A MULTIDISCIPLINARY APPROACH TO BIOFLOC TECHNOLOGY (BFT) FOR VOCATIONAL EDUCATION AND TRAINING APPLIED RESEARCH

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ABSTRACT:

The main objective of this article is to contribute to the establishment and dissemination of Biofloc Technology (BFT) in Vocational Education and Training (VET). This technology is presented as a tool to develop knowledge and practice in different techniques related to several VET fields such as Maritime-Fishing, Chemistry, Health, Security and Environment or Food Industry. For this purpose, a table has been elaborated as a guide to get started in the study of this technology. It contains the general information to characterise the main processes within a BFT system: main factors to be measured, the type of sample, main target techniques and equipment and interesting remarks as well as the field of study in VET. Thus, this article highlights the value of BFT as a technology that can enforce collaborative work among different disciplines and can help to increase environmental awareness. Moreover, by implementing BFT, environmental challenges such as food demand and sustainable production of food with high nutritional value and traceability safety.

KEYWORDS: Biofloc technology, multidisciplinary approach, applied research in VET

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INTRODUCTION

Due to an incessant growing population, the demand for food is rising. Therefore, it is needed to rethink how to obtain and produce food making the least impact on the environment. With increasingly polluted seas and dwindling fish stocks, aquaculture faces the challenge of meeting the claim for animal protein sources using natural resources rationally and minimizing waste while contributing to economic and social sustainability (Nisar et al., 2022). This means promoting an aquaculture approach aligned with the 2030 Agenda for Sustainable Development Goals, including Zero Hunger (SDG 2), Decent Work and Economic Growth (SDG 8), Industry, Innovation, and Infrastructure (SDG 9), Reduced Inequalities (SDG 10), Responsible Consumption and Production (SDG 12), Climate Action (SDG 13), Life Below Water (SDG 14), and Life on Land (SDG 15).

Biofloc Technology (BFT) is presented as one of the solutions to this challenging present. Compared to other aquaculture techniques, as Recirculating Aquaculture Systems (RAS), it is not necessary to remove nitrogen (ammonia, nitrite) rich wastewater due to the addition of carbohydrate sources. The media reaches an optimum C:N ratio for bacterial growth and with an extra input of aeration the formation of suspended flocs is triggered (Figure 1). These flocs, which are rich in heterotrophic bacteria and zooplankton communities, become a high quality food supply. Therefore, in this closed system, no water renewal is needed as a complex trophic network is developed, where waste material is recycled (Avnimelech, 1999); De Schryver et al., 2008; Ju et al., 2008; Ekasari et al., 2010). Furthermore, inoculating some probiotics in the dissolved organic carbon media and adding this bacterial broth to the water environment, water quality and gut microbiota is improved. This way, less disease outbreaks happen and health conditions of grown species are enhanced (Romano, 2017; Vasava et al., 2020) Thus, multiple biochemical processes and dynamics take place in the BFT system and these all affect the survival, health, growth and nutrition values of cultivated species.

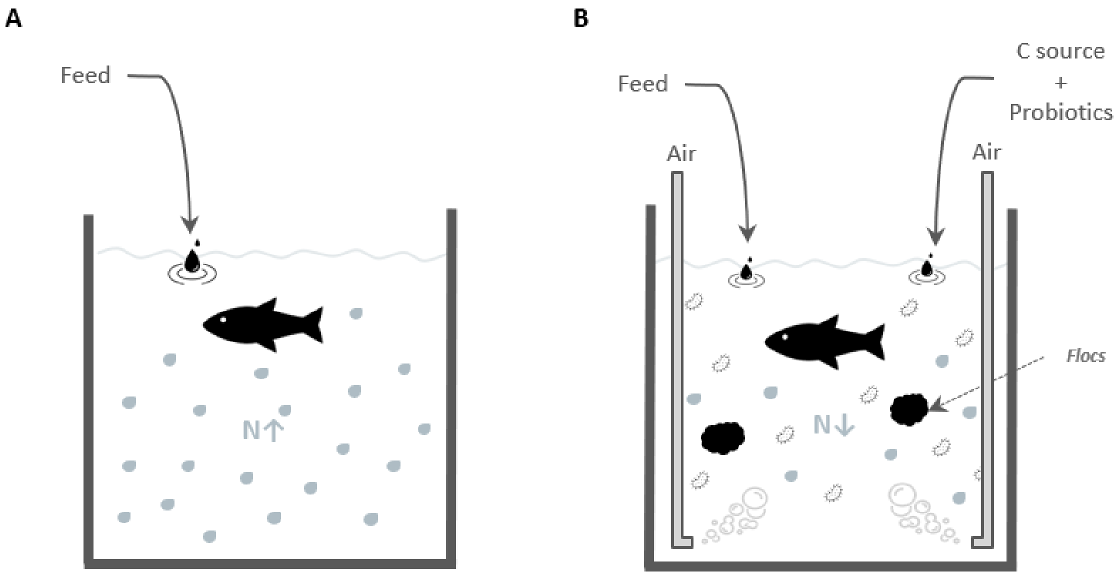

Figure 1. A) After feeding, cultured fish excretes ammonia and inorganic nitrogen counpunds accumulates in the medium. B) In BFT systems, due to aeration, organic carbon addition, and probiotic intake, heterotrophic bacteria and microbiological communities increase by utilizing inorganic nitrogen available in the water, leading to the development of flocs.

Many studies have been carried out to research BFT from different disciplines to ensure its viability as a sustainable food production system and also, as a high nutritional value food producing system for humans. (Jamal et al., 2020; Crab et al., 2012; Nisar et al., 2022)

The main purpose of this article is to provide Vocational Education and Training a multidisciplinary approach to BFT. Acquiring knowledge of the basic monitoring and assessment of BFT is an opportunity for training in techniques from a multidisciplinary approach. Besides, it is a chance to integrate into learning practises eco-friendly technical solutions and awareness of sustainability.

BFT APPLICATION IN VOCATIONAL EDUCATION AND TRAINING

Based on published literature and the experience in food innovation laboratory of Tknika`s Bioscience and Sustainability area, this article attempts to show VET can develop training opportunities and applied research around this technology. BFT factors can be assessed from several Nature Science fields, such as Aquaculture, Chemistry, Biology, Microbiology, Health, Nutrition, Food Industry and Environmental Sciences (Emerenciano et al., 2017; Ibrahim et al., 2021; Samanez et al., 2017; Saha et al., 2022).

The following table (Table 1) provides a guide to how to get started in the study of this technology. In order to ensure the correct functioning of a BFT system and optimise its benefits for human nutrition and health, evaluation of key factors of this system is required. Thus, a series of factors and their analysis techniques are proposed below, as monitoring these factors chemical and biological processes are checked and moreover, and moreover, new knowledge is created from VET schools for the education and science community.

Table 1: Sample type, technique and/or equipment, interesting remarks, field in VET and references for each key factor of BFT system.(Acronyms for fields in VET: CHM Chemistry; FDI Food Industries, HTH Health, MAFS, Maritime-Fishing , SENV Security and Environment.

Key Factor	Sample type	Technique/ Equipment	Interesting remarks	Field in VET	References
pH	water	Conductimetry (by pH-meter)	Optimum pH 6,8-8. Lower values could affect the nitrification process. The optimum pH range for *Nitrosomonas* is from 7.2 to 8.8 and for *Nitrobacter* is from 7.2 to 9.0	CHM, MAFS, SENV	Emerenciano et al. (2017) Jamal et al. (2020) Chen et al. (2006)
Temperature	water	Thermometer	Range depending on grown species. Low temperatures could alter microbial growth	CHM, MAFS, SENV	Emerenciano et al. (2017) Jamal et al. (2020)
Dissolve Oxygen	water	Oximeter sensor	Never less than 4,0mg/l and at least 60% of saturation. Range depending on grown species but For proper respiration and growth species and microbiota	CHM, MAFS, SENV	Emerenciano et al. (2017) Jamal et al. (2020)
Total ammoniacal nitrogen (TAN)	water	Colourimetry, spectrophotometry	Optimum below 1mg/l. Ammonia, produced from fish waste and uneaten food, is highly toxic to fish. Toxicity values depend on pH	CHM, MAFS, SENV	Emerenciano et al. (2017) Jamal et al. (2020)
Nitrite	water	Colorimetry, spectrophotometry	Optimum below 1mg/l. Through the nitrogen cycle, ammonia is first converted to nitrite. Monitoring these compounds ensures proper biological filtration. Optimum below 1mg/l	CHM, MAFS, SENV	Emerenciano et al. (2017) Jamal et al. (2020)
Nitrate	water	Colorimetry, spectrophotometry	Through the nitrogen cycle, nitrite converted to and then to nitrate. Monitoring these compounds ensures proper biological filtration. Optimum below 20 mg/L	CHM, MAFS, SENV	Emerenciano et al. (2017) Jamal et al. (2020)

Total Dissolved/Suspended solids-TDS/TSS	water	Turbidity sensors (for TSS) and water conductivity sensor (for TDS)	Elevated TDS and TSS impair grown animal health, growth, and immune systems; high TSS clogs gills, causing respiratory issues, while high TDS disrupts osmoregulation	CHM, MAFS, SENV	Emerenciano et al. (2017) Jamal et al. (2020);
Biofloc amount	water	Settleable solids test (using Imhoff cones)	Quantification and quality of flocs. Biofloc volume is defined as the volume of sinkable matter in 1 l water placed into an Imhoff cone in 15 min	CHM, MAFS, SENV	Huang, H. (2020)
Microbiological characterization	water, fish, floc, probiotic supplementation	General and selected growing media; PCR (Presence/ absence) or counting CFU; quality validation (fish)	Beneficial communities and inhibition of pathogen outbreaks; Gut microbiota, health, survival in fish; Food security (*Salmonella, Escherichia coli*...)	CHM, FDI, HTH, MAFS, SENV	Alvanou et al. (2023) Bereded et al. (2020) Deng et al. (2022)
Zooplankton characterization	Water, floc	Stereo microscopy, Optical microscopy	Their presence provides a supplementary food option, enhancing the nutritional diversity and diet quality for aquatic species	MAFS, SENV	Samanez et al. (2017) Streble & Krauter (1987)
Total minerals (ash) and mineral composition (N, P, K, Ca)	water, floc, fish	Atomic absorption spectroscopy and ignition (	Micronutrient deficiency affect in growth, health, and survival	CHM, FDI, HTH, MAFS, SENV	Manutsewee et al. (2007)
Nutritional composition (fat and protein	Floc, fish	Gravimetric method, Soxhlet warm method, Kjeldhal method,	Macronutrient deficiency affects in growth, health, and survival	CHM, FDI, HTH, MAFS,	Mohanty et al., (2019)

content, fatty acid profile, dry materia)		Chromatography			
Specific growth rate (SGR)	fish	total size (TL), weight gain (WG)	SGR provides a clear indicator of the growth performance and health	MAFS, SENV	Saha et al. (2022) Ibrahim et al. (2021)
Feed conversion ratio (FCR)	fish	Feed quantity and Specific growth rate (SGR)	FCR indicates how efficiently feed is converted into the body mass, also serve as an indirect indicator of the health and well-being	MAFS, SENV	Saha et al. (2022) Ibrahim et al. (2021)
Fish survival	fish	Direct monitoring	A high survival percentage indicates that the fish are healthy and the aquaculture system is well-managed	MAFS, SENV	Saha et al. (2022) Ibrahim et al. (2021)

Table 1 shows that many fields can overlap and study the same factor, as well as different factors can give similar information about chemical and biological processes. In the table there is a proposal to study the BFT knowing that it can be enriched significantly by adding more factors or techniques, even from other fields. For example, immunology techniques are used for acquiring more knowledge about fish immune response. This table contains elemental information, knowing that it is possible to go much deeper depending on the resources of each VET centre and teachers formation. Figure 2 shows a schematic diagram of proposed analysis for each sample type: water, fish, bio floc and probiotic supplementation

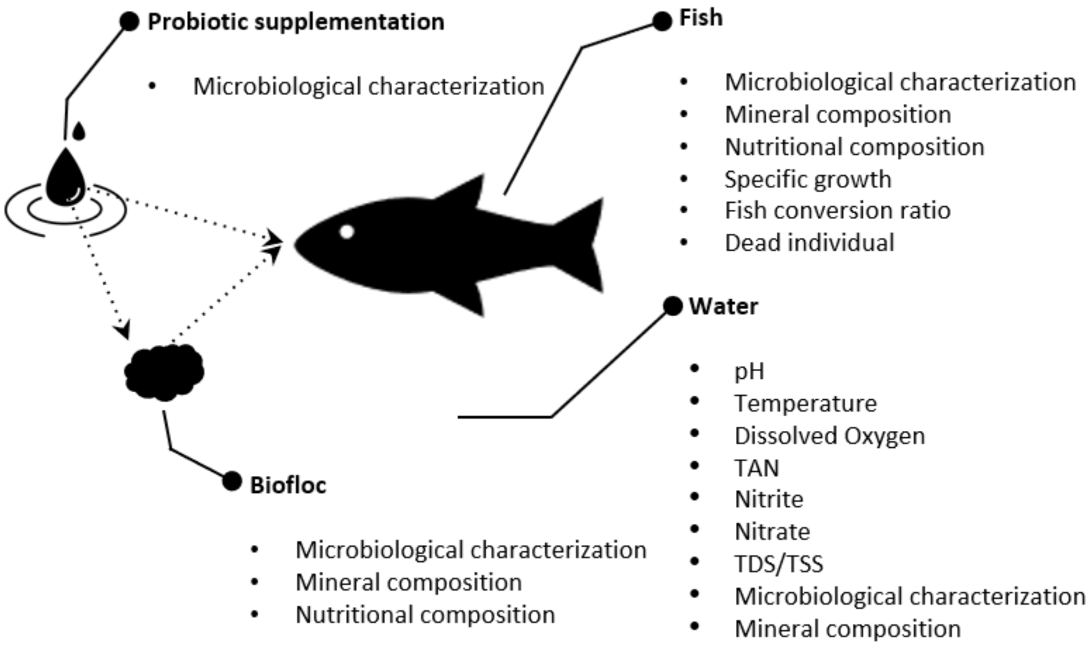

Figure 2. Schematic diagram of proposed analysis for each sample type.

CONCLUSSION

The viability of conducting BFT in Vocational Education and Training centres is considerably high. It is true that basic facilities are necessary to arrange this technology and also, a staff who supports the great potential of this technology. Nevertheless, based on Tknika´s experience, it has been concluded that, after a period of training, it is a feasible technology to implement in VET.

A global assessment from multiple fields increases the knowledge and strengthens the interest in analysing this polyhedral technology. In Basque VET system, several professional families could enrich/stretch their training: Chemistry Food Industries, Health, Maritime-Fishing and Security and Environment. In addition, networking between fields and centres can be improved with this type of multidisciplinary projects and can lead to new synergies.

BFT invites students to develop their science curiosity, building up STEAM skills as problem solving, critical thinking or creativity. Furthermore, as a teamwork activity, collaboration and communication skills can be improved. In this sense, this technology can be applied by Challenge-based collaborative learning, and simultaneously, bringing women closer to STEAM education and narrowing the existing gender gap.

In a society increasingly disconnected from the earth, it is crucial to foster students' awareness of the planet and prepare them not only to successfully enter working life, improve their skills and adapt to changing demands, but also to form better citizens in the principles of environmental, economic and social sustainability. In this regard, it should be inherent in VET to integrate sustainability into any applied research and to engage in twin transition dynamics based on the SDGs. This article aims to contribute to this purpose.

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FIGURES

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DATA AVAILABILITY STATEMENT

No new data were created or analysed in this study. Data sharing is not applicable to this article.

COMPETING INTERESTS STATEMENTS

The authors declare that they have no known competing financial interest or personal relationship that could have appeared to influence the word reported in this article.