Quality of Washed and Compacted Screenings

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ABSTRACT

A quality ratio for screenings washing is defined as the mass of BOD or COD that can still be leached from the washed screenings per the dry solids mass in the screening. There is a German standard leaching method, but it is rather difficult and time consuming. An easier method was developed and is proposed. Results are presented comparing the performance of conventional screenings wash-presses with that of superior launder-type wash-presses.

KEYWORDS: Screenings, Fine Screening, Screenings Washing, Quality Factor for Screenings Washing, Wash-Press, Super-Launder Wash-Press,

INTRODUCTION

The finer the screens, the more screenings and organics are removed from wastewater. Typical raw screenings volumes at German plants range from 8 liters per person and year for a 25 mm bar screen to 20 liters for a 3 mm perforated plate screen. Typical solids content of raw screenings ranges from 10 to 15 % DS.

Fecal matter in the screenings is odorous, attracts pathogen vectors and contains much water. Fecal matter should be washed out of the screenings. Well washed screenings can be better compacted and their transportation and disposal costs are lower.

Fine screens remove some BOD but hardly any nitrogen from the inflow. The finer the screens, the more they reduce the BOD/N ratio, which can impair the denitrification capacity during secondary treatment. BOD return from screenings washing reduces this effect.

CONVENTIONAL WASH-PRESS

Screenings wash-presses have been used for many years (see Fig. 1). They include a horizontal screw in a perforated trough. Raw screenings are dropped on the screw and spray water is added. The screw is turned several times back and forth to agitate the screenings. The spray water washes some, but not all, fecal matter from the screenings and drains through the trough’s perforations. After some washing, the screw moves the screening forward and pushes them into pressure pipe wherein a plug of screenings has formed. The screw presses additional screenings towards the plug and the plug is thus gradually moved through the pipe. A first section of the pipe is provided with small perforations permitting water to drain out of the screenings while they are pressurized, compacted and dewatered. The pressure pipe is provided with an upward bend. Counter pressure is generated by the weight of the screenings plug and friction between the screenings plug and the pressure pipe, as the screenings plug is gradually pressed through the pipe. This counter pressure depends on the length of the pipe and the angle of its bend. To prevent too high pressure, the diameter of the pipe gradually increases behind the bend. With little additional pressure the screenings plug is pushed through the pipe and drops from its end into a container.

Fig. 1: **[Conventional wash-press (Huber Technology)]**

SUPER-LAUNDER WASH-PRESS

The finer the screens, the more fecal matter they take out of the wastewater. For this reason, super-launder wash-presses were developed during the late 1990s and are increasingly often selected (see figures 2 to 7).

The difference to conventional wash-presses is that they include a launder tank on top of the screw. An impeller mixer is installed at the tank's wall. A batch of raw screenings and wash water is filled into the tank. Sometimes the screenings are flushed with water through a sluice channel into the tank, whereby the channel replaces a screw or belt conveyors for transportation of the raw screenings from several screens to the wash-press.
When the launder tank is filled with screenings and wash water, the impeller is operated to generate high turbulence in the tank for intensive washing. This can be compared with a laundry machine, only that the turbulence is far higher (clothes would be worn). After the washing cycle a valve at the bottom is opened to drain the wash water through the bottom trough. It contains much dissolved and suspended organics, predominantly fecal matter.

The pressure zone is essentially unchanged. However, resulting from excellent washing, screenings compaction is improved, the resulting dry solids concentration increased and screenings mass and volume and thus transport and disposal costs are further reduced.

Fig. 2: **Super-launder wash-presses fed through a sluice channel (Huber Technology)**

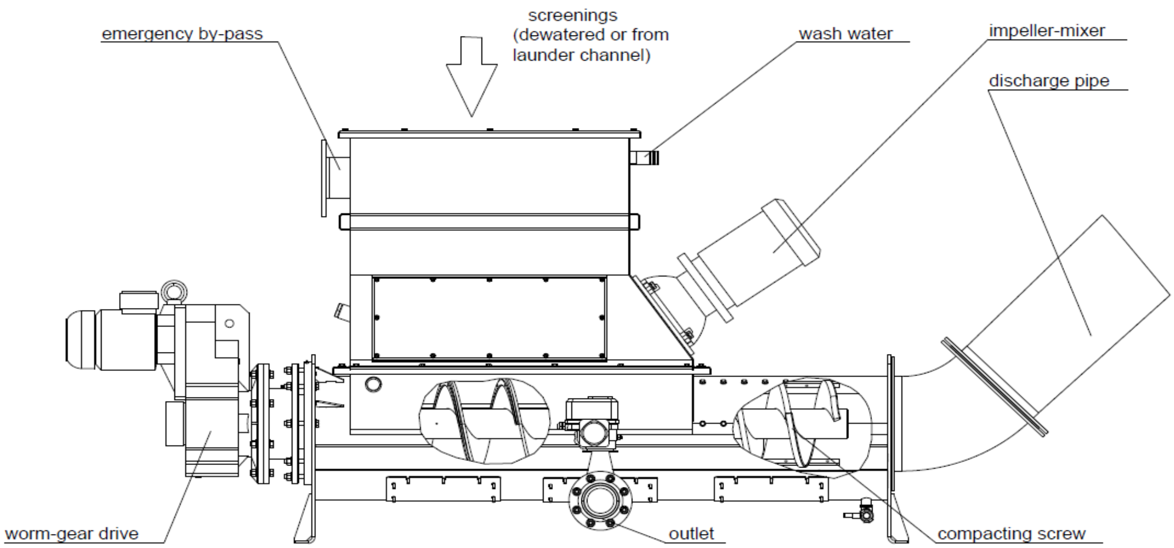

Fig. 3: Principal drawing of a super-launder wash-press (Huber Technology)

Fig. 4: Raw screenings in a sluice channel

Fig. 5: High turbulence in the launder tank

Fig. 6: Highly polluted wash water

Fig. 7: Washed and compacted screenings

QUALITY RATIO OF SCREENINGS WASHING

The quality of screenings washing can be determined as the ratio of the BOD or COD mass per dried solids mass in the screenings. This quality ratio is representative for the ratio of fecal matter contained in the screenings.

It is not possible to analyse COD or BOD directly in the screenings. BOD and COD carrying organic matter must be leached out of the screenings and is measured in the leachate. There is a German Industry Standard DIN 38 414 S4 “German standard methods for the examination of water, wastewater and sludge; sludge and sediments (group S); determination of leachability by water”.

DIN 38 414 S4 prescribes the following leaching method:

1. Determine the solids content of a portion of the sample; this can be done simultaneously with the following procedure;
2. Weigh another portion of the sample containing around 100 g DS,
3. Put the sample containing about 100 g DS into a 2 L beaker and add 1 L water,
4. Shake or tumble the beaker for 24 hours, e.g. in a tumbling apparatus (see Figure 8 left) with 10 revolutions per minute,
5. Remove leachate after sedimentation or centrifugation,
6. Filter the leachate through a 0.45 micron filter (see Figure 8 right),
7. Analyze the concentration of the substance in the filtrate,
8. Calculate the product of this concentration and the added water volume (1 L) and divide the result by the product of sample weight and solids content.

Figure 8: Tumbling apparatus (left) and leachate filtration (right)

The leaching method according to DIN 38 414 S4 is difficult and time consuming. The ratio of added water volume to sample mass to is too small for wet screenings; the standard was developed for sludge. In addition the leaching requires equipment, e.g. a tumbling apparatus, which is usually not available at wastewater treatment plants. The prescribed filter is too fine and filtration too time consuming.

For this reason we have developed the following simpler and faster method:

1. Determine the solids content from about 200 g of the sample; this can be done simultaneously with the following procedure;
2. Tear about 200 g of another portion of the sample into pieces with a maximum size of 30 mm,
3. Put about 55 to 65 g DS of this portion into a bucket which can be tightly sealed with a lid; the bucket should have a volume of 5 to 6 Liters,
4. Add 1.5 Liters of water, close the lid and let the sample soak for about 5 minutes,
5. Manually tumble the bucket rapidly 120 times whereby every tumbling should take less than 1 second (see Figure 9 illustrating a tumbling act).
6. Let the solids settle and draw 50 mL of the supernatant with a pipette,
7. Filter the leachate (supernatant) through a 8 to 12 micron paper filter,
8. Analyze the COD concentration in the filtrate, e.g by means of a cuvette test,
9. Calculate the product of this concentration and the added water volume (1.5 L) and divide the result by the product of the sample's weight and solids content.
10. The result is the leachable COD per mass of screenings solids; this is called the COD quality ratio.

Figure 9: Manual tumbling method; the movement must be so quick that the liquid surface remains almost parallel to the buckets bottom (vertical) in its highest position

With 20 comparative measurements we have determined a difference below ±10 % between the results obtained with the DIN method and our simplified test. Considering that the accuracy of the results is mainly limited by the ability to take a representative sample from screenings material, this ± 10 % difference resulting from the leaching method is small enough.

COD analysis is far easier and quicker than BOD_5 analysis. On the other hand it is more important for a wastewater plant operator to know how much BOD_5 remains in the screenings or is returned into the wastewater. For this reason we have determined COD and BOD_5 in the leachate of 20 samples from 5 treatment plants. We found a COD/BOD_5 ratio ranging between 2.7 to 3.1 with an average of 2.89. This ratio permits estimation of BOD_5 from COD and seems to be a common ratio in fecal matter.

QUALITY OF WASHED SCREENINGS

Performance tests with a launder-type wash-press were conducted by a British water company. The raw screenings from a 6 mm Step Screen contained about 320 mg BOD_5 per g of dried solids; after high-intensity washing and compaction their BOD_5 content was consistently reduced to well below 20 mg per g DS. The average BOD_5 removal ratio was over 95 %. The solids concentration of the compacted screenings was around 45 % DS.

Another performance test was conducted at a German wastewater treatment plant with a 6 mm bar screen. The launder-type wash-press was additionally provided with a hydraulically operated nozzle in its discharge pipe in order to further increase the compacting pressure. The average solids concentration of the compacted screenings could be increased from 46.5 % DS (without operation of the hydraulic nozzle) to 54.6 %DS (with its operation). This is an additional mass reduction by 15 %.

In addition to those tests we have performed many more at various treatment plants in Germany. We wanted to compare the washing quality of super-launder wash-presses with that of conventional wash-presses. Table 1 shows the results.

DISCUSSION

The quality ratio of raw screenings is difficult to determine. Some experience is needed to take representative samples. Their quality ratio varies within a wide range. It is dependent on screen type, sewer length, sewage pumping and industrial inflow. The finer the screen, the more fecal matter it removes; the further sewage flows and the more it is pumped, the more fecal matter is disintegrated; industrial effluents usually contain little fecal matter.

All investigated plants have fine screens. The results show that conventional wash presses reduced the average COD quality ratio of fine screenings from 646 to 228 mgCOD/gDS, which is a 65 % reduction. Super-launder wash-presses reduced it to an average of 35 mgCOD/gDS, which is a 95 % reduction.

Conventional wash-presses compacted the screenings to an average of 36 %DS while super-launder wash-presses achieved 45 %DS; this is by 9 % higher. Super-launder wash-presses achieved an additional 20 % reduction of screenings mass as well as transport and disposal costs.

Higher investment for a super-launder wash-press is quickly returned by cost savings, at least where screenings disposal is expensive.

Table 1: Comparison of screenings quality

	Plant	Screen	DS [%]	mg CSB/g DS
Raw screenings	B	Rotamat 8 mm	15.6	220
	A	Step Screen 6 mm	13.6	716
	D	Step Screen 6 mm	12.1	673
	I	Step Screen 3 mm	14.4	975
Average			**13.9**	**646**
Product of conventional wash-presses	T	Step Screen 3 mm	35.0	273
	S	Step Screen 3 mm	35.8	249
	R	Bar Screen 6 mm	36.4	197
	I	Step Screen 3 mm	37.3	310
	L	Rotamat 6 mm	39.8	178
	H	Step Screen 6 mm	34.5	205
	M	Bar Screen 8 mm	35.3	185
Average			**36.3**	**228**
Product from super-launder wash-presses	B	Rotamat 8 mm	44.2	37
	Q	Step Screen 6 mm	43.7	34
	P	Rotamat 6 mm	43.1	32
	O	Step Screen 3 mm	39.7	41
	D	Step Screen 6 mm	43.9	40
	N	Bar Screen 6 mm	48.7	28
	A	Step Screen 6 mm	45.0	30
	C	Step Screen 5 mm	47.9	23
	E	Step Screen 6 mm	50.2	46
Average			**45.2**	**35**

If we assume an average raw screenings volume of 15 L/(C·a) with 14 % DS, the removed dry solids mass is 2.1 kg/(C·a). With an average COD quality ratio of 646 mgCOD/gDS about 1.36 kgCOD/(C·a) or 3.7 gCOD/(C·d) are removed with the screenings. With a COD/BOD_5 ratio of 2.89 we calculate that about 1.3 gBOD_5/(C·d) are removed. The typical German BOD_5 freight is 60 gBOD_5/(C·d) and 2.1 % of this freight is removed with the screenings.

If 95 % of the removed BOD_5 is returned from a super-launder wash-press, the returned freight is 1.2 gBOD_5/(C·d) or about 2.0 % of the incoming freight. This is a small return, but it can make a difference for enhanced biological phosphorus removal and denitrification. It should be noted that this calculation is based on average results from Table 1. In individual cases the returned BOD_5 freight can be far higher, particularly where screens with fine perforations are installed. Such screens tend to remove more screenings and particularly more fecal matter.

CONCLUSION

Excellent screenings washing produces well compacted screenings and minimizes odor and vector attraction. Excellent screenings washing saves transportation and disposal costs. Where the screenings are incinerated, much water evaporation and thus energy is saved. Good screenings washing returns about 2 % of the BOD_5 freight into the wastewater and thus increases the BOD_5 /N ratio by a small amount, which can make a difference for denitrification where this ratio is low. However, savings of screenings transport and disposal cost alone justify the extra investment for best performing screenings wash-presses.

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