The wastes of Luhansk region chemical and energy enterprises and their impact on the environment

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Abstract. The chemical and energy industries are one of the most powerful generators of solid industrial waste. Such enterprises have water treatment plants. The result of the water treatment process is the formation of a water treatment sludge. The sludge composition includes carbonates and hydroxides of calcium, magnesium, iron, aluminum, and coagulated natural organic materials. A significant amount of waste in the form of fly ash and fuel slag is generated in the process of burning coal at power plants. Such wastes are usually classified as “low-risk”. Nevertheless, when wastes are stored in the storage, they create environmental and economic problems. Large areas of land are alienated for storage. Dust emissions and filtration losses are observed in the process of waste storage. The wastes impact of the Luhansk region enterprises on the environment has been studied. Waste storage facilities are located on the left bank of the Seversky Donets River in the zone of Dnieper-Donetsk structure articulation and the Voronezh antecline. Features of the territory geological environment are explained by the presence of geological disturbances, loamy-sandy and carbonate rocks, manifestations of carbonate karst. The wastes degrade the quality of surface and ground waters used for water supply in the region.

1. Introduction
The most powerful generators of solid industrial waste after mining are the chemical and energy industries. Very often they form a significant amount of waste very similar in chemical composition and hazard classification kind. Thus, powerful water treatment plants operate at chemical and thermal power plants. Chemical companies are the largest consumers of water, the average cost of which is about 1 million m³/day. Water is used as a component of raw materials and a reaction medium, for heating or cooling of reagents. The most common industrial use of water in heat exchange equipment for steam production and in cooling water systems requires low alkalinity and hardness [1].

Raw water that enters the plant is treated, primarily by chemical reagents. Reagent softening of water is based on its treatment with substances that bind Ca²⁺ and Mg²⁺ ions in water. Lime, soda ash, and other substances are used as water softeners. During this process [1] a large amount of wastewater is formed, which is called sludge water. The sludge enters the sludge storage in the form of “sludge” water. The solid substances are sedimented. The upper layer of water is pumped for further water treatment, and the sludge deposits and accumulates until the sludge storage is full.
The same sludge is formed not only at chemical enterprises but also at power plants. When stored in storage, sludge creates environmental and economic problems. Given the operation age and obsolescence of engineering equipment, it should be noted that filtration from such facilities is 10-25 % of the water supply. The components of the liming sludge are able to leach into the natural environment due to the increased pH value in the sludge storage and filtrate from it [2]. The high alkalinity of water in the process of liming is maintained to ensure the efficiency of further water purification [3]. Because sludge storages are an integral part of water treatment plants, they need to be released and restored.

The composition of the sludge mainly includes carbonates and hydroxides of calcium, magnesium, iron, aluminum, coagulated organic impurities. Such wastes are usually classified as “low-risk”, but nevertheless, when stored in dumps, the sludge affects the environment [4].

The largest power plant in the region is the Luhansk Thermal Power Plant (TPP) in the town of Shchastya. In the coal burning at the power plant, a significant amount of waste is generated in the form of fly ash and fuel slag. Ash and fuel slag are mixed with water treatment waste and disposed of in so-called ash slag dumps, such waste is also classified as “low risk”.

Despite the relative safety, the methods of waste processing proposed in scientific publications are quite diverse. In almost all developments, the organic component plays the role of ballast or harmful impurities. In order to develop effective methods of waste disposal, information on organic impurity content is required. The source of organic impurities is river water. The quantitative and qualitative composition of impurities in storage depends on meteorological conditions and seasonal fluctuations. Thus, in the spring flood period, after the ice melts, the water contains a minimum amount of soluble salts and is characterized by the maximum amount of suspended solids that are captured from the soil surface by rapid flows of meltwater. In summer, the composition of annual water is determined by the ratio of the share of surface and groundwater runoff.

Organic impurities include humic substances leached from soils and peatlands, as well as organic substances of various types that enter the water together with agricultural effluents and other types of insufficiently treated effluents. Most scientific research in recent years has identified organic impurities in the water as natural organic matter (NOM), which is characterized as a complex matrix of organic materials present in natural waters. The amount, nature, and properties of NOM differ significantly in waters of different origins and depend on the biogeochemical cycles of the environment [2]. Organic impurities in various water bodies that are sources of drinking or industrial water supply are studied quite often. However, NOM studies that have been included in the sludge, especially their transformation in waste storage processes have not been studied. To control this parameter, it is necessary to develop methods for analyzing the organic component of sludge. The chemical composition of the Seversky Donets river changes significantly depending on the predominant in their balance of waters of different origin categories (surface-slope, soil-surface, etc) [5]. Seasonal fluctuations in the chemical composition of water could necessitate some changes in water treatment processes. Thus, in the water treatment plant of Severodonetsk “Azot” in the spring, when the content of colloidal particles in the water is increased, aluminum sulfate is used as a coagulant instead of iron sulfate.

Luhansk TPP uses coal for energy production, during the combustion of which ash is formed. For the last two decades, fly ash used as an industrial product has received special attention. In [6] the possibilities of using coal ash as raw material are considered: as a reclamation agent in agriculture, in the production of glass and ceramics, in the production of zeolites, in the formation of mesoporous materials, in the synthesis of geopolymers, for use in catalysts and catalyst carriers, as an adsorbent for processes of gases and sewage, as well as for the extraction of metals. It was found that there is significant potential to increase the utilization of coal ash such as row and purified. Unfortunately, in the case of Luhansk TPP, the proposed methods
are unsuitable due to the co-storage of ash, slag, and sludge from water treatment.

Another large accumulation of waste in the Luhansk region, which belongs to the 4th class of danger is the famous “white seas” of OJSC “Lysychanska Soda”. The company no longer produces products, and waste remains. Solid waste from the soda production process using Solvay technology is formed as a result of the distillation of ammonia from the pregnant liquid. The solid part of the distillery suspension mainly comes from the lime, which is maintained in excess, which can ensure the complete decomposition of NH$_4$Cl. Solid wastes contain calcium carbonate, calcium sulfate, magnesium hydroxide, calcium hydroxide, silica, and alumina. The average solids amount of the distiller effluent is estimated at 240 kg/t of soda ash [7].

All these types of waste are characterized except the hazard class, a significant content of water-soluble calcium compounds, alkaline reaction, and the location of their storages in the immediate vicinity of the largest waterway in the region Seversky Donets River. In the described territory, these enterprises and their waste storage facilities are the largest agents of man-made impact on the geological environment and its components. The groundwater of the Cretaceous-marl aquifer, which is the most important source of drinking water supply for the population of the region, was most affected. In addition, the placement of slag and ash storages of enterprises on the area of natural-historical karst process in Cretaceous-marl rocks of the Upper Cretaceous period contributed to karst activation and creation of conditions for the development of man-made karst. It creates a significant threat to the population’s health.

The main threats associated with industrial waste storage and ash dumps of thermal power plants are the alienation of large areas of land, hydrochemical and thermal pollution of groundwater and surface water, intensification of exogenous geological processes. Water pollution can occur both due to filtration losses of industrial effluents from storage facilities and due to unauthorized discharge of industrial waste into water bodies due to upfiling storage tanks, as well as overflow of liquid waste through dams with significant water rise located near water bodies due to abnormal floods. Pollution of components of the geological environment can also occur due to sawing of ash dumps, which are especially relevant for cogeneration thermal power plants, which are located either within or in the immediate vicinity of settlements.

2. Materials and methods

The number of landfills, their area, and location, owners of landfills was determined by the registers of waste disposal sites in the Luhansk region [8].

2.1. Samples preparation

Two samples of sludge from the decarbonization department of PJSC Severodonetsk Association “Azot” was used for the research of sludge chemical composition: one was selected immediately after the process and the second was stored in sludge storage for several years. The precipitates formed during the whole operation time consist of water softening products and coagulation products - CaCO$_3$, Mg(OH)$_2$, Ca(OH)$_2$, Fe(OH)$_2$, CaSO$_4$, Al(OH)$_3$, Fe(OH)$_3$, and organic components. The precipitates that were selected immediately after the process did not contain Al(OH)$_3$, because at that season only iron (II) sulfate was used as a coagulant. Iron (III) hydroxide, aluminum hydroxide and the organic component are included in the sediment due to the coagulation process. Soluble organic compounds, usually present in water, are humic acids - a mixture of macromolecular compounds that contain various functional groups. They interact with coagulants and precipitate in the process of liming-coagulation at a pH value >10.

Humic substances of natural waters are divided into three groups:
- humic acids, which are usually found in water bodies in colloidal form;
- colloidal compounds of fulvic acids;
- dissolved fulvic acid compounds [9].
To determine the chemical composition of water treatment waste, sludge samples were taken after centrifugation, which reduces the moisture content of sludge in the summer and directly from the sludge storage. Therefore, the first sample was not stored in the sludge storage, the second was stored for several years and can be defined as an averaged sample. To analyze the chemical composition of the sludge sample was fined, dried to constant weight at 100 °C, weighed on an analytical balance to the nearest 0.0001 g, and dissolved in a mixture (3:1) of hydrochloric and nitric acids. The solutions were transferred to 50 ml volumetric flasks. The solution volume was made up to 50 ml with distilled water.

2.2. Samples examination
Calcium and iron content was determined by the titrations based on complexation reactions. In addition to the content of inorganic substances, the content of organic matter was determined. The organic component was analyzed as organic carbon by a method based on the organic carbon oxidation by potassium dichromate proposed in [10]. The method of analysis is based on the following: organic compounds are decomposed by a mixture of potassium dichromate solutions and sulfuric acid when heated, and the residue of dichromate is titrated with a solution Mohr salt. Because iron ions are present in the solution, the use of phenanthroline as an indicator is not suitable.

It was proposed to modify the method: after the decomposition of organic compounds to bind iron ions in the complex with phosphoric acid, and apply reverse titration of the residue of potassium dichromate with Mohr salt, in the presence of Diphenylamine indicator.

2.3. Environmental assessment
To study the waste storage effects on the geological environment an approach was used, which includes integrated processing and analysis of databases of geological and hydrological-hydrogeological information, laboratory and mathematical modeling. Information on groundwater pollution was obtained by sampling from observational wells located at landfills. Proven and approved methods and techniques, in particular, chemical methods of analysis were used in the process of laboratory research. Processing of the obtained results was carried out using the methods of mathematical statistics.

3. Results and Discussion
Information of wastes was determined by registers [8] is presented in table 1.

The largest in area and mass are ash and slag dumps - waste containing slag and ash from coal combustion. Fly ash is captured with the help of various gas scrubbers, the vast majority of coal-fired power plants have installed hydro-ash removal systems, which were built in Soviet times. Ash and slag dumps, account for up to 90% of all waste, depending on the ash content of a particular brand of coal and the characteristics of the combustion process. Ash is a fine material and consists of particles with a size of 0.1-0.005 mm, the particle size of the slag 20-30 mm. The chemical composition of ash and slag waste depends on the mineral composition of the fuel and varies depending on the coal deposits. The content of oxides in ash and slag waste: SiO$_2$ 37-63%, Al$_2$O$_3$ 9-37%, Fe$_2$O$_3$ 4-17%, CaO 1-32%, MgO 0,1-5%, SO$_3$ 0,05-2,5%. In the ash there is unburned fuel up to 6-7% to 25%, in the slag, as a rule, it is absent. Elements such as Ti, K, Na are present in small quantities. In some coals, there are even precious metals: Au, Ag, Pt, liquid, and scattered elements. Fly ash has unique adsorption and binder properties that can be used in wastewater treatment of various compositions and origins [11].

Most often, ash and slag are not separated at Ukrainian thermal power plants. The maximum amount of water-soluble impurities is given by ash. The solubility of slag components is so low that it characterizes it as a substance that does not have any contaminating effect. Water treatment waste is also dumped in ash dumps.
Table 1. The largest landfills in Luhansk region.

| Landfill owner | Denomination | Coordinates | Total amount, t | Total area, ha | Distance from landfill to the Seversky Donets River, km |
|----------------|--------------|-------------|-----------------|----------------|--------------------------------------------------------|
| **Severodonetsk** | Sludge storage of decarbonization station | 48.924303, 38.471735 | 208286.7 | 8,065 | 1.4 |
| | Sludge storage of industrial sewage | 48.924303, 38.471735 | 64877.7 | 13.6 | 1.4 |
| | Sludge storage of physical-chemical cleaning | 48.924303, 38.471735 | 55548.38 | 13.6 | 1.4 |
| | Sludge storage №2 | 48.924303, 38.471735 | 1353,600 | 1.8 | 1.2 |
| **“Severodonetsk TPP”** | Sludge storage | 48.923532, 38.469084 | 37366.90 | 4.72 | 1.2 |
| | Ash dump | 48.924321, 38.469677 | 4027500 | 33.64 | 1.2 |
| **Sichastia** | Ash dump №1 | 48.779881, 39.266049 | 1600000 | 879 | 2.3 |
| | Ash dump №2 | 48.779881, 39.266049 | 2644000 | 84.6 | 2.3 |
| | Section №6 of Ash dump №2 | 48.769198, 39.257924 | 2085999.6 | 5.73 | 2.88 |
| | Ash dump №3 | 48.779972, 39.261684 | 10789932.4 | 96.36 | 2.4 |
| **Lysychansk** | Storage of industrial effluents №3 | 48.891345, 38.490663 | 1,079 million t | 23 | 0.6 |
| | Storage of industrial effluents №2 | 48.891984, 38.493092 | 3.5 million t | 50 | 0.8 |
| | Storage of industrial effluents №4 | 48.892451, 38.495245 | 4.13 million t | 60 | 0.95 |

Water treatment wastes are formed in chemical and energy enterprises and have similar chemical compositions. Waste from the decarbonization department of PJSC Severodonetsk Association “Azot” was analyzed, the results of the analysis are presented in table 2.

Therefore, the chemical composition of water treatment sludge is quite stable. Because sample 2 was taken in the summer when iron (II) sulfate was used as a coagulant at the plant, the iron content was slightly higher. Sample 1 was taken directly from the storage, so it also contains the precipitate obtained in the spring, when the coagulant used aluminum sulfate. The amount of organic carbon in the accumulated sludge is due to natural causes - the biological growth of natural material that comes with river water. The hydroxide content is reduced due to the
absorption of CO$_2$ from the air.

Table 2. The content of the main components of waste water treatment, % wt.

| Component               | CaO   | MgO   | CO$_2$ | Fe(OH)$_2$ | Organic carbon | Hydroxides, water and etc |
|-------------------------|-------|-------|--------|------------|----------------|-------------------------|
| Sample 1                | 38,41 | 17,65 | 34,51  | 0,80       | 0,80           | 7,83                    |
| Sample 2                | 44,10 | 5,50  | 16,50  | 1,87       | 0,47           | 31,56                   |

According to OJSC “Lysychanska Soda” [12], the amount and chemical composition of the solid part of the sludge entering the sludge storage was determined. For the years of operation, the liquid part of the distillery liquid had been dumped into the Seversky Donets River during the flood. Thus, about 12.7 thousand tons of sludge were formed and placed annually in sludge storage facilities. The sludge consists of 19.5% calcium chloride, 23.5% sodium chloride, 4.8% ammonium chloride. The storage №1 is not present in the list, its age is more than 100 years, the drive has been reclaimed.

The locations of all the studied objects have an eastern geological structure, which allows us to identify common features of their impact on the geological environment.

The enterprise PJSC “Severodonetsk Association Azot”, its storage facilities, as well as sludge storage facilities of OJSC “Lysychanska Soda” and ash dumps of the Severodonetsk TPP are located on the territory of Lysychansky-Rubizhnoye Mining District, which involves the middle reaches of the Siversky Donets River. The ash dumps of Luhansk TPP are located downstream. All the objects are located on the sandy terraces of the left bank of the Seversky Donets in the territory which in geological and structural terms belongs to the Starobilsk-Millerovo monocline of the southern wing of the Voronezh anteclise. This is a zone of articulation of two large structures of different ages - the ancient Eastern European platform and the Donetsk folded structure of the Hercynian age. The structure is complicated by the system of brachianticlinal folds, and in the area of Lysychansky-Rubizhnoye mining district also by the system of tectonic disturbances - regional (Severodonetsk and Krasnoretsk tectonic faults) and accompanying tectonic disturbances of the 2nd and 3rd order create favorable conditions for the migration of pollutants.

In the zone of active water exchange, there are three aquifers developed - technogenic-alluvial and alluvial of sporadic distribution and an aquifer of the fissured-karst zone of the Upper Cretaceous chalk-marl deposits, which is widespread. The geological and hydrogeological section is represented by bulk soils with up to 2 - 3 m thick, well-permeable Quaternary sandy-argillaceous deposit with thickens of 0 to 30 m, and a chalk-marl deposit with a thickness of 200-250 m.

Aquifers are hydraulically connected with each other and with the surface waters of the Seversky Donets River and its tributaries. Hydraulic communication with surface waters in most cases also has a negative impact on groundwater quality.

Large reserves of Cretaceous waters, their good quality, and usable conditions determine the Cretaceous-marl aquifer as the main source of local and centralized water supply. In addition, due to the low capacity and high permeability of alluvial deposits, it does not have natural protection against pollution, which led to its depletion and deterioration of water quality in large areas.

Areas of groundwater contamination of the Cretaceous-marl aquifer in the area affected by the storages of PJSC “Severodonetsk Association Azot” have been observed since 1976 - the
time of the beginning of observations at the Rubizhnoye - Lysychansk Research and Production Site. They were formed as a result of the operation of industrial sites, storage ponds of PJSC “Severodonetsk Association Azot” and OJSC “Lysychanska Soda” and the accompanying filtration of highly mineralized and polluted wastewater into groundwater aquifers. Filtration losses through the destroyed sections of the dams and possibly the bottom of the storages are estimated to be quite significant and averaged 20-25% of the volume of effluent entering the storage.

Many years of intensive exploitation of groundwater of the Upper Cretaceous horizon by water intakes: Shchedryshchevsky, Novosyrotynsky (now liquidated), “Lisova Dacha”, Borivskey-I contributed to the spread of pollution not only downstream but also in the opposite direction. As a result, a significant area of groundwater pollution was formed in the described area.

A stable center of chemical and thermal pollution of groundwater has formed around the storages of OJSC “Lysychanska soda” due to long-term filtration of highly mineralized effluents. The main pollutants in the source of pollution are chlorides, as well as ammonium and iron, the concentrations of which in groundwater in the tens and hundreds of times higher MPC. Analysis of the hydrochemical characteristics of groundwater of the Cretaceous-marl horizon in the perennial section shows a heterogeneous change in their quality in area and depth.

As a result of gravitational differentiation and pollution by man-made solutions of fresh water within the dome of spreading in depth, two zones were formed:
- zone of partial pollution to a depth of 35-40 m of water with a dry residue of 0.2-1.0 g/dm$^3$;
- below – zone of complete pollution with the spread of groundwater with a dry residue up to 10-40 g/dm$^3$.

The total penetration depth of man-made solutions is 80-90 m. The groundwater temperature of the Upper Cretaceous aquifer in the area of the reservoir is 1.1-1.6 °C higher than the background values of 8-9 °C. Long-term operation of the fractured karst aquifer by five water intakes located around the “Lysychanska Soda” storage facility has led to a significant change in the hydrodynamic conditions of the fractured karst aquifer and intensification of man-made solutions leakage in the aquifer. Pollution of ground karst waters and changes in their hydrodynamic and geotemperature regime has led to more than a tenfold increase in the rate of dissolution of chalk-marl rocks [13].

The results of the groundwater monitoring conducted in 2019 show that despite the closure of “Lysychanska Soda”, its storage facilities continue to pose a threat to the geological environment. Thus, according to the results of hydromonitoring in the area of storage facilities of the former enterprise in 2019, as in previous years, areas of groundwater pollution were identified by various ingredients: phenols, nitrogen compounds, iron compounds, chlorides, heavy metals (manganese, lead). For some components, there is a hundredfold excess of the MPC (iron). The highest concentrations of pollutants were found in the southern contour of the reservoirs, ie downstream. Most of the pollution sites are local in nature, but, of course, all of them are derived from the presence in this area of a real source of pollution - the above-mentioned storage ponds.

As of 2019, in the area of sludge storages operation of Severodonetsk TPP and PJSC Severodonetsk “Azot”, located next to the “Lysychanska soda” storage, groundwater aquifer marl-chalk stratum are most highly mineralized - dry residual 87.5 MPC). The value was observed below the sludge accumulators near the Seversky Donets riverbed. The maximum content of chlorides (159 MPC), manganese (56.4 MPC), lithium (19.3 MPC), lead (10.0 MPC) was observed here. The highest content of ammonium (21.1 MPC), nitrates (15.5 MPC), nitrates (4.7 MPC) was determined in the observation wells in the area of the buffer pond and sludge storage of TPP.

In the area below the industrial site of PJSC “Severodonetsk Azot”, between it and the Seversky Donets river groundwater of the Upper Cretaceous has almost the maximum indicators of all the components content. Values were observed in wells №№ 82k, 51k, 68k, located 0.75-
1.0 km west of the industrial site and affected by the residual contamination of groundwater of the Upper Cretaceous with brines of the “Lysychanska Soda” storages.

An analysis of long-term test data shows that since 1998 groundwater abstraction from the Upper Cretaceous aquifer has decreased by 5-6 times. Therefore, modern sources of pollution are outside the depression funnels of existing water intakes. Contours of pollution sources are not extended by water intakes in directions opposite to the natural flow of groundwater, but are formed naturally. Despite this, the threat of toxic compounds entering drinking water remains. In general, the following types of pollution are typical for the zone of impact of the above objects on groundwater: salt, ammonia, iron compounds, phenol. Sometimes exceeding the maximum allowable concentration reaches tens or even hundreds of times. The conditions conducive to the intensification of the chalky-marl karst process also remain.

The results of groundwater status regime monitoring in the area of influence of Luhansk TPP indicate that the main sources of impact on groundwater and surface water in this area are ash dumps, industrial sites, and smoke emissions. Within the industrial site, there are a number of facilities (fuel oil and fuel storage, coal storage), which can be considered as local sources of groundwater pollution.

As of 2017, the groundwater of Quaternary alluvium in the area of Luhansk TPP influence exceeded in terms of macro indicators, groups of nitrogen compounds, some trace elements, and organic compounds. Groundwater with high salt content was observed in the area of the industrial site, ash dumps, and drainage ditches. In general, the most polluted groundwater is common in the area of ash dumps № 2 and № 3, drainage ditch, and industrial site of Luhansk TPP. This situation has been observed for many years [14]. Additional sources of pollution are waste from other parts of the plant, such as used lead-acid batteries and fluorescent lamps. Due to the course of chemical reactions during operation, corrosion processes, and the destruction of the batteries cases, sulfuric acid, and lead compounds are released into the environment. As for fluorescent lamps, they contain about 6% phosphor and mercury. Depending on the type, each lamp contains 5 to 500 mg of mercury. Once in the landfill and then in groundwater, the phosphor turns into a more dangerous stable compound - methylmercury.

4. Conclusions

In general, industrial waste storage facilities and ash dumps of TPPs are undoubtedly a source of pollution and disturbance of the geological environment and its components in any area. But they pose a significant threat in areas close to river protection zones and in areas of groundwater deposits and geological development zones. An important role is played by the presence of conditions conducive to the natural protection of the geological environment. It is a matter of concern that groundwater contaminated with salts, heavy metals and phenols is widespread in the immediate vicinity of drinking water intakes, posing a threat to public health. And the launch of processes in karst massifs when mixing man-made solutions with natural waters can lead to a 10-fold increase in karst denudation and lead to the transfer of these processes from the category of potentially dangerous to the category of emergencies that can cause significant material and people health damage.

To reduce the impact on the environment methods are developed and offered in numerous scientific publications. So, for processing of sludge of water treatment the following methods are offered:

1) Recycling of coagulants, which is usually acidic leaching of iron or aluminum compounds and subsequent separation of the mixed solution. In [15] it is proposed to perform separation using ion exchange resins. The authors of [16] tried to reduce the use of fresh coagulants by adding sludge to the coagulation process.

2) The use of sludge as raw material for building materials - bricks and cement. As sludge from water treatment is not identical in composition to natural raw materials, most publications
suggest using it as an additional component to other raw materials. In [17] the possibility of making low-porosity ceramic bricks with the addition of lime sludge to clay was investigated. In works [18, 19] it is proposed to obtain bricks with the addition of water treatment sludge. The authors of the paper [20] propose to use calcined waste for the purpose of burning the organic component. In [21], waste was used to partially replace shale clay in brick production.

3) The use of sludge in the natural environment for the application to the soil to reduce acidity [22], or in the man-made environment to improve wastewater treatment [23][13].

The proposals for the solid waste disposal of the Solvay process are quite diverse: for the neutralization of acid soils, the production of binders, Portland cement, alunite cement, concrete blocks, bricks, and roads.

In developed countries, ash slag is generally called a by-product of thermal power plants. Power plants carry out pre-sale preparation of the product, bringing its characteristics to the requirements of official regulations. In Western Europe and Japan, ash dumps have been virtually eliminated at thermal power plants. Fly ash enters the silos built next to the main buildings of the TPP. For example, in Germany at many power plants, the capacity of silos is 40-60 thousand tons, from which samples are taken for laboratory analysis of ash, and in which it is brought to compliance with regulatory requirements. Germany has the largest ash company on the European continent, Bau Mineral (BM), a subsidiary of the power system. This company is a link between thermal power plants and the construction industry. BM has its own system of transportation and storage of TPP by-products. Areas of use: additives in concrete, mortar, cement, silicate products, brick production, underground, and road construction. In Ukraine, ash slag, unfortunately, is officially called waste, and power plants offer consumers just waste, not a technologically advanced product. Ash slag from dumps have high humidity and are not classified by chemical and particle size distribution.

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