Ethiopian TVET-System

Water supply and sanitation operation

Level-IV

Based on Feb, 2017G.C. Occupational Standard

Module Title: Assessing and optimizing chemical Dosing process

TTLMCode: EIS WSW4 TTLM 0920v1

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This module includes the following Learning Guides

LG28: **Evaluate chemical addition process performance.**

LG Code: EIS WSW4M08LO1-LG_28

LG29: Investigate chemical addition plant configuration.

LG Code: EIS WSW4M08LO2-LG_29

LG30: **Investigate chemical options for process optimization.**

LG Code: EIS WSW4M08LO3-LG_30

LG31: Develop and record a plan for process optimization

LG Code: EIS WSW4M08LO4-LG_31

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics:

- Reviewing existing process performance data
- Identifying the impact of changing raw or influent water quality on chemical addition processes.
- Identifying and coordinate any additional sampling and testing required for valid evaluation of current process performance.

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, **upon completion of this Learning Guide, you will be able to**:

- Review existing process performance data
- Identify the impact of changing raw or influent water quality on chemical addition processes.
- Identify and coordinate any additional sampling and testing required for valid evaluation of current process performance.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below
3. Read the information written in the "Information Sheets 1- 3". On pages 3, 27 and 34. Try to understand what are being discussed.
4. Accomplish the "Self-checks 1, 2 and 3" in each information sheets on pages 24, 32 and 40.
5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to "Operation sheets 1, on pages 42.and do the LAP Test on page 43". However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity.
7. After you accomplish Operation sheets and LAP Tests, ensure you have a formative assessment and get a satisfactory result; then proceed to the next LG.

1.1. Introduction to chemical dosing for treat drinking water

Water treatment is any process that improves the quality of water to make it appropriate for a specific end-use. The end user may be drinking, industrial water supply, irrigation, river flow maintenance, water recreation or many other uses, including being safely returned to the environment. Water treatment removes contaminants and undesirable components, or reduces their concentration so that the water becomes fit for its desired end-use. This treatment is crucial to human health and allows humans to benefit from both drinking and irrigation use.

Several factors affect the effectiveness and efficiency of chemical dosing at water treatment works. A review of plant operations should take place prior to any remedial works to ensure that any resource expended optimizing plant operation is focused on where it is likely to be most effective. This review should examine various aspects of the treatment process that influence the effectiveness of coagulation such as raw water chemistry (alkalinity), selection of coagulants, chemical dosing and dispersion, order of dosing, pH Control and flocculent aids.

1.2. Selection of Chemical Coagulants dosing

The commonly used inorganic coagulants are aluminum sulphate (“alum”), polyaluminium chloride, ferric sulphate and ferric chloride. Selection is a function of cost, raw water quality and (sometimes) the treatment process. For soft, coloured, waters, either aluminum or iron coagulants may be used at their respective optimal pH ranges: 6.5 to 7.5 for lowland surface waters or 5.5 to 6.5 for highly coloured upland waters (aluminum) and 4.0 to 5.0 (iron). Iron coagulants can have an advantage relative to aluminum in this application, as operation at a much lower coagulation pH can be used to maximize the removal of dissolved organic matter and consequent reduction in the potential risk.

For harder waters, iron coagulants are often used if coagulation pH values of 8.0 or more occur such pH values would not be appropriate for aluminum coagulants unless separate acid dosing were applied. Increasing the dose of metallic salt will further depress the pH but will result in a very undesirable increase in the soluble metallic content of the water, which will carry through the filters to supply. Dosing with a strong mineral acid, such as sulphuric acid, will depress the pH without the unwelcome increase in the soluble metallic content of the water. In some situations, it has been found that a change of coagulant can lead to improved performance of a clarification process, particularly with higher rate processes such as Dissolved Air Flotation (DAF).

Chemical treatments are techniques adopted to make industrial water suitable for use or discharge. These include chemical precipitation, chemical disinfection, chemical oxidation, advanced oxidation, ion exchange, and chemical neutralization

1.3. Treatment performance

Treatment performance varies according to local conditions and circumstances. The ability to achieve a guideline value within a drinking-water supply depends on a number of factors, including:

- the concentration of the chemical in the raw water;
- control measures employed throughout the drinking-water system;
- nature of the raw water (groundwater or surface water, presence of natural organic matter and inorganic solutes and other components, such as turbidity);
- Treatment processes already installed.

If a guideline value cannot be met with the existing system, then additional treatment may need to be considered, or water might need to be obtained from alternative sources. The cost of achieving a guideline value will depend on the complexity of any additional treatment or other control measures required. It is not possible to provide general quantitative information on the cost of achieving individual guideline values. Treatment costs (capital and operating) will depend not only on the factors identified above, but also on issues such as plant throughput; local costs for labour, civil and mechanical works, chemicals and electricity; life expectancy of the plant; and so on. Guideline values may be progressively achieved in the long term through less capital-intensive non-treatment options, such as through agreements with land users to reduce application of chemicals (fertilizers, pesticides, etc.)

1.3.1. Primary Wastewater Treatment

- **Introduction/Clarification by Sedimentation**

Industrial wastewater treatment systems take many forms, depending on the constituents in the wastewater and the goals of the treatment (discharge requirements). Primary treatment, as the name implies, precedes any additional treatment such as biological processes (secondary treatment). The primary treatment may be the only treatment, when the final discharge is to a publicly owned treatment works (POTW), or the treated water meets recycle requirements, such as blast furnace scrubber water in the steel industry. Primary treatment may be preceded by bar screens, grit (sand) removal, equalization basin, and pH correction to protect subsequent equipment's and processes.

Wastewaters contain many different types of organic and inorganic solids, both dissolved and suspended depending on the wastewater sources. Physical-chemical processes are used to remove specific dissolved matter in the wastewater, such as heavy metals and emulsified oils, and to oxidize or precipitate toxic chemicals. These processes may include sedimentation or dissolved air flotation.

- **Clarification by Sedimentation**

Clarification of wastewater through the process of sedimentation is the separation of suspended solids by gravitational settling. The sedimentation process is used in primary settling basins, removal of chemically treated solids, and solids concentration. Sedimentation basins perform the two-fold function of producing both a clarified water product, and a concentrated slurry (sludge) product. Two distinct forms of sedimentation vessels are in common use. The clarifier is used, as the name suggests, for the clarification of a dilute suspension to obtain water containing minimal suspended solids, while producing a concentrated sludge. A thickener is used to thicken a suspension to produce an underflow with a high solids' concentration, while also producing a clarified overflow. Primary clarification is the most economical unit process for pollutant removal from a cost per unit weight of biochemical oxygen demand (BOD) or solids removed. For this reason, it is the most widely used process for wastewater treatment.

- **Forms of Solids in Wastewater**

Total suspended solids (TSS) in water are defined by the Environmental Protection Agency (EPA) as those dry solids retained on a 0.45 µm filter from a total water sample and reported as dry mg/L or percent dry solids by weight (The suspended solids include floatable material.). The soluble or dissolved solids in the water are those that pass through the 0.45 µm filter and reported as dry mg/L or percent dry solids by weight. The sum of these two is the total solids in the water. By burning the solids of each, the suspended solids and dissolved solids are further classified into volatile and nonvolatile. The volatile fraction is assumed to represent the organic fraction in the suspended and dissolved solids.

The total suspended solids in the water are additionally divided into settleable solids and no settleable solids. The no settleable solids are the fine, colloidal particle fraction held in suspension by surface charges that do not settle by gravity. Clarification processes remove only the settleable fraction of the suspended solids. If no settleable sol ids are to be removed by clarification, chemical conditioning (coagulation and flocculation) of the colloidal solids is necessary.

Standard Methods for the Examination of Water and Wastewater includes two methods for the measurement of settleable solids. The first is reported by volume as mL/L and the second is by weight in mg/L.

A one-liter Imhoff cone is used to settle a mixed sample of the wastewater for one hour. The volume of solids that settle in the cone are read by the milliliter graduations on the cone apex. The settleable suspended solids are reported by volume as mL/L.

The no settleable solids by weight are measured by settling a minimum one-liter sample in a minimum 90 mm diameter glass vessel.

A larger diameter vessel and sample may be used, but the sample depth in the container must be deeper than 200 mm. The sample is allowed to settle for one hour. A 250 mL sample is siphoned from the center of the container at a point halfway between the surface of the settled solids and the water surface without disturbing the settled or floating material. The suspended solids by weight (mg/L) are determined on the 250 mL sample, and this represents the no settleable solids. The settle able solids by weight are then the difference between the mg/L total suspended solids and the mg/L no settleable suspended solids.

- **Sedimentation Phenomena**

Four basic classes or types of sedimentation processes take place, depending on the particle concentration and the degree of particle interaction. These settling classes are discrete particle, flocculant, hindered (also called zone), and compression. More than one class of settling can take place at any one time, and it is common to have three occurring in the clarification of dilute solutions. Thickening of solutions having suspended solids concentrations greater than about 500 to 1000 mg/L typically utilize hindered and compression settling.

- **Discrete Particle Settling**

The analysis of discrete, non-flocculating particle settling is by means of the classic laws of sedimentation formed by Newton and Stokes.

Newton 's Law relates the gravitational force on the particle, with the frictional resistance or drag, and the difference between the densities of the particle and liquid. The value of the drag coefficient varies depending on turbulent or laminar flow conditions and is a function of the Reynolds number. The drag coefficient becomes a constant for the low laminar flow conditions found in clarification. Stokes incorporated this constant drag coefficient into Newton 's gravitational force equation to arrive at the classic Stokes' Law for sedimentation:

$V_o = G(\rho_1 - \rho_2)D^2 / 18\mu$

where V_o = settling velocity, cm/s

G = gravitational force, cm/s2

ρ_1= particle density, g/cm3

ρ_2= liquid density, g/cm3

D = particle diameter, cm

μ= liquid viscosity, dyne s/cm2

- **Description:**

Particles in a low solids' concentration settle as individual entities not interacting with adjacent particles.

A dilute suspension of particles that coalesce or flocculate during sedimentation. The particles increase in size and mass by agglomeration, thereby increasing the settling rate.

Suspensions of intermediate concentration in which the forces between particles are sufficient to hinder the settling of adjacent particles. The particles adhere together, and the mass settles as a blanket, forming a distinct inter face between the floc and the supernatant.

- **The settling rate starts to decrease**

The particle suspension has reached a concentration such that a structure is formed and further settling can occur only by compression of the structure. The weight of the particles being constantly added to the top of the structure by sedimentation provides this compression. The settling rate of this zone becomes very slow.

- **Application:**

Removal of grit, sand, and inorganic particles such as slag in steel mills.

Most solids in wastewater are of a flocculant nature including pulp and paper, food processing, municipal, and biological treatment. Chemically treated solids exhibit Class 2 sedimentation.

Hindered settling is characterized by biological solids and flocculated chemical suspensions, when the concentration exceeds 500-1000 mg/L, depending on the type of particle.Occurs in the lower layers of deep sludge masses, such as in the bottom of deep clarifiers and in sludge-thickening facilities.

- **Discrete particle settling**.

A terminal velocity V is selected for the sizing of a sedimentation basin so that all particles having a velocity equal to or greater than V are removed. Class 1 settling in an ideal basin is shown in Ill. 2.

The particle having a settling velocity Vo that settles through a distance equal to depth D in length L (theoretical detention period) is removed.

This is called the basin overflow rate:

V_o= Q/A

where Q = inlet flow rate, gpm or gpd (m3/h)

A = surface area of tank, ft2 (m2)

V_o = overflow rate, gpm/ft2 or gpd/ft2 (m3/[h m2] or m/h) In the ideal basin of Ill. 2, it is assumed that particles entering the tank are evenly distributed over the inlet cross-section, and a particle is considered removed when it enters the sludge zone. Thus, all particles with a settling velocity greater than V_o are removed, and particles with lower settling velocity (Vp) are rem

- **Clarification**

Suspended matter in raw water supplies is removed by various methods to provide a water suitable for domestic purposes and most industrial requirements. The suspended matter can consist of large solids, settable by gravity alone without any external aids, and no settleable material, often colloidal in nature. Removal is generally accomplished by coagulation, flocculation, and sedimentation. The combination of these three processes is referred to as conventional clarification.

Coagulation is the process of destabilization by charge neutralization. Once neutralized, particles no longer repel each other and can be brought together. Coagulation is necessary for the removal of the colloidal-sized suspended matter.

Flocculation is the process of bringing together the destabilized, or "coagulated," particles to form a larger agglomeration, or "floc."

Sedimentation refers to the physical removal from suspension, or settling, that occurs once the particles have been coagulated and flocculated. Sedimentation or subsidence alone, without prior coagulation, results in the removal of only relatively coarse suspended solids.

- **Steps of Clarification**

Finely divided particles suspended in surface water repel each other because most of the surfaces are negatively charged. The following steps in clarification are necessary for particle agglomeration:

- **Coagulation.** Coagulation can be accomplished through the addition of inorganic salts of aluminum or iron. These inorganic salts neutralize the charge on the particles causing raw water turbidity, and also hydrolyze to form insoluble precipitates, which entrap particles. Coagulation can also be affected by the addition of water-soluble organic polymers with numerous ionized sites for particle charge neutralization.
- **Flocculation.** Flocculation, the agglomeration of destabilized particles into large particles, can be enhanced by the addition of high-molecular-weight, water-soluble organic polymers. These polymers increase floc size by charged site binding and by molecular bridging.

Therefore, coagulation involves neutralizing charged particles to destabilize suspended solids. In most clarification processes, a flocculation step then follows. Flocculation starts when neutralized or entrapped particles begin to collide and fuse to form larger particles. This process can occur naturally or can be enhanced by the addition of polymeric flocculant aids.

- **Inorganic Coagulants**

Table 5-1 lists a number of common inorganic coagulants. Typical iron and aluminum coagulants are acid salts that lower the pH of the treated water by hydrolysis. Depending on initial raw water alkalinity and pH, an alkali such as lime or caustic must be added to counteract the pH depression of the primary coagulant. Iron and aluminum hydrolysis products play a significant role in the coagulation process, especially in cases where low-turbidity influent waters benefit from the presence of additional collision surface areas.

Table 1-1. **Common inorganic coagulants**

Name	Typical	Typical	Typical	Forms	Density	Typical Uses

	Formula	Strength	Used in Water Treatment		
Aluminum sulfate	$Al_2(SO_4)_3 \cdot$ 14 to 18 H_2O	17% Al2O3	lump, granular, or powder	60-70 lb/ft^3	primary coagulant
Alum		8.25% Al2O3	liquid	11.1 lb/gal	
Aluminum chloride	$AlCl_3 \cdot 6H_2O$	35% $AlCl_3$	liquid	12.5 lb/gal	primary coagulant
Ferric sulfate	$Fe_2(SO_4)_3 \cdot 9H_2O$	68% $Fe_2(SO_4)_3$	granular	70-72 lb/ft^3	primary coagulant
Ferric-floc	$Fe_2(SO_4)_3 \cdot 9H_2O$	41% $Fe_2(SO_4)_3$	solution	12.3 lb/gal	primary coagulant
Ferric chloride	$FeCl_3$	60% $FeCl_3$, 35-45% $FeCl_3$	crystal, solution	60-64 lb/ft^3 11.2-12.4 lb/gal	primary coagulant
Sodium aluminate	$Na_2Al_2O_4$	38-46% $Na_2Al_2O_4$	liquid	12.3-12.9 lb/gal	primary coagulant; cold/hot precipitation softening

Variation in pH affects particle surface charge and floc precipitation during coagulation. Iron and aluminum hydroxide flocs are best precipitated at pH levels that minimize the coagulant solubility. However, the best clarification performance may not always coincide with the optimum pH for hydroxide floc formation. Also, the iron and aluminum hydroxide flocs increase volume requirements for the disposal of settled sludge.

With aluminum sulfate, optimum coagulation efficiency and minimum floc solubility normally occur at pH 6.0 to 7.0. Iron coagulants can be used successfully over the much broader pH range of 5.0 to 11.0. If ferrous compounds are used, oxidation to ferric iron is needed for complete precipitation. This may require either chlorine addition or pH adjustment. The chemical reactions between the water's alkalinity (natural or supplemented) and aluminum or iron result in the formation of the hydroxide coagulant as in the following:

$$Al_2(SO_4)_3 + 6NaHCO_3 = 2Al(OH)_3^- + 3Na_2SO_4 + 6CO_2$$

aluminum sulfate	sodium bicarbonate	aluminum hydroxide	sodium sulfate	carbon dioxide

$$Fe_2(SO_4)_3 + 6NaHCO_3 = 2Fe(OH)_3^- + 3Na_2SO_4 + 6CO_2$$

ferric sulfate	sodium bicarbonate	ferric hydroxide	sodium sulfate	carbon dioxide

$$Na_2Al_2O_4 + 4H_2O = 2Al(OH)_3^- + 2NaOH$$

sodium aluminate	water	aluminum hydroxide	sodium hydroxide

- **Polyelectrolytes**

The term polyelectrolytes refer to all water-soluble organic polymers used for clarification, whether they function as coagulants or flocculants.Water-soluble polymers may be classified as follows:

- Anionic-ionize in water solution to form negatively charged sites along the polymer chain.
- Cationic-ionize in water solution to form positively charged sites along the polymer chain.
- Nonionic-ionize in water solution to form very slight negatively charged sites along the polymer chain.

Polymeric primary coagulants are cationic materials with relatively low molecular weights (under 500,000). The cationic charge density (available positively charged sites) is very high. Polymeric flocculants or coagulant aids may be anionic, cationic, or nonionic. Their molecular weights may be as high as 50,000,000.

For any given particle there is an ideal molecular weight and an ideal charge density for optimum coagulation. There is also an optimum charge density and molecular weight for the most efficient flocculant.

Because suspensions are normally nonuniform, specific testing is necessary to find the coagulants and flocculants with the broadest range of performance.

- **Primary Coagulant Polyelectrolytes**

The cationic polyelectrolytes commonly used as primary coagulants are polyamines and poly-(DADMACS). They exhibit strong cationic ionization and typically have molecular weights of less than 500,000. When used as primary coagulants, they adsorb on particle surfaces, reducing the repelling negative charges. These polymers may also bridge, to some extent, from one particle to another but are not particularly effective flocculants. The use of polyelectrolytes permits water clarification without the precipitation of additional hydroxide solids formed by inorganic coagulants. The phof the treated water is unaffected.

The efficiency of primary coagulant poly-electrolytes depends greatly on the nature of the turbidity particles to be coagulated, the amount of turbidity present, and the mixing or reaction energies available during coagulation. With lower influent turbidities, more turbulence or mixing is required to achieve maximum charge neutralization.

Raw waters of less than 10 NTU (Nephelometric Turbidity Units) usually cannot be clarified with a cationic polymer alone. Best results are obtained by a combination of an inorganic salt and cationic polymer. In-line clarification should be considered for raw waters with low turbidities.

Generally, waters containing 10 to 60 NTU are most effectively treated with an inorganic coagulant and cationic polymer. In most cases, a significant portion of the inorganic coagulant demand can be met with the cationic polyelectrolyte. With turbidity greater than 60 NTU, a polymeric primary coagulant alone is normally sufficient.

In low-turbidity waters where it is desirable to avoid using an inorganic coagulant, artificial turbidity can be added to build floc. Bentonite clay is used to increase surface area for adsorption and entrapment of finely divided turbidity. A polymeric coagulant is then added to complete the coagulation process.

The use of organic polymers offers several advantages over the use of inorganic coagulants:

- ✓ The amount of sludge produced during clarification can be reduced by 50-90%. The approximate dry weight of solids removed per pound of dry alum and ferric sulfate are approximately 0.25 and 0.5 lb, respectively.
- ✓ The resulting sludge contains less chemically bound water and can be more easily dewatered.
- ✓ Polymeric coagulants do not affect ph. Therefore, the need for supplemental alkalinity, such as lime, caustic, or soda ash, is reduced or eliminated.
- ✓ Polymeric coagulants do not add to the total dissolved solids concentration. For example, 1 ppm of alum adds 0.45 ppm of sulfate ion (expressed as caco3). The reduction in sulfate can significantly extend the capacity of anion exchange systems.

- ✓ Soluble iron or aluminum carryover in the clarifier effluent may result from inorganic coagulant use. Therefore, elimination of the inorganic coagulant can minimize the deposition of these metals in filters, ion exchange units, and cooling systems.

- **Coagulant Aids (Flocculants)**

In certain instances, an excess of primary coagulant (whether inorganic, polymeric, or a combination of both) may be fed to promote large floc size and to increase settling rate. However, in some waters, even high doses of primary coagulant will not produce the desired effluent clarity. A polymeric coagulant aid added after the primary coagulant may, by developing a larger floc at low treatment levels, reduce the amount of primary coagulant required.

Generally, very high-molecular-weight, anionic polyacrylamides are the most effective coagulant aids. Nonionic or cationic types have proven successful in some clarifier systems. Essentially, the polymer bridges the small floc particles and causes them to agglomerate rapidly into larger, more cohesive flocs that settle quickly. The higher-molecular-weight polymers bridge suspended solids most effectively.

Coagulant aids have proven quite successful in precipitation softening and clarification to achieve improved settling rates of precipitates and finished water clarity.

- **Color Reduction**

Frequently, the objective of clarification is the re-duction of color. Swamps and wetlands introduce color into surface waters, particularly after heavy rainfalls. Color-causing materials can cause various problems, such as objectionable taste, increased microbiological content, fouling of anion exchange resins, and interference with coagulation and stabilization of silt, soluble iron, and manganese.

Most organic color in surface waters is colloidal and negatively charged. Chemically, color-producing compounds are classified as humic and fulvic acids. Color can be removed by chlorination and coagulation with aluminum or iron salts or organic polyelectrolytes. Chlorine oxidizes color compounds, while the inorganic coagulants can physically remove many types of organic color by neutralization of surface charges. The use of chlorine to oxidize organic color bodies may be limited due to the production of chlorinated organic by-products, such as trihalomethanes. Additional color removal is achieved by chemical interaction with aluminum or iron hydrolysis products. Highly charged cationic organic polyelectrolytes can also be used to coagulate some types of color particles.

Coagulation for color reduction is normally carried out at pH 4.5 to 5.5. Optimum pH for turbidity removal is usually much higher than that for color reduction. The presence of sulfate ions can interfere with coagulation for color reduction, whereas calcium and magnesium ions can improve the process and broaden the pH range in which color may be reduced effectively.

- **Conventional Clarification Equipment**

The coagulation/flocculation and sedimentation process requires three distinct unit processes:

- high shear, rapid mix for coagulation
- low shear, high retention time, moderate mixing for flocculation
- liquid and solids separation

Horizontal Flow Clarifiers

Originally, conventional clarification units consisted of large, rectangular, concrete basins divided into two or three sections. Each stage of the clarification process occurred in a single section of the basin. Water movement was horizontal with plug flow through these systems.

Because the design is suited to large-capacity basins, horizontal flow units are still used in some large industrial plants and for clarifying municipal water. The retention time is normally long (up to 4-6 hr), and is chiefly devoted to settling. Rapid mix is typically designed for 3-5 min and slow mix for 15-30 min. This design affords great flexibility in establishing proper chemical addition points. Also, such units are relatively insensitive to sudden changes in water throughput.

The long retention also allows sufficient reaction time to make necessary adjustments in chemical and polymer feed if raw water conditions suddenly change. However, for all but very large treated water demands, horizontal units require high construction costs and more land space per unit of water capacity.

- **Up flow Clarifiers**

Compact and relatively economical, up flow clarifiers provide coagulation, flocculation, and sedimentation in a single (usually circular) steel or concrete tank. These clarifiers are termed "up flow" because the water flows up toward the effluent launders as the suspended solids settle. They are characterized by increased solids contact through internal sludge recirculation. This is a key feature in maintaining a high-clarity effluent and a major difference from horizontal clarifiers.

Because retention time in an up-flow unit is approximately 1-2 hr, up flow basins can be much smaller in size than horizontal basins of equal throughput capacity. A rise rate of 0.70-1.25 gpm/ft^2 of surface area is normal for clarification. Combination softening-clarification units may operate at up to 1.5 gpm/ft^2 of surface area due to particle size and densities of precipitated hardness.

In order to achieve high throughput efficiency, up flow units are designed to maximize the linear overflow weir length while minimizing the opportunity for short-circuiting through the settling zone. In addition, the two mixing stages for coagulation and flocculation take place within the same clarification tank.

Although up flow units may provide more efficient sedimentation than horizontal designs, many up flows clarifiers compromise on the rapid and slow mix sequences. Some types provide rapid, mechanical mixing and rely on flow turbulence for flocculation; others eliminate the rapid mix stage and provide only moderate turbulence for flocculation. However, in most cases, users can overcome rapid mix deficiencies by adding the primary coagulant further upstream of the clarifier. Figure 5-1 shows the rapid mix, slow mix, and settling zones of a typical up flow, solids-contact clarifier.

- **Sludge Blanket and Solids-Contact Clarification**

Most up flow designs are called either "sludge blanket" or "solids-contact" clarifiers. After coagulation and/or flocculation in the sludge blanket units, the incoming water passes through the suspended layer of previously formed floc. Figure 5-2 shows an upflow sludge blanket clarifier.

Because the center well in these units is often shaped like an inverted cone, the rise rate of the water decreases as it rises through the steadily enlarging cross section. When the rise rate decreases enough to equal the settling rate of the suspended floc exactly, a distinct sludge/liquid interface form.

Sludge blanket efficiency depends on the filtering action as the freshly coagulated or flocculated water passes through the suspended floc. Higher sludge levels increase the filtration efficiency. In practice, the top sludge interface is carried at the highest safe level to prevent upsets that might result in large amounts of floc carryover into the overflow. Excessive sludge withdrawal or blowdown should also be avoided. The sludge blanket level is often highly sensitive to changes in throughput, coagulant addition, and changes in raw water chemistry and temperature.

"Solids-contact" refers to units in which large volumes of sludge are circulated internally. The term also describes the sludge blanket unit and simply means that prior to and during sedimentation the chemically treated water contacts previously coagulated solids. Solids-contact, slurry pool units do not rely on filtration as in sludge blanket designs.

Solids-contact units often combine clarification and precipitation softening. Bringing the incoming raw water into contact with recirculated sludge improves the efficiency of the softening reactions and increases the size and density of the floc particles. Figure 5-3 illustrates a typical solids-contact unit.

- **In-Line Clarification**

In-line clarification is the process of removing raw water turbidity through the addition of coagulant just prior to filtration. In-line clarification is generally limited to raw waters with typical turbidities of less than 20 NTU, although up flow filters may tolerate higher loading. Polyelectrolytes and/or inorganic coagulants are used to improve filtration efficiency and run length. Polymers are favored because they do not create additional suspended solids loading, which can shorten filter run length.

Filter design may be downflow or up flow, depending on raw water turbidity and particle size. The downflow dual-media unit generally consists of layers of various grades of anthracite and sand supported on a gravel bed. After backwashing, the larger anthracite particles separate to the top of the bed, while the more dense, smaller sand particles are at the bottom. The purpose is to allow bed penetration of the floc, which reduces the potential for excessive pressure drops due to blinding off the top portion of filter media. Thus, higher filtration rates are realized without a significant loss in effluent quality. Normal filtration rates are 5-6 gpm/ft^2.

- **Coagulant Selection and Feeding for In-Line Clarification**

The choice of a polymer coagulant and feed rate depends on equipment design and influent water turbidity. Initially, in-line clarification was used in the treatment of low-turbidity waters, but it is now being used on many types of surface waters. For most waters, the use of a polymeric cationic coagulant alone is satisfactory. However, the addition of a high-molecular-weight, anionic polymer may improve filtration efficiency.

Polymer feed rates are usually lower than those used in conventional clarification, given the same raw water characteristics. Complete charge neutralization and bridging are not necessary and should be avoided, because total coagulation or flocculation may promote excessive entrapment of suspended solids in the first portion of the filter media. This can cause blinding of the media, high pressure drops, and short operating runs.

Sufficient polymer is applied only to initiate neutralization, which allows attraction and adsorption of particles through the entire bed. Often, polymer feed rates are regulated by trial and error on the actual units to minimize effluent turbidity and maximize service run length.

Because optimum flocculation is undesirable, polymers are injected just upstream of the units. Normally, a short mixing period is required to achieve the degree of reaction most suitable for unit operation. Dilution water may be recommended to disperse the polymer properly throughout the incoming water. However, it may be necessary to move the polymer injection point several times to improve turbidity removal. Due to the nature of operation, a change of polymer feed rate will typically show a change in effluent turbidity in a relatively short period of time.

- **Coagulation Testing**

Raw water analyses alone are not very useful in predicting coagulation conditions. Coagulation chemicals and appropriate feed rates must be selected according to operating experience with a given raw water or by simulation of the clarification step on a laboratory scale.

Jar testing is the most effective way to simulate clarification chemistry and operation. A multiple-paddle, beaker arrangement (Figure 5-4) permits the comparison of various chemical combinations, all of which are subjected to identical hydraulic conditions. The effects of rapid and slow mix intensity and duration may also be observed.

In addition to determining the optimum chemical program, it is possible to establish the correct order of addition. The most critical measurements in the jar test are coagulant and/or flocculant dosages, pH, floc size and settling characteristics, floc-forming time, and finished water clarity. To simulate sludge circulation, sludge formed in one series of jar tests (or a sludge sample from an operating clarifier) may be added to the next jar test. Results of jar tests are only relative, and frequent adjustments are necessary in full-scale plant operation. Monitoring and control units, such as a streaming current detector, can be used for on-line feedback control.

Zeta potential measurements have been used experimentally to predict coagulant requirements and optimum pH levels. Because the measurement technique requires special apparatus and a skilled technician, zeta potential has never become practical for controlling industrial water clarification plants. Also, because zeta potential measures only one aspect of the entire process, it may not reflect all conditions leading to coagulation efficiency.

- **Chemical Additions**

The most efficient method for adding coagulation chemicals varies according to the type of water and system used, and must be checked by means of jar testing. However, there is a usual sequence**:**

- chlorine
- bentonite (for low-turbidity waters)
- primary inorganic and/or polymer coagulant
- pH-adjusting chemicals
- coagulant aid

Waters with a high organic content exhibit an increased primary coagulant demand. Chlorine may be used to assist coagulation by oxidizing organic contaminants which have dispersing properties. Chlorination prior to primary coagulant feed also reduces the coagulant dosage. When an inorganic coagulant is used, the addition of pH-adjusting chemicals prior to the coagulant establishes the proper pH environment for the primary coagulant.

All treatment chemicals, with the exception of coagulant aids, should be added during very turbulent mixing of the influent water. Rapid mixing while the aluminum and iron coagulants are added ensures uniform cation adsorption onto the suspended matter.

High shear mixing is especially important when cationic polymers are used as primary coagulants. In general, it is advisable to feed them as far ahead of the clarifier as possible. However, when a coagulant aid is added, high shear mixing must be avoided to prevent interference with the polymer's bridging function. Only moderate turbulence is needed to generate floc growth.

1.4. local action in response to chemical water quality problem and emergency

It is difficult to give comprehensive guidance concerning emergencies in which chemicals cause massive contamination of the drinking-water supply, caused either by accident or by deliberate action. Most of the guideline values recommended in these Guidelines relate to a level of exposure that is regarded as tolerable throughout life. Acute toxic effects are considered for a limited number of chemicals. The length of time for which exposure to a chemical far in excess of the value would have adverse effects on health will depend upon factors that vary from contaminant to contaminant. In an emergency situation, the public health authorities should be consulted about appropriate action.

1.5. organizational performance quality standards

The International Organization for Standardization (ISO) is an international standard-setting body composed of representatives from various national standards organizations. In contrast to many international organizations, which utilize the British English form of spelling, the ISO uses English with Oxford spelling as one of its official languages along with French and Russian.

A standards organization, standards body, standards developing organization (SDO), or standards setting organization (SSO) is an organization whose primary activities are developing, coordinating, promulgating, revising, amending, reissuing, interpreting, or otherwise producing technical standards that are intended to address the needs of a group of affected adopters.

Most standards are voluntary in the sense that they are offered for adoption by people or industry without being mandated in law. Some standards become mandatory when they are adopted by regulators as legal requirements in particular domains.

Normally, the term standards organization is not used to refer to the individual parties participating within the standards developing organization in the capacity of founders, benefactors, stakeholders, members or contributors, who themselves may function as the standards organizations.

- **Laws, regulations, and standards**

Effective programmes to control drinking-water quality depend ideally on the existence of adequate legislation, standards, and codes. One of the functions of the basic legislation is to define the functions, authority, and responsibilities of the water-supply agency and the surveillance agency. Standards and codes should specify the quality of the water to be supplied to the consumer, the practices to be followed in selecting and developing water sources and in treatment processes and distribution systems, and procedures for approving water systems in terms of water quality. The precise nature of the legislation in each country will depend on national, constitutional, and other considerations. The authority to establish and revise drinking-water standards, codes of practice, and other technical regulations should be delegated to the appropriate government minister preferably the minister of health who is responsible for ensuring the quality of water supplies and the protection of public health

1.6. standard operating procedures (SOP)

A **standard operating procedure** (SOP) is a set of step-by-step instructions compiled by an organization to help workers carry out complex routine operations. SOPs aim to achieve efficiency, quality output and uniformity of performance, while reducing miscommunication and failure to comply with industry regulations.

A Standard Operating Procedure (SOP) is a set of written instructions that document a routine or repetitive activity followed by an organization. The development and use of SOPs are an integral part of a successful quality system as it provides individuals with the information to perform a job properly, and facilitates consistency in the quality and integrity of a product or end-result. The term “SOP” may not always be appropriate and terms such as protocols, instructions, worksheets, and laboratory operating procedures may also be used. For this document “SOP” will be used.

Standard Operating Procedure has been prepared with the objective of making the concerned persons understand their duties and responsibilities for Drinking Water Supplies to determine chemical dosage in the treatment process.

Objectives of SOP

- Restoration of water supplies to the affected area, as per standards (quality and quantity).
- To maintain the quality of drinking water as per the ISO 10500.

The Standard operating procedure for Drinking Water Supply is categorized in to following three stages:

- During normal situation (Preparedness stage),
- At the time of warning or disaster (Response stage) and
- Post disaster (Recovery and Mitigation stage)

1.7. quality assurance guidelines

Quality assurance/quality control measures for water treatment utilities refer to a set of activities that are to be undertaken to ensure compliance and above all, ensure that the water is safe for public consumption in a sustainable manner. In general, quality assurance (QA) refers to the overall management system that includes the organization, planning, data collection, quality control, documentation, evaluation and reporting activities of the group quality control (QC) refers to the routine technical activities whose purpose is, essentially, error control and thereby ensure the production of accurate and reliable results. Together, QA and QC help to produce data of known quality, enhance the credibility of an organization in reporting monitoring results, and ultimately help the organization to achieve the desired goals

- **Benefits of implementing QA/QC measures include**:
  - ✓ public health protection by providing safe water to the consumers;
  - ✓ protected source waters;
  - ✓ well maintained treatment and distribution systems;
  - ✓ good management of costs involved in treating and supplying the water;
  - ✓ identification of potential hazards and elimination of the hazards through risk assessment;
  - ✓ provides a framework for communication with the consumers (public) and with employees;
  - ✓ provides an opportunity for water utility managers and employees to identify their areas of responsibility and become involved;
  - ✓ increased involvement of stakeholders and public;
  - ✓ reduction in health care costs; and
  - ✓ Increased environmental protection.

1.8. federal, state and local environmental and water quality legislation

There are benefits to leaving environmental regulation both to the federal government to the States have greater regulatory freedom for areas like air and water pollution, presumably because they are not. Federal regulation preempts state and local legislation under the supremacy clause when the two conflict are created. Water quality criteria and standards. Many environmental laws enacted by Congress are requirements for Federal, State and local governments.

Federal legislation for protection of water quality began with the Rivers and Harbors Act of 1886 and 1889. In 1948, the Federal Water Pollution Prevention Act set a national policy for prevention, control, and abatement of water pollution. It was amended in 1956. The Federal role in water pollution control was expanded by the Water Quality Act of 1965, Clear Water Restoration Act of 1966, and Water Quality Improvement Act of 1970.

Federal legislative efforts to regulate air pollution began with the passage of the Air Pollution Control Act in 1955. The Clean Air Act was originally passed in 1963 with significant amendments in 1970, 1977, and 1990. The 1990 Clean Air Act Amendments (CAAA) introduced sweeping changes to the Clean Air Act and is the basis for many of the existing air quality regulations in the United States.

1.9. occupational health and safety requirements

The Occupational Safety and Health Act of 1970 mandates that all nongovernment employers provide a safe and healthful workplace for their employees. The Occupational Safety and Health Act of 1970 mandates that all nongovernment employers provide a safe and healthful workplace for their employees. It also provided for the creation of the Occupational Safety and Health Administration (OSHA) and the National Institute for Occupational Safety and Health (NIOSH).

- **What is dangerous about this job?**
  - ✓ Falls, slips, and trips on the level on floors made wet and slippery during the handling of water.
  - ✓ Exposure to hazardous substances because of a sudden release of toxic materials due to a work related accident, or as a result of human error such as addition of chemicals to an unsuitable device.
  - ✓ Electric shock caused by contact with “live” wires or defective electrical installations. Exposure to high levels of noise from electro-mechanical equipment.
  - ✓ Exposure to various disinfectants intended for disinfection of water and known as toxic substances.
  - ✓ Psychological stress and pressure due to environmental factors: annoying noise, water splashing, odours, high humidity, etc.
- **Hazards related to this job**
  - ✓ Accident hazards
  - ✓ Physical hazards
  - ✓ Chemical hazards
  - ✓ Biological hazards
  - ✓ Ergonomic, psychosocial and organizational factors
- **Preventive measures**
  - ✓ Wear safety shoes with non-skid soles.
  - ✓ Use ladders in good repair; make sure that ladder is in required position without the possibility of displacement and/or collapse; inspect ladder before climbing.
  - ✓ All cavities, hollow spaces, elevated working surfaces, and other locations where there is hazard of falling should be "securely fenced" by appropriate railing guards.
  - ✓ During work with these machines, ensure that work clothes are attached to the body; use appropriate headgear; guard all moving parts of equipment that may injure the worker.

- ✓ Check electrical equipment for safety before beginning to work; call a qualified electrician for testing of suspect equipment.
- ✓ All chemical supply connection points must be checked and post appropriate signs must be posted at these points.
- ✓ Apply chemical safety rules when handling or working with hazardous chemicals; read MSDS and consult a safety supervisor regarding specific chemicals.

  (a) Apply safety rules while working in a confined space: check air quality and, if necessary, exhaust ventilation before entering into a confined space; use harnesses that are held by your co-workers; use respirators and gas masks; etc.
- ✓ Use appropriate ear protection; consult a safety supervisor or a supplier.
- ✓ Work clothes should fit the climatic conditions of the work place.
- ✓ Use all safety measures recommended.

- **Water Quality Standards and Guidelines**

Water quality standards (WQS) are provisions of state, territorial, authorized tribal or federal law approved by EPA that describe the desired condition of a water body and the means by which that condition will be protected or achieved. Water bodies can be used for purposes such as recreation (e.g. swimming and boating), scenic enjoyment, and fishing, and are the home to many aquatic organisms. To protect human health and aquatic life in these waters, states, territories and authorized tribes establish WQS.

Self-Check -1	Written Test

Direction I: Multiple choice item (2 points each)

Instruction: choose the best answer for the following questions and write your answer on the answer sheet provided in the next page:

1. ________is any process that improves the quality of water to make it appropriate for a specific end-use.
   A. Water treatment
   B. Chemical dosing
   C. Water emitter
   D. all
2. Review should examine various aspects of the treatment process that influence the effectiveness of coagulation from the following except
   A. raw water chemistry (alkalinity)
   B. selection of coagulants
   C. chemical dosing and dispersion
   D. order of dosing
3. Chemical treatments are techniques adopted to make industrial water suitable for use or discharge which includes the following is/are
   A. chemical precipitation
   B. chemical disinfection
   C. chemical oxidation
   D. chemical neutralization
4. The ability to achieve value within a drinking-water supply depends on a number of factors, including the following except
   A. the concentration of the chemical in the raw water
   B. control measures employed throughout the drinking-water system
   C. nature of the raw
   D. Treatment processes already installed
5. The use of organic polymers offers several advantages over the use of inorganic coagulants may be_____**except**.
   A. sludge contains less chemically bound water and can be more easily dewatered.

B. Polymeric coagulants do affect ph.

C. Polymeric coagulants do not add to the total dissolved solids concentration.

D. Soluble iron or aluminum carryover in the clarifier effluent may result from inorganic

6. _______is required by the coagulation/flocculation and sedimentation process.

   A. high shear, rapid mix for coagulation

   B. low shear, high retention time, moderate mixing for flocculation

   C. liquid and solids separation

   D. All

7. Water-soluble polymers may be ________.

   A. Anionic-ionize in water solution to form negatively charged sites along the polymer chain.

   B. Cationic-ionize in water solution to form positively charged sites along the polymer chain.

   C. Nonionic-ionize in water solution to form very slight negatively charged sites along the polymer chain.

   D. AlL

8. Clarification of wastewater through the process of sedimentation is the separation of suspended solids by gravitational settling. True B. False

9. Standard Methods for the Examination of Water and Wastewater includes two methods for the measurement of un settleable solids. A. True B. False

10. Flocculation starts when neutralized or entrapped particles begin to collide and fuse to form larger particles. A. True B. False

11. Flocculation involves neutralizing charged particles to destabilize suspended solids.

   A. True B. False.

***Note:* Satisfactory rating – 11.5 and above points Unsatisfactory - below 11.5. points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________
Rating: ____________

Name: _________________________ Date: ___________________

Short Answer Questions

1. ________
2. _______
3. _____
4. ______
5. ________
6. ________
7. _________
8. _________
9. _________
10. __________
11. __________

Information Sheet-2	Identifying the impact of changing raw or influent water quality on chemical addition processes

2.1. Introduction to Changing raw or influent water quality to chemical addition

Changes in the quality of raw water can significantly affect the treatments necessary for drinking water. Generally, raw water quality assessments are carried out to classify the pollution level of raw waters and cannot be used directly as a control for drinking water treatments. In order to improve the adaptability of drinking water treatments and to stabilize the overall quality of treated water, a raw water quality assessment technique that is specifically related to drinking water treatments is developed

The quality of wastewater varies according to the types of influents receive such as domestic wastewater, dry and wet atmospheric deposition, urban runoff containing traffic related pollution, or agricultural runoff

Various factors influence the composition of stream water, causing variation from place to place. The quality of river and stream water is very sensitive to anthropogenic influences (urban, industrial and agricultural activities, increasing consumption of water resources) as well as natural processes (changes in precipitation inputs, erosion, weathering of earths crustal material) degrade the surface waters and impair their use for drinking, industrial, agricultural, recreation or other purposes

2.2. Impact of chemical on water quality

There are a number of sources of naturally occurring chemicals in drinking-water. All natural water contains a range of inorganic and organic chemicals. The former derive from the rocks and soil through which water percolates or over which it flows. The latter derive from the breakdown of plant material or from algae and other microorganisms that grow in the water or on sediments. Most of the naturally occurring chemicals for which guideline values have been derived or that have been considered for guideline value derivation are inorganic

- **pH**

Although pH usually has no direct impact on consumers, it is one of the most important operational water quality parameters. Careful attention to pH control is necessary at all stages of water treatment to ensure satisfactory water clarification and disinfection. For effective disinfection with chlorine, the pH should preferably be less than 8; however, lower-pH water (approximately pH 7 or less) is more likely to be corrosive. The pH of the water entering the distribution system must be controlled to minimize the corrosion of water mains and pipes in household water systems. Alkalinity and calcium management also contribute to the stability of water and control its aggressiveness to pipes and appliances. Failure to minimize corrosion can result in the contamination of drinking-water and in adverse effects on its taste and appearance.

pH Value	H^+ Concentration Relative to Pure Water	Example
4	1 000	tomato juice, acid rain
5	100	black coffee, **bananas**
6	10	urine, **milk**
7	1	pure **water**

- ✓ https://www.khanacademy.org/science/high-school-biology/hs-biology-foundations/hs-ph-acids-and-bases/v/introduction-to-ph.
- ✓ https://www.khanacademy.org/science/biology/water-acids-and-bases/acids-bases-and-ph/v/introduction-to-definition-of-ph.
- ✓ https://www.youtube.com/watch?v=Xeuyc55LqiY

- **Turbidity**

Turbidity is a measure of the degree to which the water loses its transparency due to the presence of suspended particulates. The more total suspended solids in the water, the murkier it seems and the higher the turbidity. Turbidity is considered as a good measure of the quality of water. Turbidity, typically expressed as nephelometric turbidity units (NTU), describes the cloudiness of water caused by suspended particles (e.g. clay and silts), chemical precipitates (e.g. manganese and iron), organic particles (e.g. plant debris) and organisms. Turbidity can be caused by poor source water quality, poor treatment and, within distribution systems, disturbance of sediments and biofilms or the ingress of dirty water through main breaks and other faults. At high levels, turbidity can lead to staining of materials, fittings and clothes exposed during washing, in addition to interfering with the effectiveness of treatment processes

Increasing turbidity reduces the clarity of water to transmitted light. Below 4 NTU, turbidity can be detected only using instruments, but at 4 NTU and above, a milky-white, muddy, red-brown or black suspension can be visible. Large municipal supplies should consistently produce water with no visible turbidity (and should be able to achieve 0.5 NTU before disinfection at all times and average 0.2 NTU or less). However, small supplies, particularly those where resources are limited, may not be able to achieve such levels.

Figure 2.1. turbidity

https://www.youtube.com/watch?v=LeKqhMqEoKQ.

https://www.youtube.com/watch?v=fOY2qHfBW0w

2. Color

Color and turbidity are two water quality parameters that detract from the appearance of water, making it unpleasing to drink for aesthetic reasons. Colour is organic material that has dissolved into solution, while turbidity consists of tiny particles suspended in the water column.

Tastes and odors caused by disinfectants are best controlled through careful operation of the disinfection process and pretreatment to remove precursors. Manganese can be removed by chlorination followed by filtration. Techniques for removing hydrogen sulfide include aeration, granular activated carbon, filtration and oxidation. Ammonia can be removed by biological nitrification. Precipitation softening or cation exchange can reduce hardness. Other taste- and odor-causing inorganic chemicals (e.g. chloride and sulfate) are generally not amenable to treatment

- ✓ https://www.youtube.com/watch?v=WpWjGf65V3A
- ✓ https://www.youtube.com/watch?v=jmZomizSPxw

- **presence of algae**

Treatment prior to human consumption depends on the source water quality. At present, many cities that get their main water supply from lakes and rivers are affected by varying degrees of algal pollution. The presence of algae in source water can cause a variety of problems for drinking water treatment.

The chemical preoxidants are powerful oxidants and can improve algae coagulation by inactivating algal cells, destabilization of algal cells, or liberating extracellular organic matter (EOM). Chlorine acts to kill the algae by first penetrating through the cell wall then destroying enzymes within the cytoplasm.

The strength of this correlation between algae count and chemicals consumption increased in winter season with decreasing of temperature. Reported that the total algal biomass reaches the highest value when the daily water temperature is between 21 and 24 °C, the concentration of algae cells decreases gradually when the water temperature exceeds 24 °C.

Temperature

Cool water is generally more palatable than warm water, and temperature will have an impact on the acceptability of a number of other inorganic constituents and chemical contaminants that may affect taste. High water temperature enhances the growth of microorganisms and may increase problems related to taste, odor, color and corrosion.

Chemicals from industrial sources can reach drinking-water directly from discharges or indirectly from diffuse sources arising from the use and disposal of materials and products containing the chemicals. In some cases, inappropriate handling and disposal may lead to contamination (e.g. degreasing agents that are allowed to reach groundwater). Some of these chemicals, particularly inorganic substances, may also be encountered as a consequence of natural contamination, but this may also be a by-product of industrial activity, such as mining, that changes drainage patterns. Many of these chemicals are used in small industrial units within human settlements, and, particularly where such units are found in groups of similar enterprises, they may be a significant source of pollution. Petroleum oils are widely used in human settlements, and improper handling or disposal can lead to significant pollution of surface water and groundwater. Where plastic pipes are used, the smaller aromatic molecules in petroleum oils can sometimes penetrate the pipes where they are surrounded by earth soaked in the oil, with subsequent pollution of the local water supply.

Identification of the potential for contamination by chemicals from industrial activities and human dwellings requires assessment of activities in the catchment and of the risk that particular contaminants may reach water sources.

Significance of water temperature

Temperature exerts a major influence on biological activity and growth. Temperature governs the kinds of organisms that can live in rivers and lakes. Fish, insects, zooplankton, phytoplankton, and other aquatic species all have a preferred temperature range. As temperatures get too far above or below this preferred range, the number of individuals of the species decreases until finally there are none.

Temperature is also important because of its influence on water chemistry. The rate of chemical reactions generally increases at higher temperature. Water, particularly groundwater, with higher temperatures can dissolve more minerals from the surrounding rock and will therefore have a higher electrical conductivity. It is the opposite when considering a gas, such as oxygen, dissolved in the water. Think about how much "bubblier" a cold soda is compared to a warm one. The cold soda can keep more of the carbon dioxide bubbles dissolved in the liquid than the warm one can, which makes it seem fizzier when you drink it.

Warm stream water is can affect the aquatic life in the stream. Warm water holds less dissolved oxygen than cool water, and may not contain enough dissolved oxygen for the survival of different species of aquatic life. Some compounds are also more toxic to aquatic life at higher temperatures.

- https://www.youtube.com/watch?v=KyNhmlV3U5o

Self-Check -2	Written Test

Direction I: Multiple choice item (2 points each)

Instruction: choose the best answer for the following questions and write your answer on the answer sheet provided in the next page:

1. The quality of wastewater varies according to the types of influents receive from the following except
   A. domestic wastewater
   B. dry and wet atmospheric deposition
   C. urban runoff containing traffic related pollution
   D. agricultural treated runoff water
2. Which one of the following is not the consequence of influent present in drinking water
   A. Change color of water
   B. Change the temperatures of water
   C. Decrease turbidity of water
   D. Develop algae
3. Which one of the following statement is true
   A. quality of river and stream water is very sensitive to anthropogenic influences degrade the surface waters
   B. The quality of wastewater varies according to the types of influents receive
   C. Chemicals from industrial activities and human dwellings require assessment of activities in the catchment
   D. All
4. Chemical pollution is mainly due to the discharge of organic and inorganic substances released into water.
   A. True B. False
5. Organic matter is considered as a major source of water pollution caused by wastes of food, animal and human excreta, garbage etc. The excess of organic matter in water causes a threat to aquatic life because?
   A. the space available to aquatic life decreases
   B. microorganisms consume dissolved oxygen to decompose organic matter
   C. organic matter is swallowed by small animals

D. Decomposition of organic matter increases the temperature of water.

Direction II: Matching Items of A with Items of B for the following questions. Use the Answer sheet provided in the next page: Each question worth one point.

A	B
1. Ph is equal	A. Potential of Hydrogen
2. Full form of PH	B. Acidic
3. A ph less than 7	C. $-\log_{10} c$
4. H^+ Concentration of pure water	D. 1000
5. Measure of relative clarity of a liquid	E. 10
6. H^+ Concentration of tomato juice	F. 1
7. H^+ Concentration of Urine, Milk	G. Ph and alkalinity
8. Key *water quality parameters*	*H.* Turbidity
9. Colour	*I.* Indicators of ecosystem conditions
10. Algae	J. Organic material that has dissolved into solution
	K. Temperature

***Note:* Satisfactory rating – 5 and above points** **Unsatisfactory - below 5 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Name: _______________ Date: _________________

Score = ___________

Rating: ____________

Answer Questions

1. _______
2. ________
3. _______
4. _______
5. _________
6. ___________
7. _____________
8. _______

3.1. Introduction to water sampling and testing for valid evaluation the current performance

3.1.1. Jar testing

Jar test is intended to simulate the coagulation/flocculation process and determine appropriate dosages. The lab-scale results are used to optimize the performance of systems such as water treatment plants by determining the concentration of coagulant to be added to the source water**.** The laboratory jar test is to select and quantify a treatment program for removal of suspended solids or oil from raw water or a dilute process or waste stream. Jar tests are conducted on a four- or six-place gang stirrer, which can be utilized to simulate mixing and settling conditions in a clarifier. Jars (beakers) with different treatment programs or the same product at different dosages are run side-by-side, and the results compared to an untreated jar, or one treated with the current program.

Jar Testing equipment needed

- ✓ Gang Stirrer
- ✓ Graduated Beakers, 1500 ml
- ✓ 2 Graduated Pipets, 10 ml
- ✓ 1 Graduated Cylinder, 1000 ml
- ✓ Scale for weighing chemicals
- ✓ Analytical Equipment
- ✓

Figure 3.1 jar test

3.1.2. Flocculation growth

Flocculation and coagulation treatment chemicals are used in effluent wastewater water treatment processes for solids removal, water clarification, lime softening, sludge thickening, and solids dewatering.

Flocculation, in the field of chemistry, is a process in which colloids come out of suspension in the form of floc or flake, either spontaneously or due to the addition of a clarifying agent. The action differs from precipitation in that, prior to flocculation, colloids are merely suspended in a liquid and not actually dissolved in a solution. In the flocculated system, there is no formation of a cake, since all the flocs are in the suspension.

3.1.3. mixing energy

When salt water and fresh water mix in estuaries, a chemical process occurs that can be harnessed for electricity generation. The flow of water across the membrane builds up pressure on one side that can be used to drive turbines and generate power.

Urban water infrastructure systems require significant amounts of energy for proper operation of major processes, which may include water intake, conveyance, treatment, and distribution systems, to deliver a safe and high-quality drinking water to customers.

3.1.4. UV absorbance

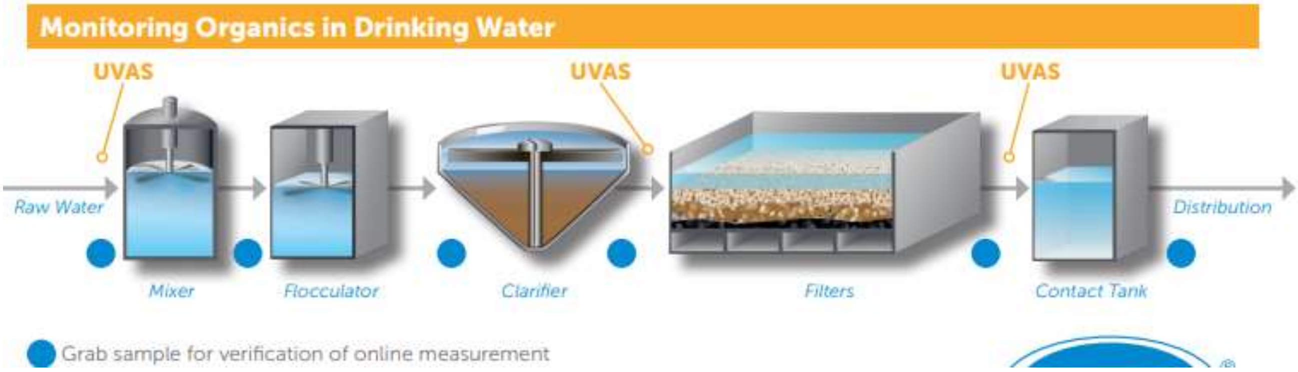
Organic material is one of the most prevalent impurities in source water, and it affects the color, taste, and odor of water Organics in source water come from naturally occurring organic matter (NOM) as well as introduced organics coming from pollution. By monitoring NOM in raw water, you can get an early indication of unexpected events, which allows you to respond quickly in adjusting your treatment process. A well-established method for monitoring organic load is to measure UV absorption at 254nm, as many organics absorb UV light at that wavelength. The amount of absorbed UV light is used to monitor NOM levels.

UV absorbance measurements are very significant with regards to operating water treatment process systems.

The UV process probe UVAS plus is specifically designed for the continuous measurement of the UV absorption of dissolved organic substances in water. The measured value is available without delay and can be expressed as the spectral absorption coefficient (SAC) in m-1. In addition to the drinking water plant inlet, it is helpful to measure organics at various treatment steps as:

- ✓ During the chemical oxidation process in raw water
- ✓ During the coagulation process using aluminum, iron or polymer compounds

- ✓ During activated carbon filtration
- ✓ During final disinfection



3.1.5. pH test

PH indicates the sample's acidity but is actually a measurement of the potential activity of hydrogen ions (H+) in the sample. pH measurements run on a scale from 0 to 14, with 7.0 considered neutral. Solutions with a pH below 7.0 are considered acids. Solutions with a pH above 7.0, up to 14.0 are considered bases. All organisms are subject to the amount of acidity of stream water and function best within a given range.

What causes the pH of a stream to vary?

The pH of a body of water is affected by several factors.

- ✓ One of the most important factors is the bedrock and soil composition through which the water moves, both in its bed and as groundwater. Some rock types such as limestone can, to an extent, neutralize the acid while others, such as granite, have virtually no effect on pH.
- ✓ Another factor which affects the pH is the amount of plant growth and organic material within a body of water. When this material decomposes carbon dioxide is released. The carbon dioxide combines with water to form carbonic acid. Although this is a weak acid, large amounts of it will lower the pH.
- ✓ A third factor which determines the pH of a body of water is the dumping of chemicals into the water by individuals, industries, and communities. Remember - something as "harmless" as shampoo rinse water is actually a chemical brew and can affect the pH along with other chemical parameters of water. Many industrial processes require water of exact pH readings and thus add chemicals to change the pH to meet their needs. After use, this altered pH water is discharged as an effluent, either directly into a body of water or through the local sewage treatment plant.

- ✓ A fourth factor which affects pH is the amount of acid precipitation that falls in the watershed. Acid rain is caused by nitrogen oxides (NOx) and sulfur dioxide (SO_2) in the air combining with water vapor. These pollutants are primarily from automobile and coal-fired power plant emissions. Acid rain is responsible for many of our first order streams becoming acidic. Serious problems can occur in spring when streams receive a massive acid dose as acidic snows melt.
- ✓ A fifth factor stems from coal mine drainage. Iron sulfide, a mineral found in and around coal seams, combines with water to form sulfuric acid. This acid, ferrous oxide (known as "yellow boy"), and huge quantities of silt are the major pollutants from coal mining. Combined with the problem of acid rain, the pH of some stream waters can be drastically lowered.

3.1.6. Color

Many surface waters are colored, due primarily to decomposition of organics, metallic salts or colored clays. This color is considered as "apparent color" as it is seen in the presence of suspended matter, whereas "true color" is derived only from dissolved inorganic and organic matters. Samples can be centrifuged and/or filtered to remove turbidity in order to measure true color. Waters which obtain their color from natural organic matter usually pose no health hazard. However, because of the yellowish brown appearance of such waters, the consumers may not find the water aesthetically acceptable.

3.1.7. Turbidity

Turbidity is caused by suspended materials which absorb and scatter light. These colloidal and finely dispersed turbidity-causing materials do not settle under quiescent conditions and are difficult to remove by sedimentation. Turbidity is a key parameter in water supply engineering, because turbidity will both cause water to be aesthetically unpleasant and cause problems in water treatment processes, such as filtration and disinfection. Turbidity is also often used as indicative evidence of the possibility of bacteria being present. Turbidity measurements performed using proprietary nephelometric instruments are expressed as Nephelometric Turbidity Units (NTU). The nephelometric apparatus is designed to measure forward scattering of light at 90o to the path of an incandescent light beam. Suspended particles present in a water sample reflect a portion of the incident light off the particle surface. The light reflected at 90o is measured by a photoelectric detector and is compared against light reflected by a reference standard. No interference exists for the turbidity test. Locally, the Public Utilities Board (PUB) of Singapore requires all water treatment facilities to produce water containing less than 1 NTU.

3.1.8. residual aluminum or iron

The aluminum and iron contents in drinking water can mainly be derived from the water treatment process because these metal ions is commonly used as reactant for coagulation-flocculation. When the optimum physico-chemical condition of the treatment of raw water is not well established, the probability of the presence of residual coagulants in treated water increases. In most water treatment plants, variation in raw water quality and the quantity make necessary a good monitoring of the optimum condition of treatment. In spite of these, consumers are exposed to dangerous consumption of residual coagulant in drinking water.

3.2. Quality of treatment chemicals

Chemicals from water treatment and distribution reach drinking-water by the most direct route. They fall into three broad categories**:**

- ✓ Substances resulting from the addition of chemicals used in the treatment process for coagulation and disinfection, these chemicals are intentionally added and can give rise to residues or by-products;
- ✓ Disinfectants that are deliberately added with the intention of maintaining a residual in distribution, usually to the tap these chemicals may also give rise to by-products;
- ✓ Substances that leach from materials used in distribution or plumbing, or that arise from the corrosion products of pipes.

The WHO Guidelines for Drinking-water Quality (WHO, 2004) cover a significant number of potential substances from water treatment or distribution (summarized in Table 78.1), but only a few of these substances are of practical significance. It is important that water supply agencies properly manage any chemicals that they use.

In many cases, the best method of control is through management practices, such as optimization of the treatment process, and regulation of materials and chemicals that come into contact with drinking-water, rather than through monitoring and chemical analysis. This chapter gives guidance on the importance of potential chemicals derived from water treatment or distribution, from a management perspective.

- **The most commonly used chemicals for water treatment process are:**

  - ✓ Algicide.
  - ✓ Chlorine.
  - ✓ Chlorine dioxide.
  - ✓ Muriatic acid.
  - ✓ Soda ash or Sodium bicarbonate.

- ✓ These include:
  - ✓ Collection;
  - ✓ Screening and Straining;
  - ✓ Chemical Addition
  - ✓ Coagulation and Flocculation;
  - ✓ Sedimentation and Clarification;
  - ✓ Filtration;
  - ✓ Disinfection
  - ✓ Storage;
  - ✓ Finally, Distribution.

Self-Check -3	Written Test

Direction I: Multiple choice item (2 points each)

Instruction: choose the best answer for the following questions and write your answer on the answer sheet provided in the next page:

1. ________is intended to simulate the coagulation/flocculation process and determine
   A. Jar test
   C. Color test
   B. Turbidity test
   D. Oder test
2. Jar Testing equipment from the following except
   A. Gang Stirrer
   B. 2 Graduated Pipets, 10 ml
   C. 1 Graduated Cylinder, 1000 ml
   D. All
3. _________treatment chemicals are used in effluent wastewater water treatment processes for solids removal, water clarification, lime softening, sludge thickening, and solids dewatering.
   A. Flocculation and coagulation
   B. Chlorination
   C. Sedimentation
   D. Clarification
4. _______indicates the sample's acidity but is actually a measurement of the potential activity of hydrogen ions (H+) in the sample.
   A. pH
   C. turbidity of water
   B. aluminum sulphat
   D. all
5. _____is caused by suspended materials which absorb and scatter light
   A. Turbidity
   B. Color
   C. Oder
   D. Algae
6. Jar testing is a pilot-scale test of the treatment chemicals used in a particular water plant.
   A. True B. False

7. The purpose of the laboratory jar test is to select and quantify a treatment program for removal of suspended solids or oil from raw water or a dilute process or waste stream

.A. True B. False

Note: **Satisfactory rating – 5 and above points   Unsatisfactory - below 5 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Name: _____________ Date: _______________

Score = ___________
Rating: ____________

Answer Questions

1. _______
2. ________
3. _______
4. _______
5. ___________
6. ___________
7. _____________

Operation Sheet _1	Procedure for conduct jar tests

Steps for conducting jar test

Step1. Select appropriate tools and equipment

Step2. Fill the appropriate number of (matched) 1000 mL square transparent jars

Step3. With well-mixed test water, using a 1000 mL graduate.

S**tpe4**. Place the filled jars on the gang stirrer, with the paddles positioned identically in each Beaker.

Step5. Mix the beakers at 40 – 50 rpm for 30 seconds.

Step6. Leave the first beaker as a blank1, and add increasing dosages of the first polymer to subsequent beakers. Inject polymer solutions as quickly as possible, below the liquid level and about halfway between the stirrer shaft and beaker wall.

Stp7. Increase the mixing speed to 100-125 rpm for 15-60 seconds (rapid mix).3,4 6. Reduce the mixing to 40 rpm and continue the slow mix for twice the duration of the rapid mix. Note relative floc sizes.

Step8. Turn the mixer off and allow settling to occur. Note relative rates of settling.

Step9. After settling for a period of time (typically 10 or 15 min.), note supernatant appearance. If desired, the latter may be quantified using a turbidimeter or clarity wedge (for turbidity), or determined gravimetrically (for suspended solids).

Step10. Remove the jars from the gang stirrer, empty the contents and thoroughly clean the beakers.

Stpe11. Repeat the procedure from Step 1, but substituting for the Blank the dosage selected as providing the desired level of performance in the first series of test.

LAP Test	Practical Demonstration

Name: _____________________________ Date: ________________

Time started: ________________________ Time finished: ________________

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within _______hours.

Task 1. Conduct jar test to keep quality of water

Instruction Sheet	Learning guide 29: Investigate chemical addition plant configuration

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics:

- Reviewing existing fault reports and other plant asset information.
- Investigating the operational status of plant components with reference to manufacturer and plant designer specifications.
- Carrying out plant configuration investigations to identify potential deficiencies.

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, **upon completion of this Learning Guide, you will be able to**:

- Review existing fault reports and other plant asset information.
- Investigate the operational status of plant components with reference to manufacturer and plant designer specifications.
- Carry out plant configuration investigations to identify potential deficiencies.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below
3. Read the information written in the "Information Sheets 1- 3". On pages 45, 51 and 64 . Try to understand what are being discussed.
4. Accomplish the "Self-checks 1, 2, and3" in each information sheets on pages 49, 60 and 74.
5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to "Operation sheets 1, on pages 77 .and do the LAP Test on page 78". However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity.

7. After you accomplish Operation sheets and LAP Tests, ensure you have a formative assessment and get a satisfactory result; then proceed to the ne

Information Sheet-1	Reviewing existing fault reports and other plant asset information

1.1. Introduction to existing plant faults in water treatment

Efficient asset information management, collaboration and integrated best practice workflows improve execution on major and routine maintenance activities, reduce the downtime of facilities, support technical and process innovation and mitigate compliance and reputational risk. Plant Asset Management optimizes the efficiency of technical documentation and maintenance activities with real time machine data. It also integrates with and extends Enterprise Asset Management (EAM) platforms. Chemical dosing processes and workflows are integrated in Plant Asset Management, improving visibility, consistency, compliance and quality of maintenance activities according to industry and corporate best practices. Templates are available for industrial assets and maintenance procedures, as well as checklists, reports and test protocols

Renewing and replacing the nation's public water infrastructure is an ongoing task. Asset management can help a utility maximize the value of its capital as well as its operations and maintenance dollars.

Asset management provides utility managers and decision-makers with critical information on capital assets and timing of investments. Some key steps for asset management are making an inventory of critical assets, evaluating their condition and performance, and developing plans to maintain, repair, and replace assets and to fund these activities.

1.2. Asset management

Asset management is a process water and wastewater utilities can use to make sure that planned maintenance can be conducted and capital assets (pumps, motors, pipes, etc.) can be repaired, replaced, or upgraded on time and that there is enough money to pay for it.

Asset management is the practice of managing infrastructure capital assets to minimize the total cost of owning and operating these assets while delivering the desired service levels. Many utilities use asset management to pursue and achieve sustainable infrastructure. A high-performing asset management program includes detailed asset inventories, operation and maintenance tasks, and long-range financial planning.

1.2.1. Benefits of asset management

Examples of outcomes that can be realized by utilities through asset management:

- Prolonging asset life and improving decisions about asset rehabilitation, repair, and replacement
- Meeting consumer demands with a focus on system sustainability
- Setting rates based on sound operational and financial planning
- Budgeting focused on critical activities for sustained performance
- Meeting service expectations and regulatory requirements
- Improving responses to emergencies
- Improving the security and safety of assets
- Reducing overall costs for both operations and capital expenditures

1.2.2. Elements of asset management practice

Asset management is centered on a framework of five core questions, which provide the foundation for many asset management best practices:

1. What is the current state of my assets?
2. What is my required "sustainable" level of service?
3. Which assets are critical to sustained performance?
4. What is my minimum life-cycle costs?
5. What is my best long-term funding strategy?

2. Who should practice asset management?

Asset management is a scalable approach that can be used by systems of any size. Whether running a small drinking water system serving 50 customers or drinking water and wastewater systems of the largest cities, asset management means putting in place a long-term plan to sustain these systems and the services they provide.

Asset management is also used in other sectors where infrastructure needs to be managed for the long term, such as in the transportation and housing sectors. Some leading communities are adopting cross-sector asset management programs where infrastructure investments are coordinated and prioritized across the different infrastructure areas.

1.2.3. Advanced Asset Management Workshop Materials

- ✓ Advanced Asset Management Training Workshop Agenda
- ✓ Story Line
- ✓ Exercise Tables
- ✓ Pump Station Drawings
- ✓ Excel Spreadsheet Tool

Quality control measures for regionally purchased treatment chemicals in Severn Trent Water Ltd apply from the point of manufacture through to their arrival and acceptance on a water-treatment works. This approach involves a formalized examination of the control systems of treatment chemical suppliers and the introduction of standard documented acceptance procedures at each treatment works. These measures are intended to not only provide a high degree of reassurance to customers, but to ensure that staff of Severn Trent Water are purchasing and receiving cost-effective materials which are of an acceptable quality in terms of active constituents and background contaminants, before use in the treatment of water

1.3. Most common problems with raw water treatment process reviewing

1.3.1. Variation in turbidity

When plants begin to experience a variation in turbidity the cloudiness of water due to the presence of a large number of particles it can have negative effects on the quality of the process and effluent from the plant. It's helpful to have a consistent year's worth of data to evaluate the turbidity levels coming into the plant from season to season prior to designing the system.

1.3.2. Variation in flow

Many times, industrial companies make educated guesses as to what they think their flow rates are going to be. If an industrial facility is not equipped to handle these variations, they'll likely experience upsets to the system that will carry turbidity over and plug any downstream filters. Raw water treatment plants do not handle variations in flow well, so it's helpful to design the system with this in mind from the start.

1.3.3. Changing feed chemistry

Many surface and well waters have seasonal variations in water chemistry. Industrial plants need to be very careful in the design of any raw water treatment systems to be large enough to handle these changes.

All in all, it's very important to understand the variations of the contaminants feed water chemistry and design a system accordingly. Physical chemical processes to remove the iron and silica is typically an oxidation chemical (such as oxygen) and an aluminum-based coagulant such as alum that will precipitate out the iron and silica and allow them to settle so they can be removed in a clarification filtration system.

1.3.4. Being unaware of updates/changes to quality requirements

When you design a plant for a certain process and to make sure you meet stringent requirements, sometimes you might find out later you need to adapt your equipment to account for recent changes in regulations. This is a common occurrence that sometimes happens after plants have been installed for years. The plant may be running well and designed to deliver a certain kind of effluent quality, and then one day the standards of the quality requirements become more stringent and the plant no longer meets the requirements at the facility.

1.3.5. Secondary waste

One of the biggest mistakes made in designing raw water treatment plants is not looking carefully at the secondary waste generated by the process**.**

Contaminants from the feed water impact the volume and processing requirements in secondary waste. Also, sometimes these secondary wastes need to be treated and discharged, yet many times they are discharged to a publicly owned treatment works or wastewater facility and they must meet the requirements of that facility.

1.4. Fault reporting

Fault reporting is a maintenance concept that increases operational availability and that reduces operating cost through three mechanisms.

- Reduce labor-intensive diagnostic evaluation
- Eliminate diagnostic testing down-time
- Provide notification to management for degraded operation

The main aim of the system is to allow a better way of keeping track of problems and their solution by relying less on person-to-person communication and individual memories

Self-Check -1	Written Test

Direction I: Multiple choice item (3 points each)

Instruction: choose the best answer for the following questions and write your answer on the answer sheet provided in the next page:

1. Purpose of efficient asset information management, collaboration and integrated best practice workflows
   A. improve execution on major and routine maintenance activities,
   B. reduce the downtime of facilities,
   C. Support technical and process innovation and mitigate compliance reputational risk.
   D. All
2. Plant Asset Management optimizes the efficiency of technical documentation and maintenance activities with real time machine data.
   A. True B. False
3. Chemical dosing processes and workflows are integrated in Plant Asset Management, to improving
   A. Visibility
   B. Consistency
   C. Compliance and quality of maintenance activities
   D. All
4. Reviewing most common problems with raw water treatment process from the following
   A. Variation in turbidity
   B. Variation in flow
   C. Changing feed chemistry
   D. All

5. Outcomes that can be realized by utilities through asset management is ____.

A. Prolonging asset life and improving decisions

B. Improving responses to emergencies

C. Improving the security and safety of assets

D. All are correct

6. Asset management is centered on a framework of five core questions, which provide the foundation for many asset management best practices:

   A. What is the current state of my assets?

   B. What is my required "sustainable" level of service?

   C. Which assets are critical to sustained performance?

   E. All are correct

7. Advanced Asset Management Workshop Materials

   A. Advanced Asset Management Training Workshop Agenda

   B. Exercise Tables

   C. Pump Station Drawings

   D. Excel Spreadsheet Tool

***Note:* Satisfactory rating – 6 and above points**   **Unsatisfactory - below 6 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________   Date: _______________

Short Answer Questions

1. _________
2. __________
3. ___________
4. ____________
5. ______________
6. _______________
7. _____________

Information Sheet-2	Investigating the operational status of plant components with reference to manufacturer and plant designer specifications.

2.1. Introduction to operational status of water treatment plant

The rapid growth of population has exerted the portable water demand, which requires exploration of raw water sources, developing treatment and distribution systems there is a need to investigate the water treatment plants for their operational status and to explore the best feasible mechanism to ensure proper drinking water production with least possible rejects and its management

Essential efficiency parameters include monitoring for leaks in the distribution network, backwash water rates tied to filter quality output, sludge thickening rates and smart pump operation. Water treatment plant operators should consistently evaluate their water management practices to ensure that the plant is operating efficiently, thus minimizing energy costs and improving water conservation efforts.

When water treatment plants are not operating efficiently, it can be extremely costly. The combination of inefficient and older pumping and process equipment, combined with outdated water management practices can result in higher operating costs and lower revenue collected, which can negatively impact a treatment plant's bottom line

- **Steps can** help water treatment plants to achieve better water efficiency and realize potential cost savings by reducing water waste.
  - ✓ Conduct a self-assessment
  - ✓ Evaluate technology
  - ✓ Perform a pump audit
  - ✓ Install smart technology
  - ✓ Review the data

2.2. Investigating Plant components

2.2.1. mixing equipment

Chemical mixing facilities should be designed to provide a thorough and complete dispersal of chemical throughout the wastewater being treated to insure uniform exposure to pollutants which are to be removed. The intensity and duration of mixing of coagulants with wastewater must be controlled to avoid over mixing or under mixing. Over mixing excessively disperses newly-formed floe and may rupture existing wastewater solids

Water Treatment | Chemical Feed Equipment and Flash Mixing

- ✓ Solution Feeders.
- ✓ Diaphragm Pump.
- ✓ Peristaltic Pump.
- ✓ Rapid-Mix (Flash Mixing) Facilities.
- ✓ Mechanical Mixers.
- ✓ Single Blade Mechanical Mixer.
- ✓ Multi-Blade Mechanical Mixer.
- ✓ Inline Mechanical Mixer.

Figure 2.1. different type of mix feeder

2.2.2. streaming current detector

A streaming current detector (SCD) is an instrument for measuring the charge that exists on small, suspended particles in water. The SCD is the instrument that can be used to measure coagulated particle stability for the feedback control of coagulant dosage.

Figure 2.2. streaming current detector

2.2.3. dosing pumps

A dosing pump, which is a positive displacement pump, is designed to inject a chemical or another substance into a flow of water, gas or steam. Dosing pumps, which are typically small, provide an extremely precise flow rate for maximum control. They are the central part of an integrated dosing system designed for automatic dispersion of chemicals. This dosing definition applies to a wide range of applications and industries, from waste water treatment to food processing.

How Does a Dosing Pump Work?

A dosing pump draws a measured amount of liquid into its chamber and injects the chemical into a tank or pipe that contains the fluid that is being dosed. It's powered by an electric motor or an air actuator and has a controller that turns the pump on and off and manages the flow rate. Some models include more sophisticated control systems.

Types of Dosing Pumps

These four dosing pump types are designed for different pressures, chemicals and applications. They vary by pumping action and mechanism.

- **Diaphragm (constant injection) pumps** use a diaphragm, piston and valves on both the inlet and outlet to fill and empty its chamber. Drawing in the piston fills the chamber, and a specific amount of chemical is injected at a preset speed, usually a percentage of the maximum flow rate. Certain pump models are capable of variable dosing rates.
- **Diaphragm (pulse injection) pumps** also use the diaphragm mechanism, but instead of a constant flow rate, a solenoid coil takes in the chemical and injects it in pulses. The flow rate is the length of time between pulses. It is less accurate than the constant injection pump but is simple in design and inexpensive.
- **Lobe pumps** let a certain volume of fluid through meshing gear impellors. It is not as accurate as a diaphragm pump and it is only suitable for high viscosity fluids that will self-lubricate to minimize wear. They're not made for low flow rates, as it is difficult to ensure accuracy.

- **Peristaltic pumps** are highly accurate for dosing. A flexible bent tube lets the fluid pass, and the flow is controlled by a roller that moves by way of a mechanical arm on the outside. This pushes product in the tube into the dosing tube and main fluid stream.

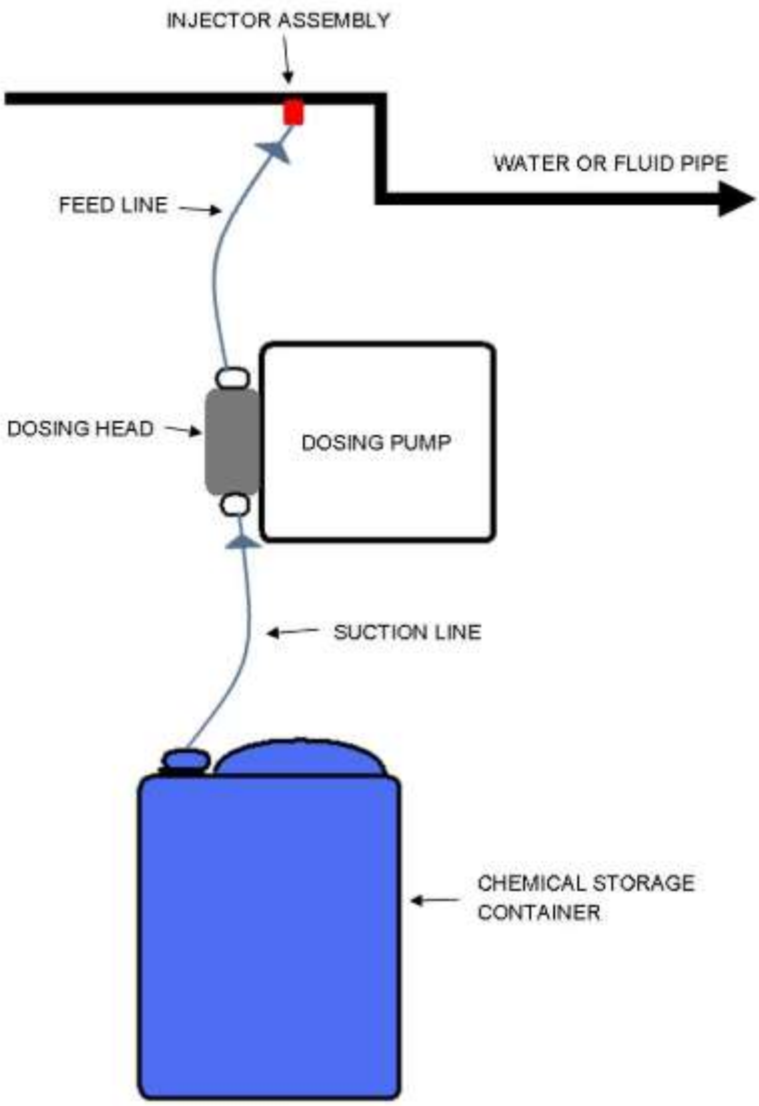


Figure 2.3. 1chemical dosing system lay out

2.2.4. chemical injection equipment

As the name implies, a chemical injection system is a piece of equipment designed to inject chemicals into a system at the required pressure for the system. It may function continuously or intermittently, and it can be used in a wide range of settings for many different purposes. For instance, it could be found in either the upstream or downstream oil and gas industry and it might be used for everything from well cleaning, corrosion prevention, or improving pipeline flow or oil recovery. In all of these various settings and purposes it is frequently beneficial to integrate the chemical injection system into a process skid. Let’s take a look at the finer points of a chemical injection system as well as the benefits that are reaped through utilizing an integrated process skid.

2.2.4.1. Components of Chemical Injection Systems

The following list will briefly discuss each of the major components of a typical chemical injection system. Depending on their purpose and physical setting, different chemical injection systems may vary, however, most employ each of the following in some way:

Tanks-Tanks are one of the most fundamental aspects of any chemical injection system because they required to store the chemicals which need to be injected into the system. Tank size and structure may vary, but typically they will be horizontal and cylindrical. They may feature a flat, conical, or dished bottom with a flat or dished top.

Pumps-Pumps are another fundamental aspect of chemical injection system because they provide the source for generating the flow the pressure required to achieve the system’s objective. Pumps may be of a diaphragm or plunger type and may feature a number of different power sources including electric motor, air operated motor, solar power motor, or solenoid driven motor.

Valves and instrumentation-Valves and instrumentation are needed to measure and monitor what is going on within the system. For instance, they will often monitor the liquid level inside the tank, allow for the calibration of the flow rate, monitor and adjust the pressure within the system, and set off alarms and other fail safes designed to ensure safety and proper function. Specific gauges and valves may vary depending on the exact purpose of the chemical injection system and the client’s own unique set of requirements and needs.

Electrical-A chemical injection system’s electrical system provides a way for the system to be started or stopped either locally or remotely. Typically, the various controls and functions will be routed to a control panel for ease of use and function.

Skid Structure-All skid mounted chemical injection systems will also of course feature a skid structure as part of their fundamental component parts. The skid structure provides the structure itself for the system and is designed in such a way to protect the system while accommodating its various parts. It will usually feature structural steel which has been continuously welded. Often it will also feature a drip pan designed to collect drained chemicals.

2.2.4.2. Advantages of Chemical Injection Systems

By integrating the chemical injection system into a modular process skid, customers are able to gain a number of significant advantages. For instance, compared to non-skid mounted units, modular process skids are:

- More cost effective
- More space efficient
- Feature greater safety
- Can be fabricated and installed quickly
- Reduce downtime at the worksite
- Have greater quality assurance
- Are constructed in more controlled environments
- Can be used even in hazardous areas

2.2.5. turbidity meter

The turbidity meter indicates the turbidity in FTU (Formazine Turbidity Unit), this unit is identical to NTU (Nephelometric Turbidity Unit). The turbidity meter is often used in drinking water treatment.

Turbidity measurements are of extreme importance in quality monitoring in water, wastewater, beverage production, electroplating and petrochemical applications. Light passing through liquid which contains un dissolved solids, such as algae, mud, microbes and other insoluble particles, is both absorbed and scattered. Turbidity increases with the amount of un dissolved solids present in the sample. However, the shape, size and composition of the particles also influence the degree of turbidity

Figure 2.4. turbidity meter

2.2.6. particle counter

The particulate water quality in a distribution network is not always constant but can deteriorate over time. Discoloration problems can occur, especially in distribution systems with a low flow rate. Until now, particulate water quality in the distribution network has been mainly monitored by measuring the turbidity. However, as turbidity is an indirect measurement method, it does not give quantitative and qualitative information about the water quality, and therefore a more advanced approach was used in this research. Several particle counters have been used simultaneously to measure the particulate water quality at different locations in a transportation system. It was found that larger particles were present further away from the treatment location, although these sized particles were not present directly after treatment. The particulate water quality in the transportation system was also assessed by filtering time integrated large volume water samples. Both organic and inorganic measurements were used to characterize the particle composition

2.2.7. Manufacturer and plant designer specifications.

Manufacturers' and plant designers' specifications May include:

- **Dosing pump capacity and calibration charts**

Mechanical and digital dosing pumps. Search by pump design. See our selection of dosing pumps here. BIM Drawings. Quick sizing. Pump replacement tools. Sizing & selection tools. Types: Circulator pumps, End suction, Split case, Groundwater pumps, inline single stage. Check calibration. Liquid feeder pumps are used to pumps be correctly calibrated so the doses are accurate. GPD required or dose range anticipated;

- ✓ Flow rate
- ✓ Pressure on the line being pumped

This diagram shows the design of a peristal pump.

- **Chemicals Dosing Pumps Calibration Basics**

Calibration of chemical feed pumps is important to ensure that the proper amount of water treatment products is being fed to your systems. All chemical feed pumps are designed to pump at a certain rate; however, the actual flow rate can vary depending upon many conditions. Factors such as discharge pressure, chemical viscosity, type of suction (flooded or lift), and pump age will affect the flow rate. This simple procedure should be used on a regular basis to ensure that you are feeding the proper amount of product to your water systems.

- **Safety**

Prior to running calibration on chemical pumps, review product MSDS forms and use proper personal protective equipment.

If you are using the same calibration cylinder to calibrate multiple pumps, be sure to rinse it with water between calibrations.

- **Calibration Notes**
  - ✓ If possible, you should run the calibration with the pump connected to the system that it feeds. The more closely you replicate the actual operating conditions of the pump, the more accurate your calibration will be.
  - ✓ Most calibration cylinders provide both mL and GPH. If mL is the only scale provided, then be sure to record your starting level before running the test.
  - ✓ Run the calibration with the pump set to the actual speed and stroke setting that the pump usually runs at. Use this formula to calculate the capacity at this setting:

(Pump capacity, gph x Pump speed, % x Pump stroke, %)

Example: (1, gph x 50% x 50%) = (1 x 0.5 x 0.5) = 0.25 gph

- **Calibration Procedure**

1. Calculate the capacity of the pump at the speed and stroke rate at which the test will be run.
2. Fill the calibration cylinder with the product that the pump is feeding.
3. Record the starting level of the calibration cylinder.
4. Run the pump for the desired amount of time, generally 0.5 - 1.0 minute.
5. Record the ending level of the calibration cylinder.
6. Calculate the actual feed rate (assuming a 1-minute test):

((mL pumped, 1 min x 60 minutes) / 3,785)) = gallons per hour

Example: (50 mL x 60 minutes) / 3,785 = 0.79 gallons per hour

Depending on your system, you will need to adjust your pump or controller settings to account for any difference between the design and actual feed rates.

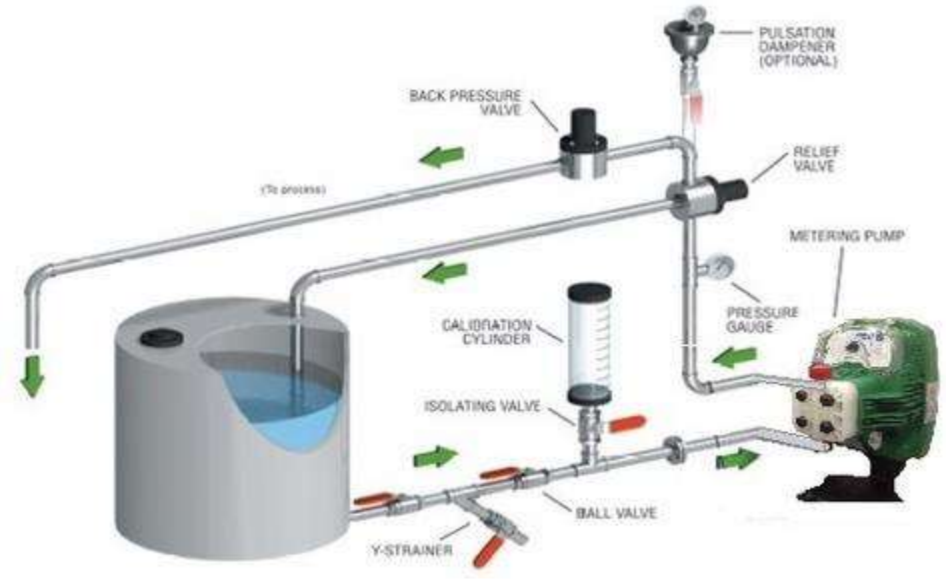


Figure 2.5. Dosing Pump Calibration

2.2.8. detention times

Detention time is a measure of how long a given molecule of water resides within a pond before being discharged. detention time. The actual or theoretical (calculated) time required for water to fill a tank at a given flow; pass through a tank at a given flow; or remain in a settling basin, flocculating basin, rapid-mix chamber, or storage tank. Detention time is calculated by dividing the volume of the tank or basin by the flow rate.

The detention time shall be established on the basis of the raw water characteristics and other local conditions that affect the operation of the unit. Based on design flow rates, the detention time should be:

- ✓ two to four hours for suspended solids contact clarifiers and softeners treating surface water or groundwater under the direct influence of surface water, and;
- ✓ One to two hours for suspended solids contact softeners treating only groundwater. The reviewing authority may alter detention time requirements.

3. mixing intensity for flash or rapid mixing and flocculation

Review focuses on rapid mixing in the coagulation process for improved natural organic matter (NOM) removal in water treatment. Rapid mixing aims to instantly and efficiently disperse coagulant species into raw water, before flocculation, sedimentation, and filtration processes. Mechanical mixing with a longer retention time cannot guarantee an instantaneous and uniform coagulant dispersion

- **Rapid mixing unit**: provide complete mixing of the coagulant and raw water. Destabilization of colloidal particle early stages of floc formation.(occur in rapid mixing unit)
- Design of Slow Mixing (Flocculation) Units
- Destabilized colloids resulting from coagulation may still settle very slowly Flocculation is a slow mixing process in which these particles are bought into contact in order to promote their agglomeration

Self-Check -2	Written Test

Direction I: Multiple choice item (2 points each)

Instruction: choose the best answer for the following questions and write your answer on the answer sheet provided in the next page:

1. Steps can help water treatment plants to achieve better water efficiency and realize potential cost savings by reducing water waste
   A. Conduct a self-assessment
   B. Evaluate technology and Install smart technology
   C. Review the data
   D. All
2. ______facilities should be designed to provide complete dispersal of chemical throughout the wastewater being treated to insure uniform exposure to pollutants
   A. Chemical mixing equipment
   B. Streaming current
   C. Turbidity meter
   D. Dosing pump
3. _______is an instrument for measuring the charge that exists on small, suspended particles in water.
   A. streaming current detector (SCD)
   B. Chemical mixing equipment
   C. Turbidity meter
   D. All

4. _______indicates the turbidity in FTU (Formazine Turbidity Unit), this unit is identical to NTU (Nephelometric Turbidity Unit).
   A. The turbidity meter
   B. Current meter
   C. Chemical mixing equipment
   D. Streaming current
5. Which one of the following statement is correct
   A. Rapid mixing unit provide complete mixing of the coagulant and raw water.
   B. Large enough to settle in the sedimentation stage.
   C. Wastewater is mixed gently with a small amount of energy
   D. All
6. In a Water Treatment, Chemical Feed Equipment and Flash Mixing, there is___.
   A. Solution Feeders.
   B. Diaphragm Pump.
   C. Mechanical Mixers.
   D. All are correct
7. The streaming current detector has built-in features that provide optimal control **except**____.
   A. Maintains coagulant dosing at the optimum point without overdosing
   B. Assures regulatory compliance with turbidity standards
   C. Provides best available technology for water quality
   D. Mechanical Mixers.
   E. Several models available to meet your control needs
8. One of the following is **not** advantages of a dosing pump.
   A. Extremely rigid pressure characteristic curve
   B. Very precise metering
   C. Flow rate of 1 ml/h to 1,500 m^3/h
   D. Dry-run safe
9. Which one is the delivery characteristics of a dosing pump?
   A. Extremely rigid pressure characteristic curve
   B. Hermetically tight
   C. Very precise metering
   D. Pressure range from vacuum up to 1,200 bar
   E. Self-priming under certain conditions
10. Which one is an advantage of Chemical Injection Systems?
   A. More cost effective
   B. More space efficient

C. Reduce downtime at the worksite

D. Have greater quality assurance

E. All are answers

Note: **Satisfactory rating – 10 and above points Unsatisfactory - below 10 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: ____________

Name: ___________________________ Date: ________________

Short Answer Questions

1. ___________
2. ___________
3. ___________
4. ___________
5. _______
6. _________
7. _________
8. __________
9. __________
10. _______

Information Sheet-3	Carrying out plant configuration investigations to identify potential deficiencies.

3.1. Introduction to water treatment plant configuration

The design of treatment processes and devices shall depend on evaluation of the nature and quality of the particular water to be treated, seasonal variations, the desired quality of the finished water and the mode of operation planned. The design of a water treatment plant shall consider the worst condition that may exist during the life of the facility.

3.1.1. Micro screening

Micro screening is a mechanical treatment process capable of removing suspended matter and organic loading from surface water by straining. It shall not be used in place of filtration or coagulation.

- Design consideration shall be given to the:
  - ✓ nature of the suspended matter to be removed;
  - ✓ corrosiveness of the water;
  - ✓ effect of chemicals used for pre-treatment;
  - ✓ duplication of units for continuous operation during equipment maintenance;
  - ✓ provision of automated backwashing

- design shall provide:
    - ✓ durable, corrosion-resistant screen;
    - ✓ provisions to allow for by-pass of the screen;
    - ✓ protection against back-siphonage when potable water is used for backwashing;
    - ✓ proper disposal of backwash waters

3.1.2. Clarification

Clarification is generally considered to consist of any process or combination of processes which reduce the concentration of suspended matter in drinking water prior to filtration.

Plants designed to treat surface water, groundwater under the direct influence of surface water, or for the removal of a primary drinking water contaminant shall have a minimum of two units each for coagulation, flocculation, and solids removal. In addition, it is recommended that plants designed solely for aesthetic purposes also have a minimum of two units each.

- Design of the clarification process shall:
    - ✓ permit operation of the units either in series or parallel where softening is performed and should permit series or parallel operation in other circumstances where clarification is performed;
    - ✓ be constructed to permit units to be taken out of service without disrupting operation, and with drains or pumps sized to allow dewatering in a reasonable period of time
    - ✓ provide multiple-stage treatment facilities when required by the reviewing authority;
    - ✓ be started manually following shutdown
    - ✓ Minimize hydraulic head losses between units to allow future changes in processes without the need for re pumping.

3.1.2.1. Presedimentation

Waters containing high turbidity may require pretreatment, usually sedimentation, with or without the addition of coagulation chemicals.

- ✓ Basin design:-Pre sedimentation basins should have hopper bottoms or be equipped with continuous mechanical sludge removal apparatus, and provide arrangements for dewatering.
- ✓ Inlet: - Incoming water shall be dispersed across the full width of the line of travel as quickly as possible; short-circuiting must be prevented.
- ✓ Bypass: - Provisions for bypassing pre sedimentation basins shall be included.
- ✓ Detention time:- Three hours detention is the minimum period recommended; greater detention may be required.

3.1.2.2. Coagulation

Coagulation refers to a process using coagulant chemicals and mixing by which colloidal and suspended material are destabilized and agglomerated into settle able or filterable flocs, or both. The engineer shall submit the design basis for the velocity gradient (G value) selected, considering the chemicals to be added and water temperature, color and other related water quality parameters. For surface water plants using direct or conventional filtration, the use of a primary coagulant is required at all times.

- **Mixing** – The detention period should be instantaneous, but not longer than thirty seconds with mixing equipment capable of imparting a minimum velocity gradient (G) of at least 750 fps/ft. The design engineer should determine the appropriate G value and detention time through jar testing.
- **Equipment** - Basins should be equipped with devices capable of providing adequate mixing for all treatment flow rates. Static mixing may be considered where the flow is relatively constant and will be high enough to maintain the necessary turbulence for complete chemical reactions.
- **Location**:- the coagulation and flocculation basin shall be as close together as possible. If flow is split between basins, it is recommended that a means of measuring and modifying the flow to each train or unit be provided. .

3.1.2.3. Flocculation

Flocculation refers to a process to enhance agglomeration or collection of smaller floc particles into larger, more easily settle able or filterable particles through gentle stirring by hydraulic or mechanical mean.

- **Basin Design**:- Inlet and outlet design shall minimize short-circuiting and destruction of floc. Series compartments are recommended to further minimize short-circuiting and to provide decreasing mixing energy with time. Basins shall be designed so that individual basins may be isolated without disrupting plant operation. A drain and/or pumps shall be provided to handle dewatering and sludge removal.
- **Detention**: - The detention time for floc formation should be at least 30 minutes with consideration to using tapered (i.e., diminishing velocity gradient) flocculation. The flow-through velocity should be neither less than 0.5 nor greater than 1.5 feet per minute.
- **Equipment**: - Agitators shall be driven by variable speed drives with the peripheral speed of paddles ranging from 0.5 to 3.0 feet per second. External, non-submerged motors are preferred.

- **Other designs**:-Baffling may be used to provide for flocculation in small plants only after consultation with the reviewing authority. The design should be such that the velocities and flows noted above will be maintained.
- **Superstructure**: - A superstructure over the flocculation basins may be required.
- **Piping**:-Flocculation and sedimentation basins shall be as close together as possible. The velocity of flocculated water through pipes or conduits to settling basins shall be no less than 0.5 nor greater than 1.5 feet per second. Allowances must be made to minimize turbulence at bends and changes in direction.
- If flow is split, it is recommended that a means of measuring and modifying the flow to each train or unit be provided.
- Consideration should be given to the need for additional chemical feed in the future.

3.1.2.4. Sedimentation

Sedimentation refers to a process that allows particles to settle by gravity and typically precedes filtration. The detention time for effective clarification is dependent upon a number of factors related to basin design and the nature of the raw water. The following criteria apply to conventional gravity sedimentation units:

- A minimum of four hours of settling time shall be provided. This may be reduced to two hours for lime-soda softening facilities treating only groundwater. Reduced detention time may also be approved when equivalent effective settling is demonstrated or when the overflow rate is not more than 0.5 gpm per square foot (1.2 m/hr).
- **Inlet devices**: - Inlets shall be designed to distribute the water equally and at uniform velocities. Open ports, submerged ports, and similar entrance arrangements are required. A baffle should be constructed across the basin close to the inlet end and should project several feet below the water surface to dissipate inlet velocities and provide uniform flows across the basin.
- If flow is split, a means of measuring the flow to each train or unit shall be provided.
- **Velocity** - The velocity through a sedimentation basin should not exceed 0.5 feet per minute. The basins must be designed to minimize short-circuiting. Fixed or adjustable baffles must be provided as necessary to achieve the maximum potential for clarification.

- If flow is split, it is recommended that a means of modifying the flow to each train or unit be provided.
- **Outlet devices** - Outlet weirs or submerged orifices shall maintain velocities suitable for settling in the basin and minimize short-circuiting. The use of submerged orifices is recommended in order to provide a volume above the orifices for storage when there are fluctuations in flow. Outlet weirs and submerged orifices shall be designed as follows:
  - ✓ The rate of flow over the outlet weirs or through the submerged orifices shall not exceed 20,000 gallons per day per foot (250 m3 /day/m) of the outlet launder or orifice circumference.
  - ✓ Submerged orifices should not be located lower than three (3) feet below the flow line.
  - ✓ The entrance velocity through the submerged orifices shall not exceed 0.5 feet per second.
- **Overflow** - An overflow weir or pipe designed to establish the maximum water level desired on top of the filters should be provided. The overflow shall discharge by gravity with a free fall at a location where the discharge can be observed.
- **Superstructure**: - A superstructure over the sedimentation basins may be required. If there is no mechanical equipment in the basins and if provisions are included for adequate monitoring under all expected weather conditions, a cover may be provided in lieu of a superstructure.
- **Drainage**:-Sedimentation basins must be provided with a means for dewatering. Basin bottoms should slope toward the drain not less than one foot in twelve feet where mechanical sludge collection equipment is not required.
- **Flushing lines**: - Flushing lines or hydrants shall be provided and must be equipped with backflow prevention devices acceptable to the reviewing authority.
- **Safety** - Permanent ladders or handholds should be provided on the inside walls of basins above the water level. Guard rails should be included. Compliance with other applicable safety requirements, such as OSHA, shall be required.
- Sludge collection system shall be designed to ensure the collection of sludge from throughout the basin.
- **Sludge removal** - Sludge removal design shall provide that:
  - ✓ Sludge pipes shall be not less than three inches in diameter and arranged to facilitate cleaning;

- ✓ to sludge withdrawal piping shall prevent clogging;
- ✓ valves shall be located outside the tank for accessibility; Sludge disposal - Facilities are required by the reviewing authority for disposal of sludge
- ✓ The operator can observe and sample sludge being withdrawn from the unit.

3.1.2.5. Solids contact unit

Units are generally acceptable for combined softening and clarification where water characteristics, especially temperature, do not fluctuate rapidly, flow rates are uniform and operation is continuous. Before such units are considered as clarifiers without softening, specific approval of the reviewing authority shall be obtained

- Solid conduct unit is depending on?

- ✓ Installation of equipment
- ✓ Operating equipment
- ✓ Chemical feed
- ✓ Mixing
- ✓ Flocculation
- ✓ Sludge concentrators
- ✓ Sludge removal
- ✓ Cross-connections
- ✓ Detention period
- ✓ Water losses
- ✓ Weirs or orifices
- ✓ Up flow rates
- ✓ Tube or plate settlers

Water treatment plant including an effluent treatment plant: There are three different sections in a WTP: a pretreatment (PT) plant, a post treatment or dematerialized water (DM) plant, and a waste treatment or effluent treatment (ET) plant. Depending on plant size and configuration, the ET plant may be an elaborate system involving many I/Os, so a separate PLC with communication to the main system may be economical

- **General Plant Layout consideration**
  - ✓ functional aspects of the plant layout;
  - ✓ provisions for future plant expansion;
  - ✓ provisions for expansion of the plant waste treatment and disposal facilities;
  - ✓ access roads
  - ✓ site grading
  - ✓ site drainage
  - ✓ walks
  - ✓ driveways
  - ✓ Chemical delivery.
- **Building lay out**
  - ✓ adequate ventilation;
  - ✓ adequate lighting
  - ✓ adequate heating
  - ✓ adequate drainage

- ✓ dehumidification equipment, if necessary;
- ✓ accessibility of equipment for operation, servicing, and removal;
- ✓ flexibility of operation
- ✓ operator safety

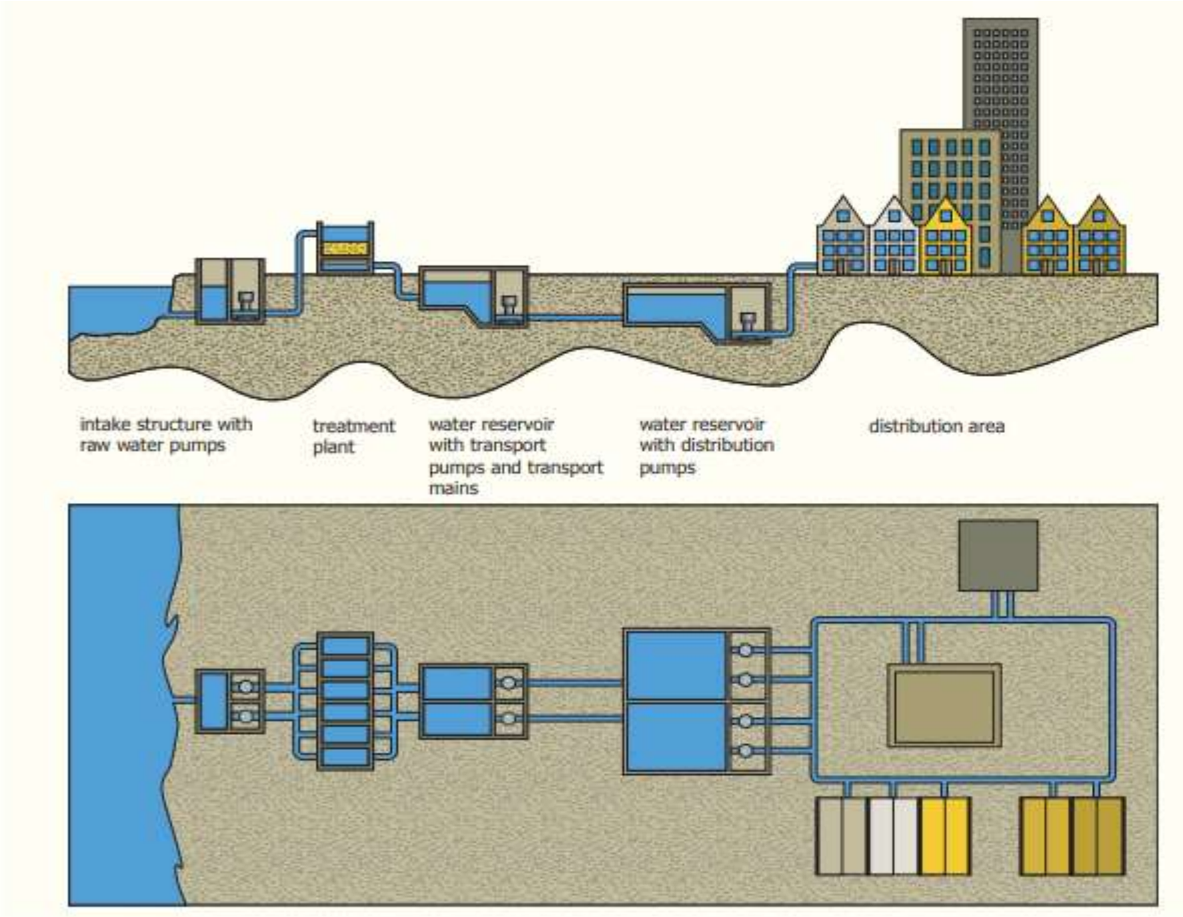


Figure 3.1. Drinking water scheme

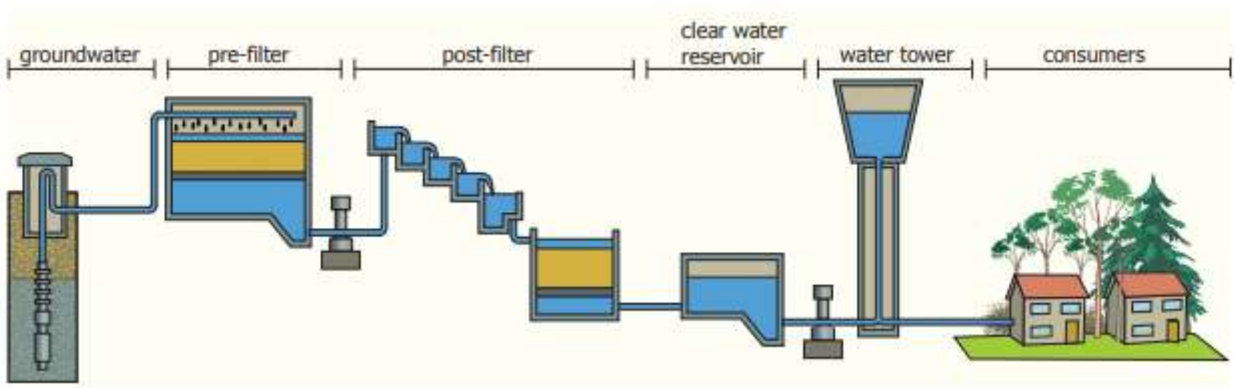
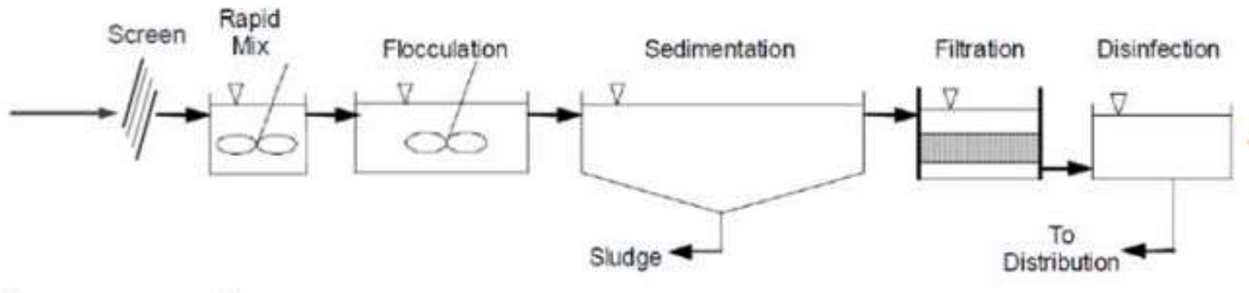


Figure 3.2. Treatment of groundwater with double aeration/filtration



- WTP Unit processes which include:
  - ✓ Intake Screen Design
  - ✓ Coagulation Flash Mixer
  - ✓ Flocculates
  - ✓ Sedimentation / Clarification Design
  - ✓ Granular Active Carbon Filtration Design
  - ✓ Disinfection / Chlorination dosage
  - ✓ Sludge / Residual Management

3.3. Identifying water treatment plant configuration to add chemical

Most important determinant is the source to add chemical. The water supply should be obtained from most feasible source. Feasible means adequate protection by natural means-dilution, storage, sedimentation, sunlight, aeration which tend to have natural purification of in surface waters and in case of ground waters the natural purification by infiltration through soil and percolation should be available or adequate protection by treatment is any combination of the processes of coagulation, sedimentation sorption, filtration disinfection or other processes to produce water to meet the requirements of standard.

If the source is not adequately protected, the supply shall be adequately protected by treatment. Frequent sanitary surveys should be made to identify health hazards.

Further the adequate capacity to meet the peak demands without development of low pressure should exist. Then the water treatment plant near such source should be located.

It has to be further seen that the point to treatment connection to the consumer service piping free flow should be available.

The selection of treatment train depends upon the quality and variability of the raw water source and the treatment objectives. A thorough survey of the quality and the quantity of all possible sources is the first and most important task for designing water supply processes.

Drinking water treatment plant operation and maintenance includes the following tasks:

- Operate and adjust equipment controls to purify and clarify water.
- Inspect equipment and monitor operating conditions, meters, and gauges to determine load requirements and detect malfunctions.
- Add chemicals, such as ammonia, chlorine, and lime, to purify and disinfect water and other chemicals, such as ferric chloride, peroxide, and polymers, to enhance water treatment.
- Collect and test water samples, using test equipment.
- Record operational and laboratory data, observations of processes, and meter and gauge readings on specified forms.
- Clean and maintain tanks, basins and filter beds, using hand tools and power tools.
- Maintain, repair, and lubricate equipment, using hand tools and power tools.

3.4. Surface water with direct treatment

From a global point of view, the direct treatment of surface water is the most applied method for drinking water production. This is mainly because large cities have developed along river banks, making surface water directly available. In order to be suitable for drinking water, suspended solids must be removed together with pathogenic bacteria. Over the years the removal of micro pollutants has become necessary as well, together with the construction of storage basins, to use when the concentration of micro pollutants is too high. Micro pollutants often originate from human activities upstream. The first step in the treatment process is the application of micros trainers because of this algal

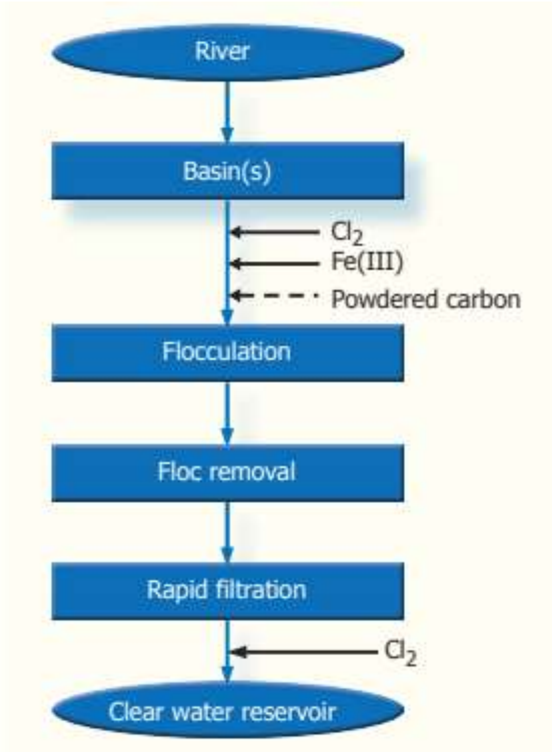


Figure 3.3. Traditional treatment scheme for direct treatment of surface water

3.5. Problems with traditional treatment

Contemporary treatment originated from the chlorination issue and the increased river water pollution. Chlorination may lead to exceeding of this standard; but without sufficient chlorination, the disinfection would be inadequate, a worse condition from the point of view of public health.

3.6. Characteristics of temporary direct treatment

- Characteristics of the current treatment of surface water for production of drinking water are:
  - ✓ storage reservoirs with a retention time of 1 - 3 months, making an intake stop possible in case of severe river contamination, and with a depth of over 20 meters to control algae growth
  - ✓ process reservoirs with a retention time of about 1 month and a depth of over 20 meters, leading to significant self-purification (sedimentation of suspended solids, ammonium oxidation) while still keeping algae growth under control
  - ✓ removal of suspended solids by coagulation (adding flocculants), flocculation and floc removal by filtration, possibly preceded by sedimentation or flotation
  - ✓ primary disinfection using a minimal amount of chlorine or ozone
  - ✓ removal of micro pollutants by activated carbon filtration
  - ✓ secondary disinfection using a minimal amount of chlorine or chlorine dioxide

3.7. Policy Statement on Water Treatment Plants

It is recommended that a professional engineer be on site to oversee the installation and initial startup of pre-engineered water treatment plants

- **Factors to be considered include:**
  - ✓ Raw water quality characteristics under normal and worst case conditions. Seasonal fluctuations must be evaluated and considered in the design.
  - ✓ Demonstration of treatment effectiveness under all raw water conditions and system flow demands. This demonstration may be on-site pilot or full scale testing or testing off-site where the source water is of similar quality. On-site testing is required at sites having questionable water quality or applicability of the treatment process. The proposed demonstration project must be approved by the reviewing authority prior to starting.

- ✓ Sophistication of equipment. The reliability and experience record of the proposed treatment equipment and controls must be evaluated.
- ✓ Unit process flexibility which allows for optimization of treatment.
- ✓ Operational oversight that is necessary. At surface water sources full-time operators are necessary, except where the reviewing authority has approved an automation plan. See Policy Statement on Automated/Unattended Operation of Surface Water Treatment Plants.
- ✓ Third party certification or approvals such as National Sanitation Foundation (NSF), International Underwriters Laboratory (UL) or other acceptable ANSI accredited third parties for; a) treatment equipment and b) materials that will be in contact with the water.
- ✓ Suitable pretreatment based on raw water quality and the pilot study or other demonstration of treatment effectiveness. Pretreatment may be included as an integral process in the pre-engineered module.
- ✓ Factory testing of controls and process equipment prior to shipment.
- ✓ Automated troubleshooting capability built into the control system.
- ✓ Start-up and follow-up training and troubleshooting to be provided by the manufacturer or contractor.
- ✓ Operation and maintenance manual.
- ✓ Cross-connection control including, but not limited to the avoidance of single wall separations between treated and partially or untreated surface water.
- ✓ On-site and contractual laboratory capability. The on-site testing must include all required continuous and daily testing as specified by the reviewing authority. Contract testing may be considered for other parameters.
- ✓ Manufacturer's warranty and replacement guarantee. Appropriate safeguards for the water supplier must be included in contract documents. The reviewing authority may consider interim or conditional project approvals for innovative technology where there is sufficient demonstration of treatment effectiveness and contract provisions to protect the water supplier should the treatment not perform as claimed.
- ✓ Water supplier revenue and budget for continuing operations, maintenance and equipment replacement in the future.
- ✓ Life expectancy and long-term performance of the units based on the corrosivity of the raw and treated water and the treatment chemicals used.

Self-Check -3	Written Test

Direction I: Multiple choice item (3 points each)

Instruction: choose the best answer for the following questions and write your answer on the answer sheet provided in the next page:

1. The design of treatment processes and devices shall depend on evaluation of the following except
   A. nature and quality of the particular water to be treated
   B. without seasonal variations
   C. the desired quality of the finished water
   D. the mode of operation planned
2. _______is a mechanical treatment process capable of removing suspended matter and organic loading from surface water by straining
   A. Micro screening
   B. Sedimentation
   C. Sludge removal
   D. Piping
3. Which one of the following is not design consideration of Micro screening of water treatment plant
   A. nature of the suspended matter to be removed
   B. effect of chemicals used for pre-treatment
   C. duplication of units for continuous operation during equipment maintenance;
   D. With out of automated backwashing
4. Which one of the following is essential during Coagulation of water treatment plant
   A. Mixing
   B. Location
   C. Equipment
   D. All
5. Which one of the following is /are plant configuration to apply Flocculation
   A. Basin Design
   B. Detention time
   C. Equipment
   D. Piping
6. Which one of following criteria is/are apply to conventional gravity sedimentation
   A. Inlet devices
   B. Drainage
   C. Flushing lines
   D. Safety

Note: **Satisfactory rating - 6and above points** **Unsatisfactory - below 6 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Short Answer Questions

1. ____________
2. _______________
3. ________________
4. _______________
5. __________________
6. ___________________

Operation Sheet_1	Procedures for conducting system investigation on operational problems

Steps for conducting system investigation on operational problems

Step1. Select appropriate tools and equipment

Step2. Identify the plant location

Step3. Identify method of problem identification

Step4. Identify problems

Step5. Describe the current situation

Step6. Take temporary counter measures on the spot

Step7. Find the rout cause

Step8. Propose solution

Step9. Establish an action plan

Step10. Check results

LAP Test	Practical Demonstration

Name: ______________________________ Date: ________________

Time started: ________________________ Time finished: ________________

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within _______hours.

Task 1. Conduct investigation of operational problem of water treatment plant of your surrounding

Instruction Sheet	Learning guide 30: Investigate chemical options for process optimization.

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics:

- Reviewing current chemical addition practices to identify potential deficiencies.
- Investigating dosing options for current chemicals.
- Identifying and investigating new or additional chemicals and related dosing options

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, **upon completion of this Learning Guide, you will be able to**:

- Review current chemical addition practices with reference to organizational procedures to identify potential deficiencies.
- Investigate dosing options for current chemicals.
- Identify and investigate new or additional chemicals and related dosing options

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below
3. Read the information written in the "Information Sheets 1- 3". On pages 80, 89, and 91. Try to understand what are being discussed.
4. Accomplish the "Self-checks 1, 2, and 3" in each information sheets on pages 84, 89, and 96
5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to "Operation sheets 1, on pages 98 ad 77and do the LAP Test on page 99". However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity.
7. After you accomplish Operation sheets and LAP Tests, ensure you have a formative assessment and get a satisfactory result; then proceed to the next LG

Information Sheet-1	Reviewing current chemical addition practices to identify potential deficiencies

1.1. Introduction to reviewing current chemical addition practice

The current practice of adding coagulants, pH adjustment chemicals, oxidants, disinfectants. Chemical options for process optimization. Review current chemical addition practices with reference to organizational procedures to identify potential by considering the number of reagents, solvents, and hazardous materials used by Supercritical fluids present an interesting case in conflicting green chemistry. In addition to thermometers that are filled with mercury-alternative liquids, Selection of hazardous chemicals to be considered for addition to or removal from the Hazardous chemicals.

Performance measurement provides information on the progress and current status of as such, a number of standard practices are used to identify appropriate handling. Material Safety Data Sheet (MSDS) review of chemicals being used.

Chemical manufacturers and importers are required to review available scientific in addition, chemicals that have been evaluated and found to be a suspect or operations in work areas where hazardous chemicals are present. work practices and occupational safety and health hazards of the workplace, and all for example, the written plan must list the chemicals present at the site and indicate When reviewing your written program regarding information and training, consider the methods that the employer will use to inform employees of the hazards.

1.2. Identifying Chemicals in drinking-water to review current chemical addition

A number of chemical contaminants have been shown to cause adverse health effects in humans as a consequence of prolonged exposure through drinking-water. However, this is only a very small proportion of the chemicals that may reach drinking-water from various sources. Collection, treatment, storage and distribution of drinking-water involve deliberate additions of numerous chemicals to improve the safety and quality of the finished drinking-water for consumers (direct additives).

1.3. source of chemicals to review current chemical additions

✓ **Naturally occurring chemicals**

All natural water contains a range of inorganic and organic chemicals. The former derive from the rocks and soil through which water percolates or over which it flows. The latter derive from the breakdown of plant material or from algae and other microorganisms that grow in the water or on sediments.

- ✓ **Chemicals from industrial sources and human dwellings**

Chemicals from industrial sources can reach drinking-water directly from discharges or indirectly from diffuse sources arising from the use and disposal of materials and products containing the chemical (for example Beryllium)

- ✓ **Chemicals from agricultural activities**

Chemicals are used in agriculture on crops and in animal husbandry. Nitrate may be present as a consequence of tillage when there is no growth to take up nitrate released from decomposing plants, from the application of excess inorganic or organic fertilizer and in slurry from animal production

- ✓ **Chemicals used in water treatment or from materials in contact with drinking-water**

Chemicals used in water treatment and chemicals arising from materials in contact with water may give rise to contaminants in the final water

- ✓ **Pesticides used in water for public health purposes**

Some pesticides are used for public health purposes, including the addition to water to control the aquatic larval stages of insects of public health significance (e.g., mosquitos for the control of malaria and typhus).

1.4. Identifying local actions in response to chemical water quality problems and emergencies

It is difficult to give comprehensive guidance concerning emergencies in which chemicals cause massive contamination of the drinking-water supply, caused either by accident or by deliberate action

- **Trigger for action**

May include:

- ✓ detection of a spill by, or reporting of a spill to, the drinking-water supplier;
- ✓ an alarm raised by the observation of items, such as chemical drums, adjacent to a vulnerable part of the drinking-water supply;
- ✓ the detection of a substance in the water;
- ✓ a sudden change to water treatment; or
- ✓ Consumer complaints (e.g., an unusual odor, taste or discoloration).

- **Investigating the situation**

Each incident is unique, and it is therefore important to determine associated facts, including what the contaminant is; what the likely concentration is, and by how much has been exceeded, if at all; and the potential duration of the incident. These are important in determining the actions to be taken.

- Evaluating the significance to public health and individuals
- Determining appropriate action
- Consumer acceptability
- Ensuring remedial action, preventing recurrence and updating the water safety plan

1.5. Policy Statement on Design Considerations for The Optimization of Rapid Rate Filtration at Surface Water Treatment Plants

Treatment plant design should allow for the voluntary pursuit of optimized performance goals to provide improved public health protection and to assure continuous regulatory compliance. The capability for surveillance and data collection should be provided for each unit process in order to achieve better process control and operation, to enhance problem diagnostics, and to document overall improvement.

- Minimum Data Monitoring Requirements
  - ✓ Daily raw water turbidity (every 4 hours)
  - ✓ Individual basin settled water turbidity (frequency of data acquisition from continuous meters should be not less than every 15 minutes)
  - ✓ Filtered water turbidity (frequency of data acquisition from continuous meters should be not less than every one minute)
  - ✓ Filter backwash (each backwash)
- Sedimentation
  - ✓ Settled water turbidity ≤ 2 NTU, 95th percentile of maximum daily values when annual average source turbidity > 10 NTU
  - ✓ Settled water turbidity ≤ 1 NTU, 95th percentile of maximum daily values when annual average source turbidity ≤ 10 NTU
- Filtration
  - ✓ Filtered water turbidity ≤ 0.10 NTU, 95th percentile of maximum daily values recorded
  - ✓ Maximum filtered water turbidity ≤ 0.30 NTU
- Post Backwash Turbidity

- ✓ Plants with filter-to-waste capability
  - Minimize spike during filter-to-waste
  - Return to service ≤ 0.10 NTU
- ✓ Plants without filter-to-waste capability
  - Maximum turbidity ≤ 0.30 NTU
  - Return to service ≤ 0.10 NTU within 15 minutes of startup

- Disinfection
  - ✓ Required chemical values are achieved at all times

Self-Check -1	Written Test

Direction I: Multiple choice item (2 points each)

Instruction: choose the best answer for the following questions and write your answer on the answer sheet provided in the next page:

1. Which one of the following source of chemicals to be review current chemical additions
   A. Naturally occurring chemicals
   B. Chemicals from agricultural activities
   C. Chemicals used in water treatment
   D. Pesticides used in water for public health purposes
2. Identifying local actions in response to chemical water quality problems and emergencies from the following
   A. Trigger for action
   B. Investigating the situation
   C. Identify the problem
   D. All
3. Which one of the following is Minimum data monitoring Requirements for surface water requirement
   A. Daily raw water turbidity (every 4 hours)
   B. Individual basin settled water turbidity
   C. Filtered water turbidity
   D. Filter backwash
4. Which one of the following parameter is consider during design for the Optimization of rapid rate Filtration at Surface Water Treatment Plants
   A. Sedimentation
   B. Filtration
   C. Post Backwash Turbidity
   D. Disinfection

Note: **Satisfactory rating - 4 and above points Unsatisfactory - below 4 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________
Rating: ____________

Name: _____________________________ Date: ___________________

Short Answer Questions

1. _____
2. ______
3. _______
4. ________

Information Sheet-2	Investigating dosing options for current chemicals

2.1. Introduction to chemical dosing option

There are different types of chemical dosing system to apply chemicals in the treatment plant either manually or mechanically depending on different factors. Several factors affect the effectiveness and efficiency of chemical coagulant dosing at water treatment works. A review of plant operations should take place prior to any remedial works to ensure that any resource expended optimizing plant operation is focused on where it is likely to be most effective. This review should examine various aspects of the treatment process that influence the effectiveness of coagulation such as raw water chemistry (alkalinity), selection of coagulants, chemical dosing and dispersion, order of dosing, pH Control and flocculent aids

Chemical dosing is, in most cases, carried out using automated equipment, but there are different types, dozens of equipment manufacturers and hundreds of product variants available to choose from. The challenge for system owners is to select the correct one for their particular application.

A typical dosing system comprises several components, including a chemical storage tank, chemical metering pumps, and system componentry including control valves, switches, gauges, indicators and transmitters to indicate the presence or absence of flow, flow rates and operating pressures.

Chemical pumps can handle applications in many different industries, from general industrial applications to oil and gas, brewery and distillery, semiconductor and others. Corrosion is a major concern with many chemicals. Acids such as sulfuric acid and hydrochloric acid are especially corrosive. In addition to acids, chemicals that pose corrosion problems to varying degrees are chlorine, alkaline solutions, and water. Care must be taken to select a pump manufactured from a material that is compatible with the chemical media.

2.2. Factors to consider when selecting a chemical pump

The first step in chemical pump selection is a proper understanding of the application requirements and the chemical media properties along with selecting the pump with the specifications to perform the task. However, it is important to pay attention to details and get the experts involved since there are quite a few things to consider when deciding which type of metering pump is best for your application.

The volumes and pressures of material pumped through the equipment may vary greatly for different situations, but it must always be precise. In order for this to work effectively, very specific technology is required. It is crucial to understand this

- **Flow Rate**

This is one of the most important things to consider. Knowing your expected or desired flow rate is going to be a crucial step in choosing the proper equipment technology when selecting the proper size and style of your metering pump.

- **Operating Environment**

The operating environment will most definitely impact the performance of the pump. If the pump will be operating in cold temperatures for example, you must make sure the fluid that is being pumped will not freeze at that specific temperature.

- **Fluid Composition**

This is the most important factor when selecting a pump in order to avoid corrosion and unnecessary wear and tear on your pump. The composition of your pumping fluid is also important when deciding on your metering pump type and size. What's the chemical makeup of the fluid to be pumped? What's the consistency? Is it a slurry (thick suspension of solids in liquids), or is it a clean fluid? Thicker ones will require the use of special fluid ends. Extremely thick liquids that contain solids may even require special diaphragms in order to operate efficiently.

2.3. Chemical Risk Assessment

The goal of chemical risk assessment is to have a full understanding of the nature, magnitude and probability of a potential adverse health or environmental effect of a chemical and to determine the chemical dosing option to the treatment plant to protect public health. It takes into account of both hazard and exposure. Risk assessment forms the foundation of regulatory decisions for industrial chemicals, pesticides, pharmaceuticals, cosmetics, food additives and food contact substances in developed countries today.

In general, chemical risk assessment consists of the following three steps:

- ✓ **Hazard characterization**: determining the relationship between the magnitude of exposure to a hazard and the probability and severity of adverse effects.

- ✓ **Exposure assessment**: identifying the extent to which exposure actually occurs. Exposure levels are usually estimated or measured.
- ✓ **Risk characterization**: combining the information from the hazard characterization and the exposure assessment in order to form a conclusion about the nature and magnitude of risk, and, if indicated, implement additional risk management measures.

The picture below summarizes the complete procedure of chemical risk assessment under REACH.

Tasks	Human Health	Environment
Hazard Characterization	Derive GHS classification for both acute/chronic effects, and local/systemic effects.	Derive GHS classification;
	Evaluate how mobile the substance is (e.g. volatility, water solubility, dustiness) and, depending on the uses, which routes of exposure;	Determine whether the substance should be a PBT substance;
	Derive no-effect levels for human health (DNEL) from available toxicology studies; take into account the foreseeable routes of exposure and populations.	Evaluate in which environmental compartment the substance will predominantly end up (e.g. degradability and distribution behavior);
	When no DNEL can be derived a qualitative or semi-quantitative characterization should be made.	Derive Predicted-No-Effect-Concentration (PNEC) for various environmental compartments from available eco-toxicity studies.
Exposure Assessment	Gather info on operational conditions (for example, the duration and frequency of use or the amount used) and risk management measures (e.g. local exhaust ventilation or a certain type of glove).	Gather info on operational conditions (for example, the amount produced/used and emission percentage) and risk management measures (e.g. waste treatment measures).

	Calculate exposure estimate for potential routes of exposure and populations	Estimate Predicted Environmental Concentration (PEC) for potential environmental compartments or use measured data.
	• Workers: dermal and inhalation.	• Fresh surface water
	• Consumers: oral, dermal and inhalation	• Marine surface water • Soil • Sediment • STP micro-organism • Air • Predator
Risk Characterization	Risk characterization ratio (RCR) = Exposure Estimate/DNEL	Risk characterization ratio (RCR) = PEC/PNEC
	• RCR<1, acceptable risk;	• RCR<1, acceptable risk;
	• RCR>1, unacceptable risk.	• RCR>1, unacceptable risk.

Self-Check -2	Written Test

Direction I: Multiple choice item (2 points each)

Instruction: choose the best answer for the following questions and write your answer on the answer sheet provided in the next page:

1. A typical dosing system comprises several components from the following including except
   A. Chemical Storage Tank,
   B. Chemical Metering Pumps,
   C. System Componentry Including Control Valves, Switches, Gauges, Indicators
   D. All
2. Factors to consider when selecting a chemical pump
   A. Flow Rate
   B. Operating Environment
   C. Fluid Composition
   D. All
3. Factors affecting chemical dosing option from the following
   A. Nature of chemical
   B. Type of treatment plant
   C. location of treatment plant
   D. all
4. chemical dosing of a treatment plant is either manually or mechanically
   A. True B. false

Note: **Satisfactory rating - 4 and above points Unsatisfactory - below 4 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Name: ______________________________ Date: ______________

Score = ___________
Rating: ____________

Short Answer Questions

1. __________
2. ___________

3. ___________

4. ____________

Information Sheet-3	Identifying and investigating new or additional chemicals and related dosing options

3.1. Introduction to types of chemicals

A chemical substance is a form of matter having constant chemical composition and characteristic properties. Some references add that chemical substance cannot be separated into its constituent elements by physical separation methods, i.e., without breaking chemical bonds. Chemical substances can be simple substances, chemical compounds, or alloys. Chemical elements may or may not be included in the definition, depending on expert viewpoint.

A few chemical contaminants have been shown to cause adverse health effects in humans as a consequence of prolonged exposure through drinking-water. However, this is only a very small proportion of the chemicals that may reach drinking-water from various sources. Typically changes in water quality occur progressively except for those substances that are discharged or leach intermittently to flowing surface waters or groundwater supplies from, for example, contaminated landfill sites.

3.1.1. Poly aluminum chloride (PACL)

Poly aluminum chloride is a 'coagulant' chemical added to water to help remove small particles of dirt and contaminants that can make people sick, and block the water system's filters. The intake site systems, the clean water left at the top of the tank is then directed into the next step of the treatment process.

The Poly aluminum chloride and dirt that's dropped to the bottom of the tank is called sludge. One of the reasons we are trailing Poly aluminum chloride is that we don't yet know how much sludge we will get at each intake site. This is because each intake site is different. The monitoring reports from the trials will be used to inform Government and landowners' views on longer term Poly aluminum chloride l use, and also to inform sludge management.

3.1.2. aluminum sulphate

Aluminum sulfate is a chemical compound with the formula $Al_2(SO_4)_3$. It is soluble in water and is mainly used as a coagulating agent (promoting particle collision by neutralizing charge) in the purification of drinking water and waste water treatment plants, and also in paper manufacturing.

3.1.3. aluminum chlorohydrate (ACH)

Aluminum Chlorohydrate (ACH) solution is a highly polymerized solution of polyaluminum hydroxychloride. It is characterized by the highest aluminum concentration (23% Al2O3) in any commercially available aluminum based solution. In solid product the aluminum oxide content is 46%-50%. The basicity of Aluminum Chlorohydrate (ACH) at 83% is also the highest available for any polyaluminum based solution. Basicity refers to the degree of acid neutralization and also represents a measure of how highly polymerized the aluminum in Aluminum Chlorohydrate (ACH) is. The highly polymerized aluminum species in Aluminum Chlorohydrate (ACH) have much higher cationic charges than the aluminum in standard salts such as alum or aluminum chloride, and even other polyaluminum products. Therefore, Aluminum Chlorohydrate (ACH) can offer both a higher level of performance and lower overall dosages. The high degree of acid neutralization (basicity) also means that the effect on pH when applying Aluminum Chlorohydrate (ACH) will be negligible. Aluminum Chlorohydrate (ACH) also effectively coagulates over a broader pH range (as high as 5-9.5) versus traditional metal salts and lower basicity ACl.

3.1.3.1. Use and advantages:

- **Urban drinking water treatment**

Aluminum Chlorohydrate (ACH) is used as flocculent in municipal water, drinking water, domestic water treatment. The products is produced by pure aluminum and high purity hydrochloric acid, this product conform to the requirements of USP-34 Specification, which is internationally recognized as drinking water treatment agent.

Switch to high aggregate of aluminum recognized benefits

- ✓ Improve turbidity removal capacity and flocculation speed.
- ✓ Enhance the TOC (total organic carbon) removal.
- ✓ Reduce turbidity filter, shorten the filter travel and improve production ability.
- ✓ Improve the eliminating ability to the fluorine, cadmium, radioactive pollution and floating oil.

- ✓ Reduce reagent use, simplify the operation process and eliminate pH value influence. Do not add second electrolytes.
- ✓ Reduce tap water production cost.

- **Urban sewage and industrial wastewater treatment**
    - ✓ Increase de coloring function
    - ✓ Clean up TSS (the total suspended solids)
    - ✓ Remove heavy metals such as lead (Pb), cadmium (Cd) and mercury (Hg) chromium (Cr+6)
    - ✓ Remove phosphorus, fluoride and oily in the suspended solids
    - ✓ Reduce 50% sludge
    - ✓ Reduce reagent use, simplify the operation process, eliminate pH value influence. Do not add second electrolytes. Reduce tap water production cost.

      - Effectively reduce the COD, BOD, TOC white water
- **Paper industry**
    - ✓ Sizing agent (AKD) of the precipitation agent
    - ✓ Size adhesive
    - ✓ Anionic garbage removal agent
    - ✓ Retention aid agent and filter aid agent
    - ✓ It is additives for control resin obstacles
- **Cosmetic raw materials**
    - ✓ Be used as the ingredient for pharmaceuticals, antiperspirant, the special cosmetic in diary chemical industry.

3.1.4. ferric chloride

Ferric chloride is known as a flocculent (FLOCK-u-lent). Flocculants are chemicals that help make tiny particles clump together so they can be removed from water. Even after large pieces of debris are removed using filters, natural surface water still may be full of tiny particles that are too small to sink. These simply float through the water, giving water a cloudy appearance. Adding ferric chloride to a tank of brown, cloudy water causes tiny pieces of STUFF to come together. Eventually, the clumps grow large enough to sink down to the bottom of the tank, clearing the water above

Ferric chloride ($FeCl3$) is a chemical compound consisting of two elements--iron (Fe) and chlorine (Cl). "Fe" comes from the Latin word for iron which is ferrum. The small "3" next to Cl in the chemical formula means that for every atom of iron, there are three atoms of chlorine.

3.1.5. ferric sulphat

Ferric Sulfate in a variety of strengths and differing soluble iron percentages appropriate for use as a coagulant or flocculent in water or wastewater treatment. Are used in many different municipal and industrial applications. In water and wastewater treatment operations, ferric salts are used as coagulants or flocculants for water clarification,

Product Benefits

- High performance primary coagulant
- Excellent for drinking water, wastewater treatment and effluent treatment applications
- Effective over a wider pH range
- Available in convenient liquid
- Chloride free
- Cost effective coagulant
- Excellent for the treatment of wastewater where low pH is required – removal of fats, oil and grease, high color
- Cold Water Treatment
- Heavy Metals Removal
- Phosphorus Removal
- Selenium Removal
- Sludge Thickening Conditioning and Dewatering

3.1.6. polyDADMAC

PolyDADMAC is a high performance; cationic coagulant polymer used in water and waste water treatment. It is scientifically formulated for use in wastewater treatment and sludge dewatering applications.

Product Benefits

- High performance cationic coagulant polymer based on PolyDADMAC developed for wastewater treatment and sludge dewatering applications
- Reduces required doses of basic reagents used in coagulation process
- Effective in precipitating anionic surfactants
- Minimizes sludge
- Improves sludge dewatering stages and results in improved effluent output
- Highly effective when used for the secondary decantation of biological sludge coming from aerobic and anaerobic digesters
- Enhances rapid sludge settling
- Sympathetic to the existing biological flora
- Effective across a wide range of pH

3.1.7. Polyacrylamide

Polyacrylamide (PAM) is a commercially relevant cationic polymer utilized mainly for water treatment due to its high efficiency and rapid dissolution. Being a cationic polymer, PAM can increase the settling rate of bacterial floc and improve the capture of dispersed bacterial cells, suspended solids, and cell fragments; therefore, one of its largest uses is to flocculate solids in a liquid. Cationic polymers are widely used for removing undesirable organisms from water. Polyacrylamide and its co-polymers are used as flocculants or coagulants in industrial wastewater treatment.

3.1.8. sulphuric acid

Sulfuric Acid H_2SO_4: The most widely used and produced chemical in the world. Available in concentrations ranging from 0% to 98% sulfuric is also the least expensive acid to use. Sulfuric acid is used almost universally for neutralization reactions

3.1.9. hydrated lime

Hydrated Lime or Calcium Hydroxide is produced by reacting quicklime with water. Hydrated lime is used for water treatment. Hydrated lime or quicklime is mixed with water to give alkaline slurry which neutralizes the low pH of acids

3.1.10. caustic soda

Caustic soda is one of the common names for sodium hydroxide (NaOH), which is also known as lye. Its common name derives from its chemical identity as a sodium hydrate and because it is caustic or corrosive. In pure form, caustic soda is a waxy, white solid

Caustic soda (sodium hydroxide or (NaOH) is a commonly used water treatment chemical that raises the pH of water by absorbing water and carbon dioxide. Caustic soda increases the pH of water and can easily change hard water to a much closer approximation to neutral when injected into the water treatment system.

Self-Check -3	Written Test

Direction I: Multiple choice item (5 points each)

Instruction: choose the best answer for the following questions and write your answer on the answer sheet provided in the next page:

1. chemical contaminants have been to cause adverse health effects in humans through drinking-water
   A. True B. True
2. _____is a 'coagulant' chemical added to water to help remove small particles of dirt and contaminants that can make people sick, and block the water system's filters
   A. Poly aluminum chloride
   B. Aluminum sulfate
   C. hydrated lime
   D. sulphuric acid
3. ___________ is soluble in water and is mainly used as a coagulating agent (promoting particle collision by neutralizing charge) in the purification of drinking water and waste
   A. Aluminum sulfate
   B. Poly aluminum chloride
   C. hydrated lime
   D. sulphuric acid
4. Use and advantages aluminum chlorohydrate (ACH)
   A. For Urban drinking water treatment
   B. For Urban sewage and industrial wastewater treatment
   C. For Improve turbidity removal capacity and flocculation speed
   D. All
5. Advantage of aluminum chloro hydrate (ACH) in urban drinking water treatment
   A. Improve turbidity removal capacity and flocculation speed.
   B. Enhance the TOC (total organic carbon) removal.
   C. Reduce turbidity filter, shorten the filter travel and improve production ability.
   D. Improve the eliminating ability to the fluorine, cadmium, radioactive pollution

Note: **Satisfactory rating – 5 and above points Unsatisfactory - below 5 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Name: ______________________Date: ________________

Score = ___________

Rating: ____________

Short Answer Questions

1. __________
2. ___________
3. ____________
4. _____________
5. _____________

Operation sheet -1	Procedure for assessing chemical risks

steps chemical assessment

step1.select appropriate PPE

Step2. Select appropriate tools and equipment

Step3. Identify the hazards.

Step4. Identify cause of hazard

Step5. Decide who might be harmed and how.

Step6. Evaluate the risk and decide on precautions.

Step7. Record your significant findings.

Step8. Review your risk asse

LAP Test	Practical Demonstration

Name: ______________________________ Date: ________________

Time started: ________________________ Time finished: ________________

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within _______hours.

Task1. Assess chemical risk in your surrounding water treatment plant.

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics:

- Determining plant configuration or chemical options for process optimization.
- Planning a trial to test the performance of the determined optimization options.
- Compiling report with recommendations on optimization options.

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, **upon completion of this Learning Guide, you will be able to**:

- .Determine plant configuration or chemical options for process optimization.
- Plan a trial to test the performance of the determined optimization options.
- Compile report with recommendations on optimization options.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below
3. Read the information written in the "Information Sheets 1,2 and 3". On pages 101,108 and 111. Try to understand what are being discussed.
4. Accomplish the "Self-checks 1 and 2" in each information sheets on pages 106, 110and 113.
5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to "Operation sheets 1, and 2 on pages 114 and do the LAP Test on page 15 ". However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity.
7. After you accomplish Operation sheets and LAP Tests, ensure you have a formative assessment and get a satisfactory result; then proceed to the next LG.

1.1. Introduction to plant configuration to chemical optimization

Water treatment plant optimization is a continuous process to meet current and future regulations and provide water of superior quality. Optimizing water treatment plant operation is a concept should be applied to all plants because some operational improvements can always be made. Optimization at a water treatment plant can be considered achieved when certain goals are being met to attain the most efficient use of the water treatment plant facilities. The most important goals are to reduce the water wastes, manage the energy consumption and achieve the chemical cost performance that means the chemical cost for obtaining an aimed treatment effect. Understanding and control of the physicochemical nature of water and colloidal suspensions play an important rule to obtain several goals for optimization. One of these optimization goals for the plant operation is the colloids removal improvement with economic coagulant dosing

1.2. Benefits of water and waste water treatment plant Optimization

- Improved Plant Performance, Reliability, Flexibility, and Efficiency
- reduced operating costs associated with energy use, chemical use, and labour;
- reduced capital costs of expansion or upgrading;
- improved operating practices
- reduced chemical costs;
- improved effluent quality;
- improved biosolids quality;
- increased treatment plant capacity;
- reduced sludge production or biosolids management costs;
- reduced capital costs for plant upgrading or expansion; or
- Reduced odor production.

The best practice for water and waste water treatment optimization includes the following elements.

- .Evaluate the water and waste water treatment plant to establish the baseline or benchmark conditions, prioritize opportunities for optimization, and determine performance or capacity limiting factors.
- Identify and implement operational or process changes to address performance or capacity limiting factors.

- Conduct follow-up monitoring to document the benefits.

1.3. Method of optimizing chemical dosing

1.3.1. location of chemical dosing points

Suspended particles vary in source, charge, particle size, shape, and density. Correct application of coagulation and flocculation depends upon these factors. The most factors to determine the amount of chemical adding or chemical dosing is identifying the location of chemical dosing point. In most case chemical adding location is depend on the

- nature of water quality,
- chemical quality,
- method of adding chemicals
- types of material used to adding chemicals
- flow rate

1.3.2. mixing or reaction detention times

During optimization of chemical dosing in plant configuration determine the detention and react time of chemicals in treatment plant to increase and decrease the amount of chemical dosing in the system.

1.3.3. type of mixer or impeller

Chemical mixing facilities should be designed to provide a thorough and complete dispersal of chemical throughout the wastewater being treated to insure uniform exposure to pollutants which are to be removed. The intensity and duration of mixing of coagulants with wastewater must be controlled to avoid over mixing or under mixing. Under mixing inadequately disperses coagulants resulting in uneven dosing. This in turn may reduce the efficiency of solids removal while requiring unnecessarily high coagulant dosages. In water treatment practice several types of chemical mixing units are typically used. These include high-speed mixers, in-line blenders and pumps, and baffled mixing compartments or static in-line mixers (baffled piping sections)

- **Types of Impeller**

1. **Axial Flow Patterns**

The benefit of the axial flow pattern is that it can solve two challenges of mixing: solid suspension and stratification. They provide exceptional top to bottom motion in a tank, especially when it is placed over the center of a baffled vessel.

In axial mixing processes, the superficial and annular velocities can be altered to adjust the mixing levels. Axial impellers can come in one of several different subcategories. One of these is a marine impeller, which gets its name from its resemblance to propellers used on watercraft. Then there are pitched blade impellers, which are known for the versatility and ability to create a balance of flow and shear.

2. **Radial Flow Patterns**

The other flow type of impellers in mixing is the radial flow classification. They're often preferred for low-level mixing and applications in longer tanks, producing rather high shear rates due to their angle of attack. Most radial flow impellers consist of four to six blades. Radial flow impellers are efficient in applications like gas/liquid mixing and dispersion.

- **Selecting an Impeller**

Learning how to choose a mixing impeller requires considering a number of different factors that are pertinent to your industry and application.

✓ **Viscosity**

The primary factor to be taken into consideration when selecting the impeller type is viscosity. Viscosity affects several aspects of impeller design and selection. Highly viscous liquids also require a longer length of time to completely mix, so this detail should also be taken into consideration when selecting an impeller. When mixing highly viscous materials, baffles are not necessarily considered to be preferable because they can impede top-to-bottom flow in these cases. In many cases, a hydrofoil impeller blade is well-suited for lower viscosities, while an axial flow or turbine pitched blade is better for mixing highly viscous substances. Furthermore, density of a substance is an important characteristic related to viscosity.

✓ **Tank Design and Placement**

The size and dimensions of the mixing tank must be determined. The aspect ratio of the vessel is an important figure, and ideal mixing occurs when it's as close to unity as possible. Improper impeller placement can result in disinformation throughout the contents of the vessel and staged flow patterns. A common misconception assumes that vertexing and swirling in a mixture are both favorable indicators of quality. While the contents of a vessel are in motion with swirling/vertexing, they are merely rotating rather than actually mixing with one another. Baffles are flat plates installed on the interior wall of a mixing tank, and they can be very efficient in disrupting vertexing that might be taking place in a mixer. Additionally, baffles help the contents move from the top to the bottom of the tank. They're welded to the wall of the tank.

Tank design is the principal aspect in determining the quantity of impellers necessary to achieve equal mixing in an application. Volumetric specifications, as well as the shape and positioning of a mixer {vertical, horizontal, etc.}; are both essential units in calculating the quantity of impellers. As the tank gets larger, more impellers will need to be added in order to accomplish proper mixing. The size of the impeller itself is primarily determined by the desired mixing intensity of a particular application. Intensity is related to the diameter when greater intensity is needed for adequate emulsification and mixing.

- ✓ **Impeller Construction Materials**

A common and suitable material for impellers in many different applications is stainless steel. Stainless steel is exceptionally resistant to corrosion and contamination, which further extend the lifespan of an impeller. Cleanliness is a necessity, especially in sanitary applications. Stainless steel is easy to clean and maintain. Impellers can be manufactured in various grades of stainless steel. Other common choices include carbon steel, titanium, and nickel alloys. They can also be finished with different coatings to cater to the needs of an application, and reinforced to extend their lifespan.

- **Four Main Types of Mixing Blades and Dispersing Impellers**

When selecting a mixer, it is important to consider the parts involved in the mixing and dispersing process. The impeller blades you use with your mixers will ultimately determine the accuracy of your mixture. An impeller blade is usually made of stainless steel, carbon steel, aluminum, brass, bronze or plastic, and is designed to accelerate the liquid in a specific direction. Different impeller blades are used for specific mixture types. There are four main impeller blade types that you can choose from; airfoil, pitch blade, propeller blade, or radial blade.

1.4. Chemical Application

No chemicals shall be applied to treat drinking waters unless specifically permitted by the reviewing authority.

Plans and specifications Plans and specifications shall be submitted for review and approval,

Plans and specifications shall be submitted for review and approval, as provided and shall include:

- ✓ descriptions of feed equipment, including maximum and minimum feed ranges;
- ✓ location of feeders, piping layout and points of application;
- ✓ storage and handling facilities;
- ✓ operating and control procedures including proposed application rates;
- ✓ descriptions of testing equipment, and; system including all tanks with capacities, (with drains, overflows, and vents), feeders, transfer pumps, connecting piping, valves, points of application, backflow prevention devices, air gaps, secondary containment, and safety eye washes and showers.

- **Chemicals shall be applied to the water at such points and by such means as to**:
  - ✓ assure maximum efficiency of treatment
  - ✓ assure maximum safety to consumer
  - ✓ provide maximum safety to operators
  - ✓ assure satisfactory mixing of the chemicals with the water
  - ✓ provide maximum flexibility of operation through various points of application, when appropriate, and
  - ✓ prevent backflow or back-siphonage between multiple points of feed through common manifolds
- **equipment design shall be**
  - ✓ feeders will be able to supply, at all times, the necessary amounts of chemicals at an accurate rate, throughout the range of feed
  - ✓ chemical-contact materials and surfaces are resistant to the aggressiveness of the chemical solution
  - ✓ corrosive chemicals are introduced in such a manner as to minimize potential for corrosion
  - ✓ chemicals that are incompatible are not stored or handled together
  - ✓ all chemicals are conducted from the feeder to the point of application in separate conduits
  - ✓ chemical feeders are as near as practical to the feed point
  - ✓ chemical feeders and pumps shall operate at no lower than 20 per cent of the feed range unless two fully independent adjustment mechanisms such as pump pulse rate and stroke length are fitted when the pump shall operate at no lower than 10 percent of the rated maximum, and; h. gravity may be used where practical.

Self-Check -1	Written Test

Direction I: Multiple choice item (2 points each)

Instruction: choose the best answer for the following questions and write your answer on the answer sheet provided in the next page:

1. Water treatment plant optimization is a continuous process to meet current and future regulations and provide water of superior quality

A. True B. True

2. Which one of the following is the benefits of water and waste water treatment plant optimization?
   A. Improved Plant Performance, Reliability, Flexibility, and Efficiency
   B. Increase reduced operating costs associated with energy use, chemical use, and labour;
   C. reduced capital costs of expansion or upgrading;
   D. improved operating practices

3. The best practice for water and waste water treatment optimization includes the following elements
   A. . Evaluate the water and waste water treatment plant to establish the baseline
   B. Identify and implement operational or process changes to address performance
   C. Conduct follow-up monitoring to document the benefits.
   D. All

4. chemical adding location is depend on the following
   A. nature of water quality,
   B. chemical quality,
   C. method of adding chemicals
   D. all

5. During optimization of chemical dosing in plant configuration determine the detention and react time of chemicals in treatment plant to increase and decrease the amount of chemical dosing in the system

   A. True B. false

Note: **Satisfactory rating – 54 and above points Unsatisfactory - below 5points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________
Rating: ____________

Name: ___________________________ Date: ________________

Answer Questions

1. __________
2. ___________
3. ___________
4. _____________
5. ______________

2.1. Introduction to planning performance test in chemical dosing optimization

The basic principles for evaluating water quality and treatment plant performance in a clear, innovative and didactic way, using a combined approach that involves the interpretation of monitoring data associated with (i) the basic processes that take place in water bodies and in water and wastewater treatment plants and (ii) data management and statistical calculations to allow a deep interpretation of the data.

2.1.1. Performance Testing

Performance testing is a form of testing that focuses on how a system running the system performs under a particular load. This is not about finding software bugs or defects. Performance testing measures according to benchmarks and standards. It should give developers the diagnostic information they need to eliminate bottlenecks.

2.1.2. Types of performance testing

To understand how will perform on users' systems, there different types of performance tests that can be applied during chemical adding optimization. This is non-functional testing, which is designed to determine the readiness of a system. (Functional testing focuses on individual functions of software.)

2.1.2.1. Load testing

Load testing measures system performance as the workload increases. That workload could mean concurrent users or transactions. The system is monitored to measure response time and system staying power as workload increases. That workload falls within the parameters of normal working conditions.

2.1.2.2. Stress testing

Unlike load testing, stress testing also known as fatigue testing is meant to measure system performance outside of the parameters of normal working conditions. The software is given more users or transactions that can be handled. The goal of stress testing is to measure the software stability.

2.1.2.3. Spike testing

Spike testing is a type of stress testing that evaluates performance when workloads are substantially increased quickly and repeatedly. The workload is beyond normal expectations for short amounts of time.

2.1.2.4. Endurance testing

Endurance testing also known as soak testing is an evaluation of how performs with a normal workload over an extended amount of time. The goal of endurance testing is to check for system problems such as memory leaks

2.Scalability testing

Scalability testing is used to determine if system is effectively handling increasing workloads. This can be determined by gradually adding to the user load or data volume while monitoring system performance. Also, the workload may stay at the same level while resources are changed.

2.1.3. Volume testing

Volume testing determines how efficiently system performs with a large, projected amounts of data. It is also known as flood testing because the test floods the system with data.

Self-Check 2	Written Test

Direction I: Multiple choice item (3 points each)

Instruction: choose the best answer for the following questions and write your answer on the answer sheet provided in the next page:

1. The basic principles for evaluating water quality and treatment plant performance in a clear, innovative and didactic way, using a combined approach that involves the interpretation of monitoring data

   A. True   B. False

2. ________is a form of testing that focuses on how a system running under a particular load.

   a. Performance testing
   b. Work load test
   c. Evaluation test
   d. All

3. Types of performance testing from the following

   A. Load testing
   B. Stress testing
   C. Volume testing
   D. ALL

***Note:* Satisfactory rating – 4. 5 points Unsatisfactory - below 4.5 and 5 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________
Rating: ____________

Name: _________________ Date: ________________

Answer Questions

1. _____________
2. ______________
3. _______________

Information Sheet-3	Compiling report with recommendations on optimization options.

3.1. Introduction to maintaining recodes and report

Record Maintenance and Reporting Records are essential for many reasons. They promote the efficiency of water treatment system, remind the operating personnel about their routine operation and maintenance, provide the basic system's data and operator details and help in the preparation of reports. Precise and comprehensive records are key to an effective maintenance program. Water utility managers and operating personnel need to know what type of information is essential for their system and prepare and record the information accordingly. Further, they shall keep all the relevant information required for the operational and treated water quality monitoring plans. All the records shall bear the signature of the operating personnel in charge of the water treatment system and these records shall be available during the inspection of Environment Officer (EO) or other regulatory personnel.

The purpose of a report is to communicate. Your job, therefore, is to create a straight-forward piece of writing which, step by step, conveys to the readers clearly and unambiguously what happened, why and your recommendations.

The report shall include a historical summary of meteorological conditions and of raw water quality with special reference to fluctuations in quality, and possible sources of contamination. The following raw water parameters shall be evaluated in the report:

- ✓ color;
- ✓ turbidity;
- ✓ bacterial concentration;
- ✓ microscopic biological organisms;
- ✓ temperature;
- ✓ total solids
- ✓ general inorganic chemical characteristics;
- ✓ Additional parameters as required by the reviewing authority.

The report shall also include a description of methods and work to be done during a pilot plant study or, where appropriate, an in-plant demonstration study.

The report should be written by a qualified technician or manager with input and collaboration from field workers to help interpret the results and make appropriate recommendations.

6.1 Data Recording Form 1

Location: ______________________ Sample Taken By: ______________________

Date of Sampling: ______________________ Sample Tested By: ______________________

Sample Description	Sample ID #	Turbidity (NTU)	pH	Chlorine (mg/L)	Iron (mg/L)	Manganese (mg/L)	Arsenic (mg/L)	Nitrate (mg/L)	Fluoride (mg/L)	*E. coli* Plate Count (CFU/100 mL)	x Dilution Factor Total Count (CFU/100 mL)

Date of Report: ______________________

Comments:

6.2 Data Recording Form 2

Technician Name:______________________ **Sample Date:**______________________

Sample Location	Sample Description	*E. coli* Plate Count (CFU/100 mL)	X Dilution Factor Total Count (CFU/100 mL)	Comments and Observations

WHO Guidelines	pH -	Turbidity <1 NTU (large supplies) <5 NTU (small supplies)	Iron -	Manganese -	Arsenic 0.01 mg/L	Fluoride 1.5 mg/L	Chlorine 5 mg/L	Nitrate 50 mg/L
Country Standards	pH	Turbidity NTU	Iron	Manganese	Arsenic	Fluoride	Chlorine	Nitrate
Test Results								

Self-Check 3	Written Test

Direction I: Multiple choice item (3 points each)

Instruction: choose the best answer for the following questions and write your answer on the answer sheet provided in the next page:

1. Record Maintenance and Reporting Records are essential for the following reasons.
   a. promote the efficiency of water treatment system,
   b. remind the operating personnel about their routine operation
   c. maintenance, provide the basic system's data and operator details and help in the preparation of reports
   d. all
2. raw water parameters shall be evaluated in the report from the following
   a. color
   b. turbidity
   c. temperature
   d. all

***Note:* Satisfactory rating – 2and above points** **Unsatisfactory - below 2 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________
Rating: ____________

Name: _________________ Date: ________________

Answer Questions

1. _____________
2. ______________

Operation sheet_1	Procedure for essential report writing stages

Steps for Writing the report

Step 1. Decide on the 'Terms of reference'

Step 2. Decide on the procedure

Step 3. Find the information

Step 4. Decide on the structure

Step 5. Draft the first part of your report

Step 6. Analyse your findings and draw conclusions

Step 7. Make recommendations

Step 8. Draft the executive summary and table of contents.

Operation sheet_1	Procedures for performance testing to investigate water quality problems

Steps for testing to investigate water quality problems

Step1. Identify the testing environment

step2. Identify performance metrics

step3. Plan and design performance tests

step4. Configure the test environment

step5. Implement your test design

step6. Execute tests

step7. Analyze, report, retest

LAP Test	Practical Demonstration

Name: _____________________________ Date: ________________

Time started: ________________________ Time finished: ________________

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within _______hours.

Task1. Write maintains activity result report to your department

Task2. Test environmental water quality performance to add chemical

- "Guidance on Safe Storage of Chemicals in Laboratories" (PDF).
- "Safe Storage of Hazardous Chemicals in Stockrooms, Workshops and Laboratories" (PDF).
- ^ "STORING CHEMICALS IN THE LABORATORY". chemistry.umeche.maine.edu. Retrieved 2018-02-23.
- ^ Jump up to:[a] [b] Chemical Inspection & Regulation Service. "The UN Globally Harmonized System of Classification and Labeling of Chemicals (GHS)". Retrieved 22 February 2018.^ "Chemical storage".
- Guideline for the Inspection of Wastewater Treatment Works (2009)
- GUIDELINESFOR DRINKING WATER QUALITY, Volume 1, Recommendations, World Health Organization, Geneva, 1984.
- GUIDELINES FOR DRINKING WATER QUALITY, Volume 2, Health Criteria and Other Supporting Information, World Health Organization, Geneva, 1984.
- GUIDELINES FOR DRINKING WATER QUALITY, Volume 3, Water Quality Control in Small-Community Supplies, World Health Organization, Geneva, 1984.
- Occupational Health and Safety Service. "Safe storage of hazardous chemicals in stockrooms, workshops and laboratories"

- “Optimizing coagulation process for low to high turbidity waters using aluminum and iron salts,” 2010.
- Coagulation and flocculation in water and wastewater treatment, 2nd Editionn, 2006.
- “Application of plant-based coagulants for waste water treatment,” 2011.
- Optimizing natural organic matter removal from low turbidity waters by controlled pH adjustment of aluminum coagulation, 1997.
- Automatic control for chemical dosing in laboratory scale coagulation process by using an optical monitor, 1996.
- “Optimisation of Physical Parameters of Coagulation-Flocculation Process in Water Treatment, 2011.
- Ministry of the Environment, Guidelines for the Design of Water Treatment Plants, 1982,
- Ministry of the Environment, Guidance Manual for the Optimization of Ontario Water Treatment Plants Using the Composite Correction Program (CCP) Approach, 1998,

❖ The impact of optimized coagulation on fouling for coagulation/ultrafiltration process, Desalin, 2013.
❖ Optimization of time requirement for rapid mixing during coagulation using a photometric dispersion analyzer, 2014.
❖ "Effectiveness of natural polyelectrolytes in water treatment,", 1991.
❖ WHO, World Health Organization, Water Quality and Health Strategy,2013.
❖ The Effect of Sediment on Water Quality of the Yellow River and Control of Water Pollution in Major Rivers, 2016.
❖ Poly-aluminum silicate chloride-A systematic study for the preparation and application of an efficient coagulant for water and wastewater treatment, 2009.
✓ http://dwi.defra.gov.uk/private-water-supply/index.htm.
✓ https://www.khanacademy.org/science/high-school-biology/hs-biology-foundations/hs-ph-acids-and-bases/v/introduction-to-ph.
✓ https://www.khanacademy.org/science/biology/water-acids-and-bases/acids-bases-and-ph/v/introduction-to-definition-of-ph.
✓ https://www.youtube.com/watch?v=Xeuyc55LqiY.
✓ https://www.youtube.com/watch?v=LeKqhMqEoKQ.
✓ https://www.youtube.com/watch?v=fOY2qHfBW0w.
✓ https://www.youtube.com/watch?v=WpWjGf65V3A
✓ https://www.youtube.com/watch?v=jmZomizSPxw
✓ https://www.youtube.com/watch?v=ehLdQMNPiok
✓ https://www.youtube.com/watch?v=BrN5Ye6ylkU
✓ https://www.youtube.com/watch?v=KyNhmlV3U5o.
✓ https://www.youtube.com/watch?v=qV_1jfmhpnA
✓ Chemical risk assessment basics part 1: Physico-chemical properties
✓ Chemical risk assessment basics part 2: Ecotoxicology and e-fate studies
✓ Chemical risk assessment basics part 3: Toxicology studies.