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Ecological engineering land treatment systems ——A new development in China*

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Abstract——This paper elucidated the necessity and possibility of developing the technology of land treatment on the basis of the analysis of shortage and pollution status of water resources in China. The historical development of this technology in the world was briefly reviewed and the distinction between land treatment and conventional wastewater irrigation was discussed in details. The fundamental characteristics and functions as well as the integrity and compatibility of this ecological engineering were also summarized. It was finally concluded that this technology for wastewater treatment has broad prospects of application in China.

Keywords: wastewater treatment; ecological engineering land treatment system (EELTS); water pollution; water resources; sewage irrigation.

1 Introduction

The practice of applying organic wastes and waste water to soils is not a recent innovation. More than two thousand years ago, ancient Chinese farmers disposed of human wastes, animal manure and agricultural wastes on land for the useful purpose of raising valuable crops and for increasing soil fertility. The initiative of irrigation farm with waste water could be traced back to the remote era of Athens (Gao, 1991).

However, no method of sewage treatment is entirely free from all drawback and disadvantages. Sewage farming is no exception. After a period of rapid development, it began to decline both in England and elsewhere. Nevertheless, the decline was not long and just temporary. In the early 1970s, such global problems as environmental pollution and energy crisis brought great threat to the mankind. It was then realized that secondary treatment plants were too costly and energy-consuming, and that the effluents from the plants were enriched with appreciable quantities of nutrients such as nitrogen and phosphorus which might cause eutrophication of the receiving streams, lakes and oceans. The 1972 Amendments to the

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Federal Water Pollution Control Act noted that it was a national goal for the United States to minimize the discharge of wastes to surface waters. This goal resulted in greater attention to water conservation and reuse, to waste utilization possibilities, and to greater interest in the use of the land as an acceptor of wastes. So far, this alternative method for wastewater treatment has been developed into a complete and true technology.

This revival also arised from a widespread desire to conserve water by recycling. Also, it was thought that land disposal of wastewater would minimize water pollution problems attributed to the presence of large amounts of chemical constituents that could cause severe water quality deterioration in water-based disposal systems. Additional interest in land disposal has been created by the possibility that nutrients present in wastewaters, such as nitrogen and phosphorus, could be recycled to the land where they might then serve as fertilizer for terrestrial plants(Lee, 1976).

Recently more attention has been paid to some new LTSs such as wetland and subsurface capillary seepage systems. In western Europe and the U. S., wetland attracts much more interests. Subsurface capillary seepage has been proved to be conspicuously effective since its application in 1920s in the countryside of Japan.

2 Distinction between land treatment and sewage irrigation farming

Although it is derived from traditional direct irrigation with untreated sewage, modern land treatment concept has been developed into an integral technology and differs from irrigation farming in at least six aspects as follows(Zhou, 1988):

2.1 Continuous operation

Traditional wastewater irrigation has been practiced for hundreds of years. Its principle purpose is to utilize the resources in wastewater to increase the production of vegetation especially in arid and hot regions, however, without consideration of continuous operation. It was a common practice in most Chinese wastewater irrigation areas that wastewater was returned into the streams without storage in winter or in time when plants did not need irrigation. On the contrary, land treatment emphasizes wastewater treatability, design of storage pond, water balance, distribution methods, hydraulic loading rates and selection or combination of covering crops to ensure continuous operation, especially in winter.

2.2 Loading of pollutants

Wastewaters from industries and municipalities are considered as resources with traditional irrigation rather than wastes that need to be put "out of sight, out of mind" (Pratt, 1977). With sewage irrigation, there is only one important concept of wastewater concentration. However, land treatment places much emphasis on determination of the hydraulic loading rate based on the analysis of land-limiting constituents(LLCs), usually of nitrogen, soil permeability, irrigation requirements, trace elements or toxic organics.

2.3 Ecological combination

The crop is a critical component in land treatment. It removes nutrients, reduces erosion, maintains or increases infiltration rates, and can produce revenue where markets exist. When a storage pond is not available for non-growing seasons, crop combinations are often preferred. For example, double crop combinations that are commonly used in areas with a long growing season include: (a) short season varieties of soybeans, silage corn, or sorghum as a summer crop; and (b) barley, oats, wheat, vetch, or annual forage grass as a winter crop(USEPA, 1981). In western Shenyang of China, a pilot scale slow rate infiltration LTS was established with a complex crop combination of rice, energy sorghum, willow and scholar tree, which played an very important role in regulating hydraulic loading.

2.4 System design

Once a site has been chosen from all available alternatives, a LTS should be elaborately designed to achieve planned goals. The type selection of land treatment process is dictated by site conditions, climate, and regulatory requirements. The major design variables such as crop selection, hydraulic loading rate, land area requirements, storage requirements and application method would be determined. When selecting the type of distribution system, the designer must consider the terrain, crop, soils and capital and operation/maintenance costs. If the reuse of renovated water is proposed, a supplementary collection system also need to be designed with such variables as proper travel distance, depth and spacing of drain lines for underdrains(USEPA, 1981).

2.5 Operation/maintenance management

Since land treatment systems are of natural ecosystems, they are somewhat elastic and can withstand a certain amount of stress prior to permanent change or collapse. In the absence of proper care in the distribution of sewage and management of lands, damage to lands and deterioration of effluent quality may occur under certain circumstances. Land worked beyond its capacity would not only fail to produce healthy crops, be disabled from discharging its primary function of affording satisfactory treatment to sewage, but do damage to itself. At such a stage when sewage is spread on lands in quantities far in excess of their agricultural requirements and their capacity to assimilate the liquid, damage to the land is a natural consequence(Mahida, 1981).

Thus, tillage should be operated securely, soil chemical properties be maintained in good conditions, crop be managed to maximize biomass production, quality of water after preapplication treatment be regulated in order to maintain treatment efficiency. To determine if the effluent quality requirements are being met, to determine if any corrective action is necessary to protect the environment or maintain the renovating capacity of the system, and to aid in system operation, water quality, soils and vegetation must be monitored regularly (USEPA, 1981).

2.6 Protection of receiving streams

The primary cause of concern about land disposal or application of wastewaters is the presence in these wastewaters of various types of chemical pollutants that could cause water quality deterioration in surface and particularly groundwater around the disposal site. Traditional wastewater irrigation often ignores this problem. As to land treatment, adequate design, construction, flexibility and monitoring must be included as part of the capital improvement and operation and maintenance budget to ensure that the chemicals in effluents will not exceed their critical concentrations so that good protection of nearby streams be provided from adverse effects. In order to give ample protection of the ground and surface waters, land application systems must be designed as a treatment device and not merely as a means of disposal.

3 Ecological principals of land treatment systems

Land treatment is defined as the controlled application of wastewater onto the land surface to achieve a designed degree of treatment through natural physical, chemical, and biological processes within the plant-soil-water matrix(USEPA, 1981). It should be regarded as an ecological engineering which combines ecological principals with engineering methods. The main ecological principals in it include integral optimization, recycling of materials, and geographic diversity(Gao, 1990a).

3.1 Integral optimization

Each biosystem level has emergent properties and reduced variance as well as a summation of attributes of its subsystem components. The old folk wisdom about the forest being more than just a collection of trees is indeed a first working principle of ecology (Odum, 1983). Land treatment is a systematic engineering including control of discharging sources, transportation of wastewater, pretreatment, land distribution, cultivation and collection or renovated water. Thus, a comprehensive design should be integrally optimized for the LTS to maximize its functions of purifying the applied wastewater and reusing the nutrients and water resources in the wastewater.

3.2 Recycling of materials

The rational underlying land treatment systems derives from general and specific needs in the area of utilization of the earth's soil mantle as an engineering system for wastewater disposal. Utilization of the soil as a " living filter" has been acclaimed as the most ecologically appropriate treatment technique because recycling of materials is a built-in reality. However, the recycling processes are very complex because of the large number of interacting variables involved. The fate of wastewater materials in the multi-compartment plant-soil system is determined by a great number of processes, including physical retention, adsorption on solid surfaces, plant and microbial uptake, microbial mineralization, volatilization, leaching, chemical breakdown, and precipitation(Spyridakis, 1976).

3.3 Geographic diversity

Among all sites available for land disposal, one differs from another on such aspects as land use, soils, climate, topography and geohydrology. So, preceding any wastewater LTS design, extensive site investigation and adequate planning should be made to collect necessary information and to ensure selection of the most cost-effective and efficient process and a suitable site that is feasible for local conditions.

In addition, land treatment also reflects engineering rules in at least three aspects, i. e. (1) systematic design aimed at a specific situation, (2) rigorous engineering construction, and (3) proper operation and management.

4 Characters of the ecological engineering LTS

A LTS is a multi-compartment system with soil, air, water and organisms interacting and being affected by human activities such as cultivation and wastewater application, which enables it an ecological engineering with multiple functions, a variety of objectives and site-specific properties.

4.1 Multiple functions

4.1.1 Production

Previously, the objective of land treatment was simply the disposal of wastewaters, but more recently, an increasing important goal has been the utilization of nutrients in the wastewaters, especially nitrogen and phosphorus, for raising profitable crops. It was reported that during the period 1963 to 1970, the annual yield increase of a land disposal system in State College, Pennsylvania, ranged from 0 to 350% for corn grain, 5% to 130% for corn silage, 85% to 190% for red clover, and 79% to 140% for alfalfa (Sopper, 1976). Among the major municipal wastewater irrigation areas in China, the harvest of rice in Chengdu, Sichuan Province, increased from 1.5—2 to 5—6 tons/ha; in Shenfu, Liaoning Province, from 2 to 6—6.75 tons/ha (Gao, 1990b).

4.1.2 Purification

The constituents of concern in municipal wastewaters can be generally divided into four categories (Gao, 1990b; The Shenyang Institute of Applied Ecology, 1990):

(1) High toxic substances, including biological nondegradable organics, heavy metals, carcinogenic, mutagenic or teratogenic agents, radioactive fission products, pathogens and viruses;

(2) Dissolved inorganic substances, including N, P, K, Ca, Mg and other plant nutrients;

(3) BOD, including organic wastes and common toxic organic chemicals; and

(4) suspended solids.

The addition of wastewater to a LTS immediately triggers and modifies a whole series of complex chemical, physicochemical, physical, and biological reactions. The soil-water-plant matrix is the principal medium in which treatment and removal of wastewater constituents such as BOD, SS, N, P, trace elements, microorganisms and trace organics take place. The mechanisms responsible for purification consist of (The Shenyang Institute of Applied Ecology, 1990):

(1) Uptake, transformation and breakdown by plant roots and leaves;

(2) Degradation, transformation and adsorption by soil microbes such as fungi, actinomycete and bacteria;

(3) Adsorption, complexing and precipitation by soil organic matters or inorganic colloids;

(4) Ion exchange;

(5)Physical retention;

(6) Volatilization of soil solution, and so on.

4.1.3 Manipulation

Land disposal of wastewater effluents is an engineering alternative, which, like other treatment alternatives, should be planned, designed, constructed and operated under proper manipulation control so that the system can maximize its treatment efficiency and minimize the pollution treat to nearby aquatic environment.

On the stage of design, the land-limiting constituent(LLC) should be determined on the basis of calculation for the assimilative capacity at a specific plant-soil system site. This is then the controlling parameter requiring the largest land area. On a constituent-by-constituent basis, in-plant source control or pretreatment processes prior to land disposal should be analyzed and selected to reduce the total level of the LLC(Overcash, 1981).

On both temporal and spatial scales, crops that have high nutrient uptake capacity and tolerance to high hydraulic and /or pollutant loading rates might be selected and combined to form an ecological structure. The combinations of agronomic and forested areas could provide the greatest flexibility in operation(Sopper, 1976).

A monitoring program including observation on water quality, the soil receiving wastewater, and in most cases, vegetation growth, is essential for protecting the environment, maintaining the renovative capacity of the system, and aiding in system operation (USEPA, 1981).

4.2 Variety of objectives

The objectives often vary from one LTS to another. However, there are obviously some common goals to be achieved for wastewater disposal on soil-plant systems, which are as follows:(Gao, 1990b; USEPA, 1981):

(1)Treatment of applied wastewater effluents;

(2) Economic return from use of water and nutrients to produce marketable crops;

(3) Conservation and recovery of renovated water by wells or underdrains with subsequent reuse or discharge;

(4) Ground water recharge;

(5) Maintaining the biological quality of planted crops;

(6) Preventing the secondary environment pollution, especially of long-term effects, by reducing the pollution load to a minimum degree to the marine and fresh water ecosystems.

4.3 Site specific importance(Overcash, 1981)

A fundamental principle emerges as extremely important in selecting and designing any LTS process is absolutely site-dependent or site-specific, which reinforces the concept of a design procedure rather than arbitrary design criteria[kg/(ha · a)] for all sites. The specific site or potential sites must first be identified and the information be used from these sites to determine the rate of application of a wastewater or constituents within it. This was learned from experiences with successful and unsuccessful systems, in which the critical difference was in accounting for site-specific properties such as land use, land price, soils, climate, topography and geohydrology . Land-based treatment design criteria are generally not transferable from location to location, only the method of data collection and design calculation are general.

5 Review of the studies on LTSs in China

Even though wastewater irrigation farming has been practised for decades in China, the first case study on ecological engineering wastewater LTSs began in 1982 in southwestern suburb of Shenyang, Liaoning Province (Gao, 1986a, 1986b; 1991; The Shenyang Institute of Applied Ecology, 1990). An experimental and pilot-scale slow rate infiltration LTS(SR-LTS) has been developed to treat 600 tons of municipal wastewater mixed with industrial and domestic effluents on an area of 14 ha with main covering vegetation of rice. A frame model for this SR-LTS is given in Fig. 1.

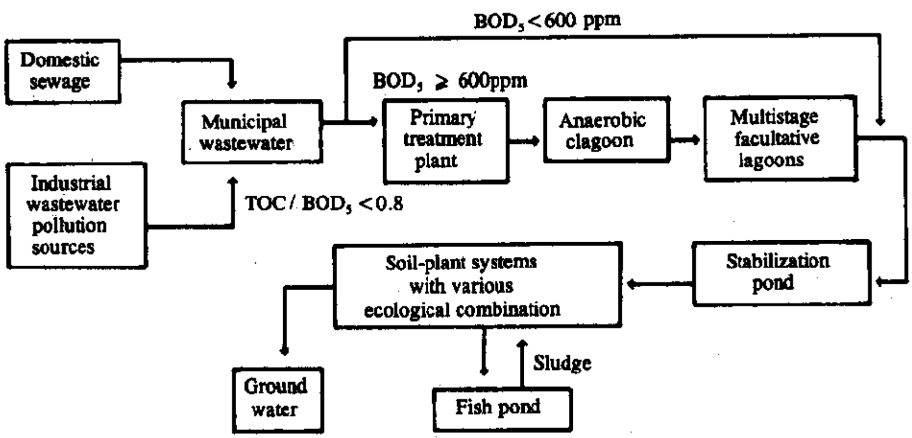


Fig. 1 Proposed model for the SR-LTS in western Shenyang (with small modification) (The Shenyang Institute of Applied Ecology, 1990)

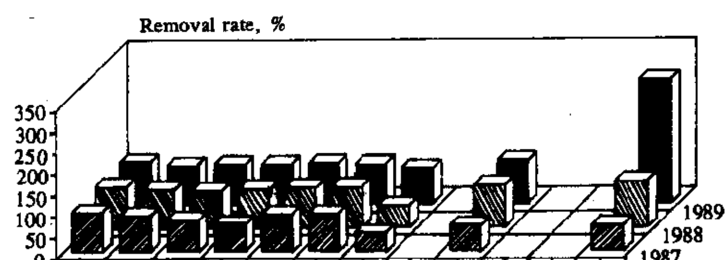
In the past decade, an interdisciplinary research program has been carried out on this land treatment system, which included: (a) investigation on the municipal wastewater constituents and site information; (b) calculation of LLC; (c) ecological combination of covering vegetation; (d) system design; (e) purification functions of the SR-LTS; (f) ecological effects and ecotoxicology of wastewater land disposal; (g) possibility of winter operation; (h) comprehensive benefit analysis including economic, social and environmental benefits; (i) fate of some priority organic pollutants in the SR-LTS; and (j) groundwater pollution prospect and its countermeasures(Gao, 1986b; 1990; Huang, 1990; Yang 1990, 1992).

On the basis of statistical data obtained from 1987 to 1989, the performance of the SR-LTS in terms of conventional comprehensive parameters is demonstrated in Fig. 2 and Table

1, which indicate that this system was operated very well and most of the parameters of its effluent met the standards for surface water discharging. Table 2 compares the Shengyang SR-LTS with traditional wastewater irrigation in western Shengyang, the conventional biochemical treatment plant in Jizhuang of Tianjin, China and the SR-LTS in Muskegon County, Michigan, USA, showing that the purification functions of the SR-LTS in western Shengyang met or even exceeded those of secondary treatment plants and the SR-LTS in Muskegon County, even though its effluent concentrations of some constituents such as E. coli. and SS were not satisfying.

During the period of 1986 to 1990, the Chinese Environmental Protection Agency(EPA) also sponsored research projects on LTSs except the above-mentioned Shenyang project, for example, on rapid infiltration in Beijing, slow rate in Kunming, Yunnan Province, overland flow in Beijing, wetland in Tianjin, and a combined system(OF followed by RI) in Atush, Xinjiang Uygur Autonomous Region (Gao, 1991; Huang, 1990; Leach, 1990). All these studies have been ratified by the Chinese EPA to continue for another five years till 1995. At the sametime, a number of small to large scale LTSs have been built up and under design or construction in many regions of China. For example, a large scale LTS(RI) with a treatment flow of 30000tons/day is being built in Xinjiang Uygur Autonomous Region(Huang, 1990). And a subsurface capillary seepage system for domestic sewage treatment in the Shenyang University of Industry was just completed in November 1991 under the cooperation of Meitetsu Environmental Improvement Joint Stock Company of Japan and the Shenyang Institute of Applied Ecology, the Chinese Academy of Sciences. This system has been operated successfully since its termination.

The purpose of all the research work was to find cost-effective and energy-efficient alternative technology, which is also compatible with the practical economic and technical conditions in China, to substitute traditional biochemical treatment for treating municipal wastewater by means of ecological engineering; to develop LTSs which can purify and utilize wastewater on a sustainable basis; and to develop a strategy for the control of specific pollutants(Gao, 1990; The Shenyang Institute of Applied Ecology, 1990).



	BOD	COD	TOC	K-N	NH_4^+	TP	SS	Coliform	$-[(NO_3^- + NO_2^-)-N]$
1989	97.4	88.8	90.9	91	94.6	91.7	81.9	99.1	292.6
1988	97.9	89.8	86.3	91.1	94.6	96.6	51.5	99.9	108.2
1987	94.6	84.1	74.6	65	88.2	88.8	44.6	60.3	61.9

Fig. 2 Removal rate of conventional parameters through the Shenyang SR-LTS

Table 1 Evaluation of the quality of the effluent from the SR-LTS in western Shenyang

Parameters	NO_3	NO_2^-	K-N	T-P	DO	COD_{cr}	Cl^-
Effluent *	2.011	0.038	1.82	0.096	5.08	22.27	216.78
Grade * *	I	I	IV	IV	III	V	I
Parameters	BOD_5	CN^-	Phenol	Oil	Bap	Hg	Cd
Effluent	2.23	0.005	0.002	0.02	0.0002	0.0002	0.003
Grade	I	I	I	I	I	IV	II
Parameters	Pb	As	Cr	Cu	Zn	pH	NH_3
Effluent	0.014	0.009	0.02	0.02	0.08	6.6	0.0017
Grade	I	I	II	II	II	I—V	V

* Average concentrations of three years (in mg/L) except pH; * * Environmental quality standard for surface water (GB3838-88), the Chinese EPA

6 Status of water shortage and water pollution in China

China is not abundant with its freshwater resources. Its annual water resource is about $2800\times10^9 m^3$, ranking sixth in the world, while that per capita is only 2630 m^3, which is a quarter of the world average and 88th in the world. There are also significant differences between eastern monsoon and northwestern arid China. Distinctive climatic and geomorphological conditions exist over the vast territory of China, which have formed extremely uneven patterns on stream runoff. Water is abundant in south but scarce in the north. More than 45% of the area of China has annual rainfall less than 400 mm/a. Only 9% of the total water resources is available to 40% of the total cultivated area in northern China (Wang, 1990; Zhang, 1990).

According to the recent statistical data, there have been more than 200 cities facing the challenge of water shortage. Now, the daily shortage is 12×10^6 tons in all, among which 8×10^6 is of industries. The stress of water shortage has been one of the main factors inhibiting the development of industries, which causes a 3.7×10^9/a reduction of the national economic income.

In recent years, with the rapid development in China's national economy, industrialization, urbanization and increase of population, the discharge of wastewater increased significantly. In 1987, the total amount of wastewater was 34.9×10^9 tons, 80% of which was discharged from urban areas into rivers, lakes and seas, and most of which had not been treated (The Editorial Board of Chinese Statistics, 1988). And it has been forecasted that the total annual amount of wastewater in 2000 will attain to 63.8×10^9 tons (Jiang, 1988).

Increasing volumes of municipal wastewater are usually correlated with increasing demands on the local water supply which in times of drought can cause serious water shortages. Hence, it is somewhat paradoxical that communities while experiencing water shortages will at the same time discharge millions of gallons of wastewater into local streams for rapid removal from the area. As a result, water pollution and aquatic ecological damage in some urban areas have been quite serious (Zhang, 1990). Among 532 rivers under national monitoring, 82% of them have been contaminated in various degrees. 93% of 44 rivers which flow through 42 large or moderate cities have been polluted, among which 79% are highly or moderately polluted. Over 65% of the national population is estimated now to drink polluted water.

For many years, in the arid and semi-arid areas in China, polluted streams have been conducted and pumped into nearby agricultural fields for direct irrigation without any pre-application treatment, which resulted in serious soil and crop pollution. Reduction in crop yields due to an excess of accumulated or naturally occurring microelements have been observed in areas both in China and in many other countries (Chaney, 1977; Gao, 1986b; 1990b).

7 Prospects of future application of LTSs in China

Water pollution and damage of agricultural ecosystems caused by discharge of untreated wastewaters have become a great challenge to both Chinese government and the society. From 1980 on, the Chinese government has taken environmental protection as a basic national policy. More than 120000 projects throughout the country were instituted for pollution treatment facilities between 1981 and 1988(The Chinese EPA, 1988b). In order to eliminate water shortage and water pollution, and to improve the quality of the environments, the government has decided to increase the ability of wastewater treatment and reuse by various methods including developing land treatment and constructing biological secondary treatment plants.

It can be anticipated that the high cost of conventional wastewater treatment facilities together with increasingly restrictive governmental water quality and effluent discharge regulations will give much strong impetus to consideration of land disposal. Wallace (Wallace, 1976) reported that the cost of a spray irrigation system was estimated as $153000 less than the cost of an activated sludge system with final disposal through a spreading basin for a 1×10^6 gallon/day(about 3800 tons/day). The actual saving was even larger than estimated.

Energy efficiency is another reason for the selection of land treatment. When expressed on a basis of energy used per unit amount of BOD_5 removed, the conventional systems with stream discharge were two to three times more energy intensive than pretreatment-land application (Overcash, 1981). So far, studies on the techno-economic analysis of the LTSs in China indicate that the capital investment, power consumption and operation costs of a LTS with a treatment flow of 1000—6000 tons/day are 0.25—0.50, 0.15—0.20 and 0.25—0.63 of traditional secondary treatment process respectively(Gao, 1991; Huang, 1990).

In 1986 the Environmental Protection Commission under the State Council of China promulgated " some regulations on technical strategies concerning water pollution control", encouraging wastewater reuse and the use of land treatment technology. According to the "prospective outline for Chinese environmental protection program in 2000", the amount of discharging domestic sewage should be constrained to about 20×10^9 tons/a, and its treatment percentage should be raised to 20%—30%. At present, the percentage of treated industrial wastewater is only 3.44%. However, this segment is going to be raised to 30%—

Table 2 Purification assessment of the SR-LTS in western Shenyang in comparison with other systems for wastewater treatment

Constituents	Systems	Influent concentration*	Effluent concentration*	Removal rate, %
BOD_5	A	96.2	2.23	97.7
	B	96.2	41.4	57
	C	121.4	15.6	87.1
	D	205	3	98.5
COD	A	207.8	22.3	89.3
	B	207.8	117.8	43.3
	C	296.6	62.4	79.0
	D	545	28	94.9
NH_4^+-N	A	15.7	0.85	94.6
	B	15.7	11.1	29.3
	C	—	—	—
	D	6.1	0.6	90.2
NO_3^--N	A	0.91	2.01	−120
	B	0.91	0.86	6.3
	C	—	—	—
	D	—	1.9	—
TP	A	1.71	0.096	94.4
	B	1.71	0.97	43.3
	C	—	—	—
	D	2.4	0.05	97.9
SS	A	61	19	68.8
	B	61	58	4.9
	C	166.2	22.7	86.4
	D	249	7	97.2
E. coli., No./100ml	A	6.6E9	1.9E6	97.1
	B	6.6E9	3.8E9	94.2
	C	—	—	—
	D	$>10^6$	$<10^2$	—

Notes: * = units in mg/L except *E. coli.*; A = The SR-LTS in western Shenyang; B = traditional wastewater irrigation in western Shenyang; C = The secondary biochemical wastewater treatment plant in Jizhuang of Tianjin, China; D = the SR-LTS in Muskegon County, Michigan, USA.

40% by the end of this century. Thus, it is urgent and necessary to develop cost-effective and less energy-consuming technologies for wastewater treatment. Land treatment is believed to be recommended for first consideration and selection. If such amount of wastewaters could be treated by land disposal, enormous investment, as well as considerable amount of energy, will be saved.

It can be predicted that ecological engineering LTSs will be given priority in considering the selection of sewage treatment technologies by small to moderate towns or cities. In fact, land treatment is now used in developed countries such as the Unite States as an alternative of tertiary treatment methods for effluents from secondary plants. In China, however, it is impossible for all the towns and cities to build up secondary treatment plants, for, as we know, being lack of sufficient fund and energy, let alone advanced tertiary treatment. Municipal wastewaters in large Chinese cities such as Beijing, Shenyang, Tianjin and Shanghai are thought to be not suit for land treatment because of their complex constituents and high toxicity and too expensive land for wastewater disposal. However, in small or moderate cities, the municipal wastewaters are often simple in composition and feasible for land disposal since it contains very little amount of toxic or non-degradable substances, which can be assimilated by the soil-plant system. And land with reasonable price is usually available in these towns or cities which are mostly located in rural areas. This makes land disposal more attractive and acceptable. By and large, it can be concluded that land treatment has broad prospects of application in China.

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