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Technological Design of Sewage Disposal in Small Town of China using SBR Method

Bachelor's Thesis

CENTRAL OSTROBOTHNIA UNIVERSITY OF APPLIED SCIENCES

Degree Programme in Chemistry and Technology

May,2010

Thesis abstract

Thesis Abstract Department	Date	Author(s)
Central Ostrobothnia University of Applied Sciences,Kokkola	May, 2010	Gao chao

Degree programme

Degree Programme in Chemistry and Technology

Name of thesis

Technological Design of Sewage Disposal in Small Town of China using SBR Method

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Supervisor Kaj Jansson

The study is related to the drainage engineering design of a small town in Shenyang City, the People's Republic of China. The purpose of this study is to resolve the problem of pollution to the local river that adversely affects the local residents' living and constrains economic development.

This sewage disposal plant is located in the northeast of the small town and at the east side of the river. The sewage is mainly from the local urban wastewater and a little from the industrial wastewater. The total quantity of sewage is $56689m^3/d$. The BOD, SS, and COD of the sewage seriously run out of the limit. According to the feature of the sewage, economic effect, disposal efficiency, and technical factors, the SBR technology (i.e. Sequencing Batch Reactor Activated Sludge Process) that has a high purification efficiency and automation, less cost, and steady disposal effect is adopted.

The paper involves in a detailed design and calculation for the structure of the grille, grit tank, SBR reactor tank, and disinfection contact tank.

Keywords:

SBR technology; sewage disposal; aeration

FORWORD

I would like to express my gratitude to all those who gave me the possibility to complete this thesis. I want to thank all the teachers and staffs in Central Ostrobothnia University of Applied Sciences, and the teachers who have taught me in my previous education.

I have worked as an intern with an Environmental Protection Monitoring Station which is located in Shenyang city, Liaoning province, China. I went there three times. The first time is from Dec. 18, 2007 to Feb. 28, 2008; the second time is from July 15, 2008 to Aug. 10, 2008 and the last time is from July 20, 2009 to Aug. 15, 2009. The internship period is in all more than 4 months. I was honored to be a member of census enumerators. I have learnt a lot from there, and I got this thesis topic from my supervisor Qian Min, and all the data about the small town I was been given by my instructor Li Chunyang. And also he gave me a big help with the huge and difficult calculations. Without his guidance and help, this thesis could not be done.

I would like to thank my supervisor, Kaj Jansson, who help me to conceive and develop the main idea of this thesis.

I am also deeply indebted to Esko Johnson, whose advices were essential in writing this thesis, Thanks for spending a lot of time on me.

I further give my gratitude to all my schoolmates, colleagues, Finnish family and friends, their existence during the past years has made my study, work and life in Finland an interesting and memorable experience.

17.05.2010 Kokkola

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1 INTRODUCTION

Water is the most widely distributing and important natural resource in the world. It nourishes every single creature on the earth and serves the people and society all round. It is commonly used by human in the aspects of living, industry, agriculture, fishing, and transportation. Generally, the first three waters closely related to human life and production cannot be utilized directly from salty water in large-scale but only from the fresh water.

In the water environment, the fresh water resource is limited and natural water sources change by various seasons and locations. What is more, the natural water body is vulnerable to general pollution, which results less and less optimal water can be utilized directly and can hardly satisfy the increasing demand of the people's living and industrial and agricultural production. Thus, to protect and cherish the water resource is the common responsibility of the entire society.

The thesis is about how to design sewage disposal system using the method of SBR for a small town in Liaoning Province, the People's Republic of China. The objective of the thesis is to resolve the problem of pollution to the local river that adversely affects the local residents living and constrains economic development. We shall try to satisfy the increasing needs produced by the human activity, also try our best to protect and treasure water.

With development of economy, the sewage drainage in China increases and is constricted by technology and economy. Many drainage systems cannot meet the standard, and what is more, water pollution is aggravating. A number of new sewage disposal technologies and processes with high effects and low costs that can guarantee the drainage standards are needed urgently in China. Fortunately, with great efforts of the environmentalists, many sewage disposal technologies and processes have been adopted in China, such as the SBR method.

In this study, an attempt will be made to answer the following research questions:

What is the SBR method and what are its advantages?
What are the design bases and principles?
What is the technology plan to be selected?
How do we design the way to dispose sewage using SBR method for a small town in Shenyang City, the People's Republic of China?

2 THE OPERATIONAL PRINCIPLE OF SBR METHOD AND THE DESIGN OF SEWAGE TREATMENT PLAN

2.1 SBR definition and advantages

SBR is the abbreviation of Sequencing Batch Reactor Activated Sludge Process. It is an activated sludge sewage disposal technology operated by intermittent aeration mode, also named SBR Activated Sludge Process. (Beijing Research Center for Environmental Technology and Equipment 1999, 355-367.)

SBR technology has the following advantages:

1. The ideal circulation process increases the driving force during the biochemical reaction, making it more efficient. It alternates with both aerobic and anaerobic conditions, making it more effective.
2. The operation is stable; sewage is precipitated under ideal static condition, taking less time. The output water is in better quality.
3. In the reaction pool, there is remained water to be processed, which can dilute and buffer the sewage, effectively resisting the collision between the water and the organic feculence.
4. The sections in the process can be adjusted according to the condition and quality of the sewage.
5. Requited equipment is less, the structure is simple, and it is easy to operate and maintain.
6. Due to the grads of consistency for DO and BOD, the expansion of active mud can be easily restricted.
7. SBR system is also capable to work in a combined architecture, and is suitable for the sewage treatment plant to build extensions.
8. The process is able to switch from aerobic, hypoxia, and anaerobic

conditions, which is ideal for dephosphorization and denitrogenation.

9. The system is low cost. The main part consists of one reacting machine, without any pools first and second precipitation tanks. The adjusting pool can be omitted. It is compactly structured, and does not require much more area to build in. (Beijing Research Center for Environmental Technology and Equipment 1999, 367-371.)

2.2 The principle followed in design of sewage treatment plan

Principles followed are the national environmental protection policy and the local rules and regulations, code and standard; adopt the advanced processing technology to guarantee the sewage disposal standard; utilize the high-efficiency, high-quality equipment and well-designed control system for the convenience of management and operation; balance the profit of environment, economy and society, and try to use less engineering investment and cost under ensuring the water outlet quality; coordinate the sewage disposal plant with the surroundings by overall planning and reasonable arrangement; properly dispose the sludge generating from the sewage purification against secondary pollution.

2.3 Location choice principles

The site of the sewage disposal plant is an important issue, which should follow the principles below. The site should be located at the downstream of the water supply and urban area, and the downwind of the dominating wind, and at least 500 meters to the urban area. The sewage disposal plant should be close to the receiving water body and the flood issue should be concerned; we shall consider the geological condition of the location of the sewage disposal plant so as to save the engineering cost and construction convenience, and utilize the topographic condition and build the sewage disposal plant along the slope to save energy.

2.4 The principle and characteristic of SBR process

2.4.1 Choice of technology plan

With the development of economy, many types of secondary treatment processing methods of urban wastewater have formed, such as traditional activated sludge process, Sequencing Batch Reactor activated sludge process (SBR method), anoxic-oxic biological nitrogen removal process (A1/O process), anaerobic-oxic biological phosphorus process (A_2/O process), A—B method process, oxidation ditch process (OD) process. Each process has its own advantages and disadvantages.SBR technology is suitable for the development trend of current oxic biochemical treatment process, and it is an easy and high-efficiency sewage disposal technology with low energy consumption. (Zhang 1996, 1-5.)

The features below shall be taken into consideration: The ideal impelling process can enlarge the biochemical reaction impelling force and efficiency, and the anaerobic-oxic alternate condition in tank can guarantee the purification effect. The nitrogen and phosphorus removal process should be controlled properly to change the oxic, anoxic, and anaerobic operating condition, so as to make a good nitrogen and phosphorus removal process effect. The stable operating effect can ensure that the sewage has sediment under the ideal and static condition that needs less time and has a high efficiency and better water outlet quality.

The main equipment has only a sequencing batch reactor, and has no secondary sedimentation tank and sludge return system. The regulation tank and the primary sedimentation tank can be omitted.

For the economic issue, the SBR technology is of compact design, with less land used. It is low cost. The main part consists of one reacting machine, without any pools first and second precipitation tanks. The adjusting pool can be omitted. It is compactly structured, and does not require much more area to build in.

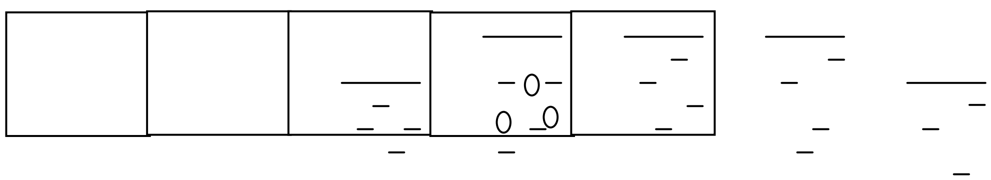
For the plant construction issue, the SBR method is suitable for combined type structure, and is convenient for the expansion and reconstruction of the sewage disposal plant.

For the daily maintenance, each process of the technology can be adjusted according to the water quality and water amount freely which with the few facilities. The single formation is easy to be operated and managed.

For the town that has a relative large quantity of sewage, the SBR method is often adopted. The sequencing batch reactor activated sludge process (SBR method) can meet the design requirements.

2.4.2 Basic principles of SBR technology

SBR method process normally consists of 5 stages: water intake stage, reaction stage, sedimentation stage, water drainage stage and idle stage. These five stages are completed in the SBR reactor tank. The Graph 1 is the basic operation mode of SBR method. (Zhang 2003, 6-9.)



Water intake stage→Reaction stage→Sedimentation stage→Water drainage stage→Idle stage

Graph 1. The basic operation mode of SBR technology

The water intake procedure is the stage in which the reactor tank receives the sewage. Before the sewage flows into the tank, the process is called a water drainage or idle stage. Therefore, in the reactor tank, there is high-density activated sludge mixed liquid left, and at this time, the water level in the reactor tank is of the lowest level. During the water intake procedure, the sewage flows into the tank without drainage, and the reactor tank is of adjusting function, which is not subject to load change that occurs during the continuous water intake and outlet procedure. In the SBR tank, although the water quantity and quality changes, the process makes less effect to the water quality.

As the sewage fills the preset volume, the aeration or mixing is carried out for a complete reaction. At the end of the reaction and before the sedimentation procedure, brief and slight aeration is made in order to remove the gas on the sludge, which can also be used at the end of the reaction procedure to remove the sludge discharge.

The sedimentation procedure acts as the function of the secondary sedimentation tank. The aeration and mixing shall be stopped. We shall carry out the gravity sedimentation of the activated sludge granule and the separation of the upper clear liquid. Because the procedure is of static sedimentation, the sedimentation efficiency is higher.

The upper clear liquid after the sedimentation procedure is the disposed water draining to the lowest water level. The activated sludge at the bottom of the reactor tank can be used as the returned sludge of the next cycle. The excessive sludge should be used for other purposes. In addition, the left treated water in the reactor tank can be used for circulated water or dilution water.

The idle procedure is the period between sedimentation-drainage to the beginning of next cycle. During this period, the mixing or aeration is made according to needs. Under the anaerobic condition, the mixing cannot only save the energy but can conserve the activity of the sludge.

3 THE URBAN METEOROLOGICAL DATA AND WATER ENVIRONMENT INDEX

3.1 The index of pollutant in urban swage

The urban population density is 150 persons/ hectare, and the total urban area is 1119.46 hectare, and the daily quantity of sewage is 160L/person.

Table 1. Water discharge capacity and water quality of industrial enterprise and public buildings

Name of enterprise or public buildings	Average water discharge capacity (m^3/d)	Maximum water discharge capacity (m^3/h)	SS (mg/L)	COD (mg/L)	BOD (mg/L)	Ammonia-nitrogen (mg/L)	Total Phosphorus (mg/L)	pH	Temperature (°C)
A	1100	300	180	450	200	27	6	7.0	20
B	900	250	260	400	180	26	7	7.2	20
C	700	200	280	380	160	30	5	7.4	20

3.2 Hydrological data of receiving water body

From the each condition, the minimum water discharge capacity monthly, the highest water level and the normal water level were chosen here.

Table 2. Disposal data at discharge side of the sewage disposal plant with receiving water body is river

	Flow rate (m^3/s)	Flow velocity (m/s)	Water level elevation (m)	Water temperature (°C)	DO (mg/L)	BOD_5 (mg/L)	SS (mg/L)	SS permitted increment (mg/L)
Minimum water discharge capacity (monthly)	50	0.6	75	1	7	6	20	5
Highest water level	120	1.2	80	22	5	5	130	5
Normal water level	80	0.9	78	17	6	5	60	5

3.3 Water outlet quality

The designed sewage disposal plant in this study meets the CASE-II water body standard (Level One) in Discharge Standard of Pollutants for Municipal Wastewater Treatment Plant (GB18918—2002).

Table 3. Discharge Standard of Pollutants for Sewage Treatment Plant

Project	COD (mg/L)	BOD_5 (mg/L)	SS (mg/L)	Ammonia-nitrogen (mg/L)	Total Phosphorus (mg/L)	PH
Contaminant concentration	≤60	≤20	≤20	15	0.5	6.5—8.5

4 TECHNOLOGICAL DESIGN CALCULATION OF SEWAGE DISPOSAL

The technological design calculation of sewage disposal is actually the theoretical foundation of the operation of the sewage disposal technology. After reading some materials, I confirm the calculation formula and method. (Gao & Wang 2003, Yu Erjie, et al 1999; Zhang 2000, Cui & Liu & Zhang 2004).

4.1 Calculation of quantity of sewage and sewage disposal degree

4.1.1 Design flow rate of sewage

As the area of the small town is S=1119.46 hectare. The population of the small town is N=150*1119.46=167919 persons. The average living quantity of sewage is Q_1=26867040L/d. The average industrial quantity of sewage is Q_2=31.25L/s. The total average quantity of sewage is Q_T=29566944L/d. The maximum industrial quantity of sewage is Q_M=18000 m^3 /d. The design quantity of sewage is Q_D=56688.77 m^3 /d. (The processes of calculations could be found in Appendix 1.).

4.1.2 Design population

The industrial enterprise wastewater quantity, the concentration of suspended matters in the wastewater, and the concentration of biochemical oxygen demand are converted into the equivalent population of the industrial enterprise wastewater. The value of BOD_5 and SS in the domestic sewage are 30g/ (rd) and 45g/ (rd). Then the Table 4 is concluded:

Table 4. The converted equivalent population of the industrial enterprise sewage

Name of enterprise or public buildings	Average water discharge capacity Q/(m^3/d)	Suspended matters (SS)			Five days' biochemical oxygen demand (BOD_5)		
		Concentration C/(g/m^3)	Total CQ/(g/d)	Equivalent population	Concentration C/(g/m^3)	Total CQ/(g/d)	Equivalent population
A	1100	180	198000	4400	200	220000	7333
B	900	260	234000	5200	180	162000	5400
C	700	280	196000	4356	160	112000	3734
Amount	2700		628000	13956		494000	16467

As presented in Table 4, the total design population of the town can be calculated as shown in Table 5.

Table 5. Calculation table of design population

	Design population /person	
	Calculated as SS	Calculated as BOD_5
Domestic sewage in residential area	167919	167919
Industrial wastewater in industrial area	13956	16468
Amount	181875	184387

4.1.3 Polluted degree calculation of the sewage water quality

As the domestic sewage discharge of one person per day was 160L/(r·d), the average concentration of suspended matters in domestic sewage was $C_{SS(L)}$ =

$\frac{45}{160}$ =0.2813g/L=281.3mg/L. The average concentration of biochemical oxygen demand in domestic sewage was $C_{BOD_5(L)}$ = $\frac{30}{160}$ =0.1875g/L=187.5mg/L. Chemical oxygen demand of the domestic sewage was $C_{COD(L)}$ =400 mg/L. Total nitrogen of the domestic sewage was $C_{N(L)}$ =40 mg/L. Total phosphorus of the domestic sewage was $C_{P(L)}$ =8 mg/L. After calculation, the results were got, C_{SS} =0.2769g/L=276.9mg/L.

C_{BOD_5} =0.1871g/L=187.1mg/L. C_{COD} =0.4014g/L=401.39mg/L. C_N =38.86mg/L. C_P =7.83mg/L.(The processes of calculations could be found in Appendix 2.).

4.1.4 Calculation of sewage disposal degree

The SS concentration was calculated according to the permitted SS increment using the formula of SS concentration at water outlet of sewage C_e =p ($\frac{Q}{q}$ +1) +b. In the formula, C_e was permitted contaminant discharge concentration at sewage discharge side, mg/L; p was after drainage and mixing of the sewage into the water body or and river, the permitted SS increment in the mixed water, mg/L, p=0.1 mg/L; q was the sewage flow rate drained into the water body, m^3/s: q=0.47 m^3/s; b was before sewage drainage into the river, the original SS concentration in the river, mg/L, b=2mg/L; Q was minimum average monthly flow rate under 95% river reliability, m^3/s, Q=4.2 m^3/s. After calculation: C_e =5* $\frac{50}{0.656}$ +2=388.1 mg/L.

Degree of treatment of SS was E= $\frac{C_i - C_e}{C_i}$ *100%. In the formula, E was degree of treatment of sewage need; C_i was original average concentration of SS in sewage, mg/L; C_e was average concentration of the matter in the treated water permitted to be drained into the water body, mg/L. Then the result was got that E= $\frac{276.9-388.1}{276.9}$ *100%=-40.2%.

The SS concentration was calculated according to the Integrated Wastewater Discharge Standard: In Level 1 drainage standard of Level 2 sewage disposal engineering for new-built towns in stipulations of the Integrated Wastewater Discharge Standard, the maximum permitted SS concentration was prescribed, C_e =20 mg/L. Degree of treatment of SS was E= $\frac{C_i - C_e}{C_i}$ *100%=

$\frac{276.9-20}{276.9}$*100%=92.78% .The relative high value of the degree of treatment in the calculation was adopted, so the degree of treatment of SS was E=92.78%.

The degree of treatment of SS can obviously denoted that even if the sewage was drained directly into the river, the pollutants in the sewage made less influence to the river. So, the degree calculation of treatment of BOD_5 could omit the influence of the minimum concentration of DO and the maximum concentration of the BOD_5 in the water body, but according to Level 1 drainage standard of Level 2 sewage disposal engineering in new-built towns of the national Integrated Wastewater Discharge Standard. As the maximum permitted discharge concentration of BOD_5 was L_{5e} = 20 mg/L, the degree of treatment was $E=\frac{187.1-20}{187.1}$ *100% = 89.3%.

Degree of treatment of COD was based on Level 1 drainage standard of Level 2 sewage disposal engineering in new-built towns of national Integrated Wastewater Discharge Standard, the maximum permitted discharge concentration of COD was C_e =60mg/L, and the degree of treatment was E= $\frac{401.39-60}{401.39}$ *100%=85.1%.

4.2 Structure design of sewage disposal

4.2.1 Design and calculation of the grille

The grille was used to remove the relatively big suspended matters, floating objects, fibrous matters and solid granules in the wastewater, in order to guarantee the normal operation of the next treatment procedure and the pump and relieve treatment load of subsequent operating units against mud pipeline block. (Xu & Yu 2002, 6-8.)

Design content: in this program, the grille was connected to the water intake channel, the water from the lift pump station initially flows into the pressure regulating well, and then into the grille channel. The effective water depth of the water intake channel was generally 0.2—0.5 m, h=0.5m; and the flow velocity of the water intake channel was generally 0.4—0.9m. The v=0.8 m/s was taken, and the width of the water intake channel was $B_1=\frac{Q_{max}}{hv}$ =

$$\frac{0.656}{0.5*0.8}=1.64 \text{ m.}$$

Grille: the design flow rate Q_S=0.656 m^3/s, and via grille flow velocity was generally 0.6—1.0m, v=0.9m/s; and the grille inclination angle was generally $60^o—70^o$: $\alpha=60^o$; water depth in front of the grille h=0.5m. In this study, the grille gap was generally 10mm—40mm, e=21mm=0.021m.

By looking up the handbook, the values of the grille, Number of grille gap was n=68.

Width of grille groove was B=1.04m. Length of gradually wide part of water intake channel was l_1=0.3m; Length of gradually narrow part of grille groove and water outlet channel were l_2 =0.15m; The hydraulic head loss when passing through the grille was h_1=0.097m; Extra height of the channel in front of the grille h_2 was generally 0.3m; Total height of the rear grille groove was H=0.5+0.097+0.3=0.9m; Total length of grille groove was L=2.41m.

4.2.2 Design and calculation of the grit tank

The function of the grit tank is to separate the inorganic particles with relatively big density from the wastewater. The grit tank is generally set before the sewage disposal plant, in order to protect the water pump and the pipeline against damage. The sludge treatment structure volume should be shrunk so as to increase the contents of organic compounds in the sludge and the value of the sludge being the fertilizer. The type of the grit tank: according to the direction of the water flow in the tank, it can be divided into horizontal flow grit tank, vertical flow grit tank, aeration grit tank, bell-type grit tank and dole grit tank. (Zeng 2001, 44-46.)

The aeration grit tank is adopted. As the water flow is uneven in the common grit tank and the flow velocity changes much, which leads less choice efficiency to inorganic particles and the sand tends to rot due to anaerobic decomposition. The aeration grit tank has the aeration and sand removal function, and not only can decrease the organism in the sand below 5%, but also has the multiple functions of pre-aeration, oil removing, and deodorization. (Gu 1985.)

The aeration value was 0.2 m^3 air/1 m^3 sewage, and the quantity of sewage was 56688.77 m^3/d, and air volume needed for aeration was 11337.76 m^3/d.

Total effective volume of tank was V= $Q_{max}\cdot t*60$. In the formula, V was total effective volume of tank, m^3; Q_{max} was maximum design flow rate, m^3/s; t was flow time min at maximum design flow rate, generally between 1—3min. 2min was adopted. After calculation: V=0.656*2*60=78.72 m^3

Cross-section area of water flow was A= $\frac{Q_{max}}{v_1}$. In the formula, A was cross-section area of water flow, m^2; v_1 was horizontal flow velocity at maximum design flow rate, m/s, generally between 0.06—0.12m/s: v_1 =0.08m/s, was adopted. After calculation: A= $\frac{0.656}{0.08}$ =8.2 m^2

The total width of the tank was B= $\frac{A}{h_2}$. In the formula, B was Total width of the tank, m; h_2 was Effective design water depth, m, was generally 2—3m: h_2

=2m. After calculation: B=$\frac{8.2}{2}$=4.1m.

Width of each chamber of the tank was b=$\frac{B}{n}$. In the formula, b was width of each chamber of the tank, m; n was Number of the chambers in the tank, 2. After calculation: b=$\frac{4.1}{2}$=2.05m. Ratio of width and depth $\frac{b}{h_2}$=$\frac{2.05}{2}$=1.03. It was generally at 1-2 and meets the requirements.

Length of the tank was L=$\frac{V}{A}$. In the formula, L was length of the tank, m. After calculation: L=$\frac{78.72}{8.2}$=9.6m. Ratio of length and width $\frac{L}{b}$ = $\frac{9.6}{2.05}$ =4.7<5, which meets the requirements.

Air volume needed per hour was q=d*Q_{max}*3600. In the formula, q was air volume needed per hour, m^3/h; d was air volume needed of 1 m^3 sewage, m^3/m^3, generally at 0.2. After calculation: q=0.2*0.656*3600=472.32m^3/h.

4.2.3 Design and calculation of the SBR tank

After the calculation of the urban population and the quantity of sewage, the water intake amount of the sewage Q was 0.656m^3/s=56689m^3/d; and the original water intake BOD_5 was 187.1mg/L; the water temperature was at 10—20°C; and the water quality was BOD_5≤20mg/L. About calculation of sewage disposal degree, after the original sewage flowing through the aeration grit tank, the SS descent 50%, and the BOD_5 descent 25%. In the original sewage, the SS concentration was 276.9 mg/L, and the BOD_5 concentration was 187.1 mg/L, then the SS value of the sewage flowing into the SBR reactor tank was C_{ss}=276.9*(1-50%) =138.45 mg/L, C_{BOD_5} Of BOD_5: C_{BOD_5} =187.1*(1-25%)=140.33mg/s.

Before the removal ratio, the indissolvable BOD_5 value was calculated in the treated water, BOD_5=7.1 b X_a C_e. And in the formula, b was self-oxidation rate of microorganism, generally between 0.05-0.10. Here I adopt 0.08; X_a was the active microorganism ratio during the treatment, 0.4; C_e was solid floating matters concentration in the treated water, 40mg/L.

After the calculation the results were got: BOD_5 =7.1*0.08*0.4*40=9.09mg/L, soluble BOD_5 concentration in the treated water was 20-9.09=10.97mg/L and the removal rate of the BOD_5 was η =

$$\frac{140.33-10.91}{140.33}*100\%=92.23\%.$$

The pre-adopted BOD—sludge load rate was 0.16 kg (BOD_5)/kg (MLSS) εd. However, for a conservative calculation, this value needs to be checked in the following formula: $N_s = K_2 S_e f/\eta$. In the formula, N_S was sludge load rate; K_2 was coefficient,0.018; S_e was soluble BOD_5 value in the treated water, S_e =10.91mg/L; f, MLVSS/MLSS was generally between 0.7—0.8, 0.75 was adopted; η was removal rate of BOD_5, 92.23%. After calculation: N_S =

$$\frac{0.018*10.91*0.75}{0.9223}=0.16.$$

Therefore, the value 0.16 kg (BOD_5)/kg (MLSS) ·d was suitable.

According the determined value of N_S, the corresponding value of SVI was between 100-200: it was 120, and the value of X can be made by the following formula: X= $\frac{R*r*10^6}{(1+R)*SV}$. In the formula: X was sludge concentration of the mixed aeration liquid, mg/L; R was sludge recycle ratio: 50%; r was coefficient, 1.2; SVI was sludge volume index. After calculation: X= $\frac{0.5*1.2*10^6}{(1+0.5)*120}$=3400mg/L.

Operation cycle and time calculation of the SBR reactor tank, $T_A = \frac{24C_s}{L_s m C_A}$. In the formula, T_A was Aeration time; C_S was average water intake BOD_5 concentration, mg/L; L_S was BOD_5 Sludge load, 0.16 kg (BOD_5)/kg (MLSS) ·d; $\frac{1}{m}$ was discharge ratio, generally between $\frac{1}{2}$ and $\frac{1}{6}$, it adopted $\frac{1}{2.5}$; C_A was MLSS concentration in SBR tank, 3400mg/L. After calculation: T_A = $\frac{24*140}{0.16*2.5*3400}$=2.48h, approximated to 2.5h.

As to the sedimentation time, As MLSS>3000mg/L, V_{max} =4.6*$10^4 * C_A^{-1.26}$; As MLSS<3000mg/L, V_{max} =7.4* 10^4 *t* $C_A^{-1.7}$. In the formula, V_{max} was initial sedimentation velocity of the activated sludge interface, mg/h; C_A was MLSS concentration in the SBR tank (ml/L). As MLSS=3400 mg/L >3000mg/L, the formula V_{max} =4.6* 10^4 * $C_A^{-1.26}$ was adopted. After calculation: V_{max} =4.6*$10^4 * 3400^{-1.26}$=1.63m/h.

The necessary sedimentation time was $T_S = \frac{H * \frac{1}{m} + \varepsilon}{V_{max}}$. In the formula: T_S was sedimentation time, h; H was Water depth in the reactor tank, 5m; $\frac{1}{m}$ was discharge ratio, $\frac{1}{2.5}$; ε was safety elevation (minimum water depth above the activated sludge interface): 0.5m; V_{max} was Initial sedimentation velocity of the activated sludge interface, 1.63mg/h. After calculation: T_S = (5* $\frac{1}{2.5}$ +0.5)/1.63=1.5h.

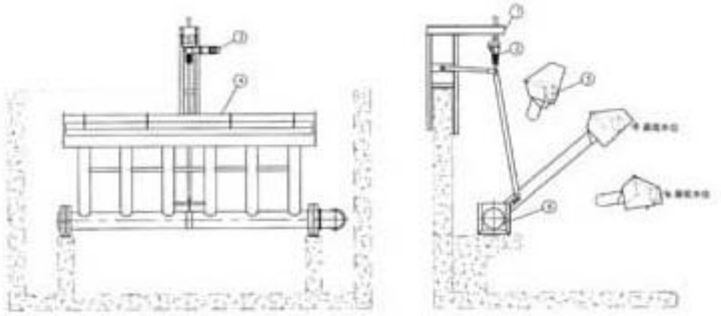
As to the discharge time, the sedimentation time was 2h, and the discharge time was at about 2h (generally between 0.5—0.3h), and the total time was 4h. Period of time of one cycle was $T_S \geq T_A + T_B + T_D$ =2.5+1.5+4=8h. Number of cycles was: n= $\frac{24}{8}$ =3. One cycle was 8h.

Water intake time was $T_F = \frac{T_C}{N}$. In the formula: N was number of chambers.

After calculation: $T_F = \frac{T_C}{N} = \frac{8}{4}$ =2h. The working process of one cycle was: the aeration begins at 1 hour after water intake.

Volume calculation of the reactor tank was V= $\frac{Q_s * m}{n * N}$. In the formula, V was reactor tank volume; Q_s was sewage water intake amount (m^3 /d), 56689 m^3 /d; $\frac{1}{m}$ was discharge ratio, $\frac{1}{2.5}$; n was number of cycles, n=3; N was number of chambers, N=4. After calculation: $V=\frac{56689*2.5}{3*4}$=11810.2 m^3 .

As to the upper clear liquid discharge device (decanter), the rotary decanter was chosen. The driving device of the rotary decanter was composed of motor and reducer. The lifting device was composed of worm wheel, worm shaft, screw rod, four-bar mechanism, drainage branch pipe and main pipe, water outlet weir trough, float bowl, granule dam device, and underwater bearing. Through the driving device and four-bar mechanism, the rotary decanter converted the vertical movement of the screw rod into the rotary movement of the outlet weir and the drain pipe, so as to remove the upper clear liquid. The granule dam device of the float bowl formed a water outlet area without floating granules at the upper, lower and both sides of the water in front of the weir, and the float bowl floated onto the water surface that can automatically adjust the distance to the weir. (Gao etc 2003, 105-107.)



1. Rack 2.Lifting device 3.Driving device 4.Outlet weir 5.Float bowl 6.Underwater bearing.

Graph 2. Sketch of rotary decanter

The 5 decanters of the same type were allocated, and one of them was backup machine. According to the flow rate, the MRD600 decanter was chosen: flow rate 600 m^3 /h, decanting depth 1.5—2m, motor power 0.75kW, complete machine weight was 2500kg.

As to the operational mode of SBR tank, in this study, totally 4 aeration tanks were designed in two paralleled rows. The water flows in from the center of the SBR tank on one side, and the distribution pipe was used to ensure that the water distribution was even in four tanks. One water outlet pipe was located at the center of the opposite tank wall, and the sludge was lifted by submersible sewage pump at its tail end of each.

Calculation and design of the aeration system were got as below: The calculation of the average oxygen need was $O_{2\ average}$= aQS_r + bVX_V, in the formula: $O_{2\ average}$ was daily average oxygen need of the activated sludge process system, kg (O_2)/d; a was the oxygen needed for metabolizing 1Kg of BOD of the activated sludge microorganism, kg, generally between 0.42—0.53: 0.42; Q was the average flow rate of sewage, m^3/d; S_r was degraded organic pollutants, mg/L; b was the oxygen needed for oxidization of 1kg activated sludge per day, kg, generally between 0.11—0.188, and it adopted 0.11; V was the aeration tank volume, m^3; X_V was the f·X. After calculation the results were got $O_{2\ average}$= $\frac{\text{[illegible]}}{1000}$ + $\frac{\text{[illegible]}}{1000}$= 6840.28kg/d=285.02kg/h.

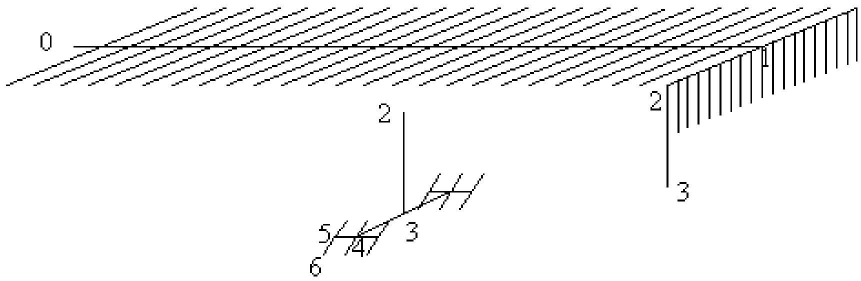
The removal value of BOD_5 was BOD_5= $\frac{\text{[illegible]}}{1000}$= 6821.39 kg/d.

The oxygen needed for removing 1Kg of BOD was ΔO_2 =6840.28 ÷ 6821.39=1kg (O_2)/kg (BOD). Ratio of maximum oxygen needed and the average oxygen needed was $O_{2max}/O_{2average}$= $\frac{344.7}{285.02}$= 1.21.

The gas supply in this system was the atmospheric air, 1kg oxygen equals to about 3.5 m^3 air, and the utilization rate of the oxygen in the water was 15%, and the air needed was 6840.28*3.5/15%=159606.53 m^3 /d=6650.28 m^3 /h. The air supply volume per hour was 6650.28 m^3.

Based on the design and calculation of the SBR reactor tank, the size of the SBR reactor tank of 53m*53m was set, and the area was 2809 m^2. The mesh mode micro-porous diffuser was adopted, and service area of each diffuser was 0.5 m^2, then the number of the air diffusers was $\frac{53*53}{0.5}$=5618. For safety sake, 5700 air diffusers were used in this study.

One transverse air-drying pipe was set at one SBR reactor tank side that was 0.5m to the water level; at the both sides of the transverse air-drying pipe, one vertical air-drying pipe was set respectively that was 1m to the tank wall. And 23 vertical air-drying pipes were set between these two vertical air-drying pipes every 2.2m interval, so the total number of the vertical air-drying pipes was 25, which were set at 0.5m above the water level. The upright air-drying pipe was set that was perpendicular to the tank bottom on every vertical air-drying pipe, and one upright air-drying pipe was set at 1.4m to wall of the reactor tank that was parallel to the transverse air-drying pipe, and then one upright air-drying pipe was set every 2.8m from this pipe. So, on one vertical air-drying pipe there were 19 upright air-drying pipes set, and there were 9 upright air-drying pipes at the both sides of each transverse air-drying pipe. The total number of the upright air-drying pipes was 350. The length of each upright air-drying pipe was 5m, and the distance from the pipe end to the tank bottom was 0.2m, and the submergence depth was 4.8m. There set 12 mesh mode air diffusers and totally 5700 air diffusers, which can entirely meet the requirements of the aeration.



Graph 3.Sketch of pipeline system

According to the experimental formula and the most disadvantaged principle of calculating the pipeline resistance loss, the total pipeline resistance was: $P=151.84kP_a$

4.2.4 Design and calculation of disinfection contact tank

The quality of the sewage has been improved after SBR treatment, and the bacteria contents descend greatly, but a considerate number of pathogens still exist. So, before draining the sewage into the water body, it must be sterilized. The chemical method was adopted to remove the hazardous microorganism in the water, which can ensure the safety drainage of the sewage. (Zhang 1989, 56.)

The chlorine disinfection was adopted in this study, which was authentic and easy to operate and the cost was very low. Two groups of contact chambers were adopted.

The volume of the contact chamber was got: $V_{Total}=1180.8\,m^3$; there sets 2 horizontal flow corridor contact chambers, and the $\frac{V_{Total}}{2}$ volume of single chamber was: V= =590.2 m^3. Surface area of contact chamber: F=196.8 m^2, Size of the contact chamber: corridor width B=4m, total length of each corridor: L_{Total}=49.2m, the height of contact chamber H was 3.38m, chlorine supply was 284kg.

Since the area of this town S was 1119.46 hectare and the total population N was 167919, then combining the local sewage drainage situation, the total flow rate and the primary contaminants concentration can be calculated:

Q_{Design}=656.12L/s=56688.77 m^3/d

C_{SS} =0.2769g/L=276.9mg/L

C_{BOD_5} =0.1871g/L=187.1mg/L

C_{COD} =0.4014g/L=401.39mg/L

Degree of treatment of each pollutant was got: Degree of treatment of SS was over 92.78%, the SS concentration in the sewage drainage was below 20 mg/L; the design BOD_5 degree of treatment was 89.3%, the actual removal rate was η =92.23%, the BOD_5 concentration in the sewage drainage was below 14.6mg/L; the degree of treatment of COD was over 85.1%, and the COD concentration in the sewage drainage was below 60mg/L.

5 CONCLUSIONS

Firstly, the purpose of this study is to resolve river pollution problems that seriously and adversely affect the local residents' living and constrain economic development. After the consideration of the degree of treatment, technological flow, economic factors, plant construction, and daily maintenance, the sequencing batch reactor activated sludge process (SBR method) was chosen.

Secondly, the SBR method has been widely used in the treatment of urban domestic swage. SBR technology is also a technology requiring for further development and perfection. With the increase of category of industrial waste water with complex contents, especially the increasing category and concentration of organic matter that is not easily degradable, the elimination of pollutants has become a key topic in the field of environment protection studies. By utilizing the limited funds to solve the increasingly serious water pollution problem, SBR technology is definitely the first choice, with the characteristics of low investment, high efficiency and low energy consumption. It is predicted that SBR technology will have much more development potential.

At last, the local sewage drainage situation is combined, after the results are calculated out, We got that the water outlet indexes of this designed sewage disposal plant meet the CASE-II water body standard (Level One) of Discharge Standard of Pollutants for Municipal Wastewater Treatment Plant (GB18918-2002).The study has resolved the problem of unqualified sewage drainage in this region.

APPENDIX 1

$Q_1 = \frac{16791*1600}{3600*24}$ =310.96l/s=26867040L/d

$Q_2 = \frac{1100*1000}{3600*24} + \frac{900*1000}{3600*24} + \frac{700*1000}{3600*24}$ =31.25L/s

$Q_T = Q_1 + Q_2$ =310.96+31.25=342.21L/s=29566944L/d

$Q_M = \frac{[illegible]}{3600}$ =208.33L/s=18000 m^3/d

$Q_D = Q_1 K_2 + Q_M$ =310.96* K_2 +208.33=656.12L/s=56688.77 m^3/d

In the formula, domestic sewage variation factor was $K_2 = \frac{2.7}{310.96^{0.11}}$ =1.44;

Q_1 is the average living quantity of sewage, L/d;

Q_2 is the average industrial quantity of sewage, L/d;

Q_T is the total average quantity of sewage, L/d;

Q_M is the maximum industrial quantity of sewage, L/d;

Q_D is the design quantity of sewage, L/d.

APPENDIX 2

$$C_{SS} = \frac{Q_1 C_{1(SS)} + \sum Q_g C_g}{Q_1 + \sum Q_g} = \frac{[illegible]}{[illegible]}$$

=0.2769g/L=276.9mg/L

$$C_{BOD_5} = \frac{Q_1 C_{1(BOD)} + \sum Q_g C_g}{Q_1 + \sum Q_g} = \frac{[illegible]}{[illegible]}$$

=0.1871g/L=187.1mg/L

$$C_{COD} = \frac{Q_1 C_{1(COD)} + \sum Q_g C_g}{Q_1 + \sum Q_g}$$

$$= \frac{[illegible]}{[illegible]}$$

=0.4014g/L=401.39mg/L

$$C_N = \frac{Q_1 C_{1(N)} + \sum Q_g C_g}{Q_1 + \sum Q_g}$$

$$= \frac{[illegible]}{[illegible]}$$

=38.86mg/L

$$C_P = \frac{Q_1 C_{1(P)} + \sum Q_g C_g}{Q_1 + \sum Q_g}$$

$$= \frac{[illegible]}{[illegible]}$$

=7.83mg/L

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