BIOCHEMICAL , ENVIRONMENTAL ENGINEERING AND WATER TREATMENT

Chem. Ayman Abd El-Baky Ahmed
Environment Department
E.G.P.C

Eng. Ibrahem Mohamed Ibrahem
Environment General Manager
E.G.P.C

INDEX:-

CONTENTS	PAGE NO.

Environmental Considerations

- The environmental impacts of a proposed wastewater treatment facility are as important, if not more so, as cost considerations, a few comments regarding applicable environmental considerations that must also be addressed are appropriate.

- The environmental evaluations should focus on social, technical, ecological, economic, political, legal, and institutional (STEEPLI) criteria .

- Environmental Impact Statement (EIS) prepared for any proposed governmental action that is determined to have a significant impact on the quality of the human environment.

- The regulations ensure that the probable environmental effects are identified, that a reasonable number of alternative actions and their environmental impacts are considered, that the environmental information is available for public understanding and scrutiny, and that the public and governmental agencies participate as a part of the decision process.

- All pertinent regulations and the inherent participate afforded must be disclosed in the EIS.

- National Environmental Policy Act of USA (NEPA) neither prohibits nor permits any action but requires full disclosure of environmental information and public participation in the decision making process.

- Subpart E of EPA,s regulations sets forth the procedures and requirements for implementing the NEPA regulations for Municipal wastewater treatment construction Grants program under the clean water act.

- The basic elements of the process include the Environmental Information Document(EID), which is generated by the grantee (owner) as an integral part of a facilities plan.

- The EID is the basis for agency review of the environmental impacts of the facilities plan and preparation of an Environmental Assessment (EA).

- The EA must be of sufficient detail so as to be an adequate basis for EPA,s independent review and decision to issue a Finding of No Significant Impact (FNSI) or to issue a notice of intent for an EIS and subsequent record of decision.

- If an EIS is required, then following development of a draft EIS and input bases on public hearings, a final EIS is prepared .

- In the resultant record of decision, the findings and the recommended actions selected are summarized.

- To address these environmental considerations adequately , engineers should consult the current version of these regulations that require an integrated regional and grantee consultation process.

- In addition, appropriate environmental regulatory agencies should be consulted regarding applicable requirements.

Municipal Water Treatment

<u>Introduction: -</u>

-The objective of municipal water treatment is to provide a potable supply – one that is chemically and microbiologically safe for human consumption. For domestic uses, treated water must be aesthetically acceptable- free from apparent turbidity, color, odor, and objectionable taste.

-The objectives of a municipal water system are to provide safe, potable water for domestic use, adequate quantity of water at sufficient pressure for fire protection, and industrial water for manufacturing. A typical waterworks consists of a source-treatment-pumping and distribution system. Sources for municipal supplies are deep wells, rivers, lakes, and reservoirs. About two-thirds of the water for public supplies comes from surface-water sources. Large cities generally use major rivers or lakes to meet their high demand; whereas the majority of towns use well water if available often groundwater is of adequate quantity to preclude treatment other than chlorination and fluoridation. Wells can than be located at several points within the municipality, and water can be pumped directly into the distribution system.

-However, where extensive processing is needed, the well pumps, or low-lift pumps from the surface water intake, convey the raw water to the treatment plant site. A large reservoir of treated water (clear- well storage) provides reserves for the high demand periods and the equalizing of pumping rates. The high-lift pumps deliver treated water under high pressure through transmission mains to distribution piping and storage.

-The amount of water required by a municipality depends on industrial use, climate, and economic considerations.

- Quality requirements for industrial uses are frequently more stringent than for domestic supplies. Thus, additional treatment may be required by the industry. For an example, boiler feed water must be dematerialized to prevent scale deposits.

1. Water processing

-Common water sources for municipal supplies are deep wells, shallow wells, rivers, natural lakes, and reservoirs. Pollution and eutrophication are major concerns in surface-water supplies. Water quality depends on agricultural practices in the watershed, location of municipal and industrial outfall sewers, river development such as dams, Season of the year, and climatic conditions. Periods of high rainfall flush silt and organic matter from cultivated fields and forestland, while drought flows may result in higher concentrations of wastewater pollutants from sewer discharges. River temperature may vary significantly between summer and winter. The quality of water in the lack or reservoir depends considerably on season of the year. Municipal water quality control actually starts with management of the river basin to protect the source of water supply. Highly polluted waters are both difficult and costly to treat. Although some communities are able to locate groundwater supplies, or alternate less polluted surface sources within feasible pumping distance, the majority of the nation’s population draws from nearby surface supplies. The challenge in waterworks operation is to process these waters to a safe, potable product acceptable for domestic use.

2. Surface-Water Treatment Systems

2.1 Lake and Reservoir Water

-The primary process in Surface-water treatment is chemical clarification by coagulation, sedimentation, and filtration, as illustrated in figure (1).

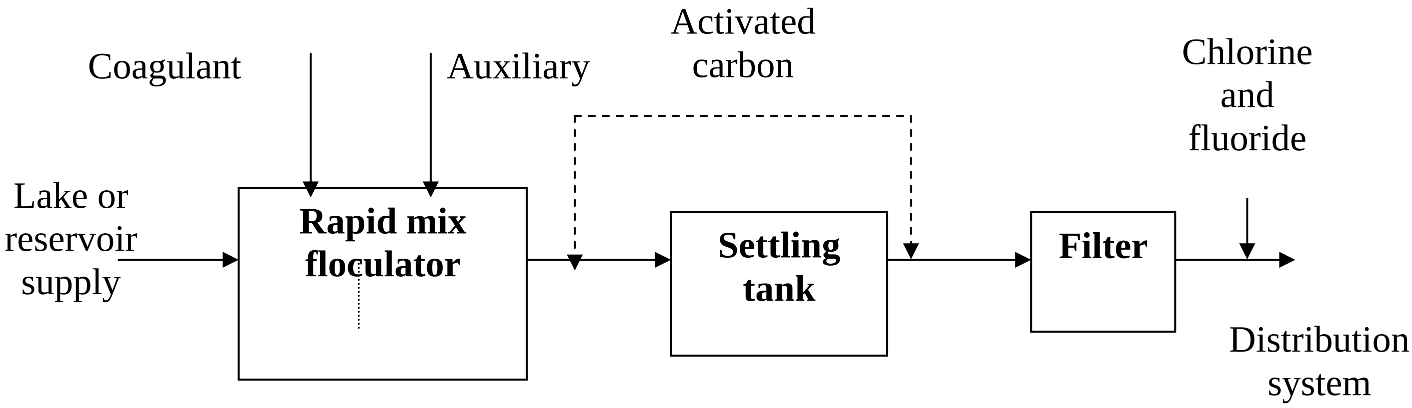

Figure (1) Schematic Patterns of Typical Lake or Reservoir
(Surface- Water Treatment System)

Lake and reservoir water has a uniform year-round quality and requires a lesser degree of treatment than river water. Natural purification results in reduction of turbidity, coliform bacteria, color, and elimination of day-to-day variations. On the other hand, growths of algae cause increased turbidity and may produce difficult- to-remove tastes and odors during the summer and fall. The specific chemicals applied in coagulation for turbidity removal depend on the character of the water and economic considerations. The most popular coagulant is alum (aluminum sulfate).

When alum is added to wastewater containing calcium and magnesium bicarbonate alkalinity, the reaction that occurs may be illustrated as follows:

$$Al_2(SO_4)_3 \cdot 18\,H_2O + 3\,Ca(HCO_3)_2 \Leftrightarrow 3CaSO_4 + 2\,Al(OH)_3 + 6\,CO_2 + 18\,H_2O$$

Aluminum sulfate   Calcium bicarbonate   Calcium sulfate   Aluminum hydroxide

As a flocculation aid, the common auxiliary chemical is a synthetic polymer. Activated carbon is applied to remove taste- and odor-producing compounds. Chlorine and fluoride are post-treatment chemicals. Pre-chlorination may be used for disinfections of the raw water only if it does not result in formation of tri-halomethanes.

When chlorine in the form of Cl_2 gas is added to water, two reactions take place: hydrolysis and ionization.

Hydrolysis may be defined as-

$$Cl_2 + H_2O \Leftrightarrow HOCl + H^+ + Cl^-$$

Ionization may be defined as-

$$HOCl \Leftrightarrow H^+ + OCl^-$$

The quantity of HOCl and OCl^- that is present in water is called the free available chlorine. The relative distribution of these two species is very important because the killing efficiency of HOCl is about 40 to 80 times that of OCl^-.

2.2 River Water

River supplies normally require the most extensive treatment facilities with greatest operational flexibility to handle the day-to-day variations in raw water quality. The preliminary step is often pre-sedimentation to reduce silt and settleable organic matter prior to chemical treatment as illustrated in figure (2), many river water treatment plants have two stages of chemical coagulation and sedimentation to provide greater depth and flexibility of treatment.

The units may be operating in series, or by split treatment, with softening in one stage and coagulation in the other. As many as a dozen different chemicals may be used under varying operating conditions to provide satisfactory finished water.

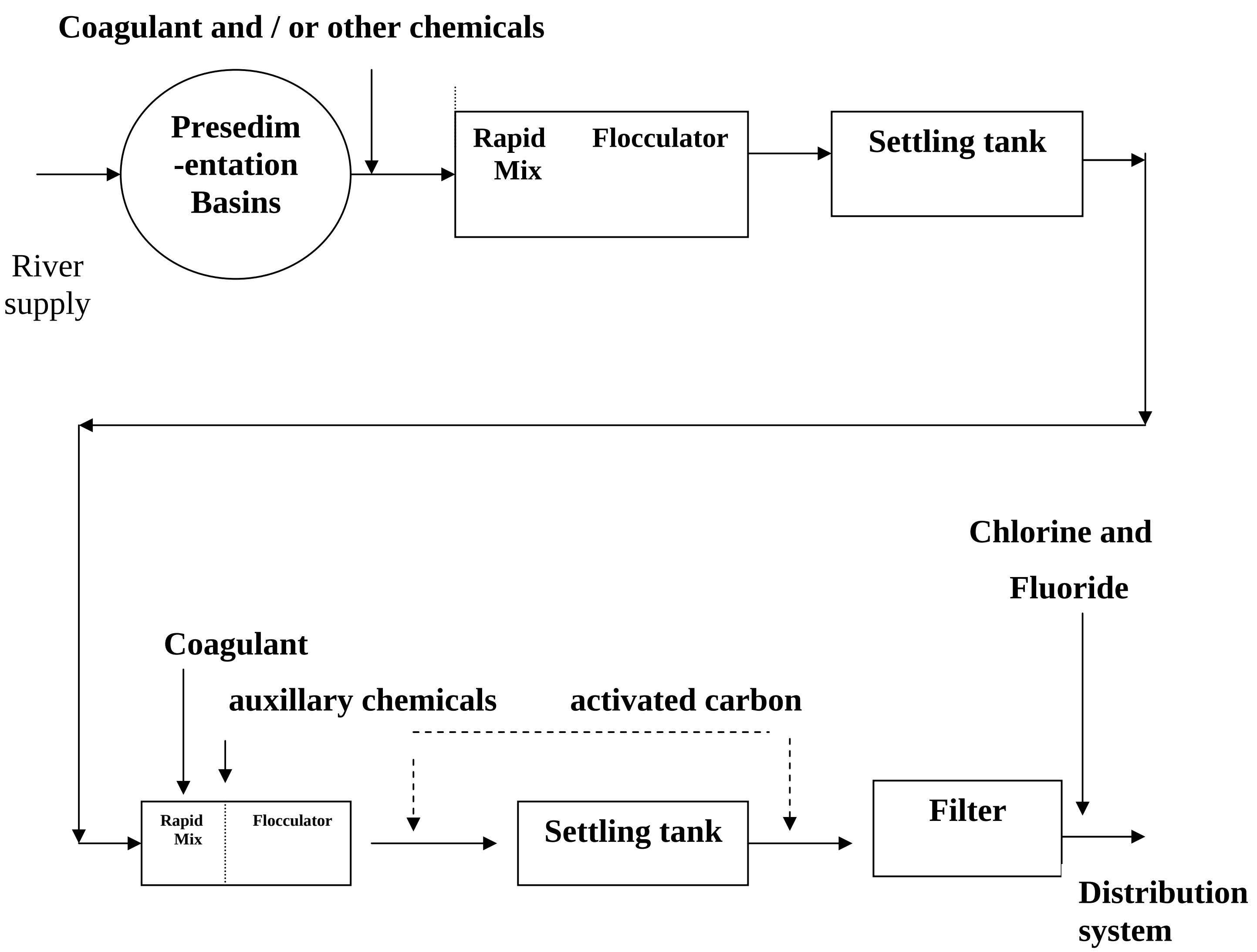

Figure (2) Schematic Patterns of Typical River supply
(Surface- Water Treatment System)

3 Wells Water

- Well supplies normally yield cool, uncontaminated water of uniform quality that is easily processed for municipal use. Processing may be required to remove dissolved gases and undesirable minerals. The simplest treatment illustrated in figure (3-a) is disinfection and fluoridation.

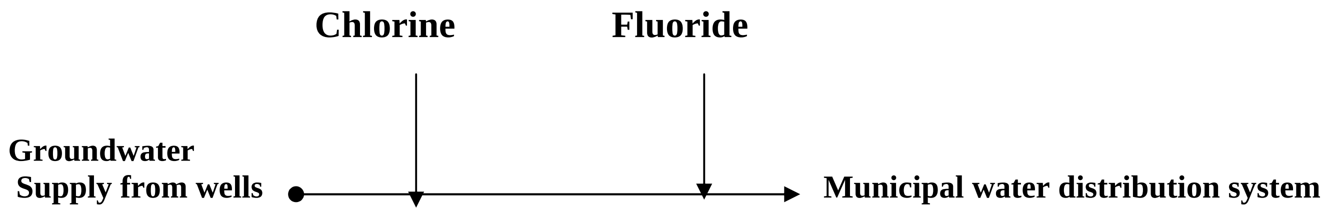

Figure (3-a) flow diagrams of typical groundwater treatment system
(disinfection and fluoridation)

- Deep well supplies may be chlorinated to provide residual protection against potential contamination in the water distribution system. In the case of shallow wells recharged by surface waters, chlorination can both disinfect the groundwater and provide residual protection. Fluoride is added to reduce the incidence of dental caries. Dissolved iron and manganese in well water oxidize when contacted with air, forming tiny rust particles that discolor the water. Removal is performed by oxidizing the iron and manganese with chlorine or potassium permanganate and removing the precipitations by filtration, figure (3-b).

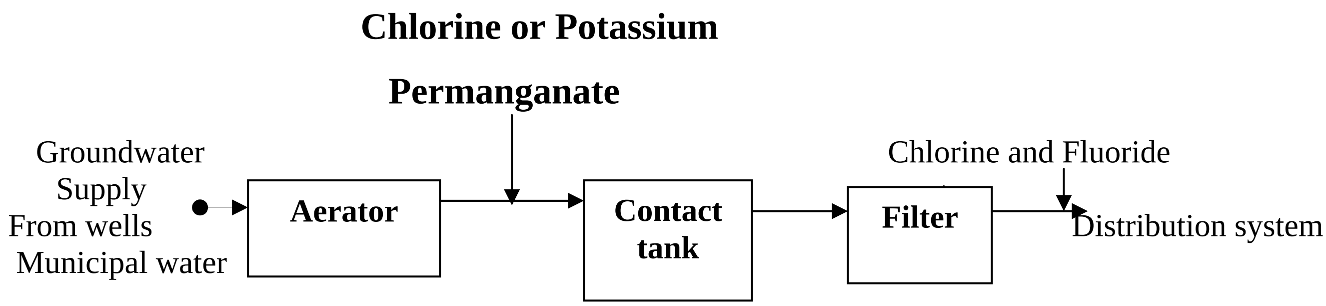

Figure (3-b) flow diagrams of typical groundwater treatment system
(Iron and Manganese Removal)

-Excessive hardness is commonly removed by precipitation softening, shown schematically in figure (3-c). Lime and, if necessary, soda ash are mixed with well water, and settleable precipitate is removed. Carbon dioxide is applied to stabilize the water prior to final filtration. Aeration is a common first step in treatment of most groundwater to strip out dissolved gases and add oxygen.

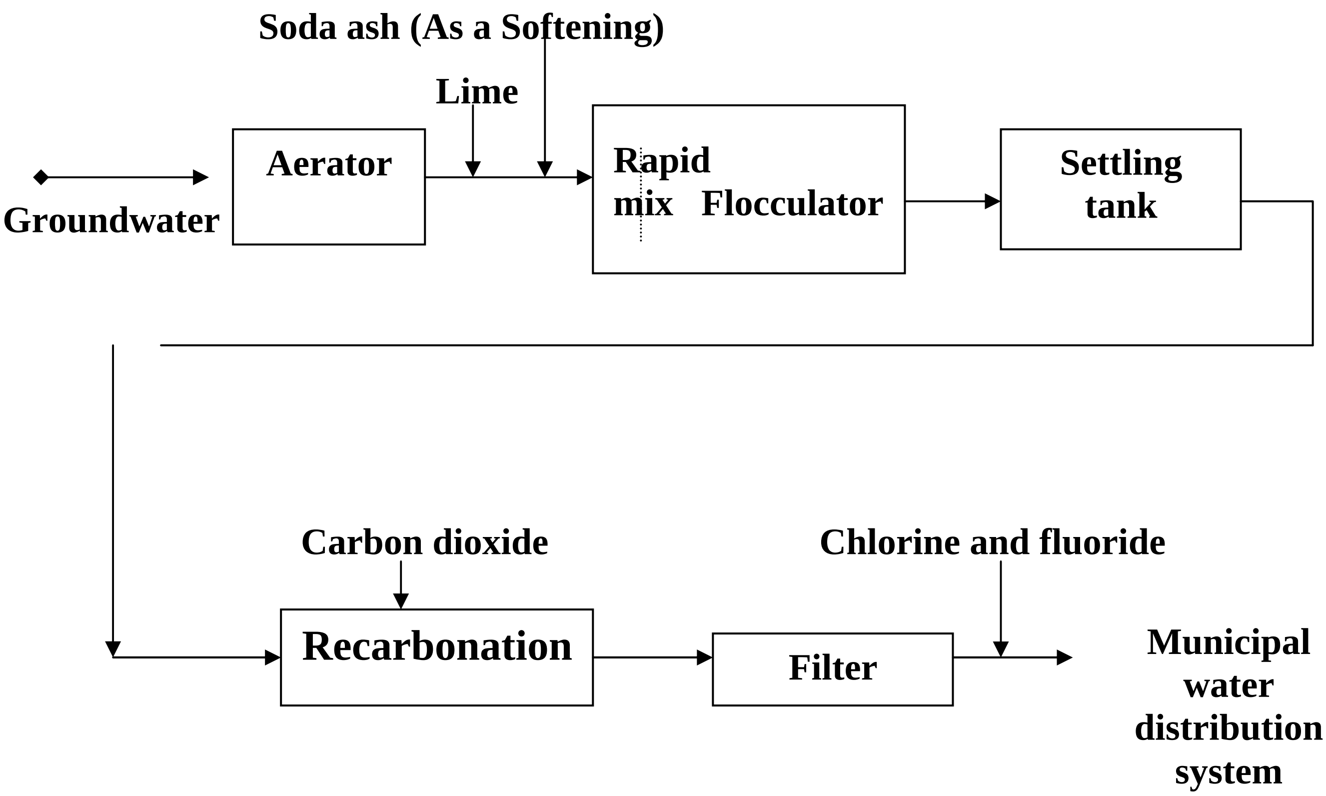

Figure (3-C) flow diagrams of typical groundwater treatment system (Precipitation Softening)

4 Waste Disposal From Water Treatment

- The two primary sources of waste from water treatment processes are sludge from the settling tank, resulting and wash water from backwashing filters. These discharges are highly variable in composition concentrated materials removed from the raw water and chemicals added in the treatment process. The wastes are produced continuously, but are discharged intermittently.

- Historically, the method of waste disposal was to discharge to a watercourse or lake without treatment. This practice was justified from the viewpoint that filter backwash waters and settled solids returned to the watercourse added no new impurities but merely returned material that had originally been present in the water. This argument is no longer considered valid, since water quality is degraded to the extent that a portion of the water is withdrawn, and chemicals used in processing introduce new pollutants. Therefore, more pollution control regulations have been enacted requiring treatment of waste discharges from water purification and softening facilities.

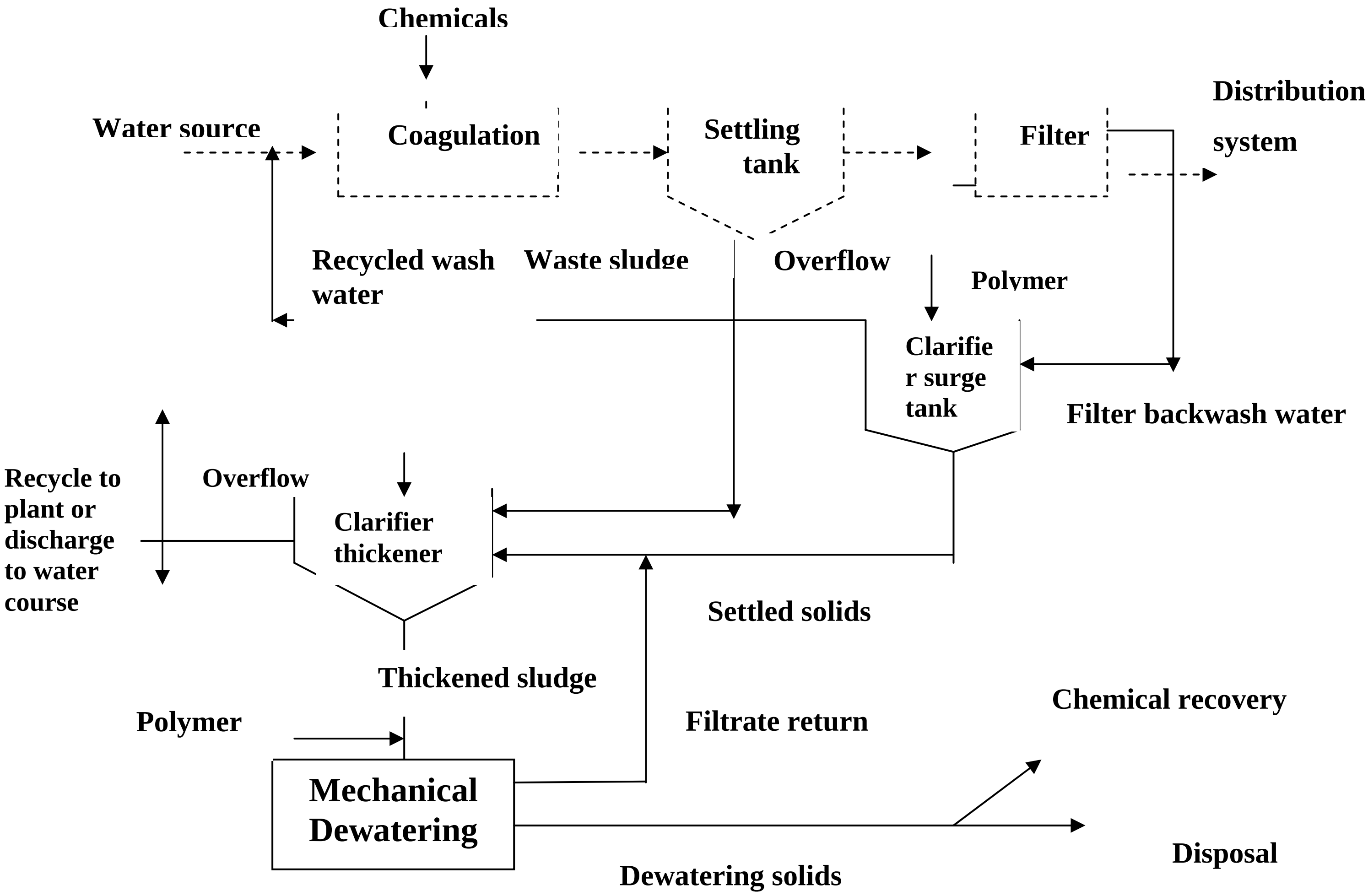

Figure (4) sketch of a dewatering system for alum sludge from a water treatment plant

- The situation of each waterworks is unique and controls to some extent the method of ultimate disposal of plant wastes. For example, they may be piped to a municipal sewer for processing or may be discharged to lagoons, provided that sufficient land area is available. Ultimate disposal by landfill, or barging to sea, requires thickening for economical handling and hauling. A variety of alternative processing methods are available; however, because of unique characteristics of each plant's waste, no specific process can be universally applied. Figure (4) is a typical system for dewatering alum sludge. Filter backwash water is discharged to a clarifier- surge tank. Overflow is recycled to the raw- water inlet of the treatment plant while settled solids are discharged, along with waste sludge from the settling tank, to a clarifier- thickener. Supernatant from this unit may be recycled to the head of the plant or may be discharged to a watercourse. Thickened sludge is mechanically dewatered, usually by centrifugation or filtration. Dewatered solids may be processed for recovery of chemicals or may be discharged to drying beds or to land burial.

-Basic information on common inorganic chemicals which using in the water and wastewater treatment plants:-

Name	Formula	Common usage
Activated carbon	C	Taste and odor control
Aluminum sulfate (filter alum)	$Al_2(SO_4)_3 .14.3\ H_2O$	Coagulation
Aluminum hydroxide	$Al\ (OH)_3$	Hypothetical combination
Ammonia	NH_3	Chloramines disinfection
Ammonium fluosilicate	$(NH_4)_2SiF_6$	Fluoridation
Ammonium sulfate	$(NH_4)_2SO_4$	Coagulation
Calcium bicarbonate	$Ca\ (HCO_3)_2$	Hypothetical combination
Calcium carbonate	$CaCO_3$	Corrosion control
Calcium fluoride	CaF_2	Fluoridation
Calcium hydroxide	$Ca\ (OH)_2$	Softening
Calcium hypochlorite	$Ca\ (OCl)_2 .2\ H_2O$	Disinfection
Calcium oxide (lime)	Ca O	Softening
Carbon dioxide	CO_2	Recarbonation
Chlorine	Cl_2	Disinfection
Chlorine dioxide	ClO_2	Taste and odor control
Copper sulfate	$CuSO_4$	Algae control
Ferric chloride	$FeCl_3$	Coagulation
Ferric hydroxide	$Fe\ (OH)_3$	Hypothetical combination
Ferric sulfate	$Fe_2(SO_4)_3$	Coagulation
Ferrous sulfate(copperas)	$FeSO_4 .7\ H_2O$	Coagulation
Fluosilicic acid	H_2SiF_6	Fluoridation
Hydrochloric acid	HCl	Not applicable
Magnesium hydroxide	$Mg\ (OH)_2$	Defluoridation
Oxygen	O_2	Aeration
Potassium permanganate	$KMnO_4$	Oxidation
Sodium aluminate	$NaAlO_2$	Coagulation
Sodium bicarbonate(baking soda)	Na_2HCO_3	pH adjustment
Sodium carbonate(soda ash)	Na_2CO_3	Softening
Sodium chloride(common salt)	NaCl	Ion – exchanger regeneration
Sodium fluoride	NaF	Fluoridation
Sodium hexametaphosphate	$(NaPO_3)_n$	Corrosion control
Sodium hydroxide	NaOH	pH adjustment
Sodium hypochlorite	NaOCl	Disinfection
Sodium silicate	Na_4SiO_4	Coagulation aid
Sodium fluosilicate	Na_2SiF_6	Fluoridation
Sodium thiosulfate	$Na_2S_2O_3$	Dechlorination
Sulphur dioxide	SO_2	Dechlorination
Sulfuric acid	H_2SO_4	pH adjustment

Sewage Wastewater Treatment

Introduction:

- Conventional wastewater treatment is a combination of physical and biological processes designed to remove organic matter from solution. The earliest method was plain sedimentation in septic tanks. Imhoff tanks used by municipalities were two – story septic tanks that separated the upper sedimentation zone from the lower sludge digestion chamber by a sloping bottom with a slot opening. Solids setting in the upper portion of the tank passed through the slot into the bottom compartment from which the digested sludge was periodically withdrawn for disposal.
- The final step in development of primary treatment was complete separation of sedimentation and sludge processing units. Currently, raw sludge is usually processed by biological digestion and mechanical dewatering .Primary sedimentation of municipal wastewater has limited effectiveness, since less than one-half of the waste organics are settleable .The initial attempt at secondary treatment involved chemical coagulation to improve settle ability of the wastes.
- Although this provided considerable improvement, the heavy chemical dosages resulted in high cost and dissolved organics were still not removed. The first major breakthrough in secondary treatment occurred when it was observed that the slow movement of wastewater through a gravel bed resulted in rapid reduction of organic matter. This process, referred to as trickling filtration, was developed for municipal installations starting in about 1910 .
- A more accurate term for a trickling filter is biological bed, since the process is microbial oxidation of organic matter by slimes attached to the stone, rather than a straining action. A second major advancement in biological treatment took place when it was observed that biological solids, developed in polluted water, flocculated organic colloids. These masses of microorganisms, referred to as activated sludge, rapidly metabolized pollutants from solution and could be subsequently removed by gravity

settling. In the 1920s, the first continuous- flow treatment plants were constructed using activated sludge to remove BOD from wastewater.

1. Classification Of Wastewater Treatment Methods:-

- A number of different treatment and disposal or reuse alternatives are then developed and evaluated, and the best alternative is selected. The contaminants in wastewater are removed by physical, chemical, and biological means. The individual methods usually are classified as physical unit operations, chemical unit Processes, and biological unit processes. Although these operations and processes occur in a variety of combinations in treatment system, it has been found advantageous to study their scientific basis separately because the principles involved do not change.

1.1. Physical Unit Operations:-

- Treatment methods in which the application of physical forces predominate are known as physical unit operations. Because most of these methods evolved directly from man's first observations of nature, they were the first to be used for wastewater treatment. Screening, mixing, flocculation, sedimentation, flotation, filtration, and gas transfer are typical unit operations.

1.2 Chemical Unit Operations:-

- Treatment methods in which the removal or conversion of contaminants is brought about by the addition of chemicals or by other chemical reactions are known as chemical unit processes.

Precipitation, adsorption, and disinfections are the most common examples used in wastewater treatment. In chemical precipitation, treatment is accomplished by producing a chemical precipitate that will settle. In most cases, the settled precipitate will contain both the constituents that may have reacted with the added chemicals and the constituents that were swept out of the wastewater as the precipitate settled.

Adsorption involves the removal of specific compounds from the wastewater on solid surfaces using the forces of attraction between bodies.

1.3 Biological Unit Processes:-

- Treatment methods in which the removal of contaminants is brought about by biological activity ore known as biological unit processes. Biological treatment is used primarily to remove the biodegradable organic substances (colloidal or dissolved) in wastewater. These substances are converted into gases that can escape to the atmosphere and into biological cell tissue that can be removed by settling. Biological treatment is also used to remove nutrients (nitrogen and phosphorus) in wastewater. With proper environmental control, wastewater can be treated biologically in most cases. Therefore, the engineer should provide the proper environment so that the process can operate effectively.

2. Application of Treatment Methods:-

- The principal methods now used for the treatment of wastewater and sludge are identified in this section. Detailed descriptions of each method are not presented because the purpose here is only to introduce the many different ways in which treatment can be accomplished.

Unit operations and processes are grouped together to provide various levels of treatment. Historically, the term preliminary and/ or primary referred to physical unit operations; secondary referred to chemical and biological unit processes; and advanced or tertiary referred to combinations of all three. These terms are arbitrary, however, and in most cases of little value. A more rational approach is first to establish the level of contaminant removal (treatment) required before the wastewater can be reused or discharged to the environment. The required unit operations and processes necessary to achieve that required level of treatment can then be grouped together on the basis of fundamental considerations. The contaminants of major interest in wastewater and the unit operations, processes, or methods applicable to the removal of these contaminants are shown in **table (1)**

Contaminant	Unit operation, unit process, or treatment system
Suspended solids	Screening and combinations – grit removal – sedimentation – filtration- flotation – chemical polymer addition – coagulation/ sedimentation – natural systems (land treatment)
Biodegradable organics	Activated –sludge variations – fixed- film reactor: tricking filters and rotating biological contactors – lagoon variations- intermittent sand filtration-physical- chemical systems - natural systems
Volatile organics	Air stripping – Off gas treatment – Carbon adsorption
Pathogens	chlorination - hypo chlorination – bromine chloride – Ozonation – UV radiation- natural systems
NUTRIENTS: nitrogen	Suspended - growth nitrification and denitrifcation variations - fixed - film nitrification and denitrifcation variations – ammonia stripping –ion exchange – breakpoint chlorination- natural systems
NUTRIENTS: phosphorus	Metal – salt addition – lime coagulation / sedimentation – biological phosphorus removal – biological & chemical phosphorus removal- Natural systems
NUTRIENTS: nitrogen& phosphorus	Biological nutrient removal
Refractory organics	Carbon adsorption – Tertiary ozonation - Natural systems
Heavy metals	Chemical precipitation – ion exchange- Natural systems
Dissolved organic solids	Ion exchange- reverse osmosis – electro dialysis

Table 1- Unit operation, unit process, or treatment system used to remove major contaminants found in wastewater.

2.1 Preliminary Wastewater Treatment:-

It is defined as the removal of wastewater constituents that may cause maintenance or operational problems with the treatment operations, processes, and ancillary systems. Examples of preliminary operations are screening and comminution for the removal of debris and rags, grit removal for the elimination of coarse suspended matter that may cause wear or clogging of equipment, and flotation for the removal of large quantities of oil and grease. Preliminary treatment in this text is distinguished from industrial pretreatment, where constituents are treated at their source before discharge to the sewer system.

2.2 Primary Wastewater Treatment:-

In primary treatment, a portion of the suspended solids and organic matter is removed from the wastewater. This removal is usually accomplished with physical operations such as screening and sedimentation. The effluent from primary treatment will ordinarily contain considerable organic matter and will have a relatively high BOD. Treatment plants using only primary treatment will be phased out in the future as implementation of the EPA secondary treatment requirements is completed. Only in rare instances (for those communities having a secondary treatment waiver) will primary treatment be used as the sole method of treatment. The principal function of primary treatment will continue to be as a precursor to secondary treatment.

2.3 Conventional Secondary Wastewater Treatment:-

Secondary treatment is directed principally toward the removal of biodegradable organics and suspended solids. Disinfections is included frequently in the definition of conventional secondary treatment. It is defined as the combination of processes customarily used for the removal of these constituents and includes biological treatment by activated sludge. Fixed- film reactors or lagoon systems and sedimentation.

2.4 Nutrient removal or control:-

The removal or control of nutrients in wastewater treatment is important for several reasons.

It is generally required for (1) discharges to confined bodies of water where eutrophication may be caused or accelerated, (2) discharges to flowing streams where nitrification can tax oxygen resources or where rooted aquatic plants can flourish, and (3) recharge of groundwater that may be used indirectly for public water supplies. in many cases , the nutrient removal processes are coupled with secondary treatment ; metal salts may be added to the aeration tank mixed liquor for the precipitation of phosphorus in the final sedimentation tanks, or biological denitrification may follow an activated sludge processes that produces a nitrified effluent .

2.5 Advanced wastewater treatment / wastewater reclamation:-

Advanced wastewater treatment is a term that has many definitions. Such as the level of treatment required beyond conventional secondary treatment to remove constituents of concern including 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 in advanced wastewater treatment are chemical coagulation, flocculation, and sedimentation followed by filtration and activated carbon. Less used processes include ion exchange and reverse osmosis for specific ion removal or for the reduction in dissolved solids. Advanced wastewater treatment is also used in a variety of reuse applications where a high quality of water is required such as for industrial cooling water and groundwater recharge. Some form of natural treatment (formerly termed land treatment) may also be equivalent to advanced wastewater treatment in terms of effluent quality.

3- Waste Water Processing:-

-The pictorial diagram in figure **(1)** summarizes processes applied in conventional municipal wastewater treatment.

- Preliminary steps include screening to remove large solids, grit removal to protect mechanical equipment against abrasive wear, flow measuring, and pumping to lift the wastewater above ground.

- Primary treatment is to remove settleable organic matter, amounting to 30 to 50 % of the suspended solids, and scum that floats to the surface.

- Secondary treatment is by aeration in open basins with return biological solids, or fixed – Media (Trickling) filters, followed by final settling.

- Excess microbial growth settled out in the final clarifier is wasted which the clear Supernatant may be disinfected with chlorine prior to discharge to a receiving watercourse.

Waste sludge's from primary settling and secondary biological flocculation are thickened and dewatered in Preparation for disposal.

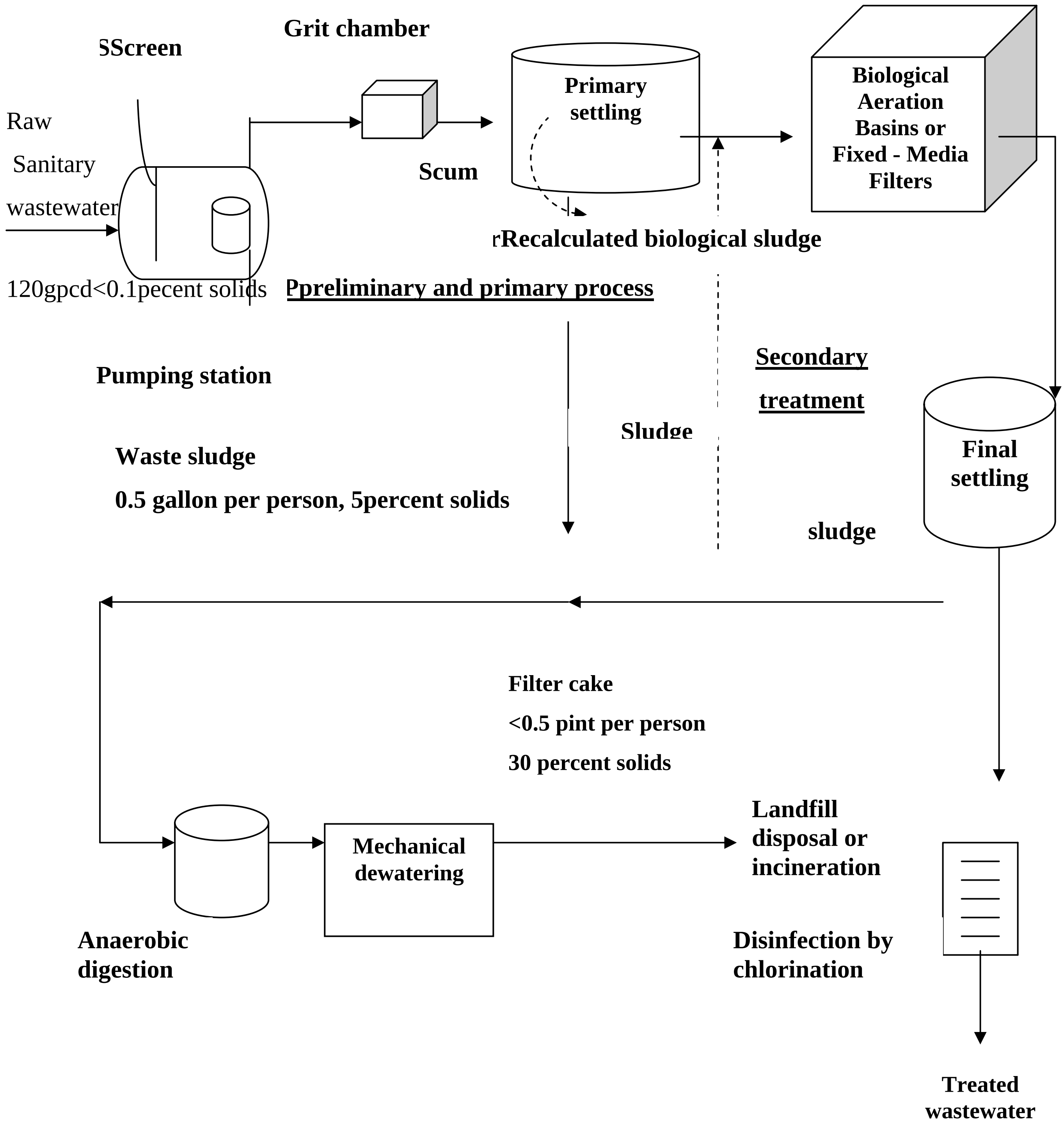

Figure (1) Schematic of a conventional municipal wastewater treatm... .floating, settle able, and biologically

Flocculated waste solids are removed from the water, stabilized and dewatered for ease of disposal.

Anaerobic bacterial digestion is used to stabilize the sludge prior to dewatering, or a mechanical process may be used to extract water directly from raw sludge after chemical conditioning. Ultimate disposal of dewatered solids may be by landfill, incineration, or land application if biologically stabilized. The overall process of conventional treatment can be viewed as thickening; pollutants removed from solution are concentrated in a small volume convenient for ultimate disposal. The contribution of raw sanitary wastewater is about **120 gal / person** (**400 L**) with a total solids content of less than **0.1 %**, **240 mg / l** suspended solids, and **200 mg/l BOD.**

Liquid waste sludge withdrawn from primary and secondary processing amounts to approximately **0.5 gal / person (2 L)** with solids content of **5 %**by weight. This is further concentrated to a handleable material by mechanical dewatering; the extracted water is returned for reprocessing. Cake from dewatering amounts to less than **0.5 pt/person (0.25 L)** with a **30 %** solids concentration.

This type of physical- biological scheme is effective in reducing the organic content of wastewater and accomplishes the major objective of **BOD** and suspended solids removal.

Dissolved salts and other refractory pollutants are removed to a lesser extent. Percent of total volatile solids, **70%** of total nitrogen, and **70%** of total phosphorus remain in the effluent after secondary biological treatment. Advanced wastewater treatment processes are needed to remove these refractory contaminants. Orthophosphate can be precipitated by chemical coagulation, nitrogen may be reduced by biological nitrification and denitrification, and activated carbon takes out refractory soluble organics. Completely mixed aeration without primary sedimentation figure **(2a)** is popular for treatment of small wastewater flows, for example, from subdivisions, villages, and tows. The size of aeration basins ranges from factory – built meta tanks with diffused aeration to accommodate the waste flow from a few hundred persons to mechanically aerated concrete- lined basins, such as an oxidation ditch, to serve a town with a population of several thousand.

Elimination of primary settling dramatically affects the character of waste sludge. Instead of a septic sludge with relatively high solids content, the waste is aerobic and much more voluminous with solids in the range of **0.5 to 2 %.**Therefore, the solids handling system for the flow scheme in figure**(2a)** frequently consists for aerobic digesters (aerated sludge holding tanks) and hauling of the stabilized liquid sludge for spreading on farmland. Larger plants may reduce the volume of sludge by gravity thickening in hopper- bottomed holding tanks after stabilization and dewatering by a belt filter press.

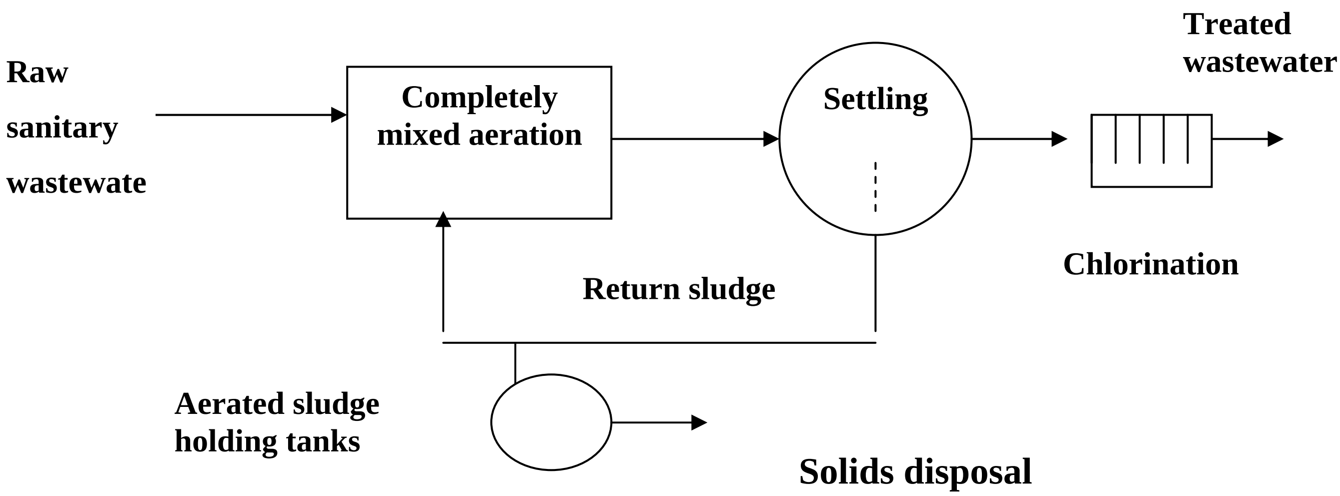

Figure (2- a) processing diagrams of system for treatment of small wastewater flow- biological processing without
Primary sedimentation.

Hundreds of villages and commercial establishments in rural areas use stabilization ponds for wastewater treatment figure **(2b)**. The organic loading applied to lagoons is very low and the liquid retention time is long, normally more than **90 days**.

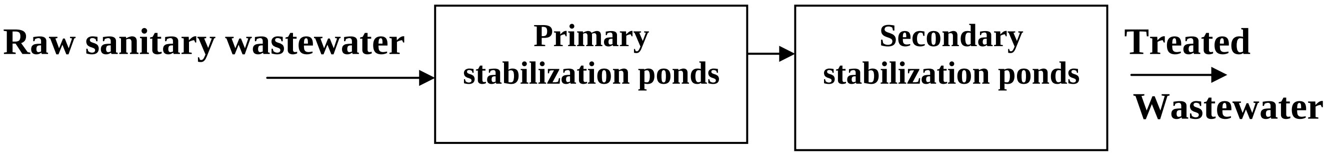

Figure (2- b) processing diagrams of system for treatment of small wastewater flow - Natural biological stabilization in ponds.

The natural biological processes that stabilize the waste are sketched in figure **(3).** In dry climates, the evaporation rate may equal or exceed the liquid loading so that the ponds provide complete retention of the wastewater. In other cases, stabilized wastewater is used for irrigation. Where lagoons overflow to streams, discharge of the treated wastewater may be limited to only warm seasons of the year when the natural purification in the lagoons is most efficient.

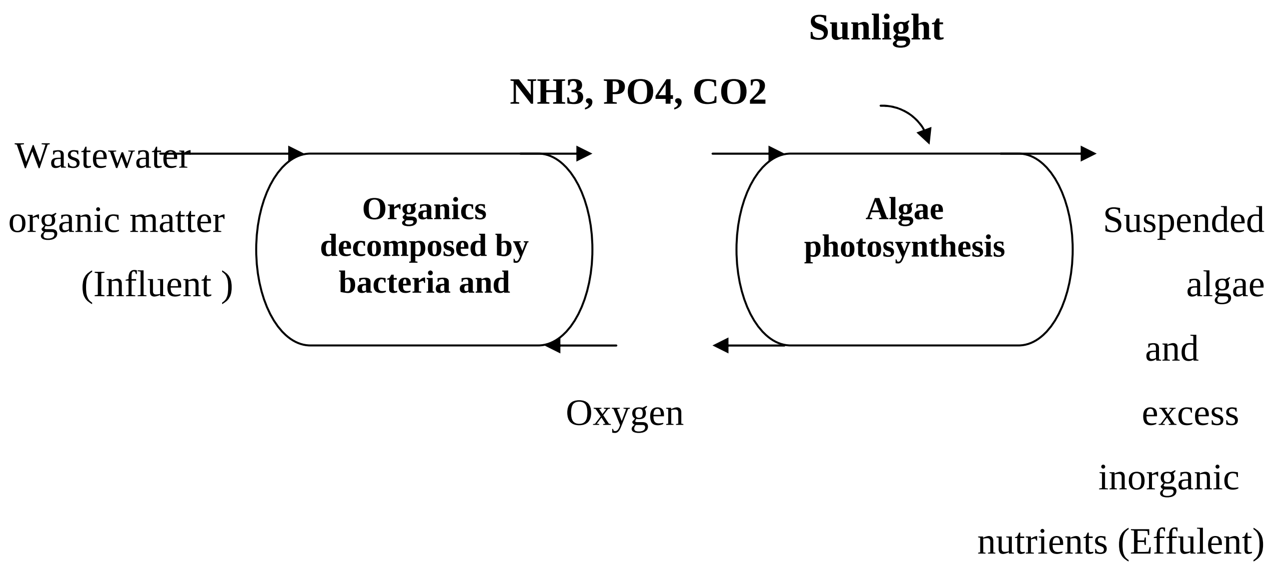

Figure (3) schematic diagram of the mutually beneficial association (symbiotic relationship) between bacteria and algae in a Stabilization pond.

Industrial (refinery) wastewater treatment

Introduction:-

- The purpose of wastewater treating is to upgrade the quality of effluent water so that it can be safety disposed of or recirculated to the refinery.
- Refinery wastewater typically contains oil, phenols, sulphides, ammonia, and/or dissolved and suspended solids. Some refinery wastewaters contain other organic and inorganic chemicals.
- The types of treatment processes utilized vary with the types of concentration of contaminant and with the effluent quality requirements.
- The types of equipment used for treating wastewater discharges can be generally classified as physical, biological, chemical and physical/chemical.
- The physical techniques are involved mainly with the removal of suspended and insoluble materials as opposed to dissolved materials.
- These include such techniques as air flotation devices, grit chambers, clarifiers, granular media filters, centrifuges, and oil separators.
- Biological treatment processes are designed for the biological degradable fraction of the wastewater.
- They include such unit operations as trickling filters, activated sludge, aerated lagoons, oxidation ponds, and rotating biological contactors.
- The choice of an overall plan for a particular refinery depends on an evaluation of many factors. Some of these factors are the characteristics of the receiving waters (e.g., flow rate, quality and use- present and projected); regulations pertaining to stream use and quality; quality and quantity of the wastewaters; quality and quantity of raw water available; refinery water requirements; and the land area available for wastewater treatment facilities.

- Five stages of wastewater treatment may be used in a refinery based on the type of wastewaters being treated and the quality and type of receiving waters. This stages are :

1- In-plant pre-treatment (including sour water stripping, neutralization, etc).
2- Primary treatment (oil/ water separation and removal of settleable solids).
3- Intermediate treatment (holding basins).
4- Secondary treatment (biological oxidation).
5- Tertiary treatment (activated carbon adsorption and filtration).

Wastewater pollutant sources:-

Pollutant	Sources
BOD5 , COD, Oil	- Process wastewater. - Cooling tower blow down (if hydrocarbons leak into cooling water system). - Ballast water. - Tank flow drainage and runoff
Total suspended solids	- Process wastewater. - Cooling tower blow down - Ballast water. -Tank flow drainage and runoff
phenolics	- Process wastewater (particularly from fluid catalytic cracking unit and cooker)
NH_3,H_2S, trace organics	- Process wastewater (particularly from fluid catalytic cracking unit and cooker)
Heavy metals	- Process wastewater. - Tankage wastewaters discharge. - Cooling tower blow down (if chromate type cooling water treatment chemicals are used).

Treatment of wastewater streams:-

- Proven refinery wastewater purification techniques are available and are presented below. These are present: In-plant pre-treatment, primary treatment, Intermediate treatment, Secondary treatment, Tertiary treatment.

1- In- plant pretreatment:-

In- plant pretreatment processes are applied to individual aqueous streams before those streams are combined with effluent flowing to primary treatment facilities. Some commonly used pretreatment processes include sour water stripping spent caustic oxidation or neutralization, acidic/ alkaline waste neutralization, and cooling tower and boiler blowdown treatment. Two additional in-plant methods of "pretreatment" include reduction of wastewater flow and of the load of contaminants, and segregated sewer system.

2- Primary treatment:-

- Primary treatment facilities are usually designed for oil/ water separation and for settleable solids from the water. Two widely used designs of gravity separators are the A.P.I separator and corrugated plant separators. In gravity separators, undissolved oil, present as small droplets in wastewater, is removed by using the lower specific gravity of oil as compared to water, which causes the oil to float to the surface, where it can be skimmed off.

3- Intermediate treatment:-

- Intermediate treatment consists of a holding basin to allow leveling of hydraulic and contaminant concentration surges (equalization), and chemical destabilization followed by dissolved air flotation units, sedimentation units, or granular media filtration units to remove suspended matter and oil that is not time constraints (very small droplets) or due to being a stable emulsion.

4- Secondary treatment:-

-This term is used for deep removal of non- dissolved oil and/or the removal of dissolved organic material. Secondary treatment processes are biological oxidation processes that degrade the soluble organic biological degradable contaminants in wastewater. The biological processes utilize microorganisms and oxygen to convert the soluble organic contaminants to CO_2 and H_2O, thereby reducing the concentration of contaminants (as biological oxygen demand – BOD) of the wastewater. Several biological processes are in widespread use. Oxidation ponds are the least complex but require large land areas and low BOD loadings relative to the other processes. Aerated lagoons utilize mechanical mixing and aeration to handle larger BOD loadings. The trickling filter process and its variations, such as the rotating biological contactors process, can handle relatively large BOD loadings. The activated sludge process and its variations can treat wastewater with high BOD loadings. Secondary treatment is applied after best results have been achieved by primary and intermediate treatment and, in some cases, after passing the wastewater through a cooling tower to obtain the necessary temperature reduction.

5-Tertiary treatment:-

- The objective of tertiary treatment is two fold: a) to safeguard against a failure in primary and secondary treatment. b) To remove remaining contaminants, which could be, interfere with immediate reuse. Holding basins are sometimes used to safeguard against a failure in water treatment at inland refineries. In these basins, additional biodegradation takes place due to the long residence time. Filtration can also be used as tertiary treatment to remove mainly entrained biomass from the bio- treater. Techniques like activated carbon adsorption may be considered for removal of dissolved organic compounds that are too slowly biodegradable to be removed in a bio- treater.

Case Study for Industrial Wastewater Treatment Plant

Assiut Oil Refining Company

Introduction:-

- The main target of this unit plant is treatment of the water, which is mixed with oil and can't be separated in the atmospheric distillation units, also as a result of the crude oil tanks drainage.

- In this unit, oil substances are being separated and recovered to the distillation unit to redistilled and to save the economic value of this oil to the company.

- Also the unit treats the water according to the healthy, environmental requirements and this water is used in the green areas irrigation in the company.

Consistency of the treatment plant:-

1- Sewer box:-

- Its function is to collect the water mixed with various petroleum materials and Hydrocarbons to be transferred to **A.P.I** separator or to fire water lagoon.

2- A.P.I separator:-

- It consists of two cells with 100 m3/he capacity for each one, each cell have a skimmer to collect the floating oil, and collecting the sludge's from the bottom of the cells.

-The function of this unit is to separate water from oil by using physical treatment which depend on the difference between the water density and the oil density as oil density is less than water which leads to easy skimming operation.

- In this unit we use the mechanical method (skimmer) as the oil is being skimmed from the water – surface which the skimmers are moving forward, and when they are moving back purge the sludge and mud to be collected in the bottom of the cells and suck it by the sludge pump.

- In addition, water mixed by oil switched to be a layer flow to easy separated water layer from oily layer, which facilitate skimming operation.

- The separated oil is being transferred to **A.P.I** oil pit and pumping it to recycled crude oil tanks (slops tanks) by pumps.
- In tanks water drained totally, after that, the oil is transferred to the crude tanks to be refined.
- On the other hand the separated water, which still contains a few of oil, it is being collected in the under basin to be treated again.

3- Dissolved air flotation (D.A.F):-

- In this unit, the rest of the mixed oil is being separated by floating oil by using dissolved air in water, also by using chemicals to collect the oil particles (coagulant polymer) and floating it , which consider as a chemical treatment for oily water..

- use flocculent polymer to precipitate the suspended solids and large molecules.

- The oil is skimmed by turning skimmers and recycling this quantity to sewer box, as for the water, it is being treated in the biological treatment plant.

- The pressure of air used is 6kg/cm.

4- Biological treatment unit:-

- It consists of a cylinder frame manufacture from a concrete material, its height 10m- and Radius 6 m, packed inside with plastic slices to enlarge the surface space to help the bacteria to increase its activity.

- The biological filter size is 300 m3/hr. with oil percentage not more than 40 ppm, the water is sprayed into the filter by pumps, with flow capacity of each is 200 m3/ hr.

- In this unit, the removing of any type of oil in the water done by bacteria found in the nature, as it feeds on oil substances and grows.

- The bacteria is helped in grows operation by adding phosphoric acid H_3PO_4.

- After these procedures and operations which applied to the oil mixed substances, the treated water specification are valid to use in irrigating the green spaces as its oil percentage is less than 5 ppm.

5- The final collection clean basin:-

- It consists of concrete basin for collecting the clean water to pump it and use in the Irrigation of the green areas in all places around the company such as workers accommodation areas, also to give a good solution to use the treated industrial wastewater.
- The schematic of the assiut industrial wastewater treatment plant is illustrated in figure **(1).**

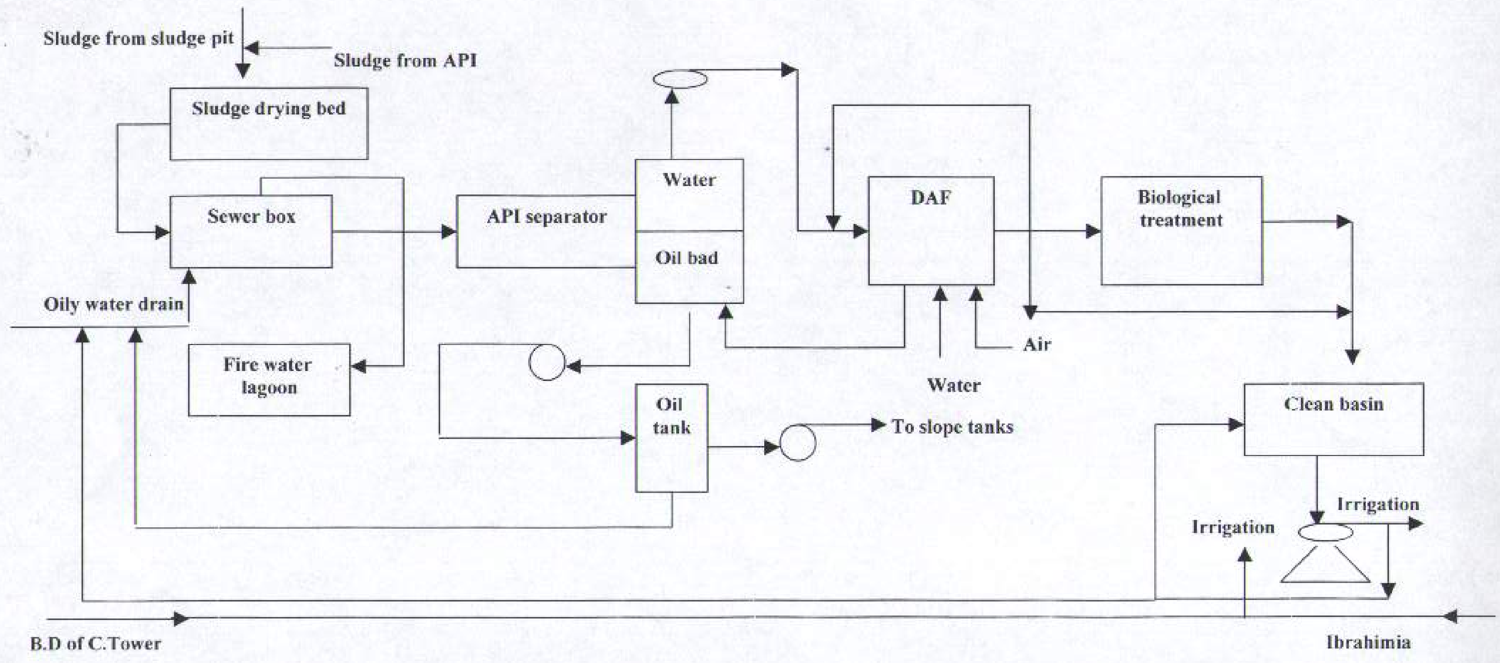

Figure (1) The schematic of the assiut industrial wastewater treatment plant .

The oil content of the effluent water during June. 2004

SAMPLING POINT	SEWER BOX	DAF INLET	DAF OUTLET
UNIT DATE	P.P.M	P.P.M	P.P.M
1.6.2004	2000	87	48
2.6.2004	2000	96	26
3.6.2004	342	43	32
4.6.2004	5000	----	46
5.6.2004	10000	----	264
6.6.2004	10000	180	90
7.6.2004	10000	263	168
8.6.2004	10000	107	14
9.6.2004	60000	37	5
10.6.2004	5000	133	24
11.6.2004	20000	----	180
12.6.2004	15000	----	80
13.6.2004	10000	381	21
14.6.2004	443	400	1.37
15.6.2004	5000	82	28
Average	**10986**	**118.13**	**68.5**
Maximum	**60000**	**400**	**264**
Minimum	**342**	**37**	**1.37**

Lagoon water analysis results

TEST	PH	T.D.S	OIL	T.S.S
N	**6-9**	**1200**	**10**	**30**
UNIT **DATE**		**P.P.M**	**P.P.M**	**P.P.M**
3.6.2004	6.2	580	5	27
4.6.2004	8.0	480	4	16
5.6.2004	7.0	600	10	9
6.6.2004	7.5	570	4	18
7.6.2004	7.9	450	6	13
8.6.2004	7.6	400	10	25
9.6.2004	7.7	700	4	11
11.6.2004	7.4	380	2	8
12.6.2004	7.8	600	3	21
13.6.2004	7.5	550	10	23
14.6.2004	6.4	520	10	27
15.6.2004	7.4	470	7	15
Average	**7.4**	**525**	**6.3**	**17.75**
Maximum	**7.4**	**700**	**10**	**27**
Minimum	**6.2**	**380**	**2**	**8**

References:-

1- Water and Wastewater Technology (Mark J. Hammer AND Mark J. Hammer ,Jr.).

2- Environmental Management Practices In Oil Refineries and Terminals (UNEP-Industry & Environment overview series).

3-Selected topics: design and operation of waste water treatment plants (prof. Hamdy Aly Ibrahim) Ain Shams University .

4- Industrial waste water treatment plant of assiut oil refining company .