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LINING OF HAZARDOUS WASTE ASH STORAGE POND AND ASH POND DYKES

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ABSTRACT

The problems associated with the ash disposed at ash pond and mounds is gaining considerable attention. The leachates from improperly located, designed and inadequately lined waste disposal ponds and landfills are causing a greater contamination, as impurities percolate to ground water as well as surface water. This paper reviews the lining of ash pond to prevent any contamination of ground water and surface water flow, using Geosynthetic material with adequate sub-surface drainage facilities and proper leachate collection mechanisms.

INTRODUCTION

Coal is one of the major source of energy in India and will continue to be so in the near future. The present generation of fly ash of all the Thermal Power Plants in the country is about 70 million tonnes and it is likely to cross 100 million tonnes by the end of this century. The estimated ash generation and coal consumption is given in Table I. The disposal of ash of such a huge amount are causing a great threat to the environment. Some of the impurities in coal ash when present in high concentration are phytotoxic, some toxic to fish and other aquatic organisms and some have adverse effects on humans and animals. The contamination of such toxic minerals can cause adverse effect on large population of India. Provision of a Geomembrane lining as a separator prevents sub-surface contamination of ground water due to toxic components of ash.

Table I
ESTIMATED ASH GENERATION & COAL CONSUMPTION

Item	Year				
	1989-90	**1995**	**2000**	**2010**	**2020**
Installed Thermal Power Capacity (MW)	45,000	54,000	70,000	98,000	137,000
Coal Consumption (Million Tones)	110	200	250	300	380
Ash Generation (Million Tones)	38	75	90	110	148

Source : CMIE (1993) Palit (1992)

ASH DISPOSAL ON LAND AND ENVIRONMENTAL CONCERN

The different environmental issues of concern due to land disposal of ash are

* Effects on soils and terrestrial vegetation
* Effects on ground water
* Effects on surface water

Effects on soils

When utility coal combustion residues are deposited on land, the soil becomes enriched in salts (sulfite, sulfate etc) resulting in variation in physical and chemical properties of the soil mixture. The leaching of utility waste constituents into soil becomes a problem for plant life in all areas on and around a disposal site because of accumulation of soluble salts and trace elements (Thakre et. Al. 1991). The chemical analysis of plants revealed that the inorganic constituents of fly ash present in elevated concentrations in the ground parts of the plants as compared to the plants growing on natural soil (Chart- 1).

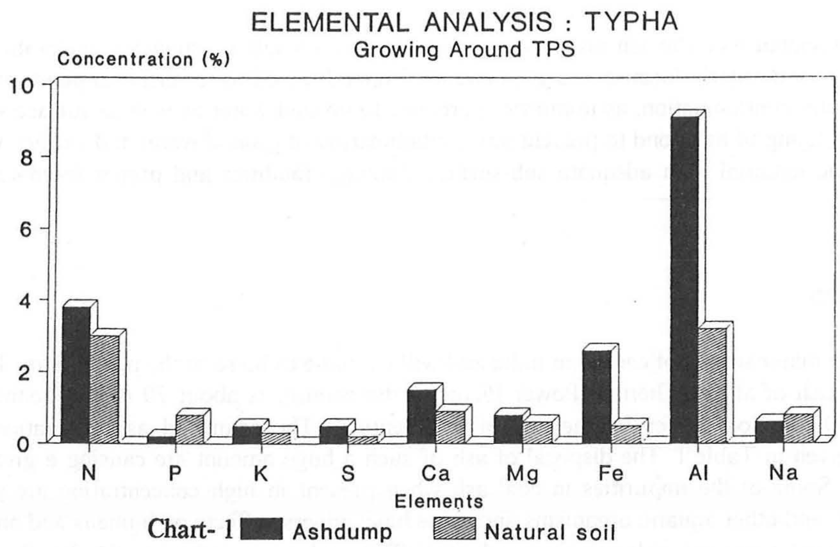

Chart- 1

The changes in physical properties of soil can be enumerated as:

- Reduction in bulk density
- Reduction in modulus of rupture
- Effects on hydraulic conductivity
- Susceptibility to wind erosion
- Susceptibility to water erosion
- Affects water holding capacity
- Enrichment of toxic trace metals

The most unusual physical effect in the field is on hydraulic conductivity which increases at low rates of fly ash application (10%), but decreases rapidly as fly ash volume increases. Accumulation of heavy metals in soils around thermal power plant (TPPs) due to aerial deposition has been widely recognized (Kaakinen & Jorden, 1974 & Klein et. Al. 1975). The fly ash particles in the size fraction of 0.1-200 micron are emitted through the stack. The temperatures encountered in the stack are very high as a result the potentially toxic elements in the coal get volatilized and are emitted in the gaseous phase which subsequent to cooling are redistributed on to the smaller particles. It has been reported that the enrichment of trace elements is higher, smaller the particle size. Studies on geo-accumilation of heavy metals around TPPs indicates that Cromium (Cr) and Zinc (Zn) top the ranking followed by Manganese (Mn) while Lead (Pb) and As have the geoaccumilation index less than 1. (Aggarawal & Thakre, 1988). The geo-accumilation index greater than one is said to have adverse effect on soil micro and macro flora. Chronological order of soil enrichment by various toxic trace metals studied at Korba TPPs airbasin has been found to be :

$$Cr > Zn > Mn > Cu > Ni > Pb > As.$$

Groundwater Effects

The leachates from improperly sited and designed waste disposal ponds and landfills represent the potential threat of contamination of groundwater (Thakre et. Al. 1986). This could occur in inadequately lined ponds, providing a greater opportunity for ground water contamination, as the soil below the ponds is always saturated and under considerable hydraulic head (These et. Al. 1978). For this reason seepage under ponds may be constant in duration and greater in volume than leachate from a landfill. Few disposal sites in India are lined. Also, due to scarcity of land and forest, very strict laws prevail in granting permission to TPPs for acquisition of more land for ash disposal. So the already available land area may have to be used by constructing steep slope embankment to accommodate more volume in the same surface area. This, will intensify the leaching to ground water stratum without adequate lining of the disposal facility. However, by using Geomembranes as a waterproof protection for the lining of pond, the problem of leaching may be solved.

Not all ground water quality degradation is related to the presence of trace metals. Waste constituents such as Iron (Fe), Aluminum (Al), Calcium (Ca), Chlorine (Cl), Sulphur Tetraoxide (SO_4) and Sulphur Trioxide (SO_3) are not generally regarded as hazardous. They are included in the secondary drinking water standards. These macro-constituents can increase hardness, salinity, alkalinity and dissolved solids, depending on the natural background water quality.

Effects on Surface Waters

The disposal of coal combustion by-products, whether in a landfill or in a pond, can have significant effects on nearby surface waters if sufficient precautions are not taken. Adjacent water bodies usually get contaminated through surface run of from a disposal site (Shown in Fig-1), lateral migration of leachate and/or discharge of pond effluents.

When a stream or any other inland water does become contaminated, the first impact is usually noticed in the fish and other aquatic organisms. Concentration levels of trace elements in water considered toxic to aquatic organisms are at lower levels than those considered harmful to terrestrial animals, humans and vegetation. For example, concentrations of As, Cd, Cr, Hg, Ni and Pb as low as 0.01 mg/l can have serious effects on certain aquatic species. **Table II** shows the toxic trace metal concentrations in the fly ash and parent rock leachates.

Table II
VARIOUS CHEMICALS PRESENT IN ASH

Chemicals		% by weight
Phosphate Pentoxide	(P_2O_3)	1.3%
Silica	(SiO_2)	53.3%
Ferric Oxide	(Fe_2O_3)	4.0%
Alumina	(Al_2O_3)	35.3%
Titania	(TiO_2)	1.4%
Lime	(CaO)	2.2%
Magnesia	(MgO)	0.5%
Sulphur Trioxide	(SO_3)	0.4%
Potassium Oxide	(K_2O)	0.5%
Sodium Oxide	(Na_2O)	0.3%

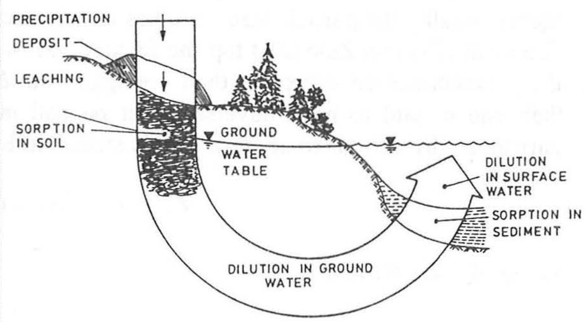

Fig. 1 : The principle mechanisms which influence dispersal of pollutants from a deposit (Hartlén & Elander, 1992)

Wet ash disposal (Ash pond)

In this system ash is disposed in the form of 'ash slurry' by mixing it with water and pumping it through pipelines into ash pond. In such cases the area is raised by bunds all around the perimeter known as ash-dyke which is generally at an elevation of 8 to 10m from original level and serves as a storage area.

ASH DISPOSAL SYSTEM

The ash generated in India is indeed , very huge in quantity. Therefore the disposal of the same is a mammoth problem. The general practice is of disposing it on isolated barren/waste lands, preferably low-lying. But the identification and availability of such vast stretches of land is a major problem, especially in a thickly populated country like India. Thus, optimum utilization of available land has induced Geosynthetics to provide techno economic solutions.

Firstly, ash disposal lagoons must be structurally safe. Many ash disposal ponds all over the world have suffered much damage or failures have been observed as the structural safety of these structures have not been been considered. Most of the times ash ponds are constructed based on empirical knowledge, like other settling ponds in the mining industry, ash pond structures serve for the disposal of useless residues preferably at a minimum cost level. At most sites only limited limited information is available on the geotechnical properties of the sediments forming the major portion of the deposit. The possibility of unexpected loads for such disposal systems -- like flood-runoff into the pond or extreme rainfall directly onto the facility - is often not taken into account.

Thus while designing an ash disposal facility, effects of pore water pressure and seepage must be catered for, the hydraulic situation must be quantitatively estimated both under normal as well as under extreme meteorological/ hydrological conditions, as the instability of the structure is affected by these factors primarily. Also at any stage in the lifetime of an ash disposal facility, the geometry of the system and the properties of its components should be known. It is impossible to explain any compromises to a resident downstream from a failing ash lagoon.

While designing ash ponds they must be considered and designed as engineering structures. An ash pond dyke can be built using geogrids as tuck-back reinforcement for stability. These can be built in any king of foundation soil, during and/or after construction, the slopes can be vegetated by using geosynthetic micro reinforcement. Such structures can be built to increase the height of existing dykes and can be built to any desired slope. Such a structure puts minimum load on the existing dyke. While the lining of the ash pond can be done with a layer of geomembrane and geonet combination so that leachate is collected and well drained through the geonet layer, while the geomembrane ensures complete impermeability.

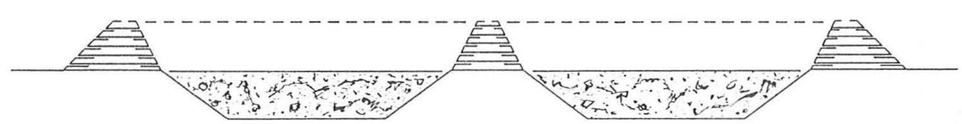

Fig. 2

LINING OF ASH POND USING GEOSYNTHETICS

Geosynthetic as a family of products has a wide range, primary among them are Geomembrane, Geogrid, Geotextile, and Geocomposite. These products can provide a techno economic solution for the construction of an ash pond. Such a solution is not only economically viable but also the construction procedure takes less time as compared to conventional alternatives, and the properties of these materials is factory controlled. The requirement of land for dumping/storage of coal ash generated by TPPs runs in to several thousand of acres. According to one estimate 28,300 Hectares of land would be required for the storage of coal ash expected to be produced by several thermal power stations. Requirement of such larger area for ash dumping can be reduced by the construction of high embankments (Geosynthetic reinforced soil structure) all around the perimeter of the existing area (shown in Fig. 2). The embankments can be formed by using high strength more oriented Geogrid as soil reinforcement, while the base of the perimeter is to be water proofed with a layer of Geomembrane. Beginning at the base of the embankment and continuing upwards Geogrid has to be laid at a particular interval along the complete width of the embankments and then wraped around the face. A layer of soil has to be over laid to a thickness of 0.5m and compacted with the appropriate equipment. The other side of the ash dyke may be vegetated after placing Geomat as micro reinforcement, thus protecting the slope from soil erosion. The internal slopes of the perimeter embankments have to be covered with a layer of Geocomposite, have a combination of Geotextile, Geonet and Geomembrane (shown in Fig- 3 and the detail is shown in Fig- 4 & Fig- 5).

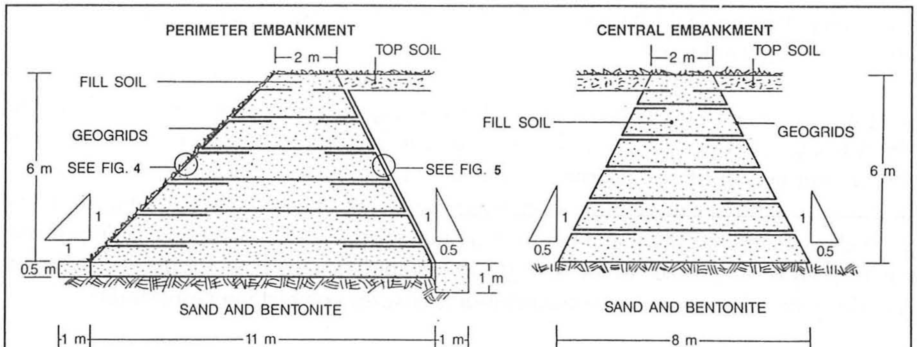

Fig. 3

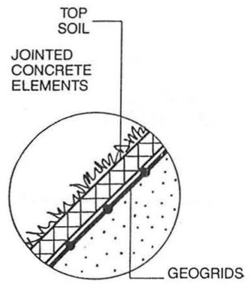

Fig. 4

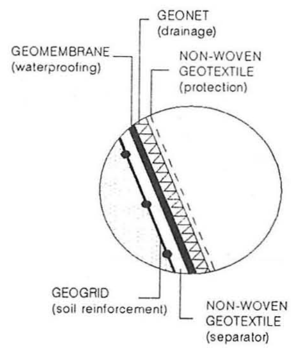

Fig. 5

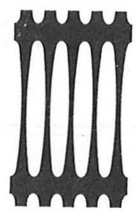
Fig. 6

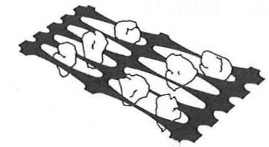
Fig. 7

The various functions of the above mentioned Geosynthetics materials are:

1. Geogrid are bi-dimensional structures (Fig- 6), act as a soil reinforcement where the particles of the soil are forced into the grid openings thus limiting their relative movements and improving shear resistance. The application of a vertical pressure compacts the soil particles and produce interlocking within the grid apertures (Fig- 7); the tensile resistance of the Geogrid is then mobilized. The Geogrid/soil structure combines the high resistance to tensile stress, creating a material with better stiffness and strength than aggregate alone.
2. The internal slopes of the perimeter embankments may be covered with Non-woven Geotextile filter to prevent the migration of soil fines due to pore water dissipation. It will also act as a drainage layer to dissipate the pore water pressure.
3. The laying of a Geocomposite as an impermeable cover (Fig- 5), utilizing a 1 mm HDPE Geomembrane as hydraulic barrier and a Geonet (combined with a Non-woven Geotextile) act as a leachate collection system.
4. The uncovered sand layer needs protection against denudation due to rain splash and resulting sand flow, which can only be achieved by providing micro reinforcement with a 15 cm thick top soil cover, which shall allow the roots of the vegetation to establish permanently over the sandy soil embankment slope. Geomat is used to protect the sandy overhead fill against rainfall runoff down the slope (Fig- 4), attracting likely chances of erosion.

CONCLUSION

The use of Geosynthetic material, instead of a traditional solution for the lining of ash pond, allows:

1. The guaranteed protection of the environment; the use of Geosynthetic material providing impermeability, drainage of leachate, filtration, strengthening of slope & green vegetation on side slopes.
2. Construction of embankments with narrow cross-section and steep slopes thus providing the maximum available capacity for waste materials.
3. Quick and simple construction; normal machinery and equipment and unskilled labor can be utilized.
4. The use of poor soil; silty sand can be improved through soil reinforcement.
5. The Protection of the side slopes, micro reinforced vegetation can be established on the external banks, improving the aesthetics of the region.

Adoption of Geosynthetic techniques shall help Thermal Power Plants to protect the environment in a long way. To highlight other applications of fly ash, it can be equally well used for building a noise barrier, which are usually very steep, because of space restrictions, with increasing high speed traffic on urban highways the noise pollution is becoming increasingly evident. Similarly in Top capping for waste dumps etc. the geosynthetic reinforced flyash encapsulation supported by vegetated top soil could possibly be the cheapest civil engineering structure that can be built to any required height and yet environment friendly as well as consuming large quantities of fly ash.

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