Using natural and technical systems of the Leningrad region for waste disposal

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Abstract. Natural-technical system - a complete, ordered spatially-temporal relationship between natural and industrial objects. These are landscape parks created by high-level designers, landfills created by engineers of giant enterprises and unique swamp, self-cleaning unique resources. The first, second, and third in this case is the result of the interaction of the elements “nature” and “technology” as a whole. Interaction is manifested in a variety of technical, geological, hydrological, atmospheric and biological processes.

1. Development of opportunities for using recycling of the natural-technical system
The components of the natural environment that interact with artificial objects are different. Their set depends on the PTS class. In some PTS, areas of the atmosphere bordering them (reclamation systems) actively interact with artificial objects; in others, areas of the hydrosphere (port facilities) or lithosphere (underground structures, pits and quarries, production wells).

Due to the very low level of separate waste collection in public utilities and industrial enterprises, landfills in our region in most cases are burial grounds, not processing complexes. Therefore, St. Petersburg and the Leningrad region are full-fledged platforms for implementing innovative programs for developing the use of automated PTS systems. The introduction of automated control systems (ACS) will not only increase the level of solid waste disposal in urban enterprises for processing, recycling and disposal of waste. Only with the integrated use of raw materials and waste products can we solve the tasks set in the "Energy strategy for Russia's development until 2030" and provide small-scale energy with environmentally friendly technologies.

The use of ACS in natural and technical systems is of great importance in high-tech highly profitable production clusters – automotive, food, textile, etc., however, in a number of industries with a longer payback period, the issue of automation of PTS is relegated to second place. In this regard, St. Petersburg, the Leningrad region and the entire North-Western economic district are full-fledged polygons for the implementation of innovative development programs in this area.

Timely measurements in each of the elements of this system play an important role in predicting deviations of PTS parameters. However, the measurement system at the stage of waste transportation is only valid in the section of weight measurement, in some cases – measurements of the radioactive background.

Every year in Russia, more than 640 million tons of agricultural waste is accumulated on farms, livestock and poultry complexes, in the crop and grain industries. By processing them in special plants, you can get about 66 billion m3 of biogas, which is equivalent to 33 billion liters of gasoline.
Using this gas in gas generators, it is possible to generate 110 billion kW of electric energy. The agro-industrial complex of the country, using these wastes, is able to fully provide itself with electricity and become energy autonomous and independent from the Central power supply. In fact, we are talking about organizing the production of energy in rural areas from biological mass, without compromising the production of food products, without in any way disrupting the balance of production of grain, meat, milk, eggs and other types of agricultural food.

At numerous field events of the all-Russian biofuel Congress, information was announced that the unification of manure available on farms and livestock complexes can produce 100 billion kW of energy.

2. Development of extracting of peat product

An important advantage of natural and technical systems of the North-West and the Leningrad region in particular is the presence not only of results of activity of inhabitants of the metropolis, expressed in the landfill, many of which still can be recycled and are now in the stage of conservation, but above all the presence of an adsorbent, compensating the presence of a large amount of waste in the excluded territories. This mentioned adsorbent is peat, a mineral, and [1] there are more than 200 peat deposits in the peat Fund of the Leningrad region, with an area of about 700 thousand hectares. GA [1]. The adsorption properties of peat are associated with the presence in the structure of such covalent matrix-bound functional groups as amine, amide, alcohol, aldehyde, carboxyl, carboxylate, ketone, phenolic, quinone, peptide, and methoxyl. Also, the adsorption properties of peat are caused by the presence of polymolecular associates characterized by a more or less definite organization at the macro level, in particular humic substances (mainly humic and fulvic acids) and lignin [2]. The high exchange capacity of humic acids, their ability to accumulate, and their influence on the migration of metal ions in soils and terrestrial landscapes opens up wide opportunities for the production of ion-exchange adsorption materials based on them [3]. It should be noted that peat lignin also has a developed surface and high adsorption properties in relation to substances of different nature [4]. Factors affecting the adsorption of metal ions by peat and its derivatives include the pH, the duration of contact of the adsorbate with the adsorbent, and the presence of competing metals. The optimal pH range for adsorption of metal ions is usually 3.5–6.5. The presence of more than one metal in the solution creates competition for adsorption centers in humic acids and lignin [5, 6].

2.1 Modeling a recycling process

To analyze the potential impact of peat on waste, an experiment was conducted to neutralize the harmful impurity of RDF-raw materials that were taken from a waste-processing landfill in the Leningrad region. This raw material is the result of an aerobic composting reactor that processes municipal waste from residents of the Leningrad region into crumbs that are not suitable, however, for pure agricultural fertilizer. That is why it was decided to use peat as one of the neutralizing additives.
A To assess the possibility of using RDF-raw materials as fertilizer, an experiment was conducted on the pH variation of acidity and evaluation of the germination of shoots of grass "shadow", which was added in an amount of 7 g in each container (table 1) with the resulting mixture and germinated for 10 days.

Table 1. Composition of formulations.

| curing formula № | RDF, gr | peat, gr | wood dust, gr | H<sub>2</sub>O, gr | Total weight, gr |
|------------------|---------|----------|--------------|----------------|-----------------|
| 1                | 53.09   | 87.7     | 20           | 35             | 195.79          |
| 2                | 30      | 113      | 17           | 35             | 195             |
| 3                | 75.79   | 75       | 10           | 35             | 195.79          |
| 4                | 44      | 102.75   | 14           | 35             | 195.75          |
| 5                | 65      | 71       | 24.75        | 35             | 195.75          |
| 6                | 80      | 71.75    | 9            | 35             | 195.75          |

Figure 2. Weighing of samples of RDF-raw materials (a), peat (b), and sawdust (c) to create formulations in containers.

Figure 3. Measurement of acidity and humidity in container.

In consultation with the administration of MPBO-2 "Yanino№2 in the person of the chief Engineer, where it was taken RDF-raw materials for experiments, it was found that its reserves in the tails of 50 000 tons [9]. During the work the company was doing some attempts of companies to take part in this compost (RDF) for use as fertilizer, however, was complaints about the lack of recommendations for
doses of 1 ton of soil for a flowerbed plants and fruit plants. The second observation was related to the smell of decomposing compost, which is a restriction on the storage of RDF raw materials near public places. It to fight these 2 comments were sent 4 of the research work [10-11].

2.2. pH Measurement component and moisture in the mortgaged samples
After 10 days, pH analyzer and moisture meter were used to measure these indicators in each of the 6 containers (Table 2), and the germination of lawn grass "shadow" was evaluated.

![Figure 4. Germination in natural light.](image)

**Table 2.** Researching of recipe.

| curing formula № | moisture of RDF, % | pH of RDF | moisture of wood dust, % | pH of wood dust | moisture of peat, % | pH of peat | moisture of total fertilizer, % | pH of total fertilizer | S germination in soil, cm² | height of sprig, cm |
|------------------|--------------------|----------|--------------------------|----------------|--------------------|----------|-------------------------------|-----------------------|------------------------|-------------------|
| 1                | 98                 | 6        | 10                       | 8              | 25                 | 7        | 5,5                           | 7,8                   | 10                     | 8                 |
| 2                | 98                 | 6        | 10                       | 8              | 25                 | 7        | 3,5                           | 8                     | 30,0                   | 4                 |
| 3                | 98                 | 6        | 10                       | 8              | 25                 | 7        | 7                             | 7,5                   | 4                      | 11                |
| 4                | 98                 | 6        | 10                       | 8              | 25                 | 7        | 5,5                           | 7,5                   | 13,5                   | 3                 |
| 5                | 98                 | 6        | 10                       | 8              | 25                 | 7        | 4                             | 7,5                   | 5,25                   | 7                 |
| 6                | 98                 | 6        | 10                       | 8              | 25                 | 7        | 3                             | 7,2                   | 3,14                   | 8                 |

So, based on the results of measurements, we construct a histogram of the dependence of humidity and ph-acidity on the formulation [11].

![Figure 5. Dependence of humidity on pH.](image)
Figure 6. Dependence of S germination in on the composition of RDF.

Thus, the area of convergence of the grass «shedou» optimal was 2 and 3 formulation, optimal humidity and pH – 5 formulation, height of shoots-2, 4 and 5.

In the laboratory of environmental control of the University, the 5th formulation was taken for consideration (table 2 and table 1) and will be testing of sample 5 on the Fluorate-0,2-5M device.

Figure 7. Fluorate-0,2-5M extract of RDF composition.

The Fluorat-02-5M is the device based on photometric, fluorimetric and chemiluminescent methods for measuring the mass concentration of organic and inorganic substances in the range of the spectrum – 250-900 nm.

The user menu of the analyzer contains the names of the methods to be performed, the method of processing the result, and the calibration coefficients. The menu contents and entered calibrations are stored in the device's non-volatile memory. During operation, the operator selects the necessary method from the menu, and after setting the background signal to the sample cell, starts the measurement process. The concentration of the detected component is displayed on the built-in display. The operator can output the analysis result to an external computer and control the device from an external computer.

As a result, a study was conducted that allowed us to determine: Composting of petroleum Products on schedule 16,3 mg/l, with oil mixtures in the water V H₂O =200мл, V C₆H₁₄ =10 ml, With the oil in the water 0,83 mg/l, НС₀ =3mmol/l, water is soft.

3. Conclusion

As a result of the experiments, the limiting threshold values for the creation of products from waste were found out. Thus, in the conducted experiment it was proved that peat in the amount of 65 grams of peat and 71 grams of RDF raw materials, as follows from table 1, goes to neutralize the hazardous waste environment. As follows from the research conducted in this article, the Leningrad region has all the resources to neutralize waste located in convenient transport accessibility: peat developments.
are located in comparative proximity to the waste processing plant. In addition, the use of a mixture of waste and peat would create a favorable product for use in agricultural land, and would also help to dispose of the tailings of the waste processing plant.

References

[1] Qingqing H 2016 Recent trends in rock dust modifications for improved dispersion and coal dust explosion mitigation J. of Loss Prev. in the process Ind. 41 121–8
[2] Qingqing H 2016 Optimized reagent dosage effect on rock dust to enhance rock dust dispersion and explosion mitigation in underground coal mines Powder Technology 301 1193–200
[3] Lindenau N I 1977 Origin, Prevention, and Suppression of Spontaneous Fires in Coal Mines (Moscow: Nedra)
[4] Yinlin J and Ting R and Peter W 2016 Comparative study of dust control practices in Chinese and Australian longwall coal mines International Journal of Mining Science and Technology 26(2) 199–208
[5] Furman E 2005 Measurement of thermal conductivity on it-λ-400 (Ekaterinburg) p 10
[6] Tuan L V 2016 The use of LABVIEW environment for the study of SAR Proc. of the VI all-Russian sc.-prac. Conf. "Scientific initiat. of foreign stud. and postgrad. in Russian univers." pp 265-7
[7] Nikulin A N, Kovshov S V, Epifancev K V and Korshunov G I 2014 The research of possibility to use the machine for biofuel production as a mobile device for poultry farm waste recycling Life Science Journal 11(4) 464-7
[8] Kocserha I and Kristály F 2010 Effects of Extruder Head’s Geometry on the Properties of Extruded Ceramic Products Materials Science Forum vol 659 pp 499-504
[9] Benbow J and Bridgwater J 1993 Paste Flow and Extrusion (Clarendon Press Oxford ) p 425
[10] Bogatov B A 1985 Managing peat bog development (Minsk: Higher School ) p 168
[11] Epifancev K, Nikulin A, Kovshov S, Mozer I and Brigadnov I 2013 Modeling of peat mass process formation based on 3D analysis of the screw machine by the code YADE American Journal of Mechanical Engineering 1(3) 73-5
[12] Epifancev K 2019 Development of software products aimed to streamline the waste management process E3S Web of Conferences 140 01007
[13] Epifancev K 2019 Research of RDF-raw materials for prospective use in hardening construction and agricultural IOP Conference Series: Materials Science and Engineering 537(6) 062017
[14] Epifancev K et al. 2019 Development software platform for collection and exchange of data in the field of waste management IOP Conf. Series: Materials Science and Engineering 537 062077