Textile production waste management, effluent and its treatment

Promotion of Sustainability in the Textile and Garment Industry in Asia-FABRIC

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

FABRIC Asia

Textile production waste management, effluent and its treatment

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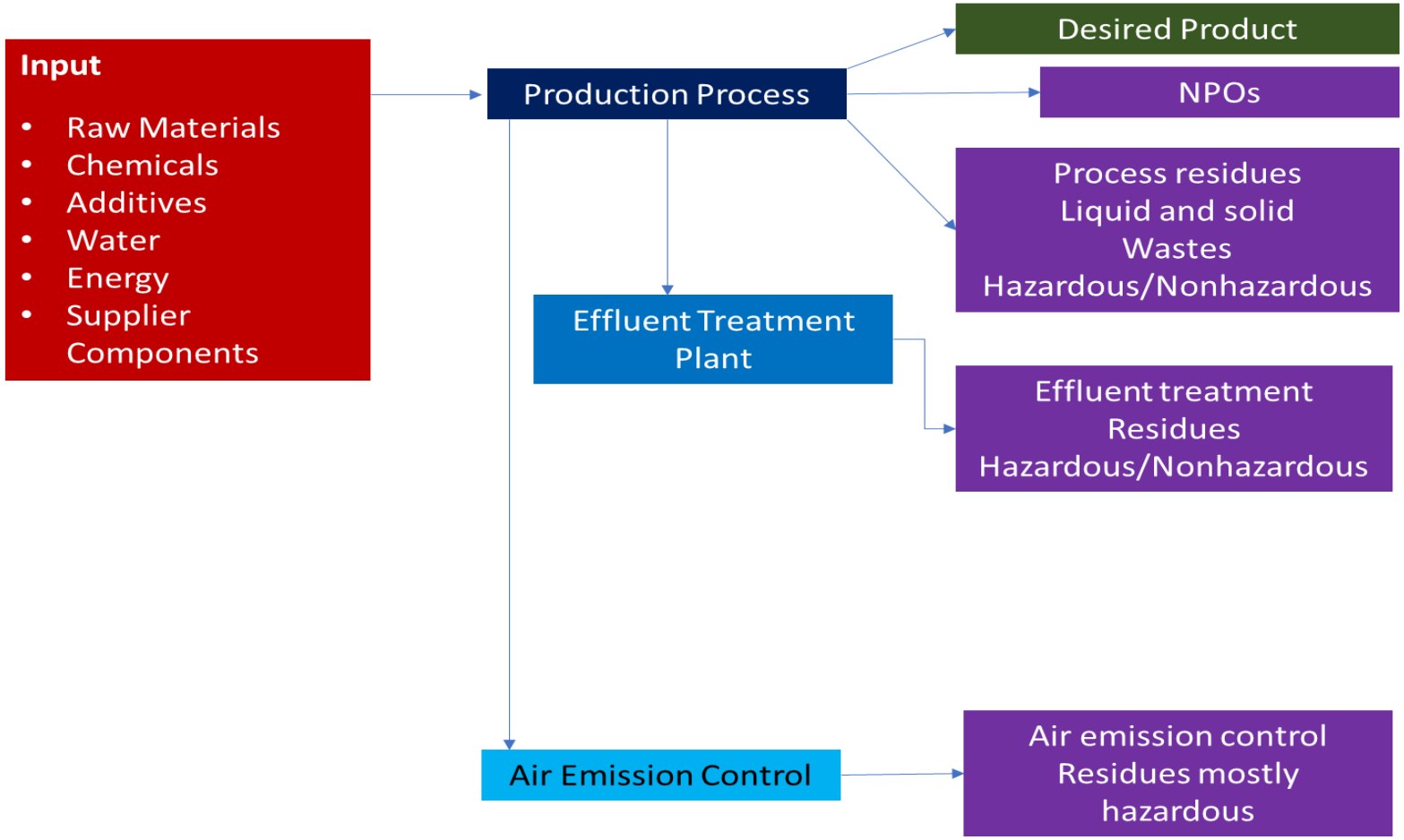
Agenda

- Textile waste management
- Impact of hazardous substance
- Reuse, recycle and recovery
- Chemicals and waste inventories
- Waste water management
- Waste water treatment

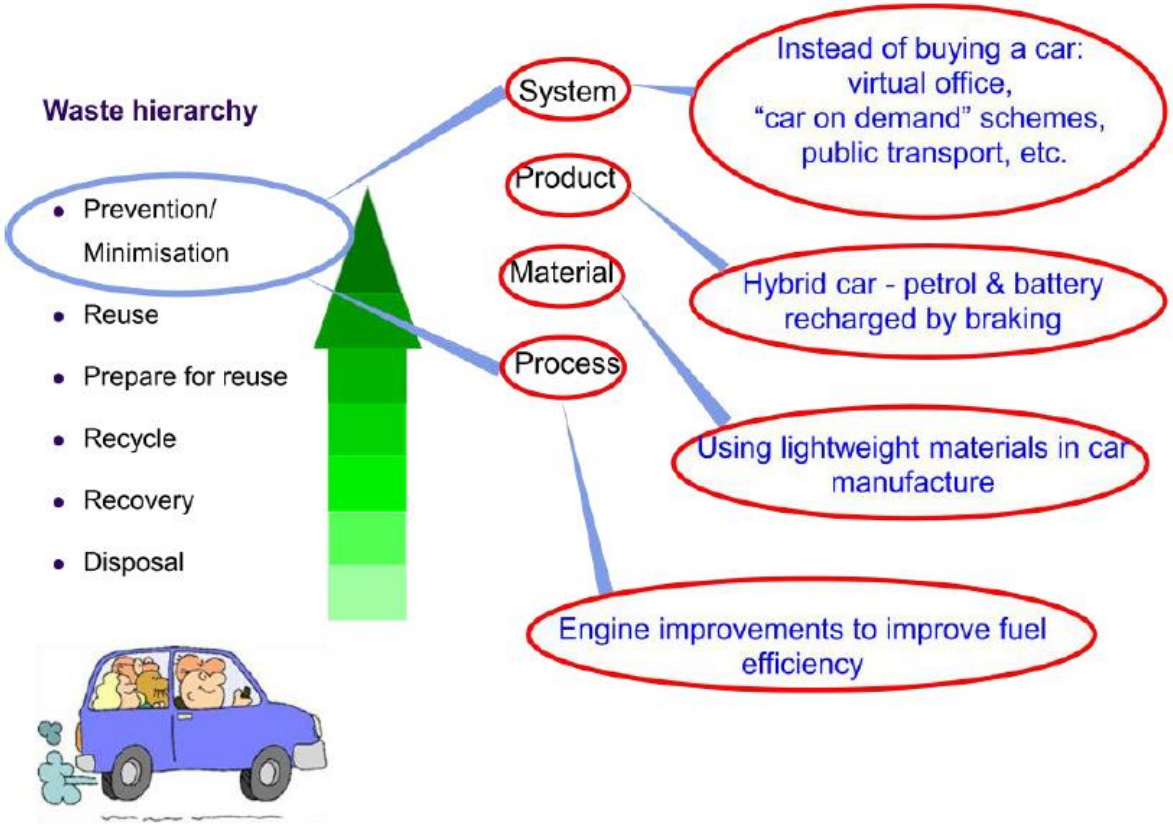
The size of the waste problem



Best Practices in Europe and USA

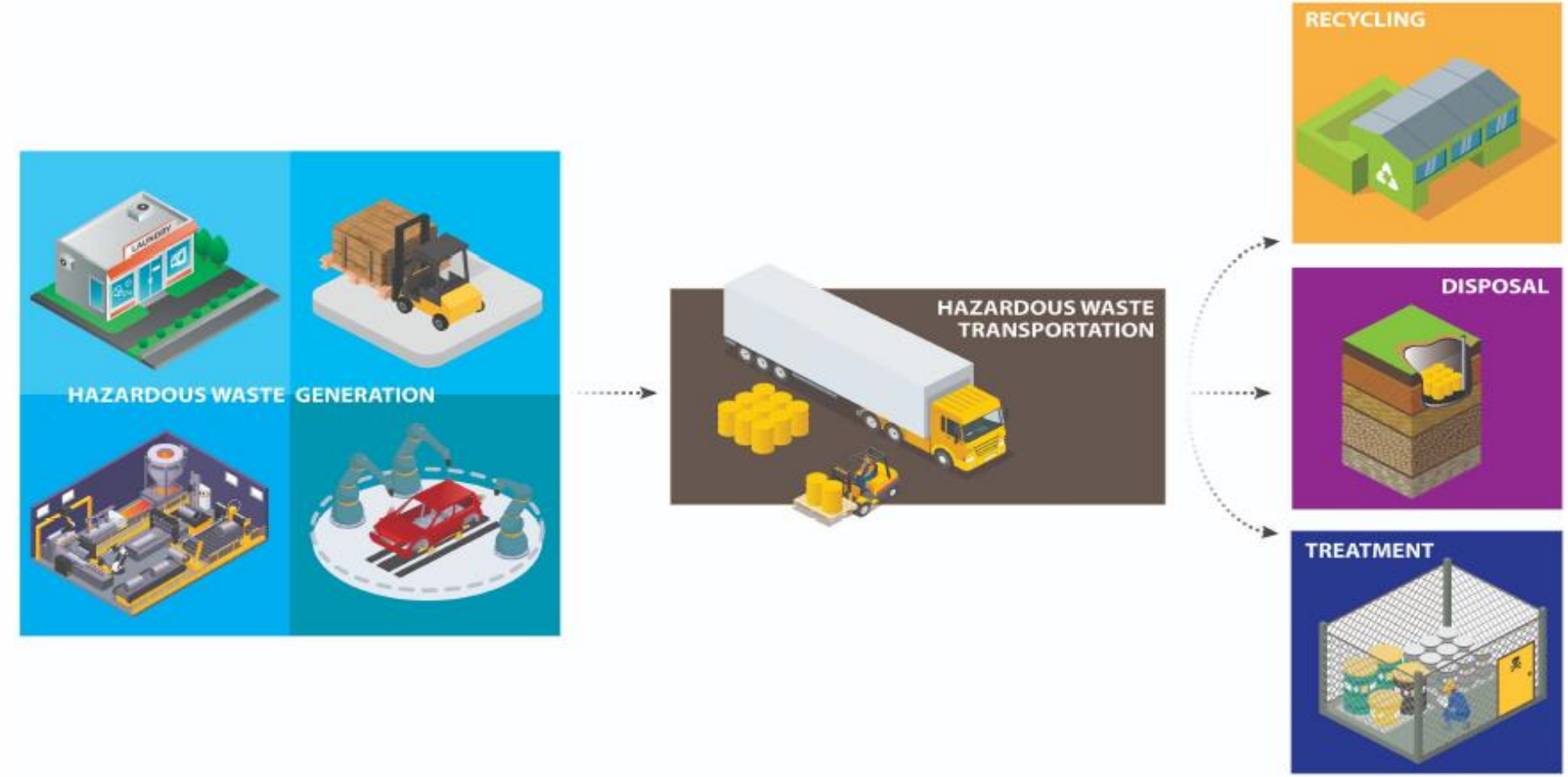
- **Avoidance**
- **Reuse and recycling**
- **Recovery of energy**
- **Treatment and disposal.**

Best Practices in Europe and USA



Source: European guidance for waste hierarchy

Cradle to Grave Approach by the US EPA



https://epa.gov/sites/default/files/2020-08/cradletograveimage2020_v2.jpg

Impact of hazardous substances on environment & health

Hazardous waste

- **Flammable/Ignitable Characteristic:**
  - Liquid Chemicals: having flash point over 60 C. Alcohols, Xylenes etc.
  - Solid chemicals: can catch fire through friction or if heated. Parafin wax.
  - Compressed gas: Hydrogen, acetylene.
  - Oxidizers: Enhances combustion. Chlorates, nitrates, perchlorates etc.

- Corrosive Characteristic:
  - ✓ A chemical is corrosive if it has a pH less than or equal to 2 or, greater than or equal to 12.5
  - ✓ If it has a corrosion rate (for steel) 0.25 inch per year
  - ✓ HCl, H_2SO_4, NaOH

Hazardous waste

- **Reactive**
  - Under normal conditions is unstable and can undergo violent changes without detonating. Example: Na metal reacts with water, tert-butyllithium reacts with air
  - Capable of detonation or, explosion. Example: Dry picric acid, Azide compounds, organic peroxides.
  - Cyanides or, sulfides. Such as Na cyanide.
- **Toxic: The toxic 'characteristic' is where the regulations start to get into listing specific chemicals. To determine whether a chemical waste exhibits the toxic characteristic, in the US federal toxic list, known as the 'D' list. Example: Arsenic, Barium, Cadmium etc.**
- **Check the lists from the US EPA or, EU (individual country guidelines)**

Hazardous waste generation

- All hazardous waste generators must determine if their waste is hazardous
- The generators will take the responsibility for documenting the hazardous waste (for identification, management, recycling or, disposal)
- The degree of regulation that applies to each generator depends on the amount of waste that generator produces
- National guidelines are to followed strictly by the generators

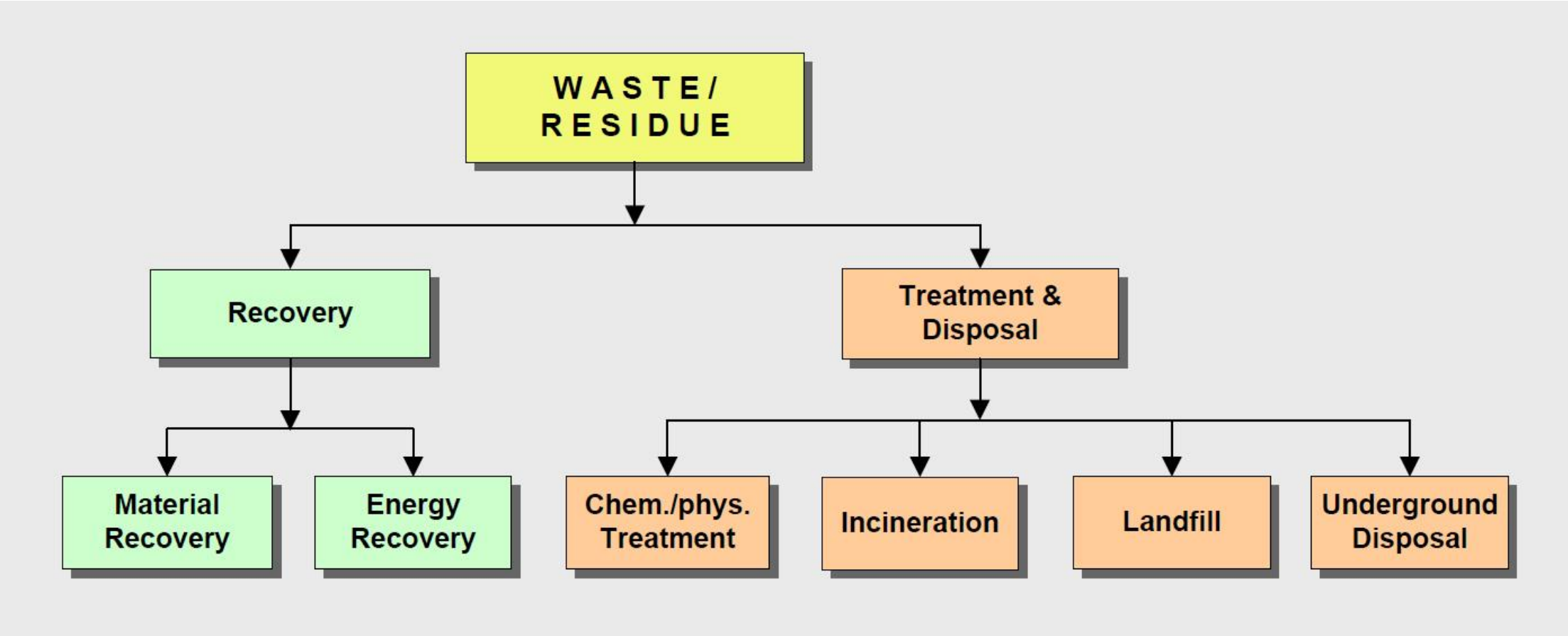
Hazardous waste transportation

- **Transporters are responsible for moving the waste to the designated facility for recycle, treat, store or, dispose of the waste**
- **As the transporters are moving regulated wastes through public roads and waterways, typical practice in USA is to follow**
  - ✓ the United States Department of Transportation Hazardous Materials Regulations
  - ✓ EPA's hazardous material regulations

Hazardous Waste Recycling, Treatment, Storage and Disposal

- The aim is to balance the conservation of resources, while ensuring the protection of human health and environment
- It is possible to recycle some hazardous wastes safely and effectively, while several wastes are to be treated and disposed of in landfills or, incinerators
- Recycling has a variety of benefits reducing consumption of raw materials and generating less amount of waste materials
- However, measures should be taken to store the hazardous waste safely so that it does not contaminate soil and drinking water
- For temporary storage of hazardous waste, treatment storage and disposal facilities are used

Reuse, recycle and recovery (EU practices)



Reuse, recycle and recovery (EU practices)

R1	Use as a fuel (other than in direct incineration) or other means to generate energy/use principally as a fuel or other means to generate energy
R2	Solvent reclamation/regeneration
R3	Recycling/reclamation of organic substances which are not used as solvents
R4	Recycling/reclamation of metals and other components
R5	Recycling/reclamation of other inorganic materials
R6	Regeneration of acids or bases
R7	Recovery of components used for pollution abatement
R8	Recovery of components from catalysts
R9	Used oil re-refining or other reuses of previously used oil
R10	Land treatment resulting in benefit to agriculture or ecological improvement
R11	Uses of residual materials obtained from any type operation from R1-R10
R12	Exchange of wastes for submission to any of the operations numbered R1-R11
R13	Accumulation of material intended for any operation in this list

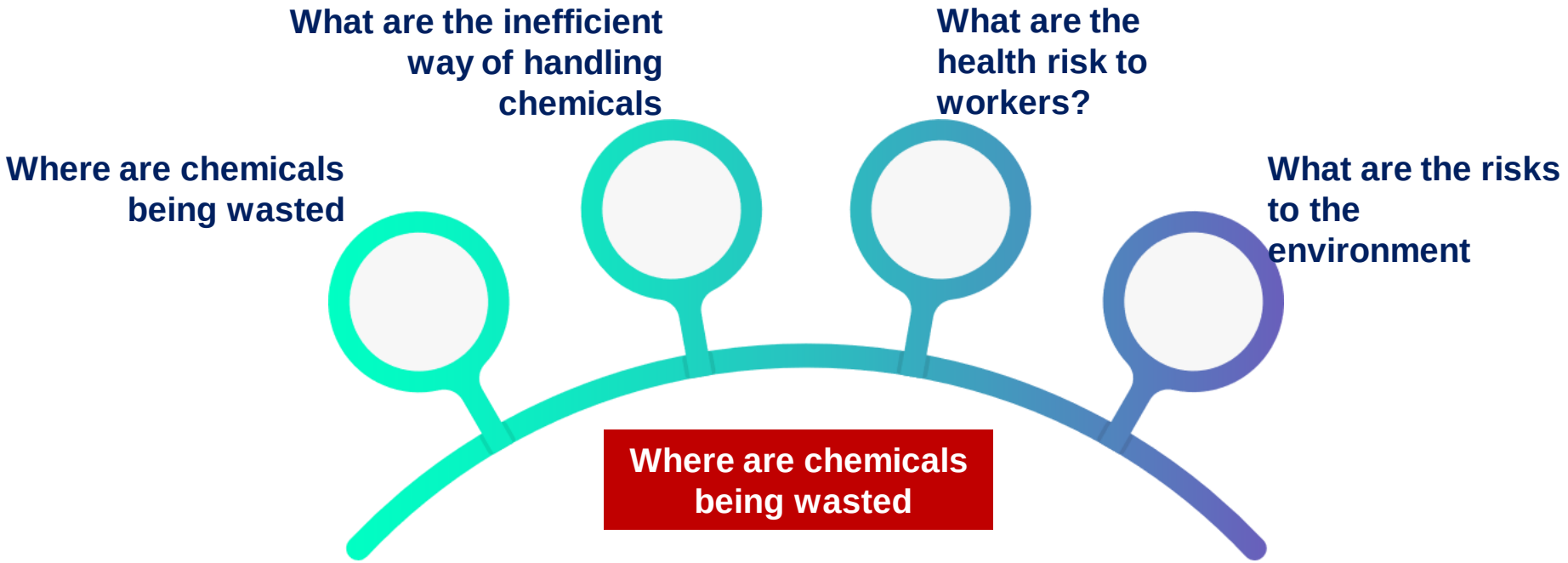
Ref: Basel annexes

Treatment and disposal (EU Practices)

D1	Deposit into or onto land (landfill)
D2	Land treatment (e.g., biodegradation of liquid or sludgy discards in soils)
D3	Deep injection (injection of pumpable discards into wells, salt domes etc.)
D4	Surface impoundment (e.g., placement of liquid or sludge discards into pits, ponds or lagoons)
D5	Specially engineered landfill (e.g., placement into lined discrete cells which are capped and isolated from one another and the environment)
D6	Release into the water body except seas/oceans
D7	Release into seas/oceans including sea-bed insertions
D8	Biological treatment not specified elsewhere in this list which results in final compounds or mixtures which are discarded by means of any of the operations in this list
D9	Physico-chemical treatment not specified elsewhere in this list which results in final compounds or mixtures which are discarded by means of any of the operations in this list (e.g. evaporation, drying, calcination)
D10	Incineration on land
D11	Incineration at sea
D12	Permanent storage (e.g. emplacement of containers in a mine)
D13	Blending or mixing prior to submission to any of the operations in this list
D14	Repackaging prior to submission to any of the operations in this list
D15	Storage pending any of the operations in this list

Ref: Basel annexes

Elements of Chemical Management



Waste management policy by Government

Gaps

- Implementation of procedures for handling hazardous materials;
- Procedure and standards for recycling of hazardous materials;
- Conditions for sale or transfer of hazardous materials for recycling;
- Treatment, storage and disposal facilities for hazardous wastes;
- Monitoring packaging labeling and storage of hazardous materials;
- Transportation of hazardous materials and manifest systems;
- Verifying reporting, records and returns;
- Legal liabilities, legal provisions and appeals
- Certified professional support for hazardous waste management service/facilities

Addressing the gaps

- By identifying and updating the rigorous list of hazardous waste that are being imported and generated in Bangladesh,
- Preparing an updated guidelines for making sure of proper management of those waste,
- Handling, recycle, storage or, disposal methods are to be established for each type of waste,
- Inspecting the storage facilities at the factories and ensuring their usability before issuing waste chemical import certificate

Addressing the gaps

- **Training of professional in the field of waste management (to provide accredited services to the factories who will need support regarding hazardous waste management),**
- **Detail Record keeping and maintaining standard safety practices at the industries,**
- **Making rules easier to understand for implementation.**

Waste inventories and waste catalogues

Chemical and Waste Inventories

Provides a comprehensive list of the chemicals entering the production facility.

In the context of resource efficient management of chemicals, the purpose of chemical inventory goes beyond warehousing requirements:

- It serves as key reference
- It can be used for identification and assessment of environment, health & safety hazards and risk
- It can be used as chemical management information tool

Elements of Inventories

Eco-map:

- Type and location of chemicals and chemical (containing) waste

Process flow diagram and mass-balancing

- Types of chemicals
- Processes involving chemicals
- Quantities of inputs and non-product outputs

Safety data sheets/technical data sheets/labels and markings

- Hazardous/non-hazardous
- Type of hazards

Chemical Inventory Template

Template 1: Chemical Inventory List

Factory Location:

Location:

Update by:

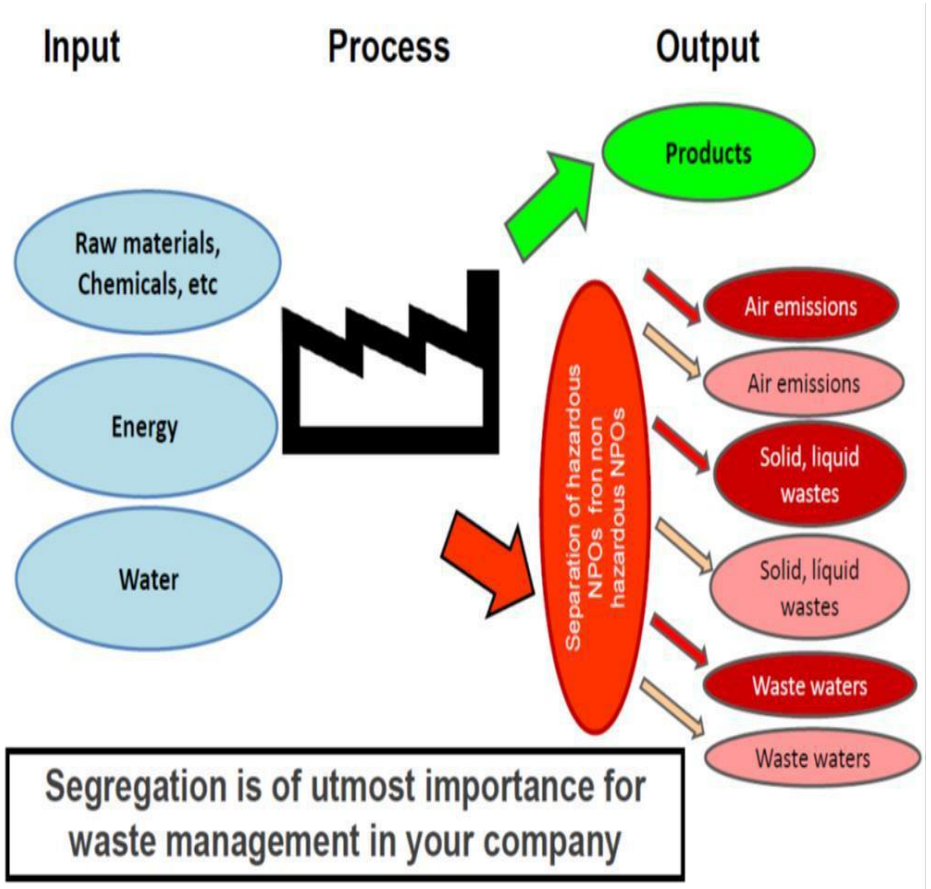
Date:

Area/Process	Chemical/ Trade name	Manufacturer/ Supplier name	Formulator/ supplier name	Purchase Info			CAS/EC member	MRSL/RSL compliant (Yes/No)	SDS Available (Yes/No)	Function/Use of the chemical	R-phrases Hazard statement	Hazard type			PPE required (as per SDS)	Storage condition (as per SDS)	Chemical in-stock	Chemical Used
				Date of Purchase	Date of expiration	Batch/Lot number						P	H	E				

NPO / Waste Inventory

Chemical process flow charts and eco-maps document and account for materials (chemicals) entering and leaving a system. The chemical inventory provides a comprehensive list of the chemicals entering your production. Not all of these chemical inputs end up in the final product, for example for technical/production process reason, fabrics will absorb only part of a dye stuff. These remaining chemicals (non-product outputs - NPO) leave the system as discharge into the air, water or residuals in solid or liquid form.

According to ZDHC CMS, factories are expected to plan how and where to safely store such chemical waste as well as to document where it is generated and how it will be disposed



NPO / Waste Inventory

The information/data gathered during the process flow analysis and mass/material balancing will provide key inputs in compiling an inventory of the non-product outputs in your factory and developing a (chemical) waste management plan and/or decide on measures to reduce non-product outputs, for example use of good basic manufacturing practices, process optimization, increase in chemical uptakes.

The remaining non-product outputs need to be managed and disposed. The on-site or off-site treatment processes themselves can produce chemical containing waste, for example treatment sludge, or used air filters.

Waste Inventory: Typical Template

Waste Name	Category/ Type	Source Process	Storage Area	Yearly Quantity	Associated Hazards	Disposal Method (actual/ recommended)	Wasted Disposal Vendor Address	License Number	License Validity Time

Example: European Waste List

Code	Designation	Note
H 1	Explosive	Substances and preparations which may explode under the effect of flame or which are more sensitive to shocks or friction than dinitrobenzene.
H 2	Oxidizing	Substances and preparations which exhibit highly exothermic reactions when in contact with other substances, particularly flammable substances.
H 3A	Highly Flammable	• Liquid substances (including extremely flammable liquids) and preparations having a flashpoint of below 21°C, or • Substances and preparations which may become hot and finally catch fire in contact with air at ambient temperature without any application of energy, or • Solid substances and preparations which may readily catch fire after brief contact with a source of ignition and which continue to burn or to be consumed after removal of the source of ignition, or • Gaseous substances and preparations which are flammable in air at normal pressure, or • Substances and preparations which, in contact with water or damp air, evolve highly flammable gases in dangerous quantities.
H 3B	Flammable	Liquid substances and preparations having a flashpoint equal to or greater than 21°C and less than or equal to 55°C.
H 4	Irritant	Non-corrosive substances and preparations which, through immediate, prolonged or repeated contact with the skin or mucous membrane, can cause inflammation.
H 5	Harmful	Substances and preparations which, if they are inhaled or ingested or if they penetrate the skin, may involve limited health risks.
H 6	Toxic	Substances and preparations (including very toxic substances and preparations) which, if they are inhaled or ingested or if they penetrate the skin, may involve serious, acute or chronic health risks and even death.
H 7	Carcinogenic	Substances and preparations which, if they are inhaled or ingested or if they penetrate the skin, may induce cancer or increase its incidence.
H 8	Corrosive	Substances and preparations which may destroy living tissue on contact.
H 9	Infectious	Substances containing viable micro-organisms or their toxins which are known or reliably believed to cause disease in man or other living organisms.
H 10	Toxic for reproduction	Substances and preparations which, if they are inhaled or ingested or if they penetrate the skin, may produce or increase the incidence of non-heritable adverse effects in the progeny and/or of male or female reproductive functions or capacity.
H 11	Mutagenic	Substances and preparations which, if they are inhaled or ingested or if they penetrate the skin, may induce hereditary genetic defects or increase their incidence.
H 12	-	Substances and preparations which release toxic or very toxic gases in contact with water, air or an acid.
H 13	Sensitizing	Substances and preparations which, if they are inhaled or if they penetrate the skin, are capable of eliciting a reaction of hyper-sensitization such that on further exposure to the substance or preparation, characteristic adverse effects are produced.
H 14	Ecotoxic	Substances and preparations which present or may present immediate or delayed risks for one or more sectors of the environment.
H 15	-	Substances and preparations capable by any means, after disposal, of yielding another substance, e.g. a leachate, which possesses any of the characteristics listed above.

Criteria that render wastes hazardous according to European Waste Regulation

Example: Textile Industry

EWL Code	European waste list (EWL) Classification	H (EU)	H (Basel)	Y (Basel)
04 02	Wastes from the textile industry			
04 02 09	Wastes from composite Mats (impregnated textile, elastomer, plastomer)			
04 02 10	Organic matter from natural products (for example grease, wax)			
04 02 14*	Wastes from finishing containing organic solvents	H3, H5	H3, H4.1	Y42
04 02 15	Wastes from finishing other than those mentioned in 04 02 14			
04 02 16*	Dyestuffs and pigments containing dangerous substances	H7, H3, H5, H8	H3, H11, H4.1	Y12
04 02 17	Dyestuffs and pigments other than those mentioned in 04 02 16			

Example: Textile Industry

EWL Code	European waste list (EWL) Classification	H (EU)	H (Basel)	Y (Basel)
04 02 19	Sludges from on-site effluent treatment containing dangerous substances	H4, H7, H10, H6	(H11, H6.1)	**Art. 1 (1) b**
04 02 20	Sludges from on-site effluent treatment other than those mentioned in 04 02 19			
04 02 21	Wastes from unprocessed textile fibres			
04 02 22	Wastes from processed textile fibres			
04 02 99	Wastes not otherwise mentioned			

Hazardous waste Characteristics (European Waste Regulation)

UN Class	Code	Characteristics
1	H1	Explosive An explosive substance or waste is a solid or liquid substance or waste (or mixture of substances or wastes) which is in itself capable by chemical reaction of producing gas at such a temperature and pressure and at such a speed as to cause damage to the surroundings.
3	H3	Flammable liquids The word “flammable” has the same meaning as “inflammable”. Flammable liquids are liquids, or mixtures of liquids, or liquids containing solids in solution or suspension (for example, paints, varnishes, lacquers, etc., but not including substances or wastes otherwise classified on account of their dangerous characteristics) which give off a flammable vapour at temperatures of not more than 60.5ºC, closed-cup test, or not more than 65.6ºC, open-cup test. (Since the results of open-cup tests and of closed-cup tests are not strictly comparable and even individual results by the same test are often variable, regulations varying from the above figures to make allowance for such differences would be within the spirit of this definition.)

Hazardous waste Characteristics (European Waste Regulation)

UN Class	Code	Characteristics
4.1	H4.1	Flammable solids Solids, or waste solids, other than those classed as explosives, which under conditions encountered in transport are readily combustible, or may cause or contribute to fire through friction.
4.2	H4.2	Substances or wastes liable to spontaneous combustion Substances or wastes which are liable to spontaneous heating under normal conditions encountered in transport, or to heating up on contact with air, and being then liable to catch fire.
4.3	H4.3	Substances or wastes which, in contact with water emit flammable gases Substances or wastes which, by interaction with water, are liable to become spontaneously flammable or to give off flammable gases in dangerous quantities.
5.1	H5.1	Oxidizing Substances or wastes which, while in themselves not necessarily combustible, may, generally by yielding oxygen cause, or contribute to, the combustion of other materials.

Hazardous waste Characteristics (European Waste Regulation)

UN Class	Code	Characteristics
5.2	H5.2	Organic Peroxides Organic substances or wastes which contain the bivalent-o-o-structure are thermally unstable substances which may undergo exothermic self-accelerating decomposition
6.1	H6.1	Poisonous (Acute) Substances or wastes liable either to cause death or serious injury or to harm human health if swallowed or inhaled or by skin contact.
6.2	H6.2	Infectious substances Substances or wastes containing viable micro-organisms or their toxins which are known or suspected to cause disease in animals or humans.
8	H8	Corrosives Substances or wastes which, by chemical action, will cause severe damage when in contact with living tissue, or, in the case of leakage, will materially damage, or even destroy, other goods or the means of transport; they may also cause other hazards

Hazardous waste Characteristics (European Waste Regulation)

UN Class	Code	Characteristics
9	H10	Liberation of toxic gases in contact with air or water Substances or wastes which, by interaction with air or water, are liable to give off toxic gases in dangerous quantities.
9	H11	Toxic (Delayed or chronic) Substances or wastes which, if they are inhaled or ingested or if they penetrate the skin, may involve delayed or chronic effects, including carcinogenicity.
9	H12	Ecotoxic Substances or wastes which if released present or may present immediate or delayed adverse impacts to the environment by means of bioaccumulation and/or toxic effects upon biotic systems.
9	H13	Capable, by any means, after disposal, of yielding another material, e.g., leachate, which possesses any of the characteristics listed above.

Best practices for storage

- Closure of containers
- Condition
- Compatibility
- Size (not larger than 55 Gallons)
- Labelling

Storage of hazardous chemicals

Best practices for storage of hazardous chemicals and waste

- Ensure all containers of hazardous chemicals are properly labeled with the identity of the hazardous chemical(s) and appropriate hazard warnings.
- Segregate all incompatible chemicals for proper storage of chemicals by hazard class. In other words, store like chemicals together and away from other groups of chemicals that might cause reactions if mixed.
- Do not store chemicals alphabetically except within a grouping of compatible chemicals.
- Flammable materials should be stored in an approved, dedicated flammable materials storage cabinet or storage room if the volume exceeds ten gallons. Keep cabinet doors closed.
- Chemicals should be stored no higher than eye level and never on the top shelf of a storage unit. Do not overcrowd shelves. Each shelf should have an anti-roll lip.
- Avoid storing chemicals on the floor (even temporarily) or extending into traffic aisles.

Source: CDC, USA

Best practices for storage of hazardous chemicals and waste

- Liquids should be stored in unbreakable or double-contained packaging, or the storage cabinet should have the capacity to hold the contents if the container breaks.
- Store acids in a dedicated acid cabinet. Store highly toxic or controlled materials in a locked, dedicated poison cabinet.
- Volatile or highly odorous chemical shall be stored in a ventilated cabinet. Chemical fume hoods shall not be used for storage as containers block proper air flow in the hood
- All chemicals should be labeled and dated upon receipt in the lab and on opening. This is especially important for peroxide-forming chemicals such as ethers, dioxane, isopropanol, and tetrahydrofuran.
- Solutions should be labeled and dated when prepared.

Source: CDC, USA

Disposal of Unknows

- If an unknown chemical is discovered – contact immediately for professional help for identification and analysis
- The chemical must be tested for flammability and toxicity
- Once it is confirmed that the chemical is none of those, it needs to be tested for acidity and alkalinity of the sample
- Finally, it can be disposed after neutralization of the sample
- However, if it is discovered to be flammable or, toxic, professional disposal bodies should be contacted

Gaps

- Implementation of procedures for handling hazardous materials;
- Procedure and standards for recycling of hazardous materials;
- Conditions for sale or transfer of hazardous materials for recycling;
- Treatment, storage and disposal facilities for hazardous wastes;
- Monitoring packaging labeling and storage of hazardous materials;
- Transportation of hazardous materials and manifest systems;
- Verifying reporting, records and returns;
- Legal liabilities, legal provisions and appeals
- Certified professional support for hazardous waste management service/facilities

Textile wastewater and its treatment

Effluent treatment – Concepts

- **In most part of world, pre-treated effluent discharged into municipal sewer for combined treatment in sewage treatment plants (STP)**
- **Some wastewater further treated and reclaimed as recovered water → ultimate of recovery = zero liquid discharge (ZLD).**
- **Main purpose of effluent treatment:**
  - Treated wastewater to be safely disposed or reused.
  - Effluent from textile processing operations considered as highly polluting warranting high level of treatment

Impact of untreated effluent

Possible impacts of untreated effluent

- **Water = Very valuable resource AND Wastewater = wasted water**

- **Effluent from textile processing containing various types of contaminants such as organic, inorganic and toxic.**
- **Discharge of untreated effluent → adverse impacts on receiving environment**
- **Organic matters most common pollutant**
  - major contaminant in most industrial effluents such as from distilleries, paper mills, textile factories, tanneries, breweries, fertilizer plants

Possible impacts of untreated effluent

- Damage to aquatic life, threatening availability of food for people and affecting livelihood of farmers
- Spoilt groundwater becoming unfit for domestic usage from effluent discharged to land and percolating
- Adverse effects on fertility and yield of crops and vegetation from effluent discharged on to land for irrigation
- Contamination of fresh surface water from discharge to water bodies, making unfit for further use

Treating organic and inorganic contaminants

Overview of effluent treatment – organic and inorganics

- **Organic contaminants**

- **Organic contaminants more predominant, except electroplating effluent with high level of inorganic contaminants**
- **Common treatment methods:**
  - Chemical precipitation
  - Biological degradation
  - Chemical oxidation.
  - Lower concentration of organics treated by adsorption too.

Overview of effluent treatment – organic and inorganics

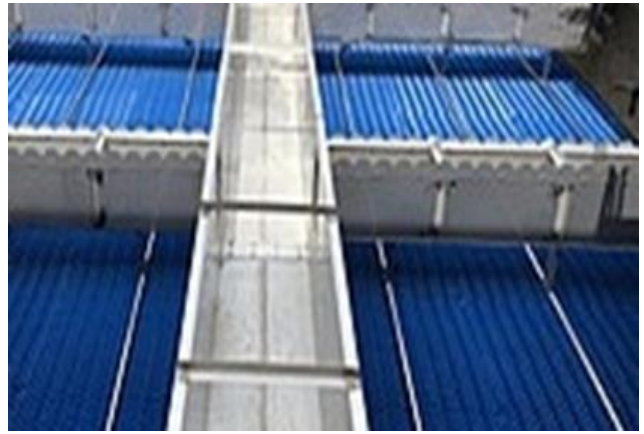
- **Organic contaminants**

- **Newer treatment technologies:**
  - thermal treatment
  - membrane based separation
  - plasma advanced oxidation
- **Very high organic effluents (e.g. spent wash from distilleries) treated for**
  - energy generation (e.g. bio-methanation)
  - co-composting.

Overview of effluent treatment – organic and inorganics

- **Inorganic contaminants – Heavy metals**

- **Vast variety of inorganic pollutants e.g. salts and heavy metals. most relevant in textile production**
- **Common treatment of metals through precipitation**
  - Possible for most heavy metals as their insoluble salts (such as hydroxides)
  - Precipitated by addition of lime and alum/ ferrous salts aided by polyelectrolytes.
  - Disadvantage: Metals transferred from liquid effluent to sludge and posing sludge disposal problem



Overview of effluent treatment – organic and inorganics

- **Inorganic contaminants – Salts**

- **Not possible to precipitate and remove salts, particularly that of sodium.**
- **Removal of salts by membrane technologies such as using Reverse Osmosis (RO).**
  - Membrane technologies leaving concentrated saline stream to be handled separately.
  - Saline reject further concentrated by evaporation/ distillation to separate it out in solid form.

Overview of effluent treatment – organic and inorganics

- **Inorganic contaminants – Salts**

  - **Concentration salt solutions (especially single salt solutions) to required levels for re-use**
  - **Less common technologies**
    - Ion-exchange
    - Electrolysis
    - Membrane distillation
    - Forward osmosis
    - Electrodialysis reversal EDR
    - Vapor compression

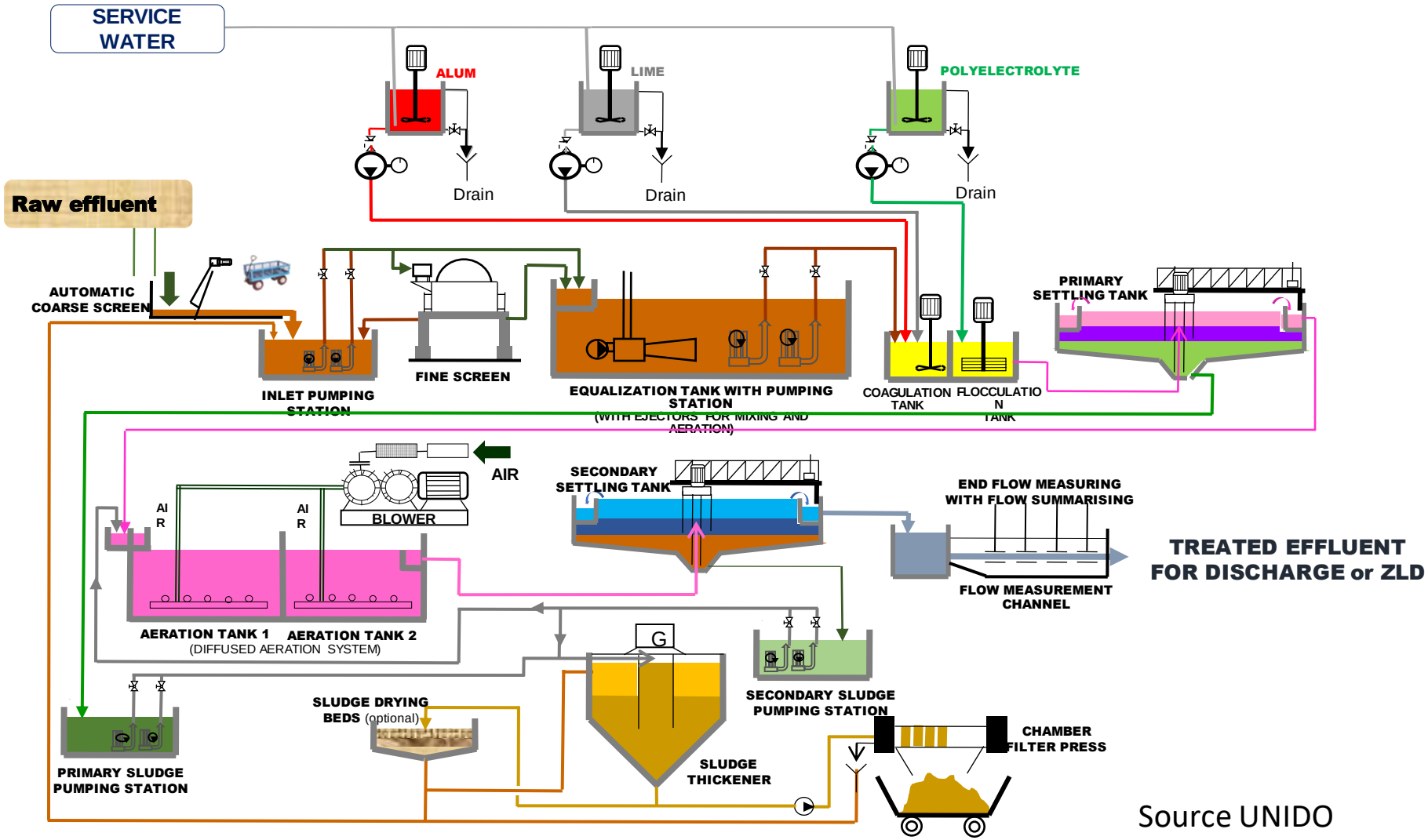
Common unit operations in effluent treatment

Unit operation	Functions	Common unit
Screening	• Removal of large particles (suspended or floating)	Manual/mechanical screens
Grit Removal	• Removal of sand like materials from the effluent.	Grit chamber
Equalization	• Homogenizing the characteristics of the effluent • Flow balancing.	Equalization tank Aerators, mixers
Coagulation/ flocculation	• Facilitating settling of colloidal solids & allowing the small solids to join together to form sludge.	Flash mixer & flocculator
Primary settling	• Removal of part organic/inorganic settleable solids	Primary clarifier/tube settler

Common unit operations in effluent treatment

Unit operation	Functions	Common unit
Biological treatment	• Removal of organics using microbial action	Aeration tank
Secondary settling	• Settling of bio-sludge, enabling biomass inventory	clarifier
Tertiary treatment	• Removes suspended solids/increase dissolved oxygen	Multigrade filter & aeration
Sludge dewatering	• Reducing moisture of liquid sludge to dried sludge	Sludge filter press/centrifuge
Sludge maturation	• Reducing moisture of dewatered sludge further	Sludge storage.

Flow chart of composite textile CETP



Source UNIDO

Organic pollutant removal

Organic pollution removal

- **Chemical precipitation**
  - **Targeting suspended and colloidal organics**
  - **Involving coagulation, flocculation and solids separation for removal but not destruction of organics.**
    - Commonly used coagulating agents: Metallic salts
    - Newer coagulation methods include electro coagulation.

Organic pollution removal

- **Chemical precipitation**
- **Basic concept**
  - Coagulated colloidal particles very small.
  - Combination of particles through flocculation to bigger flocs amenable to settling/flotation.
  - Solids separation through sedimentation as well as dissolved air flotation & filtrations

Organic pollution removal

- **Biological treatment**
  - **Most common method for organics**
  - **Basic concept:**
    - Micro-organisms used for ‘eating’ away pollutants, though actual metabolism complex.
    - Unlike in chemical treatment or filtration, organic compounds being destroyed

Organic pollution removal

- **Biological treatment**
- **Treatment categories:**

Aerobic treatment	Anaerobic treatment
Surplus oxygen in tank needed	Working in absence of oxygen
Conversion of organic material into carbon dioxide and water	Conversion of organic material into carbon dioxide and methane

Organic pollution removal

- **Anaerobic biological treatment**
- **Key features**
  - **Anaerobic micro-organisms, mostly bacteria, naturally degrading (putrefying) organic matter**
  - **Reactions mainly involving fermentation and bio-methanation**
  - **No need of air or oxygen in wastewater; anaerobic treatment less effective with dissolved air..**

Organic pollution removal

- **Anaerobic biological treatment**
- **Key features (contd.)**
  - **End product = mixture of gases (carbon dioxide and methane, other gases like hydrogen sulphide, if Sulphur containing compound in form of sulphide or sulphate).**
  - **Mixture of gas used as fuel for burning in boilers and for electricity production.**
  - **Anaerobic treatment more suitable for readily degradable high organic effluents**

Organic pollution removal

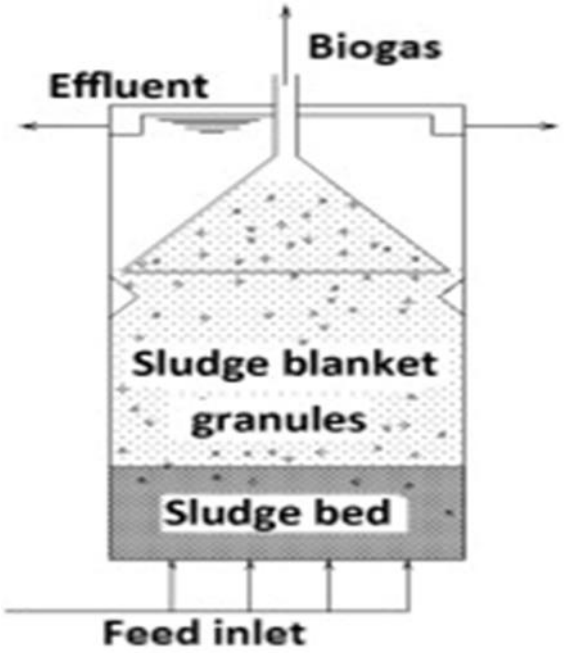
- **Anaerobic biological treatment**
- **Overview of systems**
  - ✓**Earlier anaerobic treatment units in form of anaerobic lagoons (ponds) storing effluent for long time (e.g. 30 - 40 days)**
  - ✓**Disadvantages: Large areas needed and odour issues; nowadays less common.**

Organic pollution removal

- **Anaerobic biological treatment**
- **Overview of systems**
  - **Anaerobic filters with media (synthetic media or even broken rubble chips)**
  - **High rate digestors with high organic reduction and maximum biogas production.**
  - **Sludge digestors with in built heating systems to make use of higher efficiency bacteria operating at higher temperature.**

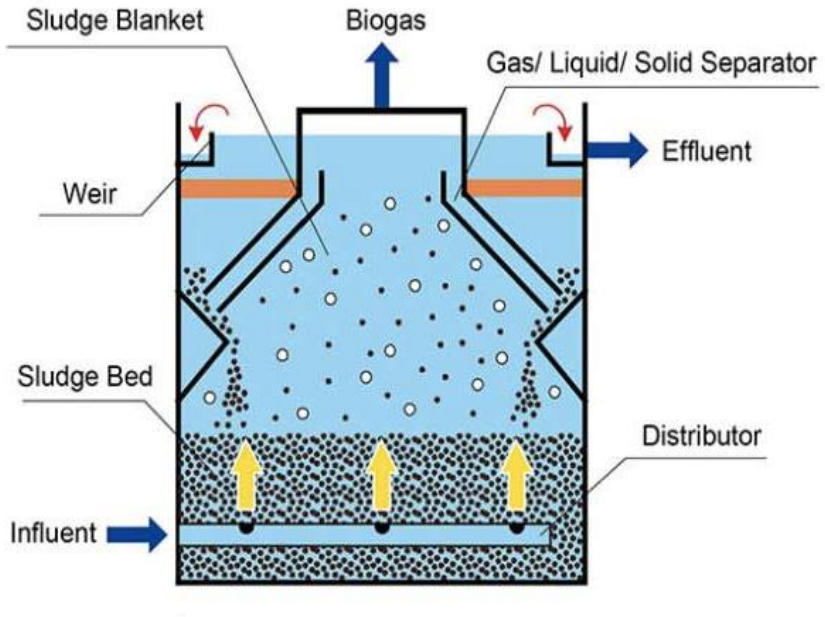
Organic pollution removal

- **Anaerobic biological treatment**
- **Emerging systems**
  - **Upflow anaerobic sludge blanket (UASB) reactors working on suspended bio-sludge containing microorganisms.**
    - Bio-sludge generated forming into granular shape after some time creating sludge blanket.
    - Kept in suspension due to upward flow of effluent in reactor.
    - Installed gas liquid solids separator at upper side of reactor to separate the bio-gas and to retain bio-sludge within reactor.



Organic pollution removal

- **Anaerobic biological treatment**
- **Emerging systems**
  - **Fluidized media bed reactors and hybrid reactors (with fixed filter and moving bio-sludge).**



Modified UASB process
(Source: ITRI, Taiwan)

Organic pollution removal

- **Aerobic biological treatment**
- **Key features**
  - **Aerobic micro-organisms, mostly bacteria, degrading organic matter into basic compounds.**
  - **End product: Carbon dioxide and water.**
  - **Once reaction completed organic matters completely destroyed.**
  - **Dissolved oxygen (DO) in water needed.**

Organic pollution removal

- **Aerobic biological treatment**
- **Key features (contd.)**
  - **Aeration concept and requirement:**
    - Organisms using up the oxygen; loss of oxygen to be compensated by external aeration
    - **Aeration systems increasing oxygen** in water through mixing water with air
    - Commonly done by either **bubbling air** into water or **splashing water** facilitating mixing of liquid and air at surface

Organic pollution removal

- **Aerobic treatment**
- **Common systems**
  - **Activated sludge process with bio-mass maintained in aeration tank.**
    - Sufficient quantity (inventory) of micro-organisms, mainly **bacteria to be kept in system**.
    - Depending on quality of inlet water, **small quantity of excess sludge** generated and to be disposed off.
    - Effluent with bio-sludge settled in clarifier
    - Settled bio-sludge returned back to aeration tank.

Organic pollution removal

- **Aerobic treatment**
- **Common systems**
  - **Depending on treatment duration activated sludge process:**
    - Conventional aeration
    - extended aeration, where extra aeration time provided for digestion of excess sludge

Example of common aerobic biological systems

Oxidation ditch

Conventional aeration tank

Organic pollution removal

- **Aerobic treatment**
- **Older systems**
  - **Being increasingly replaced**
  - **Examples**
    - Aerated lagoons, aerobic stabilization ponds due to high land area requirement and low efficiency.
    - Trickling filters with effluent being sprayed on media with wastewater trickling down sucking in atmospheric air for aeration.

Organic pollution removal

- **Aerobic treatment**
- **Emerging systems**
  - **Upgraded trickling filters with improved media**
    - Earlier media replaced with lighter synthetic media and with high level of media uniformity coefficient.
  - **Fluidized aerobic reactors common for smaller ETPs;**
  - **New ETPs using variant called as moving bed biological reactors (MBBR)**

Organic pollution removal

- **Aerobic treatment**
- **Emerging systems**
  - **Moving Bed Biological Reactors (MBBR):**
    - Aeration tank with special plastic media used for housing bacteria treating wastewater; sieves preventing escape of media.
    - Main advantages: **Less land required**, **lower operating cost.**
  - **Hybrid MBBR with suspended and attached growth systems.**

MBBR

Organic pollution removal

- **Aerobic treatment**
- **Emerging systems**
  - **Sequential batch reactor (SBR):**
    - Same tank used for both aeration and settling operations.
    - Automatic controls used for precise switching over between two tanks.
    - Used as batch process, usually with multiple units to continue operations.

SBR

Three Level Approach to Wastewater Limits

The guidelines provide a three-level approach for wastewater discharge limits, with the intent that suppliers actively execute a continuous improvement plan to reach the next level.

The three levels are:

- Foundational: At a minimum, meets legal discharge requirements and ensures effective control of ZDHC MRSL chemicals.
- Progressive: Demonstrates increasing knowledge of chemical management and applies advanced wastewater treatment processes.
- Aspirational: Demonstrates best-in-class performance and strives for continuous improvement in both chemicals and wastewater treatment process knowledge; creates industry best practices

Wastewater Parameters - Two Categories

- Conventional Parameters: Their limits are defined on the next slide and for standard methods for analysis refer to 2016 Wastewater Guidelines.
- ZDHC MRSL Parameters: These parameters, their reporting limits, and standard methods for analysis are defined for wastewater Tables 2A - 2N in 2016 Wastewater Guidelines.

Wastewater Parameters - Two Categories

The list includes:

- Alkylphenol (AP) and Alkylphenol Ethoxylates (APEOs): Including All Isomers.
- Chlorobenzenes and Chlorotoluenes.
- Chlorophenols.
- Dyes – Azo (Forming Restricted Amines).
- Dyes – Carcinogenic or Equivalent Concern.
- Dyes – Disperse (Sensitising).
- Flame Retardants.
- Glycols.
- Halogenated Solvents.
- Organotin Compounds.
- Perfluorinated and Polyfluorinated Chemicals (PFCs).
- Phthalates – Including all other esters of phthalic acid.
- Polycyclic Aromatic Hydrocarbons (PAHs).
- Volatile Organic Compounds (VOC).

Conventional Parameters

Zero discharge cannot be applied to conventional parameters, such as pH, COD. Hence foundational, progressive and aspirational limits are applied.

Where local legislation and/or permits do not cover one or more conventional parameters listed in these guidelines, the foundational level stated in these guidelines shall apply.

Conventional Parameters + sum anions + metals (mg/L unless otherwise noted)	Limits		
	Foundational	Progressive	Aspirational
Temperature [°C]	Δ15 or 35	Δ10 or 30	Δ5 or 25
TSS	50	15	5
COD	150	80	40
Total-N	30	10	5
pH	6-9		
Colour [Pt-Co]	150	50	10
BOD_5	30	15	5
Ammonium-N	10	1	0.5
Total-P	3	0.5	0.1
AOX	5	1	0.1
Oil and Grease	10	2	0.5
Phenol	0.5	0.01	0.001
Coliform [bacteria/100 ml]	400	100	25
Persistent Foam	Not visible		

ZDHC Guideline Document Draft Version

Conventional parameters showing foundational, progressive and aspirational limits.

Conventional Parameters + sum anions + metals (mg/L unless otherwise noted)	Limits		
	Foundational	Progressive	Aspirational
Anions			
Sulfide	0.5	0.05	0.01
Sulfite	2	0.5	0.2
Metals			
Antimony	0.1	0.05	0.005
Chromium, total	0.2	0.05	0.005
Cobalt	0.05	0.01	0.005
Copper	2	0.1	0.05
Nickel	0.2	0.02	0.005
Silver	0.1	0.01	0.001
Zinc	5	1	0.1
Arsenic	0.05	0.01	0.005
Cadmium	0.1	0.005	0.001
Chromium (VI)	0.05	0.005	0.001
Lead	0.1	0.01	0.005
Mercury	0.01	0.001	0.0005

EU laws should focus on reducing the amount of resources used across supply chains and on boosting the market for second-hand and repairable textiles. Fast fashion’s linear and exploitative business model must become a thing of the past.”

QUIZ

What are the three levels of ZDHC wastewater limits?

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