INDUSTRY PRIMER

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

**Good Practice Note**
Wastewater Management for the Agribusiness Sector

**Draft version V02**

For Client

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4. **References**
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
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. 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 beverages, making non-distilled fermented beverages, producing beer and wines, crafting soft drinks, and bottling mineral and other types of bottled waters.

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.

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.

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.

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.

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.
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. Also, cleansing blanching agents, salts, fibers, and soil particles increase wastewater's TSS. Sometimes, they may contain pesticide residues washed from raw materials.

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. As a result, water-related supply chain management is becoming increasingly important to identify suppliers with high water risks.

Agriculture, a key F&B industry component, significantly contributes to global water withdrawal, utilizing up to 70% of the world’s freshwater resources. 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. 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>
<thead>
<tr>
<th>Parameters</th>
<th>Brewery 12</th>
<th>Fruit and vegetable 7</th>
<th>Sugar mills with distilleries spent washing water 13</th>
</tr>
</thead>
<tbody>
<tr>
<td>COD (mg/L)</td>
<td>2,000-6,000</td>
<td>-</td>
<td>110,000 - 190,000</td>
</tr>
<tr>
<td>BOD (mg/L)</td>
<td>1200-3,600</td>
<td>190 - 6,113</td>
<td>50,000 - 60,000</td>
</tr>
<tr>
<td>TSS (mg/L)</td>
<td>2,900-3,000</td>
<td>177 - 4,133</td>
<td>13,000 - 15,000</td>
</tr>
<tr>
<td>Total N (mg/L)</td>
<td>25-80</td>
<td>-</td>
<td>5,000 - 7,000</td>
</tr>
<tr>
<td>Total P (mg/L)</td>
<td>10-50</td>
<td>31 - 86</td>
<td>2,500 - 2,700</td>
</tr>
<tr>
<td>pH</td>
<td>3.0-12</td>
<td>6.0 - 7.7</td>
<td>3.0 - 4.0</td>
</tr>
</tbody>
</table>
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 CPN. Examples in Table 2 should encourage pollution prevention at the source in an F&B processing facility.
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.

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

<table>
<thead>
<tr>
<th>Management Techniques for Pollution Prevention</th>
<th>Description of controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reducing water usage in the processing plant</td>
<td>- Conduct yearly water audits to help identify areas of inefficiency and waste.</td>
</tr>
<tr>
<td>- Conduct yearly water audits to help identify areas of inefficiency and waste.</td>
<td></td>
</tr>
<tr>
<td>- Ensure proper maintenance to reduce water leakages and cooling water usage for pumps by installing mechanical seals.</td>
<td></td>
</tr>
<tr>
<td>- Minimize wet transportation inside the process and replace it if feasible mechanical transportation options.</td>
<td></td>
</tr>
<tr>
<td>- Use clean-in-place (CIP) methods for cleaning of the equipment.</td>
<td></td>
</tr>
<tr>
<td>- Clean raw fruit and vegetables using dry methods like vibration or air jets. Minimize wet transport and replace it with mechanical transportation.</td>
<td></td>
</tr>
<tr>
<td>- 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.</td>
<td></td>
</tr>
<tr>
<td>- Implement a water monitoring system to identify areas of waste and improvement opportunities.</td>
<td></td>
</tr>
<tr>
<td>Reusing water to reduce consumption.</td>
<td>- Install water recirculation units with filters or other treatments to meet water quality for reuse.</td>
</tr>
<tr>
<td>- Separate and recirculate cooling water from process and wastewater streams.</td>
<td></td>
</tr>
<tr>
<td>- Increase the lifetime of the caustic cleaners by collecting them in an insulated settling tank and reusing them for washing equipment.</td>
<td></td>
</tr>
<tr>
<td>- Reuse process water not filtered or treated as a first rinse in wash cycles or for primary cleaning of floors and gutters.</td>
<td></td>
</tr>
<tr>
<td>Reduce pollutants loads entering the WWTP</td>
<td>- Provide bins or other receptacles for solid waste disposal and ensure employees understand what materials should be collected and treated as solid waste.</td>
</tr>
<tr>
<td>- Install equipment such as screens, filters, and traps in the processing plant to prevent solids from entering the wastewater stream.</td>
<td></td>
</tr>
<tr>
<td>- 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.</td>
<td></td>
</tr>
</tbody>
</table>

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.

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.

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.
In the F&B industry, sludge treatment is crucial 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.

3.3 EXAMPLE OF WASTEWATER TREATMENT BWMP

An example taken from one of IDB-Invest’s clients 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 physiochemical 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%.
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. 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>
<thead>
<tr>
<th>Pollutant</th>
<th>Guideline Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>6-9</td>
</tr>
<tr>
<td>BODs</td>
<td>280 mg/L</td>
</tr>
<tr>
<td>COD</td>
<td>10 mg/L</td>
</tr>
<tr>
<td>P_total</td>
<td>2 mg/L</td>
</tr>
<tr>
<td>Oil and Grease</td>
<td>10 mg/L</td>
</tr>
<tr>
<td>TSS</td>
<td>50 mg/L</td>
</tr>
<tr>
<td>Temperature increase</td>
<td>&lt; 3 °C</td>
</tr>
<tr>
<td>Total coliform bacteria</td>
<td>400 MPN/100 mL</td>
</tr>
</tbody>
</table>

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.
References

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


