INDUSTRY PRIMER

FOOD AND BEVERAGE
CORRECT MANAGEMENT OF WASTEWATER IN THE AGRIBUSINESS SECTOR FOR IDB INVEST

Futuris SUSTAINABILITY ADVISORS

IDB Invest

Title & Reference	**Good Practice Note Wastewater Management for the Agribusiness Sector**	**Draft version V02**
For Client	João Paulo Diniz Abud, IDB Invest Natazha Valarezo, IDB Invest Paula Valencia, IDB Invest	jdinizabud@iadb.org PaulaVa@iadb.org natazhav@iadb.org
Prepared by	Mauricio Morera, Wastewater Expert Mónica Salas, Wastewater Expert	ma.morera@gmail.com msalas@auroraingenieria.com
Reviewed by	Natalia Benavides, Senior Consultant, Futuris Emma Tristán, General Director, Futuris	natalia@futurisconsulting.com emma@futurisconsulting.com
Futuris' Contact	Futuris Consulting S.A Tres Ríos, Cartago, Costa Rica	@ http://www.futurisconsulting.com +506 2279-3501

DISCLAIMER

This report has been prepared by Futuris Consulting SA with all the reasonable proficiency, care, and diligence under the terms of the Contract with the client, incorporating our Stipulations and General Working Conditions, taking into account the resources dedicated to it as agreed with the client. We disclaim any responsibility to the client or third concerning any matters outside the scope of the order as defined in the Contract with the client. This report is confidential to the client and third parties specifically indicated by the written agreement between Futuris Consulting SA and the client.

We do not accept any liability of any nature to any third party notified of this report or parts of it. It is the sole discretion of such third parties to abide and trust or not the report.

Table of Contents

Acronyms

BOD	Biochemical Oxygen Demand
BWMP	Best Wastewater Management Practices
CIP	Clean-In-Place
COD	Chemical Oxygen Demand
DAF	Dissolved Air Flotation
DO	Dissolved Oxygen
EC	Electrocoagulation
EP	Emerging Pollutants
FOG	Fats, Oils, and Greases
F&B	Food and Beverage
GPN	Good Practice Note
IDB	Inter-American Development Bank
ISO	International Organization for Standardization
LAC	Latin America and the Caribbean
MET	Microbial Electrochemical Technology
SBRs	Sequencing Batch Reactors
MPN	Most Probable Number
TSS	Total Suspended Solids
UASB	Up flow Anaerobic Sludge Blanket
UV	Ultraviolet
WBG	World Bank Group
WHO	World Health Organization
WWTP	Wastewater Treatment Plant

1 Introduction

1.1 THIS INDUSTRY PRIMER AND THE GOOD PRACTICE NOTE

This industry primer has been prepared to complement the Good Practice Note (GPN) for Wastewater Management for the Agribusiness Sector[1]. A reference to the GPN has been made in the following sections to reduce duplication whenever the information in the GPN complements what is presented in this industry primer.

It provides a comprehensive overview of the best wastewater management practices (BWMPs) for managing the environmental impacts of food and beverage (F&B), helping companies ensure compliance with relevant regulations and promoting sustainable practices that protect public health and the environment. Section 2 describes the sector's characteristics, and Section 3 the BWMP, including pollution prevention BWMPs (Section 3.1) and wastewater treatment BWMPs (Section 3.2).
Information regarding key performance indicators (KPIs) is linked to the specific regulatory frameworks of each country, and this information is included in Section 2 and Annex I of the GPN. For further exploration of pollution prevention examples and BWMP in wastewater treatment, please refer to Section 4 and Section 5 of the GPN, respectively. More detailed monitoring information can be found in Section 6 of the GPN.

1.2 SOURCES OF INFORMATION

This industry primer on food and beverage wastewater has been developed using various sources of information. Primarily, it is built based on the World Bank Pollution Prevention and Abatement Handbook (1998), which provides the underlying framework for the more specialized industry guidelines known as the Environmental, Health, and Safety Guidelines for Food and Beverage Processing, published by the World Bank Group in 2007. A comprehensive compilation of references is available in Section 4. Moreover, insights from client-based interviews of IDB Invest have been incorporated.

2 Sector Characteristics and ***Wastewater Production***

2.1 GENERAL OVERVIEW OF THE SECTOR

The F&B industry encompasses a range of subsectors involved in the manufacturing, processing, and distributing of food and drink products. The F&B industry comprises various segments such as processing raw fruits and vegetables, preserving and processing meat (including beef, pork, and poultry), preserving fish, crustaceans, and mollusks, producing vegetable and animal oils and fats, creating grain mill products, starches, and manufacturing other food products. It also involves distilling, rectifying, and blending spirits, making non-distilled fermented beverages, producing beer and wines, crafting soft drinks, and bottling mineral and other types of bottled waters[2].

By 2050, a projected 70% increase in F&B production will be required to meet the needs of a global population exceeding 9.7 billion. LAC, known for its significant food export capacity, will be in a favorable position to capitalize on this expanding market. With its abundant resources and potential, LAC holds tremendous opportunities to meet the rising demand for food and emerge as a major player in the rapidly growing global food industry[3].

Similarly, the projections for 2018-2030 suggest that the LAC region will experience above-average growth in various sectors of the F&B industry. Poultry meat is expected to grow by 2.9%, while fishery products and food ingredients are projected to grow by 2.5% and 3.5%, respectively. Furthermore, South America, Central America, and the Caribbean have the potential to increase their current share of 12% in global exports of food and agricultural products, which indicates promising opportunities for these regions to expand their presence further and contribute significantly to the international food trade[3].

2.2 WATER USE WITHIN THE INDUSTRIAL PROCESS

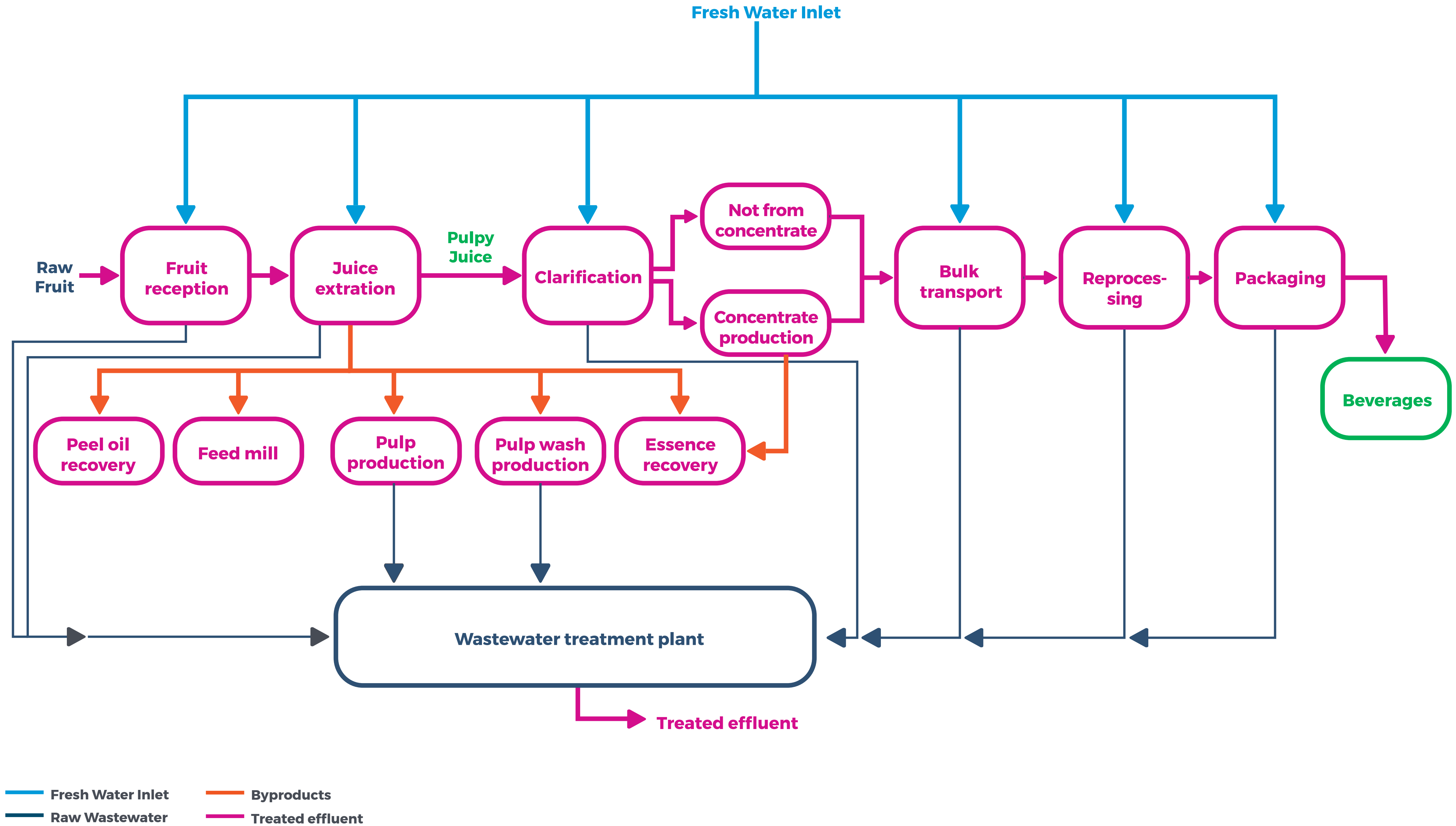
Water plays a crucial role in every stage of the value and supply chain within the F&B industry. Consequently, the industry has a significant water footprint, meaning it consumes and affects a substantial amount of water resources[4].

Water is used in every stage of the F&B production process, from its initial to final production stages. Throughout the production cycle, water is used in different activities such as ingredient preparation, mixing, cooking, cleaning, and packaging. Its presence is indispensable for maintaining hygiene standards, product quality, and overall operational efficiency.

The quantity of water consumed in the F&B industries can vary depending on factors such as the specific type of industry, process parameters, size of the industrial unit, cleaning operations, and the equipment utilized in each process[5].

To illustrate the water consumption patterns in the F&B industry, Figure 1 presents a summary flowchart of a beverage processing facility. This figure offers insights into the various stages of the processing cycle and how water is used through the cycle.

FIGURE 1 Flowchart of beverage processing



2.3 GENERAL REVIEW OF WASTEWATER GENERATION

2.3.1 PRIMARY POLLUTANTS AND THEIR SOURCES

Wastewater from the F&B industries mainly contains a high amount of sugar, flavorings, and coloring additives, which indirectly contribute to the spike of the BOD and COD[6]. Also, cleansing blanching agents, salts, fibers, and soil particles increase wastewater's TSS. Sometimes, they may contain pesticide residues washed from raw materials[7].

Overall, soft drink processing facilities, breweries, wineries, and distilleries wastewaters are generally characterized by high BOD, TSS, phosphorus (P), and nitrogen (N) concentrations. Other specific industries, such as sugar and coffee mills, are characterized by wastewater loaded with organic matter, such as sugar, bagasse, molasses (for the sugar mills), and pulp and mucilage (for the coffee wet mills). Due to the nature of these wastewaters, it is expected to have dark brown and acidic effluents that need to be treated before it is release into the environment.

2.3.2 MAIN ENVIRONMENTAL IMPACTS

Within this sector, the processing of agricultural products involves numerous subsectors and procedures, forming a complex and water-intensive supply chain[8]. As a result, water-related supply chain management is becoming increasingly important to identify suppliers with high water risks [9].

Agriculture, a key F&B industry component, significantly contributes to global water withdrawal, utilizing up to 70% of the world's freshwater resources[10]. Consequently, addressing water management practices in agriculture is crucial to ensure sustainable water usage.

Furthermore, effluent discharged from food production often poses challenges as it may not easily biodegrade or be treated by municipal wastewater facilities, potentially leading to water source contamination. Wastewater from the F&B industry, particularly those with high BOD and COD, can quickly deplete oxygen content in water bodies, endangering aquatic life and disrupting the survival of flora and fauna. If untreated wastewater is released into water bodies, it can create septic conditions, generating foul smells hydrogen sulfide and causing the precipitation of iron and dissolved salts. In the case of the sugar industry, the discharge of untreated effluents containing spent wash into water bodies can block sunlight, thereby reducing photosynthetic activity[11]. As a result, water bodies contaminated with industrial wastewater become unsuitable for aquatic life and human use.

2.4 DESCRIPTION OF INFLUENT WASTEWATER QUALITY

F&B effluent composition presents great fluctuations due to various processes. Numerous factors influence the pollutant concentration and composition of the raw wastewater, namely, the product, the production program, the operating procedures, the design of the processing plant, the level of water management being employed, and, consequently, the amount of water being reused. Ranges of quality parameters reported for raw wastewater in the food and beverage processing industry are summarized in ***Table 1***.

TABLE 1 Ranges of quality parameters for food and beverage processing raw wastewater.

Parameters	Brewery [12]	Fruit and vegetable [7]	Sugar mills with distilleries spent washing water[13]
COD (mg/L)	2,000-6,000	-	110,000 - 190,000
BOD (mg/L)	1,200-3,600	190 – 6,113	50,000-60,000
TSS (mg/L)	2,900-3,000	177 – 4,133	13,000 - 15,000
Total N (mg/L)	25-80	-	5,000 - 7,000
Total P (mg/L)	10-50	3.1 - 8.6	2,500 – 2,700
pH	3.0-12	6.0 - 7.7	3.0-4.0

3 *Best Wastewater* ***Management Practices***

3.1 POLLUTION PREVENTION BWMP

It is essential to increase the application of technologies such as water recirculation and pollution prevention management techniques to achieve sustainability. Staying updated on technological advancements and scientific research is important to attain this goal.
To effectively manage wastewater, the F&B processing industry must implement pollution prevention BWMP to prevent pollutants from entering a treatment plant; further pollution prevention information is described in Section 4 of the GPN. Examples in **Table 2** should encourage pollution prevention at the source in an F&B processing facility.

TABLE 2 Management techniques for wastewater pollution prevention in food and beverage processing

Management Techniques for Pollution Prevention	Description of controls
Reducing water usage in the processing plant	• Conduct yearly water audits to help identify areas of inefficiency and waste. • Ensure proper maintenance to reduce water leakages and cooling water usage for pumps by installing mechanical seals. • Minimize wet transportation inside the process and replace it if feasible mechanical transportation options. • Use clean-in-place (CIP) methods for cleaning of the equipment. • Clean raw fruit and vegetables using dry methods, like vibration or air jets. Minimize wet transport and replace it with mechanical transportation. • Replace older, less efficient equipment with water-efficient models. For example, install high-pressure and low-volume hoses for equipment cleaning and install spray nozzles. • Implement a water monitoring system to identify areas of waste and improvement opportunities.
Reusing water to reduce consumption.	• Install water recirculation units with filters or other treatments to meet water quality for reuse. • Separate and recirculate cooling water from process and wastewater streams. • Increase the lifetime of the caustic cleaners by collecting them in an insulated settling tank and reusing them for washing equipment. • Reuse process water not filtered or treated as a first rinse in wash cycles or for primary cleaning of floors and gutters.
Reduce pollutants loads entering the WWTP [14].	• Provide bins or other receptacles for solid waste disposal and ensure employees understand what materials should be collected and treated as solid waste. • Install equipment such as screens, filters, and traps in the processing plant to prevent solids from entering the wastewater stream. • Separate the mucilage and pulp from the wastewater stream in coffee wet mills and look for alternatives to treat it or use it as a by-product.

Management techniques for pollution prevention for specific industries and processes like sugar mills, can use excess water condensate for melting, magma making, diluting massecuite, and cleaning of evaporator system. Also, the excess condensate may be cooled and used to replace freshwater. It is important to consider installing holding tanks for storing highly polluted water during mill cleaning to avoid shock loading to the treatment systems. In the case of breweries, removing grain from the tun with dry methods, like raking or brushing, helps reduce water consumption, as well as using the rinse water of bottles for crate washing. As for wet coffee mills, it is recommended to install water-efficient de-pulping and mucilage removal equipment where possible. If mucilage removal equipment is installed, separate the mucilage and pulp from the wastewater stream and look for alternatives to treat it or use it as a by-product.

3.2 WASTEWATER TREATMENT BWMP

Given the variability in wastewater quality and quantity within the F&B industry, relying on a single standardized wastewater treatment process is not feasible. Instead, combining different technologies is employed to treat F&B industry wastewater effectively. These technologies can be utilized individually or in conjunction to ensure compliance with the required discharge standards. Different examples of technologies are listed in **Table 3**.

For instance, in industries such as sugar production, where pollution is a major concern, relying solely on a single method for effluent treatment is insufficient to meet the required standards. Common practices in the sugar industry include fertilization, composting, and concentration by evaporation, in addition to conventional physicochemical and biological treatment methods[11].
The treatment of F&B industry wastewater involves multiple stages, which can be categorized into preliminary, primary, and secondary treatment. These stages collectively address the diverse range of pollutants and contaminants in the wastewater, facilitating their removal and purification.

PRIMARY TREATMENT OR PHYSICAL AND CHEMICAL TREATMENTS

Primary treatment aims to physically remove suspended solids and organic matter from the wastewater. This stage typically involves sedimentation, where wastewater is held in basins or tanks, allowing heavier solids to settle at the bottom as sludge. The clarified effluent is then extracted from the top for further treatment. Dissolved Air Flotation (DAF) is another primary treatment process that introduces fine bubbles of air that attach to suspended solids, causing them to float to the surface for removal. DAF systems are widely used because they allow high COD, color, and turbidity removal rates [5]. However, their high energy costs and possible limited disposal of sludge because of its toxicity are factors to consider when analyzing its sustainability. Chemical treatment processes utilize the addition of chemicals to alter the properties of the wastewater and facilitate the removal of contaminants. Common chemical treatment methods include coagulation, flocculation, pH adjustment, and disinfection. Coagulants and flocculants are added to aid in aggregating and settling of fine particles, while pH adjustment is performed to optimize the performance of subsequent treatment steps.

PRELIMINARY TREATMENT

Preliminary treatment is the initial stage of wastewater treatment and focuses on removing large solids and debris. It involves various processes such as screening, where wastewater passes through screens or grates to capture large objects like packaging materials and food scraps. Grit removal is another common method to eliminate gross particles, such as sand and gravel, that could cause damage or clogging in subsequent treatment processes. Grease traps or interceptors are also employed to separate and remove fats, oils, and greases (FOGs) commonly present in F&B industry wastewater.

SECONDARY TREATMENT

Secondary treatment is dedicated to the biological removal of dissolved organic matter and nutrients that remain after primary treatment. The activated sludge process, trickling filters, and sequencing batch reactors (SBRs) are the most commonly used methods for secondary treatment[15]. In the activated sludge process, organic matter is broken down by microorganisms in aeration tanks. Trickling filters utilize biofilms on solid media to degrade pollutants as wastewater trickles through. SBRs involve sequential cycles of aeration, settling, and decanting, all within a single tank for treatment. Another commonly used technology for secondary treatment in the F&B industry is the Upflow Anaerobic Sludge Blanket (UASB) reactor. The UASB reactor is an anaerobic treatment system that utilizes a granular sludge bed to remove organic pollutants and nutrients from wastewater. It operates in an upflow direction, with wastewater entering the bottom of the reactor and flowing upwards through the sludge blanket. UASB reactors are particularly suitable for F&B wastewater with high organic strength, as they provide efficient and cost-effective treatment[2].

SLUDGE MANAGEMENT

In the F&B industry, sludge treatment is crucial role in managing the solid residue generated during wastewater treatment. Sludge contains a mixture of organic and inorganic matter, and its proper treatment is necessary to ensure safe disposal or beneficial reuse. The typical sludge treatment processes in the F&B industry include thickening, stabilization, dewatering, conditioning, and disposal or reuse.

TABLE 3 Common treatment technologies used for treating F&B wastewater.

Industry	Preliminary treatment	Primary treatment	Secondary Treatment	Tertiary Treatment	Sludge treatment	Emerging technologies
Food and beverage	Flow equalization, screens, and mechanical filters.	Sedimentation basin, DAF, and pH regulation (if needed).	Aerobic/Anaerobic biological treatments include aerobic/ SBRs anaerobic lined ponds, aerobic reactors, anaerobic filters, UASB, and biofilters.	Chlorine, UV (if pathogens are present, especially if wastewater is irrigated). Multimedia filter, sand filter, fabric filter, ultrafiltration, microfiltration.	Sludge produced in primary and secondary treatment should be dewatered before disposal using sludge drying beds,centrifuges, or decanters. It is encouraged to dry the sludge further to produce biosolids that can be repurposed.	Electrocoagulation and hybrid systems [16] Micro/ultra/nanofiltration combined with reverse osmosis [17] Chemical oxidation and electro-oxidation [18] Microbial fuel cells [19]

3.3 EXAMPLE OF WASTEWATER TREATMENT BWMP

An example taken from one of IDB-Invest's client, is described as follows: a lemon juice facility located in South America, that processes 230,000 tons of lemons per year between March and August. The wastewater system plant used for treating the wastewater consists of three stages. The first stage is a physicochemical process with static filters and a DAF. This step uses lime to neutralize the effluent. Then, the water stream enters an anaerobic second stage using UASB reactors fired with biogas to heat the same system. The third stage, which is aerobic, consists of activated sludge reactors. The treated effluent is used for irrigation of the production fields. This wastewater treatment plant configuration allows a removal of COD of 98%, a removal of BOD of 99%, and a TSS removal of 99.9%.

FIGURE 2 **Flow diagram of a lemon juice facility in South America.**

Source: Own ellaboration

3.4 KEY PERFORMANCE INDICATORS AND MONITORING

Each country has specific rules for managing and reusing wastewater, with regulations setting allowable water quality thresholds for different situations, such as the discharge into water bodies, coastal zones, and sanitary sewer systems, as well as the reuse of treated wastewater. The GPN in Section 2.2. includes a comparison of the quality parameters established in different countries. Table A- 1 in Annex I provides a comprehensive overview of the legislative framework for wastewater management in the LAC region.

The World Bank Group (WBG) EHS Guidelines for F&B Processing establish the maximum allowable discharge limits in water bodies for the parameters listed below in **Table 4**[20]. These must be achievable under normal operating conditions in appropriately designed and operated facilities and can be used as KPIs of wastewater treatment. New projects must comply with WBG's EHS Guidelines or national regulations (Annex I of the GPN), whichever is more stringent.

TABLE 4 **Permissible limits for discharges into water bodies** [21]

Pollutant	Guideline Value
pH	6-9
BOD_5	50 mg/L
COD	250 mg/L
N_{Total}	10 mg/L
P_{Total}	2 mg/L
Oil and Grease	10 mg/L
TSS	50 mg/L
Temperature increase	< 3 ˚C
Total coliform bacteria	400 MPN/100 mL

It is crucial to monitor the quality of effluents regularly and provide appropriate feedback mechanisms to prevent environmental and social impacts; more information is provided in Section 6 of the GPN for the correct management of wastewater in the agribusiness sector. Developing and implementing a program with sufficient resources and management oversight is essential to achieve a monitoring program's objective(s) for wastewater and water quality. Table 9 of the GPN describes the sampling points and analytical requirements for process water and wastewater samples, and recommends a sampling frequency. Local regulations and other requirements for monitoring wastewater and water quality should always be the top priority and supersede any general guidelines or recommendations. While the suggested sampling frequency may be a good starting point, it is essential to understand and comply with the local regulations and requirements set forth by regulatory agencies.

Regular monitoring of pH, dissolved oxygen concentration, turbidity, temperature, COD, settleable solids, and water flow in the treated effluent is crucial in the wastewater treatment process of the F&B industry. The frequency of monitoring should provide representative data, and recorded information should include the date, time, measurement results, adjustments made, and other relevant data. Using calibrated equipment and having trained operators conduct the measurements with a dedicated laboratory space at the treatment plant is important. Proper record-keeping procedures should be in place to document the monitoring results accurately. Additionally, external certified laboratories following ISO 17025 standards should provide monitoring records for microbial and physicochemical analysis, with a recommended frequency of at least quarterly, considering the regulatory frameworks of each region.

4

References

(1) Futuris Consulting. Good Practice Note: Wastewater Management for the Agribusiness Sector, 2023.

(2) Valta, K.; Kosanovic, T.; Malamis, D.; Moustakas, K.; Loizidou, M. Overview of Water Usage and Wastewater Management in the Food and Beverage Industry. Desalination Water Treat. 2015, 53 (12), 3335–3347. https://doi.org/10.1080/19443994.2014.934100.

(3) Opertti, F.; Levington, C. Innovaciones Que Están Transformando El Sector de Alimentos y Bebidas. 2019. https://blogs.iadb.org/integracion-comercio/es/las-innovaciones-que-estan-transformando-el-sector-alimentos-y-bebidas/.

(4) Weber, O.; Saunders-Hogberg, G. Water Management and Corporate Social Performance in the Food and Beverage Industry. J. Clean. Prod. 2018, 195, 963–977. https://doi.org/10.1016/j.jclepro.2018.05.269.

(5) Shrivastava, V.; Ali, I.; Marjub, M. M.; Rene, E. R.; Soto, A. M. F. Wastewater in the Food Industry: Treatment Technologies and Reuse Potential. Chemosphere 2022, 293, 133553. https://doi.org/10.1016/j.chemosphere.2022.133553.

(6) Muhamad Ng, S. N.; Idrus, S.; Ahsan, A.; Tuan Mohd Marzuki, T. N.; Mahat, S. B. Treatment of Wastewater from a Food and Beverage Industry Using Conventional Wastewater Treatment Integrated with Membrane Bioreactor System: A Pilot-Scale Case Study. Membranes 2021, 11 (6), 456. https://doi.org/10.3390/membranes11060456.

(7) OCETA. A Review of Wastewater Management and Best Practices for Dischargers in the Food Processing Sector, 2005.

(8) Aivazidou, E.; Tsolakis, N.; Iakovou, E.; Vlachos, D. The Emerging Role of Water Footprint in Supply Chain Management: A Critical Literature Synthesis and a Hierarchical Decision-Making Framework. J. Clean. Prod. 2016, 137, 1018–1037. https://doi.org/10.1016/j.jclepro.2016.07.210.

(9) Schaefer, T.; Udenio, M.; Quinn, S.; Fransoo, J. C. Water Risk Assessment in Supply Chains. J. Clean. Prod. 2019, 208, 636–648. https://doi.org/10.1016/j.jclepro.2018.09.262.

(10) World Bank Group. Water in Agriculture. https://www.worldbank.org/en/topic/water-in-agriculture.

(11) Fito, J.; Tefera, N.; Van Hulle, S. W. H. Sugarcane Biorefineries Wastewater: Bioremediation Technologies for Environmental Sustainability. Chem. Biol. Technol. Agric. 2019, 6 (1), 6. https://doi.org/10.1186/s40538-019-0144-5.

(12) Simate, G. S.; Cluett, J.; Iyuke, S. E.; Musapatika, E. T.; Ndlovu, S.; Walubita, L. F.; Alvarez, A. E. The Treatment of Brewery Wastewater for Reuse: State of the Art. Desalination 2011, 273 (2–3), 235–247. https://doi.org/10.1016/j.desal.2011.02.035.

(13) Dhote, L.; Kumar, S.; Singh, L.; Kumar, R. A Systematic Review on Options for Sustainable Treatment and Resource Recovery of Distillery Sludge. Chemosphere 2021, 263, 128225. https://doi.org/10.1016/j.chemosphere.2020.128225.

(14) World Bank. Pollution Prevention and Abatement Handbook, 1998: Toward Cleaner Production; The World Bank, 1999. https://doi.org/10.1596/0-8213-3638-X.

(15) - Microbial Treatment of Heavy Metals, Oil, and Radioactive Contamination in Wastewaters. In Wastewater Treatment; Rao, D. G., Senthilkumar, R., Byrne, J. A., Feroz, S., Eds.; CRC Press, 2012; pp 200–225. https://doi.org/10.1201/b12172-11.

(16) Khani, M. R.; Kuhestani, H.; Kalankesh, L. R.; Kamarehei, B.; Rodríguez-Couto, S.; Baneshi, M. M.; Shahamat, Y. D. Rapid and High Purification of Olive Mill Wastewater (OMV) with the Combination Electrocoagulation-Catalytic Sonoproxone Processes. J. Taiwan Inst. Chem. Eng. 2019, 97, 47–53. https://doi.org/10.1016/j.jtice.2019.02.003.

(17) Ochando-Pulido, J. M.; Martinez-Ferez, A. Novel Micro/Ultra/Nanocentrifugation Membrane Process Assessment for Revalorization and Reclamation of Agricultural Wastewater. J. Environ. Manage. 2018, 222, 447–453. https://doi.org/10.1016/j.jenvman.2018.05.092.

(18) Tiwari, A.; Sahu, O. Treatment of Food-Agro (Sugar) Industry Wastewater with Copper Metal and Salt: Chemical Oxidation and Electro-Oxidation Combined Study in Batch Mode. Water Resour. Ind. 2017, 17, 19–25. https://doi.org/10.1016/j.wri.2016.12.001.

(19) Firdous, S.; Jin, W.; Shahid, N.; Bhatti, Z. A.; Iqbal, A.; Abbasi, U.; Mahmood, Q.; Ali, A. The Performance of Microbial Fuel Cells Treating Vegetable Oil Industrial Wastewater. Environ. Technol. Innov. 2018, 10, 143–151. https://doi.org/10.1016/j.eti.2018.02.006.

(20) World Bank Group. Environmental, Health, and Safety Guidelines for Food and Beverage Processing, 2007.

(21) World Bank Group. Environmental, Health, and Safety Guidelines for Aquaculture, 2007.

IDB | Invest

@idbinvest
www.idbinvest.org