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AQUAPONICS

Aquaponics is the integration of aquaculture and hydroponic agriculture. The two methods combined create a symbiotic efficiency; nutrient-rich aquaculture byproducts are used as a liquid fertilizer for the hydroponic cultivation of plants, and the plants, in part, provide biological filtration improving water quality for aquatic organisms. Aquaponic synergy eliminates the need for costly inputs that are required for standalone aquaculture or hydroponic operations and generates a second revenue stream.

Aquaponics has the ability to conserve vital resources, particularly freshwater and soils, and to improve aquaculture and hydroponic productivity. To date, no technology has harnessed the cost-efficient benefits of aquaponics for commercial applications. Industry leaders recognize the huge cost-saving potential of aquaponics, but have lacked a scalable, proven technology to justify the transition.

Industry

Industry data on hydroponics and aquaponics are limited, however, in 2009, 73 percent of the 255,175 tons of food crops grown under protection and sold came from hydroponic systems.[1] Hydrofarm, Inc. a manufacturer of hydroponic equipment grossed $10M+ in sales volume in 2010.[2] In addition, hydroponics-dependent 'controlled environment agriculture' is gaining momentum in every industrializing part of the world, signaling market readiness.[3]

Hydroponics provides a high degree of control, water efficiency, minimal environmental degradation, and higher yields compared to traditional agricultural methods. However, equipment costs are high and play a decisive role in such technologies. The future and growth of the hydroponic, and aquaponic, industry depends on the development of growing systems and technologies that are compatible with commercial aquaculture and competitive with soil based agriculture, particularly with regards to mainstream produce like tomatoes and lettuce.

Technology

BioColumn technology isolates the principle mechanisms involved in rhizofiltration -breakdown and adsorption of waterborne contaminants using catalytic substrates, microbes, and plant roots as filters. BioColumn technology is designed to lengthen the contact time between wastewater and these filtration mechanisms while stimulating aerobic bioprocesses. This is a simple and economical method to rapidly degrade and sequester waterborne contaminants into salable plant products.

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[1] United States. United States Department of Agriculture. National Agricultural Statistics Service. "Pg. 397, Table 14: Food Crops Grown Under Protection and Sold: 2009." *2007 Census of Agriculture*. Web. 6. June. 2010 <link>.

[2] ReferenceUSA. (2011). Aquaculture. 7. May. 2011. <www.referenceusa.com>.

[3] Jensen, H. M. 1999. Hydroponics Worldwide. University of Arizona. School of Agriculture. Tucson, AZ.

Experimental Data

The efficacy of the BioColumn technology was evaluated. The effluent was derived from a body of water in which fish having weights ranging from 250-450 g were stocked at a density of 100 fish/m^3 in a 700 gallon system. This effluent was run through a bioreactor system which included 24 vertical bioreactor chambers each having a volume capacity of 5145 cm^3. Each bioreactor contained a growth medium comprising lightweight expanded clay aggregate and contained mature (1 kg total weight) terrestrial plants with established root development. Levels of nitrate, ammonia, phosphorus, potassium, calcium, magnesium, sulfate, iron, copper, manganese, zinc, boron, molybdenum, and chloride were measured before the effluent was input into the system and following a 2 minute bioreactor contact treatment time. In this system the sole source of nutrients came from the fish feed and the resultant aquaculture effluent. The composition of typical fish feed is summarized in Table 1. System influent/effluent data is summarized in Table 2.

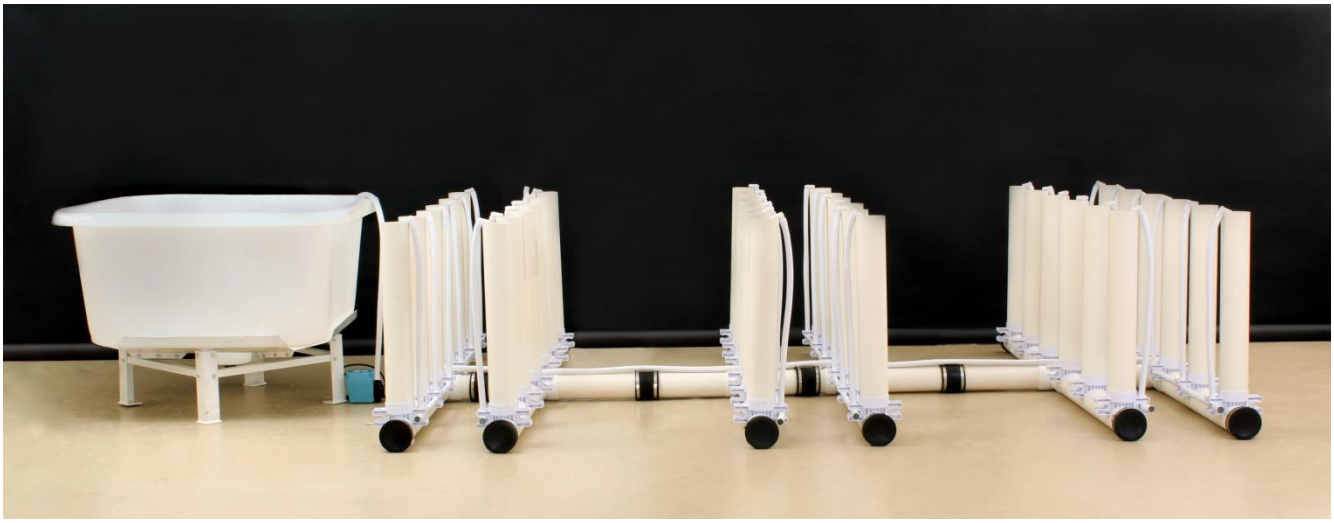


Table 1.

Aquaculture Feed Composition	
PARAMETER	PERCENT (%)
Crude Protein	45
Crude Fat	19
Crude Fiber	3
Potash	12
Sodium	2
Calcium Pantothenate	NA
Zinc Sulfate	
Copper Sulfate	
Ferrous Sulfate	
Manganese Sulfate	

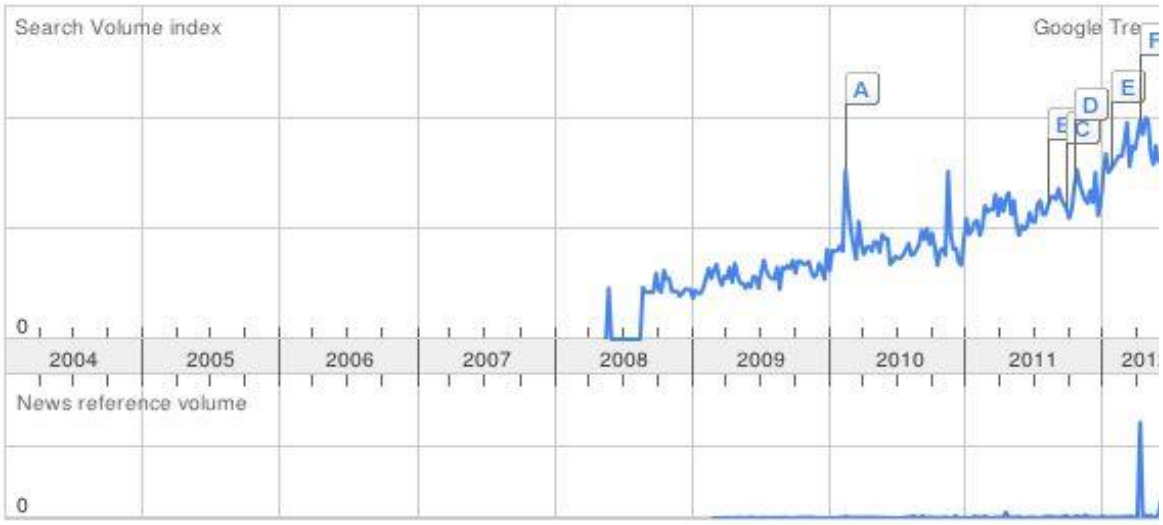
Table 2.

Elemental Analysis of Before and After Treatment			
PARAMETER	INPUT (ppm)	OUTPUT (ppm)	REDUCTION (%)
Nitrate-N (NO_3)	27.700	24.500	11.6
Ammonia-N (NH_3)	1.750	0.320	81.7
Phosphorus (P)	3.840	3.310	13.8
Potassium (K)	6.700	5.750	14.2
Calcium (Ca)	55.260	54.010	2.3
Magnesium (Mg)	9.940	9.310	6.3
Sulfate-S (SO_4)	33.900	33.800	0.3
Iron (Fe)	0.056	0.050	10.7
Copper (Cu)	0.005	0.003	33.3
Manganese (Mn)	0.040	0.030	25.0
Zinc (Zn)	0.072	0.032	55.6
Boron (B)	1.910	2.160	-13.1
Molybdenum (Mo)	0.030	0.030	0.0
Chloride (Cl)	19.350	21.400	-10.6

As will be seen, even following a relatively brief contact time, very significant reductions in critical contaminants ammonia and nitrate were achieved. It is important to regulate ammonia as elevated levels are toxic to many aquatic organisms. Likewise, significant reductions in critical metals copper, manganese, zinc, and iron were also realized. As such, the treated water stream was suitable for reintroduction into the aquaculture system or for use in other applications. Note commercial ammonia removal systems currently retail for $2-7/gallon of aquaculture system, as such BioColumn represents a novel cleantech option for wastewater treatment. Table 2. further indicates that all essential macro and micronutrients for plant physiology are present.

Market Trends

The concept of aquaponics is quickly gaining mainstream acceptance, press coverage, and usage. Major media outlets such as *The New York Times*[4], *The Wall Street Journal*[5] and *Forbes*[6] have covered Aquaponics throughout 2010 - 2013. Aquaponics continues to grow and is gaining inertia in Australia, United States, South Africa, Canada, Germany and United Kingdom, respectively. [7]



Source: Google Trends "Aquaponics"

[4] New York Times: http://mobile.nytimes.com/article?a=554693&f=25

[5] Wall Street Journal: http://online.wsj.com/article/SB10001424052748703950804575242594125593702.html

[6] Forbes: http://www.forbes.com/sites/williampentland/2013/12/04/aquaponic-farmers-claim-a-cleantech-crown/

[7] Google Trends: http://www.google.com/trends/?q=aquaponic

BioColumn Advantages

- The system offers scalability for commercial applications and can be readily assembled and disassembled for storage/transport.
- Suitable for ebb and flow or trickle down fluid delivery, which improves plant growth and filtration by delivering alternating cycles of nutrient-rich fluid and large amounts of oxygen.
- Closed-loop applications ensure that no industrial contaminants like heavy metals are present in food crops. From a biosecurity standpoint this gives operators the ability to quickly quarantine and address systemic issues.
- Pumping is primarily horizontal which greatly conserves energy inputs.
- The ergonomic design prevents back strain and injury. In outdoor applications this feature prevents animal intrusion.
- Removable parts make cleaning easy and allow operators to collect settled organic fish emulsion for terrestrial applications or sale.
- Almost entirely enclosed, the system is unparalleled when it comes to water conservation.
- Biologically stable design. Requires no complex pH buffering systems or supplemental nutrients or micronutrients.
- Engineered to handle large volumes of water for commercial applications.
- Enhanced aerobic degradation of organic waste substances minimizes odors.
- Produces high-quality organic food that is hormone, pesticide, and heavy metal free.
- Adaptable to automation of crop and biomass production.
- Integrates with channel and raft-type hydroponic systems.
- As a technique for bioremediation this technology has broad potential for industrial effluent management.