Large-scale barren saline-alkali land amelioration with FGD gypsum in Northeast China

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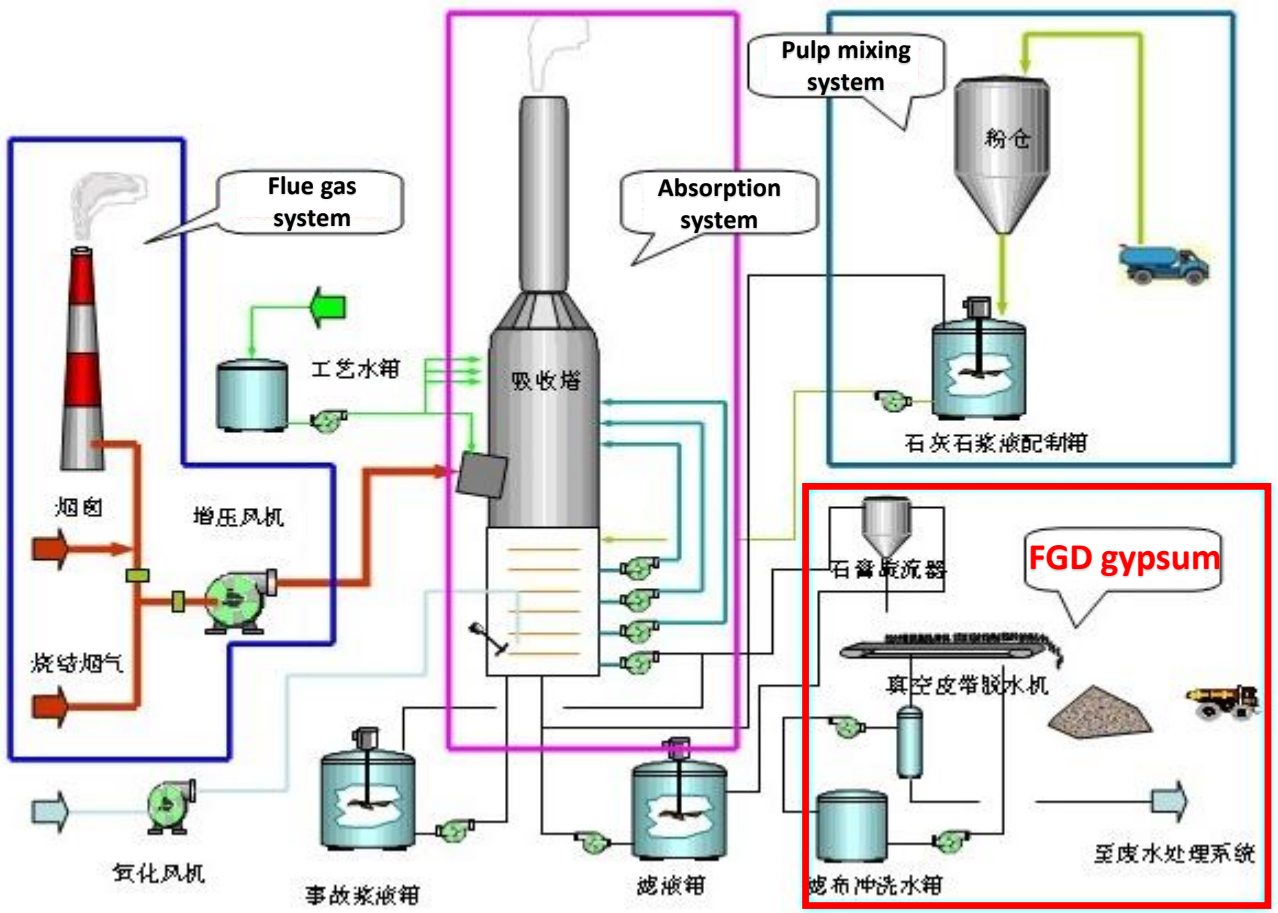
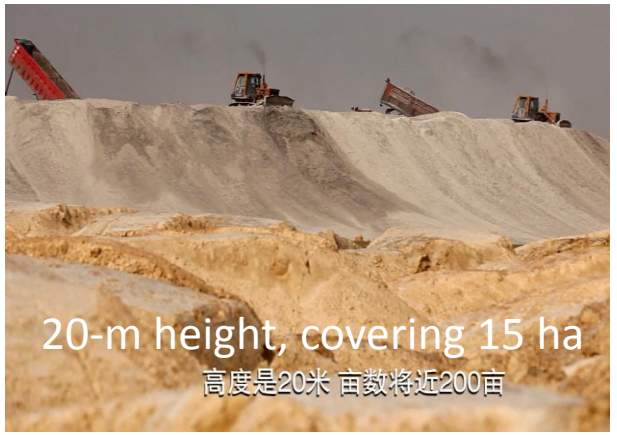
FGD gypsum: A by-product from coal-fired power plants

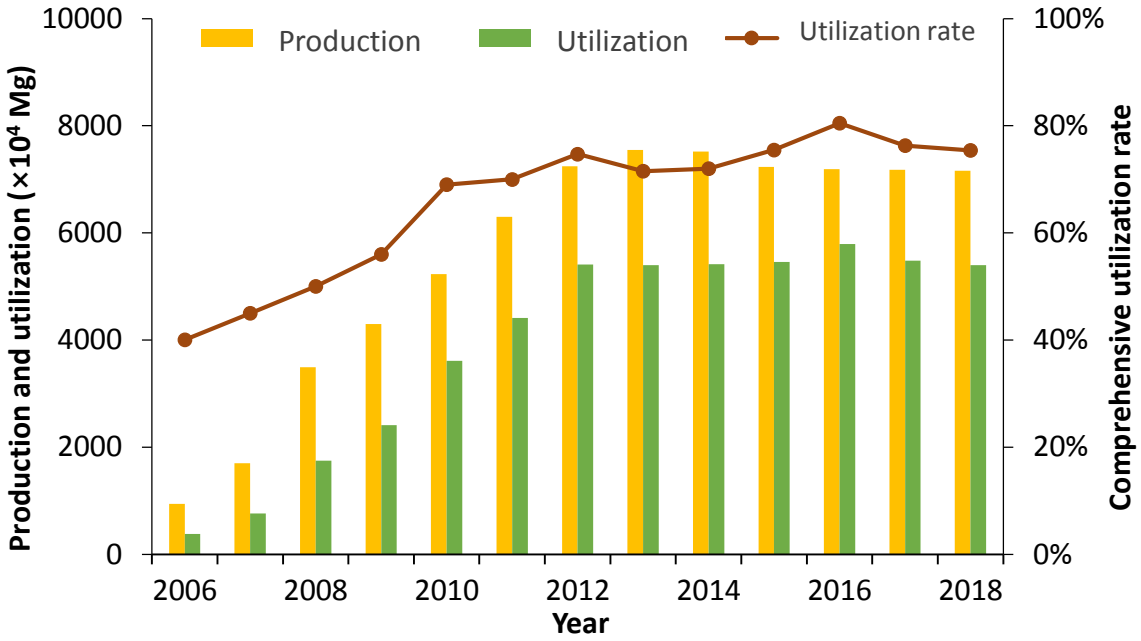


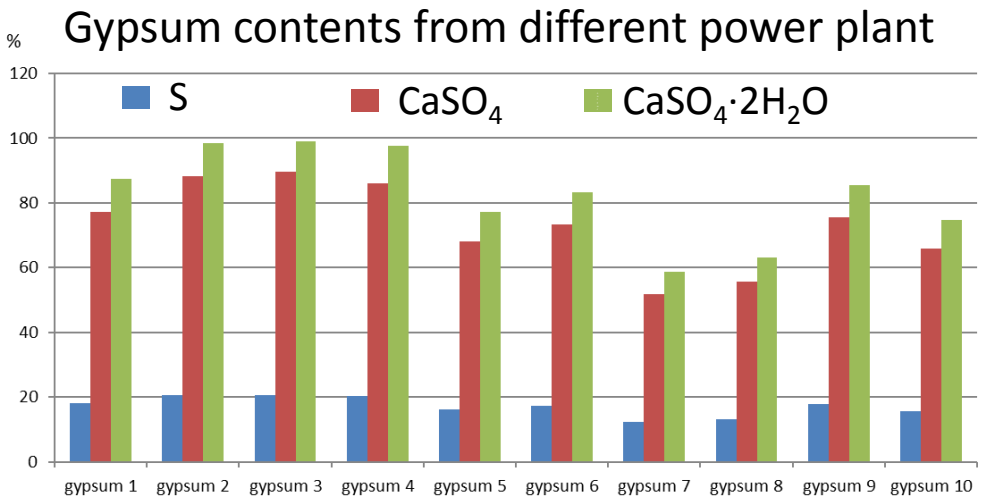
The process of wet FGD in coal-fired power plants

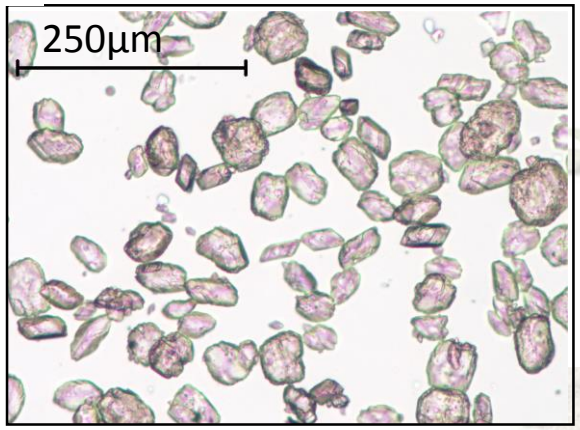


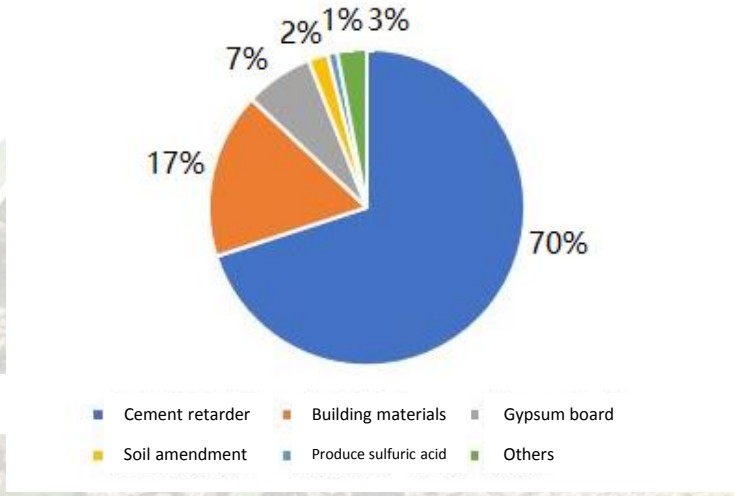
Reasonable utilization of FGD gypsum

- The main component of FGD gypsum is $CaSO_4 \cdot 2H_2O$ (>80%), its content varies greatly in different power plants
- FGD gypsum is powder with relatively small particle size, mainly varied from 50 to 80 μm
- Compared with natural gypsum, FGD gypsum has finer particle size, better uniformity and lower price, which makes it possible to be used as saline-alkali soil ameliorantion



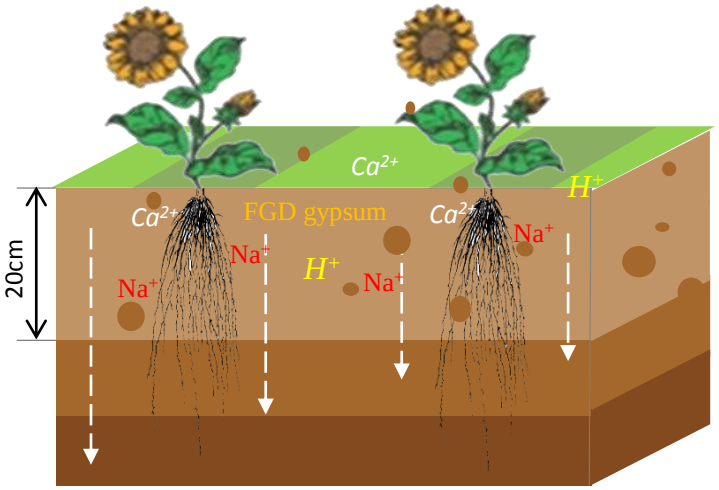






Amelioration saline-alkali soil with FGD gypsum

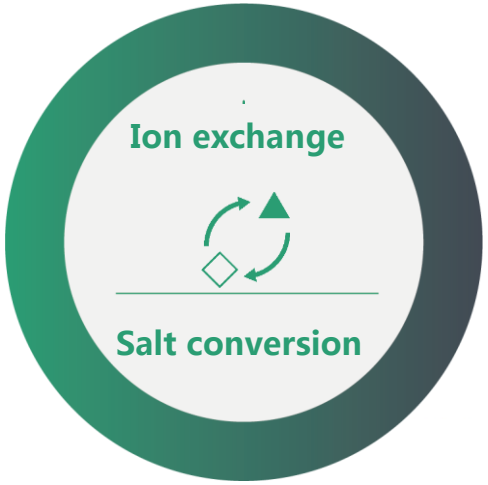
- Provides Ca^{2+} to replace exchangeable Na^{+}, K^{+} and Mg^{2+} at the cation sites of colloids
- Converts a more toxic salt into a less toxic salt
- Salt conversion and ion replacement exist simultaneously, but the former is relatively fast
- Provides mineral nutrients (Ca, S, K and B) that are essential to plants



$2Ex\text{-}Na^{+} + CaSO_4 \rightarrow Ex\text{-}Ca^{2+} + Na_2SO_4$

$2Ex\text{-}K^{+} + CaSO_4 \rightarrow Ex\text{-}Ca^{2+} + K_2SO_4$

$Ex\text{-}Mg^{2+} + CaSO_4 \rightarrow Ex\text{-}Ca^{2+} + MgSO_4$



$Na_2CO_3 + CaSO_4 \rightarrow CaCO_3 + Na_2SO_4$

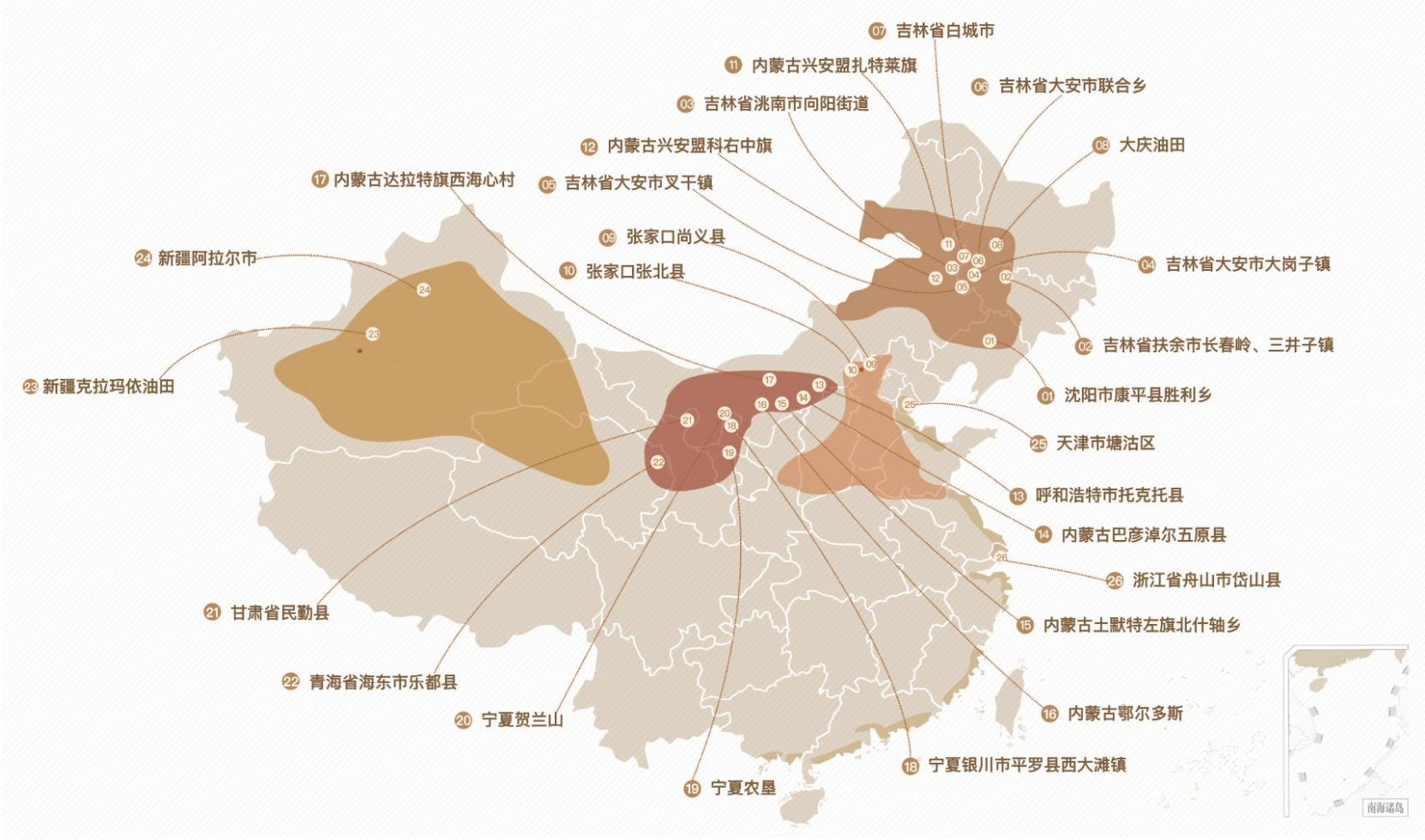
$2NaHCO_3 + CaSO_4 \rightarrow CaCO_3 + Na_2SO_4 + CO_2 + H_2O$

$MgCO_3 + CaSO_4 \rightarrow CaCO_3 + MgSO_4 + CO_2 + H_2O$

$Mg(HCO_3)_2 + CaSO_4 \rightarrow CaCO_3 + MgSO_4 + 2CO_2 + 2H_2O$

R&D of using FGD gypsum to ameliorate saline-alkali soil

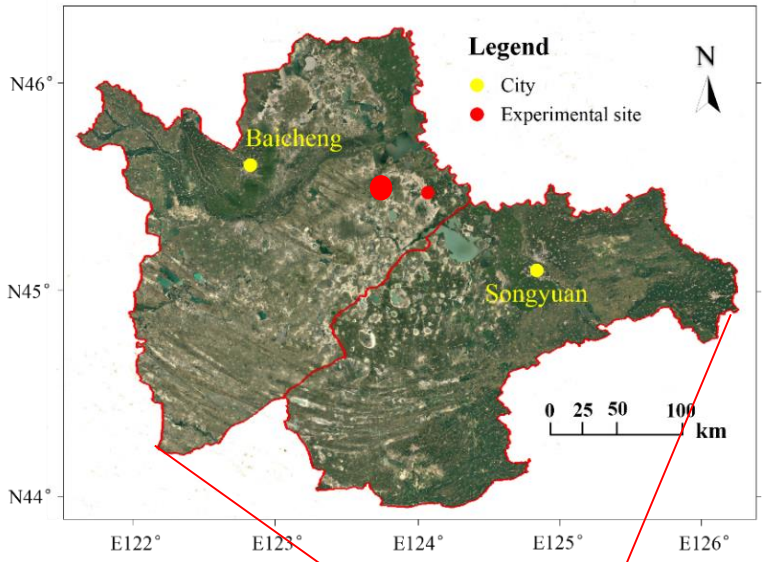
- Since 1995, we began to study the use of FGD gypsum to ameliorate saline-alkali soil
- We have successfully ameliorated about 24 thousand hectares of saline-alkali land in China
- This technology can be effectively implemented with the engineering strategies

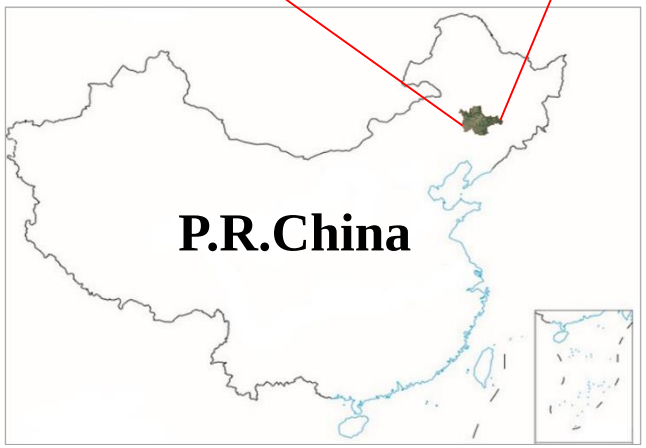


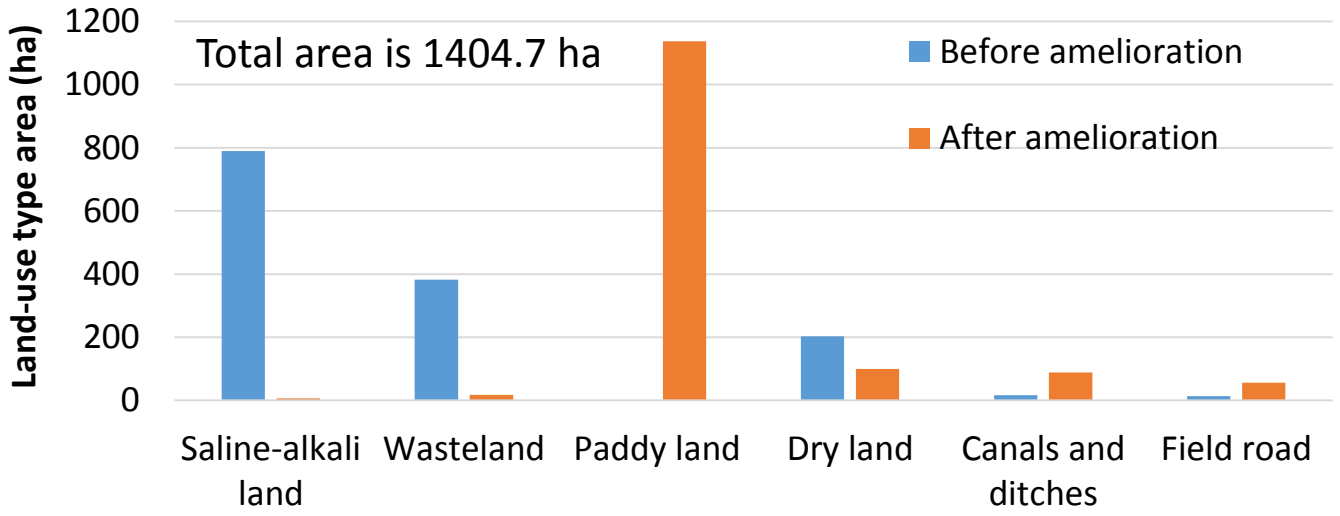
Distribution of experimental sites for ameliorating saline-alkali soil with FGD gypsum in China

A good practice conducted in the Songgen Plain of China

- **This practice was conducted in Minle village, Chagan town, Da'an city, Jilin Province, China**







The procedures for ameliorating with FGD gypsum

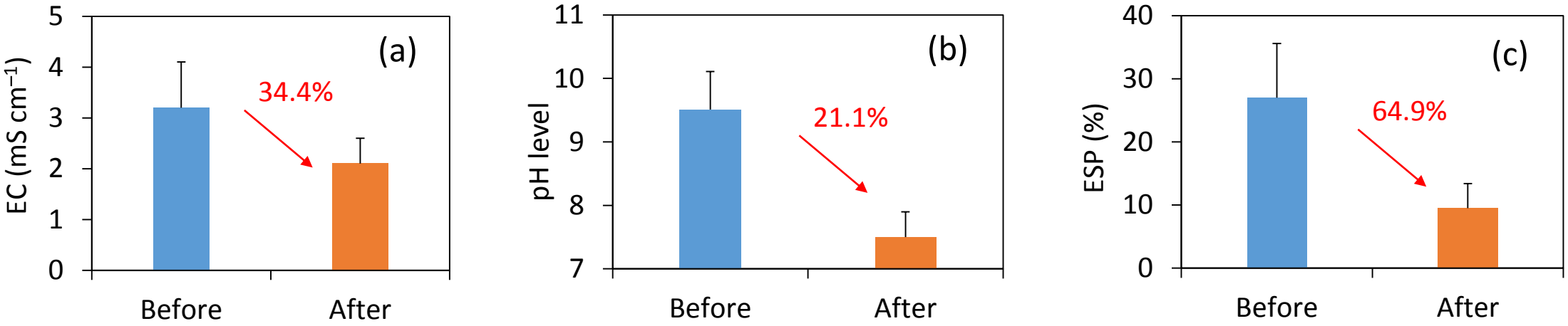
- The land was divided into several parcels
- The land in each parcel was ploughed, pulverized and then levelled
- The required rate of FGD gypsum was applied evenly to the soil surface and then the topsoil was tilled twice a
- The parcels were flood-irrigated, puddled and well levelled again
- The salt-containing water was completely drained out and then transplanted paddy rice

$$W = (0.08728 \times ESP + 0.4412) \times H \times D / (\eta \times 10)$$

W is the application rate of FGD gypsum (kg m^{-2})
ESP is exchangeable sodium percentage (%)
H is the depth of soil that is subject to reclamation (m)
D is the bulk density of a given soil (kg m^{-3})
η is the $CaSO_4$ content of the FGD gypsum (%)

Positive effects of the practice on soil amelioration

- **Salinity and sodicity in topsoil significantly decreased in the first year**

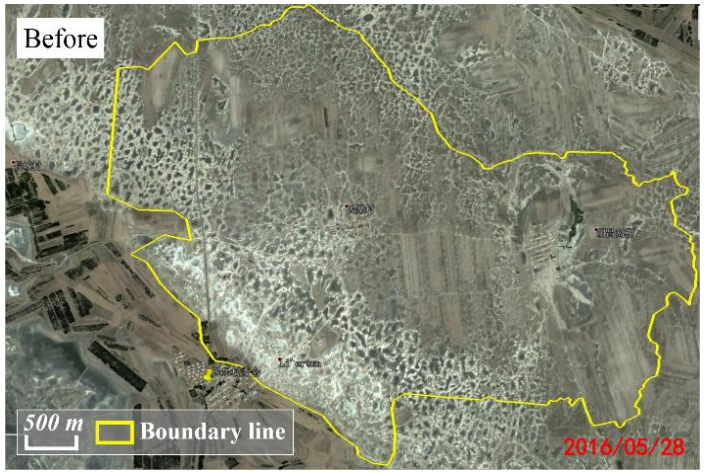


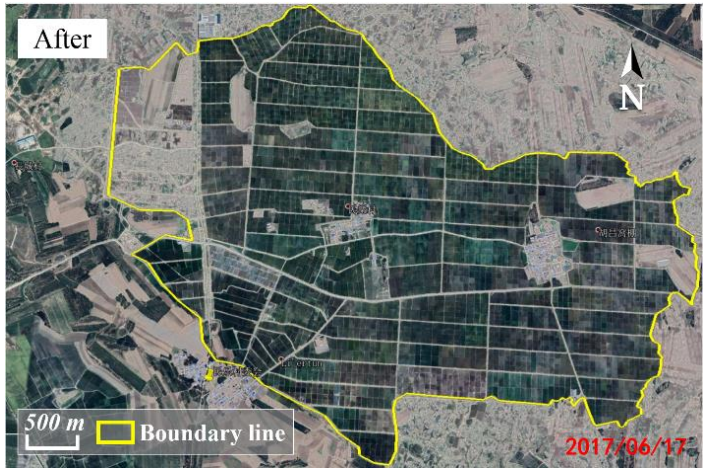
- **Soil quality increased to the level of nearby farmers' land after five years**

Sampling site	pH	EC (dS m^{-1})	ESP (%)	Soluble cations (mmol kg^{-1})			
				K^+	Na^+	Ca^{2+}	Mg^{2+}
Application site	7.9 a	0.5 a	8.9 a	0.2 a	6.5 a	0.9 a	0.3 a
Nearby farmers' lands	7.8 a	0.2 b	7.1 a	0.2 a	6.7 a	0.5 b	0.3 a

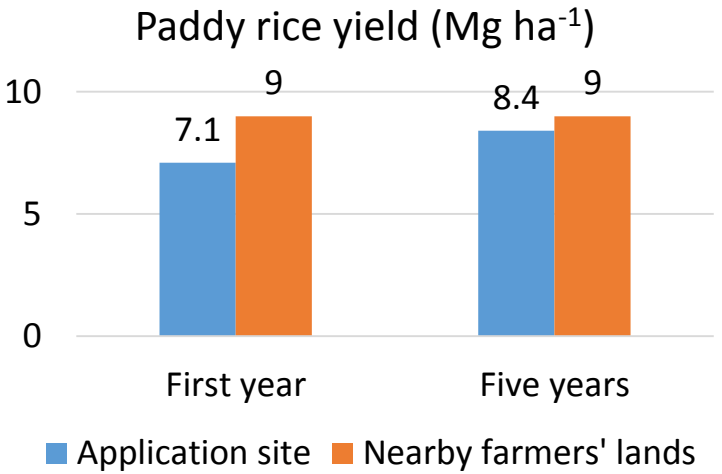
Positive effects of the practice on paddy rice yield

- **Increased grain production and capacity**





Landscape changes after one year



Other benefits of the practice

- **Increased the income of local farmers, village collective and government**

We received the thank-you banner sent by the local villagers.

Farmer

12 thousand

Allocated paddy fields and planted with paddy rice

Collective

17 million

Rented the remaining 480 ha of paddy fields for 10 years

Government

2.51 billion

The ameliorated land was committed to the national arable land balance

Other benefits of the practice

- **Established a platform for the development of modern agriculture**







Other benefits of the practice

- **Increased the quantity and quality of cultivated land**

✓ A lack of arable land is the main cause of poverty in the local village

✓ The paddy rice field area increased by 1137 ha, which is high-quality land

✓ This ensure that cultivated land is available to support national food safety

- **Improved the regional environment**

✓ Most plants struggled to grow normally due to the toxicity of salt and alkali

✓ The deserted patchy landscape has become a regular paddy rice field

✓ The original fragile ecological environment has become an artificial wetland environment





Costs of the practice

- **Amelioration costs increased with sodicity classes**
- **Purchasing and applying FGD gypsum accounted for half or more of the total costs in the land with high ESPs (≥15%)**

Land information and amelioration cost	Sodicity class					Total
	I	II	III	IV	V	
Initial soil property						
pH value	<8.5	<8.5	≥8.5	≥8.5	≥8.5	/
Exchangeable sodium percentage (%)	<10	≥10	≤15	15–30	≥30	/
Total area (ha)	105.0	509.2	297.1	135.3	90.4	1137.0
Application rate of FGD gypsum (Mg ha^{-1})	0	3	7.5	15	30	/
Costs (¥ ha^{-1})						
FGD gypsum purchase	0	320,796	467,933	426,195	569,520	1,784,444
FGD gypsum application	0	458,280	297,100	148,830	108,480	1,012,690
Ploughing	47,250	229,140	133,695	60,885	40,680	511,650
Rotary tillage	42,000	407,360	237,680	108,240	72,320	867,600
Laser levelling	126,000	611,040	356,520	162,360	108,480	1,364,400
Puddling	63,000	305,520	356,520	162,360	108,480	995,880
Drainage	42,000	203,680	237,680	108,240	72,320	663,920
Others	27,825	134,938	78,732	35,855	23,956	301,305
Mean	3,315	5,245	7,290	8,965	12,215	/

Challenges and suggestions for scaling up the practice

Challenges

- Shortage of capital investment
- The agricultural use of FGD gypsum has not been standardized

Suggestions

- Attracting enterprises to invest through preferential policies
- Establishing a national standardized limit for the metals concentration in FGD gypsum applied to agricultural lands

Summary

- The application of FGD gypsum in agricultural settings not only uses a large amount of this resource but also ameliorates large areas of saline-alkali land
- Referring to this example of best practices may result in a substantial increase in cultivated land
- Sufficient funds and preferential policies will further promote the R&D of saline-alkali land amelioration practices

GLOBAL SYMPOSIUM ON
SALT-AFFECTED
SOILS

20 - 22
October, 2021
Virtual meeting

Thank you for your attention

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