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DISPOSAL OF COAL PREPARATION WASTES: ENVIRONMENTAL CONSIDERATIONS

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ABSTRACT

The mineral wastes from coal preparation and mine development constitute a major environmental problem. Over 3-billion tons of these materials have accumulated in the U.S., and the current annual rate of waste production of 100-million tons per year is expected to double within a decade. The total number of active and abandoned coal waste dumps is estimated to be between 3000 and 5000. About one-half of these pose some type of health, environmental or safety problem. Structural weaknesses in coal refuse banks have led to tragic landslides such as those at Buffalo Creek, WV and Aberfan, Wales. Coal refuse dumps are also one of the sources of highly mineralized, acidic drainage, which affects more than 10-thousand miles of streams and waterways, and the 300 or so burning waste banks are a major source of air pollution. In addition to these problems, there is growing concern about possible environmental effects from the trace elements in the coal waste materials. In this paper, we describe the various forms of environmental pollution from coal mineral wastes, the extent and seriousness of each, and some of the control methods which are being used to alleviate or lessen the environmental impact.

1.0 INTRODUCTION

Coal, as mined, contains a great deal of extraneous rock and mineral matter. These inorganic constituents usually constitute about 10% to 20% of raw coals, but they can run as high as 50% for some coals.[1] The rock and mineral matter is expensive to ship, and it dilutes the caloric content of the coal, but, of most importance from an environmental viewpoint, these impurities produce undesirable gaseous and particulate pollutants when the coal is burned. Therefore, about one-half of the total coal mined in the U.S. is prepared or cleaned prior to utilization to remove some of the noncombustible materials.[2] The discarded rock, mineral and coaly matter from coal cleaning, together with other coal mine refuse, are the major constituents of the gob piles and culm banks, which are scattered over thousands of acres in coal-producing regions.

According to recent estimates, nearly three-billion tons of carbonaceous mineral wastes have accumulated in the U.S. as a result of coal preparation and mine development.[2] Increased coal production, wider use of indiscriminate mining techniques, improved cleaning methods, and greater emphasis on clean fuels will undoubtedly increase the rate at which wastes accumulate. A vivid example of this trend is the ten-fold increase in the rate at which wastes have been produced since 1940.[2] Although there has been a recent trend by

"Superior numbers refer to similarly-numbered references at the end of this paper."

utilities to use larger amounts of uncleaned coal, it was estimated recently that the current rate of waste production of 100-million tons per year will double by 1980.[2]

2.0 THE PRODUCTION OF REFUSE BY COAL PREPARATION

Cleaning of raw coals to remove some of the unwanted mineral matter has been done for more than a half-century.[3] Environmental concern about air pollution from sulfur dioxide has focused attention on the removal of sulfur from the coal. The newer preparation plants can recover about 90% of the BTU content of coals, while reducing sulfur content to less than 1%.[4]

Coal preparation involves a series of crushing, sizing, separating and drying steps to produce a cleaner burning product.[3,4] Prior to cleaning, the raw coal is generally crushed to at least minus 6-in. pieces.* After sizing, the coal is separated from the heavier mineral matter by various mechanical techniques, utilizing for the most part density differences as the basis for separation. This is accomplished primarily by jigs, cyclones or heavy-media baths. The cleaned coal is normally dried before it is shipped from the plant. The reject mineral waste or refuse from coal preparation is transported from the plant by conveyors or trucks and deposited in nearby disposal areas. Process water and suspended fines are fed into slurry ponds or settling basins. Sometimes, the finer coal (< 1 mm) is cleaned by froth flotation methods; the wastes from this process are also deposited in slurry ponds.

The refuse from coal cleaning is discharged from the preparation plant as a wet aggregate-like material. It is heterogeneous in both size and composition. Coal cleaning wastes are composed principally of rock and mineral matter (80% or more), but they also contain a small amount of residual coal. The major mineral constituents of these waste materials are clays, quartz, pyrites, and carbonates.[5] This reject material represents, on the average, about 20% of the raw coal.[6]

3.0 ENVIRONMENTAL PROBLEMS ASSOCIATED WITH COAL MINERAL WASTES

Coal refuse dumps can cover from one to over one-hundred acres, and may range from 20 to more than 300 feet in height or depth.[6] Most refuse piles are small, less than 500,000 cubic yards, but the bulk of the refuse resides in the very large piles, those greater than 1.5-million cubic yards.[7] The total number of sizeable active or abandoned refuse piles or impoundments is 3000-5000.[2] Of the 961 refuse piles studied by the Department of Interior in 1968, over one-half posed some form of health or safety hazard.[2] The major environmental problems associated with discarded coal cleaning refuse are: waste bank instabilities, contaminated drainage and noxious emissions from burning wastes.

*Although it is the policy of Los Alamos Scientific Laboratory to report measurements in the international system of metric units, for clarity of presentation, the units used in this paper are reported directly as they appear in the references.

3.1 Waste Bank Instabilities

Coal refuse disposal sites have been chosen more often for convenience than as appropriate places to safely dump and store the waste materials. Areas frequently used for refuse disposal include valleys, hillsides, swamps and settling basins.[8] Wastes have been piled on vegetation and top soil, near streams and residential areas. Sometimes these materials are dumped on inclines, in which case the larger rocks roll to the bottom and the finer refuse stays at the top, producing a segregated mass. These conditions, coupled with the fact that most coal wastes are poor engineering materials to begin with, occasionally produce structural instabilities in the waste piles that result in tragic consequences. A flood caused by the collapse of a refuse retaining dam at Buffalo Creek, WV in 1972, killed 116 people, and a waste bank slide at Aberfan, Wales in 1966 resulted in the deaths of 144 people, 109 of them school children. Both incidents are stark testimony to poor dumping practices.[2]

In the past five years, considerable effort has been put forth to define and alleviate the conditions responsible for refuse bank instabilities.[9] Even so, many of the older, abandoned refuse piles still pose serious structural problems.[2]

3.2 Water Contamination from Coal Refuse Dumps

The weathering and leaching of coal refuse dumps produces several types of water contaminants. These include silt, acids and dissolved mineral matter.[1,2,5] In all, about 2000 coal waste dumps are thought to be contributing to stream or waterway pollution.[2]

Siltation of the drainage from coal refuse dumps is caused by finely divided coal, minerals and discarded soil. This form of contamination is generally controllable by utilizing impoundment areas where the particles settle or are filtered as the water passes through a retaining barrier.[2]

Acid drainage occurs when iron sulfides (pyrite or marcasite) are exposed to air and water.[1,2] The sulfur is oxidized to sulfuric acid and the iron is liberated as iron sulfate. Typically, 1.5 to 2 pounds of acid and 0.5 to 0.7 pounds of soluble iron are produced per acre of refuse per day, but, in some highly mineralized areas, acid has formed at a rate of more than 300 pounds per acre per day.[2] The acids formed in refuse dumps run off into drainage areas or percolate through the pile, where considerable mineral matter is dissolved. Some of the flow from refuse dumps eventually reaches subsurface water systems. Acid drainage lowers the pH of lakes and streams, making the growth of aquatic life, which functions best under slightly basic conditions, difficult.[10] The dissolved iron in refuse or mine drainage forms ferric hydroxide, "yellow boy", which settles out on the stream bottom.[2] Quite effective in smothering lifeforms, "yellow boy" leaves a desolate terrain of yellow-orange streams and soil.

Acid drainage is one of the most serious water pollution problems in many parts of the U.S. In Appalachia alone, more than 10,000 miles of streams are affected by acids from coal mines and refuse dumps.[11] It is estimated that 3.5-million tons of sulfuric acid entered the inland waterways in 1962 from coal-mine-related sources.[12] About 70% of the acid drainage is supplied by inactive, underground mines.[11] Coal preparation plants and refuse areas are responsible for much of the remainder of the acidic effluents.

In addition to acids, the aqueous drainage from coal refuse usually contains considerable dissolved mineral or inorganic matter.[13] The drainage from coal refuse dumps typically contains high concentrations of Fe, Al, Ca, Mg and SO_4 ions, which are derived from the major minerals in the waste. The highest concentrations of total dissolved species - in the range of 1 to 5 wt % - are found in the more highly acidic solutions. Many of these dissolved elements are detrimental to soils and destructive to plant and aquatic life in levels well below those found in the effluents from coal refuse dumps. For example, it has been reported that as little as 400 ppm of Fe or Al ions in soils can result in the mortality of plants, and that fish kills may be caused by concentrations of these ions as low as 0.5 ppm.[14,15] The well-documented inability of coal mineral wastes to support vegetation is also thought to result from the toxic amounts of Fe, Al and Mn present in these materials.[14]

In addition to these well recognized problems, another potential class of water-borne contaminants is gaining recognition. Coal wastes contain a broad array of trace or minor elements.[5] Many of these elements, such as lead, cadmium, arsenic, selenium, mercury, etc. are of considerable concern because of the low tolerances of plants and animals for them. Undoubtedly some of these trace elements are carried into the environment by the aqueous leaching of refuse. Although the relative amounts of these components per unit of waste is usually small, the total absolute amount of each available in a large waste bank could cause grave consequences in water or soil if they were to be concentrated in the environment by natural processes.

3.3 Atmospheric Contamination by Burning Coal Wastes

Air pollution from burning refuse piles is also a major problem. Fires in refuse dumps have been occurring for over one-hundred years.[8] Some wastes have been burning continuously for over 20 years. This particular problem has received considerable attention in the last decade, but it is estimated that there are still approximately 300 coal waste piles now burning.[5] Burning coal refuse is responsible for approximately 1% of the nationwide total of air pollution by carbon, sulfur, and nitrogen oxides and hydrocarbons.[7] Burning waste piles are generally located close to small communities, but a few are in areas populated by more than 100,000 people.[7]

4.0 CONTROL OF ENVIRONMENTAL POLLUTION FROM COAL PREPARATION WASTES

In recent years, attempts have been made to circumvent some of the environmental problems associated with discarded coal refuse. Particular attention has been given to alleviating waste bank instabilities and to preventing and controlling acid drainage.

4.1 Prevention of Waste Bank Structural Instabilities

Refuse bank instabilities result from inadequate attention to materials parameters and failure to follow sound disposal practices. Recommended methods for alleviating waste bank instabilities include: preparation of a proper foundation for the dump, segregation of wastes according to physical characteristics, proper grading and compaction of wastes and provision of adequate drainage from the dump area.[6,16] These techniques are now being used by a large segment of the coal industry to insure the structural integrity of current disposal sites. However, eliminating the structural weaknesses in abandoned waste dumps still remains a problem. This is in no small part due to the difficulty of determining legal responsibility for these disposal areas.[2]

4.2 Prevention and Control of Water Contamination from Waste Dumps

Much attention has been given to the prevention and treatment of contaminated drainage from coal refuse dumps. Most of the effort has centered on the acid drainage problem, but controlling the large quantities of dissolved mineral matter is also becoming increasingly important. Basically, there are two approaches for controlling water contaminants from coal refuse dumps. One is to prevent the initial buildup of pollutants in drainage waters, and the other is to treat contamination after it has been formed.

The most effective means of preventing water contamination from coal refuse materials is to restrict the influx of air and water through the waste pile.[2,16] This is done by grading and compacting the waste to reduce permeability or by sealing the edges of the dump with clay or other agents. Covering of wastes with topsoil and revegetating also helps to prevent the entrance of air and water.

By far the most widely used method for treating contaminated drainage from coal wastes is to neutralize the water with alkaline agents and effect the precipitation of some of the dissolved salts.[17] There are now about 300 plants in operation in the U.S. for treating drainage from coal refuse dumps or coal mines with neutralizing agents. For some applications, particularly when dissolved salts are of major concern, ion exchange, reverse osmosis or flash vaporization may be economically effective ways of treating contaminated waste waters.[17] Several pilot scale treatment plants, based on these methods, have been constructed and tested.

4.3 Control of Contamination from Burning Wastes

Measures to prevent waste dump burning center around proper grading and compacting or sealing of the waste-pile perimeters to reduce the flow of air through the bank.[6,16] With care and attention, waste fires can be almost entirely prevented. To control or extinguish refuse fires once they have begun is another matter. Success in this area has been rather limited. The most effective method for extinguishing these fires has been to dig out the burning materials and allow them to cool at the surface. Other methods of waste fire control include sealing the piles with soil or other materials to control air circulation or injecting slurries, usually of water and finely divided incombustible materials, to essentially smother the burning waste.[5,16]

5.0 SUMMARY

The purpose of this paper has been to review the causes, consequences and available solutions for some of the major environmental problems caused by discarded coal preparation wastes. The predominant problems were seen to be waste bank structural instabilities, burning refuse dumps, acid drainage and the contamination of aqueous discharges with mineral matter. These problems result partly as a consequence of the chemical and physical nature of the waste materials, and partly because of inadequate attention to proper disposal practices. Corrective measures are available for some of the more highly recognized forms of coal refuse contamination, but difficulties are certain to increase as the national usage of cleaned coals multiplies over the next decade or two.

6.0 REFERENCES

1. Hanna, G. P., Jr.; Lucas, J. R.; Randless, C. I.; Smith, E. E.; and Brant, R. A., "Acid Mine Drainage Research Potentialities," J. Water Pollution Contr. Fed. 35, 275-96 (1963).

2. National Academy of Sciences, "Underground Disposal of Coal Mines Wastes," Report to the National Science Foundation, Washington, DC (1975).

3. Leurbrouck, A. W., Bureau of Mines Publications on Coal Preparation, 1910-1960. U.S. Bureau of Mines Inform. Circ. 8059 (1961).

4. Deurbrouck, A. W. and Jacobsen, P. S., "Coal Cleaning: State of the Art," Conference on Coal and the Environment, Louisville, KY, Oct. 22, (1974).

5. Wewerka, E. M.; Williams, J. M. and Wanek, P. L., "Assessment and Control of Environmental Contamination From Trace Elements in Coal Processing Wastes," EPA Report #600/7-76-002, 1976, pp. 226-229.

6. Sussman, V. H. and Mulhern, J. J., "Air Pollution from Coal Refuse Disposal Areas," J. Air Poll. Contr. Assn. 14 (7), 279-84 (1964).

7. McNay, L. M., "Coal Refuse Fires, an Environmental Hazard," U.S. Bur. Mines, Inform. Circ. 8515 (1971).

8. Davies, W. E., "Geologic Factors in Waste Bank Stability," Mining Cong. J., Jan. 1973, pp. 43-46.

9. Busch, R. A.; Backer, R. R.; and Atkins, L. A., "Physical Property Data on Coal Waste Embankment Materials," U.S. Bur. Mines, Rept. Invest. 7964 (1974).

10. Kimmel, W. G. and Sharpe, W. E., "Acid Drainage and the Stream Environment," Trout 17 (1), 21-5 (1976).

11. Applachian Regional Commission, "Acid Mine Drainage in Appalachia," Washington, DC (1969).

12. Reid, G. W. and Streebin, L. E., "Evaluation of Waste Water from Petroleum and Coal Processing," U.S. Nat. Tech. Inform. Serv., PB Rep. 1972, No. 214610/8 Govt. Rep. Announce. (U.S.) 73 (7), 170 (1973).

13. Martin, J. F., "Quality of Effluents from Coal Refuse Piles," Pap. Symp. Mine Prep. Plant Refuse Disposal, 1st, Louisville, KY, Oct. 22-4, 1974, pp. 26-37.

14. Massey, H. F. and Barnhisel, R. I., "Copper, Nickel, and Zinc Released from Acid Coal Mine Spoil Materials of Eastern Kentucky," Soil Sci. 113 (3), 207-12 (1972).

15. Lowry, G. L., "Some Physicochemical Properties of Weathering Coal Spoils and Their Influence on the Growth of Pine Seedlings." University Microfilms (Ann Arbor, MI), Order No. 61-4968; Dissertation Abstracts 22, 1774-5 (1961).

16. Coalgate, J. L.; Akers, D. J.; and Frum, R. W., "Gob Pile Stabilization, Reclamation, and Utilization," Research and Development Report No. 75, Interim Report No. 1, West Virginia University, School of Mines, Coal Research Bureau (1973).

17. Bhatt, H. G., "Factors Affecting the Selection of Mine Drainage Treatment Methods," Proc. Fifth Symp. on Coal Mine Drainage Research, Coal and the Environment Technical Conference, Louisville, KY, Oct. 22-4, 1974, pp. 331-56.