Conversion of Wastewater into Safe, Clean Water using Low-Cost Natural Methods

Sunwater's natural treatment methods:

Natural treatment systems:

Over the past 18 years, the key technical personnel of Sunwater Systems, Inc. developed innovative biological technology for treating and bio-converting wastewater and waste solids into water safe for agriculture, aquaculture, and industrial reuse. Our systems and processes all use:

- Natural biological and aquacultural methods;
- Solar energy and photosynthesis to provide natural, low-cost treatment and disinfection, and to produce useful by-products;
- State-of-the art Anaerobic systems to treat wastes using only 10 -20% of the energy required by conventional aerobic methods.
- A combination of well proven technologies and systems, in a series of multiple stages;
- Hundreds of specially selected micro-organisms, algae, duckweeds, and other plants proven superior at treating and breaking-down a variety of wastes and toxic compounds.

Definition of a good treatment system:

Traditional wastewater treatment practices and methods deal with wastewater as something to be treated and disposed of as quickly as possible, preferably out of the local environment and into someone else's. "Dilution is the solution to pollution" has been the guideline.

A good treatment and recycling system must:

1. Be able to remove the chemical toxins as well as particulate and dissolved wastes, and disease organisms;
2. Be capable of producing secondary, tertiary, and advanced tertiary effluents, as need;
3. Be reliable and consistent in producing safe, reusable water every day, all year-round;
4. Be ecologically sound, capable of improving rather than harming the local environment;
5. Not add harmful chemicals or create toxic sludges during the treatment process;
6. Have low construction and operating costs;
7. Produce valuable by-products from the waste nutrients, to reduce net operating costs or even achieve profits from resale of water and by-products.

Achieving all seven goals is the key. There are hundreds of existing wastewater treatment technologies that can "treat" wastewater to reduce solids, BOD, and major nutrients. But very few, if any, can do this reliably, or for low cost, or produce high quality water, or without creating further disposal or toxin problems.

Summary of the Sunwater System and process:

Series of "Aquacells" for optimizing treatment of each stage:

Our overall systems and processes are called the "Sunwater System". It is like a "living-stream" because it uses sunlight and rapidly growing organisms in a stream of ponds, lagoons, channels or cells. It is customized for each situation, and normally consists of a series aquatic cells ("Aquacells"). Each cell or stage contains different living organisms that digest and bio-convert the types of waste in each stage.

Because wastewater changes as it gets progressively treated, we maximize treatment efficiency by stocking different types and combinations of "super-strains" of bacteria, microorganisms, algae, duckweeds, and other aquatic plants in each stage. The water flows by gravity through this "Sunwater System", and can be treated to any quality level, including prepotable quality, simply by increasing the number of Aquacells and total retention time.

Small land area requirement:

Due to the high efficiency of the multiple stages, and optimization of organisms in each stage, the land area required can be relatively small compared to other "natural" pond treatment methods. A Sunwater System needs only 2-4 acres per 1.0 MGD (10,000-13,000 people) to achieve advanced secondary, and only 4-7 acres per 10,000 people to achieve tertiary quality.

Design and treatment emphasis can be adjusted to each situation:

The Sunwater System can be varied in size, length of treatment time, species makeup, and components in each stage, to suit different types of treatment situations, including:

1. Domestic Wastewater treatment and reuse;
2. Industrial Wastewater treatment and reuse;
3. Drinking water treatment/purification;
4. Toxic soil and groundwater treatment:
5. Industrial exhaust gas treatment (using a "wet-scrubbing" method);
6. Fish production (for commercial sale);
7. Algae or aquatic plant production for feed, compost, or bio-fuels.
8. Creation of recreational lakes, managed marshes, wetlands, and/or wildlife habitats.

Combination of the best features of low- and high rate systems:

The Sunwater System has been designed to combine the best features of low construction and operation costs of aerated lagoons, together with the control, reliability, advanced treatment capability, and reduced land requirements of high technology treatment plants. We reduce or eliminate expensive concrete, steel, chemicals, and electricity, and use natural ecological processes (low-cost polyethylene lined channels or raceways, hardy, pollution consuming plants and invertebrates, and greenhouses in cold climates). This allows the Sunwater System to convert raw wastewater into high-quality, reclaimed water for very low capital and operating costs. Typical costs are only 20-40% of the cost of conventional methods.

The " Sunwater System" stages, and methods:

Design flexibility to produce different quality water and byproducts:

The Sunwater Team has developed and operated a variety of wastewater and organic waste treatment and recycling systems. The specific system, process, and design recommended for each case depends on the project conditions, type of wastewater or waste solids inputs, and desired water and product outputs. The attached process flow diagrams show the different types of inputs, treatment and recycling processes, and outputs that we can create.

The Sunwater System can easily produce secondary, tertiary, advanced tertiary, or even potable water quality, by varying the number and type of stages, components, retention time, and species in each stage.

Summarized below are the main components and types of treatment systems and processes we can include to develop a treatment system tailored to each specific site and situation.

1. Covered anaerobic systems (for advanced primary and secondary treatment):

These consist of low cost earthen ponds or tanks with liners, and floating covers for odor elimination and collection of methane gas. Our covered "Anaerobic Aquacell" tanks are used for primary treatment of:

- Sewage;
- High-strength industrial waste streams;
- Solid wastes (sludges, biomass wastes from agriculture, food processing, etc.)

We normally use a two-stage anaerobic sys-

tem with an up-flow first stage followed by a horizontal second stage. This maximizes treatment of BOD and suspended solids and toxins, and increases methane gas production. We seed each of these stages with genetically superior microorganisms ("super-bugs") selected to perform specific functions in breaking down each type of waste to be encountered.

This stage traps, settles, and digests about 95-99% of fats, greases and oils, toxins (heavy metals, pesticides, herbicides, etc.), 40-80% of the BOD and suspended solids, and about 90% the pathogens. The solids are digested, stabilized, reduced in volume, and removed periodically (every 1-5 years, depending on size of this stage and type of wastes): Digested solids can be converted into compost for soil–maybe amendment.

2. 2-stage aerated-facultative lagoon (for secondary treatment):

The Sunwater 2-stage aerated-facultative lagoon greatly reduces energy and mechanical equipment for aerating and mixing by incorporating a deep anaerobic stage to settle and digest solids and BOD. The surface layers are aerated and seeded with recycle algae to maintain aerobic conditions and eliminate odors.

3. High-rate solar algae systems:

Culture of algae: These stages consists of a series of shallow, long, narrow channels or "Aquacells" through which the wastewater flows. We seed the channels with hundreds of different, hardy micro-algae, specifically selected for different types of wastewater treatment. The algae produces "free" oxygen via photosynthesis, absorbs, breaks down, and bioconverts waste nutrients.

The particular combination of species grown depends on the type of wastes, climate, effluent objectives, and type of algae feed or biomass desired. The algae biomass produced is very beneficial as an organic fertilizer, fish feed, or animal feed. It can be left in the water and used directly as a fish feed or organic soil fertilizer. Or the algae can be harvested to produce clear effluent and a high-protein feed, duckweeds, or other valuable algae by-products (see diagram).

Solar and natural disinfection: Pathogens can be reduced to safe levels, without harmful chemicals or high energy costs, by properly designing the systems to make use of:

- Direct competition and consumption of pathogens by the algae and microbial community,
- Kill-off of pathogens by the high pH (9-10) created by the shallow solar algae ponds;
- Kill-off by intense ultraviolet light from sunlight in the shallow solar algae ponds.

Algae harvesting or removal: Where stricter effluent requirements require low BOD or suspended solids in the water, the algae can be harvested by several different methods, depending on the local conditions and preferred reuse of the algae (see diagrams). These methods include:

- Filter-feeding fish (tilapia or silver carp) in specially designed tanks
- Duckweed covered channels (to trap, digest, and bioconvert the algae to duckweeds, which are easily harvested)
- Anaerobic Algae Digester (with special biofilm substrates)
- Micro screens or dissolved air flotation.

4. Duckweed treatment and biomass systems:

The Sunwater team has extensive experience culturing dozens of duckweed species (also called "watersprouts") in a variety of wastewater conditions. The main function of our duckweed technology is to create a clear, low suspended solids and BOD effluent, by blocking out sunlight to stop algae growth, in order to meet advanced secondary or tertiary quality levels. Duckweeds perform many other valuable functions, including absorbing waste nutrients, reducing nitrogen and phosphorus, removing and degrading toxins, adding oxygen to the water, and preventing odors from escaping. They have excellent food value, being 30-40% protein, and are readily consumed by fish, shrimp, poultry, hogs, cattle, and dairy cows.

Floating duckweeds are successfully being using in many locations in the U.S. to improve performance of conventional sewage lagoons.

The only limitation of duckweeds is that they can be blown onshore by winds, and temporarily die-back if water freezes. To prevent wind problems, Sunwater Systems developed several innovative floating barrier systems. Sunwater also developed simple harvesting methods that allow duckweeds to be easily skimmed from the surface with shore-based devices, eliminating need for expensive, high-maintenance boat and equipment that must work out in the pond and on top of baffles. For freezing winter climates, Sunwater developed special low-cost greenhouse structures for covering ponds and raceways, to allow reliable treatment year-round.

5. Fish culture systems for harvesting and reuse of algae and duckweed biomass:

In situations where organic wastes are the input, or secondary treated sewage is properly disinfected, filter-feeding fish such as tilapia or silver carp are a very efficient and low-cost way to harvest and bio-convert microbial and/or algae into a useful product. To reliably remove micro-algae to meet low BOD and SS requirements, the fish systems must be designed with "fish-algae-feces" collection systems, to prevent regrowth of the filtered algae biomass. We have successfully operated "fish-filter" systems to produce tertiary quality water.

Where duckweeds are the main plant cultured, the duckweeds can be easily harvested and pumped to separate fish culture tanks, to be consumed by the fish as a high protein feed.

The harvested fish can either be used for bait, lake stocking, pet food, animal food, or fish meal without and special further treatment. For human consumption, the fish must be "purged" or "finished" in special tanks (see following).

6. Fish finishing systems for purification of fish before marketing or stocking:

For creating high-quality fish for human consumption, Sunwater Farms, Inc. a related food production and marketing company, designs and operates unique "Finishing Tank" systems which serve to purge and "finish" the fish over 1-2 months. These systems use recirculating systems with fresh or saline water, and special diets, which gives the fish excellent flavor as well as purifying them to meet the highest food-grade standards. This type of system was developed by Mr. Serfling for Solar Aquafarms Inc., which for the past 5 years has consistently produced the highest quality, highest priced tilapia in the world.

7. "Managed Marshes":

Members of the Sunwater team are highly experienced at creating "managed marshes" or "constructed wetlands". These can be simple, low-cost ways to produce secondary, tertiary or pre-potable water if sufficiently large to provide long retention times of 30-100 days. Managed marshes are best designed with multiple stages (in keeping with the Sunwater Aquacell concept). Each stage is stocked with hardy types of water-loving or water-tolerant crops and vegetation (bulrushes, reeds, grasses, rice, floating plants, and certain types of trees). The species and design depends on the type of wastes treated, the water quality desired, and the type of waterfowl and other aquatic life desired.

8. Aquatic parks:

The key to creating aquatic parks for fishing, boating, swimming, and picnicking, is the ability to produce low cost and high-quality, safe, reliable water. This is where the Sunwater System excels. An abundant and diverse supply of food-chain organisms are produced with the Sunwater System, which is ideal for creating fishing lakes and aquatic parks that support an abundance and variety of sport fish and water fowl. By proper design of the lakes, with backup aeration, and stocking of a proper mix of fish and aquatic organisms, year-round fishing can be a major attraction and source of income.

9. Composting and vermiculture systems for topsoil production:

Digested solids from the primary or facultative stages are periodically removed (once per 1-5 years) and pumped or conveyed to a composting system. We use only low-cost, lowmaintenance technology based on grow-

ing earthworms ("vermi-composting"), which turn, aerate, and accelerate composting and conversion of solids into a richer, more valuable compost. Worm castings and worm compost are one of the best fertilizers and soil amendments, because it contains more bio-available nutrients and growth factors, plus live earthworms.

10. Bio-remediation of toxic soils and ground waters:

Contaminated soils and ground waters can often be most efficiently treated using bio-technology, with special genetically superior bacteria, microorganisms, and algae, selected to treat the specific toxins present. The contaminated soil can either be removed and treated on-site, using portable, high-rate Sunwater systems, or be treated in-place. To treat the contaminated soils in-place, we can use systems and methods that either "wash" the soil to extract the toxins, and then treat the toxins in separate systems, or inoculate the soil in place with the "super bugs" plus proper combinations of fertilizers and minerals to accelerate growth and detoxification by the super bugs.

11. Bio-intensive vegetable farms and tree farms (for reuse of water and solid wastes):

Sunwater team members (Land and Water Resources) are highly experienced at creating rich compost and top-soil from solid wastes, and rebuilding poor soils. We have achieved vegetable crop yields averaging 5-10 times higher than surrounding farms using conventional methods. These "Bio-Intensive" gardens and farms are a very efficient and profitable way to "dispose" of and recycle all types of solid wastes, while also creating rich top soil, and producing valuable, nutritionally superior, organically raised crops.

12. Treatment of polluted exhaust air and stack gases:

One of the most proven methods for removing air pollution from industrial exhausts and stack gases is the "wet-scrubbing" technique. This consists of towers or horizontal chambers with a fine mist spray, like rain, to wash the toxins from the air, but then they end up in the water. Sunwater can add the essential bio-technology to this wet scrubbing stage to cost-effectively treat the toxins in the water, thereby fully completing the cycle and process.

The systems provide breakdown and removal of toxins.

Removal of toxins from water: The Sunwater treatment systems concentrate and remove most of the toxins in the primary settling stages, along with the sludge. This removes most of the toxins from the wastewater stream, where they can then be dealt with separately in the anaerobic cells and/or composters. A second stage of removal takes place in the aerobic algae and aquatic plant cells, using the algae and other aquatic plants as a biological "sponge" to capture and remove toxins.

Breakdown of toxins: The sludge from the primary and secondary stages is digested anaerobically in the anaerobic cells then composted, using special microorganisms selected and stocked specifically for the types of wastes and toxins to be treated. Almost all organic toxins, e.g. oils, pesticides, herbicides, dioxin, etc., can be broken down and/or bio-converted by special bacteria. Nature has made "bugs" and plants that will consume and breakdown every known toxic compound. The key is to accelerate and stabilize this biological process by giving the organisms the proper environmental conditions, including, warm, moist or wet environments with oxygen, and sufficiently long retention times.

Heavy metals: Heavy metals cannot be broken down biologically, but many can be chelated and/or converted biologically into nontoxic, inert complexes and compounds. Then the final compost with the stabilized metals is analysed to determine the concentrations and proper rates to apply it to local soils (the earth is where the metallic compounds originated in the first place).

We have proven in pilot projects that the Sunwater Aquacell system can reliably remove toxins. In one project (see Cardiff project description), lead, cadmium, mercury, DDT and PCB's were spiked into the influent sewage at ten times normal concentrations, and were reliably removed by the system. Tilapia and freshwater shrimp raised in the final stages

met FDA food grade standards (Serfling et.al., 1980).

Land area and retention time:

The size and retention time of each cell depends greatly on:

- The type of waste input,
- The type/quality of effluent water desired,
- The type of by-products desired or most valuable at each site,
- The climate, primarily in winter time (greenhouses can be used if necessary).

For a typical site, the Sunwater System fills 70 - 80% of the land with water treatment area. In contrast, a mechanical-chemical facility uses 70 - 80% of the land area for roads and access to concrete and steel tanks. So the Sunwater System has wastewater retention times that are 48 times longer than conventional high-rate systems, for the same land area (3-10 days, versus only 1-2 days (see illustration). This gives much greater process stability, reliability, and safety to achieve high-quality water, every day, year round.

Energy savings and production

Energy savings: The Sunwater System has been specifically designed to minimize energy needs by use of:

- Solar energy and photosynthetic processes for oxygen production, breakdown of toxins, nutrient conversion, and disinfection;
- Gravity flow hydraulic designs.
- State-of-the-art anaerobic treatment methods that reduce wastes by 50-80%, use no energy, and produce methane gas.
- Final solids removed from primary ponds require little or no energy for digestion because we use a "vermiculture" composting process that uses the "free" energy of earthworms to turn, mix, and aerate the compost.

Methane or alcohol production:

In situations where net energy production is the objective, the algae or aquatic plant biomass can be harvested and digested in anaerobic cells for conversion to methane gas, or fermented into alcohol using enzymes and standard fermentation-distillation methods. As an example of the latter, in warm climate zones, one acre of shallow raceways with certain species of duckweeds could produce sufficient biomass to produce 1,000 - 2,000 cu. ft./day of methane, or 5,000 - 10,000 gals./acre/year of alcohol.

Odor control and elimination:

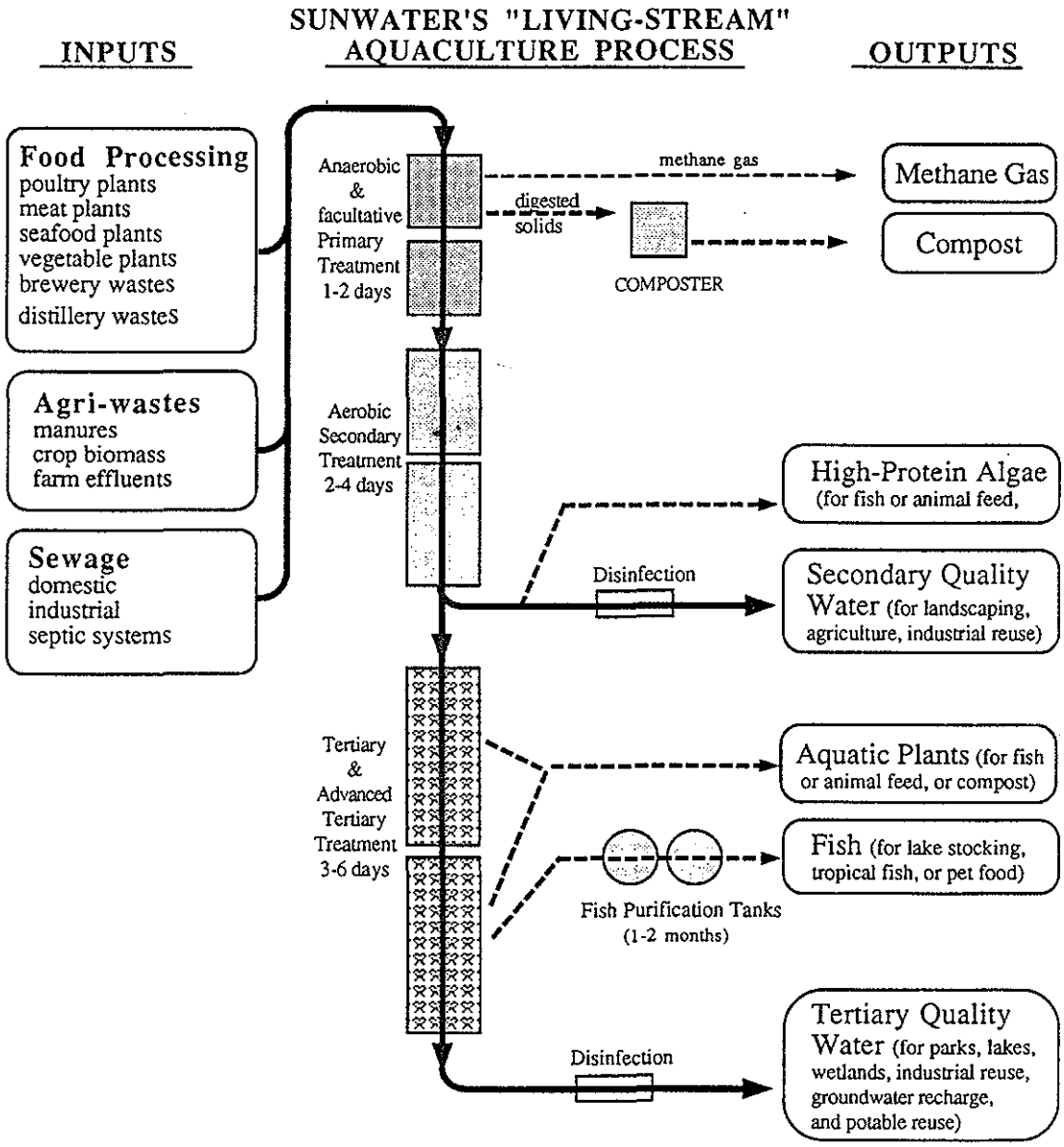
Conventional treatment plants and lagoons create serious odor problems. In contrast, Sunwater controls odors using simple, low-cost bio-technology, sources of odors are covered and the air drawn into "Bio-filters", inoculated with special microorganisms that rapidly biodegrade the odors. No expensive chemicals, ozone, or activated carbon is necessary, and no waste product is produced.

Economics

The attached graphs indicate the general relationship between treatment plant size (gals./day), quality of effluent achieved, and cost of construction and water treatment. Because each treatment situation has numerous variables that are usually different for each site, a preliminary analysis, design and cost study must be conducted to determine the best approach and to estimate cost savings compared to conventional methods.

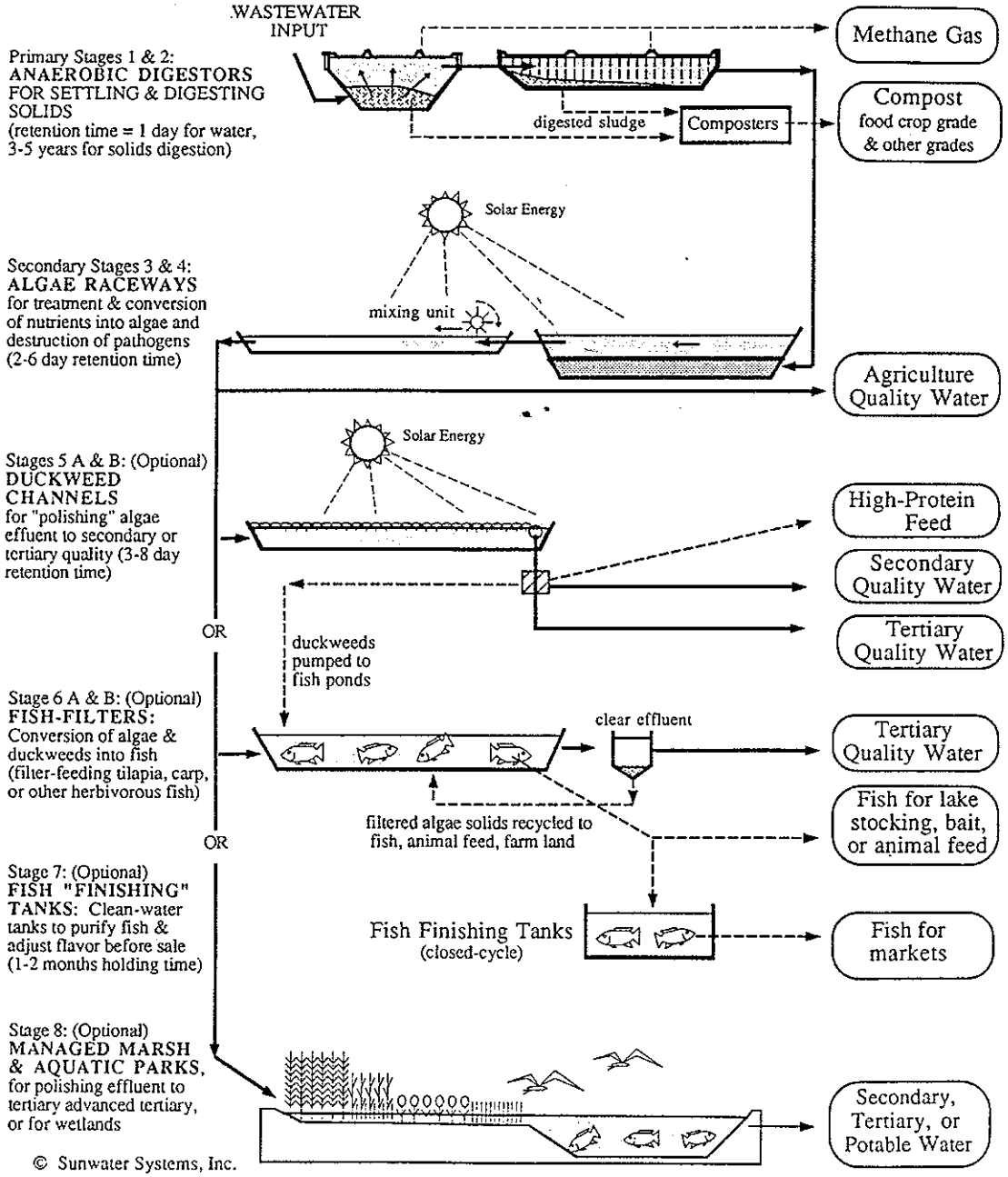
Typical Inputs and Output Products from the Sunwater Multi-Stage Aquaculture Wastewater Treatment Process

The Sunwater System is a highly efficient "living-stream" that can treat and bioconvert all types of wastewaters into a variety of clean water and valuable by-products. Each "Aquacell" can be varied in size, retention time, and species, to produce different quality water and by-products.



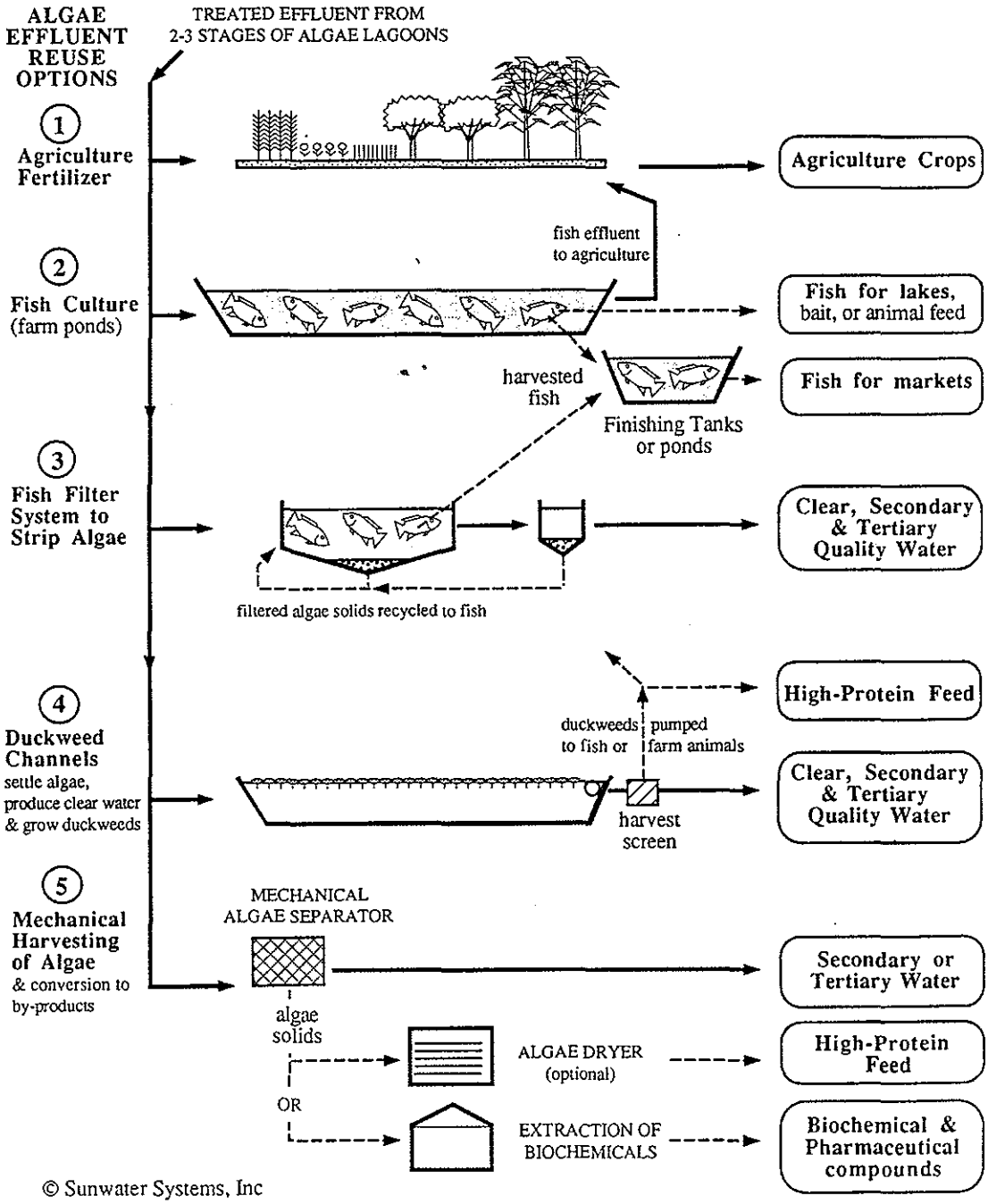
Typical Stages and Components of an Integrated Sunwater System for Treatment and Bio-Conversion Wastewater into Clean Water and By-Products

The following components, systems, and stages are varied in size and sequence, and some are optional, depending on the type of waste to be treated, and the types of final water and by-products desired.



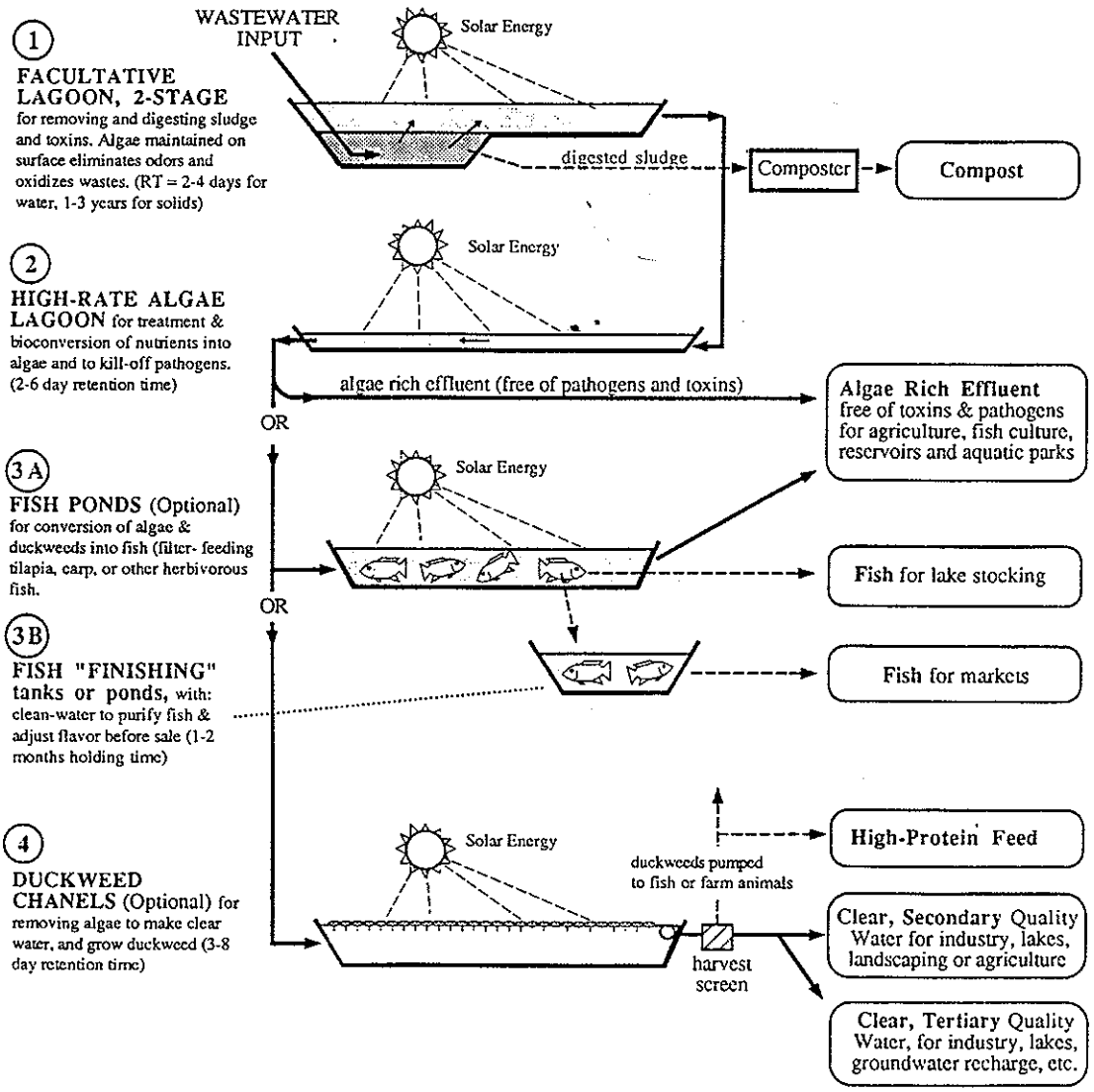
Options for Reuse of Algae Effluent, and Bio-Conversion of Algae into Fish and Other Valuable Products

Sunwater's Facultative and High-Rate algae lagoons produce a safe effluent free of toxins and pathogens, with high concentrations of micro-algae. This diagram shows the many ways we can reuse the algae, either directly with the treated effluent, or by harvesting or settling the algae, and producing a clear effluent.



A Low Cost, Low-Technology Sunwater System for Small Flows and Rural Villages

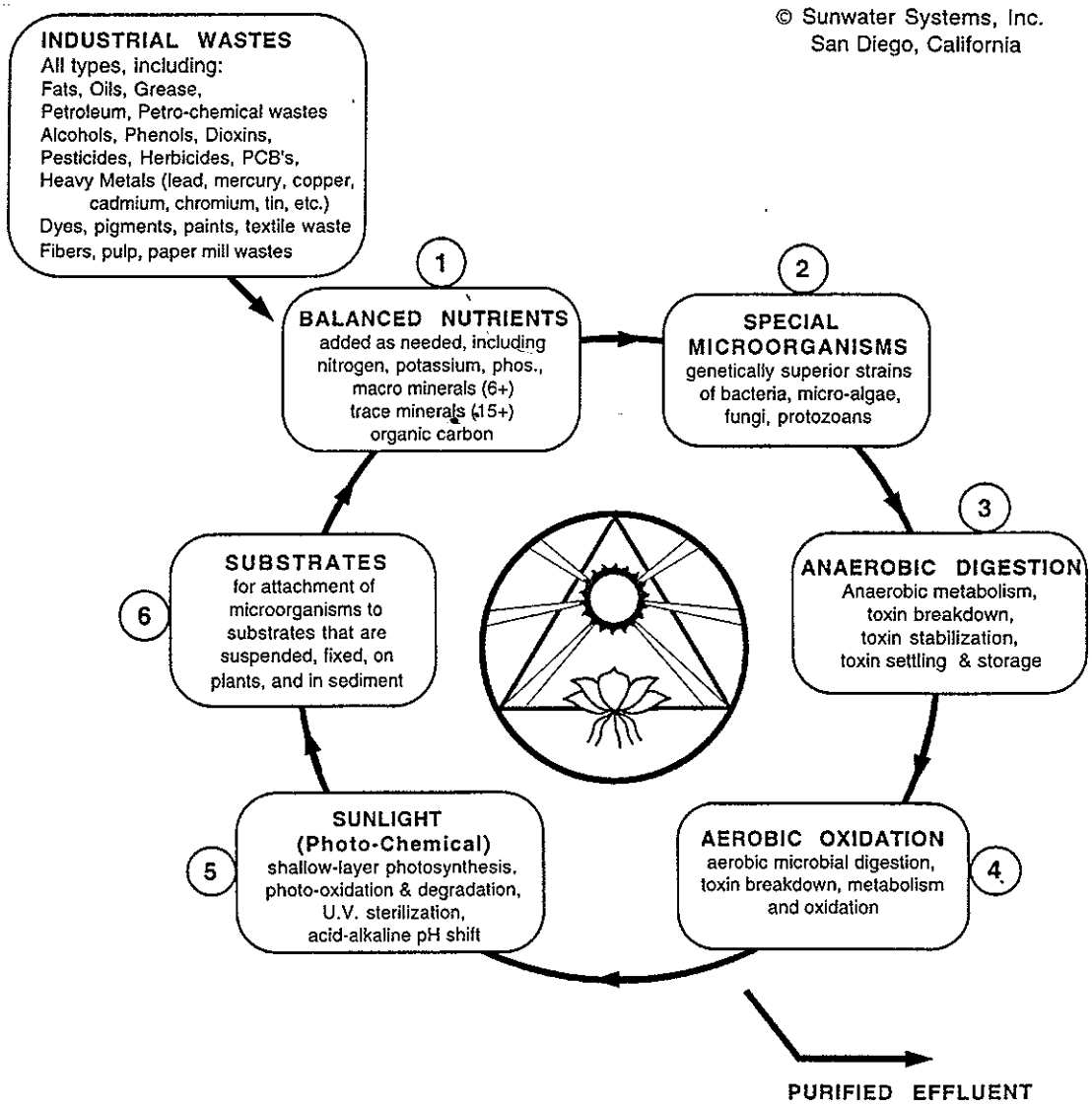
Section View of components and processes for simple, low-cost wastewater treatment for rural villages. The process can produce water free of toxins and disease organisms, safe for agriculture, aquaculture, and other reuses, with no mechanical equipment or chemicals. The Facultative Cell removes and digests toxins and sludge. The High-Rate Algae Cell oxidizes wastes, kills all pathogens, and grows high volumes of algae. This water is then safe for any reuse. The algae makes an excellent organic fertilizer for agriculture, or food for fish. If clear water is desired, a special pond covered with duckweeds will function to settle and convert algae into high protein feed.



Treatment of Industrial Waste and Toxins
Requires Six Critical Processes and Components

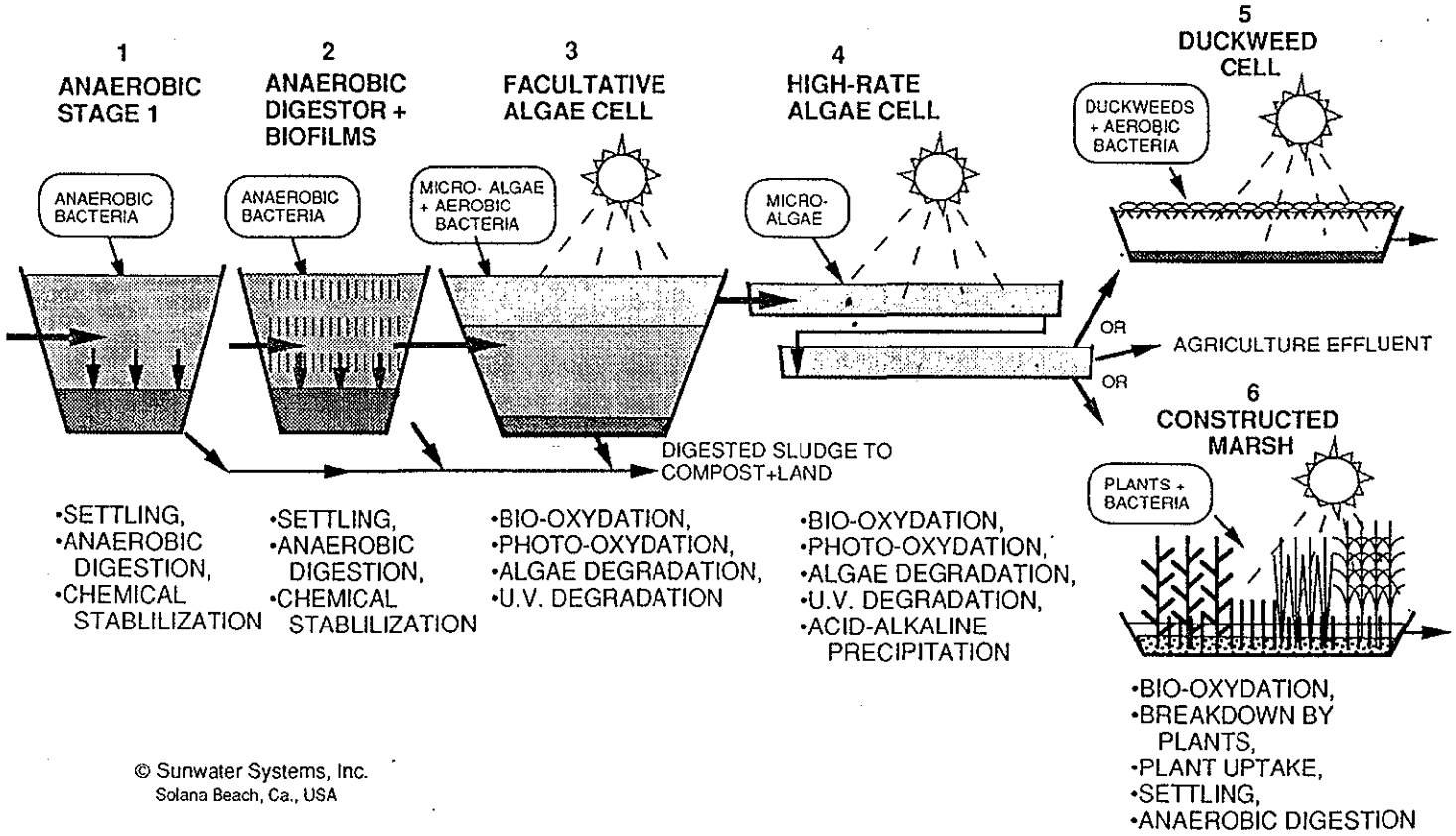
The Sunwater System is excellent for treatment of industrial wastes and toxins because:

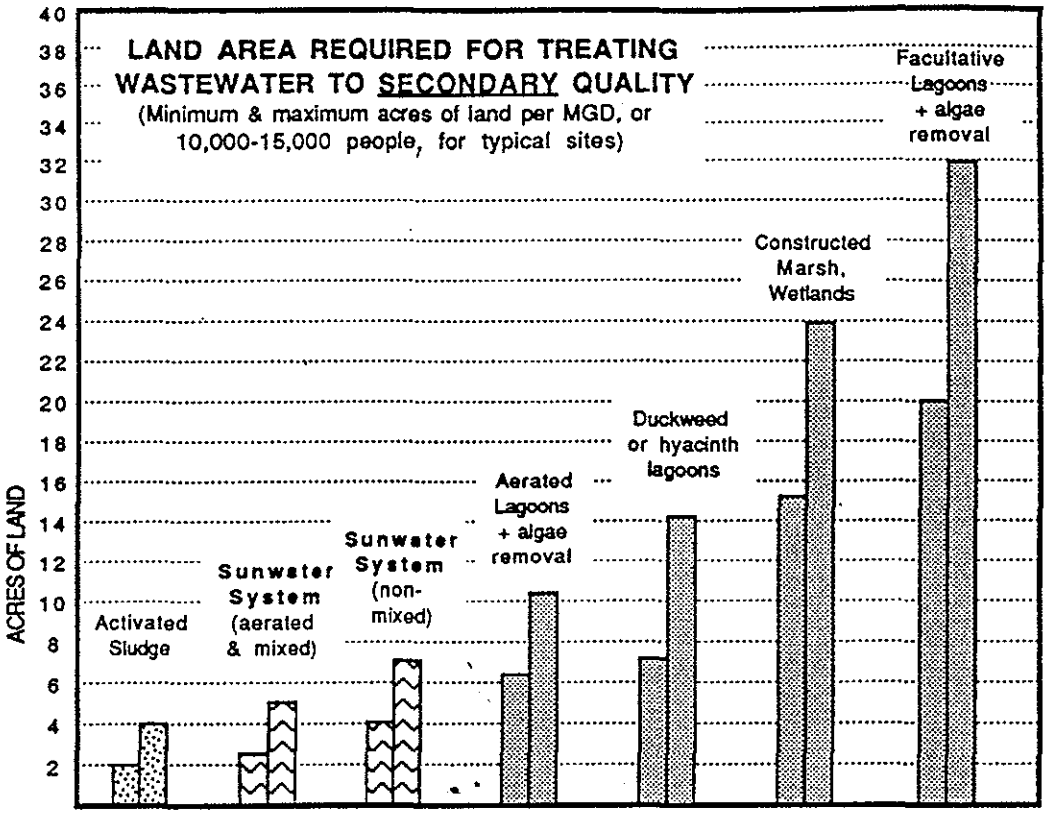
- All of the six essential processes and components shown below are included,
- Treatment is done in multiple stages where each process can be optimized,
- All of Sunwater's treatment methods use natural, biological and biochemical processes

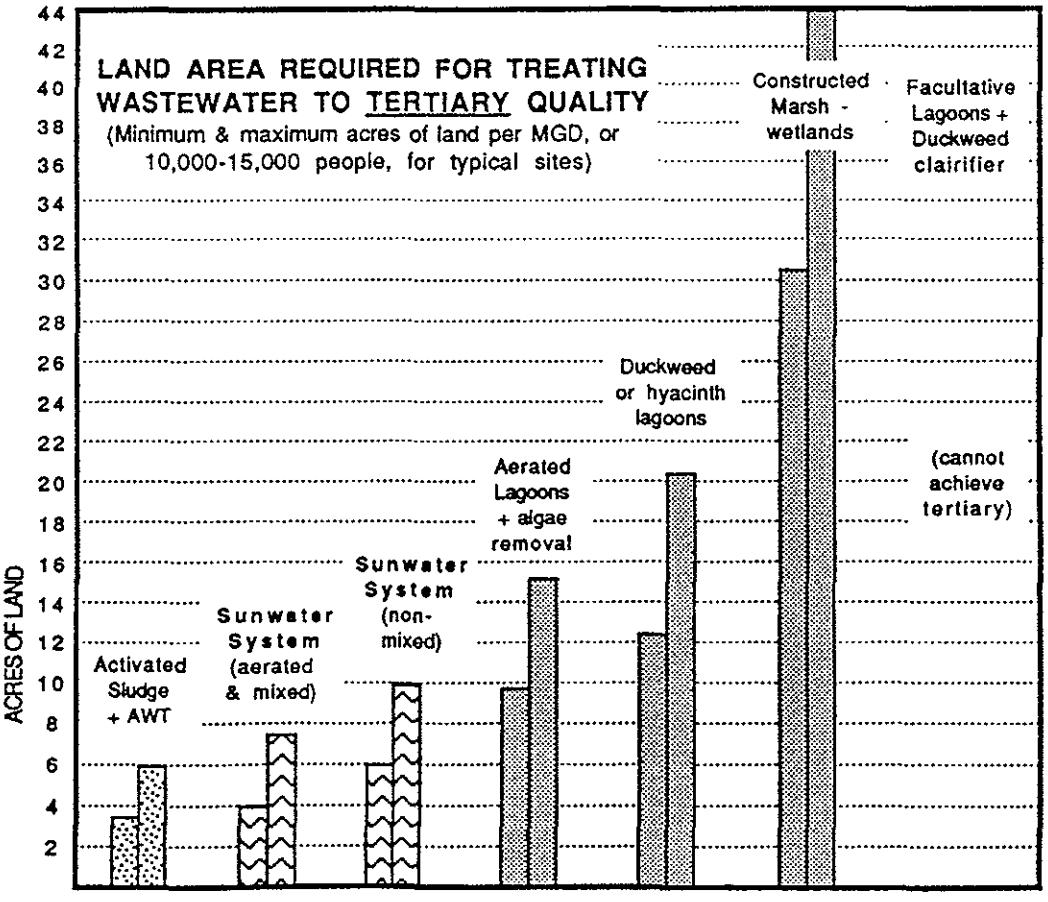


Processes for Removal and Breakdown of Toxic Waste by the Sunwater Multi-Stage System

The Sunwater System provides reliable, low-cost treatment of toxic wastes by a combination or at least 6 different, well proven systems, and natural biological processes, biochemical processes, and photo-chemical processes. The combination, sequence, and size of each stage is custom designed for each type of toxic waste, to meet local discharge requirements. Then each stage or "Aquacell" is stocked with special organisms proven for their ability to breakdown the specific types of wastes and toxins present at each site. The system can produce clean, safe effluent for agriculture, industry reuse, landscaping, aquatic parks, or discharge to local waters.




LAND AREA REQUIRED FOR TREATING WASTEWATER TO SECONDARY QUALITY
(Minimum & maximum acres of land per MGD, or 10,000-15,000 people, for typical sites)
ACRES OF LAND
40
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
Activated Sludge
Sunwater System (aerated & mixed)
Sunwater System (non-mixed)
Aerated Lagoons + algae removal
Duckweed or hyacinth lagoons
Constructed Marsh, Wetlands
Facultative Lagoons + algae removal


LAND AREA REQUIRED FOR TREATING WASTEWATER TO TERTIARY QUALITY
(Minimum & maximum acres of land per MGD, or 10,000-15,000 people, for typical sites)
ACRES OF LAND
44
42
40
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
Activated Sludge + AWT
Sunwater System (aerated & mixed)
Sunwater System (non-mixed)
Aerated Lagoons + algae removal
Duckweed or hyacinth lagoons
Constructed Marsh - wetlands
Facultative Lagoons + Duckweed clairifier
(cannot achieve tertiary)

Summary of the "Sunwater" Wastewater Treatment Project for the City of Obregon, Mexico

Introduction

Sunwater Systems, Inc. of San Diego, California, in joint-venture with a San Diego and Mexican company, recently won a privatization contract to design, build and operate two wastewater treatment facilities for the City of Obregon, Mexico. The City of Obregon has 300,000 people, and each facility will treat about 17 mgd (750 litres/sec.). The city is located about 5 hours drive south of Arizona, in the State of Sonora. The facilities will be constructed and fully operational within 12 months.

The treatment system and facilities

The system and process, developed by Sunwater Systems over 18 years, is an innovative technology using low-cost, low energy, biological and ecological methods. The system uses very little mechanical equipment, very little energy, and no chemicals, instead maximizing natural biological treatment methods. Thus, it is very low cost to construct, operate and maintain. There are three main treatment stages:

(1) An innovative Anaerobic Bioreactor, with an upflow anaerobic sludge bed stage ("UASB") and cross-flow stage, with 16 hours total retention time;

(2) An aerated-facultative lagoon, partial mix, with 1.7 days retention time, and:

(3) A final settling lagoon, with 1.7 days retention time (see process flow diagram).

The "South" Obregon facility will have an initial flow of 735 lps (16.8 mgd), and the "North" facility an initial flow of 850 lps (19.4 mgd). Total land area used for each facility, for these initial stage flows is about 80 acres (about 4 acres per 1.0 mgd). Additional land is available for reuse of effluent.

The total flow at each facility is divided into four identical modules, each with the above 3 treatment stages. The treated effluent will be used for agriculture irrigation and aquaculture of tilapia fish.

Features of the innovative treatment system

The main features and advantages of the system and process are as follows:

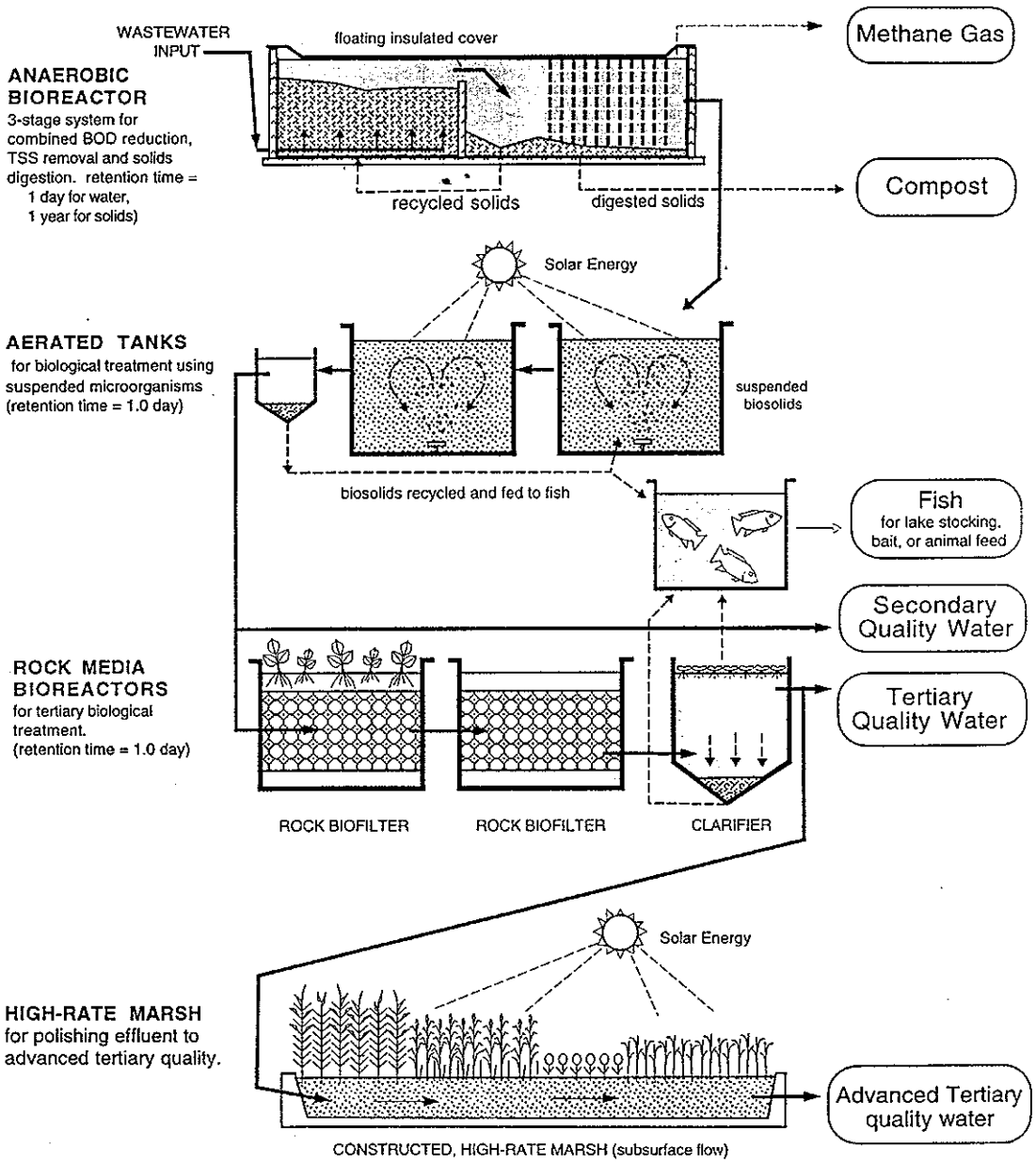
- It is a state-of-the-art system and process that incorporates the best features of high-rate, 2-stage anaerobic systems, aerated-facultative lagoons, and sedimentation lagoons.
- It uses very little mechanical equipment and has very low energy consumption. An average of only 60-100 hp, will be required on-line for aeration and mixing of each facility, compared to 1,200-2,500 hp, for aeration and mixing of conventional treatment systems.
- There are eight modules of lagoons, each treating 12.5% of the total flow (312 lps per module). This modular design will give reliability and flexibility to the system.
- In each module is a series of three cells or lagoons. The first is a state-of-the-art, 2-stage anaerobic treatment cell, with a floating cover for elimination of odors and collection of methane gas. The second lagoon is lightly aerated and partially mixed, with aerobic surface and anaerobic bottom, and has 1.7 days retention. The third lagoon is sedimentation lagoon with 1.7 days retention time.
- Disinfection will be done with a state-of the art U.V. system, to eliminate toxic chlorine chemicals.
- Effluent quality will easily exceed discharge requirements (agriculture grade, 60 ppm BOD, 90 ppm TSS), and of a quality suitable for agriculture reuse or groundwater recharge.
- The Anaerobic Bioreactor system has two stages, with a combined retention time of 16 hours. The first is an upflow sludge bed ("UASB") for rapid removal and digestion of wastes. The second stage is a cross-flow stage for sludge settling and digestion. This system can handle wide fluctuations in waste concentrations, and remove 80-95% of all

toxins, grease and oils, and pathogens, without risk of upset.

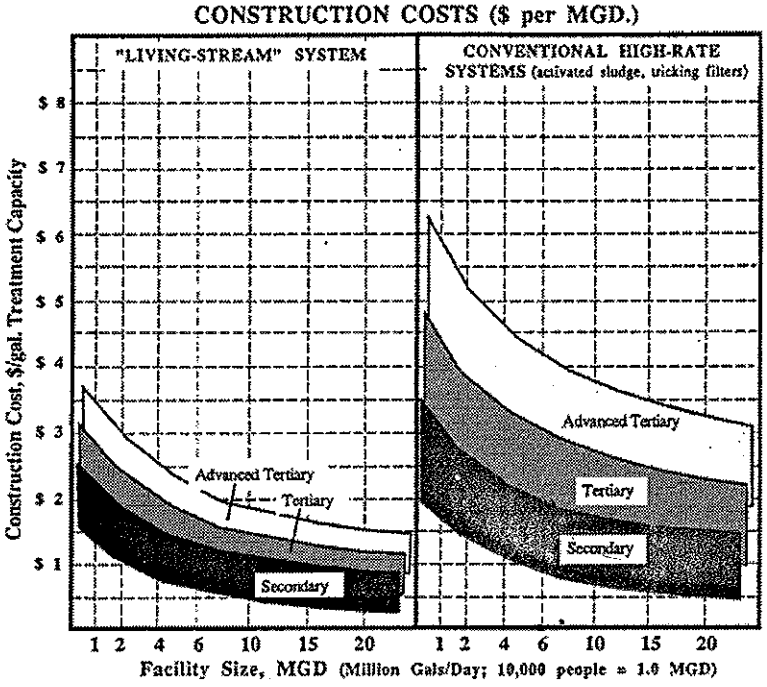
- Sludge will be well digested in the Anaerobic Bioreactor with over 1 year ave. retention time. Thus, sludge volumes will be very small, and odors essentially eliminated. Final solids will be converted to compost for beneficial agriculture reuse.
- Expansion of the Stage 1 facility can easily be done in the future by adding one module at a time, without interrupting operations.

Process Flow Diagram for Maryland Ecological Wastwater Treatment Facility

A demonstration project of an innovative ecological wastewater treatment technology for colder climates. The anaerobic system is designed, constructed and managed by Sunwater Systems, Inc. The aerated systems are designed and managed byOcean Arks International, with assistance by Sunwater Systems. The project is funded and supervised by U.S. EPA.

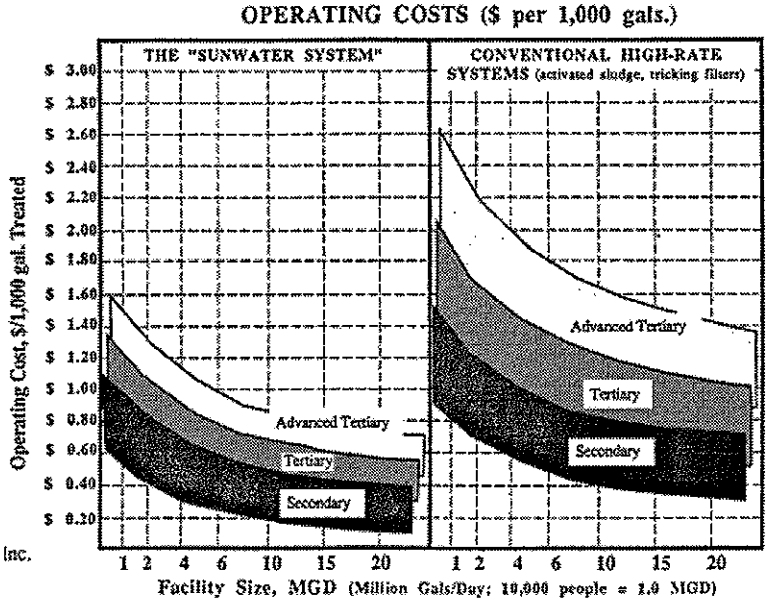


Costs of the Living Stream Systems Compared to Conventional High-Rate Treatment Systems (for Mexico)



"Secondary" quality effluent means < 30 ppm BOD & SS, suitable for most agriculture. "Tertiary" quality effluent means < 10 ppm BOD & SS. < 5 ppm total N, < 1 ppm total P, and suitable for all agriculture, and most all industries and recreational lakes and streams. "Advanced Tertiary" quality means "near potable", equal to water entering potable water treatment plants from reservoirs and rivers, suitable for all water uses.

Construction costs are average for Mexico, but can vary widely depending on each situation. Costs include ALL facility and land costs, including lift stations, headworks, sludge digestion, drying and disposal or reuse, disinfection, odor control, office and lab buildings, vehicles, roads, landscaping, design, engineering, etc. Land costs are based on $ 3,000 - 6,000 per acre.

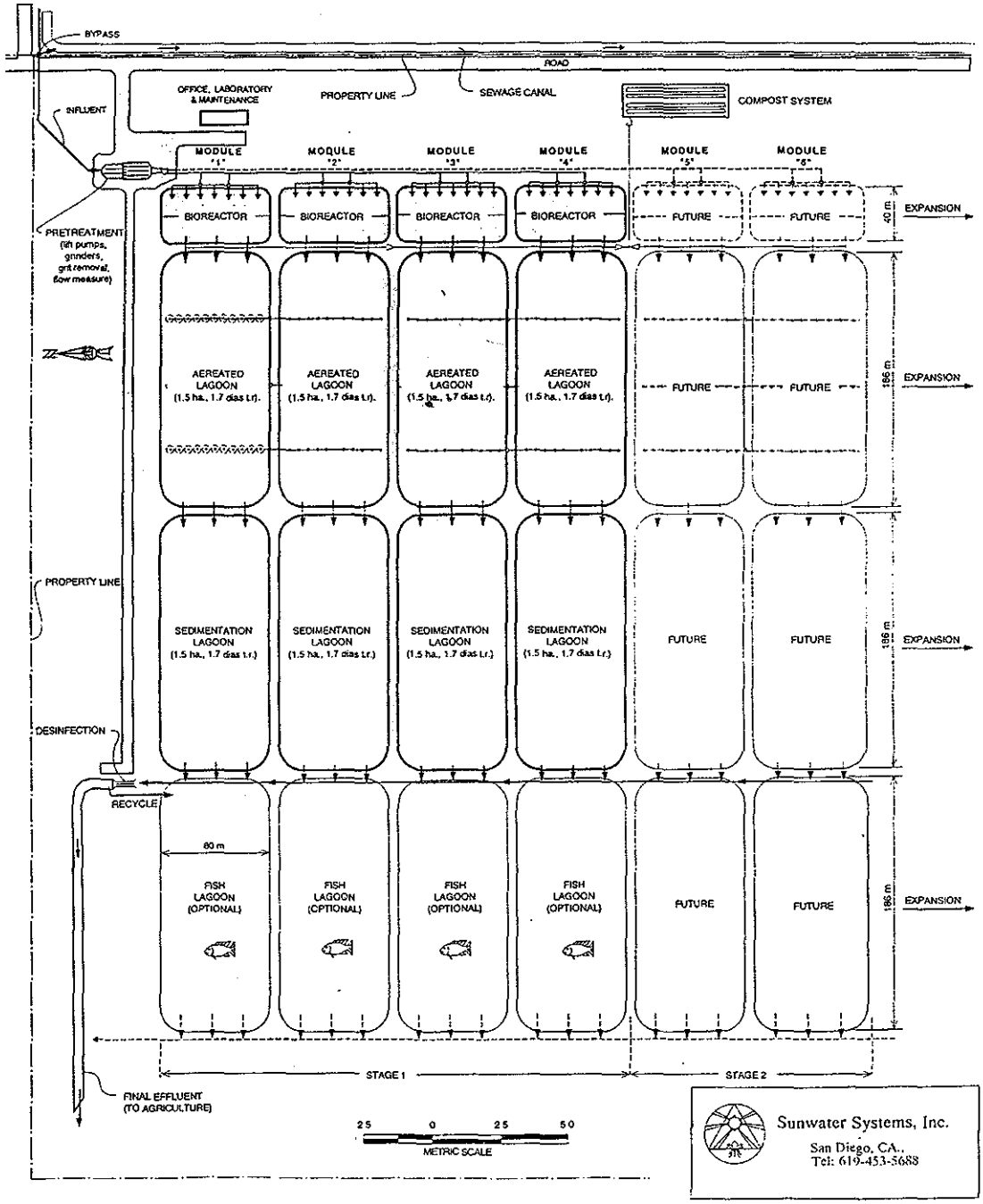


Operating costs are average for typical facilities and sites in Mexico, but can vary widely depending on each situation. For the Sunwater system, operating costs are primarily affected by the amount of aeration used to accelerate treatment, in order to reduce land area. Costs include ALL facility operating, maintenance, and overhead.

Inc.

Sunwater Systems Wastewater Treatment Facility for the City of Obregon, Mexiko

Sunwater Systems, together with U.S. and Mexican partners, recently won the privatization contract to construct and operate for 15 years two sewage plants for the city of Obregon (300,000 people). Each facility will initially treat about 750 liters/sec (17 mdg) to a quality suitable for agriculture and aquacultural reuse.

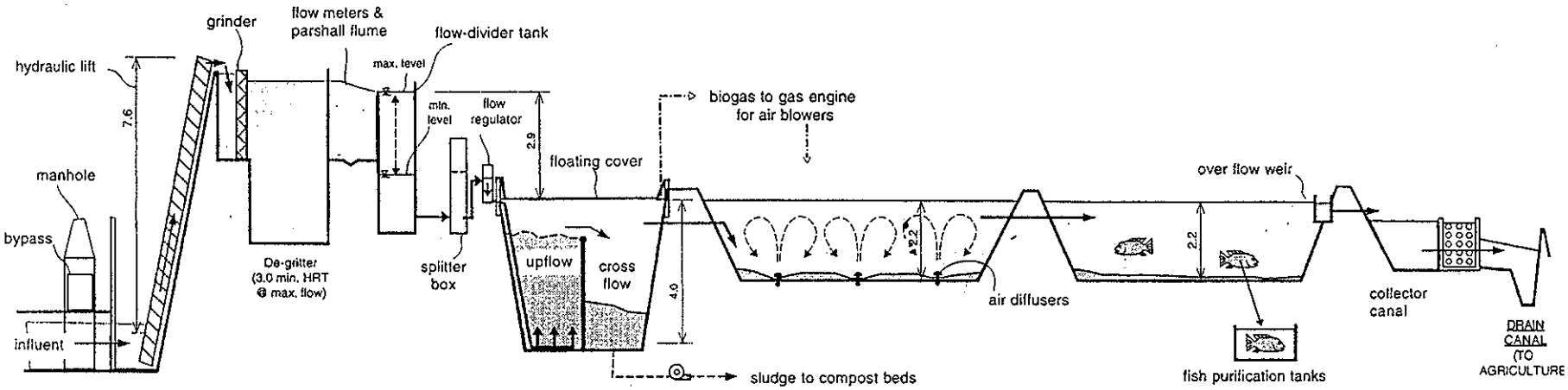


Process Flow Diagram for City of Obregon Wastewater Facility

Population: 300,000 people

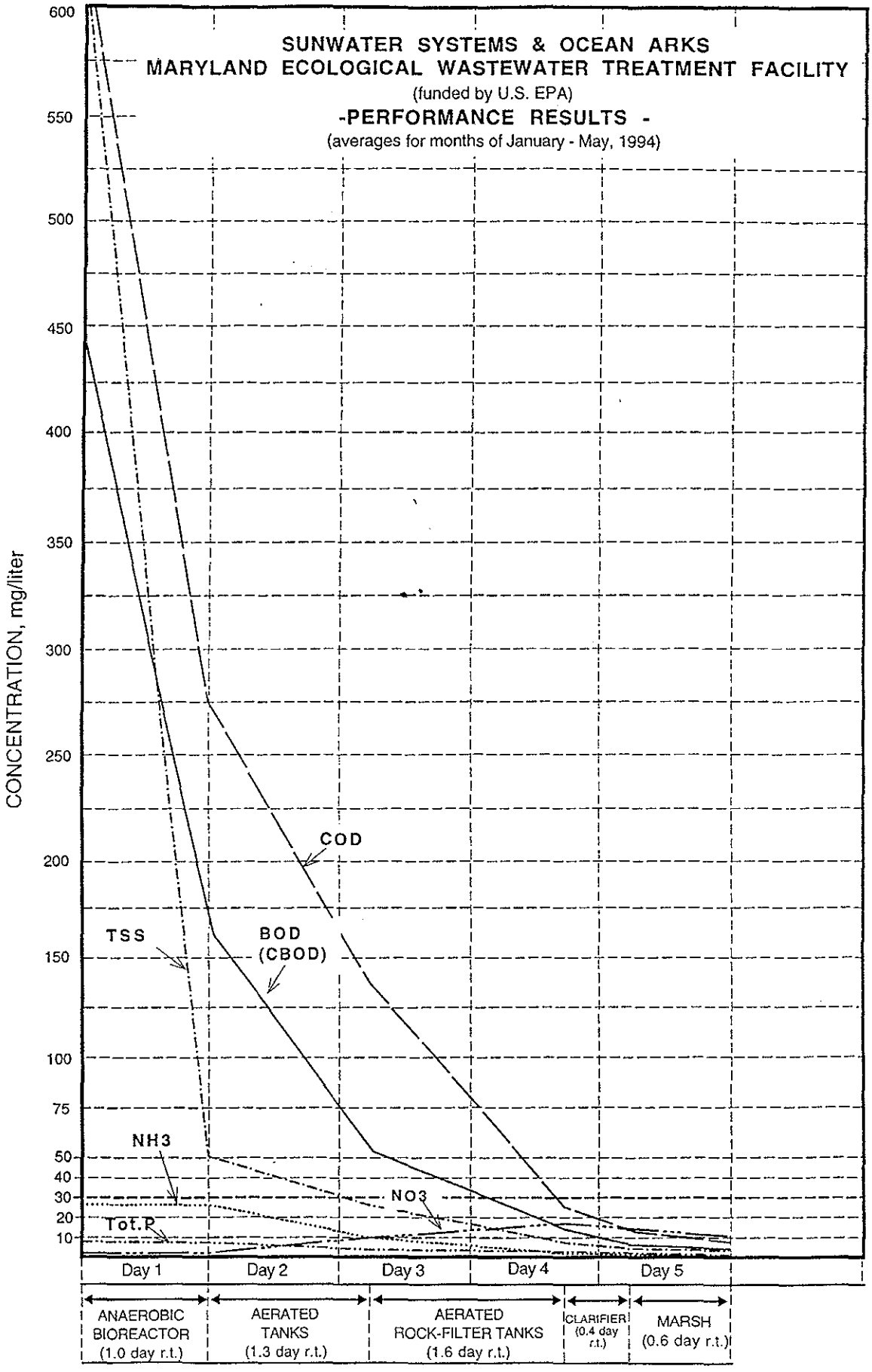
Ave. daily flow: 17 mgd (750 liters/sec.) per facility, 34.0 mdg combined.

Same design for both north & south facilities.



Sunwater Systems, Inc.

San Diego, CA.,
Tel: 619-453-5688


SUNWATER SYSTEMS & OCEAN ARKS
MARYLAND ECOLOGICAL WASTEWATER TREATMENT FACILITY
(funded by U.S. EPA)
-PERFORMANCE RESULTS -
(averages for months of January - May, 1994)
CONCENTRATION, mg/liter
600
550
500
450
400
350
300
250
200
150
100
75
50
40
30
20
10
COD
TSS
BOD
(CBOD)
NH3
NO3
Tot.P
Day 1
Day 2
Day 3
Day 4
Day 5
ANAEROBIC BIOREACTOR (1.0 day r.t.)
AERATED TANKS (1.3 day r.t.)
AERATED ROCK-FILTER TANKS (1.6 day r.t.)
CLARIFIER (0.4 day r.t.)
MARSH (0.6 day r.t.)

The Sunwater team and services

Sunwater Systems consists of a diversified team and network of experts highly experienced in:

- Wastewater treatment and reclamation;
- Domestic water treatment and purification;
- Treatment and bio-remediation of polluted soils;
- Integrated aquaculture/agriculture systems;
- Aquaculture of fish, shrimp, shellfish;
- Algae culture for water treatment and feed;
- Culture of duckweeds and other aquatic plants;
- Marsh and aquatic ecosystem management;
- High-yield, bio-intensive organic farming;
- Composting, vermiculture and Topsoil creation;
- Design, engineering, and construction

We provide technology and services for all phases of project development and management, including:

- Initial feasibility and economic studies;
- Assistance with financing;
- Detailed design and engineering;
- Construction supervision or management;
- Operations start-up, training and supervision;
- Operations Management;
- Complete "turn-key" facilities;
- By-product market analysis and planning;
- Supervision of by-product farming;
- By-product processing and marketing.

Sunwater Systems, Inc.
10525 Vista Sorrento Pkwy, Suite 200
San Diego, CA 92121, USA
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Fax: (619) 793 16 35

summary

The concept the engineering company Sunwater Systems, Inc. has for treating wastewater is based on a sequence of well-known purification processes. Chemical methods are dispensed with, and instead, individual purification stages are inoculated with optimised bacteria cultures (superbugs). The use of energy is reduced; chiefly the sun is exploited as a natural source of energy. The nutrients in the water are used to produce useful biomass.

sommaire

Le concept d'épuration des eaux usées du bureau d'études Sunwater Systems, Inc. repose sur la juxtaposition de procédés d'épuration connus. On renonce en l'occurrence à l'emploi de produits chimiques. Au lieu de cela, les différents niveaux d'épuration sont inoculés au moyen de souches bactériennes optimisées (super-bugs). Les besoins énergétiques sont réduits, le soleil, source d'énergie naturelle, étant ici le principal fournisseur. Les substances nutritives de l'eau sont valorisées pour produire une biomasse à son tour exploitable.

resumen

El concepto de la empresa de ingeniería Sunwater Systems Inc. para la depuración de aguas residuales se basa en la aplicación en serie de conocidos procedimientos de depuración. Se renuncia al empleo de la química, en su lugar se inoculan unas cepas bacterianas optimizadas (super-bugs) en algunas fases de la depuración. El empleo de energía es reducido, en lo esencial se emplea el sol como fuente de energía natural. Los nutrientes del agua se aprovechan para la producción de ulteriores biomasas útiles.

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