USE OF PAPERMILL/SEWAGE SLUDGE AND COMPOSTED SLUDGE IN MINELAND REVEGETATION[1]

by

Samuel K. Dickinson[2]

Iron Range Resources and Rehabilitation Board/Mineland Reclamation Division

Abstract. Currently, Blandin Paper Company mill waste are processed with municiple sludge from the City of Grand Rapids, Minnesota. At the same time thousands of acres of mined lands in the vicinity need revegetation. This paper summarized cooperative efforts to test sludge for use in mineland revegetation. Sludge was applied directly to iron ore tailing in varying amounts and then seeded with two grasses and one legume. Best results were obtained where 10 tons per acre of sludge was disced into the tailing. Sludge was then composted using the static pile method. Compost was used in a growth chamber as a growing medium. Initial growth was better in normal growth medium. Work will continue using other bulking agents and the compost will be field tested in taconite tailing.

Additional Key Words: Iron Mining Revegetation; Minnesota.

Introduction

Iron mining in Minnesota commenced over a hundred years ago when the first underground mine opened on the Vermilion Iron Range in the northeastern part of the State. When the softer ores of the Cuyuna and Mesabi Iron Ranges were discovered open pit mines were opened and this was followed by taconite operations that utilized the non-oxidized magnetic ore. With each advancement in mining technology operations became larger, lower grade ores were processed and more wastes were generated. In addition to leaving the large pits that normally fill with high quality water; mining has left large stockpiles of surface and rock overburden, lean ore and basins filled with finely crushed tailing. These wastes cover thousands of acres in the mining areas, fortunately, none are toxic to vegetation and many of the old mining areas have been revegetated by nature. It wasn't until 1980 that mineland reclamation was mandated in the State of Minnesota. The Mineland Reclamation Division of Iron Range Resources and Rehabilitation Board (IRRRB), has been given the responsibility of reclaiming abandoned mine lands. This work consists of eliminating unsafe conditions, reforestation and providing further uses for abandoned mine lands.

The Blandin Paper Co. is located in Grand Rapids, Minnesota which is situated at the west end of the Mesabi Iron Range. In addition to producing high quality paper each year, Blandin produces about 12,000 dry tons of waste. This waste is mainly wood fiber and clay used in paper making. These wastes are added to 300 tons of municiple wastes and both are processed in the city's wastewater treatment plant. After being dewatered the sludge is trucked to a landfill for disposal at an annual cost of about $33,000.00. When the landfill is capped about every third year, the cost is about $90,000.00 for that year. Due to new regulations and the limited landfill space available, it is anticipated that future costs will be considerably higher. In the vicinity of Grand Rapids there are thousands of acres of mined lands that need the addition of organic matter to make them more productive. Taconite tailings alone cover over 25,000 acres of land located within 30 miles of Grand Rapids. Believing that the sludge from the Grand Rapids Plant might be a beneficial soil amendment for mineland reclamation, IRRRB entered into this cooperative project with the city and Blandin Paper Co.

Direct Application of Sludge

The sludge is composed of over 90% waste from Blandin Paper Co., with the characteristics shown in Table 1. A direct application of dewatered sludge was made on the Tioga Mine Tailing Basin in August 1984. This basin was filled with natural ore (hemitite) tailing and had been inactive since

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[2]Samuel K. Dickinson is Senior Mineland Reclamation Specialist, Iron Range Resources and Rehabilitation Board, Calumet, Minnesota, 55716.

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Table 1. Sludge Characteristics.

Physical Component

Water (by original weight)	67.3 %
Total solids (by original weight)	32.7
Volatile solids (by original weight)	24.3
Volatile solids (by dry weight)	74.0
Ash (by original weight)	8.49
Ash (by dry weight)	26.0

Chemical Component

Component	Units	
COD	mg/1	313,000
phenol	mg/1	4.09
ph		6.3
TDS	mg/1	810
Nitrate	mg/1	<.008
Sulfate	mg/1	36.3
Cyanide	mg/1	<.06
Chloride	mg/1	4.81
Arsenic	mg/1	2.2
Cadmium	mg/1	1.1
Mercury	mg/1	.14
Selenium	mg/1	<.4
Lead	mg/1	90
Silver	mg/1	4.9
Phosphorus	mg/1	982
Fluoride	mg/1	.8
Zinc	mg/1	155
Barium	mg/1	200
Boron	mg/1	22.3
Chromium	mg/1	86.2
Copper	mg/1	63.3
Iron	mg/1	1,500
Manganese	mg/1	60.4
Nickel	mg/1	47.6

1961. The basin was seeded and fertilized when the mine closed but a few areas remained barren. One such barren area was selected for the test.

The objective of the study was to determine what beneficial effect varied application rate of sludge would have on the growth of three plants commonly used in reclamation, namely: smooth brome (*Bromis inermis*), birdsfoot trefoil (*Lotus corniculatus*), and Canada bluegrass (*Poa compressa*).

A primary interest of the Public Utilities Commission in Grand Rapids, was to use the maximumize amount of the sludge used. For this reason, applications were as high as 20 tons per acre on a dry weight basis. Two methods of application were also investigated; one, as an amendment incorporated into the soil and two, applied as a mulch. The study design was then layed out as shown in Figure 1.

The Public Utilities Commission hauled approximately five tons of sludge to the site. The sludge was then loaded into a Sperry-New Holland Model 679 manure spreader, whioh proved to be an effective way of applying the dewatered sludge.

The study area was divided into two basic areas, one where the sludge would be used as a mulch and another where used as a soil amendment. In the latter it was applied at 5, 10, and 20 tons per acre and then worked 6 to 8 inches into the tailing using a oonventional agriculture disc. The area was then seeded, using a hand cyclone seeder, with three replications each of: smooth brome, Canada bluegrass and birdsfoot trefoil. This area was then lightly raked to cover the seed. Three control strips (where no seed was sown) were left between replicated sets.

A comparable area was then seeded in the same manner as the above, but without having any sludge worked into the tailing prior to seeding. After the area was seeded and raked, it was mulched with 5, 10, and 20 tons of sludge per acre. In each area a section was left with no sludge applied, however, it was fertilized and seeded. A portion of this section was then covered with an erosion blanket to provide a standard type of mulch for comparison.

With the assistance of the Minnesota Pollution Control Agency (MPCA), lysimeter tubes were placed in the tailing to check water quality in the test area. The water collected from the tubes was analyzed for pH, specific conductance, nitrate (NO_3^-), chloride and ammonia nitrogen (NH_4^+). Heavy metals were not included since available information showed that they would not be a problem. Water analysis showed that no problems existed with parameters checked.

The study was initiated in eary August 1984 and was followed by a period of dry weather. Precipitation in August was 1.51 inches with the 30 year average being 3.38 inches and was followed by a drier than normal September. This resulted in poor germination the first year. Most germination occurred in early September with the first frost occurring on the 15th of that month. Because of this late germination much of the birdsfoot trefoil was killed by frost.

Plant densities were checked at the end of the 1984 and 1985 growing season and are shown in Table 2.

Study Design

Surface Applied (Mulched)	Incorporated (Disced)
20 Tons/Acre	20 Tons/Acre
10 Tons/Acre	10 Tons/Acre
5 Tons/Acre	5 Tons/Acre
0 Tons/Acre	0 Tons/Acre
Standard Mulch	Standard Mulch
<-- Three Reps Each --> Bromegrass Birdsfoot Trefoil Canada Bluegrass Control	<-- Three Reps Each--> Bromegrass Birdsfoot Trefoil Canada Bluegrass Control

Figure 1. Mill/Sewage Sludge Application Rates.

Table 2. Seedling Density.

	Mulched			Disced		
	10/84	10/85	Change 84-85	10/84	10/85	Change 84-85
	(Average stems per sq. ft. for 3 replications)					
<u>0 Tons/Acre</u>						
Smooth brome	1.13	2.69	+	7.36	12.88	+
Birdsfoot trefoil	.00	.00	0	2.12	.14	-
Canada bluegrass	3.11	6.51	+	23.64	10.05	-
Control	0.00	.00	0	8.67	1.98	-
<u>5 Tons/Acre</u>						
Smooth brome	3.40	4.10	+	17.69	20.81	+
Birdsfoot trefoil	.70	.14	-	10.19	2.12	-
Canada bluegrass	33.48	31.00	-	18.26	10.05	-
Control	0.00	.00	0	1.84	.71	-
<u>10 Tons/Acre</u>						
Smooth brome	1.70	6.94	+	23.35	23.64	+
Birdsfoot trefoil	.14	.57	+	16.70	1.27	-
Canada bluegrass	15.47	21.37	+	19.82	22.22	+
Control	.14	1.56	+	1.13	1.13	0
<u>20 Tons/Acre</u>						
Smooth brome	.57	8.21	+	20.66	6.23	-
Birdsfoot trefoil	2.26	1.27	-	12.88	2.55	-
Canada bluegrass	8.63	15.39	+	17.13	12.60	-
Control	.28	2.11	+	.57	.57	0

In all cases greater density of vegetation was achieved where sludge had been applied. Where the sludge was incorporated the highest plant density occurred on plots with 10 tons per acre of disced-in sludge. Where sludge was used as a mulch, highest density was obtained with an application of 5 tons per acre. Highest yielding plant species was Canada bluegrass. Most of the trefoil present in 1985 germinated that year from hard seed that had over wintered. Vegetation was generally short and the tissue analysis of brome and bluegrass indicated a deficiency of nitrogen, phosphorus and potash. On the control area little vegetation was established.

Trials were also run in the growth chamber using the sludge as an amendment and mulch. The best results were obtained when it was used as a mulch.

Composting of Sludge

Another possible method of disposing of the sludge would be to compost the material prior to using it in mineland reclamation. Through composting, the amount of material and moisture content is reduced, pathogens are further controlled and the end product is more desirable. During the summer of 1984 we engaged E&A Environmental Consultants of Stoughton, Mass., to assist us in composting the papermill/sewage sludge. The static pile method of composting was selected for this project. This requires the addition of a bulking agent, in this case woodchips and bark were used. The sludge was mixed with the bulking agent in a 1 to 2 mixture by volume. The woodchips and bark were supplied by Blandin Paper Co. The pile was constructed over an aeration system consisting of perforated plastic pipe connected to a 1/3 horsepower blower. Fifty pounds of nitrogen was added to assist in breaking down the sludge. Mixing was done with a front end loader. After the pile was constructed, it was covered with woodchips and hay to conserve heat.

Because of the extremely cold weather, -17° to -25° C, warm air was blown into the pile between the eighth and tenth day after the pile was constructed. The temperature in the pile rose dramatically after this heat was added. The temperature was monitored using a heat probe, from December 11 until the pile was torn down on January 15, 1985, see Table 3. To meet Minnesota Pollution Control Agency and the U.S. EPA requirements for a process to reduce pathogens, temperature in the pile must exceed 55° C for at least three days. In this case temperature reached 55° C between the seventh and the seventeenth day. In one case it exceeded this temperature for up to sixteen days, before monitoring was discontinued. Where no fertilizer was added, see Monitoring Station No. 3 (Table 3), less heat was generated, but that portion of the pile still met regulatory requirements.

After being composted for about five weeks, the pile was torn down and a small sample of the compost was removed and passed through a 1/4 inch and 1/2 inch screen. When passed through a 1/4 inch screen, on a volume basis, 68.3 percent of the bulking agent was recovered and by weight 74 percent was recovered. The bulk density of the screened compost was found to be 718 pounds per cubic yard.

The screened compost was then used as a

Table 3. Compost Pile Temperature.

Date	Monitoring Station 1	2	3	4	5	6	7	8	9	Ave.
					Degrees C					
12/11/84	5	7	7	9	4	3	6	7	6	6
12	5	9	8	9	6	5	6	7	6	7
13	3	5	7	9	9	7	5	7	6	6
14	5	5	6	7	12	10	8	6	5	7
	7	8	9	10	11	9	9	7	7	9
17	12	9	8	8	18	44	47	28	13	20
	20	8	8	7	48	43	63	24	9	26
18	25	12	8	39	51	57	62	21	18	33
	44	12	8	20	52	51	69	25	14	33
19	20	14	8	18	61	46	70	18	8	29
	51	17	8	18	62	48	64	26	14	33
20	39	16	10	22	70	60	72	63	23	42
	30	16	12	36	66	54	64	41	15	37
21	35	18	20	57	69	59	72	63	37	47
24	43	30	29	45	57	55	66	66	29	47
26	73	63	50	50	57	55	62	68	58	60
27	69	65	29	40	55	40	41	65	45	50
28	67	70	65	60	45	44	52	70	55	57
31	65	65	66	56	42	24	45	65	60	54
01/02/85	67	66	66	62	54	42	53	66	67	60
03	65	66	66	63	42	32	53	63	64	57
04	62	64	63	56	26	19	42	60	59	50
07	52	63	63	62	28	15	44	50	56	48
08	57	65	61	61	22	13	31	36	52	44
09	57	63	60	63	35	10	10	50	52	44
10	58	63	64	63	15	11	15	53	56	44
11	58	64	63	62	22	14	14	51	57	45
14	57	62	59	54	24	13	17	51	60	44
15	Pile torn down									
Ave.Temp.	41	37	33	38	38	32	41	41	34	

growing medium in our growth chamber. Two mixes of the compost were used. Mix 1 was 1/2 compost and 1/2 peat by volume. Mix 2 was 1/2 compost and 1/2 Terra Lite Forestry Mix (W.R. Grace & Co.). Planting was then done using these two mixes, as well as in the forestry mix for control. Species planted in these mixes were red pine (*Pinus resinosa*), Jack pine (*Pinus banksiana*), white spruce (*Picea glauca*), chokecherry (*Prunus virginiana*), caragana (*Caragana arborescens*), cereal rye (*Secale cereale*), and birdsfoot trefoil. Time does not allow an in depth discussion of the results of the growth chamber work. However, growth rates and root development of plants grown in a partial compost mix were less than those grown in the normal forestry mix. The plant materials started in the growth chamber were field planted and will continue to be monitored.

The remaining composted material was then run through a power screen and allowed to cure. In spring 1986 the compost will be field tested by being incorporated as a soil amendment into taconite tailing. The test area will then be seeded with plant materials normally used in the revegetation of taconite tailing. Also, during spring 1986 we will be trying shredded rubber tires as a bulking agent for the composting of papermill/sewage sludge.

Summary

In the Mesabi Iron Range of Minnesota there is a need for organic materials for use as a soil amendment in mineland reclamation. Papermill/sewage sludge and composted sludge generated in this same area shows promise in fulfilling this need. Further study will be aimed at the economics of of composting and the use of shredded rubber as a bulking agent.