many other factors [3,4]. For example, for the proposed landfill in Ketovsky district of Kurgan region dihydrosulfide (hydrogen sulfide) satisfies the specified condition. For some substances, the excess of 0.1 MPC at the border of residential development is not observed, but they are specific to the landfill. In accordance with the method of calculating the quantitative characteristics of emissions of pollutants into the atmosphere from landfills of solid household and industrial waste (NPP "Logus"), methane (52.915%), methylbenzene (toluene) (0.723 %), ammonia (0.533%) have the highest specific concentration in the average composition of biogas emitted by a landfill.

None of the selected pollutants is included in the list of substances for which the state service for Hydrometeorology and environmental monitoring in the area conducts long-term observations. Taking into account the fact that any other observations can only give an approximate estimate of background pollution for the period of measurements and from year to year, the average concentrations of pollutants in the atmospheric air can vary for several reasons, for example, fluctuations in meteorological conditions, etc. the effects of the landfill on atmospheric air according to the results of observations on the content of these substances in the atmospheric air prior to construction may not correspond to the real emission fluxes after the landfill is put into operation. For this reason, it is necessary to create a model that takes into account these factors, and this requires full-scale studies [5].

The state territorial bodies for Hydrometeorology and environmental monitoring conduct long-term observations on the priority substances for characterizing the level of air pollution in the region, enabling the most accurate assessment of the background concentration [6]. In the case of the design of individual objects, for example, such as landfill, it is necessary to obtain information about the background content of specific pollutants in the air, which are not monitored by a specialized territorial service. Due to the impossibility of determining the concentrations of the required substances and the calculation method because of the above reasons, as well as the lack of time for long-term observations, it remains to determine them experimentally.

To systematize and estimate the level of air pollution for the period under consideration, statistical characteristics such as the arithmetic mean of the impurity concentration, the standard deviation of the measurement results from the arithmetic mean, the maximum value of the impurity concentration, the coefficient of variation showing the proportion of variability from the arithmetic mean are usually used. The arithmetic mean of the impurity concentration is the main indicator of atmospheric
pollution. In addition, in order to characterize the greatest air pollution for the period of time under consideration in real conditions determine the maximum of one-time concentration of impurities.

In this case, studies were conducted to measure the concentrations of the required specific pollutants in the atmospheric air and the subsequent finding of the most probable ranges of background concentrations.

The significance of studies of the air pollution state of in the proposed area of the landfill location depends on the correctness of the control points for measurements. Due to the constant mixing of air, the level of pollution will be determined by all existing sources of emissions in the area under consideration. Since the objective of the measurements is to establish the level of air pollution characteristic of the area as a whole, in our studies the control points are selected both in areas near existing sources of emissions similar to the emissions of the projected landfill, and in areas remote from such sources and close to housing and other normalized areas. In this case, the average background concentrations most characteristic of the area will be determined. Each point was located in an open ventilated area in order to prevent overestimation or underestimation of the results of measurements due to stagnation of air mass or Vice versa, the absorption of pollution by foliage of densely growing plants.

In this research the gas analyzer GANK-4 was used for aspiration sampling of atmospheric air, which allows to quickly and accurately determine the concentrations of a wide range of substances. Figure 1 shows the locations of air quality control points (k.1, k.2, k.3) for the projected landfill. Two points were selected from the Western and Eastern sides of the territory of the planned construction, close to the garden areas, where there are specific sanitary and hygienic requirements to the quality of atmospheric air.

**Figure 1.** Location of monitoring points for ambient air quality for the proposed landfill (the settlement Ketovo region Kurgan).
So, in places of mass rest concentration of pollutants in the air should not exceed 0.8 MPC. After the commissioning of the landfill, the monitoring points will be located on the border of the nearest normalized areas, so the comparison of the values of the concentrations of specific substances in such points at the pre-design and operational stages for monitoring purposes will be the most indicative.

For each of the four substances (dihydrosulfide (hydrogen sulfide), ammonia, methane, methylbenzene (toluene)), measurements were carried out at three control points located on the West, North and East sides from the designed MSW landfill location (on the South side there is no residential development and other normalized areas). Five samples were taken at each control point.

Thus, a sample of 15 concentration values was formed for each substance.

The generalized statistical characteristics obtained during the research are shown in the diagram in figure 2. Processing of the results of observations was carried out taking into account the definition of the law describing the probability distribution of the population from which the processed sample of random variables was extracted. To do this, a hypothesis stating that the observed distribution of random variables is described by a specific law was put forward. It is known that the criteria for testing the hypothesis, called consent criteria, are divided into General and special. The General acceptance criteria are applicable to the formulation of the hypothesis of agreement of the observed results with any a priori assumed distribution. Special criteria are verified by a special hypothesis, formulating the agreement with the specific form of distribution.

![Figure 2](image-url)

**Figure 2.** Calculated, approximate background and permissible concentrations of pollutants in the air in the area of the proposed construction of the landfill:
- indicative background levels of the pollutant in the ambient air, in shares of MPC;
- the estimated maximum concentration at the control points formed by the emissions of the projected landfill at the end of its operation, in terms of MPC;
- allowable contribution of the landfill, in terms of MPC.

The calculations showed that the distribution of the random value of not all specific substances in the atmospheric air of the area of the proposed construction of the landfill is subject to the law of normal distribution. In particular, the hypothesis of the normal distribution of the total population concentrations is not confirmed for substances such as methane and methylbenzene. In both cases, this is due to the fact that at the control point near the existing storage pond of liquid domestic waste, the concentrations of these substances are significantly higher than at the control points near the boundaries of garden plots. This means that the storage pond is the main background pollutant in the
area for methane and methylbenzene. Conversely, concentrations of ammonia and dihydro
sulfide (hydrogen sulfide) are normally distributed, the content of their proposed construction of a uniform,
such uniform content, mainly due to transboundary transport.

4. Conclusions
Thus, on the basis of experimental data on the content of specific pollutants in the air in the area of the
designed landfill, the law of distribution of the random value of background dispersion of substances
was determined, and quotas of air pollution by the landfill of solid waste on the basis of existing
sanitary standards of air quality were determined.

References
[1] Chalvatzaki E, Aleksandropoulou V and Glytsos T 2012 The effect of dust emissions from open
storage piles to particle ambient concentration and human exposure Waste Management
32(12) 2456–68
[2] Kostarev S N, Sereda T G and Elancheva E N 2014 Study safety environmental protection
landfills using models anaerobic digesters Applied Mechanics and Materials 682 339–45
[3] Rincon C, De Guardia A and Couvert, A 2019 Chemical and odor characterization of gas
emissions released during composting of solid wastes and digestates Journal of
Environmental Management 233 39–53
[4] Long Y, Liu D and Xu J 2018 Release behavior of chloride from MSW landfill simulation
reactors with different operation modes Waste Management 77 350–5
[5] Sereda T G and Kostarev S N 2018 Environmental management modelling in the areas of waste
landfilling IOP Conference Series: Materials Science and Engineering 450(6) 062009
[6] Zakrutkin V, Shishkina D and Gibkov E 2018 Landfills of municipal solid wastes as sources of
impact on the environment (Ecology-geochemical aspect) 18th International
Multidisciplinary Scientific Geoconference 18(5.2) 553–60