Addressing the Conflation of Sandponics and the Integrated Aqua-Vegeculture System (IAVS) in Recent Literature

Barry Taylor

Independent Researcher, Brisbane, Australia

Correspondence: research@journalofaquaponics.com

Date: November 29, 2025

Abstract

Precise nomenclature is essential for the advancement of integrated food production systems, particularly within the fields of aquaponics and sustainable agriculture. This commentary identifies and corrects a recurring terminological conflation in recent literature where the Integrated Aqua-Vegeculture System (iAVs) is treated as synonymous with "Sandponics." Through a review of historical documentation and technical specifications, this paper demonstrates that iAVs and Sandponics are distinct methodologies with separate origins, operational principles, and input requirements. Specifically, iAVs is a biologically integrated aquaculture-horticulture system developed at North Carolina State University in the 1980s, relying on complex microbial processes to metabolize fish effluent for nutrition. Conversely, Sandponics is a proprietary sand-culture system developed by Sumitomo Electric Industries in the 1970s, dependent exclusively on chemical fertigation. The failure to distinguish between these systems introduces significant methodological ambiguity, compromises the reproducibility of data, and hinders the development of accurate protocols for food and water security research.

Keywords: Integrated Aqua-Vegeculture System (iAVs), Sandponics, Aquaponics, Nomenclature, Sustainable Agriculture, Recirculating Aquaculture.

---

1. Introduction

The emerging field of integrated food production systems relies heavily on precise and consistent nomenclature to ensure rigorous scientific comparison and technology transfer (Colt et al., 2022; Palm et al., 2024). Adherence to standardized terminology is foundational because it "ensures objectivity, clarity, and reproducibility" (Kretser et al., 2019). Furthermore, accurate citation is not merely administrative; as Buchanan (2006) notes, citation errors "diminish the usefulness of the data... and the validity of conclusions based on those data," effectively breaking the chain of evidence required for historical verification. Ambiguity in terminology can lead to the misapplication of engineering principles and the propagation of inaccurate design parameters. This commentary addresses the problematic conflation of two distinct agricultural systems - Sandponics (SP) and the Integrated Aqua-Vegeculture System (iAVs) - as observed in recent publications, notably Sewilam et al. (2022), Nair et al. (2024), and Kimera et al. (2023; 2025).

Foundational literature illustrates that these two concepts originate from different historical trajectories, feature distinct initial designs, serve unique purposes, and rely on varied operational principles. The practice of equating them creates significant ambiguity, potentially leading to misattributions of historical development and methodological errors.

2. The Conflation in Current Literature

Several recent studies explicitly define Sandponics as synonymous with the Integrated Aqua-Vegeculture System. For instance, Sewilam et al. (2022) explicitly claim "sandponics (SP), which is also referred to as an Integrated Aqua-Vegeculture system (IAVS)," a statement also cited in Kimera et al. (2023). Similarly, Nair et al. (2024) assert that "Sandponics, also known as the Integrated Aqua Vegeculture System (IAVS), presents a promising solution." Most recently, Kimera et al. (2025) refer to "Sandponics…also called the integrated vegeculture-aquaculture system."

This interchangeable usage obscures fundamental differences in the origins, primary objectives, and technological configurations of the two systems. As analyzed in the following sections, the literature establishes that these systems are mutually exclusive in their design parameters. This conflation hinders replicable and comparative research.

3. Defining the Distinct Systems

The literature clearly establishes that these systems are mutually exclusive in their historical origins, design parameters, and operational principles.

3.1. The Integrated Aqua-Vegeculture System (iAVs)

3.1.1. Historical Origins and System Overview

The Integrated Aqua-Vegeculture System (iAVs), developed and documented by Dr. Mark McMurtry, Dr. Douglas C. Sanders, and colleagues at North Carolina State University (NCSU) in the 1980s, is recognized as a foundational model for modern, sustainable aquaponics (Diver, 2006; Abdelrahman, 2018; Goddek et al., 2019). It is a closed-loop, integrated system that co-cultures fish and vegetables, designed to address waste accumulation challenges in recirculating aquaculture.

The development team integrated distinct specializations to address the complex biological interactions of the system, including horticulture and crop physiology (D.C. Sanders), plant mineral nutrition (P.V. Nelson), aquaculture and zoology (R.G. Hodson), and International Agricultural Development (H. Douglas Gross), agronomy (P.C. St. Amand), and plant pathology (J.D. Cure). Between 1984 and 1994, the iAVs project was supported by a comprehensive research consortium of 45 investigators and technical consultants. This multidisciplinary group held advanced degrees across diverse fields, including botanical mineral nutrition, aquatic veterinary medicine, soil genesis, agricultural economics, and controlled environment engineering (including specialists from NASA and the Disney EPCOT Land Pavilion).

3.1.2. Mechanical and Biological Filtration Processes

The empirical results detailed in the works of McMurtry et al. (1987–1997) offer specific, quantifiable solutions and design parameters. In contrast to typical recirculating aquaculture systems that remove solid waste prior to water reuse, the iAVs method pumps raw, unfiltered fish tank effluent - containing both dissolved nutrients and suspended organic materials (solids) - directly from the bottom of the fish tank onto sand biofilters composed of medium-coarse sand (McMurtry et al., 1993a; 1993b; 1994; 1997a; 1997b). A specific builder's grade fractionation is used: predominantly Coarse (38.8%) and Very Coarse (33.3%) inert sand, with minimal silt content (0.0% to <1% clay) and virtually zero fines (<200 microns) (McMurtry et al., 1997).

To facilitate the removal of these solids from the aquaculture component, the bottom is sloped (e.g., 45°) to direct sediment toward the pump intake (McMurtry et al., 1997). These sand beds serve a triple function: providing a physical substrate for plant roots, acting as a medium for microbial nitrification, and facilitating the mechanical trapping and mineralization of organic waste solids on the sand surface (McMurtry et al., 1993b).

Once pumped to the biofilter, water is distributed via shallow irrigation furrows. These furrows act as sediment traps, slowing water velocity and allowing organic matter to settle on the sand surface (McMurtry et al., 1993a). Empirical analysis confirms that this "furrow effect" significantly increases Cation Exchange Capacity (CEC) and concentrates essential elements within 50 mm of the furrow axis, providing a continuously renewed, localized supply of solid-phase minerals to the root zone (McMurtry et al., 1990).

To ensure complete drainage and prevent waterlogging or anaerobic zones, the bottom of the biofilter is constructed with a specific slope of 1:50 (2 cm drop per meter) toward the drainage outlet (McMurtry et al., 1997). As the filtered water drains from the sand bed, it cascades back into the fish tank, which re-oxygenates the water for the fish (McMurtry et al., 1990).

The system operates on a "reciprocating" (flood and drain) cycle, typically irrigating 8 times daily (McMurtry et al., 1997). Hybrid tilapia (Oreochromis mossambicus x O. niloticus) were utilized due to their rapid growth, high market value potential, and hardiness in intensive culture systems. The fish are fed at 08:00 (8 AM) and 13:00 (1 PM). The feed used in the original trials was specifically not fortified with vitamins or trace elements to avoid potential trace element toxicity (McMurtry et al., 1997).

3.1.3. Operational Parameters and Performance Attributes

The iAVs methodology exhibits specific operational characteristics regarding water chemistry and system maintenance, as documented in technical assessments by Dr. H. Douglas Gross (NCSU Department of Crop Science). Gross (1988) reported that iAVs facilities typically develop into functionally mature ecosystems within three months from initial startup. The longer the system is continuously operated without interruption or excess feed input rate, the more stable it will tend to become biologically and chemically (Gross, 1988).

A primary feature is inherent pH stability; the system naturally maintains a pH between 6.0 and 6.5, which is an optimal range for nutrient availability to most plants. This stability results from a biological balance where the acidifying process of nitrification is counteracted by the base-releasing effects of mineralization and plant anion uptake, removing the requirement for chemical pH adjusters often used in other hydroponic and aquaponic models (McMurtry et al., 1990a; McMurtry et al., 1997a). This stability, however, is contingent upon balancing nitrogen input with system assimilation (McMurtry 1990b). Therefore, operators must strictly adhere to established design ratios regarding fish biomass and biofilter volume, while regulating feed inputs to match metabolic demand (McMurtry 1990b; McMurtry et al., 1997). Adherence to these protocols ensures the ecosystem remains within the specific 6.4 (±.4) pH range subsequently identified as critical for prioritizing soil ecology and plant nutrient availability.

The system is designed for functional simplicity, allowing it to be operated by individuals with "unsophisticated managerial skill" (McMurtry et al., 1997a). However, prior knowledge of fish and plant care is beneficial for optimizing the biological balance of the system.

When sized correctly with medium-to-coarse sand (0.3-1.2 mm), the sand beds do not exhibit clogging and do not require periodic cleaning or replacement. The design retains and mineralizes organic solids within the sand bed, ensuring sequestered nutrients are available for plant assimilation (McMurtry et al., 1993a). This integration of solids prevents nutrient deficiencies often associated with solids removal in other systems (McMurtry et al., 1994; Tyson 2011).

The ratio of plant growing area to fish volume is also critical. Specific biofilter-to-fish-tank ratios (ranging from 0.67:1 to 2.25:1) were established through empirical trials. Studies indicated that increased Biofilter Volume (BFV) resulted in improved water quality (lower TAN and NO_2^- concentrations) and increased fish growth rates (McMurtry et al., 1997). While vegetable yield per individual plant decreased with increasing BFV, the total fruit yield per plot (total area) increased significantly, suggesting that larger biofilters maximize total system biomass production (McMurtry et al., 1993b; McMurtry et al., 1997).

Extrapolation of annualized yield data by Professor Gross demonstrated that a unit with 3 m^3 water and 14 m^2 biofilter area could yield ~150 kg fish and over 1000 kg of vegetables annually, assuming a sub-tropical or controlled environment context (Gross, 1988; McMurtry et al., 1997b). Gross (1988) further highlighted the system's trophic efficiency, noting that every 1.0 kg of feed input yields approximately 0.75 kg of fish and 6.70 kg of vegetables.

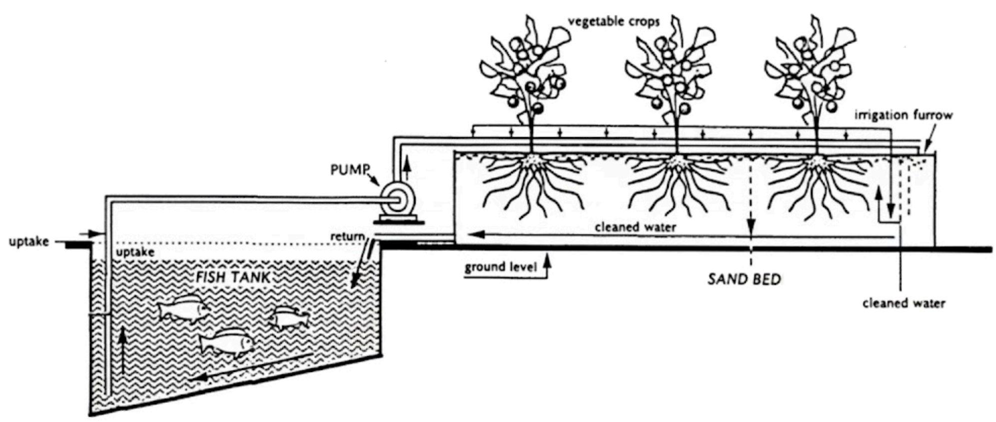

Fig. 1. Original schematic of the iAVs method. *Reproduced from McMurtry et al., (1990) with the purpose of critical comparison.*

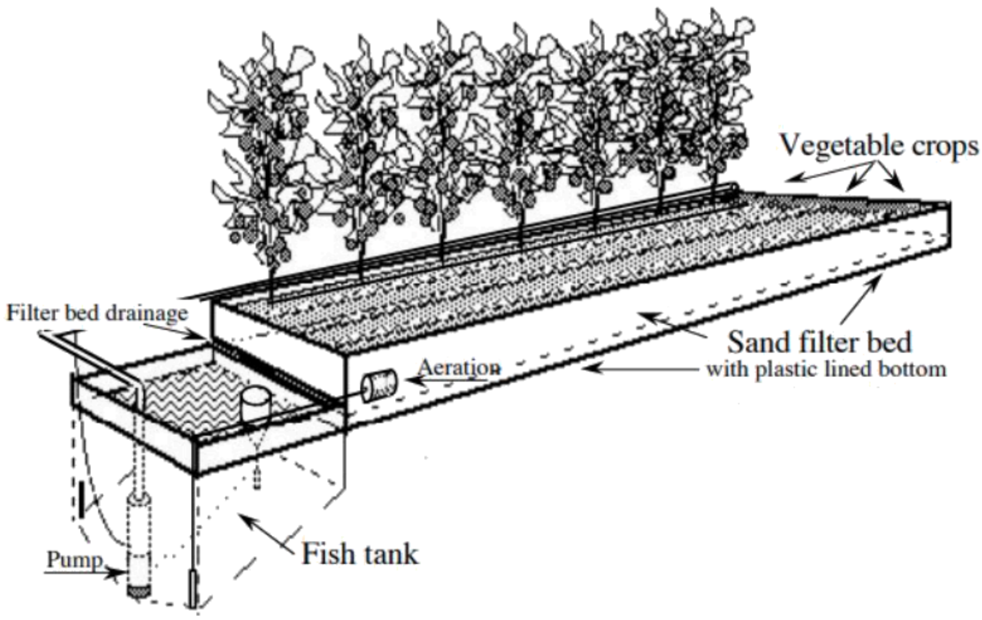

Fig. 2. Original schematic of the iAVs method. *Reproduced from McMurtry et al., (1990) with the purpose of critical comparison.*

3.2. The Sandponics System

In contrast, "Sandponics" is a proprietary trademark of Sumitomo Electric Industries, Ltd. (Baba & Ikeguchi, 2015; Kanazawa et al., 2017; Misu et al., 2018). Originally developed in 1977, it is a greenhouse-based system designed for year-round farming in a controlled environment (Baba & Ikeguchi, 2015).

The key feature of the Sandponics system is its reliance on external chemical inputs. The system uses a "Liquid fertilizer pump" and a "Liquid fertilizer Dilutor" to administer a "Standard Sandponics fertilizer" containing inorganic salts (as shown in Figure 3) (Baba & Ikeguchi, 2015; International Potato Center [CIP], 2019).

This system utilized an intermittent dripping irrigation method on air-permeable beds filled with sand (Baba & Ikeguchi, 2015). Early challenges led to the development of the "New Sandponics" (NSP) system in 2013, which transitioned to a floor irrigation method (as shown in Figure 4) (Kanazawa et al., 2017). NSP utilizes capillary action via a specialized irrigation cloth and root-proof sheets to draw nutrient solution upward from a bottom tank, a process driven by soil moisture tension rather than gravity-fed dripping (Kanazawa et al., 2017). This specific hydraulic configuration was designed to reduce the sand medium volume by 90% compared to the original system and to enable precise control of liquid fertilizer supply based on crop growth phases (Kanazawa et al., 2017).

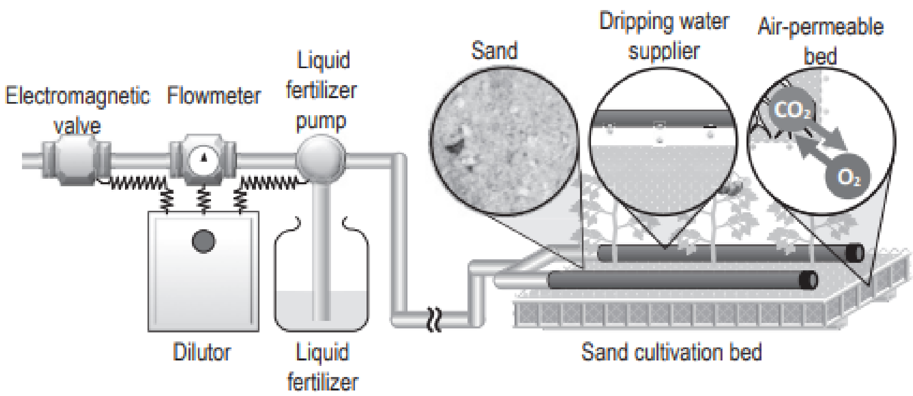

Fig. 3. Configuration of the Sandponics System*. Reproduced from Baba and Ikeguchi (2015), with the purpose of critical comparison.*

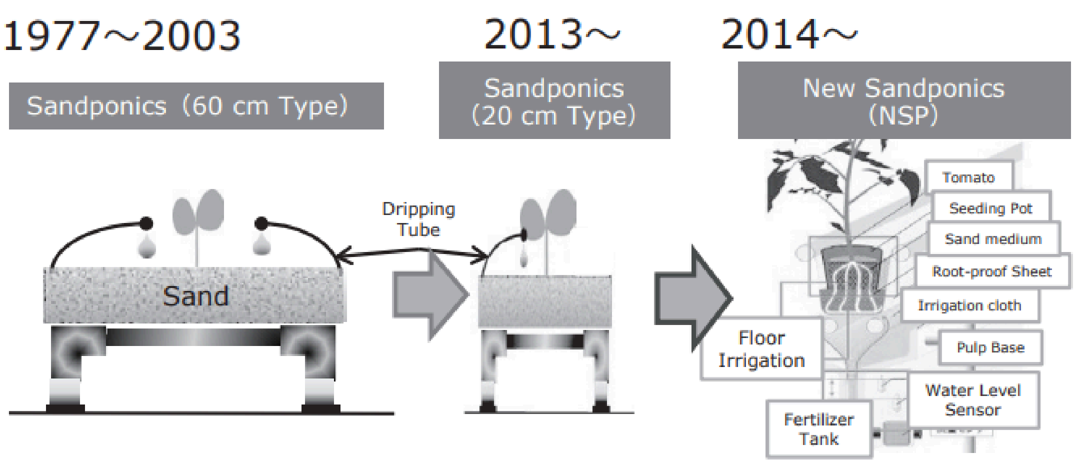

Fig. 4: *Development of Sandponics devices. Reproduced from Kanazawa (2017), with the purpose of critical comparison.*

4. Clarifying the Evolutionary Timeline

Nair et al. (2024) suggest a linear evolution in which Sandponics served as a precursor to iAVs. This assertion is not supported by the historical record. As detailed in Section 2, the two systems followed parallel, yet distinct, developmental paths. The proprietary Sandponics system has operated on chemical fertigation principles since its inception in 1977 through to the "New Sandponics" update in 2013 (Baba & Ikeguchi, 2015; Kanazawa et al., 2017). Conversely, iAVs was developed independently in the 1980s specifically as a biological solution for aquaculture waste management (McMurtry et al., 1990a). There is no evidence in the literature to suggest that the chemically-driven Japanese sand culture techniques were adapted into the biological iAVs model. Consequently, the terms are not historically or functionally interchangeable.

5. Implications of Terminology Conflation

The misattribution and conflation of these systems introduce methodological errors that compromise the scientific value of reported studies. Furthermore, data derived from systems incorrectly labeled as "Sandponics" (when they are actually iAVs) creates a false equivalence in water use efficiency and yield metrics. This renders the data difficult to interpret or replicate, effectively nullifying the utility of the research for those pursuing food and water security solutions based on specific system constraints.

The root of this terminological confusion appears to lie in a reliance on non-peer-reviewed information channels. Currently, for-profit operators such as Leedana ACG and MyAquaponics market systems utilizing iAVs biological principles under the colloquial 'Sandponics' label (Leedana ACG, 2025; MyAquaponics, 2025). While marketing strategies are the prerogative of private enterprise, their terminology must not be allowed to infect the scientific record. When academic researchers draw from these informal sources without tracing the historical primary literature, they risk legitimizing "self-promotion" as established science. This creates what Jamieson et al. (2017) describe as a "polluted science communication environment," where informal usage degrades the ability of researchers to "recognize valid science" (Redford, 2018), resulting in a literature base where distinct methodologies are indistinguishable.

The conflation of terminology subsequently risks obscuring the distinct performance metrics established for iAVs by McMurtry et al. By subsuming iAVs under the ambiguous label of "Sandponics", researchers risk producing data that fails to replicate these established efficiency baselines.

6. Conclusion and Recommendations

The foundational principle for maintaining the integrity of the science record in integrated food production systems is the necessity of rigorous methodology and precise, unambiguous language (Gott 2019; Colt 2022). Accurate terminology and adherence to established hydraulic and biological protocols are necessary to ensure the reproducibility of research. The terms "Sandponics" and "iAVs" describe mutually exclusive methodologies: one is a chemical fertigation system using sand, and the other is an integrated biological system transforming aquaculture waste into plant biomass.

The conflation of a chemical method with a biological one is not merely a semantic error but a categorical mistake that invalidates the theoretical basis of the affected studies. Consequently, journals that have published papers equating Sandponics with iAVs - such as those identified in this commentary - should consider issuing corrections or retractions to prevent the further propagation of invalid design protocols. This situation underscores a systemic lapse in the peer review process; proper scientific rigor requires reviewers to verify historical precedents and technical specifications prior to publication.

This oversight risks normalizing "inadequate acknowledgement" - a recognized integrity breach (Kretser et al., 2019) - and disseminates foundational errors that question the record's reliability (Casadevall et al., 2014; Hilgard & Jamieson, 2017). Peer review must therefore guard against a "polluted" environment (Redford, 2018) by rejecting informal colloquialisms that obscure technical distinctness. Future research must strictly distinguish between (Sandponics) and the Integrated Aqua-Vegeculture System (iAVs) to facilitate the reliable adoption of these technologies.

Competing Interests

The author serves as a volunteer administrator for iavs.info, a non-commercial educational archive dedicated to preserving the historical scientific record of the Integrated Aqua-Vegeculture System developed by Dr. Mark McMurtry. The preparation of this commentary received no external financial support, and the analysis is based exclusively on a review of peer-reviewed scientific literature. The author's motivation for this commentary is to ensure the integrity of the scientific record, thereby supporting researchers and practitioners in their contributions to global food and water security.

References

Abdelrahman, M. A. (2018). Effect of Feeding Frequency and Stocking Density on Tilapia Oreochromis Niloticus and Lettuce Lactuca Sativa Production in Aquaponics System under the UAE Condition and Business Enterprise Analysis. *Master's thesis*, United Arab Emirates University.

Baba, M., and Ikeguchi, N. (2015). Industrial Cultivation Using the Latest Sandponics System. *SEI Technical Review*, 80, 104-108.

Buchanan, Robert A. "Accuracy of cited references: The role of citation databases." *College & Research Libraries* 67.4 (2006): 292-303.

Casadevall, A., Steen, R. G., & Fang, F. C. (2014). Sources of error in the retracted scientific literature. *The FASEB Journal*, 28(9), 3847–3855.

Colt, John, et al. "Engineering design of aquaponics systems." *Reviews in Fisheries Science & Aquaculture* 30.1 (2022): 33-80.

Diver, S. (2006). Aquaponics - Integration of Hydroponics with Aquaculture. ATTRA - *National Sustainable Agriculture Information Service*.

Goddek, Simon, et al. Aquaponics food production systems: combined aquaculture and hydroponic production technologies for the future. *Springer Nature*, 2019.

Gott, James. Practicing ecologies: aquaponics and intervention in the Anthropocene. *Diss*. University of Southampton, 2019.

Gross, H. D. (1988). The Aqua-Vegeculture System. (Archived by M. McMurtry, 2015). iavs.info. https://iavs.info/the-aqua-vegeculture-system/

Hilgard, J., & Jamieson, K. H. (2017). Science as “Broken” Versus Science as “Self-Correcting”: How Retractions and Peer-Review Problems Are Exploited to Attack Science. In K. H. Jamieson, D. Kahan, & D. A. Scheufele (Eds.), *The Oxford Handbook of the Science of Science Communication* (pp. 84-92). Oxford University Press.

International Potato Center (CIP). (2019). Manual for sweetpotato pre-basic seed production using the sandponics system. International Potato Center: Lima, Peru.

Jamieson, K. H., Kahan, D., & Scheufele, D. A. (Eds.). (2017). The Oxford handbook of the science of science communication. *Oxford University Press*.

Kanazawa, S., Matsuo, K., Baba, M., Misu, H., & Ikeguchi, N. (2017). High Quality Agricultural Production Support System by Smart Sand Culture Device New Sandponics. *SEI Technical Review*, 84.

Kimera, Fahad, et al. "Growth response of kale (Brassica oleracea) and Nile tilapia (Oreochromis niloticus) under saline aqua-sandponics-vegeculture system." *Scientific Reports* 13.1 (2023): 2427.

Kimera, Fahad, et al. "Assessing changes in growth, yield, and rhizosphere microbiome of red beetroot (Beta vulgaris subsp. vulgaris var. conditiva) cultivated under a saline integrated vegeculture-aquaculture system." Agricultural Water Management 322 (2025): 109900.

Kretser, Alison, et al. "Scientific integrity principles and best practices: recommendations from a scientific integrity consortium." *Science and Engineering Ethics* 25.2 (2019): 327-355.

McMurtry, M. R., P. V. Nelson, and D. C. Sanders. "Mineral Content and Yield of Bush Bean, Cucumber, and Tomato Cultivated in Sand and Irrigated with Recirculating Aquaculture Water." North Carolina Agricultural Research Service 11019 (1987).

McMurtry, M. R., et al., (1990a). Sand culture of vegetables using recirculated aquacultural effluents. Applied Agricultural Research, 5(4), 280-284.

McMurtry, M. R. (1990b). Performance of an integrated aquaculture-olericulture system as influenced by component ratio. North Carolina State University.

McMurtry, M. R., et al., (1993a). Mineral nutrient concentration and uptake by tomato irrigated with recirculating aquaculture water as influenced by quantity of fish waste products supplied. *Journal of Plant Nutrition,* 16(3), 407-419.

McMurtry, M. R., et al., (1993b). Yield of tomato irrigated with recirculating aquacultural water. *Journal of Production Agriculture*, 6(3), 428-432.

McMurtry, M. R., et al. "Food value, water use efficiency and economic productivity of an integrated aquaculture olericulture system as influenced by component ratio." *HortTechnology*.(accepted for publication) (1994).

McMurtry, M. R., Sanders, D. C., Cure, J. D., & Hodson, R. G. (1997a). Effects of biofilter/culture tank volume ratios on productivity of a recirculating fish/vegetable co-culture system. *Journal of Applied Aquaculture,* 7(4), 33-51.

McMurtry, M. R., et al., (1997b). Efficiency of water use of an integrated fish/vegetable co‑culture system. Journal of the World Aquaculture Society, 28(4), 420-428.

Misu, Hideyuki, et al. "High-quality tomato seedling production system using artificial light." SEI Tech. rev 86 (2018): 119-124.

Nair, C. S., et al. (2024). Sandponics: A Sustainable Agriculture Solution for Food Security and Resource Efficiency in Arid Regions. *Journal of Sustainable Agriculture and Environment*, 3, e70033.

Sewilam, H., et al. (2022). A sandponics comparative study investigating different sand media based integrated aqua vegeculture systems using desalinated water. *Scientific Reports*, 12(1), 11093.

Palm, Harry W., Ulrich Knaus, and Benz Kotzen. "Aquaponics nomenclature matters: It is about principles and technologies and not as much about coupling." *Reviews in Aquaculture* 16.1 (2024): 473-490.

Tyson, Richard V., Danielle D. Treadwell, and Eric H. Simonne. "Opportunities and challenges to sustainability in aquaponic systems." *HortTechnology* 21.1 (2011): 6-13.