International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 04 Issue: 02 | Feb -2020 ISSN: 2582-3930

Industrial Waste Management

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Abstract - Systematic industrial waste management is one of an important issue due to high environmental risks caused by improper waste disposal. Types of industrial waste include dirt and gravel, masonry and concrete, scrap metal, oil, solvents, chemicals, scrap lumber, even vegetable matter from restaurants. Industrial waste may be solid, liquid or gaseous. It may be hazardous or non-hazardous waste. Hazardous waste may be toxic, ignitable, corrosive, reactive, or radioactive. Industrial waste may pollute the air, the soil, or nearby water sources, eventually ending up in the sea.

1. INTRIDUCTION

Cottage, small and medium scale industries in developing countries account for large share of employment and, in most cases, production. Recent growth of these classes of industries has been in response to high labour availability and low financial resources in most of these developing countries.

However, the urban management program of UNCHS (Habitat), together with World Bank, UNDP, and other collaborating agencies, have pointed out the general lack of technical know-how and adequate knowledge on waste management regarding the cottage, small and medium scale industries and their relative impact on the environment.

Waste is any substance which is discarded after primary use, or it is worthless, defective and of no use. The term is often subjective (because what is waste to one need not necessarily be waste to another) and sometimes objectively inaccurate (for example, to send scrap metals to a landfill is to inaccurately classify them as waste, because they are recyclable). Examples include municipal solid waste (household trash/refuse), hazardous waste, wastewater (such as sewage, which contains bodily wastes (feces and urine) and surface runoff), radioactive waste, and others.

Industrial waste is the waste produced by industrial activity which includes any material that is rendered useless during a manufacturing process such as that of factories, industries, mills, and mining operations. It has existed since the start of the Industrial Revolution. Some examples of industrial wastes are chemical solvents, paints, sandpaper, paper products, industrial by-products, metals, and radioactive wastes.

2. LITERATURE SURVEY

Wastes are unwanted or unusable materials. Waste is any substance which is discarded after primary use, or it is worthless, defective and of no use.

The term is often subjective (because what is waste to one need not necessarily be waste to another) and sometimes objectively inaccurate (for example, to send scrap metals to a landfill is to inaccurately classify them as waste, because they are recyclable). Examples include municipal solid waste (household trash/refuse), hazardous waste, wastewater (such as sewage, which contains bodily wastes (feces and urine) and surface runoff), and radioactive waste, among others. Industrial waste is the waste produced by industrial activity which includes any material that is rendered useless during a manufacturing process such as that of factories, industries, mills, and mining operations. It has existed since the start of the Industrial Revolution. Some examples of industrial wastes are chemical solvents, paints, sandpaper, paper products, industrial by-products, metals, and radioactive wastes. Other categories of waste include residential, commercial wastes, among others.

LEARNING OUTCOMES

After reading this guiding information in this article, it is expected that cottage, small and medium scale industries:-

1. Are aware of the additional sources of guidance and support that are available to them, for proper waste management.

2. Can appreciate the environmental and legislative importance of managing wastes in their industries.

3. Have an awareness of the broad range of risk and environmental issues that might impact their industries and host communities.

4. Have a broad understanding of the key aspects of waste management, especially the waste management options of reduction, reuse, recycling and disposal. Can identify potential areas within their business that may be able to reduce waste production, optimize recycling, and curb environmental pollution.

5. Can develop a waste disposal strategy for their organization; among others.

3. TYPES OF RISK ASSESSMENT ON INDUSTRIAL WASTE

There are three major interconnected steps involved in carrying out risk assessment on industrial waste: hazard identification, exposure assessment, and risk characterization.

1. **Hazard identification:** identifying and characterizing the source of the potential risk (e.g., chemicals managed in a waste management unit). the source of the potential risk has already been identified: waste management units. However, there must be a release of chemicals from a waste management unit for there to be exposure and risk. Chemicals can be released from waste management units by a variety of processes, including volatilization (where chemicals in vapor phase are released to the air), leaching to ground water (where chemicals travel through the ground to a groundwater aquifer), particulate emission (where chemicals attached to particulate matter are released in the air when the particulate matter becomes airborne), and runoff and erosion (where chemicals in soil water or attached to soil particles move to the surrounding area). To consider these releases in a risk assessment, information characterizing the waste management unit is needed. Critical parameters include the size of the unit and its location. For example, larger units have the potential to produce larger releases. Units located close to the water table might produce greater releases to ground water than units located further from the water table. Units located in a hot, dry, windy climate can produce greater volatile releases than units in a cool, wet, non-windy climate.

2. **Exposure assessment (Pathways, Routes, and Estimation):** determining the exposure pathways and exposure routes from the source to an individual. Individuals and populations can come into contact with environmental pollutants by a variety of exposure mechanisms and processes. The mere presence of a hazard, such as toxic chemicals in a waste management unit, does not denote the existence of a risk. Exposure is the bridge between what is considered a hazard and what actually presents a risk. Assessing exposure involves evaluating the potential or actual pathways for and extent of human contact with toxic chemicals. The magnitude, frequency, duration, and route of exposure to a substance must be considered when collecting all of the data necessary to construct a complete exposure assessment. The steps for performing an exposure assessment include identifying the potentially exposed population (receptors); pathways of exposure; environmental media that transport the contaminant; contaminant concentration at a receptor point; and receptor's exposure time, frequency, and duration. In a deterministic exposure assessment, single values are assigned to each exposure variable. For example, the length of time a person lives in the same residence adjacent to the facility might be assumed to be 30 years. Alternatively, in a probabilistic analysis, single values can be replaced with probability distribution functions that represent the range in realworld variability, as well as uncertainty. Using the time in residence example, it might be found that 10 percent of the people adjacent to the facility live in their home for less than three years, 50 percent less than six years, 90 percent less than 20 years, and 99 percent less than 27 years.

3. **Risk characterization:** In the risk-characterization process, the health benchmark

information (i.e., cancer slope factors, reference doses, and reference concentrations) and the results of the exposure assessment (estimated intake or dose by potentially exposed populations) are integrated to arrive at quantitative estimates of cancer and non-cancer risks. To characterize the potential non carcinogenic effects, comparisons are made between projected intake levels of substances and reference dose or reference concentration values. To characterize potential carcinogenic effects, probabilities that an individual will develop cancer over a lifetime are estimated from projected intake levels and the chemical-specific cancer slope factor value. This procedure is the final calculation step. This step determines who is likely to be affected and what the likely effects are.

ADVICE TO COTTAGE, MICRO, SMALL, AND MEDIUM ENTERPRISES ON TECHNIQUES TO USE FOR EFFICIENT WASTE MANAGEMENT SYSTEM:

There are two major levels of waste treatment*: primary and secondary levels*. Tertiary level is considered advanced and more sophisticated level. Advice will be based mostly on primary and secondary levels of waste treatment and management.

Primary treatment involves separating a portion of the suspended solids from the wastewater. Screening and sedimentation usually accomplish this separation process. *Secondary treatment* involves further treatment of the effluent. The effluent from primary treatment will ordinarily contain considerable organic material and will have a relatively high Biological Oxygen Demand (BOD). Biological processes generally accomplish the removal of the organic matter and the residual suspended solids. The effluent from secondary treatment usually has little BOD (30 mg/l as average) and a low suspended solids value (30 mg/l as average).

Some readily and moderately degradable compounds and substances are shown in table 1.

Table 1. Biodegradability of organic hazardous waste:

Readily degradable	**Moderately degradable**	**Recalcitrant**
Gasoline	Crude oil	TCE
Jet fuel	Lubricating oils	PCE
Diesel fuel	Coal tars	Vinyl chloride
Toluene	Cresotes	PCB
Benzene	Pentachlorophenol	DDT
Isopropyl alcohol	Nitro phenol	Chlordane
Methanol	Aniline	Heptachlor
Acetone	Long-chain aliphatic	
Phenol	Phthalates	

WASTE REDUCTION TECHNIQUES:

Industries should aim at source reduction, recycling and/or waste treatment.

Source Reduction means any practice which reduces the amount of any substance, pollutant, or contaminant entering any waste stream or otherwise released into the environment, prior to recycling, treatment, or disposal; and reduces the risks to public health and the environment associated with the release of such substances, pollutants, or contaminants. Where source reduction is not obtainable, recycling should be considered.

Recycling requires an examination of waste streams and production processes to identify opportunities. Recycling and beneficially reusing wastes can help reduce disposal costs, while using or reusing recycled materials as substitutes for feed stocks can reduce raw materials costs. Materials exchange programs can assist in finding uses for recycled materials and in identifying effective substitutes for raw materials. Recycling not only helps reduce the overall amount of waste sent for disposal, but also helps conserve natural resources by replacing the need for virgin materials. Where recycling is not obtainable, adequate waste treatment, followed by disposal, should be considered.

Treatment can reduce the volume and toxicity of a waste. Reducing a waste's volume and toxicity prior to final disposal can result in long-term cost savings. There are a considerable number of levels and types of treatment from which to choose. Selecting the right treatment option can help simplify disposal options and limit future liability.

INDUSTRIAL WASTE TREATMENT TECHNIQUES:

Treatment of non-hazardous industrial waste is not a federal requirement; however, it can help to reduce the volume and toxicity of waste prior to disposal. Treatment can also make a waste amenable for reuse or recycling.

Treatment involves changing a waste's physical, chemical, or biological character or composition through designed techniques or processes. There are three primary categories of treatment— physical, chemical, and biological.

Physical treatment involves changing the waste's physical properties such as its size, shape, density, or state (i.e., gas, liquid, solid). Physical treatment does not change a waste's chemical composition. One form of physical treatment, immobilization, involves encapsulating waste in other materials, such as plastic, resin, or cement, to prevent constituents from volatilizing or leaching. Few examples of physical treatment include Immobilization, Filtration, Carbon absorption, Distillation, Evaporation/volatilization, Grinding, Shredding, etc.

Chemical treatment involves altering a waste's chemical composition, structure, and properties through chemical reactions. Chemical treatment can consist of mixing the waste with other materials (reagents), heating the waste to high temperatures, or a combination of both. Through chemical treatment, waste constituents can be recovered or destroyed. Listed below are a few examples of chemical treatment. Few examples of chemical treatment include Neutralization, Oxidation, Reduction, Precipitation, Acid leaching, Ion exchange, Incineration, Thermal desorption, Extraction, etc.

Biological treatment can be divided into two categories– aerobic and anaerobic. Aerobic biological treatment uses oxygen-requiring microorganisms to decompose organic and non-metallic constituents into carbon dioxide, water, nitrates, sulphates, simpler organic products, and cellular biomass (i.e., cellular growth and reproduction). Anaerobic biological treatment uses microorganisms, in the absence of oxygen, to transform organic constituents and nitrogen-containing compounds into oxygen and methane gas (CH_4 (g)). Anaerobic biological treatment typically is performed in an enclosed digester unit. Few examples of biological treatment include;

• Aerobic: Activated sludge, Aerated lagoon, Trickling filter, Rotating biological contactor (RBC)

• Anaerobic digestion:

Some of these treatment techniques listed above, together will other treatment techniques, are discussed below:

Ion exchange chromatography

Ion exchange can be used for the removal of undesirable anionic and cationic substances from a wastewater. Cations are exchanged for hydrogen or sodium and anions for hydroxyl ions. Ion exchange resins consist of an organic or inorganic network structure with attached functional groups. Most ion exchange resins used in wastewater treatment are synthetic resins made by the polymerisation of organic compounds into a porous three-dimensional structure. Ion exchange resins are called cationic if they exchange positive ions and anionic if they exchange negative ions. Cation exchange resins are comprised of acidic functional groups, such as sulphonic groups, whereas anion exchange resins have basic functional groups, such as amine. The strength of the acidic or basic character depends upon the degree of ionisation of the functional groups, similar to the situation with soluble acids or bases. Thus, a resin having sulphonic acid groups would act as a strong acid cation exchange resin. For the other types of ion exchange resins, the most common functional groups are carboxyl (-COOH) for weak acid, quaternary ammonium (R_3N+OH-) for strong base, and amine (-NH_2 or -RNH) for weak base.

Oil and grease separation (Flotation)

In oil separation, free oil is floated to the surface of a tank and then skimmed off. The design of a gravity separator is based on the removal of all free oil globules larger than 0.15 mm. The Reynolds number is less than 0.5, so Stokes' law applies. Typically, effluent oil concentrations in the order of 50 mg/l are achieved. The hydraulic loading of a cross-flow corrugated plate separator varies with temperature and the specific gravity of the oil. Nominal flow rates are specified for a temperature of 20 °C and a specific gravity of 0.9 for the oil. A hydraulic loading of 0.5 m3 /m2 /h of actual plate area will usually result in separation of 0.06-mm droplets. Oil emulsions can be broken before separation by acidification, the addition of alum or iron salts, or the use of emulsion-breaking polymers.

Coagulation

Coagulation may be used for the clarification of industrial wastes containing colloidal and suspended solids. Paperboard wastes can be coagulated effectively with low dosages of alum. Silica or polyelectrolyte aids in the formation of a rapid-settling flock. Wastes containing emulsified oils can be clarified by coagulation. The oil droplets in water are approximately 10-5 cm and are stabilised by adsorbed ions. Emulsifying agents include soaps and anionactive agents. The emulsion can be broken by ―salting it out‖ with the addition of salts, such as $CaCl_2$. A lowering of the pH of the waste solution can also frequently break an emulsion.

Precipitation – heavy metals removal Precipitation is employed for removal of heavy metals from industrial effluents. Heavy metals are generally precipitated as hydroxide through the addition of lime or caustic (NaOH) to a pH of minimum solubility. The pH of minimum solubility varies with the metal in question. For example, the solubility of chromium and zinc are minimal at pH 7.5 and 10.2, respectively. When treating industrial wastewater that contains metals, it is necessary to pretreat the effluents to remove substances that will interfere with the precipitation of the metals. Cyanide and ammonia form complexes with many metals, limiting the removal of them. For many metals such as arsenic and cadmium, co-precipitation with iron or aluminum is highly effective for removal to low residual levels. In order to meet low effluent requirements, it may be necessary to provide filtration to remove flock carried over from the precipitation process. Filtration should reduce effluent concentrations to 0.5 mg/l or less. For chromium wastes treatment hexavalent chromium must first be reduced to the trivalent state Cr^{3+} and then precipitated with lime. The reducing agents commonly used for chromium wastes are ferrous sulphate, sodium meta-bisulphite, or sulphur dioxide.

Brine treatment

Brine treatment involves removing dissolved salt ions from the waste stream. Although similarities to seawater or brackish water desalination exist, industrial brine treatment may contain unique combinations of dissolved ions, such as hardness ions or other metals, necessitating specific processes and equipment.

Brine treatment systems are typically optimized to either reduce the volume of the final discharge for more economic disposal (as disposal costs are often based on volume) or maximize the recovery of fresh water or salts. Brine treatment systems may also be optimized to reduce electricity consumption, chemical usage, or physical footprint.

Brine treatment is commonly encountered when treating cooling tower blow down, produced water from steam assisted gravity drainage (SAGD), produced water from natural gas extraction such as coal seam gas, frac flow back water, acid mine or acid rock drainage, reverse osmosis reject, chlor-alkali wastewater, pulp and paper mill effluent, and waste streams from food and beverage processing.

Brine management

Brine management examines the broader context of brine treatment and may include consideration of government policy and regulations, corporate sustainability, environmental impact, recycling, handling and transport, containment, centralized compared to on-site treatment, avoidance and reduction, technologies, and economics. Brine management shares some issues with leachate management and more general waste management.

Solids removal

Most solids can be removed using simple sedimentation techniques with the solids recovered as slurry or sludge. Very fine solids and solids with densities close to the density of water pose special problems. In such case filtration or ultra filtration may be required. Although, flocculation may be used, using alum salts or the addition of polyelectrolytes

Oils and grease removal

The effective removal of oils and grease is dependent on the characteristics of the oil in terms of its suspension state and droplet size, which will in turn affect the choice of separator technology.

Oil pollution in water usually comes in four states, often in combination:

- free oil - large oil droplets sitting on the surface;
- heavy oil, which sits at the bottom, often adhering to solids like dirt;
- emulsified, where the oil droplets are heavily "chopped"; and
- dissolved oil, where the droplets are fully dispersed and not visible. Emulsified oil droplets are the most common in industrial oily wastewater and are extremely difficult to separate.

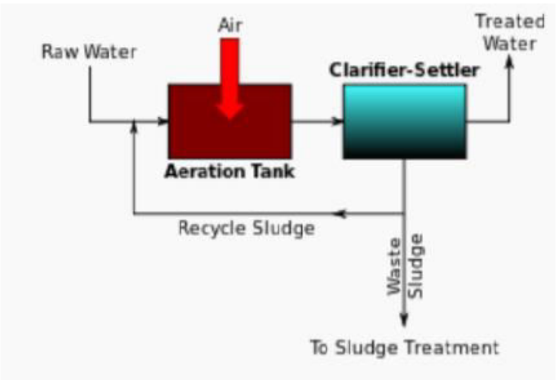
The methodology for separating the oil is dependent on the oil droplet size. Larger oil droplets such as those in free oil pollution are easily removed, but as the droplets become smaller, some separator technologies perform better than others.

Most separator technologies will have an optimum range of oil droplet sizes that can be effectively treated. This is known as the "micron rating."

Analysing the oily water to determine droplet size can be performed with a video particle analyser. Alternatively, there are commonalities in industries for oil droplet sizes. Larger droplets greater than 60 microns are often present in wastewater in workshops, re-fuel areas and depots. Twenty to 50 micron oil droplets often are present in vehicle wash bays, meat processing and dairy manufacturing effluent and aluminum billet cooling towers. Smaller droplets in the range of 10 to 20 microns tend to occur in workshops and condensates.

Removal of biodegradable organics Biodegradable organic material of plant or animal origin is usually possible to treat using extended conventional sewage treatment processes such as activated sludge or trickling filter. Problems can arise if the wastewater is excessively diluted with washing water or is highly concentrated such as undiluted blood or milk. The presence of cleaning agents, disinfectants, pesticides, or antibiotics can have detrimental impacts on treatment processes.

Activated sludge process



A generalized diagram of an activated sludge process.

Activated sludge is a biochemical process for treating sewage and industrial wastewater that uses air (or oxygen) and microorganisms to biologically oxidize organic pollutants, producing a waste sludge (or floc) containing the oxidized material. In general, an activated sludge process includes:

- An aeration tank where air (or oxygen) is injected and thoroughly mixed into the wastewater.
- A settling tank (usually referred to as a clarifier or "settler") to allow the waste sludge to settle. Part of the waste sludge is recycled to the aeration tank and the remaining waste sludge is removed for further treatment and ultimate disposal.

Trickling filter process

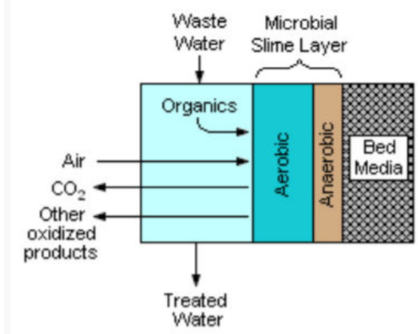
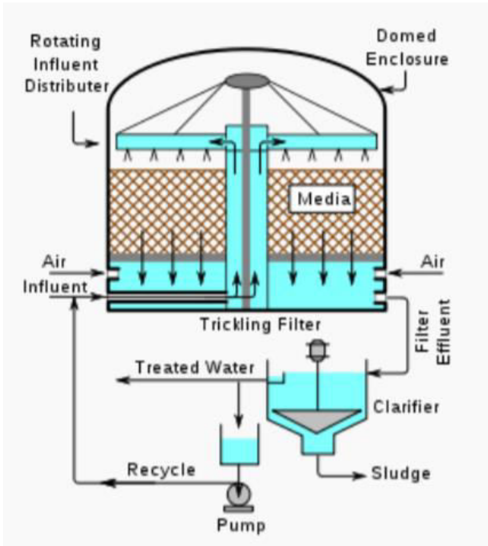


Image 1: A schematic cross-section of the contact face of the bed media in a trickling filter



A typical complete trickling filter system

A **trickling filter** consists of a bed of rocks, gravel, slag, peat moss, or plastic media over which wastewater flows downward and contacts a layer (or film) of microbial slime covering the bed media. Aerobic conditions are maintained by forced air flowing through the bed or by natural convection of air. The process involves adsorption of organic compounds in the wastewater by the microbial slime layer, diffusion of air into the slime layer to provide the oxygen required for the biochemical oxidation of the organic compounds. The end products include carbon dioxide gas, water and other products of the oxidation. As the slime layer thickens, it becomes difficult for the air to penetrate the layer and an inner anaerobic layer is formed.

The fundamental components of a complete trickling filter system are:

- A bed of filter medium upon which a layer of microbial slime is promoted and developed.
- An enclosure or a container which houses the bed of filter medium.
- A system for distributing the flow of wastewater over the filter medium.
- A system for removing and disposing of any sludge from the treated effluent.

The treatment of sewage or other wastewater with trickling filters is among the oldest and most well characterized treatment technologies.

A trickling filter is also often called a trickle filter, trickling biofilter, biofilter, biological filter or biological trickling filter.

2. CONCLUSIONS

The main sources of wastes in India are households, markets, institutions, streets, public areas, commercial areas and manufacturing industries. Waste generation in rural area is between 1.2 and 3.8 kg/day, low income 0.3 kg/capita/day and high income 0.66 kg/capita/day . There is often indiscriminate waste disposal without concern for human health impacts or environmental degradation, especially from household, cottage, small and medium scale industries.

Cottage, small and medium scale industries in urban area can use one (or combination) of some of the waste treatment techniques explained in this article to reduce environmental pollution and increase efficient waste management system. Treatment involves changing a waste's physical, chemical, or biological character or composition through designed techniques or processes. The three primary categories of treatment— physical, chemical, and biological – may be adopted for waste management to ensure sustainable green environment.

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