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ACTIVATED SLUDGE PROCESS OF WASTEWATER TREATMENT PLANT

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Abstract: Wastewater may be described as water that was used to convey pollutants away from a source of pollution. It originates in homes, businesses, schools, hospitals, prisons, and industries, and was ultimately discharged back into the environment. Solids are present in nearly every wastewater, may be very detrimental environmentally, and so are very often regulated in discharges of wastewater. The aimed of this study was to intend the usage of the Activated Sludge Process Control and operating the activated sludge process, including nutrient removal, and troubleshooting. This study was contacted with Saudi Arabia waste water plants as guideline for maintenance and troubleshoots. When troubleshooting activated sludge problems, was to overlook obvious sources and solutions in favor of the strange and unusual.

Keywords: Biochemical Oxygen Demand, wastewater treatment plant, the carbonaceous oxygen demand.

1. Introduction

Wastewater may be described as water that was used to convey pollutants away from a source of pollution. It originates in homes, businesses, schools, hospitals, prisons, and industries, and was ultimately discharged back into the environment. Depending upon the collection system, wastewater may become diluted with groundwater or surface water as it passes from the source to the point of treatment. Infiltration into sewage collection systems may account for large increases in the amount of wastewater that requires treatment. Although typical quantities of domestic wastewater generation are somewhat predictable, industrial contributions are more varied. While many industries treat wastewater on-site, it was not unusual for a publicly owned wastewater treatment plant (WWTP) in an industrialized city to treat wastewater comprised of up to 40 % industrial wastewater [1].

In the laboratory, the BOD of a wastewater was determined by diluting a portion of the wastewater sample with nutrient-rich, pH buffered dilution water in a 300 mL BOD bottle. The initial dissolved oxygen (D.O.) concentration of the diluted sample was determined and the bottle was incubated at 20°C for 5 days. The final D.O. in the bottle was determined and the BOD of the sample was calculated based on the oxygen depletion and the amount of sample dilution. If only the CBOD of the wastewater was to be determined, a nitrification inhibitor was added to the BOD bottle during dilution.

1.1 Wastewater Characteristics

1.1.1 Solids

Solids are present in nearly every wastewater, may be very detrimental environmentally, and so are very often regulated in discharges of wastewater. Solids increase the amount of sedimentation in aquatic systems, choking off plants and animals and limiting the use of the receiving water. The term solid actually includes several possible components. Only when the water was evaporated from a sample was the amount of dissolved material apparent. So total solids refers to the amount of material that would be recovered if the water was evaporated from a sample, including particulates and dissolved materials.

The term settle able solid refers to those particulates which will settle within a defined period of time under quiescent conditions. Although no longer typically used for wastewater discharge monitoring, the settle ability test was often used in controlling biological wastewater treatment plant operations, especially the activated sludge process [2]. Another solids term that was often used was colloidal solids. This refers to particles which are so finely divided that they are microscopic in size and will not settle. These may pass through a filter paper and give the water a hazy appearance.

Organic materials will burn or volatilize at a temperature of 550°C, while inorganic materials will remain as a residue and are referred to as fixed. The Table indicates typical solids composition of domestic wastewater. Overall, the amount of solids donated to a domestic wastewater was estimated at about 0.20 - 0.25 lbs/d/capita [3].

Table (1) domestic wastewater

	Fresh	Stale
Soluble	15 – 25 %	50 %
Colloidal	74 – 86 %	50 %

1.1.2 Biochemical Oxygen Demand

Another characteristic of wastewater that was closely regulated was the Biochemical Oxygen Demand (BOD). As the term implies, many of the components of wastewater cause an oxygen demand to occur on a wastewater treatment system or on a receiving stream. This demand occurs as microorganisms, mainly bacteria, feed on the pollutants in the wastewater. As bacteria metabolize the pollutants they require oxygen, and dissolved oxygen was taken from the stream. As ammonia was biologically oxidized to nitrate (nitrification), oxygen was used up. So Total BOD was the sum of the carbonaceous oxygen demand (CBOD) and the nitrogenous oxygen demand (NOD) [4].

1.1.3 Nutrients

Nitrogen and phosphorus are nutrients that are required by every living organism, becoming a component of every cell. Domestic wastes, animal wastes, food processing wastes, and many industrial wastes will contain these nutrients. Over time, the lake begins to fill in with sediment. Eutrophication was the term used to describe the aging process that lakes undergo as they gradually fill in with sediment, forming a bog or swamp. Careful control of the nutrient load discharged into the environment helps to slow that process [5].

1.1.4. Human Health Hazards and Toxins

Wastewater may contain an untold variety of components that may be hazardous to humans. Domestic wastes always present the possibility of containing infectious microorganisms, or pathogens. Wastewater treatment plant workers exposed to these may contract any of several waterborne diseases. One of the most critical aspects of wastewater treatment was to prevent the discharge of these organisms into the environment where others may also be at risk.

1.2 Problem statement

The aimed of this study was to intend the usage of the Activated Sludge Process Control and operating the activated sludge process, including nutrient removal, and troubleshooting.

2. Methodology

The methodology of the study was to look at the maintenance schedules and faults located in the Ministry of Works in the Kingdom of Saudi Arabia, and all the problems of the day were studied with these authorities to reach a fixed reference for the maintenance procedure or when facing problems.

Microsoft Excel (V 2016) has been used to coding Saudi Arabia planet problems and processing stations with accessing actual steps in the process of maintenance and operation.

Wastewater treatment processes may be grouped into two general categories, the first being physical/chemical. This category includes screening, sedimentation, filtration, precipitation, and chemical destruct systems. The second category, biological, includes processes which rely on living organisms to remove pollutants from the wastewater. This includes processes such as waste stabilization lagoons, trickling filters, rotating biological contactors, and activated sludge.

In most cases wastewater treatment was accomplished through the use of a combination of physical/chemical and biological treatment processes. For instance, a typical treatment plant might include preliminary treatment (physical) to remove large debris and grit, primary treatment (physical) to remove settle able suspended solids, secondary treatment (biological) to remove the remaining particulates and dissolved organic material, chemical precipitation to remove nutrients, tertiary filtration (physical) to remove remaining fine particulates, and chemical or ultraviolet light disinfection [6].

Preliminary treatment was intended to protect downstream processes by removing large debris that might plug or jam equipment. This often involves bar screens to remove large particulates such as sticks, rocks, rags, etc. Coarse bar screens are usually inclined in the flow with the bars spaced about 1.5" apart. The screen may be manually cleaned in smaller facilities or mechanically cleaned automatically in larger facilities. Fine bar screens have found increased use in the past several years. Often these screens are designed to remove particles as small as ¼ inch, obviously removing a larger amount of material from the wastewater flow, and providing increased protection for downstream processes [7].

2.1 Primary Treatment

Primary clarifiers may be designed as either rectangular or circular tanks with a minimum depth of about 10 feet. Tank dimensions vary according to the expected hydraulic load, but generally allow for a detention time of approximately 2 hours and a surface overflow rate of 400 – 600 gallons per day per square foot at average daily flow. Whether rectangular or circular, provision was made for collecting and removing the settled sludge, skimming and removing grease and other floating material, and discharging the clarified primary effluent to the secondary process [8].

3. Results

The Activated Sludge Process was a biological wastewater treatment process. This means that treatment occurs as pollutants are used as a food source by many different types of microorganisms. It was a suspended growth process, since the organisms are suspended in the wastewater rather than attached to a media as in the trickling filter or rotating biological contactor processes as shown in Table [9].

Table (2) basic biology concepts

Anaerobic	Organisms that need no D.O. or nitrate (NO3) oxygen
Aerobic	Organisms that must have D.O
Facultative	Organisms that can exist with or without D.O.
Heterotrophic	Organisms which consume organics in the wastewater
Autotrophic	Organisms which are able to use inorganic compounds as a food source

This suspension, referred to as mixed liquor (or Mixed Liquor Suspended Solids, MLSS), was supplied with oxygen and kept mixed by bubbling air through it. These are naturally occurring organisms; there was no need to supply them from an external source. As the organisms feed on the organic pollutants in the wastewater, the pollutants are converted to more organisms (biomass) and some byproducts. The amount of biomass produced was often estimated as about 0.7 pounds for each pound of BOD removed in the secondary process. While an individual bacterium was not visible to the eye, they stick to one another to form a biological mass which may be easily seen as a brown colored floc. Following an adequate amount of treatment time the mixed liquor flows from the aeration tank to a secondary clarifier where the biomass was allowed to settle out of the wastewater and the effluent passes to the next treatment step. The settled biomass was returned to the treatment process to provide organisms which will continue removing pollutants. This returned biomass was referred to as Return Activated Sludge (RAS) [10].

3.1 Activated Sludge Control Process

Proper operation of an activated sludge plant will require knowledge of biological and physical factors that influence the efficiency of the process. These factors include:

3.1.1 Organic Loading

Organic loading refers to the number of pounds per day of BOD entering the process. In most activated sludge plants this was based on the primary effluent, but in plants without primary clarifiers it would be based on the plant influent flow. Pounds per day of BOD loading may be easily calculated using the Pounds Formula. Multiplying the flow rate in million gallons per day by the weight of a gallon of water (8.34 Lbs/Gallon) and times the concentration in milligrams per liter of BOD in the flow yields the number of pounds per day of BOD in that flow [11].

3.1.2 Quantity of Microorganisms

The concentration of mixed liquor (MLSS) was controlled by postponed solids investigation of the postponement in the aeration boiler. Subsequently this postponement contains biological physique as well as inorganic substantial current in the wastewater, the quantity of biological mass was assessed by verifying the organic contented of the MLSS. Mixed Liquor Volatile Suspended Solids (MLVSS) was controlled by kindling a taster of the desiccated MLSS in a quiet furnace at 550°C [12].

3.1.3 Food to Microorganism Relation

Food to Microorganism Relation (F: M) was one of the chief controllers used in activated sludge places. This assistances was the operative to maintain an equilibrium among the number of food obtainable, that with the amount of microorganisms in the aeration boilers. Subsequently the food obtainable to the microorganisms was characterized by the BOD of the wastewater, the F: M rate was analyzed by separating the amount of hits of BOD incoming the secondary treatment scheme by the number of hits of MLVSS in the aeration boilers [13].

3.1.4 Cell Residence Time

Cell Residence Time (CRT), also known as Sludge Age (SA) or Solids Retention Time (SRT), may be defined as the average length of time in days that an organism remains in the secondary treatment system.

3.1.5 Wasting Rates

CRT was defined earlier in this discussion as the average length of time in days that an organism remains in the secondary treatment system. The operator determines the operating CRT for the facility and maintains it through wasting the appropriate amount of excess biomass (Waste Activated Sludge WAS) from the secondary system. In other words, the amount of biomass (MLSS) in the secondary system was controlled and maintained through solids wasting [14].

3.1.6 Return Activated Sludge

Return Activated Sludge (RAS) refers to the biological solids (mixed liquor solids) that settle in the secondary clarifier and are continuously returned back to the aeration tank. There are two important reasons for returning these organisms. First, if they were not continuously drawn from the clarifier it would quickly fill up with solids and they would be lost in the effluent. Second, these organisms are the major component of the treatment system. If they were not returned the biomass population could not be sustained and the treatment system would quickly fail. RAS brings active, hungry microorganisms back into the aeration tank where they can again feed on incoming wastes [15].

4. Discussion

4.1 High Secondary Clarifier Sludge Blanket

Use the Settle meter Test and the microscope to help determine the cause of this condition. Calculate the Sludge Volume Index (SVI) or the Sludge Density Index (SDI) to establish whether the problem was caused by poor compaction or just too much biomass in the system as shown in Table (**1** [9, 10, and 11].

Table (1) Comparsion between SVI and Low SDI

High SVI, Low SDI	Normal SVI, SDI
Microscopic Examination of MLSS - floc size, shape, structure, indicator organisms, filaments	
Possible Causes of Filamentous Bulking	Excessive amount of Biomass
Low Dissolved Oxygen Low Organic Loading Rate (F:M < 0.05) (High CRT) High Organic Loading Rate	Recalculate CRT, Wasting Rate Inadequate Sludge Storage – make sure that maximum sludge storage capacity was available

High SVI, Low SDI	Normal SVI, SDI
Nutrient Deficiency (N or P) 100 parts C to 5 parts N to 1 part P Septic Wastes / Sulfides Low pH (< pH 6.0) High Carbohydrate Load (Sugars, Syrup, etc.)	before winter to assure adequate WAS ability. High SS, BOD in supernatant from sludge handling. WAS a solid being carried through Primary Clarifiers.
Possible Cures of Filamentous Bulking	Inadequate Return Sludge Rate
Long Term – Try to eliminate or control the cause of the problem. Short Term – Control settleability with Chlorine (Cl_2) Add to Return Sludge Before Mixing With Wastewater Feed Chlorine Lbs Cl = 0.0000834 X SVI X F X W F = RAS MGD W = RAS TSS, mg/L Enough Cl2 must be dosed to kill the filaments; start with the amount calculated by the formula above, increase if settleability does not improve within one day. Discontinue Cl_2 feed when settleability was under control.	RAS Pump Control Settings Mechanical Condition of RAS Pumps, Meters, Valves Clarifier Sludge Sump blocked with debris Sludge collector mechanical problem

4.2 High Effluent BOD

The Table(2 has shown the results of BOD of reported or effluent.

Table(2) BOD Results

If Total BOD was reported	If effluent CBOD was high
also analyze the effluent for CBOD to determine if nitrification was causing the increased BOD. If this was the case and there was no ammonia limit in the discharge permit, try to get the plant out of nitrification, or call the DEQ district	Determine whether the CBOD was dissolved or particulate. If it was particulate, improve settling in the secondary clarifier or improve tertiary filtration. Look for organic overload – High F:M, possibly shock loading of high strength organic waste, from within plant or from collection system. Determine if CBOD was coming from a process downstream from the aeration tanks, such as from tertiary filters, effluent equalization,

If Total BOD was reported	If effluent CBOD was high
office and explain the problem.	polishing pond, etc. Determine nutrient balance going into A.S. system. Don't remove phosphorus before aeration tanks Recalculate F:M and CRT to assure operation was in typical range

4.3 Nitrogen

The Table (**3** has shown the results of nitrogen of effluent ammonia.

Table (3) Nitrogen reported

Excessive Effluent Ammonia	Excessive Total Inorganic Nitrogen (TIN)
Assure that processes downstream from aeration tanks (such as polishing ponds) are not contributing ammonia directly to the effluent. Carefully control supernatant from sludge handling, digestion, and storage units. This recycled flow typically contains very high ammonia concentration and was very often the cause of ammonia violations of the discharge permit. Recalculate CRT and F:M to make sure that they are in the nitrification range. Avoid over-wasting or slug loading the biomass. Assure adequate D.O. (3-5 mg/L) at the discharge end of the aeration tank Check for toxicity entering the WWTP.	Analyze for ammonia, nitrite, and nitrate. If ammonia was high, refer to the previous troubleshooting section on ammonia. If nitrite and nitrate are high, encourage denitrification. Reduce excess D.O. in aerobic reactor Avoid excessive detention time in aerobic reactor. Add carbon source (influent wastewater, methanol) to anoxic reactor

4.4 Toxicity

While not always an indication of a problem, sometimes unusual odor, color change, or foam in the influent wastewater accompany a toxicity problem. Monitor aeration tank D.O. continually if possible. If BOD load, blower output, and MLSS have remained fairly constant, a sudden increase in aeration tank D.O. may be an indication of reduced biological activity due to toxicity [11].

5. Conclusion: Resolving Troubleshooting Steps

Probably one of the most common temptations for the operator, when troubleshooting activated sludge problems, was to overlook obvious sources and solutions in favor of the strange and unusual. Although situations sometimes do arise that are difficult to determine and explain, the first approach should usually be to start with the most basic information about the problem. Look for in-plant operational or mechanical causes first, and then only if those can be eliminated, expand the search to the collection system and changes in influent wastewater characteristics.

Begin by characterizing the problem; excessive odor, mixed liquor settleability, high effluent BOD, Suspended Solids, Ammonia, Total Inorganic Nitrogen (TIN), P. Try to assure that information that was available was reliable. Occasionally, much effort was expended in tracking down a supposed problem only to discover that metering or laboratory data was not accurate. Don't assume that the laboratory data was faulty, but be sure that it was accurate.

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المعالجة النشطة لمحطة مياه الصرف الصحي

الملخص: يمكن وصف المياه العادمة بأنها ماء يستخدم لنقل الملوثات بعيدا عن مصدر التلوث. وهي تنبع من المنازل والمحلات التجارية والمدارس والمستشفيات والسجون والصناعات، وقد أعيدت إلى البيئة في نهاية المطاف. توجد المواد الصلبة في المياه العادمة والتي تكون ضاره جدا بيئيا وصحيا، وهكذا غالبا ما يتم تنظيمها وتنقيحها في تصريف المياه العادمة. ولذلك الهدف من هذه الدراسة هو العزم على استخدام التحكم في عمليه المعالجة النشطة وتشغيلها، بما في ذلك إزاله العناصر الصلبة، واستكشاف الأخطاء وإصلاحها. تقوم هذه الدراسة على محطات المياه العادمة في المملكة العربية السعودية كمبدأ توجيهي للصيانة واستكشاف الأخطاء والحلول لذلك يعتبر هذا البحث مرجع في عملية التشغيل والصيانة عند حدوث أعطال بمحطات المعالجة.

الكلمات المفتاحية: الطلب على الأكسجين البيوكيماوية، ومحطة معالجة مياه الصرف المائي، والطلب الأكسجين الكربوني.