Efficient utilization of anthropogenic waste: a particular focus on phosphogypsum and ash slag

Khamza Aminov[1,*] and *Farhad* Yuldashev[2]

[1]Research Institute of Environment and Nature Conservation Technologies, Tashkent, 100043, Uzbekistan
[2]Belgorod State Technological University, Belgorod, 308012, Russia

Abstract. The focal point of this article resides in the pressing concern surrounding the mounting stockpiles of man-made waste, specifically phosphogypsum and ash slag, which have amassed in voluminous dumps across the global landscape, collectively amounting to millions of tons. This paramount issue, reverberating on a global scale, underscores the dire need for innovative strategies for the efficient disposal of such waste materials. Within the pages of this article, we endeavor to delve into the intricacies of man-made waste management, with a spotlight on the poignant predicament posed by phosphogypsum and ash slag. These residues, often regarded as byproducts of various industrial processes, have amassed into colossal accumulations that not only present significant environmental challenges but also beckon for sustainable solutions that navigate minimal losses and optimal resource utilization. Our discourse will not only shed light on the gravity of the problem at hand but will also unveil a method that stands as an epitome of effectiveness in waste management. Through a rigorous examination of current practices, combined with a judicious exploration of novel approaches, our proposed solution surfaces as a beacon of hope—a blueprint that embodies not only technical ingenuity but also a commitment to conservation and ecological harmony. Amidst the labyrinthine intricacies of waste disposal, the approach we advocate asserts its credentials through its compelling efficacy and economic feasibility.
Keywords. Phosphozol, phosphogypsum, recycling, production waste, active mineral additive.

1 Introduction

In today's rapidly evolving world, the imperative of safeguarding our natural environment has never been more critical [1]. The acknowledgment that humanity's intricate relationship with nature is not only symbiotic but pivotal to our very survival underscores the urgency of proactive measures [2]. As stewards of our planet, it falls upon us to recognize that the

* Corresponding author: khamza.aminov1001@gmail.com

dissolution of nature's delicate equilibrium may inexorably culminate in the cessation of human existence [3].

Within the fabric of this paramount concern, we present an innovative solution—a method that not only addresses the pressing issue of two significant man-made waste streams, phosphogypsum and ash slag, but also provides a viable path towards their transformation into a valuable resource [4]. Our method is predicated on the creation of Phosphozol—an active mineral additive derived from these wastes—a tangible testament to the transformative power of sustainable ingenuity [5].

Phosphozol's versatile potential finds its canvas in the realm of construction materials. With a resolute commitment to harnessing discarded resources, Phosphozol stands poised to revolutionize the construction industry. As an additive in the production of cement, concrete, and dry building mixtures, Phosphozol not only breathes new life into discarded waste but also enriches the structural integrity and performance of the final products [6].

Moreover, Phosphozol does not confine its potential within the boundaries of construction alone. Its role extends to the domain of infrastructure, where it has proven its efficacy as an additive for asphalt and asphalt concrete [7]. The infusion of "Phosphozol" at levels ranging from 30% to 40% imparts a transformative touch, enhancing the quality and durability of the resulting asphalt and its derivatives [8].

In advocating for Phosphozol's adoption, we underscore not only its utility but its emblematic role in reshaping the narrative surrounding waste management [9]. This endeavor underscores the possibility of harmonizing industrial advancement with ecological responsibility, aligning human progress with the imperative of safeguarding our planet's fragile ecosystems. The prospect of integrating Phosphozol into the fabric of industrial practices epitomizes a symbiotic relationship between innovation and environmental preservation, one that holds the promise of a future where humanity's actions echo its commitment to nature's perpetual equilibrium [10].

"Phospozol" can be used in agriculture as an ameliorant, which is used in saline soils and effectively improves the humus of the earth and turns saline soils into fertile areas with a high content of useful elements. Calcium and other macro and microelements contained in Phosphozol neutralize sodium inclusions in saline lands.

2 Materials and methods

One of the components of Phosphozol is phosphogypsum, a waste product of the chemical production of phosphate fertilizers. More than 100 million tons of phosphogypsum are disposed of annually in dumps around the world. To obtain 1 ton of fertilizer, the manufacturer is forced to dump from 1.5 to 4 tons of phosphogypsum waste into the dump. After the land allocated for the burial of phosphogypsum is filled with waste, it is stored on other new plots of land. As a result, over time, hundreds of hectares of fertile land, instead of benefiting humanity, become objects of hazardous waste storage, one of which is phosphogypsum. Over the years, the negative impact on nature is only aggravated, since with rainwater, harmful substances from dumps penetrate into groundwater. And the winds carry particles of phosphogypsum to the surrounding areas, causing harm to people and animals. Of course, the need for the production of phosphate fertilizers, which bring great benefits to agriculture, is undeniable, but we should not forget about environmental issues and the disposal of hazardous waste.

The second component of our mineral active additive "Phosphozol" is ash and slag, which occurs in thermal power plants due to coal combustion. Dumps are also built to store ash and slag, spending huge amounts of money and occupying hectares of fertile land. Like phosphogypsum, ash and slag is produced hundreds of millions of tons annually around the world. Thermal power plants that run on coal, of course, are also necessary in human life, but again, one should not forget about nature and people's health.

3 Results and discussion

Ash and slag dumps because no less harm to human and animal health than phosphogypsum dumps. We were faced with the task of disposing of these two hazardous man-made wastes, and we coped with it, and not only solved the issue of disposal. But also received a product that brings great benefits to the national economy. The production method is as follows: having previously cleaned phosphogypsum and ash and slag from foreign objects, as well as crushed to particles of 0.5 mm, we send phosphogypsum and ash and slag to the autoclave with the help of dispensers in a ratio of 33% and 67%, respectively. In the autoclave, the mixture is processed for 25-35 minutes at a certain pressure and temperature of 150-200 °C. During the processing of phosphogypsum and ash and slag, as well as water and steam, a chemical reaction occurs in which phosphate ions are adsorbed on the silica particles of ash and slag, resulting in the neutralization of phosphoric and other acids in phosphogypsum.

Below is a technological scheme for the production of the active mineral additive Phosphozol (Tables 1 and 2).

Table 1. Chemical composition of phosphogypsum and natural gypsum stone.

Materials	Oxide content, %									
	Loss on ignition	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	R_2O_3	P_2O_3	P_2O_3 hydrogen
Phosphogypsum	15.50	14.56	3.01	0.62	25.25	1.45	35.85	3.33	0.40	0.14
Gypsum stone	17.78 out of 400	0.58	0.70	0.22	30.20	1.80	39.75	0.25	-	-

Table 2. Chemical composition of TPP ash and slag.

Name of TPP (CHP)	Loss on ignition	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	N_2O	MO	Ma	CaO+MgO
Ivanovskaya	12.39	45.86	18.70	9.45	7.00	3.40	1.13	1.91	0.161	0.408	10.40
Ryazanskaya	12.70	44.36	23.00	7.20	7.84	2.30	0.84	0.65	0.151	0.518	10.14
Smolenskaya	8.65	54.00	15.60	9.98	6.40	2.00	0.94	0.50	0.121	0.289	8.40
Tverskaya	11.00	46.70	22.60	7.03	6.89	2.52	0.65	0.55	0.136	0.484	9.41
Mosenergo-17	12.69	44.30	22.97	7.29	7.85	2.23	0.82	0.68	0.150	0.519	10.08

Angrenskaya	14.53	39.04	17.75	2.82	19.9	1.76	0.75	0.60	0.382	0.455	21.71
Average	11.09	45.71	20.10	7.30	9.32	2.37	0.86	0.82	0.263	0.450	15.70

Of course, there are a huge number of methods for neutralizing harmful acids, but almost all methods involve washing the acids with large amounts of water or using alkaline concentrates, which are by no means cheap (Figure 1).

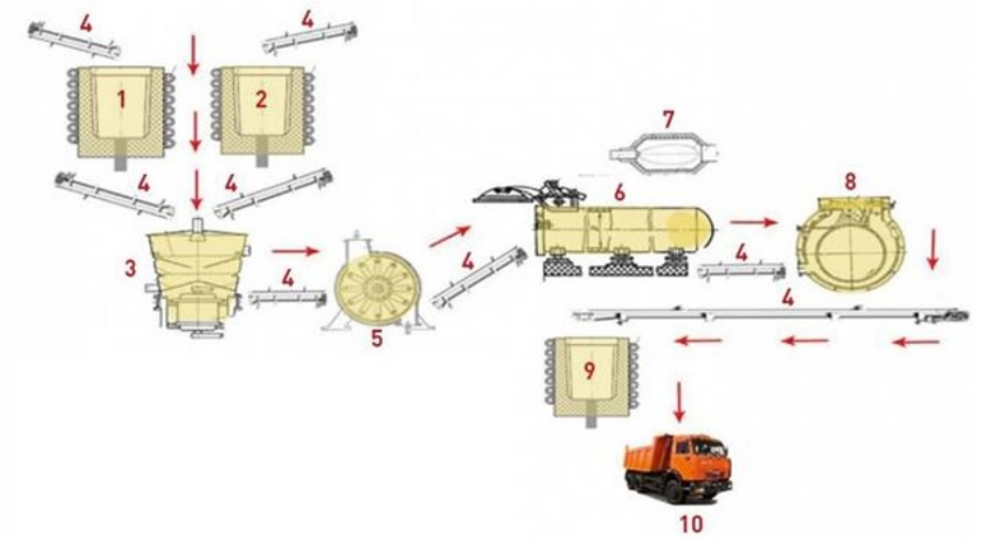

Figure 1. Technological scheme for the production of the active mineral additive "Phosphozol": 1- bunker for phosphogypsum; 2- ash bunker; 3- vibrating sieve; 4-conveyor; 5- hammer crusher; 6- autoclave; 7- steam generator; 8- dryer; 9- bunker of finished products; and, 10- car (dump truck).

Our method differs in that we use the minimum amount of water necessary to operate the autoclave and neutralize acids. In conditions of scarcity of water resources, our method is environmentally and cost-effective, especially in regions where there are already problems with water supply.

The accumulation of man-made waste in recent decades has become a serious problem due to the insufficient volume of their disposal. Meanwhile, natural raw materials and man-made waste should be considered within the framework of the concept of a technical and economic alternative. Natural raw materials used in construction and production of building materials and products belong to the category of non-renewable resources, and its extraction is accompanied by causing irreparable damage to nature. This is what determines the fundamentally important and urgent importance of finding and adopting alternative (substitute) solutions related to the possibilities of using man-made waste instead of natural raw materials. The use of natural raw materials is permissible only on the condition that man-made waste is not suitable for use in construction purposes due to its technical and technological characteristics.

This means that it is necessary to introduce technologies that will allow the disposal of already accumulated waste and reduce the amount of waste produced in the future. Unfortunately, at the moment, Uzbekistan lags behind the countries of the European Union and the United States in terms of processing.

4 Conclusions

The authors of this article propose to use the active mineral additive Phosphozol in the production of Portland cement. This method has certain advantages. Replacing expensive Phosphozol clinker will help reduce the cost of cement production, since it can replace up to 35% of the mass of cement. In addition, the use of Phosphozol will help to dispose of a large amount of waste, which will positively affect the ecological situation in the regions, since a large amount of ash and slag waste is used in the production of the additive.

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