

Waste Management
in the Chemical and Petroleum Industries

ALIREZA BAHADORI

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Contents

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Dedicated to the loving memory of my Parents, grandparents, and to all who contributed so much to my work over the years.

Preface

Oil and gas are major sources of energy and revenue for many countries today – their production h been described as one of the most important industrial activities in the twenty-first century – a obviously waste treatment and disposal assume a greater degree of importance in the petroleu chemical processing, and unconventional oil and gas industries.

Wastewater quality and the quantity produced determine the means of disposal and the costs disposal. Suspended solids, total dissolved solids, and oxygen demand of produced waters have t most impact on wastewater treatment.

Wastewater is a complex mixture of organic and inorganic compounds and the largest byproduct b volume generated during chemical processing and both conventional and unconventional oil and g recovery operations. The potential of oilfield-produced water to be a source of freshwater for wate stressed oil-producing countries and increasing environmental concerns, in addition to stringe legislations on produced water discharge into the environment, have made produced wat management a significant part of the oil and gas business.

In marginally economic coal bed projects, the water disposal costs and attendant environment accounting are critical factors in the investment decision; water disposal costs can economically ma or break a marginal project.

Before investing in a coal bed methane (CBM) process, multiple questions need to be answer concerning the water to be produced – questions concerning quantity, flow-rates, chemical conte disposal means, monitoring, and environmental regulations. Perhaps no other factor affects t economics and feasibility of CBM projects as much as water removal and disposal.

In heavy oil production, between 2 to 4.5 volume units of water are used to produce each volu unit of synthetic crude oil in an ex situ mining operation. Despite recycling, almost all of it ends up tailings ponds. However, in Steam Assisted Gravity Drainage (SAGD) operations, 90–95% of t water is recycled and about 0.2 volume units of water is used per volume unit of bitumen produced.

A major hindrance to the monitoring of oil sands-produced waters has been the lack of identificati of individual compounds present. By better understanding the nature of the highly complex mixture compounds, including naphthenic acids, it may be possible to monitor rivers for leachate and also remove toxic components. Such identification of individual acids has for many years prov impossible, but a recent breakthrough in analysis has begun to reveal what is in the oil sands-produc waters.

The extraction and use of shale gas can affect the environment through the leaking of extracti chemicals and waste into water supplies, the leaking of greenhouse gasses during extraction, and t pollution caused by the improper processing of natural gas.

A challenge to preventing pollution is that shale gas extractions vary widely in this regard, eve between different wells in the same project; the processes that reduce pollution sufficiently in o extraction may not be enough in another.

Chemicals are added to the water to facilitate the underground fracturing process that releas natural gas. Fracturing fluid is primarily water and approximately 0.5% chemical additives (fricti reducer, agents countering rust, agents to kill microorganisms). Since (depending on the size of t area) millions of liters of water are used, this means that hundreds of thousands of liters of chemica are often injected into the soil.

Only about 50 to 70% of the resulting volume of contaminated water is recovered and stored above-ground ponds to await removal by tanker. The remaining “produced water” is left in the ear where it can lead to contamination of groundwater aquifers, though the industry deems this “high unlikely.” However, the wastewater from such operations often leads to foul-smelling odors and heav metals contaminating the local water supply above-ground.

This book unravels the essential requirements for the process design and engineering of th equipment and facilities pertaining to the wastewater treatment units, solid waste disposal, an wastewater sewer systems of oil and gas refineries, chemical plants, oil terminals, petrochemic plants, unconventional oil and gas industries (coal seam gas or coal bed methane, shale gas and o sands production), and other facilities as required. Included within the scope are:

- Liquid and solid disposal systems.
- Primary oil/solids removal facilities.
- Further oil and suspended solids removal (secondary oil/solids removal), such as dissolved air flotation units.
- Granular media filters and chemical flocculation units.
- Chemical addition systems.
- Biological treatments.
- Filtration and/or other final polishing.
- Sewage systems handling domestic and medical sanitary appliances of buildings.
- Drainage systems carrying surface and rainwater.
- Wastewater gathering systems.
- Clean water drainage, e.g., from buildings and paved areas.
- Evaporation ponds and disposal by natural percolation into the subsoil in permeable ground.
- Sanitary sewage treatment.
- Sludge handling and treatment.

It is obvious that the aim of any drainage/effluent disposal system should be to segrega uncontaminated water from contaminated water or effluents and to segregate different types effluents in order to reduce the size, complexity, and costs of any treatment units that may be require for handling the contaminated water and effluents before they are discharged from a unit.

All wastewater effluents from industry that are discharged to public and/or natural water sources directed for recycling purposes inside the industry, and that may contain a wide variety of matters solution or suspension, should be controlled according to the requirements imposed by the fin destination. However, in any case, elimination of the waste or the hazard potential of the waste shou be the ultimate goal in the management.

Under no circumstances should effluent water cause oil traces on the surface or embankments of th receiving water, or affect the natural self-purification capacity of the receiving water to such an exte that it would cause hindrance to other users.

Under no conditions should polluted streams be combined with unpolluted streams if the resulta stream will then require purification. In general, the main sewer systems in the industry will b segregated according to the following categories:

- Stormwater sewer systems.
- Oily water sewer systems.
- Non-oily water sewer systems.

- Chemical sewer systems.
- Sanitary sewer systems.
- Special sewer systems.

In all areas, including process, offsite, and utility units, provisions should be made to anticipate any the above mentioned sewer systems as required.

The treatment of wastewaters involves a sequence of treatment steps. Each wastewater treatme process involves the separation of solids from water in at least some part of the operation and th removal of biochemical oxygen demand (BOD) to some extent.

The end of pipe treatment sequence can be divided into the following elements: primary or pr treatment, intermediate treatment, secondary treatment and tertiary treatment plus ancillary, sludg dewatering, and disposal operations.

The key to optimizing the treatment sequence for provision of maximum water treatment minimum cost is to identify the rule of each unit operation and optimize that operation. Optimizin the performance of specific unit operations, such as API separators, dissolved air flotation, biologic treatment, etc., can best be achieved if:

1. The properties of influent streams are considered.
2. The chemical principles that are used in solids pre-treatment are understood.
3. The variety of chemicals available for solids treatment is recognized.
4. The properties of effluent water are established based on the local environmental regulations and final disposal.
5. The protocols for quantifying results are identified.

In general, most industries require water for processing or other purposes; much of this water after u is discharged either to public and/or natural water sources or directed for recycling purposes inside th industry.

Such discharge, which may contain a wide variety of matter in solution or suspension, should b controlled according to the requirements imposed by the final destination and/or environment regulations.

Moreover, according to the type of plant and the method of plant operation, the sources of solids in wastewater treatment plant can be uncovered. Solids may also be formed by interaction of was streams in the sewer.

Wastewaters contain metal ions, such as iron, aluminium, copper, magnesium, and so on, fron corrosion of the process equipment, chemicals used in treating cooling water, salts in the water intak and chemicals used in processing.

Insoluble metal hydroxide floc may be formed when alkaline wastes are discharged and raise the p of wastewater above neutral. The wastes, containing considerable concentrations of phenols, sulfide emulsifying agents, and alkalines, should be segregated. In general, discharging any material to th oily sewer system or other drainage system should be investigated in line with the final was treatment and disposal targets.

In view of the above, this book will unravel the fundamental engineering for waste recover treatment, and disposal systems in the petroleum, chemical, and unconventional oil and gas processin industries. These new fundamental discoveries will enable the development of practical solutions these pressing environmental issues.

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Biography

Alireza Bahadori, PhD is a research staff member in the School of Environment, Science Engineering at Southern Cross University, Lismore, NSW, Australia. He received his PhD from Curti University, Western Australia. For the better part of 20 years, Dr Bahadori had held various proces engineering positions and involved in many large-scale projects at NIOC, Petroleum Developme Oman (PDO), and Clough AMEC PTY LTD.

He is the author of over 200 articles and 6 books. His books have been accepted/published b prestigious publishers such as John Wiley & Sons, Springer, Taylor & Francis and Elsevier. D Bahadori is the recipient of highly competitive and prestigious Australian Government's Endeavou International Postgraduate Research award as part of his research in oil and gas area. He also receive top-up award from State Government of Western Australia through Western Australia Energy researc Alliance (WA:ERA) in 2009. Dr Bahadori Serves as a member of editorial board for a number o journals such as *Journal of Sustainable Energy Engineering* which is published by Wiley-Scrivener.

Wastewater Treatment

Wastewater treatment refers to the treatment of sewage and water used by residences, business, ar industry to a sufficient level that it can be safely returned to the environment. It is important to tre wastewater to remove bacteria, pathogens, organic matter, and chemical pollutants that can har human health, deplete natural oxygen levels in receiving waters, and pose risks to animals ar wildlife.

1.1 Characteristics of Wastewaters

A number of chemical and physical characteristics are used to describe wastewater. The most commo are:

- Biochemical Oxygen Demand (BOD). This is a measure of the amount of unstable organic matte in the water. It measures how much oxygen is required by the available microorganisms to break down the readily available organic matter into simpler forms, such as carbon dioxide, ammonia, and water.
- Total Nitrogen (TN) and Total Phosphorus (TP). These are the sum of all forms of nitrogen and phosphorus in the water, respectively.
- Fecal microbes (which include viruses, bacteria, and protozoans). These are found in wastewater and may cause disease.
- Suspended solids, biodegradable organics, nutrients, refractory organics, heavy metals, dissolved inorganic solids, and pathogens are important contaminants that may be found in the oil, gas, and chemical processing industry's wastewaters. Table 1.1 presents a list of important wastewater contaminants and reasons for their importance.

Table 1.1 *Contaminant importance in wastewater treatment.*

Contaminants	Reason for Importance
Physical suspended solids	Suspended solids are important for esthetical reasons and because they can lead to the development of sludge deposits and anaerobic conditions
Chemical biodegradable organics	Composed principally of proteins, carbohydrates, and fats, biodegradable organics are measured most commonly ir terms of BOD (Biochemical Oxygen Demand) and COD (Chemical Oxygen Demand). If discharged untreated to th environment, the biological stabilization of these materials can lead to the depletion of natural oxygen resources anc to the development of septic conditions.
Nutrients	Carbon, nitrogen, and phosphorus are essential nutrients for growth. When discharged to the aquatic environment, these nutrients can lead to the growth of undesirable aquatic life. When discharged in excessive amounts on land, they can also lead to the pollution of groundwater.
Refractory organics	These organics tend to resist conventional biological methods of wastewater treatment. Typical examples include surfactants, phenols, and agricultural pesticides
Heavy metals	Due to their toxic nature, certain heavy metals can negatively impact upon biological waste treatment processes anc stream life.

Dissolved inorganic solids	Inorganic constituents, such as calcium, sodium, and sulfate, are added to the original domestic water supply as a result of water use and may have to be removed if the wastewater is to be reused.
Biological pathogens	Communicable diseases can be transmitted by the pathogenic organisms in wastewater.

Suspended solids can be removed by physical treatment to some extent. Removal of biodegradab organics, suspended solids, and pathogens is achieved through the secondary treatment operatio units.

Table 1.2 shows typical waste compounds classified as priority pollutants. The more stringent rul deal with the removal of nutrients and priority pollutants. When wastewater is to be reused, rul normally include requirements for the removal of refractory organics, heavy metals, and in some ca dissolved inorganic solids.

Table 1.2 *Typical waste compounds classified as priority pollutants.*

Name (Formula)	Concern
	Non-metals
Arsenic (As)	Carcinogen and mutagen. Long term: sometimes cause fatigue and loss of energy; dermatitis.
Selenium (Se)	Long term: red staining of fingers, teeth, and hair; general weakness; depression; irritation of nose anc mouth.
	Metals
Barium (Ba)	Flammable at room temperature in powder form. Long term: increased blood pressure and nerve bloc
Cadmium (Cd)	Flammable in powder form. Toxic by inhalation of dust or fume. A carcinogen. Soluble compounds o cadmium are highly toxic. Long term: concentrates in the liver, kidneys, pancreas, and thyroid; hypertension suspected effect.
Chromium (Cr)	Hexavalent chromium compounds are carcinogenic and corrosive on tissue. Long term: skin sensitization and kidney damage
Lead (Pb)	Toxic by ingestion or inhalation of dust or fumes. Long term: brain and kidney damage; birth defects.
Mercury (Hg)	Highly toxic by skin absorption and inhalation of fume or vapor. Long term: toxic to central nervous system; may cause birth defects.
Silver (Ag)	Toxic metal. Long term: permanent gray discoloration of skin, eyes, and mucus membranes.
	Organic compounds
Benzene (C_6H_6)	Carcinogen. Highly toxic. Flammable, dangerous fire risk.
Ethylbenzene ($C_6H_5C_2H_5$)	Toxic by ingestion, inhalation, and skin absorption; irritant to skin and eyes. Flammable, dangerous fire risk.
Toluene ($C_6H_5CH_3$)	Flammable, dangerous fire risk, Toxic by ingestion, inhalation, and skin absorption.
	Halogenated compounds
Chlorobenzene (C_6H_5Cl)	Moderate fire risk. Avoid inhalation and skin contact.
Chloroethene (CH_2CHCl)	An extremely toxic and hazardous material by all avenues of exposure. A carcinogen.
Dichloromethane (CH_2Cl_2)	Toxic. A carcinogen, narcotic.
Tetrachloroethene (CCl_2CCl_2)	Irritant to eyes and skin.
Pesticides, herbicides, insecticides (Pesticides, herbicides, and insecticides are listed by trade name. The compounds listed are also halogenated organic compounds.)	
Endrin ($C_{12}H_8OCl_6$)	Toxic by inhalation and skin absorption, carcinogen.
Lindane ($C_6H_6Cl_6$)	Toxic by inhalation, ingestion, skin absorption.
Methoxychlor	Toxic material.

$[Cl_3CCH(C_6H_4OCH_3)2]$	
~~Toxaphene ($C_{10}H_{10}Cl_8$) Toxic by ingestion, inhalation, skin absorption.~~	
Silvex $[Cl_3C_6H_2OCH(CH_3)COOH]$	Toxic material; use has been restricted.

1.1.1 Suspended Solids

Typically, suspended solids carry a significant portion of organic material, thus significantl contributing to the organic load of the wastewater (solids can contribute up to 60% of the BOD of wastewater). Hence, effective solids removal can significantly contribute to wastewater treatment. widely-accepted means of testing a wastewater for suspended solids is to filter the wastewater throug a 0.45 μm porosity filter. Anything left on the filter after drying at about 103 °C is considered portion of the suspended solids. Table 1.3 provides another classification system for the solids foun in wastewater.

Table 1.3 *General classification of wastewater solids.*

Particle Classification	Particle Size, mm
Dissolved	Less than 10^{-6}
Colloidal	10^{-6} to 10^{-3}
Suspended	Greater than 10^{-3}
Settleable	Greater than 10^{-1}
Supracolloidal	10^{-3} to 10^{-1}

1.1.2 Heavy Metals

Any cation having an atomic mass (weight) greater than 23 (atomic mass of sodium) is considered heavy metal. Motivations for controlling heavy metal concentrations in gas streams are diverse. Son of them are dangerous to health or to the environment (e.g., mercury, cadmium, lead, chromium some can cause corrosion (e.g., zinc, lead), some are harmful in other ways (e.g., arsenic may pollu catalysts). Unlike organic pollutants, heavy metals do not decay and thus pose a different kind challenge for remediation.

Currently, plants or microorganisms are tentatively used to remove some heavy metals such mercury. Plants that exhibit hyper accumulation can be used to remove heavy metals from soils b concentrating them in their bio-matter. Some treatment of mining tailings has occurred where th vegetation is then incinerated to recover the heavy metals.

1.1.3 Dissolved Inorganic Solids

Total dissolved inorganic solids (TDIS) are a calculated value to assess the actual inorganic sa content of a water or process water.

The following procedure can be used to determine the inorganic dissolved solids in wastewaters. sample of wastewater is filtered through a 0.45 μm filter, filtrate is collected, the water is vaporize first (at 103 °C) and then the organic fraction (at 550 °C) from the filtrate. The amount of material le in the vessel after incineration at 550 °C is referred to as the fixed or inorganic dissolved solids level

1.1.4 Toxic Organic Compounds

Wastewater systems are known to contain toxic metals, organic micro pollutants, and pathogens th may add constraints to their beneficial uses. Environmental risks related to toxic inorganics, dioxir furans, and pathogens can be controlled by:

1. Selecting a wastewater system with a low content of regulated contaminants that respects the local legislation for land application.
2. Application of a decontamination process to remove toxic metals.
3. The necessary step of sterilization for monocultures that eliminates pathogens.

These toxic organic compounds eventually reach sewage treatment plants and can be concentrated wastewater systems. Disposal of wastewater systems is one way that these pollutants can l introduced into the environment. The presence of these toxic organic compounds can add constrain to the ultimate disposal of these sludges and/or reduce the possibilities for their beneficial use.

Tables 1.4 and 1.5 provide some organic compounds that are considered toxic and/or carcinogenic.

Table 1.4 *Toxic organic compounds; occupational exposure to carcinogenic substances.*

Compound	Site	Comment
Organic substances for which there is wide agreement on carcinogenicity		
4-Aminodiphenyl	Bladder	A contaminant in diphenylamine
Benzidine	Bladder	Ingredient of aniline dyes, plastics, and rubber
Beta-naphthylamine (2-NA)	Bladder	Dye and pesticide ingredient; synonym, 2- naphthylamine exposed workers have 30 to 60 times more cases of bladder cancer
Bis (chloromethyl) ether	Lung	Used in making exchange resins; exposed workers have 7 times more cases of lung cancer; synonym, BCME
Vinyl chloride	Liver	Angiosarcoma cases among PVC workers
Additional organic substances on USDA-OSHA cancer-causing substances list		
Alpha-naphthylamine (1-NA)	Bladder	Human case implicated; used in making dyes, herbicides, (1-NA) food colors, color film; ar antioxidant
Ethyleneamine	Unknown	Carcinogenic in animals; used in paper and textile processing and manufacture of herbicide resins, rocket and jet fuels
3, 3-Dichlorobenzidine	Unknown	Carcinogenic in animal species; exposure accompanies benzidine and betanaphthylamine
Methyl chloromethyl methyl ether	Unknown	Carcinogenic in animals; synonym, CMME; BCME contaminants CMME; used in resin-making, textile, and drug production.
4, 4-Methylene bis (2-chloroaniline)	Unknown	Synonym MOCA. Tumorigenic in rats and mice. Skin absorption may be the hazard. Curin agent for iso-cyanate polymers.

Table 1.5 *Industrial substances suspected of carcinogenic potential for humans.*

Industrial Substance	Industrial Substance
Antimony trioxide production	Epichlorhydrin
Benzene (skin)	Hexamethyl phosphoramide (skin)
Benzo(a) pyrene	Hydrazine
Beryllium	4, 4-Methylene bis (2-chloroaniline) (skin)
Cadmium oxide production	4, 4-Methylene dianiline
Chloroform	Monomethyl hydrazine
Chromates of lead and zinc	Nitrosamines
3, 3-Dichlorobenzidine	Propane sulfone
1, 1-Dimethyl hydrazine	Beta-propiolactone

Dimethyl sulfate	Vinyl cyclohexene dioxide
Dimethylcarbamyl chloride	

1.1.5 Surfactants

Surfactants, or surface-active agents, are large organic molecules that are slightly soluble in water ar cause foaming in wastewater treatment plants and in the surface waters into which the waste efflue is discharged.

The surfactants present in detergent products remain chemically unchanged during the washi process and are discharged down the drain with the dirty wash water. In the vast majority of cases, th drain is connected to a sewer and ultimately to a wastewater treatment plant, where the surfactan present in the sewage can be removed by biological and physical-chemical processes.

During aeration of wastewater, these compounds are collected on the surface of the air bubbles ar thus create a very stable foam. The determination of surfactants is accomplished by measuring th color change in a standard solution of methylene blue active substance (MBAS).

1.1.6 Priority Pollutants

Priority pollutants (both inorganic and organic) are selected on the basis of their known or suspecte carcinogenicity, mutagenicity, teratogenicity, or high acute toxicity. Many of the organic priorit pollutants are also classified as volatile organic compounds (VOCs).

Representative examples of the priority pollutants are shown in Table 1.2. Within a wastewat collection and treatment system, organic priority pollutants may be removed, transformed, generate or simply transported through the system unchanged. Five primary mechanisms are involved: (volatilization (also gas stripping); (2) degradation; (3) adsorption to particles and sludge; (4) transpo through the entire system; (5) generation as a result of chlorination or as byproducts of th degradation of precursor compounds.

1.1.7 Volatile Organic Compounds

Wastewaters are collected and treated in a variety of ways, some of which result in the emission volatile organic compounds (VOCs) from the wastewater to the air. Water may come into dire contact with organic compounds during a variety of different chemical processing steps, th generating wastewater streams that must be discharged for treatment or disposal. Direct conta wastewater includes:

- Water used to wash impurities from organic compound products or reactants.
- Water used to cool or quench organic compound vapour streams.
- Condensed steam from jet eductor systems pulling vacuum on vessels containing organic compounds.
- Water from raw material and product storage tanks.
- Water used as a carrier for catalysts and neutralizing agents (e.g., caustic solutions).
- Water formed as a byproduct during reaction steps.

Direct contact wastewater is also generated when water is used in equipment washes and spill clea ups. This wastewater is normally more variable in flow-rate and concentration than the streams liste above and may be collected in a way that is different from process wastewater. Wastewater strean generated by unintentional contact with organic compounds through equipment leaks are defined ~~“indirect contact” wastewater. Indirect contact wastewater may become contaminated as a result~~ leaks from heat exchangers, condensers, and pumps.

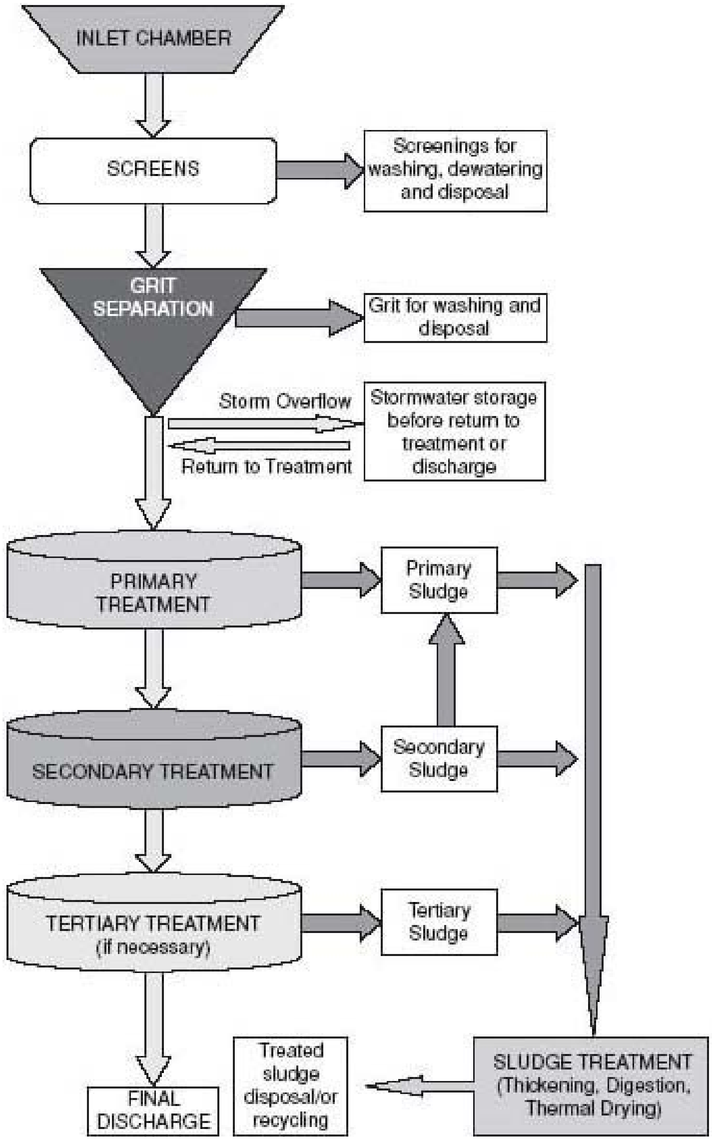
Organic compounds that have a boiling point ≤ 100 °C and/or a vapor pressure > 1 mm Hg (or 133 Pa) at 25 °C are generally considered to be volatile organic compounds (VOCs), e.g., vinyl chlorid The release of these compounds in sewers and treatment plants, especially at the head works, is particular concern with respect to the health of collection system and treatment plant workers.

1.2 Treatment Stages

Generally, the terms “preliminary” and/or “primary” refer to physical unit operations; “secondary refers to chemical and biological unit processes; and “advanced” or “tertiary” refer to combinations all three.

The application and definition of the various stages of treatment and methods to perform specif functions are described in the following sections. Figure 1.1 shows a schematic of wastewat treatment stages.

Figure 1.1 *A simplified schematic of wastewater treatment stages.*



1.2.1 Sources of Wastewater

Sources of wastewater in the oil, gas, and chemical processing industries include oily wastewater, so water, stripped sour water, water treatment waste, and blow-down streams (cooling tower, boiler, an gasifier) and so on. Each of these sources produces wastewater with slightly different characteristi and treatment requirements.

Table 1.6 provides typical wastewater qualities for some of the wastewater streams in the oil, ga and chemical processing industries.

Table 1.6 Typical wastewater qualities.

Parameter	Unit	Oily Wastewater	Stripped Sour Water	Combined High TDS Waters (Ion Exchange Waste, Boiler Blowdown, RO Reject)	Cooling Tower Blow-down
Temperature	°C	30–60	30–35	30–40	–
pH	–	7–8	7–8	7–8	8
TDS	mg/L	150–5000	50–150	500–2500	5000–6000
TSS	mg/L	300–800	10–20	50–100	16 000–19 000
Cl2 Residual	–	–	–	–	0.3–0.5
BOD	mg/L	300–500	100–300	5–150	–
COD	mg/L	300–1200	200–500	100–500	–
TOC	mg/L	–	–	<100	–
Hardness	mg/L as $CaCO_3$	–	–	–	1200–1400
Total Alkalinity	mg/L as $CaCO_3$	–	–	–	100–125
Ca^{2+}	mg/L	–	–	–	1000
Cl^-	mg/L	50–2000	–	–	1000–1500
NH_3	mg/L	20–50	40–80	–	<5
Cyanides	mg/L	1–3	–	–	–
Phenols	mg/L	5–20	20–80	–	–
H_2S	mg/L	5–10	10–40	–	–

1.2.2 Discharge Options and Quality Requirements

Produced water in the oil and gas industry has a complex composition, but its constituents can b broadly classified into organic and inorganic compounds including: dissolved and dispersed oil grease, heavy metals, radionuclides, treating chemicals, formation solids, salts, dissolved gases, sca products, waxes, microorganisms, and dissolved oxygen.

The four discharge alternatives listed below are all technically feasible. Selection of the preferr alternative is a function of the selected process, recycling opportunities, economics, regulato limitations, and social requirements. Process effects, which relate primarily to dissolved sol concentrations and financial implications, will be examined here.

- Physical and biological treatment followed by discharge to a river.
- Physical, biological, and chemical treatment followed by discharge to a river.
- Physical and biological treatment and recycling with deep well injection, thus no surface discharge.
- Physical and biological treatment, evaporation and crystallization, thus no discharge.

1.2.3 Preliminary Wastewater Treatment

Preliminary wastewater treatment is defined as the removal of wastewater constituents that may cau maintenance or operational problems within the treatment operations, processes, and ancilla systems.

Screening and comminution for the removal of debris and rags, grit removal for the elimination coarse suspended matter that may cause wear or clogging of equipment, and flotation for the remov of large quantities of oil and grease are examples of preliminary operations.

1.2.4 Primary Wastewater Treatment

In primary treatment a portion of the suspended solids and organic matter is removed from th wastewater. This removal is usually accomplished with physical operations such as screening an sedimentation.

The effluent from primary treatment will ordinarily contain considerable organic matter and wi have a relatively high BOD. The principal function of primary treatment continues to be as a precurs to secondary treatment.

Following primary treatment, the treated water is suitable for use as cooling water and utility wat but will require further treatment to be used as boiler feed water.

1.2.5 Conventional Secondary Wastewater Treatment

Secondary treatment is directed principally toward the removal of biodegradable organics an suspended solids. Disinfection is frequently included in the definition of conventional seconda treatment.

Conventional secondary treatment is defined as the combination of processes customarily used f the removal of these constituents, and includes biological treatment by activated sludge, fixed fil reactors, or lagoon systems and sedimentation.

1.2.6 Nutrient Removal or Control

Nutrient removal or control is generally required for:

1. Discharges to confined bodies of water where eutrophication might be caused or accelerated.

2. Discharges to flowing streams where nitrification could tax oxygen resources or where rootec aquatic plants could flourish.

3. Recharge of groundwaters that might be used indirectly for public water supplies.

The nutrients of principal concern are nitrogen and phosphors, and they may be removed b biological, chemical, or a combination of these processes. In many cases, the nutrient remov processes are coupled with secondary treatment; for example, biological denitrification may follow a activated-sludge process that produces a nitrified effluent.

1.2.7 Advanced Wastewater Treatment/Wastewater Reclamation

Advanced wastewater treatment or tertiary treatment is normally defined as the level of treatme required beyond conventional secondary treatment to remove constituents of concern, includin nutrients, toxic compounds, and increased amounts of organic material and suspended solids.

In addition to the nutrient removal processes, unit operations or processes frequently employed advanced wastewater treatment are chemical coagulation, flocculation, and sedimentation followed b ~~filtration and activated carbon. Less used processes include ion exchange and reverse osmosis~~ f specific ion removal or for reduction of dissolved solids.

Advanced wastewater treatment is also used in a variety of reuse applications where quality water required, such as for industrial cooling water and groundwater recharge.

1.2.8 Toxic Waste Treatment/Specific Contaminant Removal

The removal of toxic substances and specific contaminants is a complex subject and concentrations toxic pollutants are usually controlled by pre-treatment prior to discharge to the final treatme system. Many toxic substances, such as heavy metals, are reduced by some form of chemical-physic treatment such as chemical coagulation, flocculation, sedimentation, and filtration.

Some degree of removal is also accomplished by conventional secondary treatment. Wastewate containing volatile organic constituents may be treated by air stripping or by carbon adsorption. Sma concentrations of specific contaminants may be removed by ion exchange. Table 1.7 presents a list typical pollutants that have an inhibitory effect on the activated-sludge process.

Table 1.7 *Threshold concentrations of pollutants inhibitory to the activated-sludge process.*

	Concentration, mg/L	
Pollutant	Carbonaceous Removal	Nitrification
Aluminum	15–26	–
Ammonia	480	–
Arsenic	0.10	–
Borate (Boron)	0.05–100	–
Cadmium	10–100	–
Calcium	2500	–
Chromium (hexavalent)	1–10	0.25
Chromium (trivalent)	50	–
Copper	1	0.005–0.50
Cyanide	0.1–5	0.34
Iron	1000	–
Manganese	10	–
Magnesium	–	50
Mercury	0.1–5	–
Nickel	1–2.5	0.25
Silver	5	–
Sulfate	–	500
Zinc	0.8–1	
Phenols:	200	4–10
Phenol	−	10–16
Cresol	−	150
2-4 Dinitrophenol		

1.2.9 Sludge Processing

sample content of Waste Management in the Chemical and Petroleum Industries