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Fermenting Coffee in Plastic Tanks.
Upflow washing of coffee.
Water Conservation.
Technology Transfer from East Africa to Central America.
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Many small Farmers Groups that are being set up by TanCRI, PASS and Technoserve in East Africa, are being provided with plastic water tanks in lieu of cement fermenting tanks. Besides being portable they can be traded back and forth for a size appropriate to their needs. Usually 500-2,000 litres. The 2000litre size costs 85,000/-. (US$85-00). These tanks would be much more effectively used however, if they were modified to the pattern detailed below. Then they could be used to ferment, wash and soak parchment in one continuous operation, and on a 24 hour cycle, that could allow one tank to fulfil all the required functions of a small factory.

The additional requirement to achieve this however, is a small 50mm trash pump. These pumps made by Honda, Suzuki, Robin, Yamaha and all the Asian motor manufacturers, cost around US$350, and are a mass produced self priming centrifugal pump, with a vortex type open impellor, which can pump large solid particles without damage. They are lighter, smaller and much more versatile than the massive 'kivu' pumps traditionally made for working coffee. Furthermore, the coffee does not impact on a flat impellor blade or get pressure rolled through any gaps, so they are far superior to any Kivi pump. In this kind of configuration they should never need to be opened more than half throttle. So, lightly loaded, carefully looked after, and lubricated and stored away each off season, these machines do have a long life. It is important though to flush them out at the end of each day, to avoid the fermented fruit acids corroding the aluminium. A small farmers group nevertheless, could make the system work by bucketing water from the bottom trough back up to the pulper hopper. It would also work with a small hand operated diaphragm (diafram) bilge pump from a marine store. Bilge pumps, like trash pumps, can handle small solid objects like stones and coffee beans.

Making the 'Universal Process Tank:'

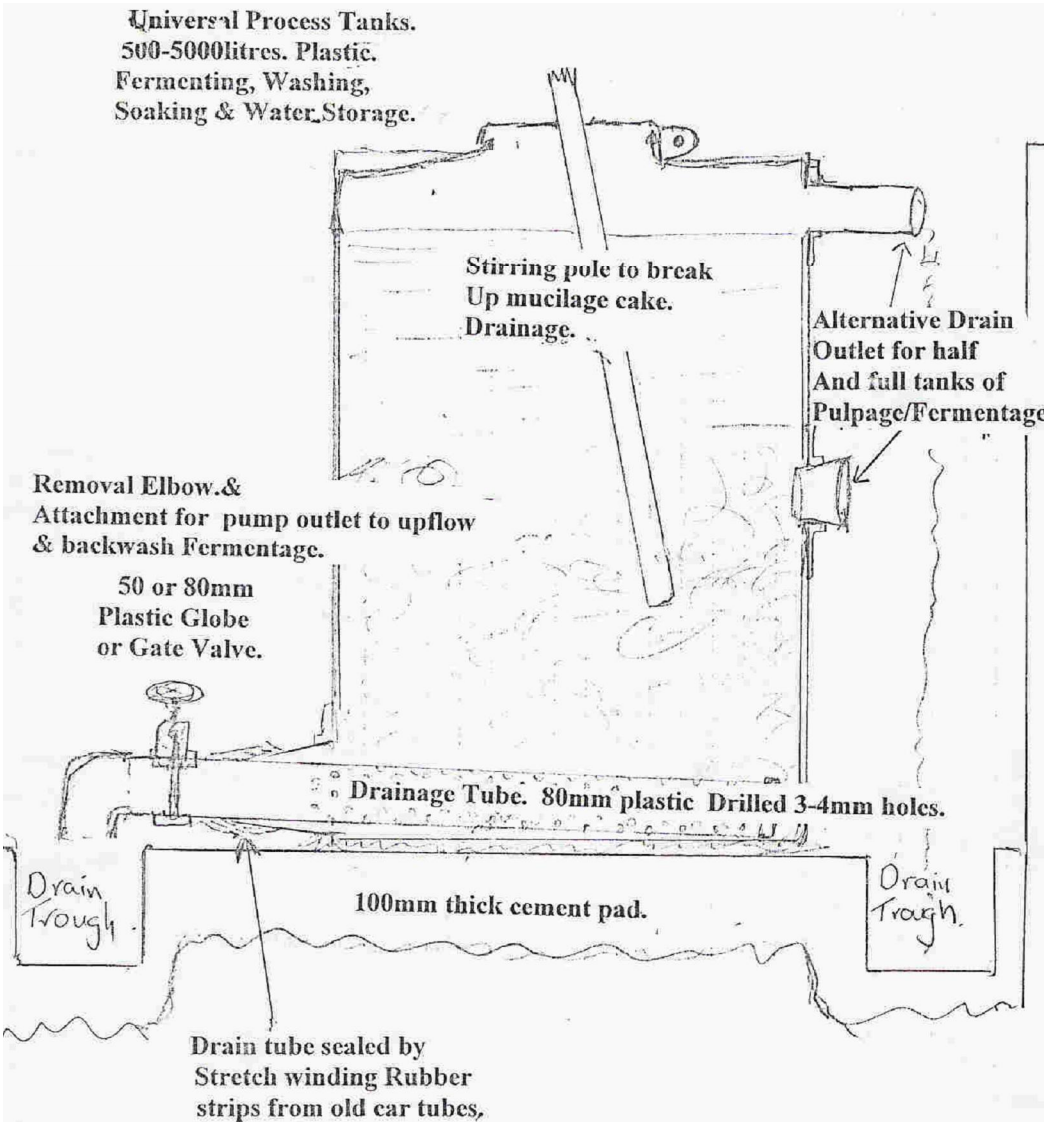
Modify the tank by cutting a 100mm hole in the side, below one of one of the four flattened portions of the stiffening ribs of the lid, and as close to the base as possible, and fix a 100mm PVC flange in place by rivets or stainless bolts, sealing the joint with Silicone rubber sealant. The bottom edge of the flange should be cut off to make the hole appear right at the bottom of the inside of the tank. In fact to completely empty the tank it is quite easy to tilt it a bit, because, to get the last dregs out the tank, it has to be empty and relatively light in weight.

A 150mm length of 100mm PVC pipe should be glued into the flange. But first, one end of the pipe should have a vee knotch cut in it 100mm deep, and about 20mm wide, and the edges squeezed together to make a taper with a slightly larger than 80mm hole. Place the pipe in a bucket of hot water and tape it together while it is soft. Any one of a series of 80mm drain tubes, filters or plugs can now be inserted into the tapered tube, depending on the task at hand. The joint is easily sealed by strapping it up with a two metre length of 50mm wide band of rubber sheet, made by cutting up an old motor tyre tube in a spiral. The rubber strapping should be stretched tight and wrap right over the full length of the vee knotch as well as the insertion piece.

Fermenting tank Fittings:

The drainage tube should be a length of 80mm. diameter SVW plastic PVC tubing long enough to go in through the flange and right across the bottom of the tank. It should be plugged at the far end, and drilled with as many 3-4mm holes as possible and each about 10mm apart. The open end should not be drilled, and should stick out about 200mm from the flange, so that it can be firmly strapped and sealed in place with the tyre tubing strip. The exposed end of the drainage tube should be fitted with an 80 or 50mm plastic globe valve. Gate valves are O.K. but not so good, because they can trap and crush beans in the sealing slot, but it is not too difficult to clean the seating knotch regularly and extract any crushed beans.

As well as the bottom vent on the front, the tanks should have two similar flanges fitted at the back. One in the flattened portion of the reinforcing ribs in the lid, and one half way up the same side for lesser amounts of pulpage, when picking is down. Both of these vents, one plugged and the other with spout, should be placed 180o opposite to the side where the bottom vent is. The drainage tube discharges into the trough in front of the tank floor which feeds the pump, and the two discharge vents into the trough across the back of the floor which discharges to waste.



Upflow Washing:

Displaced mucilage floats on water, and so the key concept to save on water usage is to push any washing water in at the bottom and float the washings and the floaters off the top, rather than trying to flush them out the bottom. This is called 'Upflow washing', and it only needs a fraction of the water required by traditional washing methods. Furthermore, the secret to fast, consistent and complete fermentation is to recycle as much as possible of the water used for pulping, only adding as much make up water as is required to balance that lost with the pulp etc. If clean water is used in pulping on the old once through basis, then the pulpage at the top of the tank takes a lot longer to ferment than that at the bottom. And, the bottom pulpage is leached of its sugars and enzymes by all the fresh clean water passing through it and out the drainage plates to waste. That, along with the excessive use of fresh water through the Aagaard pregrader, if one is used, can not only lead to take over of fermentation by yeasts and cause 'onion flavour', it will also extend the fermentation process by many hours, if not days.

If however, all of these waters are recycled back to the pulper again, then its content of sugars, actively fermenting bacteria digesting all those sugars, and the mucilage solubilising enzymes that they secrete, will be building up in concentration, and the final pulpage going into the top of the tank will be bathed in the same water as all the pulpage at the bottom, leading to consistent fermentation right through the whole tank, and in a fraction of the times previously required. For reasons that will be described in a moment, the tank should only be ¾'s full of coffee, and at least 250mm of free water space should remain below the top outlet when the tank is declared to be full!.

Four to Five hours at most:

If several tanks are required to hold the days pulping, then it is good practise to half fill each tank in the morning with water that has been warmed by pumping it over the roof. Then start pulping into the first tank, taking the water for the pulper from the bottom of that same tank. By the time the tank is ¾ filled with pulpage, all that water will have been used and some more makeup water as well. If it is necessary to make up ones own enzymes to counteract low temperatures etc. QV. "The Microbiology of Coffee Processing" then the floaters can be drawn off the water surface through the half level plug at the back of the tank. When the tank is filled to the required level with pulpage, then the bottom tap should be closed off and it should be left for 30 minutes before opening the bottom tap and draining all the mucilage to waste. This will ensure that the last pulpage into the tank has also gotten a good soak in the enzyme rich dark coloured water, whilst pulping continues into the next tank which is started with the fresh batch of water waiting in that tank. This procedure should ensure that each tank has been bathed in the same concentrations of recirculating bacteria with their sugary food and secreted enzymes as the first tank was, making every tank the same. The rapid darkening of the water, caused by condensation of the soluble red anthocyanin colours of the ripe cherries into dark coloured pigments, is nothing to worry about. If however, the pulping water starts to get excessively thick and soupy, that is an indication that the pectin based mucilage is breaking down very rapidly into oligo-saccharides, and the enzymes are in over supply! Then, some of the pulping water should be discarded and more fresh make up water added. In the case of the water taking the pulp out the rear of the pulper, that too should be caught in a channel behind the pulper/s which takes everything to one side and into a large pulp (and parchment) drainage trough usually set in the floor, with an inclined plane at the back to rake the drained pulp out and allow the water to flow back, and drain plates in the bottom at the far end, which allow the water to drain away, back down into the right side cross drain, which will take it straight back to the pump. The pulp out of the back of the pit can be usually raked further onto old parchment drying trays, and put to one side for disposal when pulping has finished for the day.

Washed or Semiwashed:

If the factory pulper has a demucilator attached, or an aqua pulper is used, there is a choice as to whether the wet parchment should be simply dried straight out of the pulper, or whether it should still be fermented, washed and soaked in the traditional East African fashion? The easiest way to answer that question is to put it to the traditional buyers of the National product. In Papua New Guinea, the answer we received from a major European Coffee Merchant was adamant. " When we want to buy semiwashed Colombian style coffee, we will buy it from Columbia, not from PNG." So, sorry Mr Penagos, we cannot all do it like you say!

There are several advantages to mechanical demucilators. The entire treatment process can be achieved in less than 24 hours, and so the factory can be that much smaller, and the fermentage will not solidify the beans in the tank. Experience in Vietnam has shown that a couple of hours of fermentation , and more especially the washing and soaking period

soaking period, gives machine demucilated coffee a much brighter coloured parchment, especially when it is dried, and most importantly, a much cleaner colour of centre cut. The appearance of that centre cut is a major assessment factor when the coffee is liquored and graded for purchase by overseas buyers.

When things go solid!

Recycling of the processing water however, if traditional pulping methods are used, will also speed up the fermentation to the point where the whole tank of fermenting coffee will go solid. If the recycle water has been highly aerated, then there is nothing to worry about for 4-5 hours, ie, after fermentation is completed. Any longer however, and the distinctive smell of acetate gives the warning that yeasts are taking over the fermentation, and unless the coffee is washed within another hour or so, fruity flavoured coffee may result. Nevertheless, small amounts of fruity essences can be clawed back by the soaking process, and no damage results. It is when the oily essences get into the oil in the beans that problems really start.

To move a tank of solid fermentage, the perforated drainage tube is removed from the bottom of the tank, the drainage channel is half filled with clean water, to supply the pump, which is then started up with the outlet hose poking back up into the bottom of the tank. Pushing the water first into the bottom of the tank with a narrow jet on the hose, will break up the solid tank of fermentage. Once the fermentage starts to move, and the front trough starts to fill with coffee as well as water, the pump outlet hose and nozzle can be redirected up into the top of the tank, and very soon everything will be circulating out of the open and now free flowing bottom port, into the front drainage channel, round through the pump and back up into the top of the tank. The tank will then soon be over brimming full of expanded, aerated and very liquid mucilage! Hence the warning not to overfill the tank during pulping. Do note that without this pumping exercise to free the mucilage, 'upflow' washing will not work at all.

When the coffee is clean and crunchy in the midst of all the aerated mucilage, the drainage tube can be slid back into the tank and bound in with strips of stretched motor tube rubber, the pump outlet connected on to the valve on the end of the bottom drainage tube, fresh water is fed to the pump, and the upflow washing commences.

With some stirring of the pole, the liquid mucilage will float off the beans and be allowed to drain to waste out the back drain trough and onto the wastes drainage channel. A further flush and recycle through the pump again with clean water, and the coffee can then be left to soak for several hours under that same, or a further batch of clean water. Within reason, the longer the coffee is left to soak at this stage the better. That is, 4- 6hours or more should be possible, and still achieve complete processing within the 24 hour period. Soaking for more than 6 hours is counter productive and will make the coffee start loosing weight.

When washing and soaking has been completed , the drainage tube is again removed and the clean washed parchment and water is allowed to spill out into the drainage channel and thence into the pump, from where it can be moved anywhere in a stream of 50% coffee & 50% water. The preferred mode is to pump up to the pulp drainage trough, so that the last batch of rinse water can be recovered and left in the tank to begin the next pulping later that day. QV later comments about recycling, feedback, and the possibility of taints etc. The drained and washed parchment is raked out the slope on the back of the trough, and into drying trays, which can be conveniently placed on the concrete pad that also holds the pulp. It may seem like an imposition to have to move the pulp each day and clean up before washing commences, but this makes for a clean hygienic factory and good quality coffee! In the same line of thinking, the plug in the end of the drainage tube should be

removable, and the inside of the tube be cleaned out every week along with the 50mm flexy hoses, by fixing a ball of rag in the middle of a length of wire, and pulling it backwards and forwards through all the places where bacterial mucilage may regrow and leave a firm slimy coating on all the surfaces that are touched. That firm mucilage growth is the capsular protection for a lot of bacteria that we don't want, so keep it down to a minimum.

Keeping those bacteria warm!

If at all possible, the pulping water should be as warm as the cherry going into the pulper. That can be up to 25oC. even on a cool day. Put your hand down into a bag of picked cherry a few hours old and feel the heat! That is the right kind of bacteria eating your mucilage. Nothing however puts bacteria off their eating quicker than a rapid temperature change due to a dose of cold water. The easiest way to warm the water is to draw off what is required earlier in the day, usually quite slowly from a small tap connected to the village supply. It can be drawn off at night if an extra tank is available for storage. That tank can be placed on the pad, alongside the other fermenting tanks, and perform double duty as an overload fermenting tank at the peak of the season. When the sun is up, the water should be pumped up over the roof of the factory, painted black of course, and down through gutters into the fermenting tank/s that will be used later in the day. As briefly mentioned above, if water is in short supply, that same warmed water may be used to final rinse the previous days coffee Any rain water catchment simply adds to the supply. A new factory should be designed so that the fermenting tanks should if possible be placed on the sunny side of the factory. Then, when pulping commences into the tank of warm water, the pulpage sinks down through the water and separates off the floaters and other debris. The pump can be connected to the outlet from the drainage plates, the tap on the end of the drainage tubes opened just to give a steady flow with the pump sucking a lot of air, and the water is pumped up into a small header tank up above the cherry hopper on top of the pulper. Do not worry about the buildup of floaters and debris on the top of the water, until it reaches the level of either of the discharge vents when it can be floated out to the back channel and, if it is not required fir making enzymes, then it is sent to waste. The pump will draw water out of the fermenting tank quicker than there is pulpage entering to fill it and, by the time that the tank is half full of pulpage, much of the water will have been lost, and more should be added by running a small hose into the trough feeding the suction inlet of the pump. If tanks are in short supply, then this small inflow of makeup water will be cold, straight out of the supply line, but by this stage it will be rapidly mixed in with a larger volume of warmed water and rapid temperature changes will be minimised.

The outflow from the bottom of the tanks via the drainage tube and channels should be controlled down so that the pump is sucking a lot of air as well as water, and is discharging a lather of bubbles instead of just water up to the pulper. This will keep the water well aerated, speed up the rate of fermentation, and discourage anaerobic bacteria and wild/rogue yeasts from multiplying too quickly.

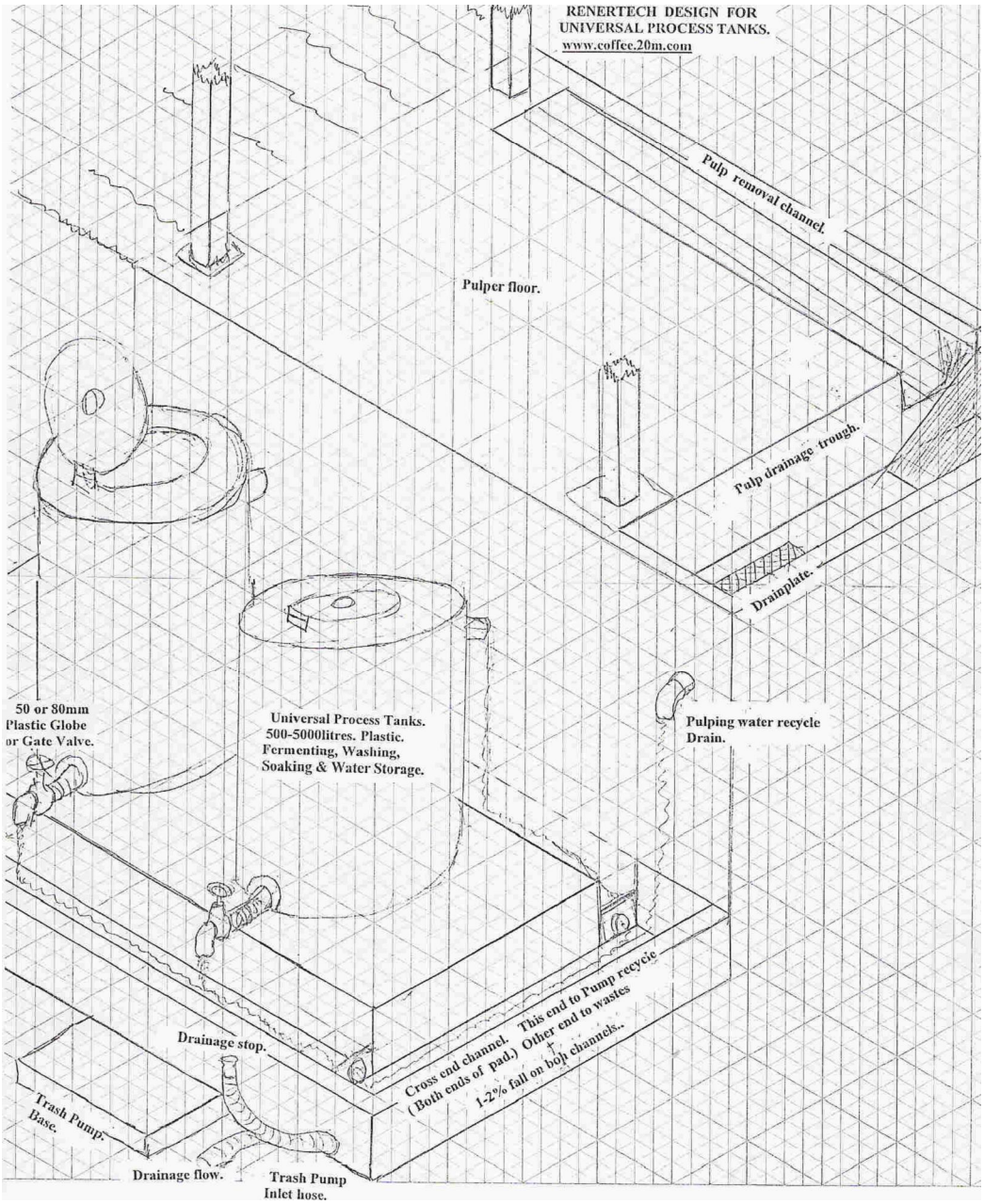
Getting clean coffee!

What solubilizes the mucilage and lifts it off from the coffee parchment is not water but enzymes! Bacterial saliva! What takes the mucilage out of the hidden areas of the centre cut is not soaking but enzymes! So, the more pectolytic enzymes in that initial pulping water, the quicker the whole process will complete itself and the cleaner and whiter the parchment will be when it is dried, even if the pulping water is as black as black! Only a couple of quick rinses and a very short soak is required to remove any colour that may be left by the main wash waters.

How Much is Too Much?

Someone always asks the question, can we save the water used to soak the parchment in the morning, and use it to pulp the fresh coffee in the afternoon? The quick answer is yes, but with care! This is what is called a feedback situation. Each day's coffee is now in contact with that of the day before, and any untoward small infection may then have the chance build up over several days. However, an experienced operator will soon learn to recognise different smells or colours or anything that is out of the ordinary, before it gets any where near being much of a problem. Then it is only a case of a thorough clean of equipment, including the inside of all pipes and hoses, and not allowing any further feedbacks to occur until everything is clear again. A dilute solution of caustic soda, (5% Sodium hydroxide) will strip any adhering films of mucilage. Then intensive recycling can recommence, and total water usage can be got down to around 2-3 litres per kg of parchment.

By a good understanding of how bacteria work, it is possible to make sure that only the good aerobic mesophylic lactic acid fermenting bacteria stay on top of the fermentation process, and all others are suppressed in one way or another. They are still there, and so potential problems are always just below the surface, but with good practise they never get a chance to breed enough to predominate.



Overall Placement:

The tank, or tanks, should be placed on a bench or pad with a drainage trough on either side, able to catch either the two top vents in the back channel, or the bottom vents into the front one. These two troughs should be perfectly horizontal so that the drainage from the tanks can be directed either left or right, to the two cross feed troughs, across each end of the bench that supports the tanks. The cross feed troughs should have enough slope, 1-2%, to flow down into either the water recycle system on the right, or to the wastes drain further out on the left.

The right recycle side trough should have a drainplate in the base, which leads down into a small sump which has a 1.5-2 metres length of flexy suction hose cemented into it. With the hose lifted up nothing can flow out. With it allowed to lie down, water will flow out down into a drainage pit as at the end of the day. And with it plugged into the pump, then the water can be recycled back up through the pulper.

. The 'trash' pump unit, be it electric motor, petrol or diesel engine powered, should be in a portable frame, and have Female 'Camlock', or 'Kliplok' hose fittings. This means

that all the other hoses, long, short or whatever, can be fitted with the much cheaper male end pieces. The other alternative is to use Unisex hose couplers, which are even cheaper again, but these tend to be much stiffer and difficult to join together in the larger sizes involved, because you have to twist the hose to make the connection, whereas the canlock fittings named above are a straight push fit..

The pulper/s should be set up on a higher level above the tanks and allow the pulpage,ie.freshly pulped beans, to flow down a chute into the open top of the tank with the lid folded back. The lid should have a 80-100mm hole cut through the centre to allow the entry of a pole for stirring the contents when wash water is being injected into the bottom vent. The lid must be able to be clamped down firmly, so that the pole can be levered against the lid to swing it round in the tank. Once any solid mucilage is broken, then the lid can be opened and the operator can see what he is doing as he works the pole to break up any lumps of solid mucilage.

The Wastes Problem:

If plenty of water is available, and the ground is porous, Wastes can be taken to a large soakaway pit, the water allowed to soak away through the soil, and the solids cleared out during the off season and used as fertiliser. Several metres of top soil is a good filter, and will take out everything from the water before it can do any damage to nearby surface water like lakes or streams. However, it should not be allowed to remain water logged. It should drain free each day.

If water is short, then all the recycling methods mentioned above can be used to the extreme. I know of a coffee factory in Papua New Guinea which placed a dam across a small gully and created a very small lake or a large pond by catching rain water. Water from that pond was pumped into the factory in the morning and after Passing through a soil filter ended up back in the pond that night. Along with additional rainfall, it usually managed to last the whole season before the factory ran out. That water was permanently a dark brown colour, but it washed out water white coffee that always got top prices and won prizes at local shows!

It is easy to strip solids and mucilage out of filtered factory water discharges, by holding the water for 12-20 hours in an 'acid pond'. As the coffee sugars ferment through alcohol and on to make vinegar, all the mucilage solubles will float to the surface, and any skin fragments and fibers that pass through the 100mesh filter will sink to the bottom. The thin sloppy mucilage layer, will thicken up, change colour from orange to black, and every week can be raked off the top as a solid mass and added back to the pulp solids filtered out earlier from the factory. The solids in the bottom of the acid pond can be also raked out from time to time by pumping out the pond if they build up too high.

The water comes out as a clear yellow acid solution at the far end of the pond. Even though it looks good, the yellow colour is like Litmus paper and will change colour to a very intense greenish black, if all the acid is neutralised. It is this black colour, which actually comes from the red colour of the coffee skins that will stain a river black for up to 20 kilometres down stream from a coffee factory. It ultimately condenses into brown swamp water, and is harmless to fish, but does not look nice at all. The best way to remove it is to first of all pass the water from the acid pond through a bed of limestone or marble chips. The water is already anaerobic but the carbon dioxide foam from off the chips takes out all the remaining oxygen with it. If it is not possible to back flush the bed from time to time with a pump, to take off the gelatinous film that builds up on the chips, then it is necessary to make two beds and rotate them on a fortnightly basis, with one allowed to dry out and peal off the dried film as it shrinks away from the chips to leave bright clean surfaces for a new cycle.

The limestone chips will remove enough acidity to allow hollow stemmed reeds and rushes to grow in the water, but not make the water alkaline enough enough to turn it black. These plants pump air down inside their hollow stems to allow their roots and the bacteria that live on the roots to survive in anaerobic conditions. If cost is not a factor, then the best way to grow the rushes is to build up a bed of stones about 300mm deep, and again a coarser grade of limestone is the best to use, and allow the water to flow through the stones and around the roots of the plants. If the rushes are simply planted in the ground it takes quite some time to grow them up while the water is flowing around their stems as well as their roots.

Creating an artifical wetlands or swamp in this way should condense the black colours into brown condensed tannins which are much more acceptable. If the swamp is big enough, then the brown colour condenses even further into insoluble 'humus' which is trapped in the roots, to build up the base of the swamp, and clear pure water will result from essentially natural processes.

Because flat land is usually a rather scarce commodity in 'coffee country', it is usual to construct these ponds and wet lands as long narrow trenches, dug on a contour around a hill side, and one above the other. In the case of the acid pond do make sure to leave good access above and below it, to be able to carry away the mucilage solids that have been raked up onto the banks and allowed to dry out.

Water that has passed through these beds is well able to be ponded again and recycled through the factory, along with a smaller supply of make water, depending on the porosity of the soil in the area, and other extraneous factors.

Ken Calvert.
Tanzania 2005.

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