

Ecosan

生态卫生

——可持续营养物管理新概念

- A New Concept of Sustainable Nutrients Management

北京建筑工程学院
马文林

Ma Wenlin

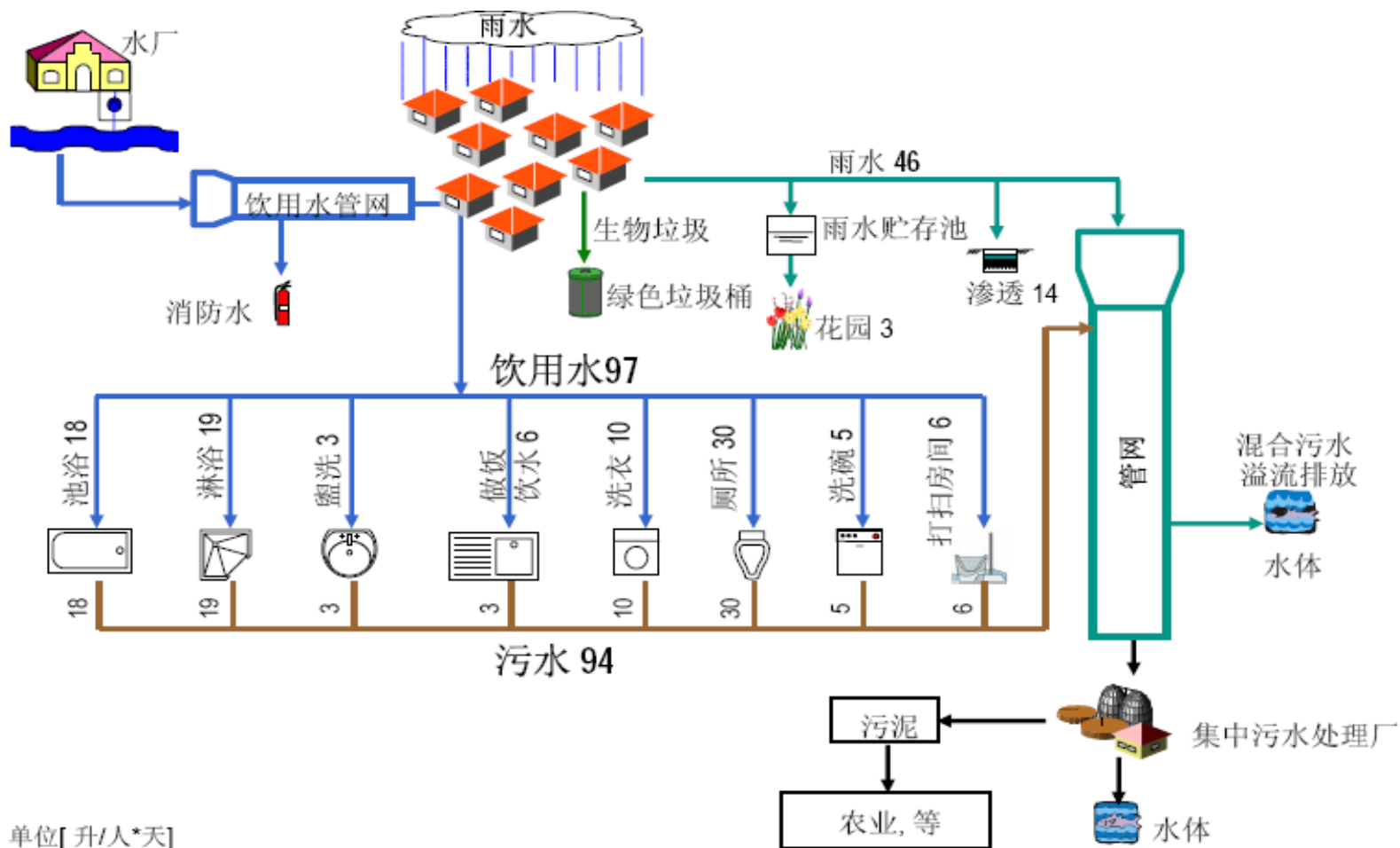
Beijing Institute of Civil Engineering and Architecture

主要内容 **Main Contents**

- ▶ 前言
- ▶ **Preface**
- ▶ 生态卫生系统的概念
- ▶ **Concept of Ecosan System**
- ▶ 生态卫生系统实例
- ▶ **Examples of Ecosan System**
- ▶ 家庭生活污水后分流处理
- ▶ **Post-diversion Grey Water Processing**
- ▶ 结论
- ▶ **Conclusion**

前言 Preface

- ▶ 传统的营养物质管理措施——污水处理厂末端集中控制。
- ▶ Measures for Management of Traditional Nutrients – Centralized Control at Terminal of Sewage Treatment Plant



Preface

Drinking Water Pipe Network

Rainwater 46

Fire water

Rainwater Storage Pool

Biological Waste Infiltration 14

Green Waste Bin Garden 3

Drinking Water 97

Pipe Network

Combined Sewage Overflow Discharge

Water Mass

Pool Bath 18 Shower Bath 19 Lavatory Wash 3 Cooking/Drinking Water 6

Laundry 10 Toilet 30 Bowl Washing 5 Room Cleaning 6

Grey Water 94

Sludge Centralized Effluent Treatment Plant Farming, etc Water Mass

Unit (Liter/Person*Day)

- ▶ 营养物经过了一个稀释再富集的过程，浪费了大量的水和能源；
- ▶ **Nutrients pass through a diluting and re-enriching process, and a large quantity of water and energy sources is wasted.**
- ▶ 剩余污泥由于重金属（如，镉）和其他的有毒物质（如多氯联苯，PCB）浓度太高被限制返回农田，使得氮磷等营养物在社会中成为直线流。
- ▶ **The remaining sludge is limited and returned to farmland for high concentrations of heavy metals (such as cadmium) and other toxic substances (such as polychlorobiphenyl, PCB), so that the nitrogen, phosphorus, and other nutrients become a rectilinear flow in society.**

小结：传统的营养物管理措施不但造成了水体严重的富营养化现象，还使得土壤营养物流失，具有很大弊端。

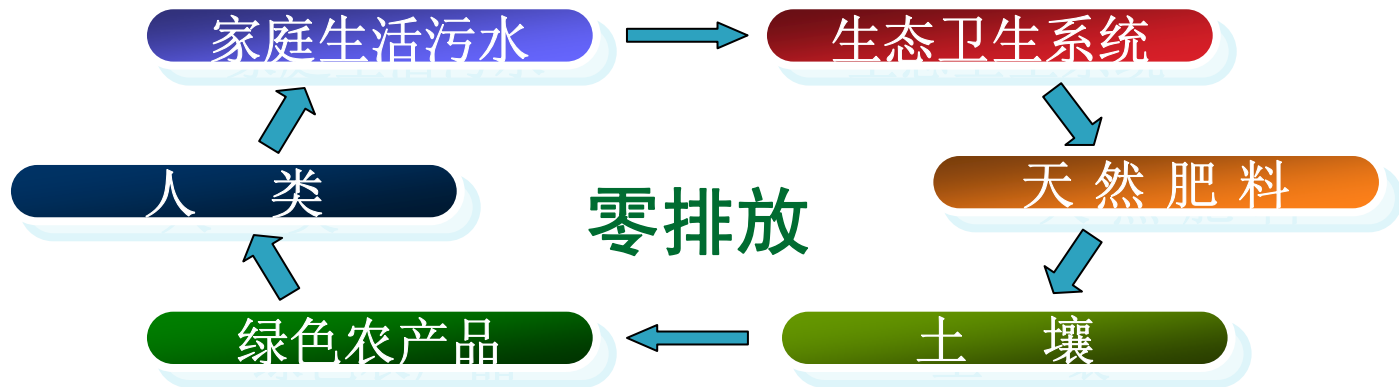
Brief Summary:

Traditional measures for nutrient management has given rise not only to serious nutrient enrichment in water mass, but also to a loss of nutrients in soil, typical of an obvious malpractice.

1. Concept of Ecosan System

1. 生态卫生系统的概念

- ▶ 生态卫生是一种在生态和经济上均体现出可持续性特点的污水管理与卫生系统——一个可持续的封闭循环系统。
- ▶ Ecologic sanitation is a kind of sewage control and sanitary system typical of sustainability both ecologically and economically – a sustainable closed-loop system.




Grey Water Ecosan System Humankind Zero Discharge

Natural Fertilizer Green Farm Products Soil

▶ 三个基本原则：

▶ Three Fundamental Principles:

- 防止污染（不是在污染之后再治理）；
 - Prevention of Pollution (instead of harnessing after contamination)
 - 使尿和粪无害化 Sanitization of Excreta
 - 把安全的产物用于农业目的
 - Application of Safe Products for Farming Purposes
- 

▶ 全新的物质处理 / 循环理念:

▶ Brand-new Matter Processing / Recycling Concept:

- Starting from matter flow and energy flow, to propose for a sustainable grey water management system adaptable to local conditions
- 不把污水和污水中的废物当作污染物来看待，不是千方百计地将其处理后“排放”，而是要尽可能地予以“回收后再利用”
- To “reuse after recovery” the grey water and waste materials in the grey water as much as possible rather than treating them as pollutants and “discharging” them after processing by all means
- 以物质循环方式从污染物产生的源头处理废物，做到生活中污物的“零排放”。
- 从物质流和能量流出发，提出适应于当地条件的生态经济的可持续污水管理系统。
- To process the waste materials from the sources where pollutants have been generated in a matter cycling manner, to achieve a “zero discharge” of sewage in life
- 实现了营养物在人类社会中的循环流，是一种可持续发展的营养物管理方式。
- It is a sustainable management style of nutrients to realize a circulation flow of nutrients in human society

2. Examples of Ecosan System

2.生态卫生系统实例

- ▶ 粪尿分离型生态厕所
- ▶ **Faeces Separated Ecosan System**
- ▶ 沼气池生态厕所
- ▶ **Biogas-plant Ecosan System**
- ▶ 生化生态厕所
- ▶ **Biochemical Ecosan System**

2.1 Urine Separation Ecosan System

2.1 粪尿分离型生态厕所

- ▶ 把粪尿分别进行收集和处理，是对传统旱厕的一种改良。
- ▶ **Faeces are separately collected and treated, as an improvement in traditional dry latrines**
- ▶ **基本结构：**尿粪分集式便器、排尿管、贮尿容器、过粪管、厕坑、排气管等。
- ▶ **Basic Structure:** Urine diverting urinal, urine discharge pipe, urine storage container, excreta pipe, toilet pit, and vent pipe, etc.



- ▶ **瑞典环科院发明单位，被联合国推荐使用；**
- ▶ **Swedish Environmental Institute as the inventor, recommended by UN for application**
- ▶ **1997年全国爱卫会将其引进中国，在广西、吉林等地推广；**
- ▶ **Introduced by National Patriotic Public Health Campaign Committee into China in 1997, and popularized in Guangxi, Jilin, and other places**
- ▶ **2002年被昆明市环境科研所引到昆明，在呈贡、晋宁沿滇池边的3个村庄进行试点；**
- ▶ **Introduced by Kunming Institute of Environmental Sciences in 2002, for pilot tests in three villages including Chenggong, Jinning alongside Tianchi**
- ▶ **目前已建设起300多所，深受群众欢迎，有人甚至称之为农村的“厕所革命”。**
- ▶ **More than 300 systems have been built up at present, highly favored by masses, and even called by some people as the “Toilet Revolution” in rural areas.**

▶ 设计原理 Design Principle

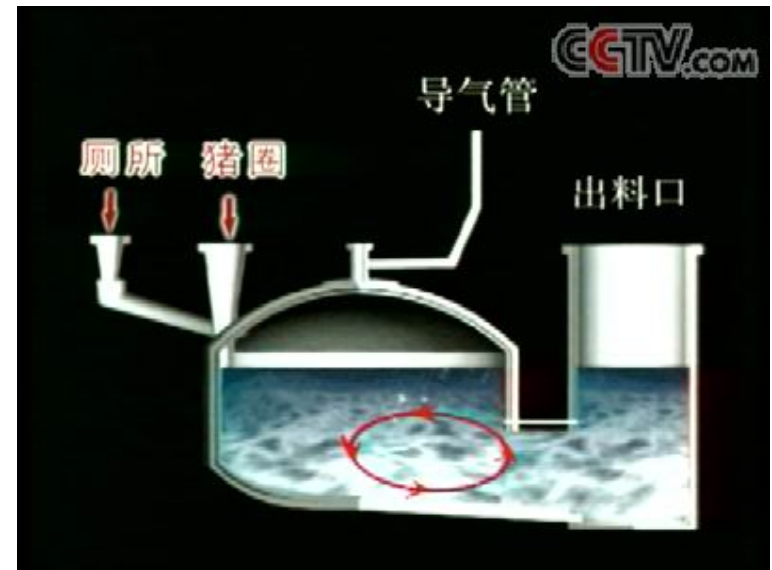
- 根据人上厕所的姿势，设计一个**大便坑**和一个**小便漏眼**，大小便自然分开收集；
- According to the human posture for using toilet, a pit for excrement and a drop hole for urine are designed, for urine to be naturally separated and collected
- 小便通过一根管线输送到一个容器里，密封接口；
- Urine is to be conveyed to a container with sealed interface through a piece of pipeline.
- 大便进入粪坑后，**用少许柴灰覆盖**，通过“烟囱”通风干燥，排水排臭。
- The excrement is covered by a little bit firewood ashes after it is entered into the pit, to be dried through ventilation of “chimney” for grey water and odor to be discharged.
- 一个4口之家的厕所，半年掏一次大便坑便可。It only takes one time for a toilet of a 4-member family to clean out the excrement pit for half a year.
- 粪便经干燥脱水，成为天然有机肥，可广泛用于农业生产。Excrements turn into natural organic fertilizer through drying and dehydration, extensively applicable to farming production.

▶ 小结Brief Summary

- 把先混合扩大污染后再去治理变为预防污染在前，可将处理减至最低限度。
- To allow prevention of pollution to precede the combined expansion of pollution before control, able to minimize treatment
- 技术含量不高，却代表了先进的卫生理念。
- It has represented an advanced sanitary concept though its technical content is not high.
- 粪坑建于地面上，不需进行防渗处理。
- The excrement pit is built on the ground, free from need for antiseepage treatment
- 该技术适应性强，是目前主要推广的技术，也是目前欠发达地区改善卫生条件最合适的技术。 This technique is highly adaptive, as a major technique to be promoted currently, and it is also the fittest technique to improve the sanitary conditions in underdeveloped regions.
- 注意：用户必须更新观念，按要求正确使用，并妥善解决覆盖物问题。
- Notice: User must update concept, to make a correct use of it as per requirements, and to properly solve the problem with covering materials.

2.2 Biogas Plant Ecosan Toilet

2.2 沼气池生态厕所



- ▶ 将沼气池与厕所连接在一起，人、畜、禽粪便经过进料口进入沼气池厌氧发酵。
- ▶ **Biogas plant is connected with toilets, for excreta of human, livestock, and poultry to enter the biogas plant for anaerobic fermentation**
- ▶ 产生的沼气是很好的能源，剩余的残余物可以作堆肥使用。
- ▶ **The biogas generated is the best energy source, and the remaining residues can serve as stockpile manure**

▶ 农村生态卫生系统典型模式：

▶ Typical Models of Rural Ecosan System:

□ 人畜—沼气—果树（南方）；

□ Human/Livestock – Biogas – Fruit Trees (South)

□ 人畜—沼气—蔬菜—大棚（北方）。

□ Human/Livestock – Biogas – Vegetables – Plastic Greenhouses (North)

▶ 家庭有机垃圾破碎后也可一同投放到沼气池中处理。

▶ Organic domestic wastes can also be placed and processed together in biogas plant after being crushed.

▶ 占地较多，不搞种养的农户建沼气池**综合效益不高**，小城镇化建设后也**难以推广应用**

。

▶ The integrated benefit for farmers who occupy larger area of land and are not engaged in planting and breeding practices to build biogas plant is not high, and it is neither easy for such plant to be extended after small townships have been constructed.

2.3 Biochemical Eco-toilet

2.3 生化生态厕所

- ▶ 生化生态厕所依据堆肥化的基本原理设计，厕所内装配有高效生物反应槽，通过向其中添加微生物菌剂、并加热，实现对粪便的高效处理。
- ▶ Biochemical eco-toilets are to be designed based on the fundamental principle of stockpile manure system, fitted with high-efficient biological reaction tank inside the toilet, thereto the microorganism bacterium agents are added and heated therein, to achieve a high-efficient disposal of faeces.
- ▶ **结构组成：**便器、分解反应槽（核心处理单元）、废气排放通道、通气系统、排水系统和其他一些附件（如搅拌器等）。
- ▶ Structure Composition: Urinal and closet, decomposition reaction tank (core processing unit), exhaust emission channel, ventilation system, drainage system, and other accessories (such as agitator, etc)

▶ **作用原理： Functional Principle:**

- 生化分解的全部过程都在分解槽内进行。
- **The entire process of biochemical decomposition is performed inside the decomposition tank.**
- 人体排泄物中绝大部分的水蒸发后通过废气管道排掉；
- **Most water in human excreta is to be drained through exhaust pipeline after evaporation.**
- 固体物质则被霉菌、细菌分解成稳定的终产物。
- **The solid matters will then be decomposed by mildew and bacteria into stable final products**

▶ 使用方法 **Operating Method**

- ❑ 在第一次使用前，一般需要向分解槽内放入适量的微生物菌剂，以及锯末和泥炭粉等混合填料。
- ❑ **Prior to the first use, it is generally required to place a proper amount of microorganism bacterium agent, as well as sawdust, peat dust, and mother mixed fillings inside the decomposition tank.**
- ❑ 粪尿不断加入后生化分解的过程可以连续进行了。
- ❑ **The process of biochemical decomposition can be continuously performed after faeces are successively added.**
- ❑ 使用过程中，需适时适量的补充泥炭粉和微生物菌剂。
- ❑ **Proper amounts of peat dust and microorganism bacterial agent shall be supplemented in due course during operating process.**

▶ **特点Features:**

- 优点：不需要建设下水管道；
- **Advantage: No need to build sewer pipeline**
- 缺点：结构复杂，造价较高。
- **Disadvantage: Complicated structure and fairly high cost**

▶ **适用场所**

▶ **Applicable Sites**

- 临时集会、偏远的加油站、分散式别墅、疗养院等场所；
- **Temporary parties, out-of-the-way gas stations, scattered villas, sanitariums, and other locations**

3. Domestic Sewage Diversion Treatment

3. 家庭生活污水分流处理

黄色水—小便（有、无冲洗水）

褐色水—大便（有、无冲洗水，不含黄色水）

黑色水—来自大、小便卫生器具的污水（大、小便及冲洗水）

灰色水—不含大、小便的其它生活污水（厨房、浴池、清洗房间的污水）

Yellow Water – Urine (Flush water available or not)

Brown Water – Excrement (Flush water available or not, no content of yellow water)

Black Water – Sewage from sanitary ware for urine and excrement (Excreta and flush water)

Grey Water – Other domestic sewage not containing faeces (sewage from kitchen, bathtub, and room cleaning)

Components of Urban Domestic Sewage after Diversion

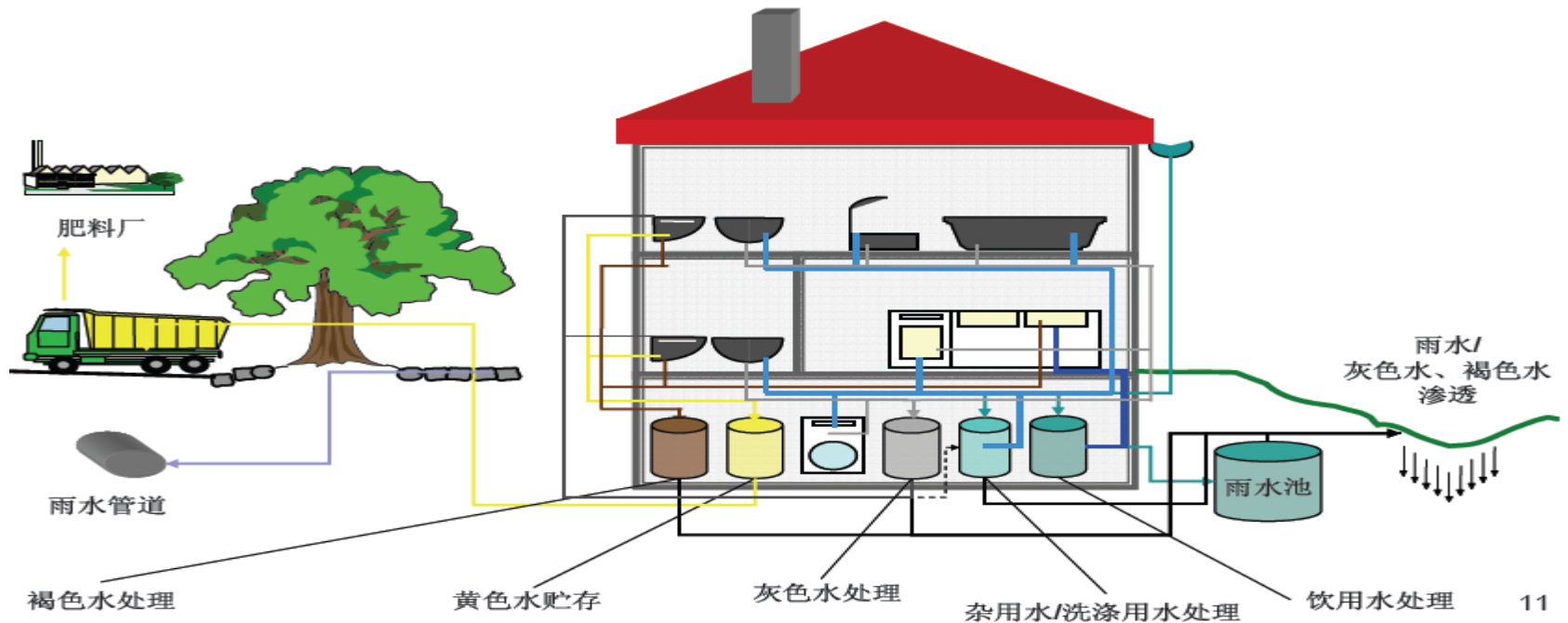
城市生活污水分流后的成分

体积 / L(p · a)		灰水	尿液	粪便
		营养物质负荷 / kg(p · a)		25 000 ~100 000
N	4~5	3%	87%	10%
P	0.75	10%	50%	40%
K	1.8	34%	54%	12%
COD	30	41%	12%	47%

Volume/L(p. a) Grey Water Urine Excrement Nutrient Load/kg (p . a)

Schematic Drawing for Complete Diversion of Domestic Sewage

生活污水完全分流示意图



Fertilizer Plant Rainwater Brown Water Disposal Yellow Water Storage Grey Water Disposal Miscellaneous/Washing Water Disposal Drinking Water Treatment Rainwater Tank Rainwater/Grey Water and/or Brown Water Infiltration

3.1 灰水

3.1 Grey Water

- ▶ 灰水通常指来自厨房、浴室和洗衣服的污水。
- ▶ Grey water normally means the sewage from kitchen, bathroom, and laundry.
- ▶ **水质特点 Characteristics of Water Quality**
 - 常含有高浓度的易降解物质，如脂肪、油和其它烹饪产生的物质、及肥皂和洗衣粉里的表面活性剂；
 - Often contains high-concentration easy degradable matters, such as fat, oil, and other substances generated by cooking, as well as soap, and surface activating agent in washing powder.
 - 致病微生物，营养物和重金属含量较低（只有使用无磷洗涤剂，才能保证低浓度的含磷量，否则需进行除磷）。
 - The contents of pathogens, nutrients, and heavy metals are comparatively low (Low-concentration phosphorus content can be assured only when phosphorus-free washing agents are used, and otherwise, dephosphorization is required.).

► 处理方法 Processing Method

- 灰水污染程度轻，只需经过简单处理，出水水质即可达处理要求，可排入池塘或用于绿化。
- In the case when degree of grey water pollution is low, only through simple treatment the effluent quality will be able to comply with the processing requirements, able to be drained into ponds or used for greening.
- 在人口密集地区，多采用生物接触氧化和膜处理技术。
- In the regions with dense population, biochemical catalytic oxidation and film processing techniques are most frequently adopted.

灰水



过滤处理

(沉砂池或过滤器，去除灰水中大颗粒固体物质、油)



自然生物处理技术

(植物滤池、土壤过滤或人工湿地等)

Grey Water Filtration Treatment Natural Bio-processing Techniques

(Septic tank or seals and filters, to remove large-granular solid matters and oil in grey water) (Plant filter, soil filtration, or artificial wetland, etc)

3.2 尿液

3.2 Urine

- ▶ 尿液是一种快速作用的、富含氮的完全肥料。
- ▶ **Urine is a complete manure with fast function rich in nitrogen content.**
- ▶ 研究证实，尿中氮的浓度约为3~7g/L，最初大多数以尿素的形式存在，在储存中会很快变为氨。
- ▶ **As proved through research, the nitrogen content in urine is about 3~7g/L, and most of urine exist initially in urea form, and will turn into ammonia quickly during storage.**
- ▶ **尿的氮效高于其它有机氮肥的肥效**，如干鸡粪，而相当于等量硝酸铵矿物肥料的90%，可根据对化学氮肥的推荐用量来估计作物对尿的需用量。
- ▶ **Nitrogen effect of urine is higher than effects of other organic nitrogen fertilizers, such as dried chicken manure, and is equivalent to 90% of the equal quantity of mineral fertilizer of ammonium nitrate. The recommended dosages for nitrogen fertilizer can be used for estimating the demand of crop for urine.**

▶ 回收利用方法

▶ Method for Recovery and Utilization

- 正常人的尿液不含致病微生物，基本上不需要处理，通过分离便器分离收集后的尿液稀释2~5倍或不加稀释可直接应用在农业生产中。
- Urine of normal people do not contain pathogens, and basically it is not required for any treatment. Urine after collection and separation through separating urinal to be diluted by 2~5 times or not to be diluted can be directly applied into farming production.
- 当收集和储存尿用作肥料时，应采取措施防止异味和氮的挥发损失，如将储存罐的盖子加以密封，可把氨的损失降到最少。
- When urine is collected and stored for the purpose of manure, measures shall taken for preventing off odor and nitrogen loss for volatilization, e.g. the lid of the storage tank to be sealed, able to minimize the loss of nitrogen.

3.3 粪便

3.3 Excrement

- ▶ 粪便也是一种肥料，但同时也有很多致病微生物，如大肠杆菌等，所以要经过无害化处理后才能施于农田。
- ▶ **Excrement is also a kind of manure, but at the same time contains many pathogens, such as bacteria coli, etc, and on this account it can only be applied to farmland after sanitization.**
- 脱水-堆肥处理法
- **Dehydrating – Stockpile Manure Processing Method**
- 真空厕所
- **Vacuum Toilet**

3.3.1 Dehydrating – Stockpile Manure Processing Method

3.3.1 脱水-堆肥处理法

- ▶ 脱水可以杀灭致病生物。
- ▶ **Dehydration is able to kill pathogens.**
- ▶ 堆肥是一种复杂的自然生物过程，可将有机物矿化并转化为腐殖质。
- ▶ **Stockpile manure is a complicated natural biological process, able to transform organic mineralization into humus.**

▶ 处理方法 Processing Method

- **脱水**：通过蒸发或向处理室、容器内加入干物质（灰、锯末和谷糠），使其中物料的含水量降低到25%以下。
- **Dehydration**: The moisture of materials wherein is to be lowered to below 25% through evaporation or by adding dry matters (ash, sawdust, and bran coat) into the processing chamber or container.
- **堆肥**：受通气、温度、湿度、pH、碳氮比等因素的影响，所需时间为8~12个月，其最佳碳氮比为15:1~30:1。
- **Stockpile Manure**: It is to be applied to the impacts of ventilation, temperature, humidity, pH, carbon-nitrogen ratio, and other factors, with a required time as 8~12 months, and its optimal carbon-nitrogen ratio is 15:1~30:1.

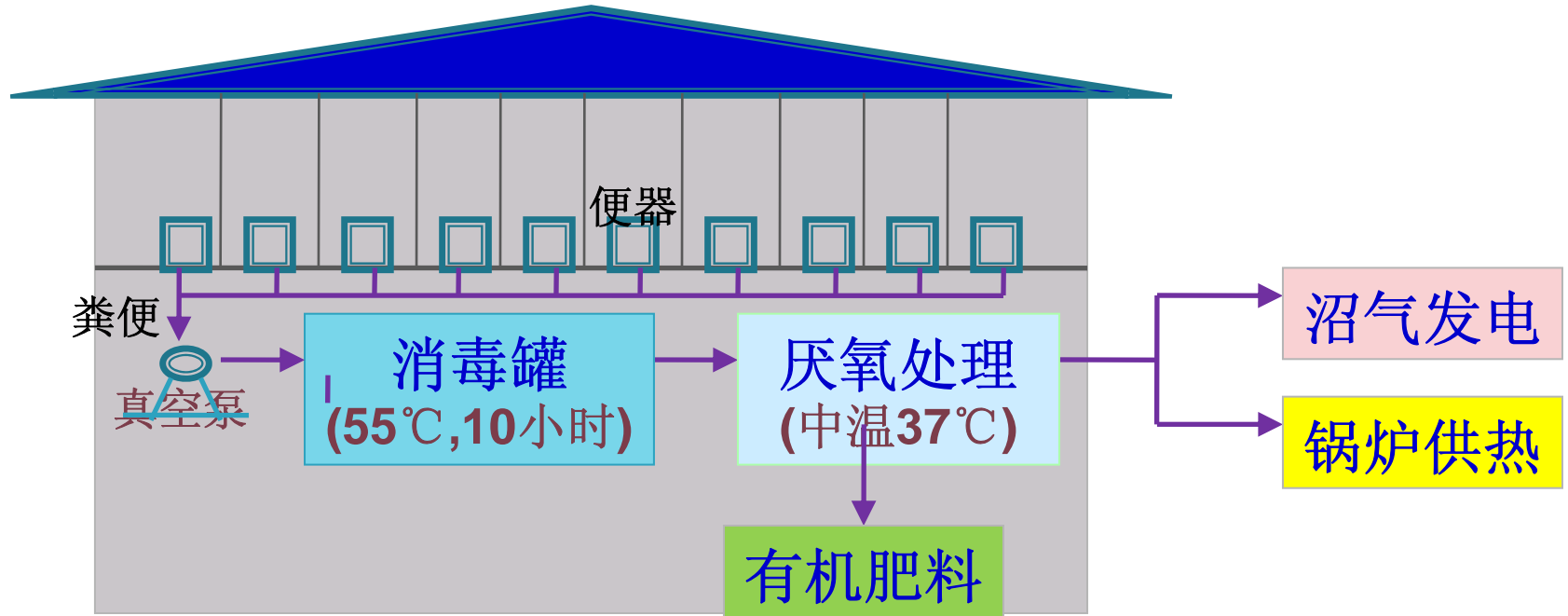
3.3.2 真空厕所

3.3.2 Vacuum Toilet

- ▶ 粪便通过真空管道输送到集中厌氧处理设备中，每次冲水仅需水1~1.2L。
- ▶ Excreta is transferred through vacuum pipeline into the device for centralized anaerobic treatment, and only 1~1.2L water is required for each flush.
- ▶ 真空泵站设于消化池旁，真空管敷设在冻土层以下以防霜冻，管径50mm。
- ▶ Vacuum pump station is set beside the digestive tank, and the vacuum pipe at the diameter of 50mm is laid with a frozen soil layer for antifrosting purpose.
- ▶ 敷设时，每15m长左右设置一个弯型（上下高差约20cm）以保证粪便的真空输送。
- ▶ One elbow (about 20cm up and down elevation difference) is to be set for about every 15m length, to ensure the vacuum conveyance of faeces.

真空厕所示意图

Schematic Drawing of Vacuum Toilet



Urinals and Closets Excreta Vacuum Pump Sterilizing Chamber (55°C,10h)
Anaerobic Treatment (Moderate Temperature at 37°C)

Organic Fertilizer

Power Generation by Biogas Heat Supply by Boiler

3.4生态站 3.4 Eco-station

- ▶ 用于城市里固体废物循环再利用和进行生态厕所人粪的二次处理。
- ▶ **Used for circulated reuse of urban solid wastes and secondary treatment of human excreta from eco-toilets**
- ▶ 原料包括从家庭源头分离的3种产物：尿、粪和源头分选的固体垃圾，他们从家庭和小区收集，转运到生态站作进一步处理。
- ▶ **Raw materials include 3 types of products from domestic source separation: Urine, Excrement, and solid wastes separated and selected from sources. They are collected from families and residential areas, to be transferred to eco-station for further treatment.**
- ▶ 经过无害化处理的粪和家庭有机垃圾相互混合，共同进行高温堆肥的二级处理。
- ▶ **The sanitized excrement is mutually mixed with domestic organic wastes, for a combined secondary treatment through high-temperature manure stockpiling.**

4. 结语

4. Concluding Remarks

- ▶ 生态卫生系统在我国相对比较容易得到认可。
- ▶ It is relatively easier for ecosan system to be accepted in China.
- ▶ **优点:** 不需要冲洗水, 没有运送粪便水的管道, 不需要粪便污水的处理厂, 也不需要去弃置有害的污泥, 重要的是它还实现了营养物质在人类社会的可持续利用。
- ▶ **Advantages:** Flush water not required, free from the pipeline for conveying black water, no need for black water treatment plant, neither harmful sludge to be discarded, and what's important is it has also achieved a sustainable utilization of nutrients by human society.
- ▶ **需进一步解决的问题:** 卫生教育和行为的改变; 相应的标准和规定的制订; 建成后的管理问题; 更加方便的生态厕所的开发等。
- ▶ **Issues to be Further Addressed:** Change in sanitary education, Formulation of Corresponding Standards and Regulations, Management of Built Toilets, and Development of More Convenient Eco-toilets, etc.