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FLUE GAS DESULFURIZATION PRODUCTS - AS SOIL AMENDMENTS FOR PROBLEMATIC SOIL

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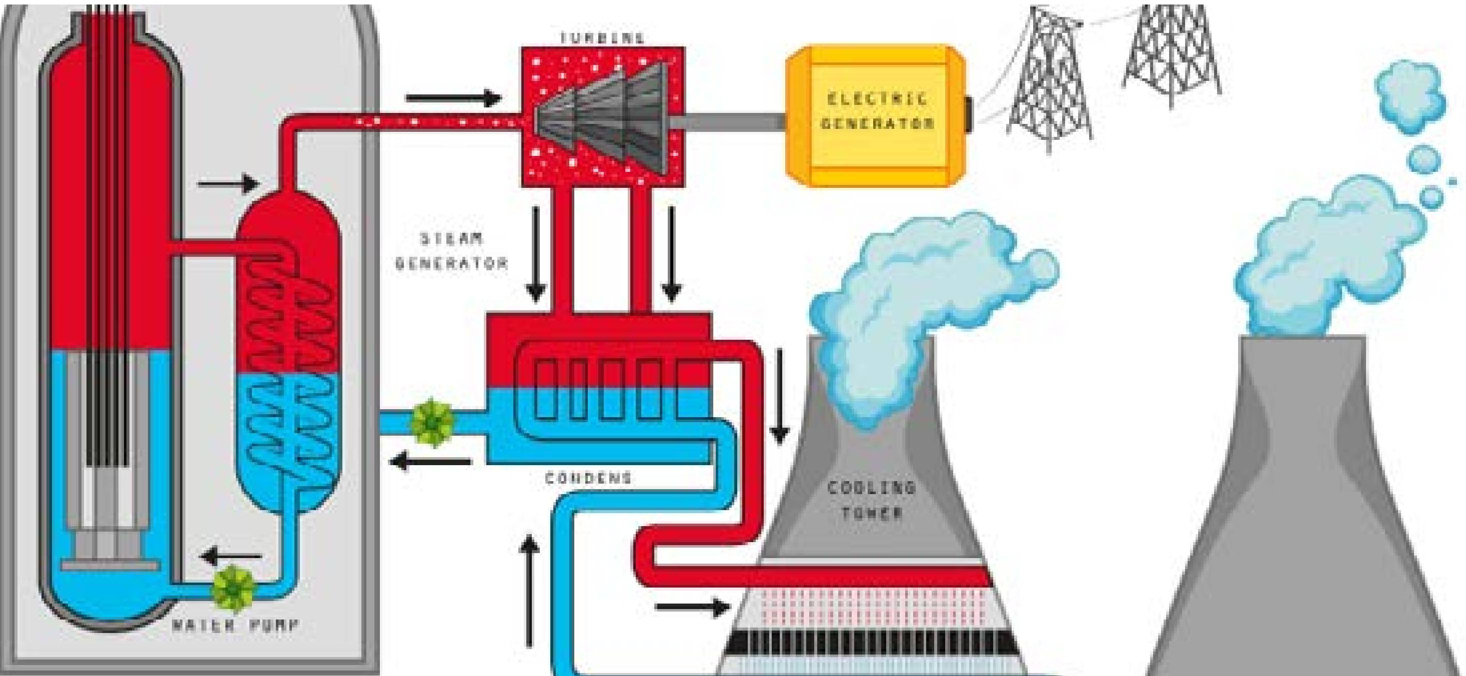
- AS SOIL AMENDMENTS FOR PROBLEMATIC SOIL

Introduction :

With its fastest economic growth and ever growing energy consumption, is is plagued by serious air pollution issues. Specifically, sulfur dioxide from coal burning plants can lead to acid rain. A majority of the coal combustion plants do not have desulfurization process due to economic constraints, even when high-sulfur-content coal is being used. The most commonly used desulfurization method in coal-fired power plants is the flue gas desulfurization (FGD) process, since it is simple to incorporate into already existing equipments and can achieve a high level of desulfurization. Desulfurization techniques produce by-products like gypsum, sulfuric acid and ammonium sulfate. Here, the slurry containing the desulfurization agent is sprayed inside the absorption tower and the produced CaSO3 is dried by the heat of the gas and the reaction heat, and is recovered as powder in a dust collection device. The by-products, however, are discarded or utilized in land reclamation due to the presence of calcium compounds other than gypsum.

The amount of salt-affected soil is on the rise because of the rise in the rate of evaporation and heavy cultivation. Alkali soil has salt on its surface and it is challenging for plants to develop on such soil because of the low hydraulic conductivity and the low permeability. Adding divalent cations to the solution of the soil can decrease clay dispersion and rise in



the hydraulic conductivity of the soil. The sodic soil reclamation involves replacement of exchangeable Na+ by Ca2+ that may be made available by the addition or presence of gypsum, soil lime, or both. Reclamation by leaching is possible following the addition of chemical amendments to the soil. Gypsum is the most frequently used alkali soil amendment since it possesses the advantages of being non-toxic to plants, having simple handling and of moderate solubility. Therefore, application of gypsum as a soil amendment can be a cost-effective and efficient measure for reclaiming saline-alkali soils. Virtually all the coal-fired power generation plants must install desulfurization facility to eliminate SO2 in flue gas.

The most widely applied desulfurization technology is wet-FGD technology with limestone, and the product is named FGD-gypsum, with main content is CaSO4. FGD-gypsum production has been amplified significantly since 2005. And it can be predicted that increasingly more FGD gypsum will be produced in the future due to stricter and stricter regulation on the SO2 emission limit. Since FGD gypsum has lots of of moisture and ash, it can be used as building gypsum only after purification and dehydration; this represents an economic loss compared to the natural gypsum produced. Somewhere, FGD gypsum was applied as cement additives, but the quantity is extremely small compared to its huge productivity. If the FGD gypsum could be disposed of directly without any use or processing, a large amount of landwill be needed. Such practice will be a loss of valuable land resources and poses a potential threat of secondary pollution to the environment.

At the same time, there are massive quantities of saline-alkali soil in the world. These soils unsuitable for cultivation of agricultural crops and some of these soils are unable to bear any kind of plant growth whatsoever. These barren lands highly restrict agricultural production in their nations and negatively affect the ecosystem. One of the most difficult tasks for agriculture is the amelioration of saline-alkali soils on such a vast scale. Amelioration of saline-alkali soil with FGD gypsum would utilize tens of millions tons of FGD gypsum, hence promoting the application of FGD technology and the industry of pollution control.

- When coal is burned for generation of electricity, coal combustion products (CCPs) are produced
- Most of the CCPs can be utilized as mineral resources
- CCPs third largest source of mineral resources
- CCPs are classified into FAs, bottom ashes,boilerslags,andFGDsbasedon their generation and characteristics.

Flue Gas Desulfurization :

It is a collection of technologies employed to eliminate sulfur dioxide from exhaust flue gases of fossil-fuel power plants.

Removal of the sulfur gases from the flue gases generally with a high-calcium sorbent such as lime or limestone". Its principal composition is CaSO4 or a combination of CaSO3 and CaSO4. In order to satisfy clean air standards, nearly all coal-fired generation plants must have a desulfurization plant for SO2 removal from the flue gas.

- It is produced when the flue gases are passed through pulverized limestone to remove sulfur dioxide.

- Gas to sorbent Reaction

$CaCO_3$ + SO_2 → $CaSO_3$. ½ H2O

Calcium carbonate Flue Gas ca cium sulphite

- Forced Oxidation Reaction

$CaCO_3$. ½ H_2O + O_2 +H_2O → $CaSO_4.2H_2O$

calcium sulphate

- Stabilized

FGD - FGD + FA, FGD +$CaCO_3$, FGD + CaO/Ca$(OH)_2$, FGD FBC, FGD + CaO/Ca$(OH)_2$ + $CaCO_3$)

- Oxidized **FGD - FGD** gypsum, high **$CaSO_4$ FGD)**

Table 1: Foot print of FGDG power stations in India

Sl.no	Power station	Capacity of plant (MW)	Location
01	Tata Trombay power plant	750	Trombay near Mumbai in the Indian state of Maharashtra.
02	Dahanu Thermal Power Station	500	Palghar district in the Indian state of Maharashtra
03	Udupi Power Plant	1200	Udupi District of Karnataka.
04	The Vindhyachal Thermal Power Station	500	Singrauli district in the Indian state of Madhya Pradesh.
05	Jhajjar Power Station	1200	Jhajjar district of Haryana
06	Cuddalore IL&FS Power Station	1200	Tamil Nadu
07	Bongaigaon Thermal Power Station	750	Assam

Table 2: Physical properties FGD gypsum

Sl.no	Parameter	Values
01	Moisture content (%)	25.00
02	Mean particle size (µm)	46.44
03	Colour	Gray
04	Texture (USDA soil textural class)	Silt
05	Bulk density (g/cm3)	1.02
06	Specific gravity	2.36

The mineral phase was identified by matching all diffraction peaks. Results showed FGD gypsum waste had crystal structure and brushite is primary mineral phase and also shows presence of calcium sulphate dehydrate gypsum and coesite. The absorption peaks appeared around wave number 3600, 3500 and 1500 cm-1 were assigned to hydroxyl group. The strong and broad peaks appeared at 1140, 1112 and 1044 cm-1 due to sulphate functional group.

Table 3: Physico- chemical properties and nutrient composition of FGD gypsum

Sl.no	Parameter	FGD gypsum	Natural gypsum
01	pH (1:5)	6.5-7.2	6.5
02	EC (ms/cm)	7.2-7.8	7.5
03	Total nitrogen (%)	0.01-0.15	0.13
04	Total phosphorus (%)	< 0.01	< 0.01
05	Total potassium (%)	0.44 – 0.65	0.05
06	Ca (g/kg)	163-272	247
07	Mg (g/kg)	6.5-12.8	1.3
07	S (g/kg)	104-267	207
07	Si (g/kg)	0.56-0.64	1.2
07	Fe (mg/kg)	1.7-14.9	0.9
07	Mn (mg/kg)	90-140	31
07	Cu (mg/kg)	0.1- 0.8	0.7
07	Zn (mg/kg)	2.5 -14.3	6.1

Benefits of FGDs addition to agricultural land

A. Mitigation of soil acidity

- Problem with limestone is that the main constituent ($CaCO_3$) is relatively insoluble hence not easily leaching into subsoil

- In a West Virginia acidic silt loam soil dissolution of applied FGD gypsum in large quantities increased exchangeable Ca and Mg and reduced exchangeable Al in soil profile leading to higher soil pH (Zhou et al., 2006). Soil ESP (exchangeable sodium percentage) and pH lowered and corn yield improved under FGDG-treated plots (Sakai et al., 2004).

B. Mitigation of sodic soil

- Alleviate soil compaction (dispersion of soil particles) caused by high Na saturation
- Improve water penetration in sodic soils
- Calcium replaces Na on clay exchange sites to enhance soil flocculation, stability and clay particle aggregation
- Improved soil structure and preventing soil crusting
- Soil pH and exchangeable sodium percentage (ESP) in topsoil (0–20 cm) declined sharply in the first year, whereas a great decline in electrical conductivity (EC) was witnessed in the second year following FGD gypsum application. After four years, levels of EC, pH and ESP in the reclaimed soils were 58.3%, 92.2% and 95.2% lower, respectively, compared to those in the initial soils (Zhao et al., 2018).

C. Source of nutrients to plants

- Excellent source of calcium and sulphur (229 and 204 ppm respectively) K & B
- FGD gypsum improved alfalfa (20-40%) and soybean (5-10%) yields and did not impose environmental risks when applied to agricultural soils (Chen et al., 2005).

D. Reduction of phosphorus availability

- Reduced movement of P from high-p soils where large amounts of P-containing materials
- FGDs with high $CaSO_4$ content convert P in soil to less soluble forms
- "FGD gypsum-filled trenches removed 50–95% of soluble P that was carried by lateral groundwater flow to surface drainage ditches which drain into the chesapeake bay" (Bryant et al., 2012).

CONCLUSION :

Gypsum mined has been utilized as a soil conditioner and source of plant nutrients in farming for centuries. Industrial waste like FGD gypsum can also be a more alternative source of gypsum and yield additional agricultural and environmental advantages in terms of providing nutrients (Ca and S) to plants, improving soil physicochemical properties and ameliorating sodic and acidic soils. No adverse effect exists with regard to heavy metals accumulation in soil and plant due to application of FGD gypsum. However, good understanding of its properties and composition is highly necessary to identify and avoid the potential environmental hazards.

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