The methods and technology for solid domestic waste neutralization in mine workings with the usage of processed products

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Abstract. The authors of this article study, develop and recommend innovative, economical and environmentally safe methods, technology and engineering for the transportation, storage, neutralization and utilization of solid domestic waste in mines obtaining and using the combustible gas and digested product suitable for fertilizing. Besides, they show the advantages of this method. According to the preliminary calculations, the payback period for all costs connected with adoption and mastering will be from 3 to 12 years.
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Introduction

Publications [1,2,3,4,5,6] show that today the unsatisfactory collection, utilization, neutralization and burial of domestic and manufacturing waste is the main source of negative impact on all elements of environment and especially on human health and life duration. Besides, they note [6,7] that the role, importance and negative influence of such waste and especially solid domestic garbage in sanitary-epidemiological, social, economic, environmental and industrial safety will grow year by year. This phenomenon is caused by large amounts of such waste with different characteristics produced annually. Its collection, utilization, neutralization and burial do not meet contemporary legal requirements. Practically everywhere, this waste contains harmful, toxic and dangerous admixtures. New harmful, often dangerous and volatile substances form under the influence of atmospheric moisture, solar radiation, chemical, biochemical, biological and other reactions. Their unit weight is equal or a little more than the unit weight of atmospheric air. Thus they pollute the lower atmosphere, ground surface and water bodies and so they have a damaging effect on people's health, animals and plants. Such processes occur in all facilities of both temporary and constant storage of waste. The monitoring [7] showed that today almost all facilities of temporary and constant storage, especially those for solid domestic waste, do not guarantee full sanitary-epidemiological, environmental, industrial and other safety.

Methods

New and contemporarily used methods, technologies and engineering principles for the collection, utilization, neutralization, usage and burial of solid domestic waste were estimated and analyzed from the point of view of ecological, social, sanitary-epidemiological, environmental and industrial safety and efficiency by theoretical and experimental research, field data and monitoring conducted many years. Theoretical and experimental research ascertained [7,8] that the most efficient and practically safe way to store and neutralize this waste is to do it in mine workings of liquidated coal mines in Rostov Region and the existing ones.

Main part

The methods, technology and engineering principles consist in the following: the solid domestic waste of industry and consumption is delivered by motor transport to the tipple of the main or auxiliary mine shaft. Then they are pressed and transshipped to mine cars or (and) special containers. Mine cars and containers are let down to the mine and transported by underground transport to the place of storage. Waste is stored in mine workings according to specially developed technology. With the help of lifting compactor, waste is stacked and consolidated to the full height of free space in the mine working – drift (around 3 m). The stacking begins from the auxiliary shaft. Preliminarily, it is necessary to build a solid wall which will separate the auxiliary shaft from the free space of mine workings where waste will be stored. Along the entire length of working mines, in the bottom and top, one should lay perforated ceramic pipes for the disposal of excess water during waste stacking and combustible gases formed in course of the long-term storage. The gas piping is outputted to the surface by the auxiliary

shaft and further to the place of usage. After the horizontal thickness reaches 10-50 m, the separating wall is built again for the full height of the free space. The distance between one separating wall and another depends on the hazard class, characteristic and daily volume of waste received for storage. Then the storage order is repeated. After the storage is complete in this compartment, all kinds of physical, chemical, physicochemical, biochemical, microbiological and other processes and transformations begin in stacked waste. Over time, the microbiological processes of anaerobic fermentation and decomposition begin to prevail over other processes and determine the final results of neutralization and utilization. The combined action of all processes and especially anaerobic decomposition start up the processes of oxidation and decomposition. Permanently high humidity (over 90%), permanently quite high temperature (22-45°C) and permanently high pressure (over 765 mm Hg) favour the anaerobic decomposition. At first, easily oxidized organic substances (proteins, fats, carbohydrates, skin, natural textile, etc.) and then hardly oxidized organic admixtures oxidize. For example, admixtures from wood: some part of them rot through and dissociate completely and another part char. Admixtures from synthetic and mechanical rubber products, various plastic, bricks and concrete decompose for quite a long period of time. Admixtures from ceramics and glass practically do not decompose or do it very slowly (they changed little for 3 years of observation). Microorganisms which need metals and metal compounds for their life process almost all kinds of metals (including heavy metals) forming mainly sulfide compounds and less sulfate, chloride and carbonate compounds (2-10%). Gradually, these compounds sink to the bottom of the drift. Over time, they consolidate considerably in the form of insoluble residue. They become practically insoluble even in mineral acids. The hydrogen sulfide oozing out during the decomposition of protein and other organic and inorganic substances do not get into the combustible gas because it gets combined with various metal ions in the form of insoluble sulfides. The combustible gas formed consists of methane (12-25%) and (3-5%) other gases (nitrogen, hydrogen, etc.). The specific quantity of combustible gas formed during fermentation is very different. Mainly, it depends on the specific quantity of organic admixtures in stacked waste. Its range is approximately 0.68-1.39 g per 1 g of organic admixtures, or 343-412 l per 1 kg of organic admixtures. The heating capacity of the combustible gas is from 4200 to 5950 kcal/m^3. It should be noted that the amount of the combustible gas formed during waste neutralization is more for 15%. Besides, the content of organic admixtures in it is more than possible. We think that this is because it comes from the rock massif. This combustible gas corresponds to household gas by its characteristics. In order to maintain necessary velocity of waste digestion and probably to completely stop it, one should permanently remove the formed combustible gas from the compartment where waste is neutralized. The water coming to the digestion compartment from ground surface should be also drained away. Over some time (from 6 months to 10 years – ascertained according to fact), when neutralization and digestion are complete, the wall is demolished from the side of auxiliary shaft. Then the digested product is exploited and outputted for its usage as a fertilizer. The fertilizing qualities of neutralized and digested waste include microelements (approximately the same as in volcanic ash) and some amount of organic substances which are easily assimilated by plants.

Conclusion

The developed and recommended methods, technology and engineering principles for the transportation, storage, neutralization and utilization of waste are economical and environmentally safe. They can be used in workings of exhausted mines and dead workings of active mines. The storage and neutralization of solid domestic waste in workings of exhausted mines have a number of advantages and disadvantages. The main disadvantages include: the mine chosen should be dried; its shafts, insets and main drifts should be restored; the system of lowering, lifting and ventilation systems for people should be restored or mounted; the inside transport system for waste should be restored or mounted. These works will need tens of millions of rubles. The most economically and technically effective methods, technology and engineering principles of for transportation, storage, neutralization and utilization are to do it in workings of active coal mines. As a rule, after coal is extracted the dead workings of active mines are isolated from active workings by temporary or permanent airtight partitions in order to prevent the penetration of harmful and dangerous gases and to reduce the consumption of clean atmospheric air used for ventilating active mine workings. In this case, the costs of waste storage will be minimal. Mainly, they will be connected with the organization and preparation of waste reception, preliminary processing, delivery and stacking in mine workings, and also with the development and transportation of products forming during waste neutralization.

Findings

The developed and recommended methods, technology and engineering principles for the transportation, storage, neutralization and utilization of solid domestic waste can be attractive for cities and settlements which do not have suitable places for the permanent storage of this kind of waste in compliance with the current legislation [9,10]. These methods are environmentally safe and economical. Technical and economic analysis shows that the payback period of all costs for the adoption and mastering of the methods and technologies is from 3 to 12 years.

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