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Plants and their Microbial Assistants: Nature's Answer to Earth's Environmental Pollution Problems

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Before my recent retirement from the U.S. Government, I was employed with NASA as a research scientist at the Stennis Space Center in Mississippi for over 18 years. These past 18 years have been a challenge to maintain funding for continuing research in the utilization of higher plants and their associated microorganisms to solve environmental pollution problems on Earth and in future space applications.[1-12] Hopefully, this research with plants and microorganisms will continue at NASA. Even though I have retired from NASA, I will continue my research and will concentrate on applying this technology to solving some of Earth's environmental pollution problems.

If man is sealed inside closed facilities, we all know he becomes a polluter of the environment. It is also common knowledge to most people that man cannot survive on Earth without green photosynthesizing plants and microorganisms. Therefore, it is vitally important that we have a better understanding of the interactions of man with plants and microorganisms. (Figure 1) Biosphere 2 and other related studies presently being conducted or planned, hopefully, will supply data that will help save planet Earth from impending environmental disaster.

I personally feel that a promising solution to the Earth's environmental pollution problems is the development of a means to utilize both air and water pollution as a nutrient source for growing green plants. To this goal, I have dedicated the past twenty years of my life. As I tour the world and lecture on this approach to environmental pollution control, people are beginning to understand and accept the idea of using nature to clean our environment.

Sewage is now being used as a nutrient solution for growing plants while the plant roots and associated microorganisms convert sewage to clean water. This new concept is rapidly gaining acceptance because it is the most economical means of treating sewage, especially for rural areas and small cities (Table 1).

Microorganisms have always been used by engineers to treat sewage and industrial wastewater. But the use of higher plants in completing nature's cycle is a new addition to this process. Although microorganisms are a vital part of wastewater treatment, it is important to have vascular plants growing in these treatment filters to feed off the metabolic by-products of microorganisms and to prevent slime layer formation from dead microorganisms. Aquatic plant roots can also add trace levels of oxygen to help maintain aerobic conditions in plant-microbial wastewater treatment filters.

One question often asked is, "Will this wastewater treatment system work in cold climates?" This question has been answered by a small town, Monterey, Virginia. Located in the mountains of western Virginia, near the West Virginia border, Monterey's temperature reaches levels of -30 degrees Fahrenheit. This small town has installed a bulrush/rock filter system to treat their waste. This system has been in operation over two years now and the latest data available indicated it was meeting design treatment levels.

The largest aquatic plant rock filter system installed to date is at Denham Springs, Louisiana. This system is treating approximately three million gallons per day of domestic sewage. With EPA grant money being phased out, the only affordable alternative for small towns and rural areas is the aquatic plant wastewater treatment system. To demonstrate the effectiveness of aquatic plant wastewater treatment systems, data from a mobile home park in Pearlington, Mississippi designed to treat 10,000 gallons per day is shown (Table 2). The owner has converted his sewage treatment system into a beautiful flower garden containing canna lilies, water iris and elephant ears.

Although the largest number of aquatic plant wastewater treatment systems installed to date have been for treating domestic sewage, the use of these systems for treating industrial chemical wastewater is rapidly increasing (Table 3). The chemical manufacturing industry, paper mills, the textile industry and animal processing plants are beginning to utilize the aquatic plant wastewater treatment process as an economical and environmentally safe method of treating their wastewater (Figure 2). The catfish farmers in Mississippi are also experimenting with aquatic plant filters for treating and recycling their fish culture waters.

Houseplants combined with activated carbon filters are also a promising solution to the complex problems of indoor air pollution. The United States Environmental Protection Agency (EPA) studies have stated that indoor air pollution represents a major portion of the public exposure to air pollution

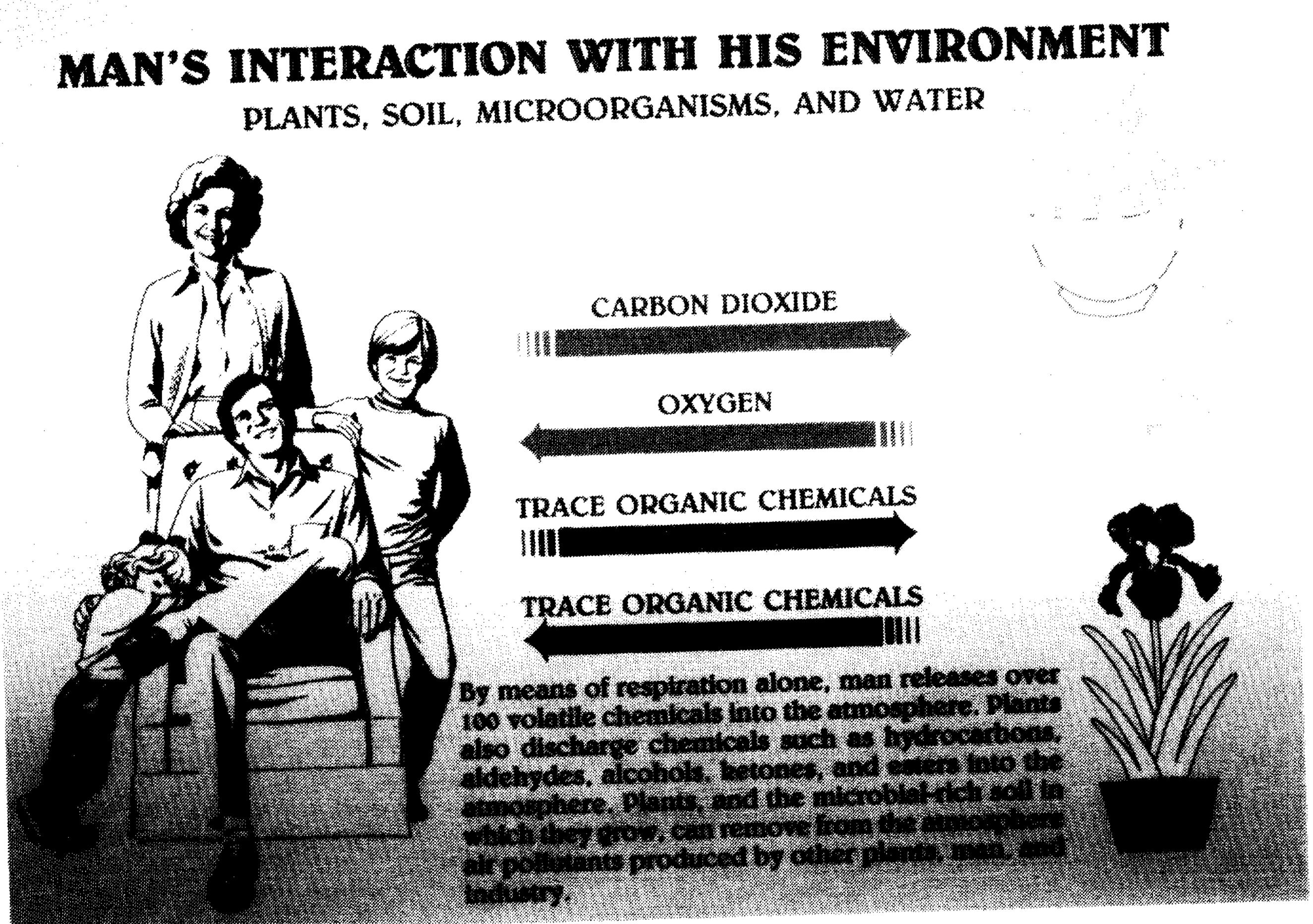

Figure 1. Man's interaction with his environment: plants, soil, microorganisms, and water.

SMALL TOWNS, MOBILE HOME PARKS SUBDIVISIONS, AND SINGLE HOMES		INDUSTRY	GOVERNMENT FACILITIES
1.Monterey Va*	16.Leakesville, Ms	1.Natchitoches, La* (Tenn Gas Pipeline Co.)	1.Carville, La* (U.S.P.H.S. Disease Center)
2.Albany, La*	17.Pearlington, Ms*	2.Theodore, Al* (Degussa Chemical Corporation)	2.NASA, John C. Stennis Space Center, Ms*
3.Benton, La*	18.Pelahatchie, Ms*	3.Columbus, Ms. (WeyerhausePaper Mill)	
4.Crowley, La	19.Union, Ms	4.New Augusta, Ms (Leaf River Forest Products, Paper Mill)	
5.Choudrant, La	20.Utica, Ms*	5.Sulphur, La (Fredeman Shipyard)	
6.Delcambre, La	21.Summit, Ms		
7.Denham Springs, La*	22.Picayune, Ms*		
8.Haughton, La*	23.Terry, Ms		
9.Livingston Parish,La*	24.Cottonwood, Al*		
10.Mandeville, La(City)*	25.Mauriceville, Tx* (Restaurant & Store)		
11.Mandeville, La (Subdivision)*			
12.St. Martinville, La			
13.Sunset, La.			
14.Sibley, La*			
15.Collins, Ms*			

*In operation. All others under construction or in planning and design phase.

Table 1. Aquatic plant wastewater treatment systems using technology developed by B.C. Wolverton, Ph.D..

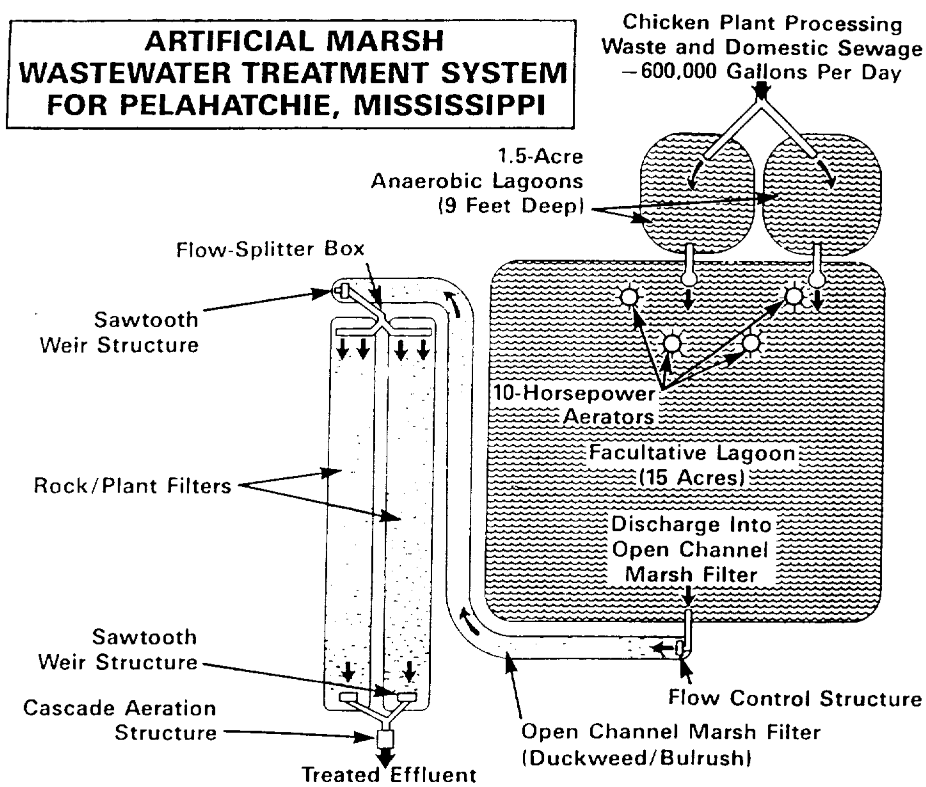

Figure 2. Artificial Marsh Wastewater Treatment System for Pelahatchie, Mississippi.

SEPTIC TANK ROCK/PLANT WASTEWATER TREATMENT SYSTEM FOR
SUNRISE HAVEN MOBILE HOME PARK, PEARLINGTON, MISSISSIPPI

	Septic Tank Effluent (mg/l)			Marsh Filter Effluent (mg/l)		
Date	BOD_5	TSS	Fecal Coliform Colonies/100 ml	BOD_5	TSS	Fecal Coliform* Colonies/100 ml
6/88	138	20	5.8×10^5	7.2	0	3,300
7/88	111	16	2.9×10^6	7.5	0	366
8/88	83	0	2.0×10^6	6.5	0	<1
9/88	119	28	1.9×10^6	5.6	0	1,333
10/88	126	136	1.1×10^6	5.2	8	2,000
11/88	95	184	2.2×10^6	2.8	0	1,800
12/88	134	270	3.8×10^6	7.9	8	1,400
1/89	86	24	3.8×10^6	6.6	12	566
2/89	97	46	1.0×10^6	5.4	6	1,500
3/89	86	16	1.0×10^6	6.3	4	3,000
4/89	183	130	1.5×10^6	7.4	5	315
5/89	164	100	6.5×10^6	4.7	0	216

*Before Chlorination

Table 2. Pearlington, Mississippi Septic Tank/Rock Plant Marsh Filter.

ARTIFICIAL MARSHES FOR TREATING INDUSTRIAL WASTEWATER CONTAINING TOXIC CHEMICALS

Chemicals (mg/L)	Marsh Plants in Rock Filter	Influent	Effluent*
Trichloroethylene	Torpedo grass	3.60	0.0009
	Southern bulrush	9.90	0.05
Benzene	Torpedo grass	7.04	1.52
	Southern bulrush	12.00	5.10
	Reed	9.33	0.05
Toluene	Torpedo grass	5.62	1.37
	Southern bulrush	11.47	4.50
	Reed	6.60	0.005
Chlorobenzene	Torpedo grass	4.85	1.54
	Southern bulrush	10.65	4.90
Phenol	Cattail	101.00	17.00
	Reed	104.00	7.00
P-xylene	Reed	4.07	0.14
Pentachlorophenol (PCP)	Torpedo grass	0.85	0.04
Potassium cyanide	Torpedo grass	3.00	<0.20
Potassium ferric cyanide	Torpedo grass	12.60	<0.20

*24-hour retention time

Table 3. Artificial marshes for treating industrial waste-water containing toxic chemicals.

ENERGY-EFFICIENT HOMES WITH BIOREGENERATIVE LIFE-SUPPORT SYSTEMS

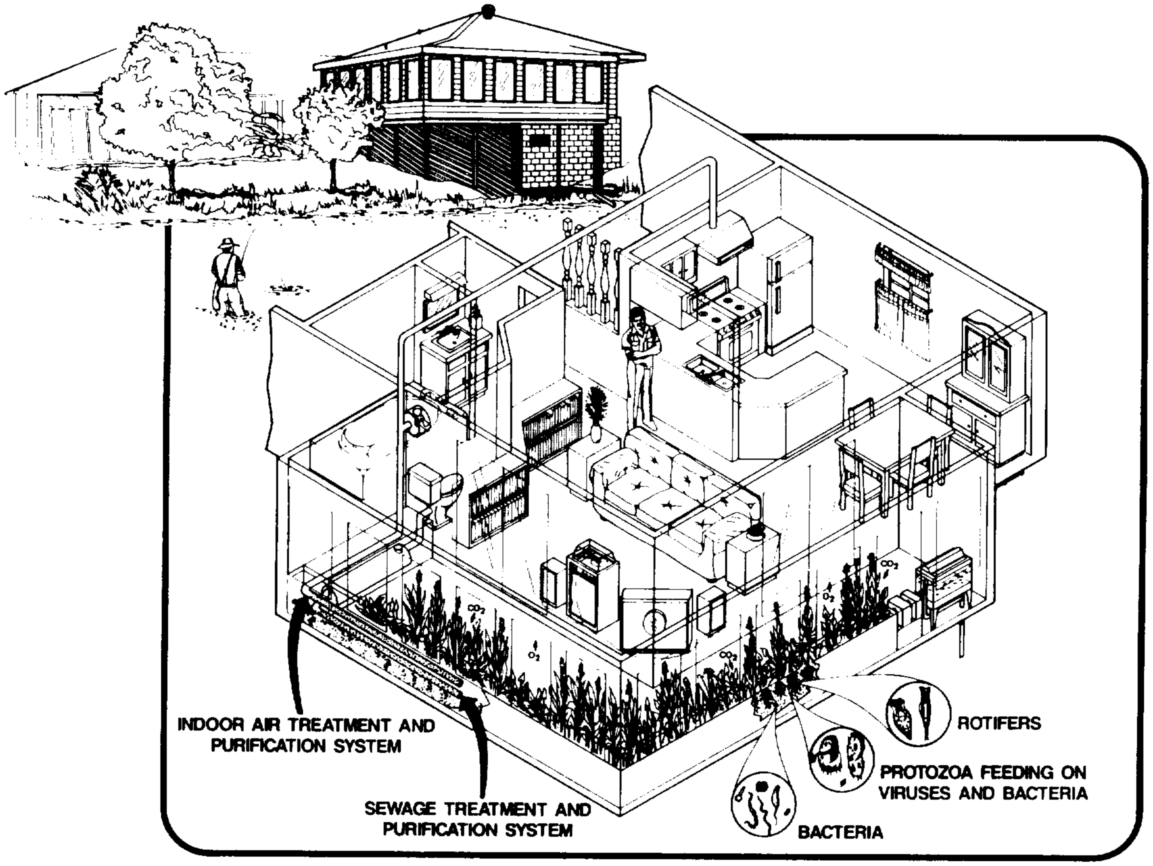

Figure 3. Energy-efficient homes with bioregenerative life-support systems.

and may pose serious acute and chronic health risks. The EPA studies also state that the potential economic impact of indoor air pollution is estimated to be in the tens of billions of dollars per year.

To enhance the efficiency of common houseplants and potting soil in removing indoor air pollutants, I recently developed a high efficiency plant filter system combining activated carbon and other adsorbent materials into a unique filter system. This patent pending system utilizes a fan to rapidly move polluted air through a mixed bed filter containing a combination of the most effective adsorbent materials in a hydroponic plant growth chamber. The hydroponic reservoir continuously supplies moisture to the plant root zone to prevent the roots from being damaged during continuous operation of the exhaust fan which moves air through the plant root adsorbent mixture bed. One of the unique components of this process is the utilization of plant roots and microorganisms to continuously clean and bioregenerate the adsorbent bed filter.

The obvious next step in development of plant and microbial filter biotechnology is to incorporate the complex wastewater treatment/indoor air purification concept into a real home environment. This I have recently accomplished in my own home. Although it took some time to convince my wife to allow me to flush raw sewage into a planter system in her house, she reluctantly allowed me to install such a wastewater treatment/indoor air purification system (Figure 3). Now we have a lovely Florida room filled with beautiful houseplants that purify the air while feeding off the wastewater.

With this accomplished, I am now feverishly attacking the air emission problems from smokestacks, incinerators, etc. This is the final part of the puzzle to be completed using green plants and microorganisms for solving Earth's water and air pollution problems. The approach to solving the point source air emission problem is to convert the air pollutants into water pollution and purify the polluted waters using aquatic plant microbial marsh filters.

Since conventional technology has failed to solve the Earth's environmental pollution problems, the most promising option left to man, in my opinion, is to harness the power of nature by using plants and their associated microorganisms to undo man's damage.

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