Hydraulic Characteristics and Plant-Microorganism Microecosystem of Sand-Sludge Soil for Anti-Desertification

Yao-Hui LIU, Prof. Onyx Wing-Hong WAI

Department of Civil and Environmental Engineering, the Hong Kong Polytechnic University, HKSAR, China

Abstract: Desertification, which is mainly caused by over deforestation and global warming, is one of the environmental problems that leads to sand storm in cities, destroying of water balance, loss of farmland, and debris flow in raining seasons. Disposal of excessive activated sludge is another environmental issue which causes troubles in the operation of wastewater treatment plant because of the huge moisture content enlarging the volume and weight. On one hand, the desertification is due to loss of moisture content; on the other hand, moisture content is undesirable for activated sludge treatment. Based on this concept, this research aims to look for methods to develop Sand-Sludge Soil (SSS) to tackle desertification in the desert boundary. The optimal sand-sludge ratio will be studied according to moisture retention ability and plant growing characteristics. To improve the interaction among SSS-plant-microorganism in the micro-ecosystem, specific bacteria will be studied and used.

Lab-scale experiments will be carried out on different weight fraction of sand-sludge mixtures with ratios of 20:80, 40:60, 60:40, 80:20, 100:0 and pure soil. Moisture distribution and retention, nutrient dispersion and utilization, leachate amount and quality, and surface runoff will be the key parameters for estimating the performance of the SSS. Pot experiments will be used to study plant growing characteristics of sedum, such as plant height, leave color and root health. Nitrogen transformation among plant protein, ammonia nitrogen, nitrite nitrogen, nitrate nitrogen will be studied in the micro-ecosystem that is irrigated by different weight fraction of water-wastewater mixtures. Identification of specific bacteria in the activated sludge that contributes to retain moisture and promote the nutrient absorption will be carried out.

The present experimental conditions are based on the desert-forest crossover area in Yulin, Shanxi province. Physical property analysis of real sand samples from Yulin indicates the sample has a mixture of 70 wt.% of British Standard B grade sand and 30 wt.% of commercial river sand. For plant growing experiments, trial runs of sedum in 40:60 SSS weight fraction showed that the rich nutrient content accelerated the growth of plant. Systematic experiments and further analysis will be carried out in the following months.

Keywords: *anti-desertification, sand-sludge soil, micro-ecosystem, activated sludge, sedum.*

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Presented by:
LIU Yaohui

Department of Civil and Environmental Engineering
The Hong Kong Polytechnic University

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1.Background

（Adapted from State Forestry Administration, China, 2005)

Region	Desertification Land		Sandy Land	
	Area (10000 hectares)	% to National Total	Area (10000 hectares)	% to National Total
National Total	**26361.68**	**100.00**	**17396.63**	**100.00**
Beijing	0.72	…	5.46	0.03
Tianjin	1.08	…	1.56	0.01
Hebei	231.67	0.88	240.35	1.38
Shanxi	162.77	0.62	70.55	0.41
Inner Mongolia	6223.82	23.61	4159.36	23.91
Liaoning	68.73	0.26	54.96	0.32
Jilin	20.26	0.08	71.07	0.41
Heilongjiang			52.87	0.30
Shanghai				
Jiangsu			59.09	0.34
Zhejiang			0.01	…
Anhui			12.69	0.07
Fujian			4.51	0.03
Jiangxi			7.50	0.04
Shandong	99.39	0.38	79.38	0.46
Henan	1.04	…	64.63	0.37
Hubei			19.16	0.11
Hunan			5.88	0.03
Guangdong			10.95	0.06
Guangxi			21.16	0.12
Hainan	3.63	0.01	6.34	0.04
Chongqing			0.27	…
Sichuan	46.80	0.18	91.44	0.53
Guizhou			0.67	…
Yunnan	3.44	0.01	4.53	0.03
Tibet	4334.87	16.44	2168.43	12.46
Shaanxi	298.78	1.13	143.44	0.82
Gansu	1934.78	7.34	1203.46	6.92
Qinghai	1916.62	7.27	1255.83	7.22
Ningxia	297.45	1.13	118.26	0.68
Xinjiang	10715.83	40.65	7462.83	42.90

stone kill two birds?

2.Objectives

- **General Objective**
- In order to find out a positive way for anti-desertification, this thesis aims to carry out the study of the hydraulic characteristics, suitable plants and the plant-microorganism microecosystem of the sand-sludge soil, which is obtained from sewage treatment plant.

- **Specific Objectives**
- 1) To study the hydraulic characteristics of sand-sludge soil, including the moisture content conservation abilities, water dispersion and distribution and mechanisms of water dispersion;

- 2) To study growing characteristics of different plants in sand-sludge soil, including the plant growing pattern, and advise which kinds of plants would be suitable for anti-desertification;

- 3) To study the bacteria in sand-sludge soil, which has active and negative effects on the plant-microorganism microecosystem, and the mechanisms of their influence in the microecosystem.

3.1 Desertification

- Land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities (UNCED, 1992).

- Menace: loss of land productivity, sand storm, debris flow

- Drylands occupy 41 % of Earth's land area suffering more than 2 billion people in the world(Uwe, 2008).

- 27.46% and 18.12% of land area in China Mainland were occupied by arid and sandy area respectively (State Forestry Administration, China, 2005).

Typical chemical composition of untreated sludge and digested biosolids (Adapted from Environment Protection Agency, USA, 1979)

	Untreated primary sludge		Digested primary sludge		Untreated activated sludge
	Range	Typical	Range	Typical	Range
Total dry solids (TS), %	5~9	6			
Volatile solid (% of TS)	60~80	65			
Grease and fats (% of TS)					
Ether soluble	6~30	-	5~20		
Ether extract	7~35	-	-		
Protein (% of TS)	20~30	25	15~2(		
Nitrogen (N, % of TS	1.5~4	2.5	1.6~3.		
Phosphorus (P_2O_5, % of TS)	0.8~2.8	1.6	1.5~4.		
Potash (K_2O, % of TS)	0~1	0.4	0~3.0		
Cellulose (% of TS)	8~15	10	8~15		
Iron (not as sulfide)	2.0~4.0	2.5	3.0~8.		
Silica (SiO_2, % of TS)	15~20	-	10~2(		
pH	5.0~8.0	6.0	6.5~7.		
Alkalinity (mg/L as $CaCO_3$)	500~1500	600	2500~3:		
Organic acids (mg/L as HAc)	200~2000	500	100~600		
Energy content, kj/kg TSS	23,000~29,000	25,000	9,000~14,000	12,000	19,000~23,000

Typical metal content in wastewater solids (Adapted from Environment
Protection Agency, USA, 1984)

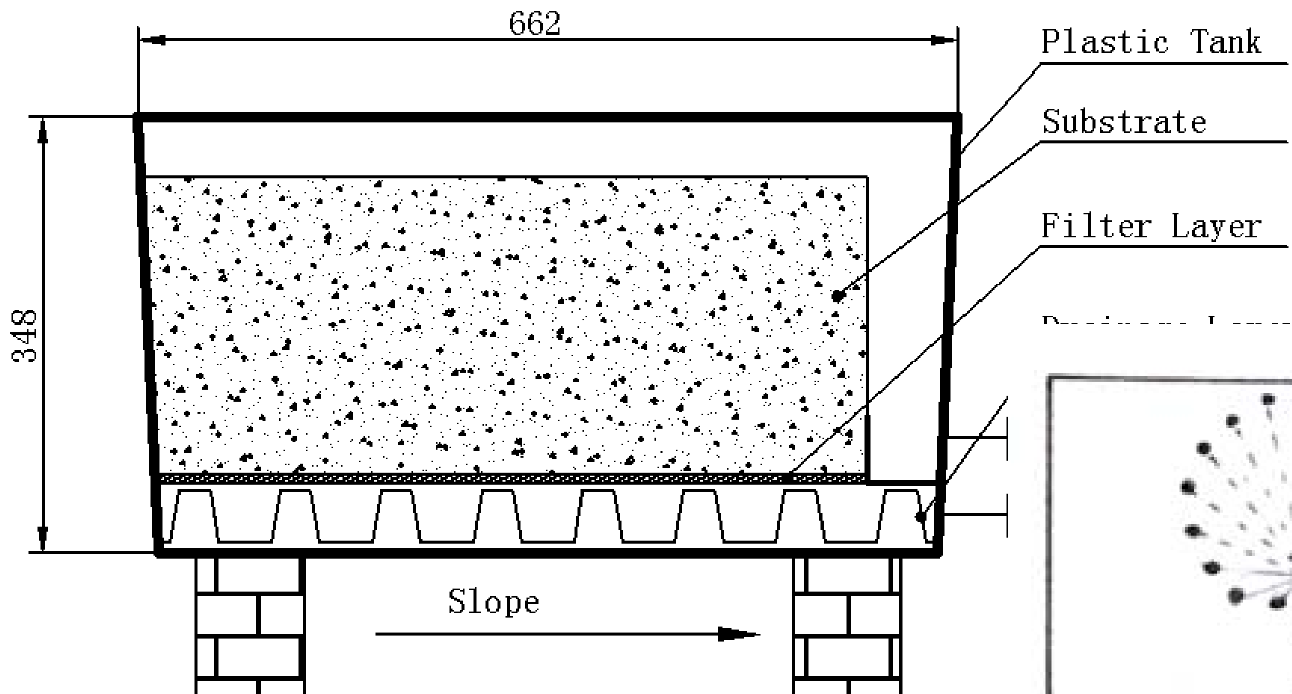
Metal	Dry solid, mg/kg Range	Median
Arsenic	1.1~230	10
Cadmium	1~3410	10
Chromium	10~99,000	500
Cobalt	11.3~2490	30
Copper	84~17,000	800
Iron	1000~154,000	17,000
lead	13~26,000	500
Manganese	32~9870	260
Mercury	0.6~56	6
Molybdenum	0.1~214	4
Nickel	2~5300	80
Selenium	1.7~17.2	5
Tin	2.6~329	14
Zinc	101~49,000	1700

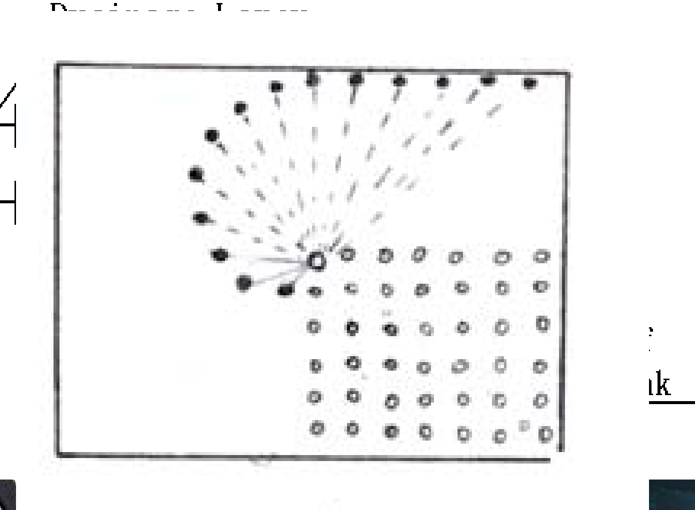
4.1 Major Materials

- Activated sludge from the thickening tank of local domestic wastewater treatment plant is used. Prior to mixing with sands, lime treatment will be carried out for stablization.

- Artificial sand mixture will be used to simulate the samples from desert boundary area in northern Shanxi province.

4.1 Water Retention, Absorption and Dispersion





another aspect for the a

- Soil recovery probe and digital
measure the water content in different depths and distances.

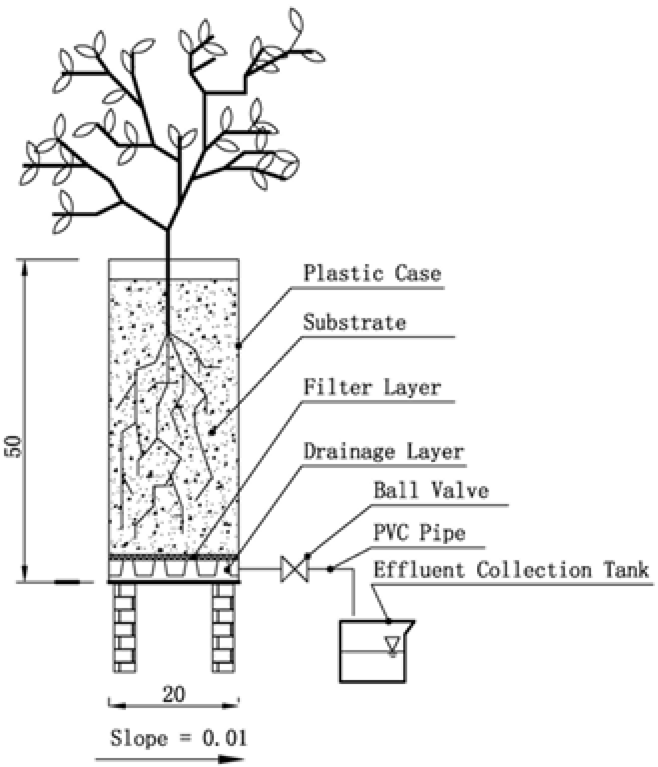
4.1 Leachate and Nutrient Dispersion

- The leachate quality would be observed on the Total Kjeldahl Nitrogen (TKN), Ammonia Nitrogen (NH_3-N), Nitrate Nitrogen (NO_3-N), Phosphor, Potassium in order to estimate the impact of effluent of the SSS to environment.

- Similar to water dispersion, a fixed amount of N, P and K solution (NH_4NO_3, Na_3PO_4,KCl) would be introduce in separate tanks and their concentration in the leachate and soil would be examined to analysis the nutrient dispersion as compare to common soil.

4.2 Plant Growing Characteristics

- Transperant plastic cases w of L-200 mm×W-50 mm× r this experiment. The area c 100 cm².
- *Sedum* will be used for exp e lower water potential towar
- The <u>plant height, growing s er uptake rate and plantdiseas</u> assessment considerations.



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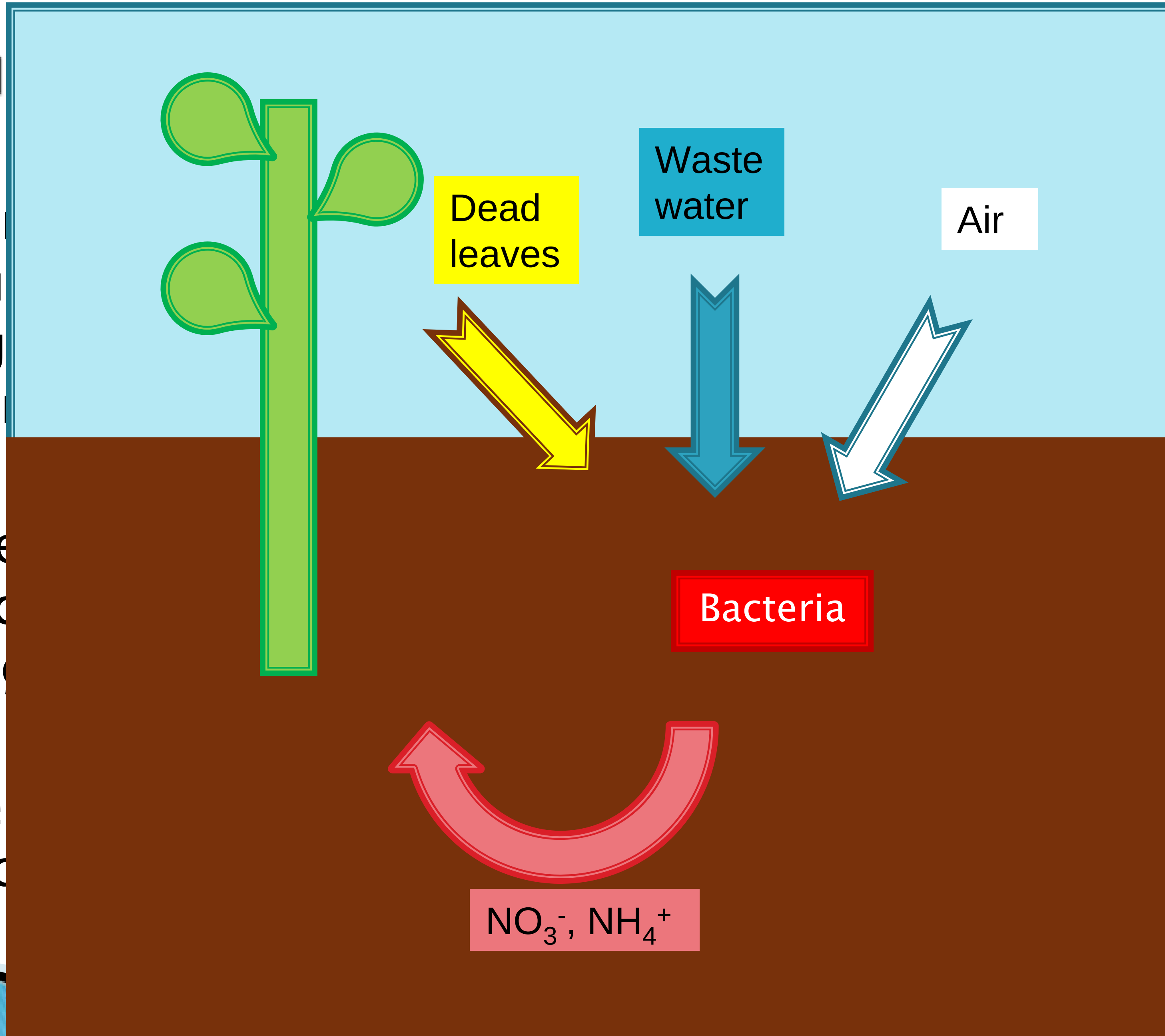
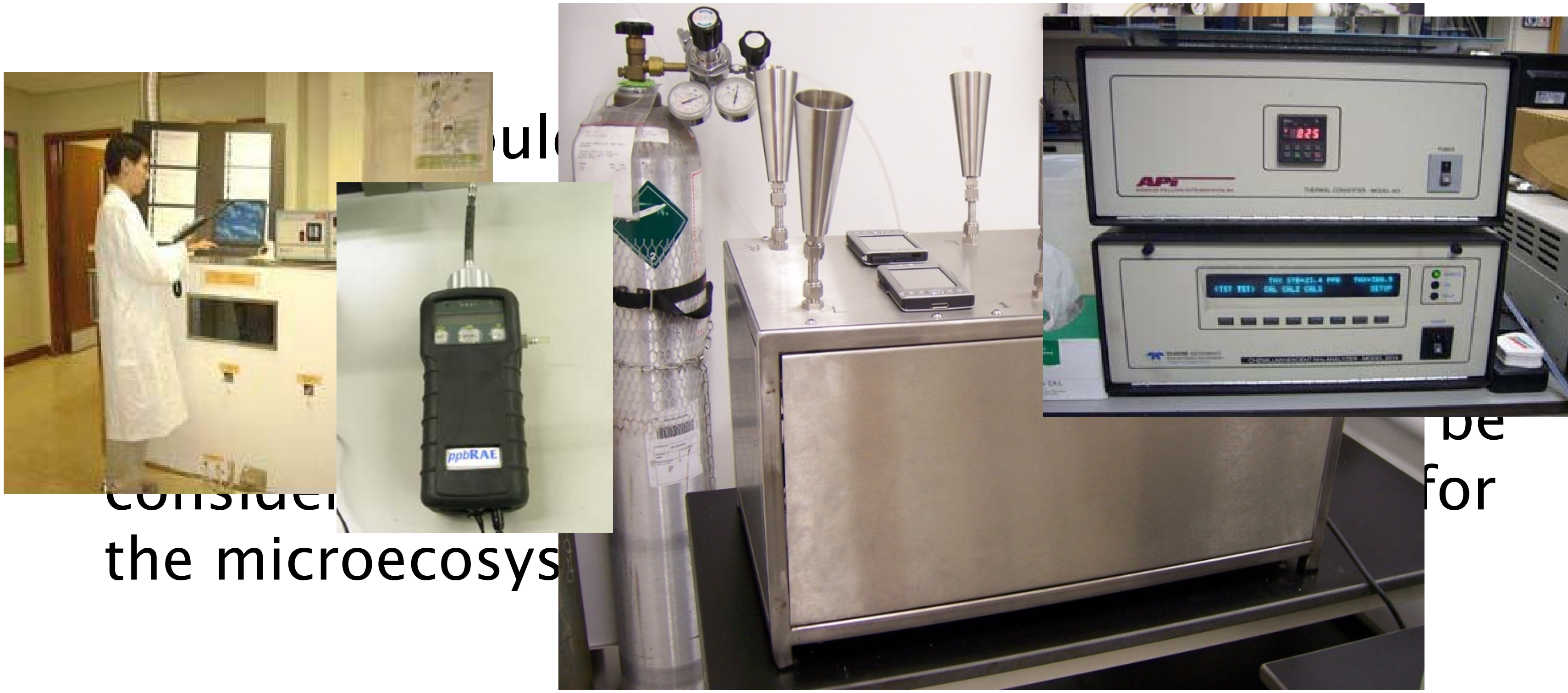


4.4 Odour Generation and Removal



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- Environmental chamber and TVOCs, NH_3 and H_2S measurement equipments are used for the analysis of odour.

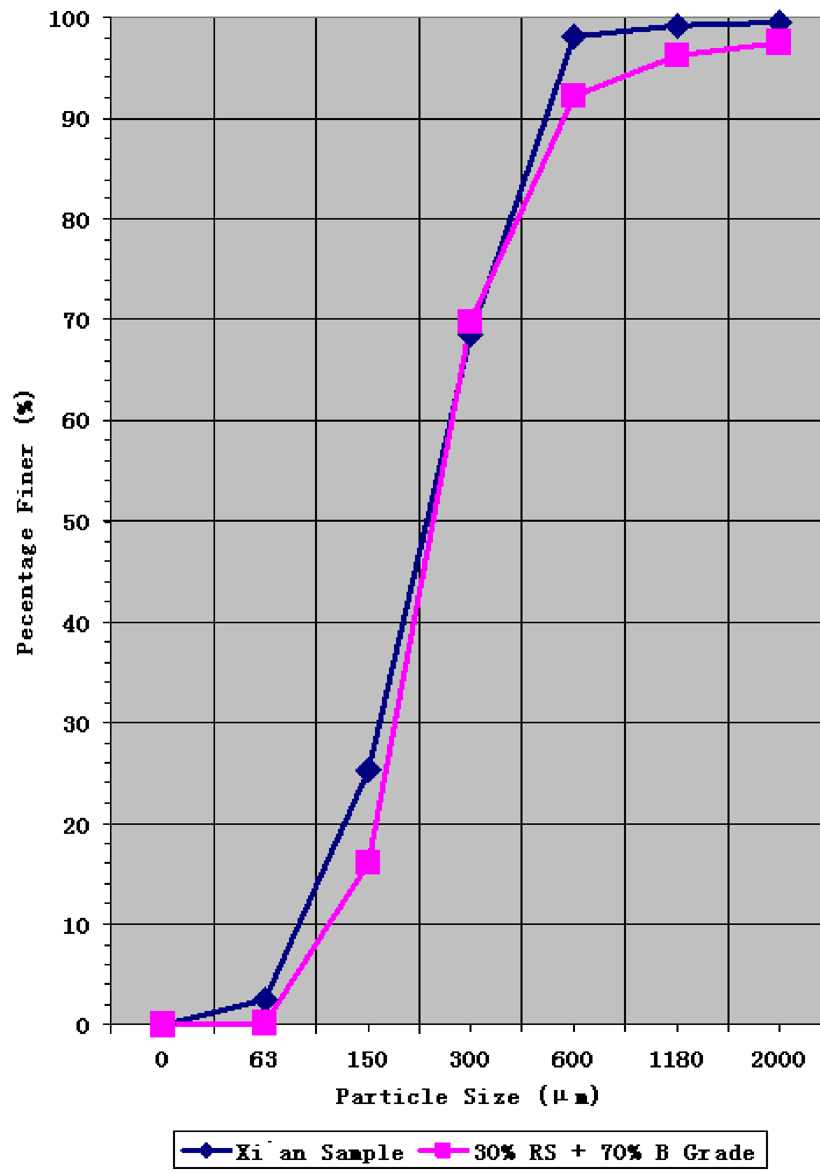
Classification of plant mineral nutrients according to biochemical function (Adapted from Mengel and Kirkby, 2001)

Mineral nutrient	Functions
Group 1	**Nutrients that are part of carbon compounds**
N	Constituent of amino acids, amides, proteins, nucleic acids, nucleotides, coenzymes, hexosamines, etc.
S	Component of cysteine, cystine, methionine. Constituent of lipoic acid, coenzyme A, thiamine pyrophosphate, glutathione, biotin, 5′-adenylylsulfate, and 3′-phosphoadenosine.
Group 2	**Nutrients that are important in energy storage or structural integrity**
P	Component of sugar phosphates, nucleic acids, nucleotides, coenzymes, phospholipids, phytic acid, etc. Has a key role in reactions that involve ATP.
Si	Deposited as amorphous silica in cell walls. Contributes to cell wall mechanical properties, including rigidity and elasticity.
B	Complexes with mannitol, mannan, polymannuronic acid, and other constituents of cell walls. Involved in cell elongation and nucleic acid metabolism.
Group 3	**Nutrients that remain in ionic form**
K	Required as a cofactor for more than 40 enzymes. Principal cation in establishing cell turgor and maintaining cell electroneutrality.
Ca	Constituent of the middle lamella of cell walls. Required as a cofactor by some enzymes involved in the hydrolysis of ATP and phospholipids. Acts as a second messenger in metabolic regulation.
Mg	Required by many enzymes involved in phosphate transfer. Constituent of the chlorophyll molecule.
Cl	Required for the photosynthetic reactions involved in O_2 evolution.
Mn	Required for activity of some dehydrogenases, decarboxylases, kinases, oxidases, and peroxidases. Involved with other cation-activated enzymes and photosynthetic O_2 evolution.
Na	Involved with the regeneration of phosphoenolpyruvate in C_4 and CAM plants. Substitutes for potassium in some functions.
Group 4	**Nutrients that are involved in redox reactions**
Fe	Constituent of cytochromes and nonheme iron proteins involved in photosynthesis, N_2 fixation, and respiration.
Zn	Constituent of alcohol dehydrogenase, glutamic dehydrogenase, carbonic anhydrase, etc.
Cu	Component of ascorbic acid oxidase, tyrosinase, monoamine oxidase, uricase, cytochrome oxidase, phenolase, laccase, and plastocyanin.
Ni	Constituent of urease. In N_2-fixing bacteria, constituent of hydrogenases.
Mo	Constituent of nitrogenase, nitrate reductase, and xanthine dehydrogenase.

5. Preliminary Result

- The mixture of 30% River Sand and 70% B Grade Sand showed 99.3% correlation on percentage finer.

	Xi'an Sample	30% River Sand+70% B Grade Sand
D_{60} (mm)	0.293	0.294
D_{10} (mm)	0.095	0.120
Uniformity Coefficient (U)	3.084	2.450
D_{95} (mm)	0.595	1.022
$D_{84.1}$ (mm)	0.452	0.485
D_{50} (mm)	0.224	0.231
$D_{15.9}$ (mm)	0.109	0.141
D_5 (mm)	0.073	0.092
Skewness	0.375	0.589



5. Future Works

- Systematically set up the lab-scale experiments and laboratory analysis.

- Enlarge the study on plants types and hydraulic modeling for SSS.

- -End of Presentation-
- Thank you!
- Q&A