RECLAMATION RESEARCH IN NORTH DAKOTA

PART B

RESEARCH PUBLICATION BRIEFS

SOIL/SPOIL PROPERTIES (SP)

Title: **LIGNITE SPOILS IN THE NORTHERN GREAT PLAINS - CHARACTERISTICS AND POTENTIAL FOR RECLAMATION**

Authors: F.M. Sandoval, J.J. Bond, J.F. Power and W.O. Willis

Organization: USDA-ARS, Northern Great Plains Research Center, Mandan, ND

Format: Paper

Reference: Proceedings of the First Annual Research and Applied Technology Symposium on Mined Land Reclamation, pp. 117-133, Pittsburgh, PA., March 1973

Key Index Words: Spoil Properties, Overburden Analysis, Topsoil, Amendments, Fertilizer Use

Brief Description

This paper describes the results of laboratory and field investigations on the coal mine spoils of North Dakota, Montana and Wyoming. The physicochemical properties of the spoil materials provide a very poor environment for vegetative growth. Materials from the Tongue River and Sentinel Butte formations within the Fort Union group were often extremely fine textured (Montmorillonitic), moderately saline, and highly sodic. Severity of the problems associated with high clay and high adsorbed sodium content increased with depth from the original surface. Low organic matter combined with fine texture enhances the sodium dispersion effect, which makes the spoil materials extremely unstable, highly impermeable, and erodible. The content of available phosphorus in spoil materials was very low. The content of available nitrogen varied considerably, depending on the age of the exposed spoils. Treatments showing promise for reclamation include fertilization (especially with phosphorus) in combination with the use of topsoil, vegetative (straw) mulches, and possibly gypsum as a calcium amendment. The response to gypsum in field studies has been disappointingly slow.

Analysis of Conclusions

The conclusions drawn in this study are still generally valid. This research provided impetus for reclamation research and development of better regulations in North Dakota.

Title: **LIGNITE MINE SPOILS IN THE NORTHERN GREAT PLAINS - CHARACTERISTICS AND POTENTIAL FOR RECLAMATION**

Authors: F.M. Sandoval, J.J. Bond, J.F. Power, and W.O. Willis

Organization: USDA-ARS, Northern Great Plains Research Center, Mandan, ND

Format: Paper

Reference: Some Environmental Aspects of Strip Mining in North Dakota (M.K. Wali, ed.), North Dakota Geological Survey Series No. 5, pp. 1-24. North Dakota Geological Survey, Grand Forks, ND, 1973

Key Index Words: Spoil Properties, Overburden Analysis, Topsoil, Fertilizer Use, Amendments

Brief Description

This paper is similar to the preceding one. It provides information on the physical and chemical properties of lignite spoils, pointing out consequent problems in reclamation.

Analysis of Conclusions

The conclusions drawn in this study are still generally valid. This research provided impetus for reclamation research and development of better regulations in North Dakota.

Title: **NITRIFICATION IN PALEOCENE SHALE**

Authors: J.F. Power, J.J. Bond, F.M. Sandoval, and W.O. Willis

Organization: USDA-ARS, Northern Great Plains Research Center, Mandan, ND

Format: Paper

Reference: Science 183:1077-1079, 1974

Key Index Words: Paleocene Shale, Overburden Analysis, Nitrification, Nitrogen

Brief Description

This paper reported that exchangeable ammonium nitrogen is present in Paleocene (Fort Union) shale below a depth of 33 feet in North Dakota and eastern Montana. Above 33 feet, exchangeable ammonium nitrogen is nitrified in situ. The lack of viable nitrifying organisms and the probable lack of oxygen prevent in situ nitrification below 33 feet. Shale samples incubated at 27°C under nonsterile conditions and those exposed to atmospheric contamination showed active nitrification without additional treatment.

Analysis of Conclusions

This study is very important for understanding the dynamics of nitrogen transformation and availability in the Fort Union mine spoils.

Title: **CHEMICAL RECLAMATION OF SODIC STRIP MINE SPOILS**

Authors: E.J. Doering and W.O. Willis

Organization: USDA-ARS, Northern Great Plains Research Center, Mandan, ND

Format: Report

Reference: USDA-Agricultural Research Service, North Central Region, ARS-ND-20:1-8, 1975

Key Index Words: Amendments, Sodicity, Infiltration

Brief Description

This study shows that the hydraulic conductivity of sodic strip mined spoils is established and maintained at an acceptable level by leaching with water high in salts. Sodic spoil material can be reclaimed chemically by using highly soluble calcium salts. It was calculated that the salt (calcium chloride) required for chemical reclamation of the spoil material used would cost more than $1,300 per acre per foot of depth reclaimed.

Analysis of Conclusions

Although chemical reclamation is effective, it is not recommended for large scale application on strip mined spoils because of the cost. A better alternative is to apply a suitably thick layer of nonsodic topsoil and subsoil on the strip mined spoils. However, some situations may require the use of chemical amendments with or without the use of topsoil.

Title: **THE PROPERTIES OF IMPORTANT AGRICULTURAL SOILS AS CRITERIA FOR MINED LAND RECLAMATION**

Authors: H.W. Omodt, F.W. Schroer and D.D. Patterson

Organization: North Dakota State University, Fargo, ND

Format: Bulletin

Reference: North Dakota State University, Agricultural Experiment Station, Bulletin, No. 492, 1975

Key Index Words: Soil Properties, Soil Types

Brief Description

This report contains a detailed discussion on the profile and various physical and chemical characteristics of soils that are important in determining what soil materials are suitable for reclaiming mined land in North Dakota.

Analysis of Conclusions

This paper provided a general basis for topsoil and subsoil criteria established by the NDPSC-Reclamation Division.

Title: **PHYSICAL, CHEMICAL AND BIOLOGICAL ASPECTS OF STRIP MINED LANDS IN WESTERN NORTH DAKOTA**

Authors: A. Bauer, G.W. Gee and J.E. Gilley

Organization: North Dakota State University, Fargo, ND

Format: Report

Reference: North Dakota Agricultural Experiment Station Final Report. Old West Regional Commission Grant No. 10470016, 605 p., 1976

Key Index Words: Revegetation, Spoil properties, Topsoil

Brief Description

This report presents the results of reclamation research conducted by NDSU from 1974 to 1976 in western North Dakota. The research involved: the determination of the physical and chemical characteristics of shaped mined lands and their effect on the establishment and performance of plants; the characteristics of surface and root zone hydrology of shaped spoil materials; and, plant establishment and culture on surface mined lands. The results were obtained through literature research, laboratory testing and analyses and field sampling and experimentation.

Analysis of Conclusions

The conclusions drawn in this report are based on studies conducted prior to 1976 when the reclamation performance standards were not as stringent as they are now. However, many observations made in this report are still valid and provide useful information for reclamation planning.

Title: **CHEMICAL AND PHYSICAL PROPERTIES OF STOCKPILED MATERIALS AT A MINESITE IN WESTERN NORTH DAKOTA**

Authors: G.W. Gee and A. Bauer

Organization: North Dakota State University, Fargo, ND

Format: Paper

Reference: North Dakota Agricultural Experiment Station Farm Research 34(2):44-51, 1976

Key Index Words: Topsoil, Soil Properties, Stockpiled Soil

Brief Description

Stockpiled topsoil materials from Indian Head Mine near Zap, ND, were analyzed for selected physical and chemical properties, along with soil samples collected from adjoining undisturbed areas. The stockpile materials had generally lower susceptibility to wind erosion than the nonmined surface soils; exhibited moderate to high crust strengths, and varied in their permeability to water. Chemically the stockpiled materials did not contain excess soluble salts, and the SAR value were generally less than 16. Nitrate nitrogen ranged from very low to high , phosphorus was invariably low, and potassium was high to very high. The results indicated that stockpiled materials reflect the mixing of surface and subsurface (A, B, and perhaps C horizon) materials.

Analysis of Conclusions

This study emphasized that stripping operations must be controlled better to segregate the soil horizons if the goal is to have materials for respreading that are physically and chemically similar to the undisturbed soils. Since this study was conducted, control on stripping depth has been improved considerably. Materials removed to serve as topsoil generally include A horizon and a part of B horizon depending upon their meeting the criteria of suitability as provided in the North Dakota reclamation rules.

Title: **THE SOIL MAP - A PREREQUISITE TO MINING AND RECLAMATION**

Author: D.D. Patterson

Organization: North Dakota State University, Fargo, ND

Format: Paper

Reference: North Dakota Agricultural Experiment Station Farm Research 34(1):12-13, 1976

Key Index Words: Soil Maps, Soil Properties

Brief Description

This paper stresses the need for inventorying and mapping soils prior to mining an area. soil information with proper interpretations is considered as one of the most important steps in the reclamation planning process.

Analysis of Conclusions

The use of soil maps and other soil related information in the reclamation of surface mined lands has already received acceptance.

Title: **EFFECTS OF SAMPLING METHOD ON RESULTS OF CHEMICAL ANALYSIS OF OVERBURDEN SAMPLES**

Authors: J.F. Power and F.M. Sandoval

Organization: USDA-ARS, North Great Plains Research Center, Mandan, ND

Format: Paper

Reference: Mining Congress Journal 63:31-41, 1976

Key Index Words: Overburden Analysis, Sampling Methods

Brief Description

The results of an experiment are presented in which the effects of different methods of obtaining overburden samples on the chemical analysis of the materials were assessed. Least contamination occurred in samples obtained by pneumatic drilling. Probably no single drilling method can be recommended for all conditions and types of overburden, and for all sampling purposes. Several drilling methods may be necessary to accommodate varying conditions or materials.

Analysis of Conclusions

This study has provided important insight about some of the analytical errors that may be caused or introduced in chemical characterization of overburden samples collected by various sampling procedures. However, the effects of sampling procedures have been assessed for only a limited number of analytical parameters. Additional work in this area would be desirable.

Title: **POTASSIUM RELEASE CHARACTERISTICS OF SPOIL MATERIALS**

Author: M. Saeed

Organization: Project Reclamation, University of North Dakota, Grand Forks, ND

Format: Paper

Reference: Proceedings of North Dakota Academy of Science 31(1):27, 1976

Key Index Words: Spoil Properties, Soil Properties, Nutrient Requirements

Brief Description

In this presentation were discussed the preliminary results of laboratory studies conducted to determine the potassium release characteristics of four different spoil materials and one unmined soil from western North Dakota.

Analysis of Conclusions

The results suggested that the North Dakota coal mine spoils are mostly well buffered against potassium depletion.

Title: **IN SITU SOIL WATER HOLDING CAPACITIES OF SELECTED NORTH DAKOTA SOILS**

Authors: D.K. Cassel and M.D. Sweeney

Organization: NDSU-Agricultural Experiment Station, Fargo, ND

Format: Bulletin

Reference: North Dakota Agricultural Experiment Station Bulletin No. 495, 1976

Key Index Word: Soil Water, Water Use, Soil Properties, Plant Responses

Brief Description

Water holding capacity of selected North Dakota soils is discussed in relation to several factors, including, but not limited to, soil depth, bulk density, particle size, relief, parent material, and soil moisture tension.

Analysis of Conclusions

An excellent paper on plant available water in North Dakota soils. Although actual measurements of changes in this parameter are somewhat lacking, the paper is still very useful.

Title: **CHEMICAL AND PHYSICAL CHARACTERIZATION OF COAL OVERBURDEN**

Author: F.W. Schroer

Organization: North Dakota State University, Fargo, ND

Format: Paper

Reference: North Dakota Agricultural Experiment Station Farm Research 34(1):5-11, 1976

Key Index Words: Overburden Analysis, Soil Properties, Spoil Properties

Brief Description

This paper describes the results of laboratory analysis conducted on soil overburden materials collected from several sites in Mercer and Dunn counties, including some reclaimed fields at four mine sites. The materials have been characterized with respect to their physical and chemical properties.

Analysis of Conclusions

This is one of the many studies in which soils and overburden materials of coal mining areas have been analyzed.

Title: **EFFECT OF LEONARDITE ON DIFFUSION OF PHOSPHORUS IN COAL MINE SPOILS**

Authors: J.W. Harrell, Jr. and M. Saeed

Organization: Project Reclamation, University of North Dakota, Grand Forks, ND

Format: Paper

Reference: Soil Science 125(5):285-290, 1977

Key Index Words: Spoil Properties, Fertilizer Use, Amendments, Leonardite

Brief Description

This paper discusses the results of laboratory experiments in which phosphorus diffusion coefficients were measured (using P^{32}) in 1) Glenharold mine spoil, 2) spoil amended with 10% leonardite, and 3) leonardite alone, as a function of applied P, water soluble P, and NH_4F - extractable P. The phosphorus diffusion coefficient values were in the relative order: spoil, spoil + leonardite, leonardite. The addition of leonardite to spoil was found to reduce the phosphorus diffusion coefficients. Leonardite adsorbed phosphorus much more than did the spoil.

Analysis of Conclusions

The results of this investigation are important as they indicate that addition of leonardite to mine spoils or soils may increase the need for phosphorus application.

Title: **LABORATORY METHODS RECOMMENDED FOR CHEMICAL ANALYSIS OF MINED LAND SPOILS AND OVERBURDEN IN WESTERN UNITED STATES**

Authors: F.M. Sandoval and J.F. Power

Organization: USDA-ARS, Northern Great Plains Research Center, Mandan, ND

Format: Handbook

Reference: USDA, Agriculture Handbook No. 525, 1977

Key Index Words: Spoil Properties, Overburden Analysis, Analytical Methods

Brief Description

This handbook provides guidelines for sampling and for chemical analysis of mine spoils and overburden samples. It was compiled to meet an urgent need for uniform laboratory methods to evaluate plant growth capabilities and limitations associated with coal lands in the Western United States. Salinity, sodicity, and nutritional deficiencies commonly characterize these materials. The procedures selected are those used by the authors and are accepted most widely as reference or standard procedures for western mined lands and associated spoils.

Analysis of Conclusions

This is a valuable reference material for spoil and overburden analysis methods. standardization of analytical methods suitable for mined lands requires further study because some of the normal soil analysis methods do not seem to predict the behavior of disturbed soils or spoil materials as well as they do in case of undisturbed soils.

Title: **CORRECTION OF NUTRIENT DEFICIENCIES AND TOXICITIES IN STRIP MINED LANDS IN SEMIARID AND ARID REGIONS**

Authors: A. Bauer, W.A. Berg, and W.L. Gould

Organization: USDA-ARS, Mandan, ND, Colorado State University, Fort Collins, CO, and New Mexico State University, Las Cruces, NM

Format: Paper (Chapter)

Reference: Reclamation of Drastically Disturbed Lands (F.W. Schaller and P. Sutton, eds.), pp. 451-466. ASA, CSSSA, SSA, Madison, WI, 1978

Key Index Words: Spoil Properties, Soil Properties, Nutrient Deficiencies, Toxicity, Revegetation

Brief Description

The paper provides an overview of research findings regarding nutrient deficiency and toxicity problems in the strip mined lands of Western United States. Evaluation of conventional soil tests for predicting fertilizer requirements on mined lands, plant responses to fertilizers, techniques of fertilizer application, and role of soil water in determining response to fertilizers are topics included in this paper.

Analysis of Conclusions

This paper emphasizes that interpretation of soil tests for determining rate of fertilizer applications needed to correct nutrient deficiencies on reclaimed mined lands may depend on the kind of plant rooting medium present at the spoil surface and its thickness. Where the plant rooting medium consists of soil materials from essentially all of the solum, corrective rates of fertilizers and other soil amendments may be excepted to equal those required on undisturbed soils of equal deficiency. However, as the thickness of organic matter containing plant-rooting medium decreases, corrective rates for a given deficiency level will be higher if another factor does not alter the potential yield level of the crop grown. This is an important conclusion as it points out the limitations of conventional soil tests for determining the fertilizer requirements on variously reclaimed mined lands. Additional work on perfecting soil tests appropriate for mined land conditions is required.

Title: **FERTILIZATION OF WHEAT, CORN, AND GRASS / LEGUME GROWN ON RECLAIMED SPOILBANKS**

Authors: A. Bauer, P. Nyren, G. Reichman, G.W. Gee, and J.E. Gilley

Organization: North Dakota State University, Fargo, ND

Format: Report

Reference: North Dakota Agricultural Experiment Station Research Center Report No. 67, 1978

Key Index Words: Soil Properties, Fertilizer Use, Analytical Methods, Overburden

Brief Description

The suitability of soil tests developed for determining nitrogen and phosphorus availability in undisturbed soils in North Dakota to predict their deficiencies and fertilizer requirements was evaluated on reclaimed sites with three crops over a 2 year period. Yield responses of wheat, corn, and grass/legume to applications of phosphorus and nitrogen fertilizers confirmed a deficiency or sufficiency of each nutrient as predicted by the soil test. The nutrient status predictive capability of the soil test was considered suitable for reclaimed sites. Rate of nutrient application to correct the deficiency, however, was considered to require adjustment from those utilized for undisturbed sites.

Analysis of Conclusions

This study also points to the need for developing better methods of predicting fertilizer requirements for variously reclaimed mined lands.

Title: **PHYSICAL ANALYSES OF OVERBURDEN MATERIALS AND MINE LAND SOILS**

Authors: G.W. Gee, A. Bauer, and R.S. Decker

Organization: North Dakota State University, Fargo, ND

Format: Paper (Chapter)

Reference: Reclamation of Drastically Disturbed Lands (F.W. Schaller and P. Sutton, eds.), pp. 665-686, ASA, CSSA, and SSSA, Madison, WI, 1978

Key Index Words: Soil Properties, Overburden Analysis, Water Management

Brief Description

This article focuses on characterization of physical properties of overburden materials of western United States coal mine lands in relation to soil water storage, water availability, surface erosion and land stability. Methods of evaluating the changes in soil water storage and availability etc. are discussed.

Analysis of Conclusions

A very informative article, useful in developing better soil-plant water management techniques for revegetation on mined lands.

Title: **USE OF SORPTION ISOTHERMS FOR EVALUATING THE EFFECT OF LEONARDITE ON PHOSPHORUS AVAILABILITY IN COAL MINE SPOILS**

Author: M. Saeed

Organization: Project Reclamation, University of North Dakota, Grand Forks, ND

Format: Paper

Reference: Soil Science 126(3):157-165, 1978

Key Index Words: Spoil Properties, Fertilizer Use, Nutrient Requirements, Amendments

Brief Description

Laboratory and growth chamber experiments were conducted to study the effect of leonardite on the availability of phosphorus in Glenharold spoil. Phosphorus sorption capacity of leonardite was higher than that of the spoil. Growth chamber studies indicated that phosphorus uptake by plants was reduced when the spoil was supplied with 10% leonardite. Leonardite decreased the growth of the thickspike wheatgrass but increased that of alfalfa.

Analysis of Conclusions

The results of this study indicate that leonardite, if used as a soil amendment, will necessitate heavier applications of phosphate because of its higher sorption capacity for this element. Additional work on the use of leonardite, a humic and fulvic acid rich material, would be desirable.

Title: **IMPROVEMENT OF SALINE- AND SODIUM-AFFECTED DISTURBED LANDS**

Authors: F.M. Sandoval and W.L. Gould

Organization: USDA-ARS, Northern Great Plains Research Center, Mandan, ND, and New Mexico State University, Las Cruces, NM

Format: Paper (chapter)

Reference: Reclamation of Drastically Disturbed Lands (F.W. Schaller and P. Sutton, eds.), pp. 485-504. ASA, CSSA, SSA, Madison, WI, 1978

Key Index Words: Salinity, Sodicity

Brief Description

This paper reviews research information on saline and sodium-affected agricultural soils and discusses the application of this information to mined lands of the Western United States. Reclamation problems that are specific to sodic and saline spoils are discussed in relation to soil/spoil-plant relationships, and the best known technology available to overcome these problems is reviewed.

Analysis of Conclusions

The information presented in this paper is based on the fundamental principles of reclamation applicable to undisturbed agricultural soils, as well as from recent studies on the lands disturbed by mining. Advances in reclamation technology are well documented.

Title: **POTASSIUM RELEASE CHARACTERISTICS OF COAL MINE SPOILS**

Author: M. Saeed

Organization: Project Reclamation, University of North Dakota, Grand Forks, ND

Format: Paper

Reference: Pakistan Journal of Scientific and Industrial Research 22:168-172, 1979

Key Index Words: Spoil Properties, Soil Properties, Nutrient Requirements

Brief Description

Potassium release characteristics of four coal mine spoils and one unmined soil from western North Dakota were studied in a growth chamber by exhaustive cropping with barley. The exchangeable K was determined by leaching with neutral ammonium acetate and total K by boiling with 1N HNO_3. The spoil materials, with the exception of that from Center mine, were found to contain a large reservoir of exchangeable (313 to 679 kg/ha) and total (1205 to 1763 kg/ha) K. The release of K from non-exchangeable sources varied from 746 to 1478 kg/ha. Mobilization of non-exchangeable K was closely related to the amounts of K extracted by barley. Non-exchangeable K accounted for 58% of the total K utilized by the test plants.

Analysis of Conclusions

The results suggest that the North Dakota coal mine spoils tested are well buffered against K depletion. Also, this study showed that the HNO_3-extractable K was a better indicator of potassium release and removal by intensive cropping than initial exchangeable-K or Woodruff's energy exchange.

Title: **WATER MOVEMENT IN A RECLAIMED SITE AND ASSOCIATED SOILS AT A MINE SITE IN WESTERN NORTH DAKOTA**

Authors: M.W. Pole, T.H. Brown, and L. Zimmerman

Organization: NDSU-Soil Science Department Fargo, ND

Format: Paper

Reference: North Dakota Agricultural Experiment Station Farm Research 37(6): 5-8, 1980

Key Index Words: Infiltration, Reclaimed Soil, Soil Properties

Brief Description

Infiltration, water retention, and internal drainage characteristics were determined for several undisturbed soils and a reclaimed soil at the Falkirk Mine. Infiltration and water movement through the soils was generally unimpeded. The infiltration equation provided excellent results in quantifying infiltration into all of the soils investigated. A water movement model developed in Montana was applied to the soils; however, it was not applicable to the reclaimed soil.

Analysis of Conclusions

Additional research is needed to determine infiltration, water movement, and drainage characteristics of reclaimed soil profiles. The data presented in this paper is only applicable to nonsaline and nonsodic soils.

Title: **THE EFFECTS OF MOISTURE ON PHOSPHORUS DIFFUSION IN COAL MINE SPOILS**

Authors: J.W. Harrell and M. Saeed

Organization: Project Reclamation, University of North Dakota, Grand Forks, ND

Format: Paper

Reference: Soil Science 129:261-265, 1980

Key Index Words: Spoil Properties, Topsoil, Fertilizer Use

Brief Description

Phosphorus diffusion coefficients were measured as a function of water tension and water content in topsoil and spoil samples from two coal mine sites in western North Dakota. The results showed that phosphorus diffusion coefficient was almost zero for water content below that held at 15 bar and increased rapidly as the water in excess of that held at 15 bar increases. For most of the measurements diffusion coefficient for the spoil material was greater than for the topsoil at a given moisture tension.

Analysis of Conclusions

The results of this investigation have a great bearing on the phosphate fertilization of mined land spoils and soils. The role of moisture in the diffusion of phosphorus in soils and spoils is elucidated.

Title: **SOIL-ALGAL RELATIONSHIPS FROM SURFACE MINED SOILS**

Authors: L.E. Shubert and T.L. Starks

Organization: University of North Dakota, Grand Forks, ND

Format: Paper

Reference: British Phycology Journal 15: 417-428, 1980

Key Index Word: Microbiology, Soil Algae, Soil Properties

Brief Description

This study was conducted to gather baseline data on chemical and physical properties of the soil and the presence of algae in surface mined soils in selected arid and semi-arid environments. Integration of analytical data suggested distinct relationships between physical and chemical properties of the soils and the algae present in them. This investigation was part of a long term project to evaluate the relationships of algae to their soil environment.

Analysis of Conclusions

This is an important study because it creates a base for further projects to investigate the role of algae in soil genesis and reclamation in arid and semi-arid areas.

Title: **TEMPORAL AND AMENDMENT EFFECTS ON SELECTED PHYSICAL AND CHEMICAL PROPERTIES OF SOME NORTH DAKOTA COAL MINE SPOILS AND TOPSOILS**

Authors: R.H. Bares, N.M. Safaya, N. Malakondaiah and M.K. Wali

Organization: Project Reclamation, University of North Dakota, Grand Forks, ND

Format: Paper

Reference: Agronomy Abstract, p. 172, 1981

Key Index Words: Spoil Properties, Amendments

Brief Description

In this paper presentation, made in the American Society of Agronomy meeting in Atlanta, Georgia, the effects of several amendments on some physical and chemical properties of spoil and soil material from six field experiments conducted in Mercer and Oliver Counties were discussed. Changes in spoil and soil properties were monitored over a period of six years; considerable site-to-site and year-to-year variability was recorded.

Analysis of Conclusions

The results of this long-term study are very useful because the effects of some uncommonly used amendments (leonardite, slack coal, boiler slag, etc.) on mine soils and spoils have been examined.

Title: **TRACE ELEMENT STATUS OF SOME COAL MINE SPOILS AND TOPSOILS IN WESTERN NORTH DAKOTA**

Authors: N.M. Safaya, R.H. Bares, N. Malakondaiah and M.K. Wali

Organization: Project Reclamation, University of North Dakota, Grand Forks, ND

Format: Paper

Reference: Agronomy Abstract, p. 190, 1981

Key Index Words: Soil Properties, Trace Elements, Amendments, Topsoil

Brief Description

This paper, presented in the American Society of Agronomy meeting at Atlanta, Georgia, discussed the results of trace elements analyses made on soil and spoil samples from six field experiments conducted at Center, North Beulah, South Beulah, and Glenharold mines in North Dakota. The effects of several amendments on aluminum, boron, cadmium, copper, iron, lead, lithium, manganese, nickel, strontium, and zinc status of mine soils/spoils were monitored over a five-year period.

Analysis of Conclusions

This is an elaborate study on the trace element status of North Dakota mine spoils and soils.

Title: **ECOLOGICAL STUDIES ON THE REVEGETATION PROCESS OF SURFACE COAL MINED AREAS IN NORTH DAKOTA: 2. PHYSICAL AND CHEMICAL PROPERTIES OF OVERBURDEN AND TOPSOIL AS AFFECTED BY TIME AND AMENDMENTS**

Authors: N.M. Safaya, R.H. Bares, N. Malakondaiah, and S.A. Nicholson

Organization: Project Reclamation, University of North Dakota, Grand Forks, ND

Format: Report

Reference: A minerals research contract report to USDI-Bureau of Mines, 177 p., 1982

Key Index Words: Spoil Properties, Amendments

Brief Description

This report discusses the long-term effects of some amendments on the physical and chemical properties of spoil and topsoil materials collected from test plots established at a total of six sites in North Beulah, South Beulah, Center, and Glenharold mines. The amendments included fertilizers, leonardite, slack, boiler slag, scoria, sand, topsoil etc. A number of soil properties including the status of elements such as nitrogen, phosphorus, potassium, calcium, magnesium, sodium, iron, manganese, zinc, copper, boron, aluminum, cadmium, lithium, nickel, lead, silicon, and strontium were quantified.

Analysis of Conclusions

The information contained in this report is very useful, for it provides a relatively long-term assessment of a large number of soil and spoil properties as affected by several common and uncommon amendments. Inclusion of a large body of data on the status of several trace elements in the North Dakota mined land is a distinguishing feature of this report.

Title: **COLONIZATION AND SUCCESSION OF ALGAE AND SOIL-ALGAL INTERACTIONS ASSOCIATED WITH DISTURBED AREAS**

Authors: T.L. Starks and L.E. Shubert

Organization: University of North Dakota, Grand Forks, ND

Format: Paper

Reference: Journal of Phycology 18: 99-107, 1982

Key Index Word: Microbiology, Soil Algae, Soil Properties, Succession

Brief Description

This study was based on the idea that algae can serve as model organisms for studying soil ecosystems. An attempt was made to correlate algal colonization and succession with the chemical content of disturbed soils. Linear regressions were generated to compare soil-algal interactions on sites with or without respread topsoil in order to develop a conceptual model to demonstrate the relationship between algal abundance and various chemical properties of soil. No chemical property of the topsoil correlated significantly with algal abundance. Changes in chemical properties in regraded spoil resulting from percolation and leaching, plant growth, and other factors directly affected algal abundance.

Analysis of Conclusions

This study illustrates the complexity of the soil-algal relationships or disturbed lands, generates a preliminary conceptual model and gives direction to future studies in this area.

Title: **THE ROLE OF TOPOGRAPHY IN REVEGETATION OF DISTURBED LANDS**

Authors: N.C. Wollenhaupt and J.L. Richardson

Organization: North Dakota State University, Fargo, ND

Format: Paper

Reference: Symposium on surface coal mining and reclamation in the Northern Great Plains, Billings, MT, 1982

Key Index Words: Topography, Water Management, Vegetation

Brief Description

The relation of topography to water management, vegetative composition, density, and yield is discussed.

Analysis of Conclusions

Topographic conditions are important considerations for optimum post-mining use over a reclaimed area.

Title: **WATER REPELLENCY OF DEGRADED LIGNITE IN A RECLAIMED SOIL**

Authors: J.L. Richardson and N.C. Wollenhaupt

Organization: NDSU-Soils Department, Fargo, and Land Reclamation Research Center, Mandan, ND

Format: Paper

Reference: Canadian Journal of Soil Science 63; 405-407, 1983

Key Index Words: Lignite, Water Repellency

Brief Description

Soil profile samples were collected from a sparsely vegetated location in a 8- to 9-year old reclaimed site at the Indian Head Coal Mine, and analyzed in the laboratory. Presence of water-repellent lignitic material at 35-53 cm in the soil profile was postulated as being the cause of poor vegetation stand. No root growth was found in or below this layer. Lignitic material was also found at 105-120 cm below the surface. No lignitic material existed at sites supporting thick vegetation. Laboratory test showed that the lignitic materials were severely resistant to water penetration. Reduced availability of water and possible chemical toxicities caused by the lignitic material were recognized as probable causes for the poor growth of vegetation.

Analysis of Conclusions

These observations lend support to the regulatory requirement that all coal materials must be covered by suitable thicknesses of soil for revegetation purpose. Presence of lignitic material in the root zone of reclaimed lands can also give a false idea about their organic matter content if appropriate tests are not conducted.

Title: **ALKALINE NEUTRALIZATION CAPACITY OF WEST CENTRAL NORTH DAKOTA OVERBURDEN MATERIALS**

Authors: G. Groenewold, S. Lucken, D. Johansen, and R.D. Koob

Organization: North Dakota MMRRI, University of North Dakota, Grand Forks, ND; and Department of Chemistry, North Dakota State University, Fargo, ND

Format: Paper

Reference: Proceedings of Conference on Municipal, Hazardous and Coal Waste Management, Miami, FL, December 1983

Key Index Words: Trace Elements, Groundwater, Waste Disposal, Fly Ash, Overburden Analysis

Brief Description

Fly ash generates a highly alkaline leachate (pH of 10-12.5). Arsenic and selenium are highly mobile under these high pH conditions. This relationship of trace metals to pH pose a potential groundwater contamination problem. These concerns would be minimized if a natural neutralization capacity existed in the overburden materials surrounding the fly ash disposal sites. The natural carbonate buffer system known to exist may provide this neutralization capacity. Cation exchange capacity was found to be an additional source of neutralization capacity.

Analysis of Conclusions

It is apparent from this study that all of the North Dakota overburden materials tested have the capacity to neutralize alkaline solutions to some degree. If liners in fly ash disposal areas are being required to prevent the migration of trace metals, it appears from this study that there is no sound basis for such a requirement.

Title: **SPATIAL VARIABILITY AND MINERALOGY OF SELECTED MINE SPOILS FROM WESTERN NORTH DAKOTA**

Author: F.E. Rhoton

Organization: NDSU - Land Reclamation Research Center, Mandan, ND.

Format: Report

Reference: North Dakota Agricultural Experiment Station Research Report No. 101, 1983

Key Index Words: Spoil Properties, Spatial Variability, Topography

Brief Description

This study was conducted to determine the spatial variability in some selected physical and chemical properties, and in the clay mineralogy of reshaped spoil materials in a 400-acre area at the Indian Head mine, near Zap, ND. Samples were collected from the root zone in four plots located at summit, shoulder, backslope, and footslope positions along a slope created by regrading operations. The minimum number of samples required to obtain an acceptable estimate of EC, pH, and particle size were used as indicators of spoil variability. Greatest variability in spoil materials, based on EC and sand content, was found at summit and shoulder positions. The mineralogy of the soils and topsoiled spoils was similar, each being dominated by smectite and illite.

Analysis of Conclusions

Determination of spatial variability in reshaped spoils and topsoiled mined lands is important for determining the topsoil thickness requirements and fertilizer management practices, respectively. Research on spatial variability of mine soils should be promoted.

Title: **AN ANALYSIS OF SOIL AND OVERBURDEN PARAMETER REQUIREMENTS FOR NORTH DAKOTA**

Author: N.M. Safaya

Organization: North Dakota Public Service Commission, Bismarck, ND

Format: Paper

Reference: Proceedings of Conference on Soil and Overburden Requirements for Successful Revegetation" (M.B. Berg, ed.), pp. 153-163, Denver, CO, 1983

Key Index Words: Soil properties, Soil Requirements, Soil Types, Toxicity

Brief Description

The North Dakota regulatory requirements pertaining to soils and overburden are discussed in relation to the available scientific information about the types of soils and geological materials found in this area. Adequacy of analytical parameters used for determining the suitability or unsuitability of soil and overburden materials is also discussed. A re-examination of the critical limits established for SAR and EC for suitability of subsoil materials has been stressed in view of some recent work on plant responses to sodicity and salinity.

Analysis of Conclusions

This paper provides a comprehensive picture of the soil and overburden requirements in the North Dakota's current reclamation regulatory program, along with the scientific rationale for the use of various parameters in determining the suitability of soil materials.

Title: **RELATIONSHIP OF SALT MOVEMENT IN RECLAIMED PROFILES TO TOPOGRAPHY**

Author: G.A. Halvorson

Organization: NDSU-Land Reclamation Research Laboratory, Mandan, ND

Format: Paper

Reference: Proceedings of Symposium on Soil and Overburden Requirements for Successful Revegetation, Denver, CO, 1983

Key Index Word: Sodicity, Sodium, Topography, Leaching,

Brief Description

This study focused on the movement of salts (primarily sodium, calcium, and magnesium) across the spoil-topsoil interface. Sodium had moved across the interface into replaced topsoil although the quantity and distance of upward movement was dependent on the replaced soil depth. Calcium and magnesium had not moved appreciably. Where no topsoil was replaced, leaching of salts occurred.

Analysis of Conclusions

Data presented in this report, although preliminary, will serve to determine where upward salt movement is occurring in reclaimed land and the extent to which it will occur at a given landscape position. This information, along with data from other studies (See SP-38, SR-6, SR-7), can be used to predict salt movement in reclaimed lands, and to determine post-mining land use.

Title: **SOIL WATER VARIATION IN SPOIL AND UNDISTURBED SITES IN NORTH DAKOTA**

Authors: S.A. Schroeder and A. Bauer

Organization: NDSU-Land Reclamation Research Center, Mandan, ND

Format: Paper

Reference: Soil Science Society of America Journal 48:656-659, 1984

Key Index Words: Soil Water, Hydraulic Conductivity, Infiltratiom, Field Capacity

Brief Description

Soil water contents were monitored over a 7 year period on reshaped, vegetated spoil and nearby undisturbed grassland sites at Center, Stanton, Beulah and Zap in North Dakota. During the length of the study, very little, if any, water percolated beyond the rooting zone (0-122 cm) at either the spoil or undisturbed sites. Measured soil water contents never approached estimated field capacity for the spoil or undisturbed sites.

Analysis of Conclusions

The study indicated that precipitation retained at the point of fall did not percolate beyond the 122 cm depth and, therefore, probably does not contribute to groundwater recharge in this area. This suggests that groundwater recharge due to precipitation probably occurs only on landscape positions where ponding results from runoff. The conditions needed for downward saturated flow in medium and fine textured spoil materials are unlikely in a semiarid region except for run-on landscape positions. Additional research should include coarse textured spoil materials and reconstructed soils.

Title: **IN-SITU SATURATED HYDRAULIC CONDUCTIVITY AND WATER-HOLDING CAPACITY OF UNDISTURBED AND SURFACE MINED SITES**

Authors: J.E. Gilley, S.A. Schroeder, and D.D. Schlenker

Organization: NDSU - Land Reclamation Research Center, Mandan, ND

Format: Report

Reference: North Dakota State University Agricultural Experiment Station Research Report No. 102, May 1984

Key Word Index: Hydraulic Conductivity, Water Holding Capacity, Infiltration

Brief Description

In this study, water transmission and storage characteristics of undisturbed soil, nonsodic spoil, sodic spoil and topsoiled spoil were studies. The test sites were established at the Indian Head Mine. Each site consisted of a 10-foot square study area (monolith) which was isolated from the surrounding area by polyethylene sheeting to prevent lateral water movement. Water movement in the profile was restricted at the undisturbed and topsoiled sodic spoil sites. Infiltration on the sodic spoil was minimal. Saturated hydraulic conductivity of 1.5 inches per hour was measured at the nonsodic spoil sites.

Analysis of Conclusions

The study concluded that for determining water transmission and storage capacity of reclaimed lands, it may be necessary to identify the properties of soil profile up to a depth of 10 feet. This conclusion has a strong bearing on the current efforts of LRRC scientist to establish productivity indices for reclaimed lands.

Title: **REPORT TO BAUKOL-NOONAN, INC. ON RESEARCH CONDUCTED AT THE BAUKOL-NOONAN, INC. MINE NEAR CENTER, ND, 1984**

Authors: NDSU-Land Reclamation Research Center Staff

Organization: NDSU-Land Reclamation Research Center, Mandan, ND

Format: Report

Reference: Unpublished

Key Index Word: Stockpiled Soil, Soil Properties

Brief Description

Core samples were taken at 1-foot increments to a depth of 10 feet at four locations on a topsoil stockpile at Baukol Noonan's Center Mine. These samples were then tested for bulk density and moisture content.

Analysis of Conclusions

No conclusions were drawn at this time. However, this study will provide information about the changes that occur in the physical properties of soils when stockpiled.

Title: **DIAGNOSTIC ASPECTS OF ALGAL ECOLOGY IN DISTURBED LANDS**

Authors: L.E. Shubert, and T.L. Starks

Organization: University of North Dakota, Grand Forks, ND

Format: Chapter

Reference: Soil Reclamation Processes - Microbiological Analyses and Application (R.L. Tate and D.A. Klein, eds.) 1985 Marcell Dekker, Inc., New York

Key Index Word: Microbiology, Soil Properties, Soil Productivity, Soil Algae

Brief Description

This chapter consolidates past studies on the microbiological aspects of mined lands and correlates patterns of algal colonization and succession with soil properties in order to generate conceptual models to predict the degree of re-establishment of equilibrium in the recovery process. Microbial populations appear to offer a rapid and sensitive method of determining the resiliency and stability of reclaimed surface soil ecosystems.

Analysis of Conclusions

The study of soil algae as an ecological indicator in the reclamation of mined lands is still in its infancy. Further research in areas of physiology and nutrition, ecosystem stability and other pertinent ecological premises are required for the development of more sophisticated models. This concept could be advanced to many other areas in which environmental impacts are considered.

Title: **ENUMERATION AND CHARACTERIZATION OF NITROGEN-FIXING BACTERIA IN A STRIPMINE SITE**

Authors: M.J. Jacobs, B.R. Funke and S.D. Merrill

Organization: Department of Bacteriology, NDSU and USDA-ARS Northern Great Plains Research Laboratory, Mandan, ND

Format: Paper

Reference: Plant and Soil 84: 3-10, 1985

Key Index Word: Nitrogen, Microbiology

Brief Description

The inputs of microorganisms capable of heterotrophic nitrogen fixation, while limited to a few kilograms per year, are considered to be significant in the successful establishment of grasslands. This study was conducted to enumerate and identify nitrogen-fixing bacteria in the rhizospheres of perennial grasses in graded spoil, with or without cover topsoil, during active growing and dormant periods. The total number of bacteria were higher in the no topsoil plots, however, the ratio of nitrogen-fixers to other bacteria was higher in the plots with covered with topsoil. The species of nitrogen-fixers identified were comparable to those observed in other similar habitats except that Bacillus spp. outnumbered the Enterobacteriacea in this study.

Analysis of Conclusions

An interesting study which begins to explore the role of soil bacteria in the reclamation of mined lands.

Title: **USE OF SOIL PARAMETERS IN THE EVALUATION OF RECLAMATION SUCCESS IN NORTH DAKOTA**

Authors: E.C. Doll and N.C. Wollenhaupt

Organization: USDA-ARS, Northern Great Plains Research Laboratory, Mandan, ND

Format: Paper

Reference: Proceedings of National Meeting of American Society for Surface Mining and Reclamation, pp. 91-94, Denver, Colorado, 1985.

Key Index Word: Reclamation Success, Productivity

Brief Description

The authors contend that vegetative productivity comparisons of reclaimed to reference areas with 90% statistical confidence, a current determinant of reclamation success in North Dakota, are both difficult and unreliable because of variation in climatic, biotic and management factors. They suggest that the degree of productivity re-establishment can be reliably estimated from measurements of total pore space and pore space continuity in reclaimed soils. They have provided a model to calculate the productivity indices of soils to quantify these types of data. Vegetative measurements would be, however, necessary in this system to estimate the stage of soil restorations and to verify the measured root zone properties.

Analysis of Conclusions

Field research is necessary to determine the accuracy and applicability of these criteria for determining reclamation success.

Title: **PREDICTING UNSATURATED HYDRAULIC CONDUCTIVITY OF SODIC SOILS**

Authors: S.D. Merrill and E.J. Doering

Organizations: USDA-ARS Northern Great Plains Research Laboratory, Mandan, ND

Format: Paper

Reference: American Society of Agricultural Engineers, 1985 Summer Meeting, East Lansing, MI, June 24-26, 1985

Key Index Word: Sodicity, Infiltration, Soil Properties

Brief Description

Spoil materials from four mines in the Northern Great Plains were used to experimentally determine unsaturated hydraulic conductivity for comparison with theoretically determined values. Theoretical values, which were based on the relationship between water content and matric potential, were higher than the experimentally determined values for sodic spoils. The results indicated that theoretical determination of unsaturated hydraulic conductivity is not completely reliable for sodic, dispersed, clayey spoils.

Analysis of Conclusions

This paper contributes additional information to our understanding of sodic, clayey spoils and their effect on water movement and availability. The study clearly shows the influence of sodicity on water movement.

Title: **SOIL-WATER CHARACTERISTICS OF CONSTRUCTED MINESOILS AND ASSOCIATED UNDISTURBED SOILS IN SOUTHWESTERN NORTH DAKOTA**

Author: N. Wollenhaupt

Organization: NDSU - Land Reclamation Research Center, Mandan, ND

Format: M.S. Thesis

Reference: M.S. Thesis, College of Agriculture and Applied Science, North Dakota State University, Fargo, ND, P., 1985

Key Index Word: Reclamation Success, Soil Properties, Productivity

Brief Description

Reclaimed and undisturbed soils were compared using measurements of bulk density, aggregate stability, water retention, and hydraulic conductivity. A soil root growth environment model was used to predict the potential productivity of constructed soils. Bulk density of reclaimed soils was significantly higher than undisturbed soils in the upper 60 cm. Available water holding capacities and aggregate size distribution of the two soils were similar. The hydraulic conductivity of reclaimed soils was consistently lower than that of undisturbed soils.

Analysis of Conclusions

This study provided very useful information concerning changes in physical soil properties during mining and reclamation. The difference in bulk density between reclaimed and undisturbed soils is critical to calculation of suitable plant growth material (SPGM) volumes available for respread. The productivity index model has the potential to become an indicator of revegetation success which eliminates problems associated with climatic variability and varying management practices. The model also may be used to plan SPGM salvage and respread operations and maximize the use of available SPGM. The model will need further refinement and correlation with actual yields before it can be implemented. Moreover, additional studies may be necessary to evaluate the effects of soil texture, moisture content and respreading techniques on the degree of compaction (increase in bulk density) of respread soils.

Title: **SALT MOVEMENT IN 9-YEAR-OLD RECLAIMED SOIL-SPOIL PROFILES**

Author: B.M. Holmes

Organization: NDSU - Land Reclamation Research Center, Mandan, ND

Format: M.S. Thesis

Reference: M.S. Thesis, College of Agriculture and Applied Science, North Dakota State University, Fargo, ND P., 1985

Key Index Word: Salinity, Sodicity, Spoil Properties

Brief Description

This study examined the magnitude and direction of salt movement in 9-year-old experimental plots. Core samples were taken from the Stanton wedge experiment and analyzed for soluble salts, sodium, calcium, magnesium, carbonates, bicarbonates, chlorides, and sulfates. Results indicated that all measured ions leached downward into spoil in profiles with 90 cm or less topsoil and subsoil. Salts had leached from the upper 60 cm in profiles containing more than 90 cm topsoil and subsoil. The author concluded that no evidence existed which would indicate that significant upward sodium migration had occurred. Sodium ion concentration peaks remained as sharp as calcium and magnesium peaks below 90 cm in plots with 90 cm or more topsoil and subsoil.

Analysis of Conclusions

Results of this study indicated that sodium accumulation near the soil/spoil interface may be a result of leaching of sodium from topsoil rather than upward migration from sodic spoil. Although peak concentrations remained below the soil spoil interface, raw data from the study indicated that elevated sodium and SAR levels were found above the soil/spoil interface. Sodification of at least 10 to 15 cm of subsoil had occurred in several profiles. This information along with data from other studies (See SP-31, SR-6, SR-7) can be used to evaluate the potential for salt movement in reclaimed lands.

Title: **NEUTRON MOISTURE METER CALIBRATION FOR MINE SPOILS CONTAINING COAL**

Author: G.A. Halvorson

Organization: NDSU - Land Reclamation Research Center, Mandan, ND

Format: Paper

Reference: Soil Science Society of America Journal 50: 496-498, 1986

Key Index Words: Soil Moisture, Neutron Moisture Meter, Spoil Properties

Brief Description

The objective of this study was to determine the effects of coal fragments in mine spoil on soil-water determinations by the neutron meter method. Calibrations were conducted on clay loam and loamy sand mine spoils, in the presence and absence of a known amount of added coal. In the presence of coal, the volumetric water content of the spoil materials was over-estimated by the neutron moisture meter method because of the structural hydrogen in coal. By accounting for the water equivalent from the hydrogen content of coal, the calibration curve could be corrected.

Analysis of Conclusions

Because of large variability in the amount and size of coal fragments in mine spoils, accurate calibration and precise measurement of moisture meter method are difficult. However, the method is suitable where only relative differences in water content over time are to be determined.

Title: **A RAPID METHOD FOR ESTIMATING WEIGHTED SOIL SALINITY FROM APPARENT SOIL ELECTRICAL CONDUCTIVITY MEASURED WITH AN ABOVEGROUND ELECTROMAGNETIC INDUCTION METER**

Authors: N.C. Wollenhaupt, J.L. Richardson, J.E. Foss, and E.C. Doll

Organization: NDSU - Soils Department, Fargo, and Land Reclamation Research Center, Mandan, ND

Format: Paper

Reference: Canadian Journal of Soil Science 66: 315-321, 1986

Key Index Words: Salinity, Soil Properties, Electromagnetic Induction

Brief Description

This paper describes a method for calibrating electromagnetic induction (EM) meters used for measuring electrical conductivity (soil salinity). The EM meter readings (representing integrated values of electrical conductivity over the meter's response depth) were correlated with weighted electrical conductivity values for the soil profile determined by the saturation paste method. The resulting regression equation provided a reliable method for quick assessment of salinity in the rooting zone.

Analysis of Conclusions

This is a quick technique for measuring salinity in soil associations of similar parent materials, and therefore useful for soil and range surveys. However, it does not replace soil sampling and testing by conventional method where specific data for electrical conductivities is needed.

Title: **OVERWINTER SOIL WATER ACCUMULATION IN VEGETATED RECLAIMED MINE LAND SPOIL**

Authors: S.A. Schroeder, J.W. Enz, and A. Bauer

Organization: NDSU - Land Reclamation Research Center, Mandan, ND

Format: Report

Reference: Land Reclamation Research Center Technical Report No. 6, 1986

Key Index Words: Soil Water, Infiltration, Spoil Properties, Groundwater

Brief Description

The objectives of this study were to measure the accumulation of soil water from winter precipitation in profiles of vegetated spoils at the Center, Beulah and Indian Head Mines, and to determine which physical or chemical site characteristics are most important in this respect. Soil water was measured in 1-foot increments to a depth of 4 feet by neutron moisture probe; physical and chemical characteristic of soil profiles were studies up to 5 feet depth, and vegetation and topographic data was also collected. Soil water accumulation ranged from -2.0 to 4.4 inches during a 4-year period. Total water monitored over time showed very slight changes at depths greater than 2 feet.

Analysis of Conclusions

Soil water accumulation models based on data from each site were better than those based on data from all sites. Inclusion of other site related data improved the models but further studies would be required to define their effects. This research needs to be continued and expanded to include subsoiled plus topsoiled sites. The need for continuing such studies is dictated both by revegetation and groundwater recharge considerations.

Title: **SATURATION PERCENTAGE**

Authors: S.D. Merrill, J.R. Deutsch, and M.W. Pole

Organization: USDA-ARS, Northern Great Plains Research Laboratory, Mandan; North Dakota Public Service Commission, Bismarck; and the North American Coal Corporation, Bismarck, ND

Format: Chapter

Reference: Reclaiming Mine Soils and Overburden in the Western United States - Analytic Parameters and Procedures (R.D. Williams and G.E. Schuman, eds.), pp. 35-58, SCSA, Ankeny, Iowa, 1987

Key Index Words: Saturation Percentage, Sodicity, Sodium Adsorption Ratio, Exchangeable Sodium Percentage, Soil Water, Water Holding Capacity

Brief Description

This paper reviews research information on saturation percentage and discusses the application of this information to mined lands in the western United States. The discussion includes a review of analytical and procedural methods, the relationship of saturation percentage to other soil parameters, and quantitative guidelines for regulators.

Analysis of Conclusions

This paper provides an excellent summary of research data on saturation percentage. This information is applicable to North Dakota reclamation since saturation percentage is one of the criteria used to determine the suitable plant growth material respread thickness under the current regulations.

Title: **CADMIUM AND ZINC**

Authors: N.M. Safaya, J.E. McLean, and G.A. Halvorson

Organization: North Dakota Public Service Commission, Bismarck, ND, Utah Water Research Laboratory, Logan, UT, and NDSU-Land Reclamation Research Center, Mandan, ND

Format: Paper (Chapter)

Reference: Reclaiming Mine Soils and Overburden in the Western United States: Analytic Parameters and Procedures (R.D. Williams, G.E. Schuman, eds.), pp.283-311, Soil Conservation Society of America, Ankeny, IO, 1987

Key Index Words: Trace Elements, Spoil Properties, Toxicity, Overburden Analysis

Brief Description

This paper provides an overview of the biological importance, geochemical abundance, chemistry and bioavailability, and methods of measuring cadmium and zinc in soil and overburden materials. Soil, plant, and management factors controlling the uptake of these elements by plants and subsequent distribution in the food chain are also discussed. The objective of this paper was to determine, from literature survey, whether the routine analysis of these elements in the western soil and overburden materials is warranted; and if so, what methods of analysis are appropriate for this purpose.

Analysis of Conclusions

The information provided in this paper is useful to both basic and applied scientists dealing with agricultural or environmental issues. It was concluded that cadmium and zinc may pose some serious problems in the reclamation of acidic mine spoils encountered in the eastern U.S., but in the western U.S., where the overburden materials are generally neutral to alkaline, the likelihood of these problems is small. However, some abandoned mine lands in the western U.S. are acidic, and may therefore require monitoring for cadmium and zinc toxicities.

Title: **PHYSICAL PROPERTIES OF CONSTRUCTED AND UNDISTURBED SOILS**

Authors: K.N. Potter, F.S. Carter, and E.C. Doll

Organization: NDSU-Land Reclamation Research Center, Mandan, ND

Format: Paper

Reference: Soil Science Society of America Journal 52:1435-1438, 1988

Key Index Words: Bulk Density, Pore Size Distribution, Hydraulic Conductivity

Brief Description

Physical and hydrologic characteristics of 4- and 11-year old reconstructed mine soils at the Glenharold Mine were studied. The reclaimed soils were compared to a similar soil from an undisturbed soil area. Bulk density, pore size distribution, and hydraulic properties were substantially different in the reclaimed soil than in the undisturbed soil. Hydraulic conductivity was lower in the reclaimed soils than in the undisturbed soil. Bulk density of the reclaimed soils was greater than in the undisturbed soils. Macroporosity was affected more than microporosity by reclamation activities.

Analysis of Conclusions

The results of this study suggest that soil physical and chemical parameters have potential for use as an index of reclamation success. However, this would require additional research to establish minimum acceptable standards.

Title: **SOIL WATER DEPLETION UNDER CROPS ON RECLAIMED AND UNDISTURBED LANDS**

Authors: S.A. Schroeder and G.A. Halvorson

Organization: NDSU-Land Reclamation Research Center, Mandan, ND

Format: Paper

Reference: Journal of Environmental Quality 17(1):130-134, 1988

Key Index Words: Soil Water, Water Use, Productivity, Topsoil

Brief Description

Undisturbed and simulated reclaimed soils at the Falkirk Mine were compared over a four year period for such factors as soil water depletion, total water useage, and crop yields. Net soil water depletion under small grain or corn was consistently, but not always significantly, less in reclaimed than in undisturbed soil profiles. Soil water depletion in the reclaimed soil was affected by topsoil thickness and spoil texture through effects on available water at planting and root penetration. When precipitation was inadequate or poorly distributed, yields were significantly less on reclaimed soils. This is probably due to shallower rooting on the reclaimed soils.

Analysis of Conclusions

Additional research is needed to determine if different methods of soil or crop management can enhance water and root penetration in reclaimed soils.

Title: **TILLAGE EFFECTS ON BULK DENSITY DURING RECLAMATION OF MINED SOIL**

Author: S.A. Schroeder

Organization: NDSU-Land Reclamation Research Center, Mandan, ND

Format: Paper

Reference: North Dakota Agricultural Experiment Station Farm Research 46(1):13-16, 1988

Key Index Words: Compaction, Bulk Density, Soil Replacement, Tillage

Brief Description

This study was conducted at the Center and Coteau (Freedom) Mines to determine if soil compaction can be reduced during reclamation operations. Several different treatments to the subsoil layer such as, deep ripping with a dozer, grader ripping, chiseling, and deep lift respread (respreading subsoil as thick as possible with minimum traffic), were employed. Following topsoil respreading several additional tillage treatments were performed. Soil compaction was then tested by taking soil cores at 6" vertical increments from each of the treatment areas and checking them for bulk density. None of the subsoil treatments were found to be effective because heavy equipment traffic during topsoil respreading negated any positive effects of the treatments. Some effect of the topsoil tillage treatments on bulk density remained in that values near the surface were lower than those at greater depths.

Analysis of Conclusions

Soil compaction is a serious problem in reclaimed soils. Further research is necessary to identify methods of reducing compaction after most or all traffic necessary for reclamation has been completed.

Title: **SPATIAL VARIABILITY IN THE CHEMICAL AND PHYSICAL PROPERTIES OF REGRADED MINE SPOIL**

Author: G. Halvorson

Organization: NDSU-Land Reclamation Research Center, Mandan, ND

Format: Paper

Reference: Proceedings of the Conference "Reclamation, A Global Perspective (D.G. Walker, C.B. Powter and M.W. Pole, eds.), pp. 589-595, Calgary, Alberta, August 1989

Key Index Words: Spoil Properties, Overburden Analysis, Reclamation, Sampling Methods

Brief Description

An expanding square sampling scheme was used on graded spoil areas at four mines in North Dakota to compare spoil variability from a small area with that in a large area. An attempt was then made to match premine overburden properties with those from the regraded spoil. This was done to determine the variability of regraded spoil, the depth of sampling necessary to characterize this variability, and ultimately to predict regraded spoil properties from premining overburden sampling data. Results indicated that considerable mixing of the overburden occurs during the mining and reclamation process. Difficulties were encountered in matching the premine overburden with regraded spoil properties because the degree of surface grading was not predictable. Sampling to a depth of 1.2 m in 0.3 m increments did not significantly improve information on variability of spoil properties compared to the surface 0.3 m alone.

Analysis of Conclusions

This project illustrates the difficulty in developing an accurate model which could predict the properties of regraded spoil based on premine overburden data. More research is needed in this area.

Title: **PREDICTING REGRADED SPOIL QUALITY FROM OVERBURDEN PROPERTY**

Author: G.A. Halvorson

Organization: NDSU-Land Reclamation Research Center, Mandan, ND

Format: Report

Reference: Report to the North Dakota Legislative Council, Pursuant to Section 5 of H.B.1005 of the fifty-second Legislative Assembly; pp. 9, June 30, 1993.

Key Index Words: Spoil Properties, Overburden Analysis, Sampling Methods

Brief Description

This report contains the results of sampling experiments conducted at the Coteau and Falkirk Mines to determine if the properties of the graded spoil could be predicted by the bore hole data of the undisturbed overburden. If such a prediction were possible, it would help estimate the amount of topsoil and subsoil that would need to be removed for eventual respreading at depths determined by the properties of the underlying spoil. The properties studied included SAR, EC, pH and percent sand, silt and clay. The results indicated that predictability of spoil properties was limited by the degree of variability in the overburden properties and the extent of regrading involved.

Analysis of Conclusions

As concluded in the previous research brief, this report affirms that predicting the properties of regraded spoil based on premine overburden data analysis is difficult in most cases.

Title: **STATUS OF A PRODUCTIVITY INDEX FOR EVALUATING RECLAMATION SUCCESS FOR BOND RELEASE**

Authors: G. A. Halvorson, S. A. Schroeder, and M. Nathan

Organization: NDSU-Land Reclamation Research Center, Mandan, ND

Format: Report

Reference: Report to the North Dakota Legislative Council, Pursuant to Section 5 of H.B.1005 of the fifty-second Legislative Assembly; pp. 31, June 30, 1993.

Key Index Words: Productivity Index, Topography, Soil Properties

Brief Description

This report summarizes the concept of Productivity Index (PI) - a measure of soil productivity based on soil and landscape properties instead of plant production data - as a method for assessing reclamation success. It also provides some discussion and data on those soil and landscape properties that are included in the PI model. The data provided in support of the PI concept and its further development have been taken from a large number of independent studies with absolutely different objectives.

Analysis of Conclusions

No final conclusions are drawn in this report; neither is there a productivity index developed and/or tested. The need for additional work in this area has been stressed.

Title: **WATER RETENTION BY SOILS CONTAINING COAL**

Author: P. P. Sharma, F. S. Carter, and G. A. Halvorson

Organization: NDSU-Land Reclamation Research Center, Mandan, ND

Format: Paper

Reference: Soil Science Society of America Journal 57:311-316, 1993.

Key Index Words: Infiltration, Coal, Lignite, Spoil Properties

Brief Description

Water retention by minesoils containing various amounts of commercial (highly water repellent) and degraded (low water repellent) lignite was studied under laboratory conditions. Subsoil and minespoil of sandy loam, loam, and sodic silty clay loam characteristics were used to obtain bulk mixtures with coal content of 5, 10, 15, 25, and 50%. Subsamples of the components and mixtures were wetted with water and desorbed at air pressures ranging from 5 to 1500 kPa. Water content of the mixtures was linearly proportional to the coal content. From the soil water content vs. pressure head relationships of the ingredients (soil and coal), water contents of soil-coal mixtures were predicted by using mass and volume balance interpolation equations. At all pressure heads, the predicted volumetric water contents approximated the measured values with a high degree of accuracy.

Analysis of Conclusions

Since coal fragments are always present in reclaimed soils, this study is definitely relevant for understanding how coal may affect water retention and infiltration in minesoils. However, in the present study coal was mixed homogeneously with soil, which does not reflect the actual field conditions. The authors are aware of this, and have indicated that this study provides a basic framework for understanding water retention properties of mine soils.

Title: **CHANGES IN BULK DENSITY OVER TIME OF SEMIARID RECLAIMED MINELANDS IN NORTH DAKOTA**

Author: S. A. Schroeder

Organization: NDSU-Land Reclamation Research Center, Mandan, ND.

Format: Paper

Reference: Planting, Rehabilitation and Treatment of Disturbed Lands, Seventh Billings Symposium, pp. 9-16, Billings, MO, 1996.

Key Index Words: Compaction, Bulk Density, Infiltration, Root Zone

Brief Description

Minesoil bulk density data collected from five reclaimed sites was reviewed to assess if any changes had occurred over a period of five or more years. Most soil cores were taken to a depth of 1.5m. The temporal effects on bulk density were generally non significant. The mean bulk density values of the upper 0.3 m thick layer remained relatively stable. At depths greater than 0.3 m the bulk densities increased with time.

Analysis of Conclusions

The author postulates that tillage, weather, and root proliferation in the are the main factors that caused the bulk density in the upper soil layer to remain stable with time. Increase in bulk density with in the deeper soil layers is attributed to soil settling and drawdown of soil water. These conclusions are valid, and point to the fact that compaction in the deeper layers of reclaimed lands is a problem that begs for a solution.

Title: **SOIL QUALITY EVALUATION FOR RECLAMATION SUCCESS: AN ALTERNATIVE MITIGATION PARADIGM**

Authors: P. P. Sharma and E. Doll

Organization: NDSU-Land Reclamation Research Center, Mandan, ND.

Format: Paper

Reference: Planting, Rehabilitation and Treatment of Disturbed Lands, Seventh Billings Symposium, pp. 17-27, Billings, MO, 1996.

Key Index Words: Root Zone, Water Management, Infiltration, Compaction, Wetlands

Brief Description

This paper critiques the present practice of spoil regrading and soil respreading and proposes to replace this paradigm with another based on the concept of soil quality and its effect on landscape hydrology. The reclaimed lands have a compacted subsoil layer that limits root growth, and transport and storage of water. The reclamation success is proposed to be evaluated on the basis of pore structural basis of root zone soil quality. This proposition is based on the premise that by routing water through root zone instead of collecting in the sedimentation basins and then releasing it off mine, the agricultural sustainability of uplands, quality of wetlands, and groundwater recharge will be improved.

Analysis of Conclusions

There is much scientific merit and economic sense in this integrated approach. The time to test this idea has come, but it will require a commitment of adequate funds.