WASTE WATER TREATMENT

A GUIDE TO TEXTILE PROCESSING EFFLUENT: CONSIDERATIONS, CONTENT, AND MANAGEMENT.

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EFFLUENT: INTRODUCTION TO WASTE WATER TREATMENT

The wastewater from textile plants is classified as one of the most polluting of many industrial sectors, considering the volume generated as well as the effluent composition. In addition, the increased demand for textile products, the use of synthetic dyes, and the increase in speciality finishing, have together contributed to textile wastewater becoming one of the substantial sources of severe pollution problems in current times.

In many countries it is mandatory for textile factories to use to treat wastewater before it leaves the factory premises. Pressure for effective effluent treatment is also mounting and many international buyers are now showing more concern over whether or not textiles are produced with due ecological consideration. This shift in the textile trade's paradigm means that in the future it is likely that the operation of an effluent treatment plant (ETP) will be integral to sustain business in the competitive world market.

The purpose of an ETP is to render effluent safe and legal to discharge to the environment and to meet the criteria set by authorities and in some cases specified by buyers.

Most wet processing facilities have their own ETP's and discharge treated effluent to a natural water course, some use shared facilities, and others use a municipal ETP. In the latter case the responsibility for proper treatment is passed on to another, albeit usually at a very high cost for the wet processes.

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EFFLUENT: CONSIDERATIONS

There are a number of considerations related to the content of textile effluent.

	COMMENTS
COD (CHEMICAL OXYGEN DEMAND)	Chemicals can react with oxygen and be oxidized. Any oxidisable chemicals that were released into waterways would react with dissolved oxygen in the water and that oxygen would be depleted. If oxygen levels drop too much the waterway cannot support life. COD is a measure of the oxygen depletion potential of the effluent.
BOD	Chemicals can be biodegraded by the action of bacteria to form simpler (and normally less harmful) chemicals. The bacteria need dissolved oxygen to 'breathe' and if biodegradable chemicals are released into waterways they act as 'food' for bacteria. The bacteria will biodegrade the chemicals but the ingestion of 'food' will mean they multiply and when more bacteria 'breathe' the oxygen levels can drop. BOD is a measure of the oxygen depletion potential of effluent – the amount of dissolved oxygen 'breathed' out of the water by chemical digesting bacteria.
COLOUR	The whole purpose of a dye is to be very strongly coloured at low concentrations. The presence of colour in effluent is largely an aesthetic problem rather a particular scientific problem – although very intense colour can stop light getting through to plants and animals that need it.
TEMPERATURE	Any water course has a natural ambient temperature that is appropriate for the species within it. If discharged effluent is considerable hotter (it is rarely colder) than the receiving water it can upset the natural balance.
TDS (TOTAL DISSOLVED SOLIDS)	This is a measure of the dissolved salts in the effluent. Salts are not removed by typical effluent treatment and levels can cause damage when introduced into fresh water courses. If salt is introduced into the process water (for example by adding salt to reactive dyebaths) then the only way to reduce levels is via dilution unless reverse osmosis is employed.
TSS (TOTAL SUSPENDED SOLIDS)	This is a measure of solids that have not been removed during effluent processing. The presence of fibres, dust, trash, bacteria can cause light transmission problems, pose a risk to simple organisms that may ingest small particles and ultimately cause silting problems in river beds.

EFFLUENT: CONSIDERATIONS

	COMMENTS
TOXINS HEAVY METALS	Aquatic species can be poisoned by toxic substances.
AMMONIA/ NITROGEN PHOSPHOROUS	Nitrogen and phosphorous compounds can act as fertilisers that can cause uncontrollable growth of plant life and algae – this can cause oxygen depletion.
AOX	Adsorbable Organic Halides can be formed by the action of halogens or halogenated chemicals on organic matter (e.g. chlorine bleaching of cotton) or they can be the breakdown products of larger halogenated chemicals such as some dyes. AOX can themselves be toxic and non-biodegradable or they can react to form even more toxic or persistent chemicals. AOX can react to form mutagens.
BACTERIA COUNT	The bacteria used in effluent treatment is different to the bacteria that may be present in a natural water course – it is not good to introduce alien species into an aquatic environment.
PHENOL	Phenol is toxic and liver and kidney damage (to humans and aquatic species). It can cause skin irritation/burns at high concentrations.
SULPHIDES	Sulphide ions are highly corrosive. Hydrogen sulphide is a particular problem in terms of odour and toxicity. Sulphur chemistry is complex but wet processing facilities where sulphur based chemicals are used (e.g sulphur dyeing, reduction clearing) need to ensure generation of H_2S is minimized.

EFFLUENT: CONSIDERATIONS

	COMMENTS
OIL AND GREASE	Oil and grease can form films over species in a water course and disrupt normal biological processes.
FOAM	Foam – rather like colour is unsightly rather than necessarily harmful. It doesn't take much chemical to form a lot of foam. However the presence of foam does indicate that the surface tension of the water has been affected.
ODOUR	Biodegradation can degrade certain chemicals into simple – but smelly chemicals, such as sulphur dioxide and hydrogen sulphide. This can be unpleasant but also damaging to aquatic species.
....RSL CHEMICALS	There is an increasing expectation that wet processing facilities not only ensure that the products they produce are free from chemicals that appear on restricted substances list but ensure that those chemicals are not present in effluent – this is not enshrined in law but is a voluntary restriction being demanded by some brands.
ANTIMICROBIALS	Great care has to be exercised when disposing of anti-microbial finish baths. Antimicrobials can undoubtedly deliver benefits to customers in terms of reduced odours on textile products but this is achieved by killing or suppressing the growth of microbes (bacteria and fungi). A critical part of effluent treatment is biological treatment where bacteria biodegrade chemicals so it is essential the chemicals that are designed to kill bacteria are not introduced in quantities that would essentially stop the effluent treatment plant from working.

EFFLUENT: CONTENT

With the exception of the chemicals that are intended to stay on the textile (dyes and the chemicals in performance finish formulations) most of the chemicals end up in the effluent. They may be present in the same form that they were inputted into the process, they may have been partially degraded (e.g. starch to sugars) or they may have reacted during the process.

A critical part of effluent treatment is biological treatment where bacteria biodegrade chemicals so it is essential the chemicals that are designed to kill bacteria are not introduced in quantities that would essentially stop the effluent treatment plant from working.

The effluent can contain the following chemical inputs:

GROUP	EXAMPLES OF INPUTS INTO WASTE WATER	COMMENTS
NATURAL IMPURITIES FROM FIBRES REMOVED DURING SCOURING	• OILS • WAXES • PECTINS • COLOURS, • TRASH/DUST	• REMOVED OILS, WAXES AND PECTINS HAVE HIGH BOD/COD
	• LANOLIN	• WOOL ONLY – NORMALLY SCOURED IN SEPARATE UPSTREAM FACILITY AND LANOLIN RECOVERED, BUT VERY HIGH EFFLUENT LOADING IF NOT
	• SERACIN	• SILK ONLY – NORMALLY DEGUMMED IN SEPARATE UPSTREAM FACILITY
CHEMICALS FROM WITHIN SYNTHETIC AND MAN-MADE FIBRES	• OLIGOMERS • PIGMENTS • POLYMER ADDITIVES • CATALYSTS	
PROCESSING AIDS USED IN FABRIC PRODUCTION	• SPINNING OILS, WAXES, LUBRICANTS • KNITTING OIL • WEAVING SIZE (STARCH, CMC, PVA)	• WEAVING SIZE CAN HAVE VERY HIGH BOD/COD
CHEMICALS USED IN SIZING/DESIZING	• STARCH • WAXES • CMC, PVA	• HIGH IN BOD, COD, SUSPENDED SOLIDS, DISSOLVED SOLIDS
SOLID WASTE	• FIBRE DUST • YARNS • PRECIPITATED, INSOLUBLE CHEMICALS • PUMICE DUST • CLEANING RAGS • LITTER	

EFFLUENT: CONTENT

GROUP	EXAMPLES OF INPUTS INTO WASTE WATER	COMMENTS
CHEMICALS USED IN SCOURING AND BLEACHING	• DETERGENTS • DISPERSING AGENTS • ALKALI • AMYLASE ENZYMES • BLEACH STABILISERS • SEQUESTRANTS • SOAP • ANTI-FOAM • SURFACTANTS	• HIGH PH, COD, DISSOLVED SOLIDS • HIGHLY ALKALINE SUSPENDED SOLIDS • FOR COTTON / LINEN SCOURING THE CHEMICAL LOAD IS VERY HIGH. • RESPONSIBLE CHEMICAL MANUFACTURERS SHOULD ENSURE PRODUCTS CAN BE RENDERED SAFE AND LEGAL BY STANDARD ETP
DYES INTENDED TO STAY ON THE TEXTILE	• UNFIXED DYES	• SOME DYES FIX AT 99% (E.G. DISPERSE DYES ON POLYESTER) LEAVING VERY SMALL AMOUNTS IN EFFLUENT WHEREAS OTHERS FIX AT ONLY 70% (SOME REACTIVE DYES ON COTTON) LEAVING HIGHLY COLOURED EFFLUENT
DYEING AUXILIARIES	• CATALASE ENZYMES • ALKALI • BUFFERS • SALT • ACID • ANTI-REDUCTANTS • ANTI-CREASE AGENTS • FABRIC LUBRICANTS • ANTI-FOAM • REDUCING AGENTS • OXIDISING AGENTS • FIXATIVES • MORDANTS • FIXATIVES • MORDANTS	• STRONGLY COLORED, HIGH COD, DISSOLVED SOLID • MOST INDIVIDUAL DYEING AUXILIARIES ARE USED IN SMALL QUANTITIES BUT THE TOTAL CONTRIBUTION TO EFFLUENT LOADING CAN BE SIGNIFICANT • RESPONSIBLE CHEMICAL MANUFACTURERS SHOULD ENSURE PRODUCTS CAN BE RENDERED SAFE AND LEGAL BY STANDARD ETP • ACIDS, ALKALIS AND BUFFERS CAN BE USED AT HIGHER QUANTITIES • SALT IS USED IN VERY LARGE QUANTITIES IN SOME REACTIVE DYEING PROCESSES AND IT IS NOT REMEDIATED BY A STANDARD ETP
DYE PRINT CHEMICALS	• UNUSED PRINT PASTE – STARCHES, GUMS, OILS • PRINT PASTE WASHED FROM SCREENS • PRINT PASTE WASHED FROM FABRICS • MORDANTS • ACID • SOAP	• PRINT THICKENERS HAVE VERY HIGH BOD/COD

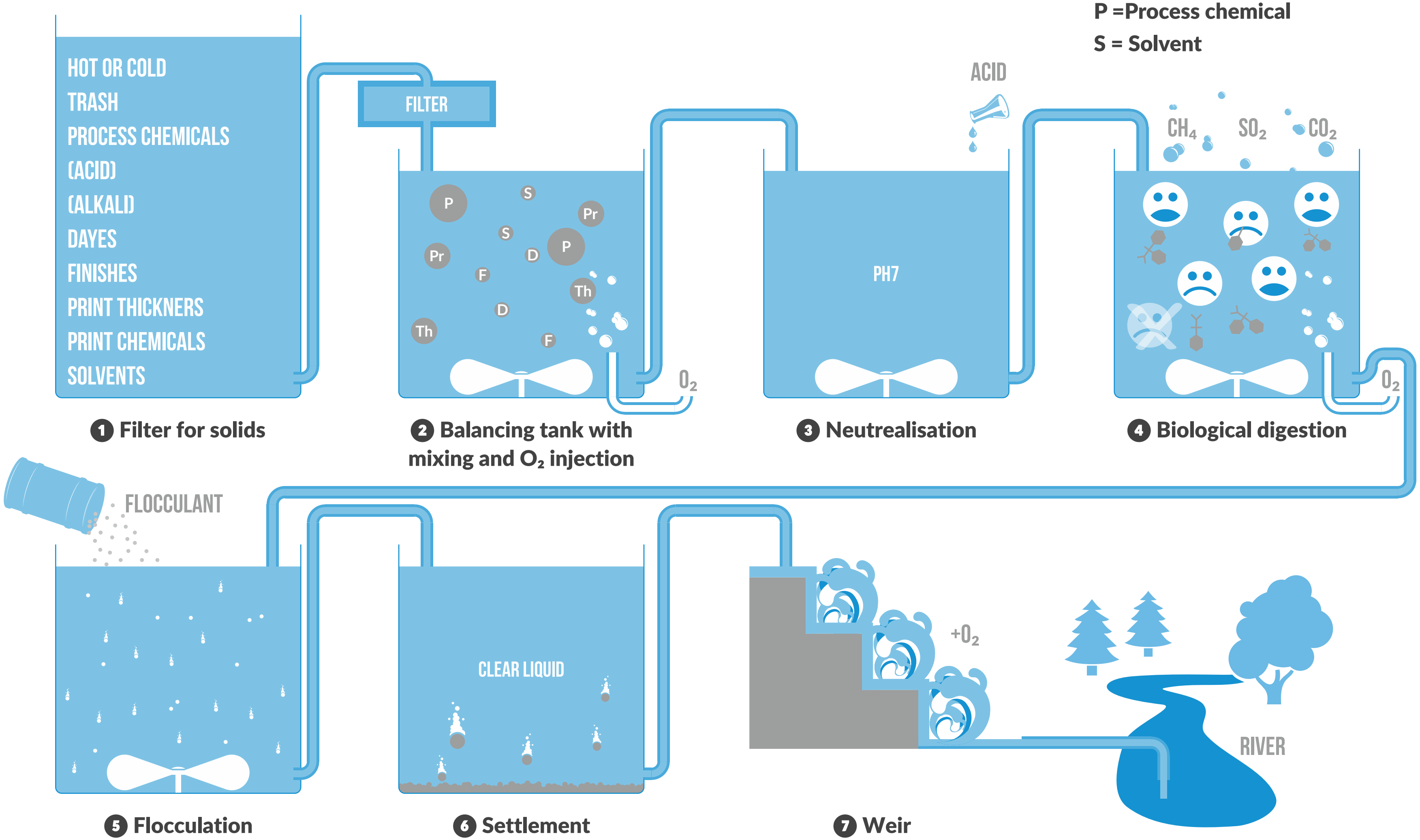
EFFLUENT: CONTENT

GROUP	EXAMPLES OF INPUTS INTO WASTE WATER	COMMENTS
PIGMENT PRINT CHEMICALS GENERALLY INTENDED TO STAY ON THE TEXTILE	• PIGMENT INK WASHED FROM SCREENS • CLEANING CHEMICALS USED TO CLEAN SCREENS (SOMETIMES VERY HARSH SOLVENTS)	
PERFORMANCE FINISHES INTENDED TO STAY ON THE TEXTILE	• ANY PERFORMANCE FINISH THAT IS NOT FULLY EXHAUSTED FROM A BATH. • RESIDUAL, UNUSED QUANTITIES OF PAD BATHS, COATING TROUGHS ETC • INORGANIC SALTS	• QUANTITIES SHOULD BE LOW BUT WHERE PRODUCTION RUNS ARE SMALL, THE UNUSED PAD BATHS CAN ACCOUNT FOR A RELATIVELY LARGE AMOUNT • GREAT CARE HAS TO BE TAKEN WITH ANTIMICROBIALS
FINISHING AUXILIARIES	• ACIDS • ALKALIS • CATALYSTS • WETTING AGENTS • DISPERSANTS • STABILISERS • THICKENERS • SOLVENTS • MORDANTS	• QUANTITIES SHOULD BE LOW BUT WHERE PRODUCTION RUNS ARE SMALL, THE UNUSED PAD BATHS CAN ACCOUNT FOR A RELATIVELY LARGE AMOUNT
CLEANING CHEMICALS CHEMICALS DELIBERATELY USED TO CLEAN FLOORS, PRINT SCREENS, MACHINES ETC	• DETERGENTS • SOLVENTS	• AMOUNT SHOULD BE LOW – SHOULD BE PURCHASED FROM REPUTABLE TEXTILE CHEMICAL COMPANIES
CHEMICAL RESIDUES	• CHEMICAL DRUMS ARE OFTEN WASHED ON-SITE PRIOR TO RE-USE OR RECYCLING.	• THE RESIDUES MUST GO TO THE ETP AND NOT SURFACE WATER DRAINS. • GREAT CARE HAS TO BE TAKEN WITH ANTI-MICROBIALS
FORMULATION AIDS CHEMICALS PRESENT IN FORMULATIONS THAT ARE NOT ACTUALLY THE ACTIVE INGREDIENT. THESE CAN BE PRESENT IN OILS, WAXES, SIZES, DYES, FINISHES SCOURING/DYEING/PRINTING /FINISHING AUXILIARIES	• E.G. EMULSIFYING AGENTS • PH BUFFERS PRESERVATIVES • STABILISERS • DILUENTS • SOLVENTS • WETTING AGENTS • ANTI-OXIDANTS • ANTI-REDUCTANTS • ANTI-FOAM	• QUANTITIES SHOULD BE LOW • RESPONSIBLE CHEMICAL MANUFACTURERS SHOULD ENSURE PRODUCTS CAN BE RENDERED SAFE AND LEGAL BY STANDARD ETP

EFFLUENT: THE ETP PROCESS

There is no single defined design or sequence of processes for an effluent treatment plant but there are some key processes that must take place to render the effluent safe and legal – and some optional ones to improve it further.

Pr = Print auxiliary
Th = Thickener
D = Dye
F = Finish chemical
P = Process chemical
S = Solvent



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EFFLUENT: THE ETP PROCESS

COARSE FILTER AND OIL TRAP	• Removal of large solid objects such as rags, yarns, litter • Skimming of surface oil
BALANCING	• A large number of different baths from wet processing are mixed together to homogenise waste streams of very different composition. • Air blowers mix the tank and start to reduce COD of effluent
NEUTRALISATION	• Balanced effluent is adjusted to correct pH for subsequent biological treatment
BIOLOGICAL TREATMENT	• Chemicals are biodegraded by action of bacteria – reducing the BOD of effluent • Biodegradation can fully biodegrade some chemicals to very simple chemicals like water, carbon dioxide and methane • Air blowers mix the tank and reduce COD of effluent • Chemicals in effluent 'feed' the bacteria and population of bacteria grows • Bacteria cannot degrade 'persistent' (non-biodegradable) chemicals and some chemicals are only partially degraded • Some chemicals bio-accumulate in bacteria
FLOCCULATION	• Chemicals are added to precipitate dissolved colour • Some other non-coloured, dissolved chemicals are also precipitated – reducing chemical content of effluent
SETTLEMENT	• Solids are separated from clear liquid, normally via gravitational settlement • Solids contain live bacteria and can be re-used in biological treatment
AERATION AND DISCHARGE	• Treated effluent is aerated (to top up dissolved oxygen levels) and discharged • This is NOT pure water but contains • dissolved salts • residues of chemical inputs that have not been fully remediated • breakdown/reaction products from chemicals inputs • Small amounts of suspended solids (which have not settled)
SLUDGE MANAGEMENT	• Sludge is de-watered and disposed • If it is free from chemical contamination it can be used as fertilizer • If it is contaminated (added ETP chemicals and harmful chemicals that have bioaccumulated in bacteria) then it must be disposed of according to local regulations for harmful waste

EFFLUENT: THE ETP PROCESS – ADDITIONAL MODULES

Denitrification

If urea is used in wet processing (it is sometimes used as a humectant in printing) then special steps have to be take to remove nitrogen from the wastewater. This can be done chemicals or microbiologically but the aim is to convert nitrogen containing compounds to atmospheric nitrogen.

ZLD

In some areas of the world, such as parts of India, there has been a 'Zero Liquid Discharge' mandate – meaning that no liquid can leave the site of a wet processing facility. The main purpose is to stop the discharge of dissolved salts, which are not removed by standard ETP's, entering water courses and causing damage. This forces the factory to recycle water and this is normally achieved by augmenting a standard ETP with a reverse osmosis module (RO). Treated effluent containing salt is forced through a semi-permeable membrane and pure water is obtained which can be re-used in processing.

Approximately 75% of the water is re-cycled using RO and the other 25% of liquid is in a highly concentrated slurry called RO permeate. The water has to be evaporated from this and condensed for re-use – this achieved using energy-intensive vacuum evaporators that convert the slurry to solid waste (mainly salt) and pure water.

Some of the salt can be re-used in some non-critical dyeing processes (e.g. dyeing black colours) but it is normally contaminated with other chemical residues so cannot be fully re-cycled. In water stressed areas the use of RO for water recycling is beneficial but there are impacts associated with greenhouse gases from energy use. There is also no satisfactory solution for all the solid water recovered from the vacuum evaporators.

Ultra-filtration and Nano-filtration

These technologies are similar in concept to reverse osmosis in that they use fine membranes that can theoretically filter out chemicals from solutions to yield clean, re-usable water but they are not in widespread use in textiles.

EFFLUENT: THE ETP PROCESS – NOTES ON...

Continuous processing, ETP capacity and flow rates

- Just because effluent goes through an ETP doesn't mean it is treated!
- The nature of a continuous ETP is that each module has a high capacity that is continuously mixed and a small volume (representing a very small % of total volume) is pumped in and pumped out on a constant basis. The flow rate is adjusted to give an appropriate minimum average dwell time to ensure the process is carried out properly.
- Inevitably a small amount of the inputs to a process tank will leave it much sooner than the average dwell time so full treatment is never attainable – however the processes are set up so that overall treatment is satisfactory.
- If the ETP is under-capacity compared to the volume of effluent emerging from the wet processing facility then it is common to increase flow rates in the ETP.
- This doesn't have a catastrophic effect on balancing but it makes spikes in certain parameters more likely, it doesn't have a major impact on neutralisation IF neutralisation is managed by constant monitoring and dosing of chemicals.
- Increased flow rate has a major effect on biological treatment:
    - The need for increased flow rate is often due to increased water usage for washing/rinsing and this makes effluent dilute as such, bacteria do not have enough food concentration and can't divide)
    - Increased flow rate means contact time (with potentially unhealthy bacteria) is low and so biodegradation is poor
    - Increased flow rate with dilute effluent can mean that bacteria are lost to the next ETP step more quickly than they can re-produce and so bacterial populations not only become unhealthy but drop
    - Increased flow rates in settlement tanks can lead to shorter settling times that results in liquids that contain solids begin released to the environment – this can be solid chemicals, dust debris and bacteria.

EFFLUENT: THE ETP PROCESS – NOTES ON…

Dilution

- There is a saying that dilution is not the solution to pollution.
- In many areas of the world water is expensive so every litre used has an impact on profitability – this is compounded by costs associated with effluent discharge (even properly treated effluent discharge).
- The costs of effluent discharge are governed by both concentration of effluent content, volume and total chemicals discharged – in this scenario you can dilute to meet concentration based parameters but there is a huge cost involved. The formula is devised so that the cheapest option for the wet processor is to minimise water consumption and chemical consumption and have low volumes of quite concentrated raw effluent that have to be properly treated before discharge
- Unfortunately in some areas of the world the low price of water (or even free water) and lax nature of enforcement of simplistic standards mean that for some wet processors dilution is a solution.
- It is financially beneficial for a wet processor to use so much water in processing that effluent passes local standards by simple balancing, neutralisation and dilution. The ETP's are sometimes only there to impress western brands – and barely function.

EFFLUENT: THE ETP PROCESS – DETAILED

1 Coarse filtering and oil trap

Before entering the ETP most effluent streams are filtered to remove large solid items that may have got into machines or drains.

Following removal of solids, it is good practice to skim oil off the surface and collect it as early in the ETP process as possible.

Many different types of oil can be used in textile processing and they are mostly removed during scouring. They are normally stabilised in a formulation by the use of emulsifying agents but once removed and placed in an effluent stream they can exist as mini-oil slicks on the liquid surface.

This oil can coat the surface of the ETP tanks and can even coat bacteria in a biological digester – seriously affecting their ability to biodegrade chemicals.

Image credit: https://commons.wikimedia.org/wiki/File:Screening_of_the_wastewater_to_remove_all_larger_objects._(6845986063).jpg

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EFFLUENT: THE ETP PROCESS – DETAILED

2 Balancing

To understand the importance of balancing it is necessary to consider that the following processes in the ETP is a biological digester containing highly sensitive, live bacteria. The effluent that is sent through to the biological treatment must not kill, or significantly adversely affect those bacteria.

All effluent goes to a balancing tank – this is a large tank where effluent streams from many different machines and processes are mixed together to create an average raw, untreated effluent. The capacity of the balancing tank can vary but can hold up to a couple of days' volume of all discharges from the factory – the greater the capacity of the balancing tank relative to the effluent discharge volume of the wet processing facility then the greater the consistency over a period of time.

- The temperature input to the balancing tank can vary enormously – from boiling scour/dye baths* to cold water rinses. If the overall temperature of the balance effluent is too high, it may be necessary to spray the effluent into the air to cool it on an on-going basis.
- The chemical loading input into the balancing tank can vary enormously -from highly loaded cotton scouring baths to almost pure water from final post-dye wash baths. Other than equalising the effluent via balancing there is very little that can be done to adjust this – although balancing itself irons out major spikes.
- The content of oxidising or reducing agents can vary enormously – from highly reducing reduction clearing baths to highly oxidising bleach baths.
- Quite often the mixing of a balancing tank is achieved using a combination of propellers and air blowers. The introduction of oxygen (in air) will deal with any excess of reducing agent.
- The presence of dissolved oxygen in water is absolutely essential for aquatic life and COD – chemical oxygen demand – is a measure of how much oxygen can be removed from a natural water course if oxidisable chemicals are introduced (the dissolved oxygen in the water is used up during the oxidation of the chemicals).
- Using air blowers to mix a balancing tank not only helps to homogenise the contents but also starts to oxidise the oxidisable chemicals in the effluent – thus reducing the COD.

Image credie: https://www.process-worldwide.com/water-treatment-for-the-dye-industry-a-394801/index2.html

EFFLUENT: THE ETP PROCESS – DETAILED

❸ Neutralising

- pH has a direct influence on wastewater treatability and so is therefore critically important to treatment.
- The pH input to the balancing tank can vary enormously - from highly alkaline reactive dyebaths to highly acidic baths from wool dyeing:
- Although balancing does a very good job of equalising the recent production effluent this can vary from day to say so it is necessary to adjust the pH of the output of the balancing tank on an on-going basis – this requires constant monitoring and constant dosing of acids/alkali to endure the pH is stable and neutral for the next phase.
- Even where a factory uses a shared ETP or municipal ETP is it common for them to have to balance and neutralise effluent before sending it for treatment.

Image credit: http://m.satakemalaysia.com/index.php?ws=ourproducts&cat=Agitators&subcat=Application&subsubcat=Water%20and%20Wastewater%20Treatment&cid=149330

EFFLUENT: THE ETP PROCESS – DETAILED

4 Biological treatment

- Common convention has it that it is a good thing if chemicals are biodegradable – and provided the smaller chemicals that are formed are safer than the larger molecules from which they are formed then this holds true. Where relatively harmless chemicals are biodegraded into more harmful breakdown products then it is questionable as to whether biodegradation is beneficial.
- Whenever anything is biodegraded by aerobic micro-organisms (ones that require oxygen to breathe) in an aqueous environment there is a guarantee that oxygen levels in the aqueous environment will be reduced. This is simply because the chemical that is being biodegraded is essentially food for the microbes that are doing the biodegradation and when microbes fed they multiply exponentially until there is either no food or no oxygen in the water.
- If dyehouse effluent, containing biodegradable material was to be discharged into a natural water course, the microbes in the water would multiply, breathe, use up dissolved oxygen until the water could not support life.
- Releasing safe, edible chemicals such as starch causes more environmental damage than the release of toxins and therefore the purpose of the biological treatment is to biodegrade the chemicals in the effluent before discharge.
- Of course the bacteria in the biological treatment tank are constantly using up dissolved oxygen so biological digesters are always aerated to keep the bacteria healthy, and to oxidise and chemicals formed by the biodegradation that cannot be biodegraded further, but could be oxidised if released into a water course.
- The biodegradable chemical content of the effluent that enters the biological digester is food for the bacteria – they 'eat' the food, digest it and turn it into chemicals with much lower potential for depleting oxygen from waterways.
- On eating the food the bacteria multiply (exponentially in the presence of concentrated 'nutritious' food) and it is sometimes necessary to remove bacteria occasionally to maintain a healthy population (it is better to have 10 million healthy bacteria than 20 million under-nourished bacteria!).

EFFLUENT: THE ETP PROCESS – DETAILED

- It seems counter-intuitive but concentrated effluent is much better for a biological treatment plant than dilute effluent. Imagine having your meal served to you on a plate as big as a football pitch and having to find each pea, carrot, potato, piece of rice – that is what dilute effluent is like for bacteria, and it is common to find that wet processing facilities that use a lot of water for processing have very low bacteria counts and / or stressed bacteria in the plant.
- There is a constant flow of liquids from the biological digester to the next stage of the ETP (settlement) and if the throughput is too fast then there is insufficient time for the bacteria to multiply and establish an effective chemical eating colony. In this case there is very little on-site biodegradation of chemicals – although the final, released effluent may be dilute!
- Dilution of effluent does NOT reduce the total effluent loading and total oxygen depletion potential of the released chemicals but it CAN trick regulators. Dilution of effluent never morally acceptable and is only economically feasible in areas where water is free or very low cost.
- Conversely bacteria have a finite lifespan and if throughput is too slow there will be too many dead bacteria in the system – which themselves are biodegradable, with the potential to cause oxygen depletion if released into waterways. If throughput is too slow then the health of the colony can also suffer and the bacteria can spend time eating their ancestors rather than chemicals in effluent!
- Bacteria are very good at digesting chemicals but there are some chemicals that are not biodegradable and there are some chemicals that bioaccumulate – what this means in laymans terms is that when the bacteria 'eat' chemicals in the digester the following can happen:
    - The bacteria biodegrade chemicals to form smaller molecules
    - The bacteria eat the chemicals and the chemicals are excreted unchanged
    - The bacteria eat the chemicals and the chemicals stay in the body of the bacteria unchanged (bio accumulation). The concentration of such chemicals can increase over the lifetime of the bacteria.
- When bacteria die they can therefore be contaminated with harmful chemicals – the solid residues (sludge) may not be safe.
- Although the discharge of large amounts of nitrogen and phosphorous compounds into water courses can be very harmful and should be avoided, these are essential nutrients for the bacteria and if their 'diet' is deficient then small quantities do need to added to ensure the bacteria are healthy.

EFFLUENT: THE ETP PROCESS – DETAILED

5 Flocculation

- After biological treatment the liquid is a slurry of bacteria, chemicals and chemical break-down products.
- Because most ETP's work on a continuous basis there will always be a percentage of the effluent content that has been biodegraded for a longer time than average and there is a percentage that has been treated for a shorter than average time.
- This means there is often dyestuffs present that have not been biodegraded (or indeed that are not biodegradable) so if the slurry that exits a biological reactor was filtered you would observe a coloured liquid.
- The strength of colour depends on the dye fixation level (e.g. 99%+ of disperse dyes are fixed on polyester, 70% of reactive dyes are fixed on polyester), levels of dilution (world class facilities use less water and the effluent is more concentrated) and dwell time in the biological treatment process (longer treatment enables more biodegradation of colour.
- The colour has to be removed and this is normally achieved using flocculation – a process where the colour is forced out of solution to make it solid so that it can be more easily removed.
- A chemical is added to the solution, mixed and the dissolved colour forms solid particles. The flocculant can be simple iron salts in the presence of lime or, in better, operations very low quantities of specially designed organic flocculants.

Image credit: Original source unknown, taken from http://www.golantec.be/Moderniseer%20uw%20zwembad.html

EFFLUENT: THE ETP PROCESS – DETAILED

- Flocculation will also precipitate some invisible, soluble chemicals (and breakdown products) so it not only removes colour but reduces the chemical content of effluent.
- The cost of the organic flocculants is much less than the simple salts but the amount of solid waste generated is much less and, because of the cost there is much less tendency to over-dose the chemicals, which is a common problem with cheap iron salts.
- The method of removal can be filtration (uncommon), floatation – where the solid is pushed to the surface of a flocculation tank using bubbles and the solid scraped off or settlement, where the solids are allowed to settle under gravity.
- Some factories use other techniques to remove colour such as the use of bleach. The use of Chlorine bleach is effective at removing colour but not good from an environmental standpoint but the use of ozone is becoming more popular. Generation of ozone is expensive and ozone is very, very toxic so needs constant monitoring but it removes colour without generating any solid waste.
- Colour removal (by flocculation or bleach) can be carried out at different stages in the process. The most common place is after biological treatment as this allows some biodegradation of colour, thus reducing flocculant cost but is can be done before biological treatment or even as the almost final stage of the ETP process.

EFFLUENT: THE ETP PROCESS – DETAILED

6 Settlement

- After treatment in the biological digester the liquid / slurry is often treated with a flocculant to encourage precipitation of some dissolved chemicals (including colour) and coagulation of any solids in the liquid.
- After mixing with flocculant the liquid is pumped to a settlement tank.
- Here the solids fall to the bottom and the liquid clears at the top. Some solid debris will float and this has to be skimmed from the surface but the clear liquid removed from the top is basically the final effluent discharge - unless colour removal is deferred to post- settlement.
- It is common to have multiple settlement tanks or a semi-continuous intake of liquid from the biological digester/flocculation tank. This is because the settlement tank has to have no or very little agitation to allow solids to settle – a fast, constant
- The design of a settling tank is often like a cone so the solids can be removed from the bottom and either re-used (it contains live bacteria that can still be of use in a biological digester) or filtered, pressed and disposed of according to local regulations.
- This solid is referred to as ETP sludge and it is an emerging issue.
- If crude flocculation using iron salts is employed immediately before settlement then the sludge is unlikely to be re-used in the biological digester but if low levels of organic flocculants are used, or flocculation is carried out before biological treatment OR after settlement then sludge re-use is possible.
- Sludge re-use should not be necessary if the population in the biological digester is healthy, given the appropriate nutrient and the dwell time is sufficient to maintain microbe numbers.
- Before final discharge of the treated effluent it should be checked for pH (particularly if highly alkaline flocculation systems have been employed) and dissolved oxygen.

Image credit: Original source unknown, taken from http://www.filterpressmanufacturer.in/filter-press-plates.html

EFFLUENT: THE ETP PROCESS – DETAILED

7 Aeration and Discharge

Some dyehouses trickle water from the settling tanks down weirs before discharge to ensure oxygen levels are topped up by rapid (and free) interchange with the air.

For more information about this report, please contact us at +49 176 24335757You can also write us at: info@europeanoutdoorgroup.com - www.europeanoutdoorgroup.com

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