Research of RDF-raw materials for prospective use in hardening construction and agricultural technologies

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Abstract. In article research methods of recycling waste. The main selected methods - the development of fertilizers for soils and the creation of innovative building material. Currently, according to the Housing Committee of Administration of St.-Petersburg annually on landfill sites is disposed of 6.5 - 9 million cubic meters per year. Of this volume, only 1.5 million cubic meters (17-23%) is sent for processing in two landfills ("Novoselki" and JSC "Pilot plant MPBO-2 Yanino", project storage tailings according to an approximate assessment have 50 000 tons of RDF-raw materials). Also in St. Petersburg and the adjacent territory of the Leningrad region there are about 250 unauthorized dumps, which are placed, according to very rough estimates, from 500 thousand to 1 million cubic meters of garbage. A distinctive feature of illegal dumps is the high concentration of heavy and rare metals in the garbage. The article discusses the possibility of using aerobic waste composting as a fertilizer for soil and a solid building material, or alternative solid binder, highly abrasive granules. The applied research methods suggest that RDF wastes are commercialized and have the prospect of becoming a separate innovative product.

1. Development of technologies for age-hardening materials

Alternative fuel RDF (refuse derived fuel) or solid secondary fuel is a fuel derived from waste. The composition of RDF includes high-calorie waste components such as plastic, paper, cardboard, textiles, rubber, leather, wood, etc.

The calorific value of RDF fuel is 20000 ± 2000 kJ / kg. The value of RDF grain is ~20-25 mm. the content of hazardous components in the fuel is strictly controlled and does not exceed the permissible norms. According to the calorific value of 1.7 kg RDF corresponds to 1 cubic meter of gas. RDF is a solid fuel produced by shredding and dehydrating solid waste (MSW) figure 1.

![Figure 1. Selection of large > 350mm and small <65mm fractions on the screen.](image-url)
The composition of the selected charge for forming pellets:
- paper and cardboard..........................14 %
- fabric and polyester blend......................6 %
- mixed packaging, polymers..................18 %
- plastic............................................2 %
- food and plant waste..........................60 %

The working body of the screw machine is the screw, the rotational motion of which transmits the motor through the coupling. When the pressure is formable into a formable mass, the sealing of the pellets reaches a maximum.

In the channel of the circular cross-section die (with radius R and length l), in which the effects on the input and output can be neglected, the equilibrium of forces acting on the cylindrical element of biomass with a layer thickness dr, moving at a speed Pz (figure 3), the balance of momentum reduces to the equilibrium of the forces. This is a consequence of the incompressibility of the liquid and the assumption that the liquid flows along straight parallel trajectories at a constant speed [1].

![Figure 2](image2.png)

*Figure 2. Equilibrium of forces acting on the mass element of the raw material RDF in the matrix.*

![Figure 3](image3.png)

*Figure 3. Simulation of interaction in the composition of RDF-charge in a rectangular matrix.*

When modeling the spillage for the layers, the density conditions corresponding to the composition of the KVA raw material used in the extruder were set [1-4].

1-paper and cardboard, 2-a mixture of fabric and polyester, 3-mixed packaging, polymers, 4-plastic, 5-food and vegetable waste. At the walls were observed (figure 4 marked with arrow) located particles having a high adhesion and adhesion to the walls. More loose, located in the center-they are the most adapted to the exit.
The developed model of the extruder (figure 4) included a feed hopper 1, building 2, screw 4, interchangeable dies 5, and the incoming particles 3, simulating the particles of peat. The presentation of the material was carried out uniformly, sufficiently for the molding material [4].

It was decided to investigate the granule obtained from RDF-raw materials for uniaxial compression [5]. Press Tinius Olsen is designed to study the breaking point of the pellet and determine the limits of its destruction. At this stage, it was the main equipment for determining the destruction of the granules with the potential use of it later as an additive in building structures. Before starting work, the granules were separated from the composition of the filling formed inside the extruder.

Thus, the limit of destruction of the sample came at 4788 N, which proves its use as a reinforcing material. The test schedule is shown in the figure below.

So for example, if a batch of brick M100 in strength, the compression ratio should be at least 100 kg / cm2, brick brand M-250 is able to withstand 250 kg, in our case with waste when exposed to the
heel of the press on the destroyed sample before its complete destruction was the limit of 500 kg, therefore the sample is strong enough [6-7].

2. Preparation of blends and formulations to assess the fertilizer of the RDF materials

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 | H2O, 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 7. Weighing of samples of RDF-raw materials (a), peat (b), and sawdust (c) to create formulations in containers.

Figure 8. 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].

2.1. 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.

![Images of germination samples](image_url)

**Figure 9.** (b) Germination in natural light, (a) S germination in soil, cm."
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                     | 30.04                  | 11                  |
| 3                | 98                | 6        | 10                       | 8              | 25                | 7        | 7                               | 7.5                   | 13.53                  | 7                   |
| 4                | 98                | 6        | 10                       | 8              | 25                | 7        | 5.5                             | 7.5                   | 7.7                    | 12                  |
| 5                | 98                | 6        | 10                       | 8              | 25                | 7        | 4                               | 7.5                   | 5.25                   | 13                  |
| 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 10. Dependence of humidity on pH.

Figure 11. Dependence of S germination in on the composition of RDF.
Thus, the area of convergence of the grass "shedow" optimal was 2 and 3 formulation, optimal humidity and pH – 5 formulation, height of shoots-2, 4 and 5

For most parameters are not applicable for agriculture (ornamental plants) 2 formulation. The root effect is the selected ratio of humidity to pH 3.5 to 8. On fecundity influenced acidity. At "pH" equal to seven, the reaction of the solution is neutral (the number Of h+ ions and IT is the same), if the value is below seven, then the soil is acidic, if above seven, then alkaline [11]. The medium in the 3rd formulation was alkaline, but this did not prevent to give high rates of convergence and length of sprouts. Added peat to the mixture increased acidity, and in turn sawdust neutralized harmful impurities of silicates in the form of fine dust of glass, which abounds in RDF raw materials. Also 2 of the formulation ratio of the composition of RDF to sawdust 50 to 50. The worst recognized 6 formulations, it has a maximum ratio of RDF in relation to sawdust and peat

3. Conclusion
As a result of the experiments, the limiting threshold values for the creation of products from waste were found out. Thus, the chain of Waste processing landfill is realized-research laboratory of new composite materials GUAP-Buyer (enterprise). The main result is the creation of trade turnover in the environment of waste processing and environmental protection of urban areas [12-13].

The development of products for the cluster of fertilizers and reinforcing materials is being implemented in parallel in the form of a pilot project at the IBO-2 "Yanino". Economic benefits in cheap materials that can be sold at a lower cost, unloading the territory of the BCH from the accumulated waste of biothermal composting.

As a result of the software product of the field experiments on the extruder MN-4, tinius Olsen press, it became possible to prove the applicability of aerobic composting products for processing in screw machines with appropriate automated control. The possibilities of their applicability as a building material (hardness up to 500 kg / cm2)

In experiments with formulations of soil for germination of grass "shadow" turned 2 the optimum formulation, at the optimum moisture content and the pH 4 formulation, at the lowest odor thresholds of 1 and 2 recipes. For most parameters are most applicable for agriculture (ornamental plants) 2 and 3 formulation.

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