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Importance of Grit Removal from Commercial Shell Egg Processing Wastewater

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Commercial shell egg processing facilities use 1.5 to 3 gallons (5.7 to 11.4 L) of water per case (1 case = 360 eggs) of packaged table eggs, producing a relatively high-strength wastewater stream (**Figure 1**). Commercial shell egg processors in Georgia annually produce approximately 7 million cases of table eggs (2.5 billion eggs), generating 10.5 to 21 million gallons of wastewater requiring treatment. Results of a 2005 survey of the U.S. commercial table egg industry showed that more than 80 percent of shell egg processing plants treat their own wastewater on-site prior to discharge, typically through land application systems. The vast majority of these facilities are located in rural areas and rely solely or in-part on the proven reliability of waste stabilization ponds (WSP) to treat their wastewater streams.

Figure 1. A portion of the 900,000 eggs entering a Georgia shell egg processing plant from layer hen barns daily. Georgia shell egg processors annually produce more than 7 million cases of table eggs (2.5 billion eggs) and, in the process, generate 10.5 to 21 million gallons of wastewater requiring treatment.

One essential element of an effectively operating commercial shell egg processing wastewater treatment system is the efficient removal of grit. The effects of poor grit removal are often not immediately apparent, but the negative effects can be substantial. These negative effects include a loss of treatment capacity and fouling of and damage to equipment. This publication is designed to give commercial egg processors the information they need to understand and effectively deal with the wastewater grit generated from the conveying, washing and grading of table eggs.

Answers to the four most commonly asked questions concerning grit in egg processing wastewater are provided:

1. **What is grit and where does it come from in an egg processing plant?**
2. **What problems can grit cause in a wastewater treatment system?**
3. **What can be done to minimize the grit entering a wastewater treatment system?**
4. **What options are available for grit capture and removal, and what are the advantages and disadvantages of each option?**

1. What is grit and where does it come from in an egg processing plant?

Grit in wastewater is defined as the heavy, substantially-inorganic particulate solids that have significantly greater specific gravities then the lighter substantially-organic particles in a wastewater stream. When wastewater enters a basin with a low velocity, the heavy grit particles quickly settle to the bottom while the lighter particles remain suspended in the water column. In typical municipal wastewater streams, grit consists of settable solids such as sand, gravel, egg shells and coffee grounds.

In commercial shell egg processing wastewater streams, grit is predominately made up of pieces of broken egg shell and the particles associated with the debris (e.g., feces and dirt) cleaned from the outside of eggs during washing (**Figure 2**).

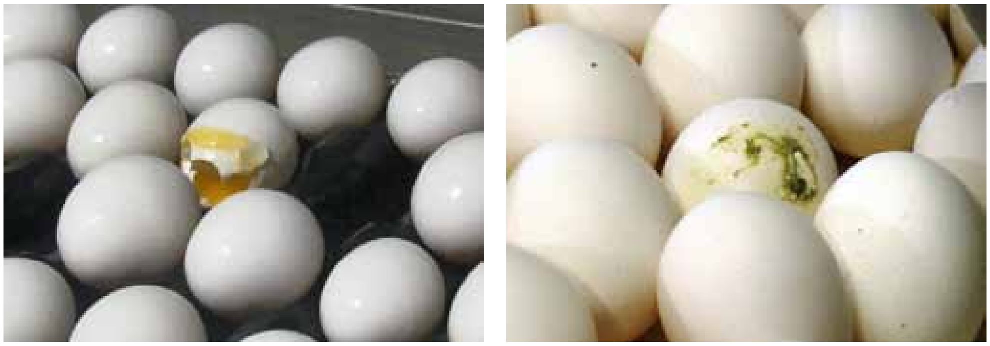

Figure 2. Grit from shell egg plants is predominately made up of external debris (e.g., feces and dirt) and broken egg shell.

The composition of grit can vary widely, even among commercial shell egg processing plants, with moisture content ranging from 15 to 65 percent, and organic content ranging from less than 1 to more than 50 percent. The specific gravity of clean inorganic grit particles can be as high as 2.7 (*Note: the specific gravity of clean water is 1.0*) and as low as 1.3 when a significant amount of organic matter is present. The bulk density of grit is, on average, about 100 lb/ft^3 (1600 kg/m^3).

2. What problems can grit cause in a wastewater treatment system?

Three major negative impacts are associated with poor removal of grit from wastewater treatment systems:

1. At any point in a wastewater collection or treatment system where flow velocity is less than 1.5 ft/sec, grit will begin to fall out of suspension and collect. These low velocity areas can include drains, channels and pipelines. As grit collects in unintended areas, clogs can form, stopping wastewater flow. The trapped organic matter in these areas can then rapidly form pockets of anaerobic (i.e., septic) digestion that produce gaseous by-products that are harmful to both collection and treatment system surfaces as well as human health.
2. Grit is extremely abrasive and will produce abnormal wear on pumps and treatment system surfaces, significantly reducing the operational life of a wastewater treatment system and its components. The life of a pump impeller can be reduced by as much as 30 percent due to the abrasive action of grit.
3. Grit will accumulate within the major treatment basins (e.g., waste stabilization ponds), eventually causing a loss in treatment capacity. In addition, since grit quickly settles out of wastewater and to the bottom of basins, the cumulative effect of the grit is often not known until major problems arise in loss of treatment efficiency (i.e., "out of sight, out of mind").

3. What can be done to minimize the amount of grit entering a wastewater treatment system?

The volume of grit entering wastewater treatment systems varies among shell egg processing plants due to differences in:

A. how much external debris is on the eggs entering the processing plant,
B. the number of broken eggs that occur during processing and how they are handled,
C. the number and configuration of egg washers and final rinse stations,
D. cleaning and sanitation procedures,
E. where and how grit is collected in the wastewater system, and
F. at what interval grit is removed from the wastewater system.

A. Amount of external debris on eggs

Dirty eggs equal grit. There is a direct relationship between the amount of external debris on the surface of the eggs entering a processing facility and the amount of grit in a processing plant's wastewater stream (**Figure 3**).

What You Can Do

Minimize external debris on eggs entering processing. Investigate causes of high levels of external debris and institute management practices to minimize external debris on eggs entering the processing facility. (For example, the longer hens have access to laid eggs, the dirtier they can become. Thus, layer cage bottoms should be checked to ensure a proper slope is maintained to efficiently move fresh-laid eggs to the conveyor system.) Cleaner eggs entering the processing plants will significantly reduce not only the grit entering the wastewater treatment system but also the overall wastewater load.

Figure 3. Minimizing the external debris on eggs within the layer house will minimize the amount of grit entering the shell egg processing facility, thus reducing the grit load on the wastewater treatment system.

B. Number of broken eggs that occur during processing and handling of broken eggs

Typically, 1 to 2 percent of shell eggs are broken during the conveying, washing and grading process. This means that a commercial egg processing facility that handles 1 million eggs per day will produce 10,000 to 20,000 broken eggs. The percentage of broken eggs varies by flock, season and type of processing equipment utilized. The longer broken eggs remain on the processing line, the more opportunity broken pieces of egg shell and liquid egg contents have to enter the wastewater stream (**Figures 4 and 5**).

Figure 4. Minimizing egg breakage begins in the layer house. Here, flexible plastic strips are used to ensure a smooth transmission of eggs onto the processing plant transfer belt. Without the aid of the plastic strips, eggs would roll unchecked onto the belt, increasing breakage.

Figure 5. Any place where eggs transition from one location to another creates a potential point for increased breakage. These points should be observed on a periodic basis to ensure that undue breakage is not occurring. If breakage is observed, preventative measures should be implemented.

What You Can Do

Minimize the occurrence of broken eggs and the amount of time broken eggs remain on the processing line. Investigate and document the number of broken eggs entering the processing facility. Also investigate and identify the key areas where broken eggs occur during processing (e.g., conveyor system, belt transfer points and egg washers). Once key areas where broken eggs occur are identified, make operational adjustments and institute management practices to minimize breakage. When breakages do occur, ensure that broken eggs are removed from the processing line as quickly as possible to minimize impact on wastewater.

Figure 6. Taking the time to observe egg washers during operation can help processors identify needed adjustments if excessive breakage is occurring during the washing process.

C. Number and configuration of egg washers and final rinse stations

Commercial washing of shell eggs is typically conducted in single (~30 percent of plants) or dual mechanical washers arranged in a series (~70 percent of plants) followed by a final egg rinse. Mechanical washers typically use a series of nozzles that spray eggs with an alkaline detergent, while brushes move in a side-to-side motion across the egg surface to remove external debris. Eggs are moved through the units by sets of rollers that turn the eggs, ensuring all surfaces come in contact with the nozzle spray and brushes (**Figure 6**).

What You Can Do

Minimize egg breakage in washers. Investigate and document the number of eggs broken during the washing/rinsing process. Make adjustments to washers (e.g., water pressure and brush height) to minimize breakage. Regardless of adjustments, external debris removed from the eggs in the washers will impact grit entering the wastewater stream; however, minimizing breakage will keep egg shell grit from entering the wastewater stream.

D. Cleaning and sanitation procedures

Extensive cleaning and sanitation of egg processing buildings and equipment are conducted on a daily basis; however, specific cleaning and sanitation procedures vary greatly from plant to plant. The first line of defense in minimizing the amount grit entering the wastewater stream is to develop clear procedures for cleaning and sanitation, and, more importantly, monitor how well the established procedures are followed.

What You Can Do

Develop procedures that emphasize dry cleaning methods, that is to say, cleaning procedures that focus on broom-and-shovel recovery of processing by-products, and not on hosing by-products down the drain. Ensure that equipment and floor drains are fitted with cover screens to maximize grit capture within the plant, and that drain screens are not removed during plant cleaning.

4. What options are available for grit capture and removal, and what are the advantages and disadvantages of each option?

It is important to note that removing grit from a wastewater stream involves two processes: **grit capture** (i.e., trapping grit on some sort of surface or in some sort of container) and **grit removal** (i.e., the physical step of moving the captured grit out of the wastewater stream).

There are two options for **grit capture** from shell egg processing wastewater treatment systems: **screens** and **grit chambers**. Likewise, there are two options for **grit removal** from shell egg wastewater treatment systems: **manual** and **mechanical**. It is important to note that these categories are not mutually exclusive and that effective grit removal systems can include a combination of screens and grit chambers with manual and mechanical operations.

Screens

Screens are perforated surfaces that are placed in a wastewater stream and are designed to retain particulate matter greater in size than the surface gap openings. Screens used for particle recovery such as grit are classified as ***Fine***, with gaps 0.059 to 0.25 inches (1.5 to 6.0 mm), ***Very Fine***, with gaps 0.008 to 0.059 inches (0.2 to 1.5 mm), and ***Microscreens***, with gaps < 0.008 inches (0.2 mm). The advantages and disadvantages of screens for grit recovery in shell egg processing wastewater are listed in **Table 1**. Based on these advantages and disadvantages, simple manually-operated static screens (**Figures 7 and 8**) are usually preferred in commercial shell egg processing.

Figure 7. A manual static screen is used just below an egg washer to capture grit particles early in the shell egg cleaning, grading and packaging process. This early intervention step will significantly reduce the amount of grit entering the wastewater treatment system.

Figure 8. A manually operated basket screen is used to capture grit prior to the wastewater treatment system at a shell egg processing plant. If cleaned on a consistent, periodic basis, static basket screens can be efficient grit recovery devices.

Table 1. Advantages and disadvantages of physical **SCREENS** for grit capture and removal in shell egg processing wastewater.

Screens	
Advantages:	**Disadvantages:**
• **Low Relative Cost.** Screens are typically the simplest and least expensive form of physical wastewater treatment. • **High Flexibility.** Screens are available in many styles, sizes and materials. Screens can be utilized as stand-alone units or in a series, which allows coarser screens to remove larger particles before further screening by finer mesh units. Screens are available in both static (i.e., manual-cleaning) and mechanical (i.e., self-cleaning) grit recovery formats depending on the desired level of operation and maintenance intensity. • **Ease of Upgrade.** Screens can usually be added relatively inexpensively to existing wastewater treatment systems to increase grit removal efficiencies.	• **Lower Efficiency** compared to grit chambers. Grit is determined by particle density as well as size, thus fine grit particles can pass through screen surfaces and still cause negative impacts in wastewater treatment systems. In addition, screens are non-selective, trapping lighter, large organic particles along with grit. • **Labor Intensive.** Screens are only effective when screen surfaces are free of debris to allow the passage of wastewater. Thus, consistent operational checks and maintenance of both static and mechanical screens are required for efficient operation. More labor-intensive static screens are usually preferred due to the low relative wastewater flow volume from egg processing and aggressive nature of grit on mechanical systems. • **Sizing Difficulties.** Screens must be sized properly to handle both the hydraulic flow and particle size of the wastewater stream to prevent 'blinding,' which is defined as the overload of a screen that results in the coating over of the gaps preventing the passage of wastewater. A balance must be found in minimizing the potential for screen blinding while maximizing grit capture.

Grit Chambers

Grit chambers are enlarged in-line channels or tanks at the head of a wastewater treatment system that allow the velocity of wastewater flow to be reduced below 1.5 ft/sec (0.45 m/sec). The desired design velocity is typically in the range of 0.7 to 1.4 ft/sec (0.2 to 0.4 m/sec). At this reduced velocity, grit is allowed to settle to the bottom of the channel or tank, while the lighter particulates stay suspended in the wastewater stream. Retention times in grit chambers typically range from 45 to 90 seconds. The required length of a grit chamber is determined using the following equation:

$$\text{Length, ft} = \frac{(\text{Depth of Channel, ft})\ (\text{Flow Velocity, ft/sec})}{\text{Settling Rate, ft/sec}}$$

where: Flow Velocity = 1.0 ft/sec*
Settling Rate = 0.075 ft/sec*†
** typical design value used*
† represents a 2 mm piece of sand

The advantages and disadvantages of chambers for grit recovery in shell egg processing wastewater are listed in **Table 2**. In most cases, grit chambers are part of the initial design in wastewater treatment plants; however, many egg processing facilities use standard septic tanks as grit chambers successfully. The use of septic tanks has the advantage of being installed as part of an initial wastewater treatment system design or added later to an existing wastewater treatment system relatively easily (**Figure 9**).

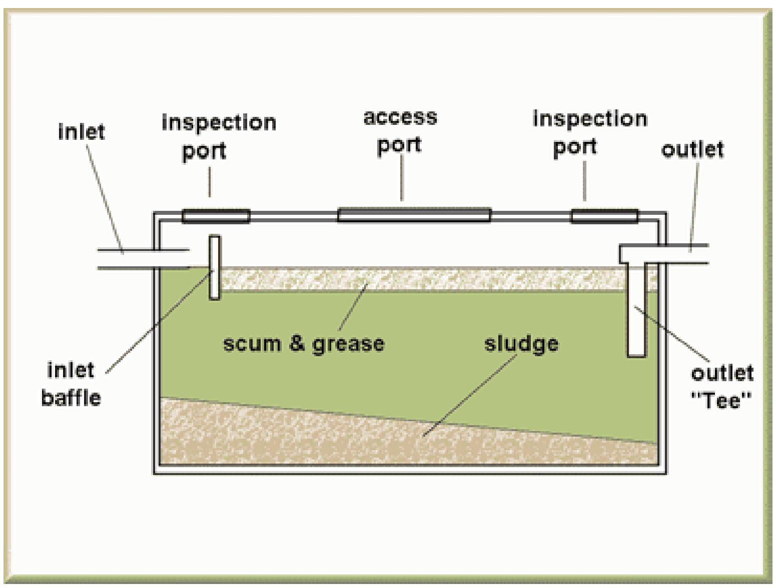

Figure 9. The use of septic tanks as grit collection chambers have become a popular choice within shell egg processing wastewater treatment systems. Septic tanks have the advantage of being easily installed within existing systems, but must be cleaned on a regular basis. (Source: http://septictankinfo.com/septic_tank_basics.shtml)

Table 2. Advantages and disadvantages of **GRIT CHAMBERS** for grit capture and removal in shell egg processing wastewater.

Grit Chambers	
Advantages:	**Disadvantages:**
• **Increased Efficiency** compared to screens. Properly sized grit chambers will remove all but the finest grit particulates. Grit chambers also minimize the impact of lighter organic particles that can be trapped by screens. • **Low Labor Requirement.** Once in operation, grit chambers require little daily operational procedures or maintenance. Grit chambers are available in both static (manual-cleaning) and mechanical (self-cleaning) grit recovery types. • **Availability of Advanced Separation Systems.** Grit chambers can be designed to include aeration (i.e., introduction of air in wastewater that effectively reduces the specific gravity of the air/wastewater mixture over normal wastewater), which enhances grit settling. Cyclone grit separators are available that use primary and secondary vortexes to accelerate the removal of grit from wastewater in a small footprint.	• **Higher Operational Costs** compared to screens. Although grit chambers and screens have comparable initial capital costs, the need for periodic grit removal from chambers often involves hiring a vacuum pump truck, which produces higher average operational costs. • **"Out of Sight, Out of Mind."** Unlike screens, where problems tend to be readily apparent, grit chambers can continue to operate even if grit isn't being removed efficiently. Since grit settles to the bottom of chambers (as well as other areas of wastewater treatment systems) it is easy to delay needed grit removal and cause long-term problems. • **Removal Difficulties.** Since grit settles to the bottom of chambers, it has to be removed periodically. Mechanical removal systems are available, but due to the severe abrasive nature of grit, these systems are prone to frequent breakdowns. Most facilities with grit chambers opt to hire outside contractors to periodically pump grit from chambers for a fee.

Summary

To effectively deal with the wastewater grit generated from the conveying, washing and grading of table eggs, commercial egg processors can take action in these five areas:

1. Minimize external debris on eggs entering the processing plant.
2. Minimize the occurrence of broken eggs and the amount of time broken eggs remain on the processing line.
3. Minimize egg breakage in washers.
4. Develop sanitation procedures that emphasize dry cleaning methods.
5. Implement an efficient grit capture and removal system that best fits the desired level of operation and maintenance intensity.

For more information or for assistance with wastewater grit at your egg processing facility, contact your local University of Georgia Cooperative Extension agent or contact the authors at bkiepper@uga.edu and critz@uga.edu.

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