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Part 3
ASH AND SLAG HANDLING

3.5. Applications of ash and slag from power coals

3.5.4. Use of ash and slag for improving the properties of soil

3.5.4.6. Biological conservation of the first section of Novocherkasskaya SDPP ash disposal area

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ABSTRACT

The results of biological conservation for the first section of Novocherkasskaya SDPP ash disposal area are given. On the grounds of carried out laboratory experiments in vegetative vessels for phytoamelioration during biological conservation for the first section of ash disposal area a perennial four-component grass mixture of melilot + awnless bromegrass + burnet + Hungarian sainfoin was recommended. This grass mixture was sown in the second 10-day period of April 2011. To the middle of vegetation good sod formation for the first section surface of Novocherkasskaya SDPP ash dump was observed and this made it possible to stop dusting and eliminate from water and wind erosion owing to developing and rooted plants of the perennial grass mixture that provided for grassing-down the recultivated area.

INTRODUCTION

Novocherkasskaya SDPP is a base-load station in Rostov power system. Basic raw material for electric power generation is coal – anthracite culm of Donetsky field from Rostov Region deposits that are characterized with low calorific value and high ash content. For the last 5 years gradual expanding of ash slags being formed when producing electricity is being observed. The level of their use is insignificant and so their main amount is placed in ash disposal area.

Ash dump territory is located on the first above the floodplain terrace of the River Don valley. The terrace relief is calm. The ash dump is a hydraulic structure of floodplain type. It has the second-class solidity and the second-class danger. The ash dump territory is enclosed by a dam. The total area of three-sectioned ash dump is 200 ha and contains 48.06 mln of ash slags.

The third section of the ash dump with 24 ha area on lower part and 17 ha area on top exhausted its capacity and is removed from service. Dispatch of ash slag material and works on dust suppression are carried out from this section.

The second section with 101 ha area on lower part and 76 ha area on top also depleted its capacity and was taken off from service. Technical stage of recultivation for the second section was carried out in 2002, biological recultivation – in 2004[1].

The first section was removed from service in April 1, 2009. The section area on top is 38 ha, on lower part it is 75 ha. In 2009 technical stage works on recultivation were done: a recultivative layer 15…20 cm thick of clay screen and ground was applied on the surface of the section.

Biological stage of recultivation was aimed at lowering intensity of wind and water erosion on the first section surface of Novocherkasskaya SDPP ash dump owing to making use of perennial grass mixture as phytoameliorants when grassing-down the ash dump directed to natural fixing its surface.

AGROTECHNICAL SURVEY

Agrotechnical survey for the first section of the ash dump was carried out in autumn 2009. Samples from horizons 0…20 cm and 20…40 cm were selected in 15-fold replication and sent to the ecological and analytical laboratory of the Russian Research Institute of Reclamation Problems (RosNIIPM).

As the results of chemical analysis revealed the applied ground had significant lack of organic matter (humus) the content of which in 0…20 cm layer was 1.47…2.72 % and in 20…40 cm layer it was 1.67…2.83 %. pH analysis indicated high level of alkalinity. The content of heavy metals (Zn, Pb, Cd, Ni, Cu) in tested samples is heightened, especially in the upper layer 0…20 cm of the ground.

The results of the recultivative layer analyses showed that the content of nitrate nitrogen in the middle layer 0…40 cm is 10.7 mg/kg. Non-uniformity on replications, however, is observed. It is explained by the fact that on the first section surface of the ash disposal area heterogeneous ground with clay predominance mainly and unequal thick of the layer was applied. The high content of labile phosphorus in the recultivative layer – 17.8…59,8 mg/kg, higher values of exchange potassium – 164…487,4 mg/kg – are even more unevenly distributed on replications.

The results of agrotechnical survey also revealed unevenness on the surface of the first section and strong packness of the recultivative layer. In this connection cultivation for surface levelling and loosing the applied ground are reasonable. Besides, fragments of construction rubble were found on the ash dump surface. To carry out qualitative cultivation it is necessary to clean the surface of the ash dump recultivated section.

LABORATORY EXPERIMENTS

To make a theoretically substantiated decision on biological conservation for the first section of Novocherkasskaya SDPP ash dump laboratory experiments in vegetative vessels were carried out. These experiments include observations after the growth and devel-

opment of perennial grasses and their mixtures according to the following scheme:

Treatment 1 – Hungarian sainfoin;

Treatment 2 – burnet;

Treatment 3 – awnless bromegrass;

Treatment 4 – couch grass;

Treatment 5 – melilot;

Treatment 6 – melilot + awnless bromegrass;

Treatment 7 – melilot + awnless bromegrass + burnet;

Treatment 8 – melilot + awnless bromegrass + burnet + Hungarian sainfoin;

Treatment 9 – melilot + awnless bromegrass + burnet + couch grass + Hungarian sainfoin.

Before establishment of a trial in vegetative vessels germinating ability of tested crops in multiple replication was carried out (table 1).

Analysis of values given in table 1 showed that the highest per cent of seed germination (90 %) was noted for such grasses as Hungarian sainfoin and burnet. Seeds of couch grass and awnless bromegrass had lower germination – 60 % and 58 %, correspondingly.

Table 1. **Values of germinating ability for grass seeds in laboratory experiments**

Experiment replication	Germinating ability, %				
	Hungarian sainfoin	burnet	awnless bromegrass	couch grass	melilot
1st replication	93	91	50	50	82
2nd replication	87	84	64	60	85
3rd replication	90	95	60	70	73
average	90	90	58	60	80

Tested grasses and their mixtures were sown in May 7, 2010. Seeding depth in vessels was 2…3 cm. Azophoska (($N_{16\%}$; $P_{16\%}$; $K_{15\%}$) was applied as a mineral fertilizer in the laboratory experiments. Dosing rate of fertilizer was $N_{90}P_{90}K_{60}$ of active matter (a.m.) per ha.

The first sprouts of tested grasses appeared in 5-7 days and in 12 days full sprouts for all the treatments of laboratory experiments were recorded. Counting of grass-cover thickness in May 20 ascertained that the highest per cent of grass germination had been in treatments 6 (99 %), 9 (95 %), 7 (89 %), 8 (89 %), 1 (82 %).

Studies of the growth and development dynamics showed that the highest heights of plants were observed for the treatments 3 (awnless bromegrass) and 1 (Hungarian sainfoin). Lower plant development was recorded for melilot (treatment 5) and burnet (treatment 2). In July 2 awnless bromegrass exceeded in height burnet two times and melilot – 1,9 times. On multispecies sowing the best development of plants was noted for grass mixture of melilot + awnless bromegrass + burnet + Hungarian sainfoin (treatment 8). For this treatment plant heights slightly exceeded values of treatment 7 where three-component grass mixture of melilot + awnless bromegrass + burnet was being studied. Plant heights for two-component and five-component grass mixture were a little lower (table 2).

Table 2. **Dynamics of linear growth for tested plants**

Treatments	Linear growth values, cm			
	1.06.10	11.06.10	21.06.10	2.07.10
Treatment 1 – Hungarian sainfoin	13,1	15,3	17,1	20,2
Treatment 2 – burnet	6,4	9,5	10,0	10,7
Treatment 3 – awnless bromegrass	16,4	18,0	19,6	21,5
Treatment 4 – couch grass	12,4	15,1	17,5	19,3
Treatment 5 – melilot	6,7	8,4	9,9	11,4
Treatment 6 – melilot + awnless bromegrass	8,6	10,9	12,7	14,3
Treatment 7 – melilot + awnless bromegrass + burnet	10,5	14,3	17,2	20,0
Treatment 8 – melilot + awnless bromegrass + burnet + Hungarian sainfoin	12,9	15,7	17,9	19,8
Treatment 9 – melilot + awnless bromegrass + burnet + couch grass + Hungarian sainfoin	8,0	10,4	12,4	16,6

Measuring plant heights and washing clean root systems were made in July 2. The results are given in table 3. Analysis of the results obtained revealed that the highest values of plant heights were observed for Hungarian sainfoin (25,9 cm), couch grass (25,5 cm) and awnless bromegrass (24,2 cm). Average rooting depths for these grasses were 5,7 cm, 6,4 cm and 6,3 cm, correspondingly. Burnet plants had an average height 12,2 cm and rooting depth – 6,2 cm. The lowest values of heights and rooting depths were noted for melilot – 11,4 cm and 5,3 cm, correspondingly.

Thus, the results of growth and development of perennial grasses in vegetative vessels made it possible to ascertain a possibility of their growth on an ash dump substratum. On the account of the results obtained four-component grass mixture of melilot + awnless bromegrass + burnet + Hungarian sainfoin is recommended for phytoamelioration when carrying out biological conservation of the first section of Novocherkasskaya SDPP ash dump.

FIELD STUDIES

Because of the emerged climatic conditions during 2010 summer period it was not possible to prepare the recultivative layer for the summer sowing and to execute sodding for the surface of the first section of the ash dump with grass mixture.

Table 3. **Average height of plants and length of rooting system on treatments**

Treatment replication	Plant height, cm	Length of rooting system, cm
Hungarian sainfoin		
1	27,4	5,7
2	21,2	4,5
3	26,0	3,7
4	29,1	8,9
average	25,9	5,7
burnet		
1	12,5	6,0
2	11,0	6,0
3	13,2	6,5
average	12,2	6,2
awnless bromegrass		
1	21,7	5,2
2	21,5	8,3
3	29,5	5,5
average	24,2	6,3
Couch grass		
1	27,7	6,8
2	25,0	6,5
3	23,8	5,8
average	25,5	6,4
Melilot		
1	11,5	6,8
2	10,1	4,0
3	12,5	5,1
average	11,4	5,3

Though perennial grasses forming this grass mixture are highly resistant to unfavorable microclimate conditions and negative properties of the recultivative layer they can not be sown into a recultivative layer that is not brought to the minute structure and heavely dried up since these grasses are fine-seeded. This would not allow to carry out qualitative sodding and obtain full-grown sprouts for the summer terms of sowing, so works on biological recultivation began in April 2011.

During the second 10-day period of April the area of recultivated ash dump section was cleaned. Then the ash dump surface was cultivated to 8…10 cm depth.

In April 15-18 precipitation fell that did not permit to roll the recultivated layer before grass mixture sowing. Perennial grass mixture was sown in April 19-20. Seeding rates were for melilot – 15 kg/ha, for awnless bromegrass – 20 kg/ha, for burnet – 20 kg/ha, for Hungarian sainfoin – 15 kg/ha. Sowing was carried out with SZT-3,6 grass seeder, while unsuitable lands were sown by hand.

After sowing precipitation fell that permited to obtain full-grown sprouts of grass mixture in the first 10-day period of May. Since the recultivated surface was well prepared for sowing and there observed high natural moisture supply on seeding depth 2...3 cm full-grown sprouts of grass mixture were obtained.

Precipitation, well prepared surface of the ash dump, optimal sowing terms – all that allowed not only to obtain full-grown sprouts, but to grow and develop adequately for perennial grass mixture on the recultivated section of the ash dump.

In May 12 heights of grasses sown were measured. On the average, for this period height of forage cereal (awnless bromegrass) was 9,2 cm while that of legumes (Hungarian sainfoin, melilot, burnet) was 5,1 cm.

During the vegetation period plant heights and depths of rooting system were being measured as well as wet and dry biomass of grass mixture plants were being determined (table 4).

Table 4. **Dynamics of linear growth and root system development for plants of four-component grass mixture, accumulation of wet and dry biomass**

Crops	Linear growth, cm	Root depth, cm	Wet biomass, g	Dry biomass, g
May 26, 2011				
melilot	11,3	11,0	0,54	0,28
awnless bromegrass	13,7	5,8	0,62	0,43
burnet	6,9	3,9	0,43	0,29
Hungarian sainfoin	10,5	7,6	0,82	0,58
June 22, 2011				
melilot	13,6	12,1	0,81	0,41
awnless bromegrass	16,8	6,8	0,83	0,57
burnet	7,1	5,8	0.51	0.34
Hungarian sainfoin	12,6	8,4	0,94	0,66
July 20, 2011				
melilot	15,4	14,3	1,19	0,61
awnless bromegrass	23,2	12,8	0,98	0,68
burnet	9,7	8,6	0,59	0,40
Hungarian sainfoin	20,2	17,0	1,19	0,84
August 30, 2011				
melilot	24,3	19,8	1,81	0,94
awnless bromegrass	27,3	15,6	2,09	1,44
burnet	11,5	10,9	0,68	0,46
Hungarian sainfoin	26,2	21,5	1,65	1,17
September 23, 2011				
melilot	27,3	23,8	2,46	1,28
awnless bromegrass	32,4	21,6	2,82	1,95
burnet	13,8	12,9	1,12	0,75
Hungarian sainfoin	29,8	23,0	2,58	1,83

Data analysis of table 4 shows that rootstock grass (awnless bromegrass) developed the most quickly. This crop had higher values of linear growth, depth of root system, accumulation of wet and dry biomass. Legumes formed above ground mass more slowly since during the first period they intensively developed the root system and then above ground mass.

During the period of grass vegetation weeds with amaranth and saltbush dominated (2-3 plants per 1 m^2) appeared.

By the middle of the vegetation period for perennial grass mixture there had been good sodding of the first

ash dump section that made it possible to stop dusting and eliminate from water erosion owing to developing and rooted plants that provided for grassing the recultivated area.

In conclusion it should be noted that the works being carried out are not the final stage of biological recultivation for the first worked off section of Novocherkasskaya SDPP ash disposal area. Since this process takes long observation after the recultivated area tending works after vegetation will be go on and monitoring of the recultivated section of the ash dump will be carried out as well.

REFERENCES

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