Water Pollution Potential from Craft Distilleries – Grain Mash Alcohol Production

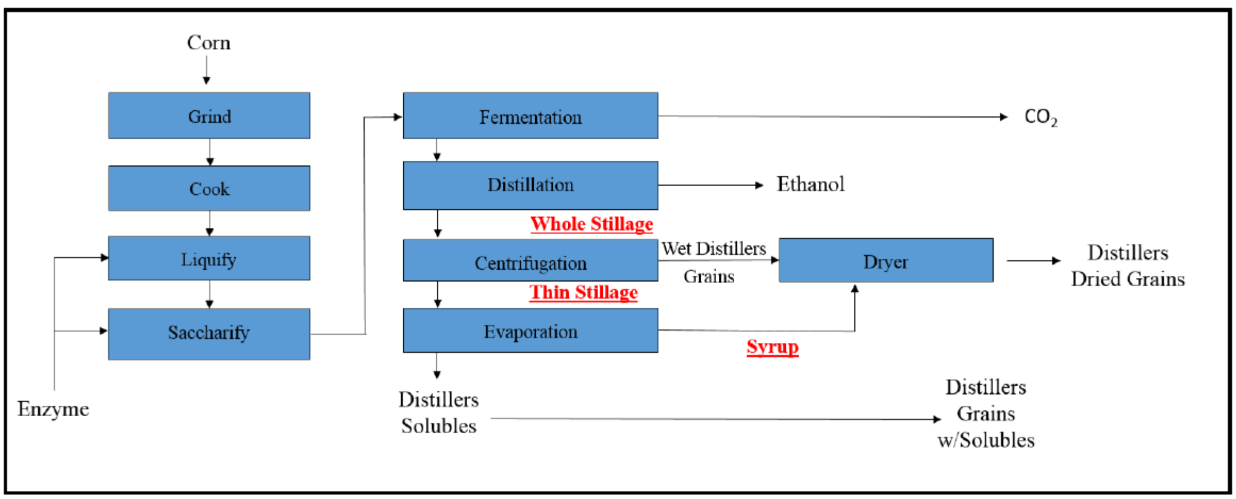
SUMMARY

The water pollution potential of effluent output from a craft distillery (generally a distillery that produces less than 150,000 proof gallons of spirit per year) will depend on several variables including the size of the operation, the type of raw materials used, the production process and the treatment of spent material before fluids are discarded.

Most municipal water treatment systems would easily handle the average effluent from a typical craft distillery. However, it is good for the craft distillery to document its pollution potential and share it with local officials. This would help clear up any misconceptions of impacts exceeding reality, or otherwise assist both parties in mitigating future material impacts to the operation of the distillery or the local waterworks.

This paper will focus on the stillage effluent as this is the primary discarded liquid output from distillery operations; the others being de minimis with respect to pollution concerns (for example, water used for cooling and cleaning). This paper will also focus on grain mash distilling, as this type of distillery product tends to have the highest pollution potential.

GENERAL GRAIN MASH DISTILLING PROCESS RELATED TO STILLAGE EFFLUENT OUTPUT



- **Whole stillage** – as the name implies – is the exact contents of the still concluding distillation.
- **Thin stillage** – is the liquid remaining after the majority of the solids are separated from the stillage.

The primary difference between whole and thin stillage will be the quantity of total suspended solids. These solids are “spent grain” as the grinding, cooking, mashing, fermenting and distilling process expends their qualities and neutralizes their cellular composition. What remains in a thick stillage is 11% - 15% solids comprised of all of the other non- starch components of the corn kernel that pass through the process (germ, protein, gluten, hull & fiber etc.). The quantity of suspended solids in distillery effluent can be the primary consideration for some municipal waterworks. So these quantities should be disclosed and discussed in advance of operations or in advance of changes to operations that would materially increase the amount of total suspended solids.

TABLE OF POLLUTION POTENTIAL FOR STARCH-BASED STILLAGE

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Table 3. Chemical composition of liquid phase in starch stillage [g/L] (except pH [-], density [°Blg], COD and BOD_5 [g O_2/l]).

Parameter	Type of stillage																		
	Maize (Dahab and Young, 1981)	Maize (Cibis, 2004)	Wheat (Weiland and Thomsen, 1990)	Wheat (Nagano et al. 1992)	Wheat (Hutnan et al. 2003)	Wheat (Hutnan et al. 2003)	Barley (Kitamura et al. 1996)	Barley (10%) and sweet potato (90%) (Shin et al. 1992)	Rye (Cibis, 2004)	Grain (Laubscher et al. 2001)	Awamori (rice) (Tang et al. 2007)	Jowar (shorgum) (Khardenavis et al. 2007)	Rice (Khardenavis et al. 2007)	Starch waste feedstocks (Cibis, 2004)	Potato (Cibis et al. 2002)	Potato (Cibis et al. 2002)	Potato (Cibis et al. 2006)	Potato (Weiland and Thomsen, 1990)	Sweet potato (Nagano et al. 1992)
pH	-	3.70	3.8-4.0	4.6	3.35	3.7	3.7-4.1	5.1	3.94	4.0-4.5	3.65	3.6	2.9	3.88	3.69	3.62	3.88	3.9-4.9	4.5
Density	-	2.9		-	-	-	-	-	3.1	-	-	-	-	12.2	4.6	4.7	7.9	-	-
Suspended solids	-	-	40-65	18.4-23.0	38.6	70.34	-	15.3	-	1.0**	-	-	-	-	-	-	-	20-50	16.6
COD (BOD_5)	59.4 (43.1)	21.85	40-55	17.5-20.8 (12.5-13.6)	90.75	107.0	97 (83)	17.6	28.98	20-30	56 (50)	10.8	35	122.33	48.95	51.75	103.76	20-55	12.1 (8.5)
TOC	-	9.15	-	-	-	-	-	-	10.70	-	28.33	-	-	45.60	-	-	35.15	-	-
Reducing substances	-	4.05	-	-	-	-	-	-	11.81	-	-	0.1	2	37.06	10.47	10.6	37.44	-	-
Glycerol	-	3.95	-	-	-	-	-	-	3.22	-	-	-	-	3.81	3.04	3.25	5.96	-	-
Lactic acid	-	6.63	-	-	-	-	-	-	3.51	-	1.4	-	-	61.14	-	-	17.53	-	-
Propionic acid	-	0.21	-	0.8-1.24	-	-	-	-	0.12	-	0.623	-	-	2.77	-	-	2.64	-	0.80
Succinic acid	-	0.21	-	-	-	-	-	-	0.31	-	1.059	-	-	0.23	-	-	0.430	-	-
Acetic acid	-	0.44	-	2.1-6.6	-	-	-	-	0.27	-	0.132	-	-	4.14	-	-	2.10	-	1.90
Sum of organic acids	-	9.67	-	-	-	-	-	-	5.29	-	10.795***	0.65***	1.46***	75.11	-	-	24.46	-	-
Total nitrogen	0.546	0.67	-	1.5-1.6	4.09*	8.8*	6.0	-	0.83	0.17-0.18*	2.18*	0.126	0.140	2.57	0.52	0.81	1.05	-	1.20
Ammonia nitrogen	-	0.096	-	0.5-0.6	-	-	-	0.01	0.19	-	0.052	-	-	0.361	0.235	0.07	0.308	-	0.18
Total phosphorus	0.228	0.441	-	0.17-0.18	0.40	0.218	-	-	0.47	0.27-0.30	-	-	-	0.816	0.259	0.327	0.277	-	0.140
Phosphate phosphorus	-	0.363	-	-	-	-	-	0.039	0.28	-	0.004	0.0642	0.0416	0.588	0.167	0.260	0.165	-	-

Note: * TKN = Total Kjeldahl Nitrogen. ** TSS = Total Suspended Solids. ***VFA = Volatile Fatty Acids.

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This table covers most of the most common starch-based raw material and references the scientific paper associated with each material dataset. It reports on quantities of grams per liter of stillage.

For this paper we will focus on the second column "Maize (Cibis 2004)". In this data, the study author used a thin mash example as there are zero suspended solids listed. The assumption here is that the distillery would employ a grain-water separator following distillation. The de-watered grains would become animal feed and the separated liquid would become the "thin mash" effluent.

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Other than the quantity of suspended solids, the primary parameters to consider are:

1. PH – The acidity or basicity of the effluent
2. COD – Chemical Oxygen Demand = the oxygen demand of biodegradable pollutants plus the oxygen demand of non-biodegradable oxidizable pollutants
3. TOC – Total Organic Carbon = the measure of organic carbon pollutants.
4. N – Nitrogen
5. P – Phosphorus

Using the data as per this preceding chart column for a corn (maize) –based thin mash, the following table demonstrates the general pollution potential of a variety of still sizes per run of the still.

LITERS	COD (g)	TOC (g)	N (g)	P (g)	pH
200	4,370	1,830	134	88	3.7
400	8,740	3,660	268	176	3.7
800	17,480	7,320	536	353	3.7
1200	26,220	10,980	804	529	3.7
1600	34,960	14,640	1,072	706	3.7
2000	43,700	18,300	1,340	882	3.7
2500	54,625	22,875	1,675	1,103	3.7
3000	65,550	27,450	2,010	1,323	3.7
4000	87,400	36,600	2,680	1,764	3.7

As mentioned before, the quantity of suspended solids in a thick mash is in the 11% to 15% range. The actually percentage would depend on a number of factors including the size of the grist from milling, and the efficiency of mashing fermenting and distillation. Splitting the difference with an average of 13% suspended solids in a 28 gallon thick mash (about 2 lbs. of grain per gallon of water) would result in:

LITERS	GALLONS	WATER (L)	GRAIN (lbs)	TSS (lbs)
200	53	160	85	11
400	106	320	169	22
800	211	640	338	44
1200	317	960	507	66
1600	423	1,280	676	88
2000	528	1,600	845	110
2500	660	2,000	1,057	137
3000	793	2,400	1,268	165
4000	1057	3,200	1,691	220